HAWAIʻI CLEAN ENERGY

DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

SUMMARY

(DOE/EIS-0459)

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COVER SHEET

TITLE: Hawai‘i Clean Energy Draft Programmatic Environmental Impact Statement (Draft PEIS)

RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE), Offices of Electricity Delivery and Energy Reliability (OE) and Energy Efficiency and Renewable Energy (EE)

COOPERATING AGENCIES: State of Hawai‘i (Department of Business, Economic Development and Tourism), U.S. Environmental Protection Agency (USEPA), Bureau of Ocean Energy Management, National Park Service, Natural Resources Conservation Service, U.S. Marine Corps, U.S. Navy, and Federal Aviation Administration

LOCATION: State of Hawai‘i (Islands of O‘ahu, Hawai‘i, Kaua‘i, Lāna‘i, Maui, and Moloka‘i)

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ABSTRACT: The Draft PEIS evaluates DOE’s proposed action to develop guidance that can be used to support the State of Hawai‘i in achieving the Hawai‘i Clean Energy Initiative (HCEI) goal of meeting 70 percent of the State’s energy needs by 2030 through clean energy. For the Draft PEIS, DOE and the State of Hawai‘i grouped 31 clean energy technologies and activities into five categories: (1) Energy Efficiency, (2) Distributed Renewable Energy Technologies, (3) Utility-Scale Renewable Energy Technologies, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution. For each activity or technology, the Draft PEIS identifies potential impacts to 17 environmental resource areas and potential best management practices that could be used to minimize or prevent those potential environmental impacts.

DOE invites comments on this Draft PEIS during the 90-day comment period that begins with the EPA publication of a Notice of Availability in the *Federal Register*. The Hawai‘i Clean Energy PEIS Website http://hawaiicleanenergypeis.com provides information on eight public hearings to be held at several locations in Hawai‘i between May 12 and 22, 2014. Comments on the Draft PEIS may be made orally or in writing at a public hearing; or by email to hawaiicleanenergypeis@ee.doe.gov; online at http://hawaiicleanenergypeis.com; or in writing to Dr. Summerson at the above address. Written and oral comments will be given equal weight, and any comments submitted after the comment period will be considered to the extent practicable.

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ACRONYMS

BOEM	U.S. Bureau of Ocean Energy Management
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
DBEDT	Hawaiʻi Department of Business, Economic Development and Tourism
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPAct 2005	*Energy Policy Act of 2005*
FR	*Federal Register*
HCEI	Hawaiʻi Clean Energy Initiative
HIREP	Hawaiʻi Interisland Renewable Energy Program
MOU	Memorandum of Understanding
NEPA	*National Environmental Policy Act of 1969*
NOI	Notice of Intent
NPS	U.S. National Park Service
NRCS	U.S. Natural Resources Conservation Service
PEIS	Programmatic Environmental Impact Statement
PV	photovoltaic
U.S.C.	United States Code

S.1 Introduction

The *Hawai'i Clean Energy Draft Programmatic Environmental Impact Statement* (Draft PEIS) analyzes the potential environmental impacts, and best management practices that could minimize or prevent those potential environmental impacts, associated with 31 clean energy technologies and activities grouped into five categories: (1) Energy Efficiency, (2) Distributed Renewable Energy Technologies, (3) Utility-Scale Renewable Energy Technologies, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution. The information in the PEIS could help DOE, the public, other Federal and State agencies, Native Hawaiian and other organizations, and future energy developers better understand and plan for greater use of renewable energy and energy efficiency in Hawai'i.

With about 85 percent of its energy derived from imported petroleum and petroleum products, the State of Hawai'i remains the most oil-dependent State in the Nation. Roughly equal amounts of petroleum are used for electricity generation, ground transportation, and commercial aviation (about 28 percent each), with the rest used for marine transport, military, and other uses. Unlike other states, Hawai'i relies heavily on imported oil to meet its electricity generation needs. Whereas less than 1 percent of electricity on the U.S. mainland is generated using oil, in Hawai'i, the figure is 74 percent. Furthermore, electricity prices in the State are three times higher than the United States national average. Section 355 of the *Energy Policy Act of 2005* (EPAct 2005) directs the U.S. Department of Energy (DOE) to assess the economic implications of Hawai'i's dependence on imported oil as the principal source of energy and to explore the technical and economic feasibility of increasing the contribution of renewable energy resources for both electricity generation and fuel for various modes of transportation.

In furtherance of the provisions of Section 355 of EPAct 2005, DOE and the State of Hawai'i entered into a Memorandum of Understanding (MOU) in January 2008. This MOU established a long-term partnership known as the Hawai'i Clean Energy Initiative (HCEI) to transform the way in which energy efficiency and renewable energy resources are planned and used in the State. A goal of the HCEI is to meet 70 percent of Hawai'i's energy needs by 2030 through clean energy, which refers to a combination of 40 percent from renewable energy generation and 30 percent from energy efficiency and conservation measures. In addition to State-mandated renewable energy and energy efficiency goals, the HCEI includes a goal to reduce oil used for ground transportation by 70 percent by 2030, and a goal to meet as much of in-State demand for transportation fuels with renewables as feasible by 2030. In support of HCEI goals, the Hawai'i State Legislature passed and the Governor signed into law House Bill 1464 in 2009, establishing the current Renewable Portfolio Standard and Energy Efficiency Portfolio Standard in the State of Hawai'i.

S.2 Purpose and Need

The purpose and need for DOE action is based on the 2008 MOU with the State of Hawai'i that established the long-term HCEI partnership. Consistent with this MOU, DOE's purpose and need is to support the State of Hawai'i in its efforts to meet 70 percent of the State's energy needs by 2030 through clean energy.

DOE's primary purpose in preparing this PEIS is to provide information to the public, Federal and State agencies, Native Hawaiian and other organizations, and future energy developers on the potential environmental impacts of a wide range of energy efficiency activities and renewable energy technologies that could be used to support the HCEI. This environmental information could be used by decisionmakers, developers, and regulators in determining the best activities and technologies to meet future energy needs. The public could use this PEIS to better understand the types of potential impacts associated with the various technologies and activities.

The State of Hawaiʻi's intent regarding the Clean Energy PEIS is for the Federal, State, and county governments, the general public, and private developers to use the PEIS as a reference document when project-specific environmental impact statements (EISs) are prepared.

DOE prepared this PEIS pursuant to *National Environmental Policy Act of 1969* (NEPA), as implemented by the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500 through 1508) and DOE NEPA implementing procedures (10 CFR Part 1021).

S.3 Proposed Action

DOE's proposed action is to develop guidance that can be used in making decisions to support the State of Hawaiʻi in achieving the goal established in the HCEI to meet 70 percent of the State's energy needs by 2030 through energy efficiency activities and renewable energy technologies.

Most clean energy projects have the potential to cause environmental impacts, especially if not implemented properly. However, careful adherence to Federal, State, and county laws, regulations, and permitting requirements; implementation of well-planned best management practices and mitigation measures; along with early consideration of local community concerns about the projects could alleviate or mitigate many of the potential environmental impacts.

Early consideration of such guidance, especially in project planning and development, could substantially streamline the project-specific environmental review, permitting processes, and community interactions, as well as lessen the potential for controversy over specific projects. DOE application of this guidance would be limited to those actions where DOE has authority for a Federal decisionmaking role; however, the information in this PEIS and in any forthcoming guidance could be potentially useful for any proposed project whether Federal, State, or private.

For this PEIS, DOE and the State of Hawaiʻi identified 31 clean energy technologies and activities associated with potential future actions and grouped them into five clean energy categories. These are listed in Table S-1 and briefly described below. Activities and technologies were selected for clean energy categories based on their ability to make a timely contribution to the reduction of Hawaiʻi's reliance on fossil fuels and their stage of technical development, which makes the technology more likely to advance to the implementation or commercialization stage. Four of these technologies or activities are only described in Chapter 2 and not carried forward for detailed impacts analyses. The reasoning for this treatment is provided in the descriptions below.

This PEIS analyzes each of these technologies and activities at a programmatic level for the islands of Kauaʻi, Oahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi. Potential impacts are analyzed on an island-by-island basis when feasible. DOE is not proposing to develop any specific project, activity, or technology at this time and, therefore, cannot and does not analyze impacts of specific projects.

In the absence of specific, proposed projects, DOE defined "representative projects" for each activity and technology to allow the PEIS to evaluate and present the typical impacts (beneficial and adverse) associated with the respective activity or technology at the scale of a hypothetical project. The representative projects for each activity and technology characterize projects that could be implemented in Hawaiʻi by 2030 based on realistic capacity factors and feasibility. The representative projects are hypothetical and not intended to represent any real or proposed project and are provided for analytical purposes only.

Table S-1. Clean Energy Categories and Associated Technologies or Activities

Clean Energy Category	Technology or Activity
Energy Efficiency	Energy Efficient Buildings
	Energy Conservation
	Ground Source Heat Pumps
	Initiatives and Programs
	Sea Water Air Conditioning
	Solar Water Heating
Distributed Renewables	Biomass
	Hydroelectric
	Hydrogen Fuel Cells
	Photovoltaic
	Wind
Utility-Scale Renewables	Biomass
	Geothermal
	Hydroelectric
	Municipal Solid Waste
	Marine Hydrokinetic Energy
	Ocean Thermal Energy Conversion
	Photovoltaic
	Solar Thermal
	Wind (Land-based)
	Wind (Offshore)
Alternative Transportation Fuels and Modes	Biofuels
	Electric Vehicles
	Hybrid Electric Vehicles
	Hydrogen
	Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas
	Multi-Modal Transportation
Electrical Transmission and Distribution	On-Island Transmission
	Undersea Cables
	Smart Grid
	Energy Storage

Clean Energy Categories

Energy Efficiency

Energy efficiency refers to reducing the energy used for a given purpose or service while maintaining the same results; for example, replacing an incandescent light bulb with a different type of lighting technology that uses less energy to produce the same amount of light. Energy efficient technologies reduce the need for energy while energy efficient activities require less energy or save energy. This PEIS addresses the following energy efficient technologies and activities:

Energy Efficient Buildings

Residential and commercial buildings use energy for many purposes such as cooling, lighting, water heating, and use of appliances and electronics. Today's buildings consume more energy than any other sector of the U.S. economy including the transportation industry. In an effort to decrease energy consumption, energy efficiency measures are incorporated into building construction and retrofits.

Energy Conservation
Energy conservation is the act of reducing or going without a service or task in order to save energy; for example, turning off a light. Using less energy generally has positive potential environmental consequences. There would be no adverse environmental impacts associated with energy conservation; therefore, this activity is not carried forward for detailed impacts analyses.

Ground Source Heat Pumps
Underground temperatures are less variable than air temperatures. A ground source heat pump is an electrical-powered heating and cooling system that takes advantage of the relatively constant ground or groundwater temperature to transfer energy for space heating/cooling and water heating. At this time, ground source heat pumps are not a feasible technology for large-scale deployment in Hawaii; therefore, this technology is not carried forward for detailed impacts analyses.

Initiatives and Programs
Utility- and government-sponsored clean energy initiatives and programs can help to make renewable energy, energy efficiency, and conservation practices attractive to consumers and communities. There are several ways to provide incentives to individuals, businesses, and communities that could result in a reduced overall demand for imported fossil fuels. These range from education and training to financial incentives for using energy efficient appliances and equipment at home and in commercial operations. The State of Hawai‘i, island utilities, counties, and the Federal Government have employed several energy efficiency and renewable energy initiatives and programs for specific State-, island-, and community-level projects. There would be no adverse environmental impacts associated with initiatives and programs; therefore, this activity is not carried forward for detailed impacts analyses.

Sea Water Air Conditioning
Sea water air conditioning, also known as deep water cooling, uses the temperature differences (gradients) between deep and surface water to chill water for individual buildings or for use in larger (district) cooling air conditioning systems. This energy efficiency technology replaces the conventional electric chiller component of a cooling system with a deep, cold sea water cooling station or heat exchanger to cool a closed-loop air conditioning system that is significantly less energy-intensive.

Solar Water Heating
Solar water heating is a technology that uses the sun to heat water. It is generally considered for use in residential rooftop applications. This PEIS focuses on its use in single-family homes; however, it is scalable to multi-family residences. Solar water heating technology has the potential to reduce household energy consumption by up to 40 percent.

Distributed Renewables
Distributed renewables refer to the use of renewable energy resources for an electricity generator that is located close to the end user or even onsite. The generating capacity of a distributed generation source can range from generation at a single residence to larger installations for commercial or multi-unit housing applications. This PEIS addresses the following distributed renewable technologies and activities:

Biomass
Biomass energy encompasses multiple energy production technologies that use organic matter from trees, agricultural crops, and animal waste as well as biogenic material in urban waste streams to produce a variety of potential energy end products. Biomass energy to produce electricity and heat is discussed under both distributed renewable and utility-scale renewable energy. Biomass energy used for transportation fuels is discussed under Alternative Transportation Fuels and Modes.

Hydroelectric

Hydroelectric power, or hydropower, utilizes the energy in flowing water to spin a turbine attached to a generator to produce electricity. Hydropower plants require a water source in a geographic area generally characterized by uneven terrain such as hills or mountains to have sufficient power-generation potential. There are three common types of hydropower plant designs: impoundment, diversion, and pumped storage hydropower (the latter is discussed in the context of Energy Storage technology in the clean energy category of Electrical Transmission and Distribution).

Hydrogen Fuel Cells

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. A hydrogen fuel cell uses the chemical energy of hydrogen to react with oxygen to produce electricity. Fuel cells can be used for almost any application typically powered by batteries or internal combustion engines, and they can scale to provide energy to a laptop computer or to a utility power station. Fuel cells produce no criteria air pollutants or greenhouse gas emissions at the point of operation. However, they are heavily dependent on a cost-efficient supply of hydrogen.

Photovoltaics

Photovoltaic (PV) cells convert sunlight to electricity. Photovoltaic cells are assembled into a solar module or group of PV cells. Solar modules are placed in an area or added to a larger system to generate and supply electricity for homes and businesses. A system typically includes one or more solar modules (sometimes referred to as an array), equipment to convert direct current electricity to alternating current electricity (i.e., inverters), and connecting wiring. Some systems are designed with batteries to store the generated electricity for later use and/or sun tracking devices to increase the amount of solar energy collected.

Wind

Wind turbines convert the kinetic energy of the wind to mechanical power. The wind turbine blades are designed to act like an airplane wing. The wind causes a pocket of low-pressure air on one side of the blade, which generates “lift” and pulls the blade toward it, causing the blade to move and the rotor to turn. The rotor turns a shaft and, through a gearbox, spins a generator to make electricity. Small wind turbines generally are those with capacities ranging from 20 watts to 100 kilowatts. At the low end of this range, units with capacities of 20 to 500 watts are often referred to as micro-turbines. At the high end of the range, small wind turbines can have a similar configuration and appearance to utility-sized wind turbines.

Utility-Scale Renewables

Utility-scale renewables refer to the use of renewable energy resources from a centrally located regional power plant. Utility-scale renewable technologies include the same kinds of renewable energy resources as distributed renewables, as well as other resources whose use at the distributed scale is impractical. The generating capacities for utility-scale technologies are typically at least an order of magnitude larger than for distributed applications. This PEIS addresses the following utility-scale technologies and activities:

Biomass

Biomass energy sources for utility-scale projects are the same as those for distributed renewable energy projects. Some types of biomass resources are more or less suited for utility-scale projects. The cost-effective acquisition (i.e., collecting, processing, and transportation) of biomass resources is a key component to implementing a utility-scale biomass energy system.

Geothermal

Geothermal energy recovery systems use heat that radiates naturally from the earth. These geothermal systems can be used directly for heating buildings or in industrial processes, or they can be used to generate electricity. Because it is difficult to transport heat over any large distance, both direct use and electricity production must take place at, or very near, the geothermal system. Once converted to electricity, the energy can be transported great distances over transmission lines.

Hydroelectric
Utility-scale hydroelectric, or hydropower, is the same technology as described in Distributed Renewables but on a larger scale. According to the utilities in the State, the river resources in Hawaiʻi are not suitable for large hydroelectric impoundments, as there are no major low-head, high-flow rivers in Hawaiʻi; therefore, this utility-scale technology would not be feasible and is not carried forward for detailed impacts analyses.

Municipal Solid Waste
Municipal solid waste, more commonly known as trash or garbage, consists of everyday items used and then thrown away. This technology includes options available for converting municipal solid waste and other forms of waste to energy. Municipal solid waste-to-energy projects use similar technologies as those described for biomass facilities but also include the collection and use of methane gas released from existing landfills.

Marine Hydrokinetic Energy
Marine hydrokinetic technologies use the kinetic energy from moving water (such as waves, tides, and ocean currents) to generate electricity. The amount of energy that can be extracted from a wave is a function of the wave's height and frequency. That is, the higher and more frequent the waves, the more power that can be extracted. Marine hydrokinetic devices can be situated on the shoreline or offshore depending on the technology. This technology is in the early stages of development; consequently, there are numerous designs in various stages of viability for commercial deployment or product testing.

Ocean Thermal Energy Conversion
Ocean thermal energy conversion is a technology that relies on temperature gradients in the ocean to generate electricity. By utilizing colder deep water and warmer surface waters, it is possible to alternately condense and evaporate a fluid to drive a turbine. In general, the larger the temperature difference between the shallow and deep water, the more power a system will be able to produce.

Photovoltaics
As discussed in Distributed Renewables, PV modules convert the sun's energy directly into electricity. This technology also is currently applied to larger, utility-scale generating facilities as arrays of solar modules.

Solar Thermal
Solar thermal energy systems convert solar energy into thermal energy (heat) that can be used for the production of electricity. One big difference from solar PV technology is that solar thermal power plants generate electricity indirectly. Heat from the sun's rays is collected and used to heat a fluid. The steam produced from the heated fluid powers a generator that produces electricity.

Land-Based Wind
As discussed above for distributed wind, wind turbines convert the kinetic energy of the wind to mechanical power. Utility-scale wind projects include multiple, larger turbines in an array to maximize the available wind resource. Typical land-based wind turbines for utility-scale applications range from 1.5 to 3.5 megawatts with rotor diameters of 200-300 feet on towers about 250 feet to over 350 feet tall, dependent on the particular installation.

Offshore Wind
Offshore, utility-scale wind turbines function in the same manner as land-based wind turbines. That is, they convert the kinetic energy of the wind to mechanical power and the turning rotor spins a generator to make electricity. Most manufacturers of offshore wind turbines are currently testing prototypes with capacities of 5 to 7 megawatts with rotor diameters roughly 400 to 500 feet or larger. A primary difference between land-based and offshore wind turbine technology is the substructure upon which the wind turbine and tower is mounted. Depending on the depth of the water, offshore turbines are mounted on either shallow-water substructures (less than about 100 feet), transitional technology substructures (100 to 200 feet), or floating platforms (greater than 200 feet).

Alternative Transportation Fuels and Modes
Alternative transportation fuels and modes encompass those fuel types and methods of transportation that are different than conventional gasoline-powered automobiles. This PEIS addresses the following alternative transportation fuels, alternative transportation modes, and alternative types and methods of transportation:

Biofuels
Biofuels are fuels derived from biomass or waste feedstocks. Biomass includes wood, agricultural crops, herbaceous and woody energy crops, and municipal organic wastes such as manure. These feedstocks can be transformed using a variety of conversion technologies into conventional biofuel products (such as ethanol and biodiesel), and advanced biofuel products (such as cellulosic ethanol, biobutanol, Green Diesel, synthetic gasoline, and renewable jet fuel).

Electric Vehicles
Electric vehicles operate with an electric motor (or motors) powered by rechargeable battery packs. Some electric vehicles run solely on electrical power from the grid while others use a combination of gasoline and electricity.

Hybrid Electric Vehicles
Hybrid-electric vehicle powertrains combine a conventional combustion engine (either gasoline or diesel), a battery, and an electric motor. The wheels are driven by the internal combustion engine, the electric motor, or a combination of the two.

Hydrogen
Hydrogen is the simplest and most abundant element in the universe and can be produced from fossil fuels including oil, coal, or natural gas as well as biomass, organic waste, water, or salt water. As a transportation fuel, the energy content in 2.2 pounds of hydrogen gas is about the same as the energy content in 1 gallon of gasoline. Hydrogen can be used in internal combustion engines or in combination with hydrogen fuel cells to power electric motors.

Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas
Natural gas as an alternative transportation fuel for vehicles comes in two forms: compressed natural gas and liquefied natural gas. The fuel is used in natural gas vehicles and more commonly in compressed natural gas-powered vehicles. These vehicles are similar to gasoline or diesel vehicles with regard to power, acceleration, and cruising speed.

Multi-Modal Transportation
Multi-modal transportation options reduce the number of miles traveled by personal vehicles for work commuting and personal trips. Multi-modal transportation options include mass transit, ridesharing, car sharing, biking, walking, and telecommuting/teleworking.

Electrical Transmission and Distribution

Electrical transmission and distribution refers to the transmission of electrical power from a point of generation and the means by which it is stored and distributed to electricity users. Electricity transmission and distribution systems form an electrical grid or network that is used to manage and distribute electricity in a geographic region. While electrical transmission and distribution is not specifically addressed in the HCEI, implementation of new renewable energy technologies and/or improving the existing electrical network in Hawai‘i would directly affect transmission of such electricity and is therefore analyzed in this PEIS. This PEIS addresses the following electrical transmission and distribution technologies and activities:

On-Island Transmission

On-island transmission of electricity includes connections from the power generation source, transmission over a short or long distance, and connection to the power user. This system is often referred as the island electrical grid or simply “power grid.” The power grid is how the majority of people and companies get their electricity.

Undersea Cable

Undersea power cables, also called submarine cables, transmit power across large bodies of water; whether from one island to another or from an offshore energy facility (e.g., an offshore wind turbine platform) to an on-island electrical network. Undersea cables lie on the sea bed and connect to on-island power grids via a land-sea cable transition site. Any type of electrical power can transmit across undersea cables including that from renewable energy sources such as solar, wind, and biomass.

Smart Grid

A smart grid is a modernized electrical grid that uses analog or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. DOE describes the smart grid as an integration of five fundamental technologies: (1) integrated communications, (2) advanced components, (3) advanced control methods, (4) sensing and measurement, and (5) improved interfaces and decision support.

Energy Storage

Energy storage can take electricity that is generated at one point in time and store it for use at a different time. Incorporating energy storage in the electricity distribution chain allows utilities to decouple generation from demand which has several benefits including improved use of generated energy. The primary uses for energy storage include energy management, bridging power, and power quality and reliability.

S.4 Public Participation and Agency Coordination

S.4.1 PUBLIC PARTICIPATION

S.4.1.1 PEIS Scoping Process

In 2010, DOE announced its intent to prepare a programmatic environmental impact statement (EIS) for the wind phase of the now-defunct Hawai‘i Interisland Renewable Energy Program (HIREP). The Notice of Intent (NOI) appeared on December 14, 2010, in the *Federal Register* (75 FR 77859), and it referred to the programmatic EIS as the HIREP: Wind PEIS (DOE/EIS-0459). The NOI identified the State of Hawai‘i as a joint lead agency.

In February 2011, DOE held scoping meetings in Honolulu, Kahului, Kaunakakai, and Lānaʻi City. In meetings and submitted comments, commenters expressed concern that DOE and the State of Hawaiʻi would not analyze energy efficiency measures, distributed renewable energy assets, or the full range of potential renewable energy technologies. Commenters also expressed concern about the construction of interisland electricity transmission connections and cables; the potential disparity of impacts on islands that could host wind development projects versus those that would use the electricity; and potential impacts to cultural resources, among other issues. In response to public scoping comments received on the HIREP: Wind PEIS, as well as regulatory and policy developments since the scoping meetings, DOE consulted with the State of Hawaiʻi and broadened the range of energy efficiency and renewable energy activities and technologies to be analyzed as well as the number of islands to be evaluated. The result was a more comprehensive programmatic EIS renamed the Hawaiʻi Clean Energy PEIS.

A new scoping process began with DOE's publication of an Amended NOI in the *Federal Register* (77 FR 47828, August 10, 2012), with the State of Hawaiʻi as a cooperating agency instead of a joint lead agency. The Amended NOI identified the five clean energy categories under the expanded range of activities and technologies to be analyzed. DOE held eight public scoping meetings in September 2012 on six islands in the cities of Honolulu, Līhuʻe, Kailua-Kona, Hilo, Kahului, Lānaʻi City, Kaunakakai, and Kāneʻohe.

In addition to the Amended NOI, DOE announced the scoping meetings to encourage public participation in the PEIS process through publishing notices in six local newspapers, issuing a press release, sending postcards or emails to individuals and groups that had previously shown interest in the HIREP: Wind PEIS, and creating the Hawaiʻi Clean Energy PEIS Website (www.hawaiicleanenergypeis.com).

DOE received and reviewed more than 700 comment documents as part of the Hawaiʻi Clean Energy PEIS scoping process. Issues raised most often were related to island energy independence and self-sufficiency (e.g., opposition to generating electricity on other islands for transmission to Oʻahu); Native Hawaiian issues (e.g., to avoid impacts on subsistence lifestyle, spirituality, and traditions); cultural and historic resources; socioeconomics and communities; land use; biological resources; utility-scale land-based wind and geothermal renewables; undersea cable corridors; and concerns about health effects of smart meters. DOE prepared the *Scoping Summary Report for the Hawaiʻi Clean Energy Programmatic Environmental Impact Statement* that contains a five-page summary of these comments (available online from http://hawaiicleanenergypeis.com/eis-documents/). DOE also considered these comments during the preparation of the Draft PEIS.

S.4.1.2 Areas of Controversy

During the scoping process— through discussions with the cooperating agencies, other agency coordination efforts, and the public involvement process— DOE solicited input, including the identification of any potential areas of controversy. The following potential areas of controversy were identified:

- Island energy independence and self-sufficiency – Concerns were raised about islands being self-sufficient and energy-independent versus using local resources to generate energy for use on other islands.
- Native Hawaiian issues – Concerns, based on traditional beliefs, were raised about the use of island resources, such as using geothermal energy, to generate energy.
- Land use – Concerns were raised about the use of this finite resource for energy generation.

- Transmission lines including undersea cable – In addition to island energy dependence and self-sufficiency, concerns were raised about the overall cost and relative benefit of an interisland transmission grid.

- Analysis was too limiting – Concerns were raised about the proposal for a major project using a single technology (wind power) without adequate study of all the options and their appropriateness for use in specific locations.

As a result of considering all scoping comments, the PEIS is a programmatic evaluation of the energy efficiency activities and renewable energy technologies that could reasonably be implemented in Hawaii. The scope includes an assessment of the viability of implementation in the State of Hawaiʻi and the associated potential environmental impacts. As discussed in Section S.3 above, the PEIS does not evaluate any specific or proposed project. Implementation of these activities and technologies and the ultimate ability to achieve the goals established by the HCEI should include input from all stakeholders.

S.4.1.3 Draft PEIS Public Review and Comment Period

The publication of a Notice of Availability in the *Federal Register* by the U.S. Environmental Protection Agency (EPA) for this Hawaiʻi Clean Energy Draft PEIS initiates a 90-day public review and comment period. As part of this public review and comment period, DOE will hold eight public hearings in Hawaiʻi, from May 12 to May 22, 2014, during which the public can attend to learn about the PEIS analyses and make formal recorded comments on the Draft PEIS. DOE used notification methods similar to those used during the scoping period to notify the public and applicable Federal, State, and county agencies of the public review and comment period for the Draft PEIS. These notification methods included distributing the document to individuals and parties who submitted scoping comments and to others who requested to be included in the distribution of the Draft PEIS. DOE has made the Draft PEIS available online at the Hawaiʻi Clean Energy PEIS Website (www.hawaiicleanenergypeis.com) and on the DOE NEPA Website (www.energy.gov/nepa). DOE will consider all comments on the Draft PEIS received or postmarked during the public review and comment period in preparing the Final PEIS. Comments received after the close of the public review and comment period will be addressed to the extent practicable.

S.4.2 AGENCY COORDINATION

When implementing NEPA, a lead agency is strongly encouraged to involve Federal, State, and local government agencies. DOE has benefitted in the preparation of the Draft PEIS from the contributions of several cooperating and participating agencies.

The CEQ regulations define a lead agency as the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact statement (40 CFR 1501.5 and 40 CFR 1508.16) and a cooperating agency as any other Federal agency having jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment (40 CFR 1501.6 and 40 CFR 1508.5). A State or local governmental agency may also become a cooperating agency. Participating (or consulting) agencies are those with an interest in defining the scope of an impact assessment and collaborating with lead and cooperating agencies in determining the methodologies and level of detail to be used in analyzing the alternatives.

DOE sent invitations to various Federal agencies and the State of Hawaiʻi Department of Business, Economic Development and Tourism (DBEDT) to be cooperating agencies for this PEIS. DBEDT agreed to represent the State of Hawaiʻi as the sole cooperating agency for the State. Table S-2 lists the Federal and State agencies that agreed to be a cooperating agency or participating agency for this PEIS, followed by brief descriptions of the expertise, permitting authority, and responsibilities of each cooperating agency.

Table S-2. Cooperating and Participating Agencies

Agency	Department/Office
Cooperating Status	
U.S. Department of the Interior	National Park Service
	Bureau of Ocean Energy Management
U.S. Department of Agriculture	Natural Resources Conservation Service
U.S. Environmental Protection Agency	Region 9
U.S. Department of Defense	U.S. Marine Corps
	U.S. Navy
U.S. Department of Transportation	Federal Aviation Administration
State of Hawaiʻi	DBEDT
Participating Status	
U.S. Department of the Interior	U.S. Geological Survey
	U.S. Fish and Wildlife Service
Advisory Council on Historic Preservation	N/A
U.S. Department of Agriculture	Farm Services Agency
U.S. Department of Commerce	National Marine Fisheries Service
	National Oceanic and Atmospheric Administration, National Ocean Service – Office of National Marine Sanctuaries
U.S. Department of Transportation	Federal Highway Administration
U.S. Department of Homeland Security	U.S. Coast Guard
U.S. Department of Defense	U.S. Army Corps of Engineers

S.4.2.1 National Park Service

The U.S. National Park Service (NPS) has expertise in natural and cultural resources and is charged with protecting the U.S. National Park System including resources for future generations. In addition, the NPS monitors the condition of National Historic Trails and Landmarks and National Natural Landmarks outside of the park system, and it may provide technical preservation assistance to owners of landmarks. NPS also maintains the *National Register of Historic Places*.

S.4.2.2 Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) has expertise in and the responsibility for permitting leases and rights-of-way for renewable energy development activities on the Outer Continental Shelf and other offshore Federal waters. It also has expertise in coastal and marine biological and physical sciences, as well as marine archaeological and cultural resources. Under EPAct 2005, BOEM was granted (through its predecessor agency) the authority for regulating the production, transportation, and transmission of renewable energy resources on the Outer Continental Shelf and other offshore Federal waters.

S.4.2.3 Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) has expertise in conservation planning assistance to private landowners and in the soil sciences. NRCS derives its regulatory and permitting authority under the *Soil Conservation and Domestic Allotment Act* (16 U.S.C. § 590) and the *Food, Conservation, and Energy Act of 2008* (Public Law 110–234; known as the “Farm Bill”), as well as subsequent Farm Bills using programs such as the Conservation Stewardship Program (7 CFR Part 470); *Environmental Quality*

Incentives Program in the Food, Conservation, and Energy Act of 2008 (Public Law 110–246); and the Wildlife Habitat Incentive Program (7 CFR Part 636).

S.4.2.4 U.S. Environmental Protection Agency

The EPA administers the programmatic and regulatory aspects of 11 pollution control statutes including the *Clean Air Act* (42 U.S.C. §§ 7401 *et seq*.) and *Clean Water Act* (33 U.S.C. §§ 1251 *et seq*.). EPA has interest in all environmental resource areas, activities, and technologies. As a cooperating agency, EPA will assist in the independent review of both the Draft and Final PEISs.

S.4.2.5 Federal Aviation Administration

The Federal Aviation Administration has expertise in airport land and airspace issues and permitting authority for matters related to hazards to air navigation.

S.4.2.6 U.S. Marine Corps and U.S. Navy

The U.S. Marine Corps and the Department of the Navy both have expertise related to U.S. military installations and training, including radar, restricted areas, airspace, and training areas. All branches of the military are present on Oʻahu. The branches of the military coordinate with the U.S. Department of Defense (DoD) on renewable energy project compatibility through the DoD Siting Clearinghouse in the Office of the Deputy Undersecretary of Defense for Installations and Environment. The Clearinghouse formal review process applies to projects filed with the U.S. Secretary of Transportation under 49 U.S.C. § 44718 as well as other projects proposed for construction within military training routes or special use airspace, whether on private, State, or Federal property.

S.4.2.7 State of Hawaiʻi

State of Hawaiʻi agencies have expertise in all matters related to State energy policy, land use, Native Hawaiian culture, aquatic resources, ocean recreation, forestry and wildlife, land and coastal land management and conservation, historic preservation, and parklands. On behalf of all State of Hawaiʻi agencies, DBEDT is serving as a cooperating agency for this PEIS. The State agencies have permitting authority and will serve as information sources for many entities, including but not limited to the public and developers of future projects in Hawaiʻi.

S.5 Permitting and Regulatory Requirements

DOE prepared this Draft PEIS pursuant to NEPA, as implemented by the CEQ NEPA regulations (40 CFR Parts 1500 through 1508) and DOE NEPA implementing procedures (10 CFR Part 1021). This PEIS considers, among other regulatory items, the requirements of the *Hawaiʻi Environmental Policy Act* (Chapter 343, Hawaiʻi Revised Statutes). This PEIS does not eliminate the need for project-specific environmental review of individual projects or activities that might be eligible for funding or other forms of support by DOE or other Federal agencies. To the extent that DOE proposes to fund or undertake particular projects or activities that may fall within the scope of this PEIS, project-specific NEPA reviews for such projects and activities are expected to build on, or tier from, this PEIS. Moreover, any such projects and activities would be subject to compliance with obligations under other environmental laws such as the *Endangered Species Act of 1973* (16 U.S.C. §§ 1531-1544 *et seq*.) and the *National Historic Preservation Act of 1966* (16 U.S.C. §§ 470 *et seq*.). For those projects that do not have any connection to Federal actions, State-level environmental reviews would still have to occur as required under Hawaiʻi Revised Statutes, such as the *Hawaiʻi Environmental Policy Act* and other statutes and administrative rules.

The Hawai‘i State Energy Office has developed and made available online a comprehensive list of Federal, State, and county-specific permits that are generally required for the activities that typically accompany clean energy projects. These include permits related to siting, construction, operation, and other phases. This information is available at https://energy.Hawaii.gov and includes a link to a single downloadable document called the *Guide to Renewable Energy Facility Permits in the State of Hawai‘i*. Permit packets associated with each permit also are available for download at the above website. In addition, many Federal, State, and county permitting agencies in Hawai‘i have developed their own guidance materials describing various permitting processes, procedures, and requirements. The links to these agency websites are included in Section 2.2 of the PEIS.

To supplement these tools, a free interactive online permitting tool, the Hawai‘i Renewable Energy Permitting Wizard, is also available from the Hawai‘i State Energy Office (http://wizard.hawaiicleanenergyinitiative.org/). The wizard allows users (such as a would-be renewable energy developer) to identify the Federal, State, and county permits that may be required for a specific renewable energy project in Hawai‘i based on input provided by the user. Designed for renewable energy projects, the wizard can create a permit plan for a proposed project based on the type of renewable energy technology proposed. The permit plan also includes the recommended sequence—with estimated timelines—in which the permits may be obtained.

S.6 Structure of the Hawai‘i Clean Energy PEIS

This PEIS is arranged into a summary; eight chapters, each containing a separate, chapter-specific reference list; and three appendices:

- This Summary summarizes the contents of the PEIS. In accordance with 40 CFR 1502.12, the Summary stresses the major conclusions and areas of controversy (including issues raised by agencies and the public). Title 40 CFR 1502.12 also requires that a summary stress the issues to be resolved (including the choice among alternatives). However, since this PEIS focuses on a range of technologies and activities and analyzes their potential impacts rather than setting up a choice from among them, neither the body of the PEIS nor this Summary present issues to be resolved.

- Chapter 1, “Introduction,” provides background information on the HCEI, an overview of the NEPA process, the purpose and need for agency action, and information on public and agency coordination.

- Chapter 2, “Proposed Action,” describes each of the five clean energy categories and the associated 31 technologies and activities. The chapter discusses, from a programmatic perspective, the permitting and regulatory requirements needed to implement the technologies and activities associated with the different clean energy categories. It provides a brief primer of each activity/technology that includes a description of a representative project. The chapter includes a discussion of a no-action alternative and tables that summarize potential environmental impacts associated with the technologies and activities in each clean energy category. The chapter concludes with brief explanations of the PEIS’s treatment of cumulative impacts, irreversible and irretrievable commitment of resources, the relationship between short-term uses and long-term productivity, unavoidable adverse impacts, and DOE’s preferred alternative. This chapter also contains the glossary.

- Chapter 3, “Affected Environment,” provides the existing conditions for each of the potentially affected environmental resource areas. It considers these resource areas at the State level and on an island-by-island basis for six islands (Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i). In order to avoid redundancy in later chapters focused on technology-specific impacts, this chapter includes a discussion of the environmental impacts most often associated with construction and operation activities regardless of the clean energy activity or technology. The chapter organizes and discusses these impacts and associated best management practices in relation to the impacted resource, not the particular activity or technology. The environmental resource areas addressed in Chapter 3 include:

– Geology and Soils – The geologic characteristics of the area at and below the ground surface, the frequency and severity of seismic activity, and the kinds and quality of soils.

– Climate and Air Quality – Climatic conditions such as temperature and precipitation, ambient air quality, and criteria pollutant and greenhouse gas emissions.

– Water Resources – Marine, surface-water, and groundwater features, water quality and availability, floodplains, and wetlands.

– Biological Resources – Flora and fauna of the region and the occurrence and protection of special-status species.

– Land and Submerged Land Use – Land and submerged land use practices and land ownership information.

– Cultural and Historic Resources – Cultural, historic, and archaeological resources and the importance of those resources.

– Coastal Zone Management – The existing regulatory process for consistency with coastal zone management plans, special management areas, and shoreline setbacks.

– Scenic and Visual Resources – Scenic and visual resources in terms of land formations, vegetation, and color, and the occurrence of unique natural views.

– Recreation Resources – Existing recreation areas and uses, both on land and in the marine environment.

– Land and Marine Transportation – The existing transportation systems in the area.

– Airspace Management – Existing airport systems and military air bases and operation as well as the processes for managing the safe utilization of the airspace for intended uses.

– Noise and Vibration – Ambient noise and vibration levels, analytical techniques, and the identification of sensitive receptors.

– Utilities and Infrastructure – Existing electric utilities and electrical transmission and distribution services.

– Hazardous Materials and Waste Management – Solid and hazardous waste generation and management practices, wastewater services, the types of waste from current activities, the means by which waste is disposed, and pollution prevention practices.

– Socioeconomics – The labor market, population, housing, public services, and personal income.

- Environmental Justice – The identification of low-income and minority populations that could be subject to disproportionately high and adverse environmental impacts.

- Health and Safety (including Accidents and Intentional Destructive Acts) – The existing public and occupational safety conditions, including information on health and safety regulations and worker safety and injury data. The impacts chapters also provide a perspective of potential impacts from accidents and intentional destructive acts.

- Chapters 4 through 8 present the environmental impact analyses of each activity/technology by environmental resource area. The analyses are based on the potential programmatic-level impacts from the representative projects (Chapter 2) on the affected environment (Chapter 3) to provide potential impact perspectives. Each section within each chapter also presents best management practices and mitigation measures specific to an activity or technology.

  - Chapter 4, "Environmental Impacts from Energy Efficiency"
  - Chapter 5, "Environmental Impacts from Distributed Renewables"
  - Chapter 6, "Environmental Impacts from Utility-Scale Renewables"
  - Chapter 7, "Environmental Impacts from Alternative Transportation Fuels and Modes"
  - Chapter 8, "Environmental Impacts from Electrical Transmission and Distribution"

This PEIS includes three appendixes:

- Appendix A, "Public Notices"
- Appendix B, "Distribution List"
- Appendix C, "List of Preparers"

S.7 Potential Environmental Impacts and Best Management Practices

As identified in Section S.3, DOE is not proposing any specific projects associated with this Draft PEIS. Therefore, this PEIS uses representative projects to evaluate the potential environmental impacts from the various activities and technologies that could be implemented to assist the State in meeting the Renewable Portfolio Standard and Energy Efficiency Portfolio Standard established as part of the HCEI. This Draft PEIS also describes best management practices that could be implemented to keep those impacts to a minimum or prevent them altogether.

Chapter 2 presents several summary tables that provide an overview of the potential environmental impacts for the activities and technologies associated with each of the five clean energy categories. Each table presents the following:

- A reference to specific sections in Chapter 3 for those impacts that would be common among most construction and operation activities. (These impacts are set forth in one place in Chapter 3 to avoid repeating them for each distinct activity or technology in later chapters.)

- The potential environmental impacts specific to the stated activity/technology.

Accompanying each summary table is a chart that illustrates the resource areas that could be affected by each activity/technology. The clear circles indicate that no potential impacts would be expected for the activity/technology in that resource area. The light-gray circles indicate that the activity/technology would be expected to result in impacts similar to those common among most construction and operation activities (described in Chapter 3). The black circles indicate that there could be potential impacts specific to an activity or technology for that resource area. These charts are also presented below as Tables S-3 through S-7.

Best management practices and mitigation measures are identified in several places in the PEIS. For those potential impacts common among construction and operation activities, and not technology-specific, best management practices are presented in Chapter 3 for each resource area. For the activity/technology-specific impacts, the best management practices and mitigation measures are presented in Chapters 4 through 8 with the impacts analysis for that activity/technology. Implementation of these best management practices and mitigation measures are important to prevent or minimize the potential environmental impacts to that resource.

Table S-3. Characterization of the Potential for Environmental Impacts – Energy Efficiency

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Energy Efficient Buildings	○	●	○	○	○	●	○	◍	○	○	○	◍	●	●	◍	◍	◍
Sea Water Air Conditioning	●	●	●	●	●	●	●	●	●	●	○	●	●	●	◍	◍	◍
Solar Water Heating	○	●	○	○	○	●	○	◍	○	○	○	◍	●	●	◍	◍	◍

○ = No potential impacts.
◍ = Potential impacts are common among most construction and operation activities.
● = Potential impacts are specific to an activity or technology.

Table S-4. Characterization of the Potential for Environmental Impacts – Distributed Renewables

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Biomass	◐	●	●	◐	◐	◐	◐	●	◐	●	○	●	●	●	◐	●	◐
Hydroelectric	◐	●	●	●	●	◐	○	●	◐	○	○	●	◐	◐	◐	●	◐
Hydrogen Fuel Cells	◐	●	◐	○	○	○	○	○	○	○	○	○	○	○	○	○	◐
Photovoltaics	○	●	○	○	○	●	○	●	○	○	○	○	●	●	○	○	◐
Wind	◐	●	◐	●	●	●	◐	●	●	○	●	●	●	●	○	○	◐

○ = No potential impacts.
◐ = Potential impacts are common among most construction and operation activities.
● = Potential impacts are specific to an activity or technology.

Table S-5. Characterization of the Potential for Environmental Impacts – Utility-Scale Renewables

Activity/Technology		Resource Areas																
		Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Biomass	Direct Combustion – Steam Turbine	●	●	●	●	●	◍	●	●	●	●	●	●	●	●	◍	◍	◍
Biomass	Biodiesel Plant/ Electric Plant	●	●	●	●	●	◍	●	●	●	●	●	●	●	●	◍	◍	◍
Geothermal		●	●	●	●	●	●	●	●	●	◍	○	●	●	●	◍	●	●
Municipal Solid Waste		◍	●	●	●	●	◍	●	●	●	●	●	●	●	●	◍	◍	●
Marine Hydrokinetic Energy		●	◍	●	●	●	●	●	●	●	●	○	●	◍	●	◍	◍	●
Ocean Thermal Energy		○	●	●	●	●	●	●	●	●	●	●	●	●	●	◍	◍	●
Photovoltaic Systems		◍	◍	◍	●	●	◍	●	●	●	◍	●	◍	●	●	◍	◍	◍
Solar Thermal Systems		●	◍	●	●	●	●	●	●	●	◍	●	◍	●	●	◍	◍	◍
Wind (Land-Based)		◍	◍	●	●	●	●	●	●	●	◍	●	●	●	●	◍	●	●
Wind (Offshore)		●	◍	◍	●	●	●	●	●	●	◍	●	●	●	◍	◍	●	●

○ = No potential impacts.
◍ = Potential impacts are common among most construction and operation activities.
● = Potential impacts are specific to an activity or technology.

Table S-6. Characterization of the Potential for Environmental Impacts – Alternative Transportation Fuels and Modes

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Biofuels	●	●	●	●	●	◍	◍	◍	●	●	○	●	●	●	◍	○	○
Plug-In Electric Vehicles	●	●	○	○	●	○	○	○	○	●	○	◍	●	●	◍	○	○
Hybrid Electric Vehicles	○	●	○	○	○	○	○	○	○	●	○	○	○	●	○	○	○
Hydrogen	◍	●	◍	○	●	◍	○	◍	◍	●	○	●	●	●	◍	○	○
Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas	◍	●	○	◍	◍	◍	○	○	○	●	○	○	●	●	○	○	◍
Multi-Modal Transportation	◍	●	◍	◍	●	◍	○	●	●	●	○	●	○	●	◍	○	○

○ = No potential impacts.

◍ = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

Table S-7. Characterization of the Potential for Environmental Impacts – Electrical Transmission and Distribution

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
On-Island Transmission	◍	◍	●	●	●	●	●	●	●	◍	●	●	●	●	◍	○	●
Undersea Cables	●	●	●	●	◍	◍	●	●	◍	●	○	●	●	●	◍	○	●
Smart Grid	○	○	○	○	○	○	○	○	○	○	○	○	●	●	◍	○	●
Energy Storage	○	○	◍	○	○	◍	◍	○	○	○	○	○	●	●	◍	○	◍

○ = No potential impacts.
◍ = Potential impacts are common among most construction and operation activities.
● = Potential impacts are specific to an activity or technology.

S.8 Overview of Potential Environmental Impacts from Technologies and Activities in the Clean Energy Categories

This section (1) provides an overview of the major conclusions about potential impacts from the five clean energy categories and (2) presents tables that summarize the notable impacts associated with clean energy technologies and activities (based on the representative projects analyzed in this Draft PEIS). Table S-8 summarizes impacts for many of the technologies and activities other than those in the Utility-Scale Renewables category. The representative projects analyzed for the Utility-Scale Renewables category have more potential environmental impacts and so are presented separately in Table S-9. The other activities and technologies not listed in these tables (generally the energy efficiency activities, distributed renewable technologies, and the alternative transportation fuels and modes) have the smallest potential for environmental impacts. Chapter 2 contains a more detailed version of the tables that summarize potential impacts from all technologies and activities for all resource areas.

Major Conclusions

Many of the technologies and activities evaluated in this PEIS have the potential benefit of reducing greenhouse gas emissions due to the reduced need for and use of fossil fuels as an energy source. The potential for other environmental impacts varies across the different energy categories depending on the technology, size, and location of the analyzed projects, but generally can be characterized as follows:

- Activities and technologies in the Energy Efficiency category would have the smallest potential for notable environmental impacts. The small size and, in most cases, minimal nature of these activities and technologies would result in no or minimal potential impacts across the resource areas. However, sea water air conditioning could potentially impact water quality and biological resources, due to the return of warmer water for discharge. These potential impacts can be minimized or eliminated through the consideration and implementation of the various best management practices identified and discussed in this PEIS.

- Activities and technologies in the Alternative Transportation Fuels and Modes category would have a moderate potential for notable environmental impacts. All of the alternative fuels would benefit the environment through a reduction in criteria pollutants and greenhouse gas emissions as well as a reduction in the use of fossil fuels. The development of certain biofuels, however, could have adverse impacts related to using large land areas for the production of feedstock, the application of herbicides and fertilizers, and the introduction of invasive species. These and other potential adverse impacts can be minimized or eliminated through the use of best management practices such as proper handling, storage, and use of chemicals and the screening of plant species for invasive characteristics.

- Activities and technologies in the Distributed Renewables category typically would involve small projects; therefore, potential impacts from these technologies are not likely to be significant. Implementation of renewable energy projects at the residential scale (particularly solar photovoltaic, which can be deployed quickly in multiple locations) can exceed the capacity of a local power grid or utility. This can cause delays in bringing new energy sources to the electrical grid, require system upgrades, and have other consequences on local circuits. These and other potential adverse impacts can be minimized or eliminated through the use of best management practices identified and discussed in the PEIS.

- In the Electrical Transmission and Distribution category, the two technologies with the greatest potential for environmental impacts on valuable resources are on-island transmission and undersea cables. These projects are long and linear, and the potential impacts are predominantly associated with construction activities and the route of the transmission lines/cables. Potential construction and routing impacts can be minimized or eliminated through the use of construction- and location-specific best management practices.

- Among the technologies and activities analyzed in this PEIS, the greatest potential for environmental impacts is associated with the Utility-Scale Renewables category since it would include those technologies with the largest physical footprint and generation of the largest amount of electricity. All of these technologies would have the potential to impact numerous resource areas. Such potential impacts generally would be highest during construction and include noise, increased air emissions, changes to scenic and visual landscapes, and potential impacts to biological and cultural resources. The most common potential long-term impacts associated with these technologies would include changes to land and submerged land use and scenic and visual resources. These potential impacts would be location-dependent and could be minimized or eliminated through the use of the location-specific best management practices identified and discussed in the PEIS.

In addition, during project siting, all of these activities—but especially the Electrical Transmission and Distribution and the Utility-Scale Renewables categories—share the characteristic of encountering one or more host communities that could be impacted in numerous ways. In Hawai‘i, this almost always includes the potential to impact Native Hawaiian communities, lifestyles, and values. The potential for project acceptance and success can be greatly enhanced by early and sincere involvement of the various communities in project planning and concern for “fairness” in project definition.

In addition to impacts from a technology standpoint, the State of Hawai‘i has indicated particular interest in the potential impacts to four environmental resource areas.

- Biological resources due to the large number of threatened and endangered species and unique island habitat;
- Land and submerged land use based on the finite characteristics of this resource to the islands’ environments;
- Cultural and historic resources because of the strong and long standing beliefs of the native population and their relationship with the islands’ physical environment; and
- Scenic and visual resources because of both the cultural and historic aspects, as well as the importance to the tourism appeal of the islands.

Table S-8. Summary of Impacts for Selected Technologies and Activities

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Geology and Soils			
	General impacts during construction.	**<u>Onshore</u>** General impacts during construction. **<u>Offshore</u>** Potential disturbance of marine sediments during construction (short-term) with minor impacts: • Sediment disturbance at the horizontal directional drilling breakout point • Drilling mud/slurry release at the horizontal directional drilling breakout point • Sediment disturbance at trenching locations. No impacts to geology and soils during operation.	**<u>Onshore</u>** Potential soil erosion and contamination during construction (short-term). **<u>Offshore</u>** Potential disturbance of marine sediments during construction (short-term) and operations.
Climate and Air Quality			
Air Quality	General impacts during construction	General impacts during construction.. Beneficial impacts resulting from higher penetration of renewable generation on each connected island grid.	General impacts during construction (short-term). The use of a sea water air conditioning system would require 75 percent less electricity than a standard cooling system; therefore, there would be a beneficial impact to air quality from a reduction of criteria pollutants resulting from electricity generated by fossil fuels.
Climate Change	General impacts during construction	General impacts during construction.	Minor impacts during construction. Reductions in greenhouse gas emissions as a result of reduction of electricity generation using fossil fuels.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Water Resources			
Surface Water	General impacts during construction. Operation impacts include possible alteration of stormwater runoff along transmission corridor as vegetation is reestablished. Any single drainage path expected to experience minimal alteration.3 Potential application of herbicides to maintain transmission corridor could produce negative environmental impacts if they reach surface waters.	**Onshore** General impacts during construction. Potential impacts if increase in impermeable surfaces at built up land-sea transition sites. **Offshore** Sediment disturbance/dispersal and increased turbidity during horizontal directional drilling. Potential site-specific impacts may occur to habitats or communities of concern. No operation impacts.	**Onshore** General impacts during construction (short-term). No operation impacts. **Offshore** Sediment disturbance/ dispersal and increased turbidity. Potential site-specific impacts may occur to habitats or communities of concern. Potential increase in nutrient levels (nitrate and phosphates). Potential for sea water temperature variability impact.
Groundwater	General impacts during construction. No adverse operation impacts unless herbicides applied to maintain transmission corridor.	General impacts during construction.	General construction impacts. No adverse operation impacts. Potential fresh water (groundwater) savings if wastewater is used as the cooling medium. Potentially beneficial; fresh water savings with an open cooling system.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Biological Resources			
	General impacts to terrestrial ecosystems during construction, including potential access roads. Operational maintenance of cleared areas around towers and vegetation height along transmission corridor. Potential bird and bat collisions with towers and lines, especially nocturnal flying species.	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Potential localized disturbance impacts to benthic communities at the horizontal directional drilling breakout point and along cable route during construction due to direct displacement or indirect sedimentation. Potential operation impacts on sensitive species by electromagnetic fields along undersea cable route.	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Minimal and localized impacts to marine organisms from water discharge temperature. Potential increase in nutrient levels resulting in increased marine productivity. Potential localized disturbance impacts to benthic communities at discharge point. Potential entrainment of smaller organisms at the intake pipe.
Land and Submerged Land Use			
Land Use	Transmission line corridors and location of substations and switching yards could result in changes of land ownership patterns and land use.	General impacts during construction and operation.	Short-term land disturbance impacts at the cooling station locations and along distribution line routes during construction.
Submerged Land Use	None; the on-island transmission project would not extend offshore.	Short-term submerged land disturbance impacts along the undersea cable corridor during construction. Potential temporary impacts during maintenance/ expansion activities. Potential land use impacts along undersea cable corridor.	Potential land use impacts related to expansions/maintenance of the cooling stations and/or distribution network.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Cultural and Historic Resources			
	General impacts during construction and operation. The visual impact of on-island transmission projects may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	General impacts during construction.	Potential adverse impacts to cultural, historic, and related natural resources during construction and operation (both on and offshore).
Coastal Zone Management			
	General impacts during construction and operation. Potential impacts to coastal zone resources (site-specific).	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project/site-specific).	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project- and/or site-specific).
Scenic and Visual Resources			
	General impacts during construction. Long-term visual impacts associated with towers, transmission lines, cleared transmission corridors, substations, and switching yards.	Short-term impacts to visual resources during construction. Short-term visibility of cable-laying ships. Long-term visual impacts associated with the new transition sites.	Short-term impacts to visual resources during construction. Long-term visual impacts associated with the new cooling station.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Recreation Resources			
	General impacts during construction. Long-term obstruction to some recreational activities; conversely, some activities could be enhanced by improved access (e.g., from access roads for installed transmission infrastructure).	General impacts during construction. Short-term impacts during construction; limited to no impacts during operations.	General impacts during construction. Potential short-term impacts to offshore recreation during installation of the subsurface piping. The short-term impacts could include: (1) restricted access to recreation areas near the area of installation of the underwater piping and on-shore facility, and (2) possible visual impairment from areas near the construction of the facilities that could have a negative effect on the ongoing recreational activities.
Land and Marine Transportation			
Land Transporta-tion	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., towers and tower foundations). Short-term impacts during line stringing. Impacts during construction if transmission line installation required road crossings.	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., cables and installation equipment). General impacts during construction of the land-sea transition sites	General impacts including localized short-term traffic impacts during construction and/or if road crossings are needed.
Marine Transporta-tion	None; the on-island transmission project would not extend offshore.	Potential short-term impacts on harbor operations, local marine transportation, and military marine (including submarine) operations.	Potential short-term (temporary) impacts on harbor operation, local marine transportation, and military marine operations Potential impacts to military submarine operations.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Airspace Management			
	Potential air traffic impacts during construction if helicopters are used to transport supplies or for line stringing. Potential construction and operation impacts and hazards to civilian and military aviation due to topography and high presence of low-altitude aviation. Potential long-term impacts from radio frequency interference.	None; construction and operation of undersea cable and land-sea transition sites would not require any tall structures and therefore would not impact airspace management.	None; construction and operation of sea water air conditioning would not require any tall structures and therefore would not impact airspace management.
Noise and Vibration			
	Short-term noise and vibration impacts during construction. Potential vibration and humming noise during operation from loose hardware. Sizzles, crackles, hissing noises possible, especially during periods of higher humidity.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of undersea cables would be negligible. Noise and vibration impacts from land-based converter stations would be dependent on the location and compatibility with the existing noise levels and land uses.	Short-term noise and vibration impacts during construction. Noise levels could temporarily exceed regulatory levels. Exposure to elevated noise and vibration levels may result in temporary impacts to marine & mammal behavior and marine mammal prey species. No long-term ambient noise or vibration impacts are expected during operation. A positive benefit could be the elimination of noise currently generated from cooling towers as buildings convert to sea water air conditioning systems.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Utilities and Infrastructure			
	Potential impacts related to adding electricity capacity to the grid.	Potential impacts related to adding electricity capacity to the local power grid. Connecting the electrical grids of two or more islands would have the beneficial impacts of: • Enabling the transmission of power and ancillary services in both directions and allow the two networks to operate in a coordinated fashion • Improving the power system economics and reliability on each island • Reducing renewable energy curtailments A full list of benefits can be found at http://energy.hawaii.gov/renewable-energy/oahu-maui-gridtie	Potential reduction in energy consumption (may require modification of the utility structure to meet the Renewable Portfolio Standard).
Hazardous Materials and Waste Management			
Hazardous Materials	General impacts from exposure to hazardous materials during construction. Potential impacts from exposure to hazardous materials during operation and maintenance from use of herbicides to maintain transmission corridor	General impacts during construction and operation, particularly during development of converter stations.	General impacts from exposure to hazardous materials during construction. No adverse operation impacts.
Waste Management	None; any vegetation cleared likely would be composted or reused.	Any waste generated onboard the construction vessels and barges would be disposed of at the appropriate landfill.	General waste management impacts during construction.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Wastewater	General impacts during construction.	General impacts during construction and operation, particularly during development of converter stations.	General wastewater impacts during construction. No adverse operation impacts. Potential beneficial impacts may occur if wastewater were utilized in place of sea water. This would minimize the amount of wastewater from other sources that would have to be treated by the local municipality.
Socioeconomics			
	Minimal beneficial impacts during construction and operation.	Minimal beneficial impacts during construction and operation.	Beneficial – few jobs created.
Environmental Justice			
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Depending on siting, impacts to visual and scenic resources could have the potential to be disproportionately high and adverse with respect to environmental justice communities. The likelihood of significant environmental impacts from this technology is small. The likelihood for environmental justice impacts also is small.

Table S-8. Summary of Impacts for Selected Technologies and Activities (continued)

Resource Area	On-Island Transmission	Undersea Cables	Sea Water Air Conditioning
Health and Safety			
	Potential health and safety impacts to workers during installation, maintenance, and repairs of the transmission lines. Typical industrial hazards. Additional health and safety risks specific to electrical generation, transmission, and distribution industry. Potential minor health and safety impacts to the public during operation of the transmission lines as a result of electromagnetic fields generated. Limited to areas immediately adjacent to transmission lines.	General construction and operation impacts. Potential health and safety impacts to workers during installation, maintenance, and repairs of the undersea cables and transition sites, including increased safety risks associated with the marine environment. Additional health and safety risks specific to electrical generation, transmission, and distribution industry.	General waste management impacts during construction.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Geology and Soils					
	General construction impacts. Potential soil erosion and degradation from agricultural activities.	General construction impacts. Potential soil erosion and degradation from agricultural activities.	General construction impacts including land disturbance. Potential well blowouts during drilling. Potential for increased risk to personnel and equipment from hot fluids and steam and geothermal gases such as hydrogen sulfide. Potential lava flow hazards and risks during operation associated with active volcanoes.	General construction impacts. No operation impacts.	General construction impacts including soil disturbance. Potential impacts associated with on-island electrical transmission lines. Potential impacts to marine sediments and marine communities. No operation impacts.
Climate and Air Quality					
Air Quality	General construction impacts. Potential increase in criteria pollutant emissions (including nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) during combustion. Potential increase in criteria pollutant emissions (including carbon dioxide) from biomass production (equipment, fertilizer/ pesticide application, harvest, and transport).	General construction impacts. Additional criteria pollutant emissions during construction of the biodiesel plant. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) from combustion. Increased criteria pollutant emissions (including carbon dioxide) emissions from biomass production	General construction impacts. Potential emission of the non-condensable gases during operations. Potential for trace amounts of nitrogen oxides, negligible amounts of sulfur dioxide or particulate matter, and small amounts of carbon dioxide. Potential health impacts from naturally present hydrogen sulfide.	General construction impacts. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide, as well as carbon dioxide) from combustion. Potential increase in pollutant emissions (including cadmium, carbon monoxide, dioxins/furans, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter, and sulfur dioxide) during project operations.	General construction impacts. Potential land disturbance and associated fugitive dust at nearby onshore construction related areas. Potential short-term, minor increase in criteria pollutant emissions from construction equipment and marine vessels. Typically, no air quality impacts during operations.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Climate Change	Potential impacts from increased biogenic carbon dioxide greenhouse gas emissions. Decreased greenhouse gas emissions from electricity production using fossil fuels.	Potential increase in carbon dioxide emissions would result in increased greenhouse gas. Decreased greenhouse gas emissions from electricity production using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	Decreased greenhouse gas emissions from electricity production using fossil fuels.	Potential increase in greenhouse gas emissions from construction equipment and marine vessels. Potentially beneficial impacts from greenhouse gas reduction associated with less electricity production using fossil fuels.
Water Resources					
Surface Water	General construction impacts. Potential for increased stormwater runoff. Increased water demand for crop irrigation (ex: sugarcane crop – more water/acre). Potential adverse impacts from runoff contamination associated with fertilizer/ pesticide applications.	General construction impacts. Potential for increased stormwater runoff. Increased water supply demand for crop irrigation. Potential adverse impacts from runoff contamination associated with fertilizer/pesticide applications.	General construction impacts. Potential for minor impacts to surface waters from runoff contaminated with geothermal fluids ("drift") during ops. Potential impacts to surface waters from leaks or releases of low-boiling point organic working fluids (e.g., isobutene or isopentane) during operations.	General construction impacts. Potential water resource discharge impacts from blowdown chemicals. Potential stormwater contamination from solid waste activities, such as stockpiling, dumping, and moving.	**Onshore** General construction impacts. Potential for increased stormwater runoff from new building sites (site-specific). **Offshore** Potential ocean sediment disturbance. Potential increased turbidity to communities of concern (site-specific) in marine waters.
Groundwater	General construction impacts. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/ pesticide applications via runoff or local recharge.	General construction impacts. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/ pesticide applications via runoff or local recharge.	General construction impacts. Potential for groundwater contamination/ drinking water supplies from drilling mud used. Potential for increased impacts to water resources from increased water demand (site-specific; i.e., particularly to Maui's Central aquifer sector).	General construction impacts. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential increase in water demand.	**Onshore** General construction impacts. Limited water supply impacts for facility operations. **Offshore** No groundwater impacts.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Groundwater (continued)			Potential groundwater impacts from geothermal fluids removed from the subsurface.		
Biological Resources					
	Potential for general construction impacts. Potential impacts to vegetation or wildlife (including to the wide-ranging Hawaiian hawk and the Hawaiian hoary bat) species (site-specific). Potential beneficial impacts – may create a market for selective harvesting of invasive woody species, such as albizia trees. Potential impacts from the introduction of new, invasive plant species. Potential impacts associated with use of genetically modified plants.	General construction impacts. Potential for loss of wildlife habitat. Potential impacts from the introduction of new, invasive plant species from commercial feedstock production. Potential impacts associated with use of genetically modified plants.	General construction impacts. Potential impacts to biological resources including land disturbance and disturbance by human activity. Potential increase in invasive species establishment in disturbed sites. Potential biological impacts on flights of marine birds (such as shearwaters and petrels) from facility lighting (site-specific).	General construction impacts. Potential for construction impacts including land disturbance to wildlife in adjacent habitats, particularly near important nesting and feeding areas, wetlands, or roost sites (site-specific). Potential for impacts to biological resources during operations (site-specific).	Potential construction impacts include displacement of marine mammals, reptiles, and fish both from physical activity and noise transmission through ocean waters. Potential marine habitat impacts including to marine pools, beaches (both rocky and sand), and coral reefs. Potential loss of beach nesting habitat for sea turtles and marine birds; and resting sites for the Hawaiian monk seal. Potential collision hazards to marine mammals and reptiles during anchor cabling. Potential localized noise (sound waves) impacts (potential auditory injury), avoidance, physical injury to marine mammals, fish, or other species, and alteration of water dynamics from submerged oscillating or rotating components. Potential electromagnetic field impacts from the undersea power cable.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Land and Submerged Land Use					
Land Use	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential conversion of undeveloped land or land under current land uses.	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Undeveloped land or land under current land uses could be converted to energy uses.	Potential change in land use or ownership by purchase or through land leases. Potential impacts to undeveloped land or land with current uses from conversion to an energy facility. Potential land use easement impacts.	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential land use conversion impacts (i.e., the creation of transmission corridors).	Potential land disturbance impacts during construction.
Submerged Land use	Biomass projects would be land-based and not impact submerged land uses.	Biomass projects would be land-based and not impact submerged land uses.	Geothermal projects would be land-based and not impact submerged land uses.	Because the representative project would be entirely land-based, there would be no impacts to submerged land use.	Potential localized impacts to the ocean floor from tethering and power cable installation, including obstruction of local marine habitats.
Cultural and Historic Resources					
	General construction and operation impacts.	General construction and operation impacts.	General construction and operation impacts. Potential adverse impacts to ethnographic resources as active volcanoes and rift zones are considered sacred by Native Hawaiians. Potential for adverse viewshed impacts from facility development, transmission lines, and other ancillary facilities; particularly to geothermal resources located within and adjacent to the Hawai‘i Volcanoes National Park.	General construction and operation impacts.	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Coastal Zone Management					
	Potential impacts to special management areas, shorefront access, and shoreline erosion (site-specific) through water runoff and sedimentation.	Potential impacts to special management areas, shorefront access, and shoreline erosion through water runoff and sedimentation (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts including land disturbances, structural developments, lighting, and other impacts to special management areas, shorefront access. Potential alteration of shorefront access (site-specific) and alteration of ocean currents.
Scenic and Visual Resources					
	Short-term visual impacts during construction. Long-term visual impacts from introduction of a new facility. Potential impacts from harvest of biomass. Potential visual impacts from truck traffic during delivery.	Short-term visual impacts during construction. Long-term visual impacts from introduction of a new facility. Potential impacts during crop harvest. Potential visual impacts from truck traffic delivery.	Potential short-term construction impacts. Potential long-term visual impacts from the power plant, night lighting, visibility of the transmission line, and the presence of steam plumes at facilities using water-cooled systems.	General visual impacts during construction. Long-term visual impacts from the municipal solid waste combustion facility (site-specific). Long-term visual impacts from truck traffic delivery of municipal solid waste (site-specific).	General visual impacts during construction. Long-term visual impacts (i.e., onshore/ offshore—marine hydrokinetic energy technology and location specific). Long-term visual impacts from navigation lighting for devices.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Recreation Resources					
	General construction impacts. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	General construction impacts. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	General construction impacts. Potential long-term recreational resource impacts including access restrictions, noise, and visual impacts from the new facilities. Potential permanent loss of recreational values (site-specific). Potential lighting impacts to nearby recreation resources such as campgrounds where dark night sky is valued.	General construction impacts. Potential long-term recreation resource impacts including from visual and noise impacts (site-specific). Potential recreational resource impacts from truck traffic. Potential impacts to recreation resources (i.e., nearby campgrounds or areas where a dark night sky is valued) from facility lighting.	General construction impacts. Potential long-term recreation resource impacts from visual impacts (site-specific). Potential effects to water-based recreation activities (i.e., swimming, surfing, boating, and fishing) resulting from access restrictions or use alterations to promote recreation user safety and prevent collisions or malfunctions to offshore technologies. Potential wave attenuation impacts at the shore (technology and site-specific; i.e., dependent on the array of devices and location).
Land and Marine Transportation					
Land Transportation	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance.	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance.	Potential short-term impacts on roadway traffic during project construction.	Potential for localized transportation impacts from transporting municipal solid waste.	None.
Marine Transportation	None; it is unlikely that bulk biomass would be shipped between islands.	None; it is unlikely that bulk biomass would be shipped between islands.	None identified.	Because the representative project would be entirely land-based, there would be no impacts to marine transportation. Transfer of municipal solid waste between islands is not anticipated.	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Marine Transportation (continued)					Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.
Airspace Management					
	Potential hazards to aircrafts from emission stacks for those project locations nearby airports.	Minimal potential hazards to aircrafts from emission stacks for those project locations nearby airports.	None; the development and operation of a geothermal facility would not result in any tall structures or steam exhausts that would require further consultation on airspace management impacts.	Potential impacts if emission stacks are less than 200 feet.	None; the marine hydrokinetic energy representative project would not include any tall structures and therefore would not impact airspace management.
Noise and Vibration					
	Short-term noise and vibration construction impacts. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses. Noise impacts from truck traffic delivery (site-specific).	Short-term noise and vibration construction impacts. Long-term noise and vibration operation impacts (site-specific). Noise impacts from truck traffic delivery (site-specific).	Short-term and long-term noise and vibration impacts would result from exploration, construction, and operation. Potential impacts from noise and vibration would be wholly dependent on sound levels and the proximity of sensitive receptors to the source. Noise and vibration levels would be reduced with implementation of best management practices.	General impacts during construction and operation.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Unless deployed in large arrays of generators, long-term noise and vibration impacts from marine hydrokinetic energy technologies would be minimal with implementation of best management practices.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Utilities and Infrastructure					
	General construction and operation impacts. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction and operation impacts. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, large effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction impacts. Potential for minor to moderate impacts to electric utilities (site-specific, i.e., moderate effects to Maui and minor effects to Hawaii’s utilities).	General construction and operation impacts. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction impacts.
Hazardous Materials and Waste					
Management Hazardous Materials	General construction impacts. Potential exposure to high quantities of fertilizers (primarily nitrogen), herbicides, and pesticides.	General construction impacts. Potential exposure to high quantities of fertilizers, herbicides, and pesticides. Potential hazardous materials exposure impacts from biodiesel leaks or accidents.	General construction impacts. Potential impact from exposure to hazardous materials if chemicals used during exploration/flow testing or from drilling fluids that were improperly handled or released into the environment. Potential impact from exposure to hazardous materials if an accidental spill or chemical release were to occur during operations from lubricating oils, hydraulic fluids, coolants, solvents, and/or cleaning agents. Potential impact from exposure associated with naturally occurring hydrogen sulfide.	General construction impacts. Potential exposure to hazardous materials from municipal solid waste delivered to the site. Potential impact from exposure to hazardous materials associated with the flammability of syngas production.	General construction impacts. Potential exposure to hazardous materials including fuels from boats, marine vessels, barges, lubricants and hydraulic fluids contained in the wave or tidal energy devices during operations and maintenance.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Waste Management	General construction impacts.	General construction impacts. Potential increase in byproduct waste generated	General construction impacts. Potentially adverse impacts if additional waste were generated on the island of Hawai‘i. Minor amounts of hazardous waste may be generated including paints, coatings, and spent solvents.	General construction impacts. Potential exposure to hazardous waste (i.e., infectious waste, electronics, lead acid batteries, firearms, propane tanks, sludge, agricultural wastes, soil, and some noncombustible inorganic materials (such as concrete, stone). Potential waste management impacts from ash waste byproducts. Potentially beneficial impacts resulting from decreased municipal solid waste in landfills.	Potential landfill impacts to O‘ahu and Hawai‘i (pending the resolution of existing landfill capacity constraints) if non-recyclable materials add to existing landfill capacity constraints.
Wastewater	Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during blowdown from the steam cycle and cooling system.	General construction impacts. Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during the blowdown from the steam cycle and cooling system.	General construction impacts. Potential wastewater impacts in the event of a leak containing geothermal waste fluids.	General construction impacts. Potential impacts to wastewater services from blowdown.	Potential impacts to wastewater services from vessel effluent during construction. No operation impacts.
Socioeconomics					
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.

Table S-9a. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste-to-Energy Facility	Marine Hydrokinetic Energy
Environmental Justice					
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	No effects identified. Because of the uncertainty of the marine hydrokinetic energy designs and the low potential for adverse impacts, there would be no disproportionately high and adverse impacts to minority or low-income populations. There would be no environmental justice impacts from the marine hydrokinetic energy representative project.
Health and Safety					
	General construction and operation impacts.	General construction and operation impacts.	General construction and operation impacts. Potential health and safety effects from drilling including hydrogen sulfide worker exposure. Potential health and safety impacts from physical, thermal, and chemical hazards such as hydrogen sulfide exposure.	General construction and operation impacts.	General construction and operation impacts. Potential for public health and safety effects including to boats, both civilian and military marine vessels, and to the public onshore in the event the device were destroyed, damaged or if the loss of mooring/ spatial stabilization were to occur.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Geology and Soils					
	None; the only potential impacts to geology and soils would be the interface of the undersea cable to connect the ocean thermal energy conversion facilities with the grid.	General construction impacts from land disturbance/soil erosion. No operation impacts.	General construction impacts from land disturbance. Potential for soil contamination in the event of a leak or accidental release of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	General construction impacts from land disturbance/soil erosion. No operation impacts.	General onshore construction impacts from land disturbance/soil erosion. Potential impacts to marine sediments (e.g., natural migration of sand) from anchor/mooring devices, undersea cables, and land/sea transition zones. No operation impacts.
Climate and Air Quality					
Air Quality	General construction impacts. Limited, intermittent, and short-term air quality impacts during construction. Potential land disturbance and related fugitive dust at nearby onshore construction related areas, including areas where offshore electrical lines connect with the onshore regional electric grid.	General construction impacts. No operation impacts.	General construction impacts. No operation impacts.	General construction impacts. No operation impacts.	General construction impacts. Potential increased criteria pollutants from construction equipment including marine vessels (powered by fossil fuels, e.g., diesel, or gasoline) during construction. Potential for fugitive dust at nearby onshore construction-related areas.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Air Quality (continued)	Potential increase in criteria pollutant emissions during construction from equipment or marine vessels powered by fossil fuels. Potential operational emissions from auxiliary diesel generators on the platform.				
Climate Change	Potential increase in greenhouse gas emissions from construction equipment and operation of diesel generators on the platform. Potential greenhouse gas emissions reduction from a mix of technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of different technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.
Water Resources					
Surface Water	Potential ocean sediment disturbance resulting in increased turbidity and impacts to coral or other bottom communities of concern. Potential water quality impacts from discharge not meeting water quality criteria for marine waters (i.e., nutrient levels such as nitrite plus nitrate, phosphate, and phosphorous.).	General construction impacts. Potential stormwater runoff from the site (dependent on the amount of impermeable surface/nature of the preconstruction site).	General construction impacts. Potential stormwater runoff contamination in the event of leaks or accidental releases of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	General construction impacts. Potential for increased stormwater runoff as a result of increased impermeable surfaces (wind turbine foundations, electrical support buildings, and paved roads or parking areas) – (site-specific).	General construction impacts including horizontal directional drilling for electrical cables and for the construction of a substation. No potential onshore effects during operations. Potential for increased turbidity at breakout point from drilling mud or slurries used during horizontal directional drilling.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Surface Water (continued)	Potential increased algal bloom impacts from increased nutrient levels. Potential impacts from temperature variation and elevated chlorine levels of discharge.				Potential impacts to coral or other bottom communities of concern from high turbidity (site-specific).
Groundwater	Minimal groundwater impacts during construction and operation.	General construction impacts. Potential changes in runoff to the site and potential associated change in groundwater recharge.	Minor groundwater impacts during construction. Potential changes in runoff to the site and potential associated change in groundwater recharge.	General construction impacts.	General construction impacts. No operation impacts.
Floodplains and Wetlands	None identified.	Potential impacts during construction (site-specific).	Potential impacts during construction (site-specific).	Potential impacts during construction (site-specific).	Potential impacts during construction (site-specific).
Biological Resources					
	Potential for short-term and small disturbances during placement of the cabling lines, moors, and anchors. Potential disturbance to deep and shallow marine habitats and shorelines (including marine pools, sandy and rocky beaches, seagrass habitat, shallow benthic communities, and coral reefs at multiple depths) during construction (site-specific).	General construction impacts. Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	General construction impacts. Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands) from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	General construction and operation impacts. Potential impacts to biological resources including loss of vegetation and wildlife (migratory birds, threatened and endangered plants and animals, critical habitat, and other high value areas such as wetlands and native plant communities) from site development (site-specific). Potential for mortality of avian species and bats (site-specific).	General construction and operation impacts. Potential disturbance impacts to the ocean floor and marine communities/ habitats (i.e., coral reefs, shallow benthic communities, seagrass habitat, beaches, and possibly marine pools) during installation of anchors, undersea cables (site-specific). Potential impacts to marine animals from temporary construction noise impacts.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Biological Resources (continued)	Potential impacts to the marine environment from introduction of an electromagnetic field along the undersea cable. Potential attraction of marine fish, mammals, and seabirds to structures and for biofouling organisms. Potential impacts to marine communities from nutrient rich discharge waters. Potential impacts to marine organisms due to intake pipes. Potential collision hazards to marine mammals from mooring lines.			Potential impacts to seabirds by attracting/disorienting them from onsite lighting.	Potential for increase in marine mammal collisions from ships and boats during construction. Potential increase for hazards to marine mammals congregating in marine subsurface structures. Potential for increased collision hazard for large marine mammals (i.e., whales) from mooring cables. Potential hazards (increased risk for mortalities by rotor blade collision) to seabirds in areas surrounding wind turbines due to potential aggregation of forage fish near submarine structures, tower safety lighting, and potential use of aboveground platform structures as resting areas. Potential introduction of an electromagnetic field into the marine environment along the cable resulting in potential impacts to marine mammals with electrosensory systems.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Land and Submerged Land Use					
Land Use	Typical land use impacts associated with the interface of an undersea cable and the electrical grid.	Potential land use impacts including land disturbance and possible conversion of undeveloped land and land in other current use to an energy generating facility. Potential change in land ownership patterns and/or easements required for the project (i.e., project site, access roads, corridors to the nearest electrical grid). Potential impacts to adjacent land uses (roads, residential/ commercial areas, historic sites, scenic locations, and airports) from the glint and glare of the solar panels.	Potential change in land ownership patterns through purchase and or land use leases for both the solar thermal project site and any linear corridors required to tie-in to the existing electrical grid. Potential impacts to undeveloped land or land currently used for other uses could be converted to energy uses.	Potential land use impacts including land disturbance during site preparation and turbine installation, as well as access road construction and support structures. Potential conversion of undeveloped land or land with other current land uses for energy use. Potential landownership changes and obtainment of land use easements.	Potential change in local landownership patterns. Potential land disturbance during construction of the tie-in to the existing transmission grid.
Submerged Land Use	Potential for large obstructions in the ocean floor from structures.	None; PV projects would be land-based and not impact submerged land uses.	None; solar thermal projects would be land-based and not impact submerged land uses.	None; land-based wind turbines would have no potential effects to submerged land use.	Potential impacts to sea floor requiring a submerged lands lease.
Cultural and Historic Resources					
	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Cultural and Historic Resources (continued)				The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource..	The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.
Coastal Zone Management					
	Potential impacts to designated special management areas from the cable crossing the shoreline (site-specific). Potential shorefront access impacts from the cable crossing the shoreline (site-specific). Potential shoreline erosion impacts from the cable crossing the shoreline (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific); Potential for adverse impacts to those locations near the shoreline. Potential for increase in runoff and sedimentation and impacts to coastal water habitats from land clearing.	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).
Scenic and Visual Resources					
	General visual impacts during construction. Potential long-term visual impacts onshore from the introduction of a transition site.	General visual impacts during construction. Potential long-term visual impacts from solar panels, including in association with new facilities and associated buildings.	General visual impacts during construction. Potential long-term dynamic visual impacts from parabolic troughs/mirrors (glare/ reflected light), thermal storage tanks, steam condenser, cooling towers (plumes) and generator as well as road access, parking, maintenance facilities, and transmission line tie-in.	General short-term visual impacts during construction including site preparation activities such as clearing, construction of access and onsite roads, equipment laydown areas, installation of turbine foundations, erection of turbines, and connection to the grid.	Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, the sweeping movement of the blades, lighting for the marine and aviation navigation, and the land/sea transition site.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Scenic and Visual Resources (continued)		Potential glinting, glare, and visual effects depending on the panel orientation, sun angle, viewing angle, viewer distance, and other visibility factors; may also be dependent on individual viewer sensitivity. Potential long-term visual effects from routine maintenance activities.	Potential for individual discomfort from glare effects, depending on viewer sensitivity, viewer location, viewer movement, and time of day. Potential increase in light pollution impacts (skyglow, light trespass, and glare) from security lighting and other exterior lighting around buildings, parking areas, work areas and during maintenance activities (vehicle-mounted lights).	Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, movement of the rotor blades, shadow flicker, blade glinting, flashing aviation warning lights, roads, vehicles, and workers conducting maintenance activities. Depending on viewer sensitivity, potential for long-term impacts to viewers nearby due to the strong vertical lines/ large sweep of turbines/ moving blades that can dominate views or command visual attention. Depending on viewer sensitivity, potential for long-term shadow flicker impacts for viewers close enough to fall within the shadows cast by the turbines.	Depending on viewer sensitivity, potential for long-term impacts to viewers due to the strong vertical lines/large sweep of turbines/ moving blades that can dominate views or command visual attention.
Recreation Resources					
	General construction impacts. Potential long-term impacts in the vicinity of onshore and offshore facilities from access restrictions and potential visual impacts from the facilities.	General construction impacts. Potential long-term impacts such as land cover required for the arrays and associated facilities required for the project resulting in access restrictions to area as well as visual impacts created by the presence of the facilities and maintenance activities.	General construction impacts. Potential long-term impacts from access restrictions to the site and visual impacts associated with the new facilities. Potential impacts to recreation resources from light pollution, particularly those areas where a dark night sky is valued (i.e., campgrounds).	General construction impacts. Potential long-term impacts such as access restrictions due to the presence of wind turbines, movement of the rotor blades, shadow flicker, blade glinting, aviation warning lights, roads, vehicles, and workers conducting maintenance activities.	General construction impacts. Potential long-term impacts including access restrictions due to the presence of the wind turbines, the sweeping movement of the rotor blades, lighting for marine and aviation navigation, and the land/sea transition site.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Recreation Resources (continued)		Potential impacts to nearby recreation areas from panels and other components that reflect and result in glinting, glare, and other visual effects.		Potential impacts to nearby recreation areas from strong vertical lines of the turbines dominating views and large sweep of moving blades commanding visual attention. Potential intrusion to the natural scenery and viewshed depending on the viewer sensitivity. Potential impacts to the night sky for nearby recreation areas (i.e., campgrounds) from aviating warning lights.	
Land and Marine Transportation					
Land Transportation	None.	Short-term transportation impacts associated with construction traffic.	Short-term transportation impacts associated with construction traffic.	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the construction site).	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the harbor for transport to the construction site).
Marine Transportation	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.	None; installation and operation of a utility-scale PV system would not impact marine transportation.	None; installation and operation of a solar thermal system would not have any marine transportation impacts as it would be totally land-based.	Minor impacts on marine transportation from shipment via marine cargo ship.	Potential navigation hazards to domestic and military marine transportation including to military submarine operations from undersea structures (mooring cables and power lines extending down to the ocean floor).

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Airspace Management					
	Potential impacts to military transportation operations (marine surface and aviation operations). Potential impacts on approach paths to airports.	Potential hazards to aircraft and pilots from sunlight reflection; dependent on the magnitude of reflection (glint and glare) from solar power systems.	Potential hazards to both military and civilian aircraft from reflections of the concentrated solar power facility. Potential air turbulence hazards to both military and civilian aircraft (likely limited to low altitude aircraft i.e., helicopters or during take-offs and landings) from Conservation Stewardship Program plants employing a dry cooling system.	Potential hazards to airspace navigation, both military (training and operations) and civilian (including tourist industry helicopters/ fix-winged aircraft). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor induced turbulence.	Potential hazards to airspace navigation, both military (training and operations) and civilian (including tourist industry helicopters/ fix-winged aircraft). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor-induced turbulence.
Noise and Vibration					
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of an ocean thermal energy conversion facility 3.5 miles off-shore would be minimal with implementation of best management practices.	General construction impacts.	General construction impacts.	General construction impacts. Operational noise and vibration impacts from land-based wind turbines would occur when wind conditions are favorable, day or night.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of wind turbines located 5 miles offshore would be minimal with implementation of best management practices.
Utilities and Infrastructure					
	General construction impacts. Potentially moderate effects to electric utilities (site-specific).	General construction impacts. Potential minimal impacts to electric utilities (site-specific).	General construction impacts. Potential minimal impacts to electric utilities (site-specific).	General construction impacts. Potential minor impacts to electric utilities (site-specific).	General construction impacts. Potential impacts to electric utilities (site-specific).

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Hazardous Materials and Waste Management					
Hazardous Materials	General construction impacts. Potential exposure to hazardous materials during operations from large quantities of ammonia and/or chlorine gas/liquid, including through accidental releases or leaks. Potential for fires or explosions from chorine and gaseous ammonia combinations.	General construction and operation impacts. Potential exposure to trace amounts of hazardous materials (i.e., cadmium, selenium, arsenic) if panels were broken.	General construction impacts.	General construction impacts.	General construction impacts. Potential hazardous materials impacts associated with construction from MRS sites and the potential use of batteries for energy storage.
Waste Management	General construction impacts.	General construction and operation impacts. Potential hazardous waste impacts resulting from trace amounts of cadmium, selenium, or arsenic if solar panels are broken and/or during solar panel decommissioning/disposal.	General construction impacts.	General construction impacts.	General construction impacts. Minimal construction and demolition waste. Potential impacts during the decommissioning and dismantling of the wind turbine as result of turbine removal.
Wastewater	Potential impacts to wastewater effluent from added chlorine.	General construction impacts. Potential impacts from wastewater discharge resulting from disposal of PV modules at their end-life, particularly from potential leaching or contamination from cadmium containing materials.	General construction impacts.	General construction impacts.	Minor and limited wastewater impacts from construction and during operations/maintenance activities from personnel and machinery operations.

Table S-9b. Summary of Impacts for Utility-Scale Renewable Technologies and Activities (continued)

Resource Area	Ocean Thermal Energy Conversion	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Socioeconomics					
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.
Environmental Justice					
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. No disproportionately high and adverse impacts to minority populations or to low-income populations from solar photovoltaic panels operations.	Minimal potential for environmental justice impacts due to small environmental impacts to general population.	Small environmental justice impacts. Potentially adverse impacts to minority populations or to low-income population associated with potential visual and scenic, noise and vibration, or other resource impacts in the affected areas.	Small potential for environmental justice impacts. Potentially adverse impacts to minority populations or low-income populations associated with general environmental impacts in the affected areas.
Health and Safety					
	General construction and operation impacts. Potential worker exposure to chlorine and ammonia gases.	General construction and operation impacts.	General construction and operation impacts.	General construction and operation impacts.	General construction and operation impacts. Potential for public health and safety impacts including to boats, both civilian and military marine vessels, and to the public onshore in the unlikely event the device were destroyed, damaged or if the loss of mooring/ spatial stabilization were to occur.

S.9 Alternatives Considered by DOE

DOE NEPA implementing regulations require that a PEIS analysis include a no-action alternative, which provides a baseline for comparison against the impacts of the proposed action. Under the no-action alternative, DOE would continue to support, through funding and other actions, the State of Hawai‘i in meeting its HCEI goals on a case-by-case basis, but without guidance to integrate and prioritize funding decisions and other actions.

Implementation of the HCEI in Hawai‘i will occur whether or not DOE develops guidance to assist in making decisions or other actions related to clean energy in Hawai‘i. Therefore, the potential environmental impacts associated with each of the renewable energy technologies likely would also occur under the no-action alternative; however, there may not be formal guidance in place that would assist DOE in taking actions that maximize the benefits of certain technologies while minimizing the potential adverse environmental impacts in important resource areas. If the goals of the HCEI were not met, the State of Hawai‘i would remain heavily dependent on fossil fuels and statutory greenhouse gas targets probably would not be met.

Preferred Alternative

CEQ regulations [40 CFR 1502.14(e)] require DOE to identify its preferred alternative, if one exists, in this Draft PEIS. DOE plans to incorporate the information presented in this PEIS into draft guidance that could build upon the permitting requirements, best management practices, and potential mitigation measures identified to minimize potential environmental impacts for future development of renewable energy projects and energy efficiency activities. Therefore, DOE’s proposed action is also the preferred alternative.

HAWAI‘I CLEAN ENERGY

DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

(DOE/EIS-0459)

APRIL 2014

COVER SHEET

TITLE: Hawai‘i Clean Energy Draft Programmatic Environmental Impact Statement (Draft PEIS)

RESPONSIBLE FEDERAL AGENCY: U.S. Department of Energy (DOE), Offices of Electricity Delivery and Energy Reliability (OE) and Energy Efficiency and Renewable Energy (EE)

COOPERATING AGENCIES: State of Hawai‘i (Department of Business, Economic Development and Tourism), U.S. Environmental Protection Agency (USEPA), Bureau of Ocean Energy Management, National Park Service, Natural Resources Conservation Service, U.S. Marine Corps, U.S. Navy, and Federal Aviation Administration

LOCATION: State of Hawai‘i (Islands of O‘ahu, Hawai‘i, Kaua‘i, Lāna‘i, Maui, and Moloka‘i)

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ABSTRACT: The Draft PEIS evaluates DOE’s proposed action to develop guidance that can be used to support the State of Hawai‘i in achieving the Hawai‘i Clean Energy Initiative (HCEI) goal of meeting 70 percent of the State’s energy needs by 2030 through clean energy. For the Draft PEIS, DOE and the State of Hawai‘i grouped 31 clean energy technologies and activities into five categories: (1) Energy Efficiency, (2) Distributed Renewable Energy Technologies, (3) Utility-Scale Renewable Energy Technologies, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution. For each activity or technology, the Draft PEIS identifies potential impacts to 17 environmental resource areas and potential best management practices that could be used to minimize or prevent those potential environmental impacts.

DOE invites comments on this Draft PEIS during the 90-day comment period that begins with the EPA publication of a Notice of Availability in the *Federal Register*. The Hawai‘i Clean Energy PEIS Website http://hawaiicleanenergypeis.com provides information on eight public hearings to be held at several locations in Hawai‘i between May 12 and 22, 2014. Comments on the Draft PEIS may be made orally or in writing at a public hearing; or by email to hawaiicleanenergypeis@ee.doe.gov; online at http://hawaiicleanenergypeis.com; or in writing to Dr. Summerson at the above address. Written and oral comments will be given equal weight, and any comments submitted after the comment period will be considered to the extent practicable.

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACHP	Advisory Council on Historic Preservation
AIA	American Institute of Architects
ARRA	*American Recovery and Reinvestment Act of 2009*
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BDSD	Business Development and Support Division
BMPs	Best Management Practices
BOEM	Bureau of Ocean Energy Management
Btu/h	British Thermal Units per hour
CAA	*Clean Air Act*
CAES	Compressed Air Energy Storage
CEQ	Council on Environmental Quality
CFL	Compact Fluorescent Light
CFR	*Code of Federal Regulations*
CH_4	Methane
C-MORE	[The] Center for Microbial Oceanography Research and Education
CO_2	Carbon Dioxide
CSP	Conservation Stewardship Program
CTAHR	College of Tropical Agriculture and Human Resources
CWA	*Clean Water Act*
CWRM	Hawaii Commission on Water Resource Management
dBA	A-weighted decibel
DBCP	Dibromochloropropane
DBEDT	Department of Business, Economic Development and Tourism
DC	Direct Current
DHS	U.S. Department of Homeland Security
DLIR	Department of Labor and Industrial Relations
DLNR	Department of Land and Natural Resources
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DPS	Distinct Population Segments
DVD	Digital Video Disk
EA	Environmental Assessment
EEPS	Energy Efficiency Portfolio Standards
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EGS	Enhanced Geothermal Systems
EIS	Environmental Impact Statements
EMF	Electromagnetic Field
ERDL	Environmental Research and Design Lab
ESA	*Endangered Species Act*
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FR	*Federal Register*

FSA	Farm Service Agency
GMO	Genetically Modified Organisms
GW	Gigawatts
H_2S	Hydrogen Sulfide
HART	Honolulu Authority for Rail Transit
HB	House Bill
HC&S	Hawaiian Commercial & Sugar Co.
HCDA	Hawaii Community Development Authority
HCEI	Hawaii Clean Energy Initiative
HCP	Habitat Conservation Plan
HDOH	Hawaii Department of Health
HDOT	Hawaii Department of Transportation
HECO	Hawaiian Electric Company
HEER	Hazard Evaluation and Emergency Response
HELCO	Hawaii Electric Light Company
HEPA	*Hawaii Environmental Policy Act*
HEPCRA	*Hawaii Emergency Planning and Community Right-to-Know-Act*
Hg	Mercury
HIREP	Hawaii Interisland Renewable Energy
HMEC	Hawaii Model Energy Code
HNEI	Hawaii Natural Energy Institute
HOC	Hawaii One Call Center
H-POWER	Honolulu Program of Waste Energy Recovery
HRS	Historic Preservation Review
HRS	Hawaii Revised Statutes
HSEO	Hawaii State Energy Office
HTF	Heat-Transfer Fluid
HVDC	High-Voltage Direct Current
ICC	International Code Council
IECC	International Energy Conservation Code
IES	Illuminating Engineering Society
ITL	Incidental Take License
KIUC	Kauai Island Utility Cooperative
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
Leq	Equivalent Noise Level
Ldn	Day-Night Average Level
$Li_4Ti_5O_{12}$	Lithium Titanate
$LiFePO_4$	Lithium Iron Phosphate
Li-ion	Lithium-Ion
LNG	Liquefied Natural Gas
LUC	Land Use Commission
MECO	Maui Electric Company
MJ	Mega Joules
MMPA	*Marine Mammal Protection Act*
MOU	Memorandum of Understanding
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality Standards
NaCl	Sodium Chloride
NaS	Sodium Sulfur
NASA	National Aeronautics and Space Administration

NELHA	Natural Energy Laboratory of Hawaii Authority
NEPA	*National Environmental Policy Act*
NFPA	National Fire Prevention Association
NGV	Natural Gas Vehicle
Ni-Cd	Nickel-Cadmium
NiMH	Nickel-Metal Hydride
NM	Nautical Miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOS	National Ocean Service
NPDES	Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
OCCL	Office of Conservation and Coastal Lands
OCS	Outer Continental Shelf
OEQC	Office of Environmental Quality Control
OTEC	Ocean Thermal Energy Conversion
P	Phosphorus
PCB	Polychlorinated Biphenyl
PEIS	Programmatic Environmental Impact Statement
PPA	Power Purchase Agreement
PSB	Polysulfide Bromide
PSD	Prevention of Significant Deterioration
PUC	Public Utilities Commission
PURPA	*Public Utility Regulatory Policies Act of 1978*
PV	Photovoltaic
RFP	Request for Proposals
RFS2	Renewable Fuel 2 Standards
RISE	Rewarding Internships for Sustainable Employment
RPS	Renewable Portfolio Standards
SBCC	State Building Code Council
SHPD	State Historic Preservation Division
SHWB	Solid and Hazardous Waste Branch
SMES	Superconducting Magnetic Energy Storage
SPIDERS	Smart Power Infrastructure Demonstration for Energy Reliability and Security
TMDLs	Total Maximum Daily Loads
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDOT	U.S. Department of Transportation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
U.S. PACOM	United States Pacific Command
V	Volt
VCR	Videocassette Recorder
VDC	Volts Direct-Current
VRB	Vanadium Redox Battery
ZnBr	Zinc Bromide

UNDERSTANDING SCIENTIFIC NOTATION

DOE has used scientific notation in this PEIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers of 10. The number written in scientific notation is expressed as the product of a number and a positive or negative power of 10. Examples include the following:

Positive powers of 10	Negative powers of 10
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1 \div 10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1 \div 100 = 0.01$
and so on, therefore,	and so on, therefore,
10^6 = 1,000,000 (or 1 million)	10^{-6} = 0.000001 (or 1 in 1 million)

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3×10^{-6} can be read 0.000003, which means that there are 3 chances in 1 million that the associated result (for example, a fatal cancer) will occur in the period covered by the analysis.

METRIC PREFIXES

Prefix	**Symbol**	**Multiplication factor**		**Scientific notation**
tera-	T	1,000,000,000,000	=	1×10^{12}
giga-	G	1,000,000,000	=	1×10^{9}
mega-	M	1,000,000	=	1×10^{6}
kilo-	k	1,000	=	1×10^{3}
deca-	D	10	=	1×10^{1}
deci-	d	0.1	=	1×10^{-1}
centi-	c	0.01	=	1×10^{-2}
milli-	m	0.001	=	1×10^{-3}
micro-	μ	0.000001	=	1×10^{-6}
nano-	n	0.000000001	=	1×10^{-9}
pico-	p	0.000000000001	=	1×10^{-12}

CHAPTER 1

Introduction

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1 INTRODUCTION

Chapter 1 provides an overview of the *Hawaiʻi Clean Energy Programmatic Environmental Impact Statement* (DOE/EIS-0459; Hawaiʻi Clean Energy PEIS). The chapter is divided into five main sections: Section 1.1 includes background information about the State of Hawaiʻi's clean energy goals; Section 1.2 describes the environmental review process pursuant to the *National Environmental Policy Act of 1969* (NEPA; 42 U.S.C. §§ 4321 *et seq*.) and the U.S. Department of Energy's (DOE's) purpose and need for agency action; Section 1.3 addresses the *cooperating agency* process and those entities with a role in the development of the Hawaiʻi Clean Energy PEIS; Section 1.4 discusses the *scope* of this PEIS and the public *scoping process* DOE used to obtain input on the issues it should address in the PEIS; and Section 1.5 provides a summary of the organizational structure of this PEIS.

1.1 Background

With about 85 percent of its energy derived from imported petroleum and petroleum products, the State of Hawaiʻi remains the most oil-dependent State in the nation (EIA 2012). Roughly equal amounts of petroleum are used for electricity generation, ground transportation, and commercial aviation (about 28 percent each), with the rest used for marine transport, military, and other uses (DBEDT 2013a). Unlike other states, Hawaiʻi relies heavily on imported oil to meet its electricity generation needs. Whereas less than 1 percent of electricity on the mainland is generated using oil, in Hawaiʻi, the figure is 74 percent (DBEDT 2013a). Furthermore, even though per capita energy usage in Hawaiʻi is among the lowest in the nation (in part due to its tropical climate), electricity prices in the State are three times higher than the United States national average (DBEDT 2013a). Hawaiʻi's heavy dependence on imported oil is due in part to the State's geographical isolation in the Pacific Ocean. Section 355 of the *Energy Policy Act of 2005* (EPAct 2005) directs DOE to assess the economic implications of Hawaiʻi's dependence on imported oil as the principal source of energy and to explore the technical and economic feasibility of increasing the contribution of *renewable energy* resources for both electricity generation and fuel for various modes of transportation.

1.1.1 HAWAIʻI CLEAN ENERGY INITIATIVE GOALS AND IMPLEMENTING LEGISLATION

In furtherance of the provisions of Section 355 of EPAct 2005, DOE and the State of Hawaiʻi entered into a Memorandum of Understanding (MOU) in January 2008. This MOU established a long-term partnership known as the *Hawaiʻi Clean Energy Initiative* (HCEI) to transform the way in which energy efficiency and renewable energy resources are planned and used in the State. The goal of the HCEI is to meet 70 percent of Hawaiʻi's energy needs by 2030 through clean energy, which refers to a combination of renewable energy generation and energy efficiency and conservation measures. The 70-percent goal is in relation to the State's total estimated energy needs in 2030 compared with a business-as-usual scenario, and comprises 40 percent from renewable energy resources and 30 percent from multiple energy efficiency and conservation measures. In addition to State-mandated renewable energy and energy efficiency goals, the HCEI includes a goal to reduce oil used for ground transportation by 70 percent by 2030, and a goal to meet as much of in-State demand for renewable fuels as feasible by 2030 (Braccio and Finch 2011).

Hawaiʻi's Renewable Portfolio Standard (RPS) is a policy that requires electricity retailers to provide a minimum percentage or quantity of their electricity supplies from designated or defined renewable energy sources.

Hawaiʻi's Energy Efficiency Portfolio Standard (EEPS) is a policy that sets usage levels as legally mandated targets for the reduction of electricity usage to be achieved through efficiency measures and technologies. Programs and technologies include improvements in energy efficiency of public buildings and creating incentives to achieve electricity use reductions.

In support of HCEI goals, the Hawaiʻi State Legislature passed and the Governor signed into law House Bill (HB) 1464 in 2009, establishing the current *Renewable Portfolio Standard* (RPS) and an *Energy Efficiency Portfolio Standard* (EEPS) in the State of Hawaiʻi. The RPS requires each electric utility that sells electricity for consumption in the State of Hawaiʻi to meet the following percentages from renewable sources:

- 10 percent of its net electricity sales by December 31, 2010;
- 15 percent of its net electricity sales by December 31, 2015;
- 25 percent of its net electricity sales by December 31, 2020; and
- 40 percent of its net electricity sales by December 31, 2030.

The Hawaiʻi EEPS calls for a reduction in electricity use of 4,300 gigawatt-hours via efficiency measures by 2030 compared with a business-as-usual scenario. The 4,300 gigawatt-hours represent 30 percent of the projected growth in Statewide demand for electricity by 2030 (DBEDT 2011). The EEPS also gives the Hawaiʻi Public Utilities Commission the authority to write interim 5-year goals for 2015, 2020, and 2025.

Targets for alternative transportation fuels and modes were also established in support of HCEI goals. The *HCEI 2011 Road Map* sets forth a goal of displacing the equivalent of 70 percent of ground transportation fuel demand with non-fossil fuels. It seeks to achieve this through a combination of fuel economy improvements, accelerated deployment of electric vehicles and supporting infrastructure, reduced vehicle miles traveled, and incorporation of renewable fuels into the transportation sector (Braccio and Finch 2011).

Already, Hawaiʻi is beginning to ramp up its energy efficiency measures and use of renewable energy resources. According to the Hawaiʻi State Energy Office, Statewide energy consumption in 2012 had already been reduced by 14.5 percent since the initiative was established (DBEDT 2013a). In addition, the percentage of electricity needs being met through energy efficiency and renewable energy measures has nearly doubled since 2007, with most of the gain occurring since 2009. In 2007, renewable generation and energy efficiency met 15.8 percent of Hawaiʻi's needs, in 2009 it was 18.8 percent, and in 2012 that figure was 28.2 percent (DBEDT 2013b). The *Energy Resources Coordinator's Annual Report* provides an overview and summary of the State of Hawaiʻi's clean energy agenda and accomplishments achieved in 2013 (DBEDT 2013c).

The State of Hawaiʻi has set forth the following five points as the core of its energy policy: (1) diversifying the State's energy portfolio; (2) connecting the islands through integrated, modernized grids; (3) balancing technical, economic, environmental, and cultural considerations; (4) leveraging its position as a test bed to launch an energy innovation cluster; and (5) allowing the market to pick winners.

1.1.2 NOTICE OF INTENT AND AMENDED NOTICE OF INTENT

DOE has been active in helping to advance the State of Hawai‘i’s clean energy goals by providing technical research and analysis, direct staff involvement, competitive solicitations, and funding. In 2010, DOE announced its intent to prepare a programmatic environmental impact statement (EIS) for the wind phase of the Hawai‘i Interisland Renewable Energy Program (HIREP). The *Notice of Intent* (NOI) appeared on December 14, 2010, in the *Federal Register* (75 FR 77859), and it referred to the programmatic EIS as the HIREP: Wind PEIS (DOE/EIS-0459). The NOI identified the State of Hawai‘i as a joint lead agency.

The NOI invited comments from Federal, State, and local government agencies, Native Hawaiian and other organizations, and members of the public, and a subsequent *Federal Register* notice (76 FR 2095, January 12, 2011) announced times and places of public scoping meetings. In February 2011, DOE held scoping meetings in Honolulu, Kahului, Kaunakakai, and Lāna‘i City. In meetings and submitted comments, commenters expressed concern that DOE and the State of Hawai‘i would not analyze energy efficiency measures, distributed renewable energy assets, or the full range of potential renewable energy technologies. Commenters also expressed concern about the construction of interisland electricity transmission connections and cables, the potential disparity of impacts on islands that could host wind development projects versus those that would use the electricity, and potential impacts to cultural resources, among other issues.

DOE and the State of Hawai‘i recognize the need for a broader range of activities and technologies to meet HCEI goals. Even though DOE was not required to alter the scope of its NEPA review to include renewable and non-transmission alternatives in addition to wind, in response to public scoping comments received on the HIREP: Wind PEIS, as well as regulatory and policy developments since the scoping meetings, there was consensus between the DOE and State of Hawai‘i to broaden the range of energy efficiency and renewable energy activities and technologies to be analyzed as well as the number of islands to be evaluated consistent with the Statewide nature of the HCEI.

A new scoping process began with DOE’s publication of an Amended NOI in the *Federal Register* (77 FR 47828, August 10, 2012), this time with the State of Hawai‘i as a cooperating agency instead of a joint lead agency. The Amended NOI identified the following five clean energy categories under the expanded range of energy efficiency activities and renewable energy technologies to be analyzed: (1) Energy Efficiency, (2) Distributed Renewables, (3) Utility-Scale Renewables, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution. The Amended NOI further stated that the Hawai‘i Clean Energy PEIS would analyze potential environmental impacts of only those clean energy activities and technologies that were eligible under Hawai‘i’s RPS and EEPS, and that it would analyze such potential impacts on an island-by-island basis for the islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i. The definition of renewable energy for Hawai‘i’s RPS is presented in the Hawai‘i Revised Statutes, Section 269-91. The technologies evaluated in this PEIS are not exclusive; they represent the most prominent examples of renewable energy technologies currently employed.

The Amended NOI identified a set of technologies or activities within the five clean energy categories (see Section 1.2.2) for which this PEIS evaluates environmental impacts relative to environmental resource areas (see Section 1.2.3).

The Amended NOI once again invited Federal, State, and local government agencies, Native Hawaiian and other organizations, and members of the public to submit comments and participate in public meetings on the proposed scope of the PEIS. This included the ***proposed action***, the range of reasonable alternatives, potential environmental impacts, and other issues to be considered. DOE also invited, through the Amended NOI and direct email, government agencies with jurisdiction by law or special expertise to be cooperating agencies in the PEIS preparation. Section 1.3 identifies those agencies that agreed to become cooperating agencies and discusses their roles in preparation of this PEIS.

DOE held eight public scoping meetings from September 11 through September 20, 2012, on six islands in the cities of Honolulu, Lihue, Kailua-Kona, Hilo, Kahului, Lānaʻi City, Kaunakakai, and Kāneʻohe. Section 1.4.4 presents a summary of the comments received at these scoping meetings and through other means during the scoping period.

1.2 Environmental Review Process

DOE prepared this PEIS pursuant to NEPA, as implemented by the *Council on Environmental Quality* (CEQ) NEPA regulations (40 CFR Parts 1500 through 1508) and DOE NEPA implementing procedures (10 CFR Part 1021). This PEIS considers, among other regulatory items, the requirements of the *Hawaiʻi Environmental Policy Act* (Chapter 343, Hawaiʻi Revised Statutes).

This PEIS does not propose any specific project, activity, or technology. It merely analyzes the potential environmental impacts associated with a broad range of activities and technologies that could be implemented in the future to comply with the HCEI. This PEIS does not eliminate the need for project-specific environmental review of individual projects or activities that might be eligible for funding or other forms of support by DOE or other Federal agencies. Rather, to the extent that DOE proposes to fund or undertake particular projects or activities that may fall within the scope of this PEIS, project-specific NEPA reviews for such projects and activities are expected to build on, or tier from, this PEIS and to be more effective and efficient. Moreover, any such projects and activities would be subject to compliance with obligations under other environmental laws such as the *Endangered Species Act of 1973* (16 U.S.C. §§ 1531 - 1544 *et seq*.) and the *National Historic Preservation Act of 1966* (16 U.S.C. §§ 470 *et seq*.).

For those projects that do not have any connection to Federal actions, State-level environmental reviews would still have to occur as required under Hawaiʻi Revised Statutes, such as the *Hawaiʻi Environmental Policy Act* and other statutes and administrative rules.

1.2.1 PURPOSE AND NEED FOR AGENCY ACTION

The purpose and need for DOE action is based on the 2008 MOU with the State of Hawaiʻi that established the long-term HCEI partnership. Consistent with this MOU, DOE's purpose and need is to support the State of Hawaiʻi in its efforts to meet 70 percent of the State's energy needs by 2030 through clean energy.

DOE's primary purpose in preparing this PEIS is to provide information to the public, Federal and State agencies, Native Hawaiian and other organizations, and future energy developers on the potential environmental impacts of a wide range of energy efficiency activities and renewable energy technologies that could be used to support the HCEI. This environmental information could be used by decisionmakers, developers, and regulators in determining the best activities and technologies to meet future energy needs. The public could use this PEIS to better understand the types of potential impacts associated with the various technologies.

The State of Hawaiʻi's intent regarding the Clean Energy PEIS is for the Federal, State, and county governments, the general public, and private developers to use the PEIS as a reference document when project-specific EISs are prepared.

1.2.2 PROPOSED ACTION

DOE's proposed action is to develop guidance that it can be used to support the State of Hawai‘i in achieving the goal established in the HCEI to meet 70 percent of the State's energy needs by 2030 through energy efficiency measures and renewable energy resources.

For this PEIS, DOE and the State of Hawai‘i identified 31 clean energy technologies and activities associated with potential future actions that could require an environmental review and grouped them into the five clean energy categories. DOE identified in its Amended NOI. This PEIS analyzes each of these technologies and activities at a programmatic level (rather than project/location-specific level) by considering the potential environmental impacts on the human environment. Table 1-1 shows how each technology and activity is grouped within the five clean energy categories. The table also provides a roadmap for locating the PEIS section that provides a brief primer on a technology/activity, and the PEIS chapter that discusses the respective potential environmental impacts.

Table 1-1. Clean Energy Categories and Associated Technologies or Activities

Clean Energy Category	Technology or Activity	Primer Section	Impacts Chapter
Energy Efficiency	Energy Efficient Buildings	2.3.1.1	4
	Energy Conservation	2.3.1.2	
	Ground Source Heat Pumps	2.3.1.3	
	Initiatives and Programs	2.3.1.4	
	Sea Water Air Conditioning	2.3.1.5	
	Solar Water Heating	2.3.1.6	
Distributed Renewables	Biomass	2.3.2.1	5
	Hydroelectric	2.3.2.2	
	Hydrogen Fuel Cells	2.3.2.3	
	Photovoltaic	2.3.2.4	
	Wind	2.3.2.5	
Utility-Scale Renewables	Biomass	2.3.3.1	6
	Geothermal	2.3.3.2	
	Hydroelectric	2.3.3.3	
	Municipal Solid Waste	2.3.3.4	
	Marine Hydrokinetic Energy	2.3.3.5	
	Ocean Thermal Energy Conversion	2.3.3.6	
	Photovoltaic	2.3.3.7	
	Solar Thermal	2.3.3.8	
	Wind (Land-based)	2.3.3.9	
	Wind (Offshore)	2.3.3.10	
Alternative Transportation Fuels and Modes	Biofuels	2.3.4.1	7
	Electric Vehicles	2.3.4.2	
	Hybrid Electric Vehicles	2.3.4.3	
	Hydrogen	2.3.4.4	
	Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas	2.3.4.5	
	Multi-Modal Transportation	2.3.4.6	
Electrical Transmission and Distribution	On-Island Transmission	2.3.5.1	8
	Undersea Cables	2.3.5.2	
	Smart Grid	2.3.5.3	
	Energy Storage	2.3.5.4	

As mentioned previously, DOE is not proposing any specific project, activity, or technology. The Federal action that is being evaluated in this PEIS is the development of guidance that DOE could use in making future decisions about funding or other actions to support the State of Hawai‘i in achieving the HCEI goals.

1.2.3 ENVIRONMENTAL RESOURCE AREAS

DOE identified the following environmental resource areas that the technologies/activities could potentially affect. Chapter 3 of this PEIS provides a baseline assessment of these resource areas for the State of Hawai‘i and the six principal Hawaiian Islands.

- Geology and soils;
- Climate and air quality (including climate change and greenhouse gas emissions);
- Water resources (including floodplains and wetlands);
- Biological resources (including threatened and endangered species, special status species, and related sensitive resources);
- Land and submerged land use;
- Cultural and historic resources;
- Coastal zone management;
- Scenic and visual resources;
- Recreation resources;
- Land and marine transportation;
- Airspace management;
- Noise and vibration;
- Utilities and infrastructure;
- Hazardous materials and waste management;
- Socioeconomics;
- Environmental justice (background information to analyze the potential for disproportionately high and adverse impacts to minority and low-income populations); and
- Health and safety (including accidents and intentional destructive acts).

1.3 Agency Coordination

1.3.1 NEPA PROCESS

Under NEPA, a lead agency is strongly encouraged to prepare NEPA analyses and documentation in cooperation with State and local governments, other concerned public and private organizations, and other cooperating agencies.

CEQ regulations define a *lead agency* as the agency or agencies preparing or having taken primary responsibility for preparing the EIS (40 CFR 1501.5 and 40 CFR 1508.16) and a *cooperating agency* as any other Federal agency having jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment (40 CFR 1501.6 and 40 CFR 1508.5). A State governmental agency may also become a cooperating agency. *Participating* (or consulting) *agencies* are agencies with an interest in defining the scope of an impact assessment and collaborating with lead and cooperating agencies in determining the methodologies and level of detail to be used in analyzing the alternatives.

1.3.2 COOPERATING AND PARTICIPATING AGENCIES

DOE sent invitations to various Federal agencies and the State of Hawai‘i Department of Business, Economic Development and Tourism (DBEDT), to be cooperating agencies for this PEIS. DBEDT agreed to represent the State of Hawai‘i as the sole cooperating agency for the State. Table 1-2 lists the Federal and State agencies that have agreed to be a cooperating agency or participating agency for this PEIS.

Table 1-2. Cooperating and Participating Agencies

Agency	Department/Office
Cooperating Status	
U.S. Department of the Interior	National Park Service
	Bureau of Ocean Energy Management
U.S. Department of Agriculture	Natural Resources Conservation Service
U.S. Environmental Protection Agency	Region 9
U.S. Department of Defense	U.S. Marine Corps
	U.S. Navy
U.S. Department of Transportation	Federal Aviation Administration
State of Hawai‘i	DBEDT
Participating Status	
U.S. Department of the Interior	U.S. Geological Survey
	U.S. Fish and Wildlife Service
Advisory Council on Historic Preservation	N/A
U.S. Department of Agriculture	Farm Services Agency
U.S. Department of Commerce	National Marine Fisheries Service
	National Oceanic and Atmospheric Administration, National Ocean Service – Office of National Marine Sanctuaries
U.S. Department of Transportation	Federal Highway Administration
U.S. Department of Homeland Security	U.S. Coast Guard
U.S. Department of Defense	U.S. Army Corps of Engineers

The following sections describe each cooperating agency office’s expertise, permitting authority, and responsibilities for any future clean energy project.

1.3.2.1 National Park Service (NPS)

The NPS has expertise in natural and cultural resources and is charged with protecting the U.S. National Park System including resources for future generations. In addition, the NPS monitors the condition of National Historic Trails and Landmarks and National Natural Landmarks outside of the park system, and it may provide technical preservation assistance to owners of landmarks. NPS also maintains the *National Register of Historic Places*.

Specific to this PEIS, the NPS’s primary environmental resource areas of interest include cultural and historic resources, scenic and visual resources, land and submerged land use, recreation resources, and biological resources.

1.3.2.2 Bureau of Ocean Energy Management (BOEM)

BOEM has expertise in and the responsibility for permitting leases and rights-of-way for renewable energy development activities on the Outer Continental Shelf and other offshore Federal waters. It also has expertise in coastal and marine biological and the physical sciences, as well as marine archaeological and cultural resources.

Under EPAct 2005, BOEM was granted (through its predecessor agency) the authority for regulating the production, transportation, and transmission of renewable energy resources on the Outer Continental Shelf and other offshore Federal waters. Specific to this PEIS, BOEM's primary environmental resource areas of interest are water resources (ocean), submerged land use, and marine transportation. Technologies of interest include utility-scale renewables and transmission associated specifically with offshore wind, undersea cables, and marine hydrokinetic energy.

1.3.2.3 Natural Resources Conservation Service (NRCS)

NRCS has expertise in conservation planning assistance to private landowners and in the soil sciences. NRCS derives its regulatory and permitting authority under the *Soil Conservation and Domestic Allotment Act* (16 U.S.C. § 590) and the *Food, Conservation, and Energy Act of 2008* (Public Law 110–234; known as the "Farm Bill"), as well as subsequent Farm Bills, using programs such as the Conservation Stewardship Program (7 CFR Part 470); *Environmental Quality Incentives Program in the Food, Conservation, and Energy Act of 2008* (Public Law 110–246); the Wildlife Habitat Incentive Program (7 CFR Part 636); and others.

Specific to this PEIS, NRCS's primary environmental resource areas of interest include geology and soils, land and submerged land use, water resources (surface water use and quality and groundwater), biological resources (invasive species), air quality (climate change), and socioeconomic issues. Technologies of interest include distributed and utility-scale renewables and transmission issues, in particular, photovoltaic, geothermal, land use, and biomass and associated feedstock.

1.3.2.4 U.S. Environmental Protection Agency (EPA)

The EPA administers the programmatic and regulatory aspects of 11 pollution control statutes including the *Clean Air Act of 1990* (42 U.S.C. §§ 7401 *et seq*.) and *Clean Water Act of 1972* (33 U.S.C. §§ 1251 *et seq*.). EPA has interest in all environmental resource areas, activities, and technologies. As a cooperating agency, EPA will assist in the independent review of both the Draft and Final PEIS.

EPA's involvement as a cooperating agency does not constitute formal or informal approval of any part of this project under any statute administered by EPA, nor does it limit in any way EPA's independent review of the Draft or Final PEIS pursuant to Section 309 of the *Clean Air Act*.

1.3.2.5 Federal Aviation Administration (FAA)

The FAA has expertise in airport land and airspace issues and permitting authority for matters related to hazards to air navigation. Specific to this PEIS, FAA's primary environmental resource areas of interest include airspace management and public health and safety. Technologies of interest include utility-scale renewables and transmission related to on- and offshore wind and land-based transmission lines.

1.3.2.6 U.S. Marine Corps and U.S. Navy

The U.S. Marine Corps and the Department of the Navy are cooperating agencies for this PEIS. Both have expertise related to U.S. military installations and training including radar, restricted areas, airspace, and training areas. All branches of the military are present on O‘ahu. The branches of the military coordinate with the Department of Defense (DoD) on renewable energy project compatibility through the DoD Siting Clearinghouse in the Office of the Deputy Undersecretary of Defense for Installations and

Environment. The Clearinghouse formal review process applies to projects filed with the U.S. Secretary of Transportation under 49 U.S.C. § 44718 as well as other projects proposed for construction within military training routes or special use airspace, whether on private, State, or Federal property.

HCEI goals are similar to the mandates required of Federal agencies (e.g., EPAct 2005, the *Energy Independence and Security Act of 2007*, and Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance”). The U.S. Pacific Command (PACOM) is a Unified Combatant Command of the Armed Forces of the United States, headquartered in Honolulu and recognizes that the success of the HCEI depends on the cooperation of U.S. military forces stationed in Hawaiʻi. In 2009, the U.S. Army Chief of Staff signed the U.S. PACOM Energy Cooperation Strategy with the State of Hawaiʻi and has agreed to support the HCEI by matching or exceeding its goals.

Specific to this PEIS, the Marine Corps and Navy’s primary environmental resource areas of interest include airspace management, accidents and intentional destructive acts, land use and submerged land use, and land and marine transportation. Technologies of interest are distributed and utility-scale renewables and transmission; particularly, anything on military lands, airspace, training areas, or restricted areas. These technologies could include wind (related to radar obstruction or navigation hazards), photovoltaic (related to reflectivity), and marine hydrokinetic energy and ocean thermal energy conservation such as may affect sea navigation.

Further, the Marine Corps is interested in matters related to the island of and waters around Oʻahu, while the Navy is interested in matters related to the islands of and the waters around Oʻahu and Kauaʻi.

1.3.2.7 State of Hawaiʻi

State of Hawaiʻi agencies have expertise in all matters related to State energy policy, land use, Native Hawaiian culture, aquatic resources, ocean recreation, forestry and wildlife, land and coastal land management and conservation, historic preservation, and parklands. On behalf of all State of Hawaiʻi agencies, DBEDT is serving as a cooperating agency for this PEIS. The State agencies have permitting authority and will serve as information sources for many entities, including but not limited to the public and developers of future projects in Hawaiʻi.

The State of Hawaiʻi has a vested interest in all environmental resource areas, clean energy categories, and activities and technologies evaluated in this PEIS.

1.4 Scope of the PEIS

This section discusses the scope of an EIS under NEPA and the scoping process that a lead agency must undertake as part of NEPA (Sections 1.4.1 and 1.4.2). Section 1.4.3 discusses DOE’s scoping process with respect to the Hawaiʻi Clean Energy PEIS. Finally, it provides a summary of the comments DOE received during the 2012 scoping period (Section 1.4.4).

1.4.1 DEFINING SCOPE

CEQ regulations define the scope in a NEPA process as a range of actions, reasonable alternatives, and impacts to be considered in an EIS (40 CFR 1508.25). A given scope may depend on its relationship to other EISs as described by the concept of *tiering* between a broader EIS and a subsequent EIS or *environmental assessment* (see 40 CFR 1508.28 for discussions on tiering).

Because this is a programmatic EIS and does not evaluate any specific project or proposal, DOE has prepared this document with the intent that future, project-specific NEPA evaluations could benefit from the information contained herein and build on, or tier from, this PEIS to streamline the future, project-specific environmental reviews.

1.4.2 SCOPING PROCESS

The scoping process refers to an early and open process undertaken by a lead agency to determine the scope of issues to be addressed and to identify the significant issues related to the proposed action. The scoping process begins with publication of an NOI in the *Federal Register*.

Subsequent steps include the following:

- An invitation to all affected agencies and the public to participate;
- Determination of scope and significant issues to be analyzed in the NEPA document;
- Elimination of issues that are not significant or have already been covered by prior environmental reviews;
- Allocation of assignments among lead and cooperating agencies, with lead agency maintaining overall responsibility for the document;
- Indication of other NEPA documents being or that will be prepared related to but not part of the scope under discussion;
- Identification of other environmental review and consultation requirements to facilitate concurrent preparation of analyses and integration with the NEPA document;
- Indication of the relationship between timing of the preparation of environmental analyses and the agency's tentative planning and decisionmaking schedule.

1.4.3 HAWAI‘I CLEAN ENERGY PEIS SCOPING PROCESS

As the lead agency, DOE undertook the scoping process for the Hawai‘i Clean Energy PEIS and filed the Amended NOI (77 FR 47828) on August 10, 2012, announcing the 60-day public scoping period. As part of the Amended NOI, DOE invited all affected Federal, State, and local agencies and other interested parties to participate by submitting comments and/or attending one of eight public scoping meetings on six islands in September 2012.

In addition to the Amended NOI, DOE announced the scoping meetings to encourage public participation in the PEIS process through published notices in six different local newspapers, issuing a press release, sending postcards or emails to individuals and groups that had previously shown interest in the HIREP: Wind PEIS, and creating the Hawai‘i Clean Energy PEIS website (www.hawaiicleanenergypeis.com). The website serves as a central online information location for PEIS announcements and documents throughout the PEIS process.

Prior to the public scoping meetings, a known expert in Hawaiian culture, on behalf of DOE, conducted small talk story sessions (informal, small group discussions) with local community groups and Native Hawaiian organizations. These sessions were designed to provide information on the status and scope of the PEIS and encourage participation in the formal public scoping process. The expert selected the groups based on their previous involvement and interest in the HIREP: Wind PEIS.

DOE held eight public scoping meetings between September 11 and September 20, 2012, on six islands in the cities of Honolulu, Lihue, Kailua-Kona, Hilo, Kahului, Lānaʻi City, Kaunakakai, and Kāneʻohe. DOE representatives, representatives from DBEDT, a representative from BOEM, and DOE contractor staff attended every meeting. The known expert in Hawaiian culture facilitated the public scoping meetings. The facilitator's role was to ensure the meetings began on time and progressed in an orderly and fair fashion so that all members of the public were given the opportunity to make a formal comment. In some instances, and where the facility rules allowed, the meetings ran over the pre-established time so that all members of the public that had signed up to speak could provide their oral comments.

Each scoping meeting opened with a presentation given by the DOE NEPA Document Manager and included background information on the partnership between DOE and the State of Hawaiʻi, the history of the HCEI, the NEPA process, the planned scope of the Hawaiʻi Clean Energy PEIS, and ways to comment on the scope of the PEIS. Eight illustrative posters with photos and text were on display at these meetings presenting these same subjects. Project representatives were on hand for informal conversations about the topics the posters represented.

Meeting attendees were provided an opportunity to sign up to present a formal, transcribed comment for inclusion in the Administrative Record. In addition, and as needed, DOE made the court reporter available to transcribe comments from individuals who wished to speak in a more private setting at the meeting location. These private comments also are included in the Administrative Record.

Other opportunities for submitting comments during the scoping period included submitting comments via the PEIS website; emailing comments to hawaiicleanenergypeis@ee.doe.gov; faxing comments to DOE at (808) 541-2253, Attention: Hawaiʻi Clean Energy PEIS; and sending comments via U.S. mail to the DOE's Hawaiʻi office, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247.

1.4.4 SUMMARY OF HAWAIʻI CLEAN ENERGY PEIS COMMENTS

DOE received a total of 738 comment documents as part of the Hawaiʻi Clean Energy PEIS scoping process. These included:

- 44 public comment letters/faxes;
- 84 comment documents submitted at the PEIS public scoping meetings;
- 256 oral comments transcribed at the PEIS public scoping meetings; and
- 354 public comment documents received via email and the PEIS website.

DOE reviewed each scoping comment document, identified individual comments within each document, and grouped them into four broad subject areas: (1) PEIS process and structure, (2) environmental resource area, (3) island-specific concerns, and (4) clean energy category (energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution). DOE then categorized comments by detailed topic areas.

Topics cited most often in the public scoping comments for this PEIS relate to island energy independence and self-sufficiency, Native Hawaiian issues, cultural and historic resources, socioeconomics and communities, land use, biological resources, utility-scale wind (land-based) and geothermal renewables, and undersea cable corridors.

The *Scoping Summary Report for the Hawaiʻi Clean Energy Programmatic Environmental Impact Statement* contains a five-page summary of these comments (available online from http://hawaiicleanenergypeis.com/eis-documents/).

1.5 Structure of Hawai‘i Clean Energy PEIS

This PEIS is arranged into eight chapters as follows:

- Chapter 1, “Introduction,” provides background information and an overview of the NEPA process and the PEIS including its purpose and structure.

- Chapter 2, “Proposed Action,” describes each of the five clean energy categories and the associated 31 technologies and activities. The chapter discusses, from a programmatic perspective, the permitting and regulatory requirements needed to implement the technologies and activities associated with the different clean energy categories. It provides a brief primer of each activity/technology that includes a description of a representative project. The chapter includes a discussion of a no-action alternative and tables that summarize potential environmental impacts associated with the technologies and activities in each clean energy category. The chapter concludes with brief explanations of the PEIS’s treatment of cumulative impacts, irreversible and irretrievable commitment of resources, the relationship between short-term uses and long-term productivity, unavoidable adverse impacts, and DOE’s preferred alternative. This chapter also contains a glossary.

- Chapter 3, “Affected Environment,” provides the existing conditions for each of the potentially affected environmental resource areas. It considers these resource areas at the State (regional) level and on an island-by-island basis for six islands (Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawaii). In order to avoid redundancy in later chapters focused on technology-specific impacts, this chapter also includes a discussion of the environmental impacts most often associated with construction and operation activities regardless of the clean energy activity or technology. The chapter organizes and discusses these impacts and associated best management practices in relation to the impacted resource, not the particular activity or technology.

- Chapters 4 through 8 present the environmental impact analyses of each activity/technology from and/or to each environmental resource area. The analyses are based on the potential programmatic-level impacts from the Chapter 2 representative projects on the Chapter 3 affected environment information to provide potential impact perspectives. Each section also presents best management practices and mitigation measures specific to an activity or technology.

  - Chapter 4, “Environmental Impacts from Energy Efficiency”
  - Chapter 5, “Environmental Impacts from Distributed Renewables”
  - Chapter 6, “Environmental Impacts from Utility-Scale Renewables”
  - Chapter 7, “Environmental Impacts from Alternative Transportation Fuels and Modes”
  - Chapter 8, “Environmental Impacts from Electrical Transmission and Distribution”

- The PEIS includes three appendixes:

  - Appendix A, “Public Notices”
  - Appendix B, “Distribution List”
  - Appendix C, “List of Preparers”

1.6 References

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1.7 Glossary

Cooperating Agency: Any Federal agency other than the lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in proposed legislation, a proposed action or reasonable alternative (40 CFR 1501.6 and 1508.5). A State, local, or tribal governmental agency may serve as a cooperating agency. *Related terms: Lead agency, participating agency.*

Council on Environmental Quality (CEQ): A division within the Executive Office of the President that coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. Established under the National Environmental Policy Act (NEPA) of 1969, CEQ is tasked with ensuring that Federal agencies meet their obligations under NEPA by overseeing Federal agency implementation of the environmental impact assessment process and to act as a referee during agency disagreements.

Environmental Assessment (EA): A concise public document that an agency prepares under the National Environmental Policy Act (NEPA) or the Hawaiʻi Environmental Policy Act (HEPA) to provide sufficient evidence and analysis to determine whether a proposed agency action would require preparation of an environmental impact statement (EIS) or a finding of no significant impact. A Federal agency may also prepare an EA to aid its compliance with NEPA when no EIS is necessary or to facilitate preparation of an EIS when one is necessary. The EA must include brief discussions of the need for the proposal, alternatives, environmental impacts of the proposed action and alternatives, and a list of agencies and persons consulted. *Related terms: Finding of No Significant Impact (FONSI), environmental impact statement (EIS).*

Environmental Impact Statement (EIS): The detailed written statement that is required by the National Environmental Policy Act (NEPA) or the Hawaiʻi Environmental Policy Act (HEPA) for a proposed major agency action significantly affecting the quality of the natural or human environment. The EIS includes, among other information, discussions of the environmental impacts of the proposed action and all reasonable alternatives, adverse environmental effects that cannot be avoided should the proposal be implemented, the relationship between short-term uses of the human environment and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources. *Related terms: Finding of No Significant Impact (FONSI), environmental assessment (EA).*

Hawaiʻi Clean Energy Initiative (HCEI): The partnership established through the 2008 Memorandum of Understanding (MOU) between the State of Hawaiʻi and the U.S. Department of Energy in furtherance of the provisions of Section 355 of the Energy Policy Act of 2005 (EPAct 2005) in order to transform the way in which energy efficiency and renewable energy resources are planned and used in the Hawaiian Islands. The overarching goal of HCEI is to meet 70 percent of Hawaiʻi's energy needs by 2030 through energy efficiency and conservation measures and renewable energy generation, collectively referred to as clean energy. The 70 percent goal includes 30 percent from energy efficiency measures and 40 percent from locally-generated renewable sources. *Related terms: Energy efficiency, energy efficiency portfolio standard, renewable energy, and Hawaiʻi renewable portfolio standard.*

Hawaiʻi Energy Efficiency Portfolio Standard (EEPS): A policy that sets usage levels as legally mandated targets for the reduction of electricity usage to be achieved through efficiency measures and technologies. Programs and technologies include improvements in energy efficiency of public buildings and creating incentives to achieve electricity use reductions. *Related terms: See energy efficiency, Hawaiʻi Renewable Portfolio Standard.*

Hawai‘i Renewable Portfolio Standard (RPS): A policy that requires electricity retailers to provide a minimum percentage or quantity of their electricity supplies from designated or defined renewable energy sources. Related terms: See Renewable Energy, Hawai‘i Energy Efficiency Portfolio Standard.

Lead Agency: As defined by CEQ regulations, this is the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact (40 CFR 1501.5 and 1508.16). *Related term: cooperating agency and participating agency.*

Notice of Intent (NOI): A notice that an EIS will be prepared and considered. The NOI is a document prepared as part of the NEPA/HEPA process.

Participating Agency: Participating (or consulting) agencies are agencies with an interest in defining the scope of an impact assessment and collaborating with lead and cooperating agencies in determining the methodologies and level of detail to be used in analyzing the alternatives. *Related terms: cooperating agency and lead agency.*

Programmatic Environmental Impact Statement (PEIS): A programmatic evaluation of the potential environmental consequences of implementing a proposed Federal program or policy on a regional scale. Subsequent site-specific environmental impact statements or environmental assessments may then be prepared on a proposed action included within the program or policy.

Proposed Action: Activity proposed to accomplish a Federal agency’s purpose and need. An EIS analyzes the environmental impacts of the proposed action. A plan that contains sufficient details about the intended actions to be taken, or that will result, to allow alternatives to be developed and its environmental impacts analyzed (40 CFR 1508.23). *Related term: affected environment.*

Renewable Energy: For the purposes of this PEIS, renewable energy includes energy derived from renewable sources such as the sun, wind, falling water, the ocean, geothermal, biomass, waste-to-energy, as well as hydrogen produced from renewable energy sources.

Scope: The range of actions, alternatives, and impacts to be considered in an EIS. *Related terms: scoping process, environmental impact statement.*

Scoping (or Scoping Process): The early and open process undertaken by a lead agency to determine the scope of issues to be addressed and for identifying the issues related to a proposed action while involving the public and other key stakeholders in developing alternatives and weighing the importance of issues to be analyzed in a NEPA/HEPA EIS.

Tiering: The coverage of general matters in broader EIS with a subsequent narrower EIS(s) or EA(s) incorporating the general discussion by reference and concentrating solely on the issues specific to the subsequent EIS(s) or EA(s).

CHAPTER 2

Proposed Action

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2 PROPOSED ACTION

Chapter 2 describes the five clean energy categories and their associated technologies and activities to enable stakeholders (e.g., project developers, government reviewers, funding authorities, and the general public) to evaluate which projects would be deployable in support of Hawai‘i Clean Energy Initiative (HCEI) goals. Section 2.1 describes the proposed action in relation to the goals of HCEI. Section 2.2 discusses, from a programmatic perspective, the permitting and regulatory requirements needed to implement the technologies and activities associated with the different clean energy categories that DOE's proposed guidance would consider. Section 2.3 provides a primer of the five clean energy categories, including characterizations of existing deployment across Hawai‘i, feasibility and permitting requirements specific to certain technologies, and a "representative project" that generically characterizes a project that could be implemented in the State of Hawai‘i. These representative projects are not based on a planned or proposed project; they form the basis against which environmental impacts can be evaluated. Section 2.4 addresses the no-action alternative, and Section 2.5 provides a summary of potential environmental impacts associated the technologies or activities of each clean energy category as evaluated across 17 environmental resource areas. The potential impacts are detailed in Chapters 4 through 8.

2.1 Proposed Action—DOE's Proposed Programmatic Environmental Guidance

2.1.1 BACKGROUND

The State of Hawai‘i historically has had the greatest dependence on imported oil of any state in the Nation to meet its energy needs (roughly 85 percent) with a disproportionate reliance on oil to generate electricity and electricity prices three times the U.S. average (EIA 2012a). This is in addition to heavy reliance on petroleum for transportation fuel. This reliance creates both environmental and economic risks for the State of Hawai‘i.

Recognizing these risks and pursuant to Section 355 of the *Energy Policy Act of 2005* (EPAct 2005), HCEI was established by the January 2008 Memorandum of Understanding between DOE and the State of Hawai‘i to transform the way in which energy efficiency measures and renewable energy resources are planned and used in the State. The HCEI goals are to meet 70 percent of Hawai‘i's energy needs by 2030 through clean energy efforts including energy efficiency and conservation measures (30 percent) and renewable energy generation from local sources (40 percent). In 2009, the State of Hawai‘i enacted legislation (HB 1464) to implement these clean energy goals.

In Chapter 1, DOE presented its purpose and need for agency action in the form of the development of policy guidance that it could use in making decisions about future funding or other actions to support the State of Hawai‘i in achieving HCEI goals. The State of Hawai‘i intends that Federal, State, and county governments, the general public, and private developers use the PEIS as a reference document when preparing project-specific environmental impacts statements and environmental assessments. DOE's action would assist residents and government decisionmakers in Hawai‘i to understand the most viable options that are available to achieve the goals of the HCEI. For purposes of this PEIS, DOE has divided the potential future actions into five clean energy categories. This Draft PEIS analyzes, at a programmatic level, the potential environmental impacts of future DOE actions that would fall within these categories and be subject to DOE's proposed guidance.

As described in Section 1.2.2, DOE would develop programmatic environmental guidance, which it would use to further integrate environmental considerations into its analysis and support of proposed clean energy projects in Hawai‘i.

As with most human endeavors, most clean energy projects have the potential to cause environmental impacts—especially if not implemented properly. However, careful adherence to Federal, State, and county laws, regulations, and permitting requirements; implementation of well-planned best management practices and mitigation measures; along with early consideration of local community concerns about the projects could alleviate many of the potential environmental impacts.

Early consideration of this guidance, especially in project planning and development, could substantially streamline future project-specific NEPA reviews, permitting processes, and community interactions, as well as lessen the potential for controversy over specific projects. DOE application of this guidance is limited to those actions where DOE has authority in a Federal decisionmaking role; however, the information in this PEIS and in any forthcoming guidance could be useful for any proposed project, whether Federal, State, or private.

2.1.2 CLEAN ENERGY CATEGORIES AND THEIR ASSOCIATED TECHNOLOGIES OR ACTIVITIES

HCEI identified four key energy sectors, each with specific goals. These sectors include end-use efficiency, electricity generation, transportation, and fuels. The clean energy categories selected for this PEIS were generally based on these key energy sectors. Ultimately, the goal of HCEI is to reduce reliance on fossil fuels in Hawai‘i, whether from the generation of electricity or from transportation. As mentioned previously, the five clean energy categories identified in this PEIS are energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution. Within each category DOE has identified a set of common technologies or activities that are currently or could reasonably be deployed in Hawai‘i. Table 2-1 lists the clean energy categories and associated technologies and activities, along with the PEIS section where the technology or activity is described.

Table 2-1. Clean Energy Categories and Associated Technologies or Activities

Clean Energy Category	Technology or Activity	Section
Energy Efficiency	Energy Efficient Buildings (A)	2.3.1.1
	Energy Conservation (A)	2.3.1.2
	Ground Source Heat Pumps	2.3.1.3
	Initiatives and Programs (A)	2.3.1.4
	Sea Water Air Conditioning	2.3.1.5
	Solar Water Heating	2.3.1.6
Distributed Renewables	Biomass	2.3.2.1
	Hydroelectric	2.3.2.2
	Hydrogen Fuel Cells	2.3.2.3
	Photovoltaics	2.3.2.4
	Wind	2.3.2.5

Table 2-2. Clean Energy Categories and Associated Technologies or Activities (continued)

Clean Energy Category	Technology or Activity	Section
Utility-Scale Renewables	Biomass	2.3.3.1
	Geothermal	2.3.3.2
	Hydroelectric	2.3.3.3
	Municipal Solid Waste	2.3.3.4
	Marine Hydrokinetic Energy	2.3.3.5
	Ocean Thermal Energy Conversion	2.3.3.6
	Photovoltaics	2.3.3.7
	Solar Thermal	2.3.3.8
	Wind (Land-based)	2.3.3.9
	Wind (Offshore)	2.3.3.10
Alternative Transportation Fuels and Modes	Biofuels	2.3.4.1
	Electric Vehicles	2.3.4.2
	Hybrid-Electric Vehicles	2.3.4.3
	Hydrogen	2.3.4.4
	Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas	2.3.4.5
	Multi-Modal Transportation (A)	2.3.4.6
Electrical Transmission and Distribution	On-Island Transmission	2.3.5.1
	Undersea Cables	2.3.5.2
	Smart Grid	2.3.5.3
	Energy Storage	2.3.5.4

Note: Entries designated with the letter “A” are considered activities rather than technologies.

2.1.3 ENVIRONMENTAL RESOURCE IMPACT AREAS

DOE identified the following 17 environmental resource areas for analysis on a programmatic (rather than project-specific) level. These resource areas encompass the physical, biotic, cultural, and social environments that could potentially be impacted by the activities or technologies identified in Table 2-1.

- Geology and soils
- Climate and air quality
- Water resources
- Biological resources
- Land and submerged land
- Cultural and historic resources
- Coastal zone management
- Scenic and visual resources
- Recreation resources
- Land and marine transportation
- Airspace management
- Noise and vibration
- Utilities and infrastructure
- Hazardous materials and waste management
- Socioeconomics
- Environmental justice
- Health and safety (including intentional destructive acts)

Chapter 3 of this PEIS provides a discussion of the affected environment for each of these environmental resource areas. The discussion includes an overview of each resource for the State of Hawai‘i and more specific information for each of the six islands being addressed. This material provides a baseline understanding of each environmental resource area, from which the reader can get an appreciation of the potential for environmental impacts from each of the technologies being assessed.

2.2 Permitting and Regulatory Requirements

This PEIS does not identify any specific proposal or project for the development of an energy efficiency activity or renewable energy technology. Rather this PEIS analyzes and presents the typical environmental impacts that would be associated with these types of activities or technologies if they were to be implemented in the future (refer to Chapters 4 through 8). For this reason and in order to be beneficial to would-be developers of specific projects; Federal, State and county agencies; the general public; and other stakeholders, this section provides a programmatic overview of the types of permitting and regulatory requirements that would be applicable for such future projects. This includes Federal, State of Hawai‘i, and county ordinances.

Project-specific permitting and regulatory requirements are highly dependent on both technology type and project location. In addition, this section is not intended to be exhaustive in its identification of these requirements but instead it seeks to provide a perspective of the programs and regulations that are presently in place to ensure that the proper environmental reviews occur before the implementation of proposed activities and technologies in the future.

The Hawai‘i State Energy Office strongly recommends that renewable energy applicants consult with the State Energy Office and the appropriate permitting agencies prior to submitting permit applications. The State of Hawai‘i has provided several guides to help projects comply with the appropriate regulations, which are provided in detail in Section 2.2.1 and 2.2.2 below. Section 2.2.3 lists the types of permits that may be required. Section 2.2.4 provides an overview of the roles and responsibilities of project proponents and the Federal, State, and county agencies in the permitting and regulatory review and approval process. General permitting and regulatory requirements for potential activities and technologies are described in Section 2.2.5. Where permits or requirements are specific to a particular type of technology or activity, these are described individually within the detailed activity and technology descriptions in Section 2.3.

2.2.1 PERMITTING INFORMATION WEB PAGE AND GUIDEBOOK

The Hawai‘i State Energy Office has developed and made available online a comprehensive list of Federal, State, and county-specific permits that are generally required for the activities that will accompany clean energy projects. These include permits related to siting, construction, operation, and other phases. This information is available at http://energy.hawaii.gov and includes a link to a single downloadable document that contains the same information. That document is called the *Guide to Renewable Energy Facility Permits in the State of Hawai‘i* (referred to herein as the “Guidebook” and cited as DBEDT 2013a), and it synthesizes and, where necessary, supersedes the previous county-specific guidebooks that were issued in 2010. Excerpts from this Guidebook have been included in this PEIS. Permit packets associated with each permit also are available for download at the above website. The Hawai‘i State Energy Office currently is updating the Guidebook, permitting website, and information on the large number of permits required for renewable energy development in Hawai‘i. In addition, many Federal, State, and county permitting agencies in Hawai‘i have developed their own guidance materials describing various permitting processes, procedures, and requirements. Where appropriate, this PEIS provides references to these other guidance materials.

2.2.2 ONLINE PERMITTING WIZARD

To supplement these tools, a free interactive online permitting tool, the Hawai‘i Renewable Energy Permitting Wizard, is also available from the Hawai‘i State Energy Office (http://wizard.Hawai‘icleanenergyinitiative.org/), which allows users (such as a would-be renewable energy developer) to identify the Federal, State, and county permits that may be required for a specific renewable energy project in Hawai‘i, based on input provided by the user (DBEDT 2013b). Designed for renewable energy projects, the Wizard can create a permit plan for a proposed project based on the type of renewable energy technology proposed. The permit plan also includes the recommended sequence—with estimated timelines—in which the permits may be obtained. Note that as of the writing of this Draft PEIS, the Hawai‘i State Energy Office currently is in the process of updating the Wizard content and functionality.

2.2.3 TYPES OF PERMITS

Permits serve as safeguards to communities and the environment from potential adverse impacts and ensure better enforcement of environmental laws (Zapka 2009). Permits and regulatory requirements for potential clean energy projects are categorized by the Guidebook into four general groups (DBEDT 2013a):

- Environmental permits and reviews
  - NEPA and *Hawai'i Environmental Policy Act* (HEPA) environmental impact reviews
  - Endangered species reviews and habitat conservation
  - Historic, archaeological, and cultural reviews
  - Water, air, and soil protections and reviews

- Land use permits
  - Review for compatibility with existing zoning, special districts, land use waivers, and land use plan amendments (note that in Hawai'i, each parcel is likely to be governed by two zones: the State land use district and the overlying county zoning district)

- Construction and operation permits
  - Site preparation and criteria for erecting a new building or structure, including electrical, plumbing, and drainage patterns

- Utility permits and approvals
  - Required for all utility construction, reconstruction, and maintenance activities

2.2.4 ROLES AND RESPONSIBILITIES

Clean energy projects in Hawai'i are developed in a regulatory environment that is administered by Federal, State, and county agencies. The agencies review different aspects of proposed actions depending on their regulatory authority and issue required permits. Clean energy projects in Hawai'i present new technological and permitting challenges that increase the need for coordination among applicants and the various Federal, State, and county agencies. The State of Hawai'i has many protected cultural, historic, and ecological resources, as well as overlapping land use jurisdictions. It can typically take 1 to 5 years to permit a large clean energy project in Hawai'i, and large energy projects in Hawai'i average 15 Federal, State, and county permits (with some projects requiring more than 40 approvals). The Hawai'i State Energy Office has developed both the Guidebook and the Permitting Wizard to encourage electronic permit processing, increase inter-agency communication, educate developers and agencies, and encourage early public involvement. Engaging impacted communities early in the process and addressing concerns raised prior to submitting permit applications can significantly shorten permitting timelines as agencies are typically more comfortable with permit approvals of specific projects that have community support. Future legislation to further streamline and prioritize the permitting processes could provide predictability to private companies and encourage their commitment of substantial amounts of capital, time, and effort necessary to develop renewable energy projects.

Obtaining the proper permits would be the responsibility of the engineering firm designing the project and the contractor performing the construction. Environmental permits and reviews are regulated at the Federal, State, and county levels. At the county level, the entire area of the State is encompassed by county government, except for Kalawao County and the City and County of Honolulu. The City and County of Honolulu is a consolidated city/county government on the island of O'ahu and is considered a municipal government. The island of Kaua'i is governed by the County of Kaua'i; the island of Hawai'i is governed by the County of Hawai'i; and the islands of Maui, Lāna'i, and Moloka'i are governed by the

County of Maui. Kalawao County on Molokaʻi is a considered an adjunct of the State government and not counted as a separate county government. The role of Federal, State, and county permitting and regulatory agencies is described in Table 2-2 including website links for more information. There are other State agencies with which project developers may want to confer when planning a clean energy project in Hawaiʻi, depending on the site and nature of the project, including the Department of Taxation, the Office of Hawaiian Affairs, and the Department of Hawaiian Home Lands.

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles

Agency	Role
Federal	
Advisory Council on Historic Preservation (ACHP)[a]	The ACHP operates under three standing committees: (1) Preservation Initiatives focus on partnerships and program initiatives such as heritage tourism to promote preservation with groups such as State and local governments, Indian tribes, and the private sector; (2) Communications, Education, and Outreach conveys the ACHP's vision and message to constituents and the general public through public information and education programs and a public recognition program for historic preservation achievement; and (3) Federal Agency Programs administers the *National Historic Preservation Act* (NHPA) Section 106 review process and works with Federal agencies to help improve how they consider historic preservation values in their programs. State Historic Preservation Officers (SHPOs) administer the national historic preservation program and Section 106 compliance at the State level. ACHP's Policy Statement on the ACHP's interaction with Native Hawaiian Organizations contains the commitments and principles that ACHP will implement when interacting with Native Hawaiian Organizations on matters relating to NHPA (ACHP 2008). The ACHP has also released a handbook, which identifies the significant role that Native Hawaiian Organizations play in consultation during the Section 106 process (ACHP 2011). **http://www.achp.gov/renewable_energy.html**
Council on Environmental Quality (CEQ)	The CEQ coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. In addition, NEPA tasks the CEQ with ensuring that Federal agencies meet their obligations under the Act by overseeing Federal agency implementation of the environmental impact assessment process and to act as a referee during agency disagreements. However, the regulatory role remains with the Federal agency responsible for the proposed action. **http://ceq.hss.doe.gov/index.html**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Environmental Protection Agency (EPA)[b]	The mission of the EPA is to protect human health and the environment. The EPA's primary responsibilities include the regulation of air quality, water quality, and chemicals in commerce; the development of regulatory criteria for the management and disposal of solid and hazardous wastes; and the cleanup of environmental contamination. Most Federal environmental statutes envision a primary role for states, so EPA works closely with State, tribal, and local governments and other stakeholders to implement their environmental compliance and enforcement programs. EPA also provides financial assistance to States and local governments to aim them in administering pollution control programs and in complying with certain Federal environmental requirements. The EPA administers the programmatic and regulatory aspects of 11 Federal pollution control statutes including the *Clean Air Act* (CAA) *and Clean Water Act* (CWA). The EPA has a unique role in the NEPA process. Under Section 309 of the Clean Air Act, EPA is required to review and publicly comment on the environmental impacts of major Federal actions including actions which are the subject of EISs. In addition, EPA carries out certain procedural duties associated with filing and publishing EISs. EPA's Office of Federal Activities has been designated the official recipient of all EISs prepared and filed by Federal agencies. **http://www.epa.gov/compliance/nepa**
Federal Energy Regulatory Commission (FERC)	FERC is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas terminals and interstate natural gas pipelines as well as licensing hydropower projects. Among other responsibilities, FERC is responsible for: • Regulating the transmission and wholesale sales of electricity in interstate commerce; regulating the transmission and sale of natural gas for resale in interstate commerce; • Approving the siting and abandonment of interstate natural gas pipelines and storage facilities; • Reviewing the siting application for electric transmission projects under limited circumstances; ensuring the safe operation and reliability of proposed and operating liquefied natural gas terminals; • Licensing and inspecting private, municipal, and state hydroelectric projects; • Protecting the reliability of the high voltage interstate transmission system through mandatory reliability standards; enforcing FERC regulatory requirements through imposition of civil penalties and other means; and • Overseeing environmental matters related to natural gas and hydroelectricity projects and other matters. FERC's Office of Energy Projects fosters economic and environmental benefits for the Nation through the approval and oversight of hydroelectric and natural gas pipeline energy projects. That office has the engineering and environmental expertise to certify new gas pipeline projects and to authorize and monitor hydroelectric projects and focuses on project siting and development, balancing environmental and other concerns, ensuring compliance, and safeguarding the public. **http://www.ferc.gov/about/offices/oep.asp**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Department of Agriculture (USDA)	USDA's mission is provide leadership on food, agriculture, natural resources, rural development, nutrition, and related issues based on sound public policy, the best available science, and efficient management. **http://www.usda.gov** **Farm Service Agency (FSA)**[a] administers farm commodity, crop insurance, credit, environmental, conservation, and emergency assistance programs for farmers and ranchers. The FSA implements the Conservation Reserve Program that sets aside private lands for the conservation of natural resources. FSA published a Programmatic EA in 2006 for implementation of the Hawai‘i Conservation Reserve Enhancement Program Agreement to enroll 30,000 acres of cropland and marginal pastureland. The FSA also operates the Biomass Crop Assistance Program to provide financial assistance to owners and operators of agricultural and non-industrial private forest land who wish to establish, produce, and deliver biomass feedstocks. **http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ecrc&topic=landing** **Natural Resources Conservation Service (NRCS)**[b] is the USDA's principal agency for providing conservation technical assistance to private landowners, conservation districts, tribes, and other organizations. Energy is a key resource for which NRCS provides conservation planning assistance to private landowners, so NRCS will use the PEIS when conducting environmental compliance in the planning process. NRCS authorities regarding conservation planning are from the *Soil Conservation and Domestic Allotment Act*, found in 16 U.S.C. § 590a(2). NRCS is also authorized under the *Food Conservation and Energy Act* of 2008 (and subsequent Farm Bills) using various programs such as the Conservation Stewardship Program (7 CFR 1470.3); Environmental Quality Incentive Program (Public Law 110-246); Wildlife Habitat Incentive Program (7 CFR Part 636) and others. **http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Department of the Interior (DOI)	DOI's mission is to protect America's natural resources and heritage, honor cultures and Tribal communities, and supply energy to power the Nation's future. DOI's Office of Native Hawaiian Relations is responsible for matters related to Native Hawaiians and serves as a conduit for the DOI's field activities in Hawaiʻi. **http://www.doi.gov/ohr/nativeHawaiians/list.cfm** **Bureau of Ocean Energy Management (BOEM)**[b]: BOEM is an agency with DOI that was granted the authority for regulating the production, transportation and transmission of renewable energy sources on the Outer Continental Shelf through the *Energy Policy Act of 2005* (EPAct 2005). BOEM has specific subject matter expertise in coastal and marine biological and physical sciences in addition to marine archaeological and cultural resources. **http://www.boem.gov/OEP/; http://www.boem.gov/Renewable-Energy-Program/Regulatory-Information/Index.aspx** **National Park Service (NPS)**[b]: The NPS, another DOI agency, has special expertise on the unique natural and cultural resources within and surrounding units of the National Park System within Hawaiʻi. Moreover, through its *Organic Act*, the NPS is charged with protecting park resources unimpaired for the enjoyment of future generations. This includes activities both inside and near park units. In accordance with 36 CFR 65.7, NPS monitors the condition of National Historic Landmarks and National Natural Landmarks and may offer preservation assistance. NPS also maintains the National Register of Historic Places in accordance with NHPA. **http://www.nature.nps.gov/environmentalquality/external.cfm** **U.S. Fish and Wildlife Service (USFWS)**[a]: The USFWS, also part of DOI, manages all designated National Wildlife Refuges and is the regulatory and management authority for all Federally listed plant and animal species under the *Endangered Species Act* (ESA). In addition, USFWS has regulatory authority for the protection of migratory birds under the *Migratory Bird Treaty Act* and bald and golden eagles under the *Bald and Golden Eagle Protection Act*. To ensure fish and wildlife resources receive equal consideration to other features of water resource development projects, the *Fish and Wildlife Coordination Act* requires Federal agencies involved with such projects to first consult with the USFWS and the respective state fish and wildlife agencies regarding the potential impacts of the project on fish and wildlife resources. **http://www.fws.gov/permits/overview/overview.html** The Pacific Islands Fish and Wildlife Office within the USFWS is an ecological services office headquartered in Honolulu. It carries out the USFWS mission in the Hawaiian Islands. The USFWS Pacific Islands Fish and Wildlife Office's Renewable Energy Development webpage is http://www.fws.gov/pacificislands/red.html. **U.S. Geological Survey (USGS)**[b]: As a Federal agency with special expertise in the earth sciences, the USGS may elect to evaluate, review, and prepare technical comments on EISs and associated documents prepared by other Federal agencies. In addition, through its Environmental Affairs Program, the USGS has established policies to implement NEPA. **http://water.usgs.gov/eap**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Department of Commerce (DOC)	DOC's mission is to promote job creation, economic growth, sustainable development, and improved standards of living for all Americans by working in partnership with businesses, universities, communities, and the Nation's workers. DOC also provides effective management and monitoring of the Nation's resources and assets to support both environmental and economic health. **http://www.doc.gov** **National Oceanic and Atmospheric Administration (NOAA)** is an agency within the DOC that provides environmental information such as weather forecasts and climate monitoring and scientific research to help manage U.S. coastal ecosystems, fisheries, and the marine environment and related commerce. **http://www.ppi.noaa.gov** NOAA's **National Ocean Service (NOS) Office of National Marine Sanctuaries**[a] has permitting authority for all activities that are prohibited (15 CFR Part 922) in marine sanctuaries. If a proposed activity includes any prohibited action, a permit is likely required. Section 304(d) of the *National Marine Sanctuaries Act* requires interagency consultation between NOAA and Federal agencies taking actions, including authorization of private activities, "likely to destroy, cause the loss of, or injure a sanctuary resource." **http://sanctuaries.noaa.gov/protect/enforcement/welcome.html** NOAA's **National Marine Fisheries Service (NMFS)**[a] has regulatory authority for the protection of marine mammals under the *Marine Mammal Protection Act* (MMPA), management and protection of marine threatened and endangered species. This includes implementation of ESA including cooperating with States, interagency consultation, enforcement, and permitting for conservation plans. It also includes protection and management of Essential Fish Habitat under the *Magnuson-Stevens Fishery Conservation and Management Act* (MSA). The NMFS Office of Protected Resources works to conserve, protect, and recover species under the ESA and the MMPA in conjunction with their regional offices, science centers, and various partners. **http://www.nmfs.noaa.gov/pr/permits/**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Department of Transportation (USDOT)	The mission of the USDOT is to ensure a fast, safe, efficient, accessible and convenient transportation system that meets vital national interests and enhances the quality of life of the American people, today and into the future. **http://www.dot.gov** **Federal Highway Administration** (FHWA)[a] is an agency within the U.S. Department of Transportation that supports State and local governments in the design, construction, and maintenance of the Nation's highway system (Federal Aid Highway Program) and various Federally and tribal owned lands (Federal Lands Highway Program). FHWA's Office of Planning, Environment, and Realty serves as FHWA's advocate and national leader for environment protection and enhancement, comprehensive intermodal and multi-modal transportation planning, and for fair and prudent acquisition and management of real property. **http://www.fhwa.dot.gov/hep** **Federal Aviation Administration (FAA)**[b] has the mission to provide an efficient aerospace system. The FAA's Environmental Policy Team falls under the Airspace Policy and Air Traffic Control Procedures Group, handling environmental matters for Mission Support Services for Air Traffic Organization. The team develops environmental policy, standards, and guidance and provides technical advice to FAA headquarters, service areas, and field offices. The team also represents Mission Support Services at meetings and conferences on environmental activities that affect air traffic operations and the National Airspace System. **https://oeaaa.faa.gov/oeaaa/external/portal.jsp**
U.S. Department of Homeland Security (DHS)	The **U.S. Coast Guard (USCG)**[a] within the DHS has a primary role in marine navigational safety through its Aids To Navigation program and vessel traffic management responsibilities. Any offshore renewable energy development that requires marking for navigational safety would fall under the authority of the USCG. **http://www.uscg.mil/top/missions**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
U.S. Department of Defense (DoD)	The **U.S. Marine Corps (USMC)** [b] and **U.S. Navy (Navy)**[b] protect DoD mission capabilities from incompatible development by collaborating with DoD Components and external stakeholders to prevent, minimize, or mitigate adverse impacts on military operations, readiness, and testing. USMC and Navy are committed to maintaining an effective, consistent, transparent, and timely process for evaluating the impact of energy projects on military test, training, and operational missions. The DoD Siting Clearinghouse is a "one-stop-shop" for comprehensive, expedited evaluation of energy projects and their potential effect on DoD operations. The Clearinghouse's formal review process applies to projects filed with the Secretary of Transportation, under section 44718 of title 49, U.S. Code (FAA's obstruction evaluation process), as well as other projects proposed for construction within military training routes or special use airspace, whether on private, State, or Federal properties. FAA's airspace jurisdiction for Obstruction Evaluation extends 12 nautical miles from the U.S. shoreline. Offshore renewable energy projects beyond 12 nautical miles would have to contact the DoD Clearinghouse directly to request a formal review. **http://www.acq.osd.mil/dodsc** **U.S. Army Corps of Engineers (USACE)**[a] restores degraded ecosystems; constructs sustainable facilities; regulates waterways; manages natural resources; and, cleans up contaminated sites from past military activities. USACE works in partnership with other Federal and State agencies, non-governmental organizations and academic institutions to find innovative solutions to challenges that affect everyone – sustainability, climate change, endangered species, environmental cleanup, ecosystem restoration and more. USACE also manages, designs and executes a full range of cleanup and protection activities that focus on reducing risk and protecting human health and the environment. **http://www.usace.army.mil/Missions/Environmental.aspx** The Pacific Ocean Division is one of nine divisions worldwide that make up the USACE. The Pacific Ocean Division is responsible for carrying out the USACE mission in the Pacific region, including in the Hawaiian Islands. **http://www.pod.usace.army.mil**
State of Hawai‘i	
Department of Agriculture (DOA)	The **Hawai‘i DOA** supports, enhances and promotes Hawai‘i's agriculture and aquaculture industries. **http://hdoa.hawaii.gov/**
Department of Business, Economic Development, and Tourism (DBEDT)[b]	**DBEDT** is Hawai‘i's resource center for economic and statistical data, business development opportunities, energy and conservation information, and foreign trade advantages. Within DBEDT are a series of offices and commissions that help carry out this mission that are discussed in more detail below. **http://dbedt.hawaii.gov/**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
Hawaiʻi State Energy Office (HSEO)	**HSEO** provides a catalyst through investment, policy, and regulatory frameworks that enables the development of clean energy businesses, projects and the growth of new jobs for Hawaiʻi. The HSEO is tasked with implementing Hawaiʻi's State Energy Policy, which is rooted in one principle: a commitment to maximize the deployment of cost-effective investments in clean energy production and management for the purpose of promoting Hawaiʻi's energy security. The policy is implemented following a 5-point energy strategy that includes: (1) diversifying Hawaiʻi's energy portfolio; (2) connecting the islands through integrated, modernized grids; (3) balancing economic, technical, environmental, and cultural considerations; (4) leveraging Hawaiʻi's position as a test bed to launch an energy innovation cluster; and (5) allowing the market to pick the winners. **http://energy.hawaii.gov/energypolicy/**
State Land Use Commission (LUC)	**LUC** works with the State Legislature, county planning departments, interest groups and landowners to define constitutionally mandated standards and criteria for protecting important agricultural lands in the State of Hawaiʻi. The Commission also engages the county planning departments in enhancing and clarifying the special permit process in the Agricultural Land Use District. The Land Use Commission is also working to establishing data warehouses with the county planning departments with respect to storage and retrieval of land use data; and developing cooperative memorandum-of-understanding with the University of Hawaiʻi Department of Urban and Regional Planning with respect to planning practicum and faculty consultation. **http://luc.hawaii.gov**
Office of Planning	The **Office of Planning** guides the development of the State through a continuous process of comprehensive, long-range, and strategic planning to meet the physical, economic, and social needs of Hawaiʻi's people, and provide for the wise use of Hawaiʻi's resources in a coordinated, efficient, and economical manner – including the conservation of natural, environmental, recreational, scenic, historic, and other limited and irreplaceable resources which are required for future generations. The Office of Planning's three main objectives are: (1) fix responsibility and accountability to successfully carry out statewide programs, policies and priorities; (2) improve the efficiency and effectiveness of the operations of the executive branch; and (3) ensure comprehensive planning and coordination to enhance the quality of life of the people of Hawaiʻi. **http://planning.hawaii.gov**
Hawaiʻi Community Development Authority	**The Hawaiʻi Community Development Authority** works to stimulate the economic development of specific community districts by planning and implementing community development programs and facilitating capital investments. The Authority's main objectives are: 1) plan and implement capital improvement projects to upgrade infrastructure and develop public facilities to meet Hawaiʻi's economic and recreational needs, and 2) implement long term planning initiatives to support residential development in a mixed-use community. **http://www.hcdaweb.org**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
Department of Health (HDOH)	The **Environmental Management Division** implements and maintains Statewide programs for controlling air and water pollution, for assuring safe drinking water, and for the proper management of solid and hazardous waste. The division also regulates the State's wastewater. **http://health.hawaii.gov** The **Clean Air Branch** is responsible for the implementation of a Statewide air pollution control program through services which include engineering analysis and permitting, monitoring and investigations, and enforcement of the Federal and State air pollution control laws and regulations. **http://health.hawaii.gov/cab** The **Clean Water Branch** administers and enforces Statewide water pollution laws and rules. This is achieved through permitting of point sources, compliance monitoring, inspections, investigations of complaints, and ambient water quality monitoring. **http://health.hawaii.gov/cwb** The **Solid and Hazardous Waste Branch** oversees management of all solid waste generated within the State through the promotion of pollution prevention and waste minimization activities, and the development of partnerships with both generators and the regulated community. SHWB also works to prevent releases, or threats of releases, of petroleum, hazardous substances, pollutants or contaminants into the environment through aggressive enforcement of environmental laws and regulations. **http://hawaii.gov/health/about/admin/health/environmental/waste/index.htm**l The **Hazard Evaluation and Emergency Response Office** provides risk assessments, responds to the release of hazardous substances and oversees the cleanup of contaminated sites. The office responds to at least 150 incidents a year. Office activities include evaluating health effects of air and water pollutants when no standards exist. **http://eha-web.doh.hawaii.gov/eha-cma/Org/HEER** The **Office of Environmental Quality Control (OEQC)** was established to help stimulate, expand and coordinate efforts to maintain the optimum quality of the State's environment. OEQC's main duty is implementing Chapter 343, Hawai'i Revise Statutes (HRS) Environmental Impact Statement Law. Office planners review and comment on hundreds of environmental disclosure documents each year. Twice a month, OEQC publishes The Environmental Notice which announces the availability of Environmental Assessments (EA) and Environmental Impact Statements (EIS) under public review. **http://hawaii.gov/health/environmental/oeqc/index.html** The **Hawai'i Occupational, Safety & Health Division** administers the Occupational Safety and Health Program through several activities, including: safety and health standards, inspections, and consultation. **http://labor.hawaii.gov/hiosh/about-us**
Department of Labor & Industrial Relations (DLIR)	The **DLIR** administers programs designed to increase the economic security, physical and economic well-being, and productivity of workers, and to achieve good labor-management relations, including the administration of workers' compensation, employment security, apprenticeship training, wage and hour, and industrial relations laws. **http://labor.hawaii.gov**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
Department of Land and Natural Resources (DLNR)	The **DLNR** is responsible for managing, administering, and exercising control over public lands, water resources, ocean waters, navigable streams, coastal areas (except commercial harbors), minerals, and all interests therein. DLNR includes within it various commissions, divisions, and offices that assist in carrying out this mission. The ones relevant to this PEIS include are discussed in more detail below. **http://dlnr.hawaii.gov** The **Commission on Water Resource Management** of DLNR sets overall water conservation, quality and use policies; defines beneficial and reasonable uses; protects ground and surface water resources, watersheds and natural stream environments; establishes criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establishes procedures for regulating all uses of Hawai‘i's water resources. **http://www.state.hi.us/dlnr/cwrm** The **Division of Forestry and Wildlife** of DLNR manages and protects watersheds, native ecosystems, and cultural resources and provides outdoor recreation and sustainable forest products opportunities, while facilitating partnerships, community involvement and education. **http://hawaii.gov/dlnr/dofaw** The **Engineering Division** of DLNR provides engineering services and technical assistance to other Departmental divisions and other State agencies to implement capital improvement or repair and maintenance projects and administer programs for water and land development, mineral resources development, and prevention of natural disasters. **https://dlnr.hawaii.gov/eng** The **Land Division** of DLNR is responsible for managing State-owned lands in ways that will promote the social, environmental and economic well-being of Hawai‘i's people and for ensuring that these lands are used in accordance with the goals, policies and plans of the State. Lands that are not set aside for use by other government agencies come within the direct purview of the division. These lands are made available to the public through fee sales, leases, licenses, grants of easement, rights-of-entry, month-to-month tenancies or kept as open space area. For more information, please visit: **http://hawaii.gov/dlnr/land** The **Office of Conservation and Coastal Lands** of DLNR is responsible for overseeing approximately 2 million acres of private and public lands that lie within the State Land Use Conservation District. In addition to privately and publicly zoned Conservation District lands, the Office is responsible for overseeing beach and marine lands out to the seaward extent of the State's jurisdiction. **http://hawaii.gov/dlnr/occl** The **State Historic Preservation Division (SHPD)** of DLNR works to preserve and sustain reminders of earlier times which link the past to the present. SHPD's three branches, History and Culture, Archaeology, and Architecture, strive to accomplish this goal through a number of different activities. The division's Statewide Inventory of Historic Properties contains information on more than 38,000 historic sites in Hawai`i. Reviews of development projects are the primary means of lessening the effects of change on our historic and cultural assets. **http://hawaii.gov/dlnr/shpd**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
Department of Land and Natural Resources (DLNR) (continued)	The **Division of Aquatic Resources** manages the State's aquatic resources and ecosystems through programs in commercial fisheries and resource enhancement; aquatic resources protection, habitat enhancement, and education; and recreational fisheries. Major program areas include projects to manage or enhance fisheries for long-term sustainability of the resources, protect and restore the aquatic environment, protect native and resident aquatic species and their habitat, and provide facilities and opportunities for recreational fishing. **http://state.hi.us/dlnr/dar**
Department of Transportation (HDOT)	The Hawaiʻi **Department of Transportation (HDOT)** is responsible for planning, designing, constructing, operating, and maintaining State facilities in all modes of transportation, including air, water, and land. Coordination with other Federal, State, and county programs is maintained in order to achieve these objectives. Within HDOT are various divisions that help the agency in carrying out its mission. These are discussed in more detail below. **http://hidot.hawaii.gov** The **Highways Division** provides a safe, and efficient and accessible highway system through the utilization of available resources in the maintenance, enhancement and support of land transportation facilities. **http://hidot.hawaii.gov/highways/home/doing-business/guide-to-permits** The **Harbors Division** maintains, repairs and operates the ten commercial harbors which comprise the Statewide harbors system, plan, design and construct harbor facilities, provide program planning and administrative support; manage vessel traffic into, within, and out of harbor facilities; provide for and manage the efficient utilization of harbor facilities and lands, and maintain offices and facilities for the conduct of maritime business with the public. **http://hidot.hawaii.gov/harbors/doing-business** The **Airports Division** develops, manages, and maintains a safe and efficient global air transportation organization. **http://hidot.hawaii.gov/airports/**
Public Utilities Commission (PUC)	The **PUC** regulates all franchised or certificated public service companies operating in the State prescribes rates, tariffs, charges and fees; determines the allowable rate of earnings in establishing rates; issues guidelines concerning the general management of franchised or certificated utility businesses; and acts on requests for the acquisition, sale, disposition or other exchange of utility properties, including mergers and consolidations. **http://puc.hawaii.gov**
County	
City and County of Honolulu	The City and County of Honolulu **Department of Planning and Permitting** provides services and information on building permits, development projects, and planning activities for the City and County of Honolulu. **http://www.honoluludpp.org**
County of Kauaʻi	Project permits required in the County of Kauaʻi are issued by the **Department of Planning** and the **Department of Public Works**. **http://www.Kauaʻi.gov** The **Planning Department** is responsible for the administration and enforcement of the Zoning and Subdivision Ordinances, as well as the County's planning program, which includes long-range and regulatory policy documents like the General Plan and Comprehensive Zoning Ordinances. **http://www.Kauaʻi.gov/Government/Departments/PlanningDepartment/ZoningandLandUsePermits/tabid/649/Default.aspx**

Table 2-2. Federal, State, and County Permitting and Regulatory Agencies and Their Roles (continued)

Agency	Role
	The **Department of Public Works** is responsible for the planning, design, and construction of all new improvements to County-owned facilities, excluding Department of Water projects. The maintenance, repair and upkeep of all County facilities, the collection and disposal of garbage and refuse, the collection and treatment of sewage, the review and enforcement of the various codes and other regulations pertaining to public and private construction work are also responsibilities of this Department. **http://www.Kaua‘i.gov/Government/Departments/PublicWorks/Engineering/DesignampPermitting/tabid/133/Default.aspx**
County of Maui	Project permits required in the County of Maui are issued by the **Department of Planning** and the **Department of Public Works**. **http://www.co.maui.hi.us/index.aspx?nid=124** **http://www.co.maui.hi.us/index.aspx?nid=121**
County of Hawai‘i	Project permits required in the County of Hawai‘i are issued by the **Department of Planning** and the **Department of Public Works**. **http://www.Hawai‘icounty.gov** The Department of Planning provides oversight on all planning and land use matters, and administers Subdivision and Zoning Codes. **http://www.cohplanningdept.com** The Department of Public Works administers regulatory and code enforcements for building, engineering, and transportation. **http://www.Hawai‘icounty.gov/public-works**

a. Participating agency.
b. Cooperating agency.

2.2.5 GENERAL PERMITTING AND REGULATORY REQUIREMENTS

This section describes the typical permitting and regulatory requirements applicable to most proposed clean energy projects in Hawai‘i. Potential requirements applicable to proposed land-based and marine-based projects are discussed, followed by a description of typical Federal, State, and county requirements. Depending on the proposed project, not all of the typical Federal, State, and county permits would be applicable. Permitting and regulatory requirements specific to certain activities and technologies are discussed in Section 2.3.

The potential Federal, State, and county permitting and regulatory requirements vary widely by technology and activity, even when grouped by energy category, and depend on the specific project location and design. In general, more permits would be required for a utility-scale project than for a distributed-scale project. According to a National Renewable Energy Laboratory (NREL) report (NREL 2013a), renewable energy project developers should be aware that there are a number of particularly complex permits that must be obtained, which can be time-consuming. These include Conservation District Use Permits, State Land Use Boundary Amendment, HDOH air permits, and Special Management Area permits. For proposed clean energy projects that would integrate into existing facilities or industrial operations, permitting may be accomplished through modification of existing permits.

In March 2012, BOEM kicked off a renewable energy task force with the State of Hawai‘i in order to streamline coordination of ocean renewable energy deployment in the outer continental shelf, which begins 3 miles off the coast of Hawai‘i. The task force includes officials from State and local agencies with relevant regulatory jurisdiction, as well as relevant Federal agency representatives. Any marine-based projects beyond the 3-mile area around Hawai‘i must consult with the BOEM to address all relevant permitting requirements for mooring, cabling, and transmission connections. For marine-based projects within the 3-mile buffer, the project developers need to seek a variety of permits from Federal, State, and county regulatory agencies addressing the various issues related to coastal zone management, environmental and cultural sensitivities, and a State environmental review, among other possible permits for construction and rights-of-way. The Hawai‘i DLNR controls all submerged lands within the 3-mile State buffer, other than those lands controlled by the Federal government (e.g., military installations and Federal parks). Additionally, FAA airspace jurisdiction for Obstruction Evaluation extends to 12 nautical miles from shore, while U.S. territorial seas extend to 24 nautical miles. Offshore renewable energy projects beyond 12 nautical miles would have to contact the DoD Clearinghouse directly to request a formal review.

2.2.5.1 General Federal Requirements

Typical Federal agency permitting and regulatory considerations include regulation of discharges into navigable waters of the United States, species review and protection approvals, archaeological and cultural review and protection approvals, and clean water approvals. Examples of Federal clean energy reviews and approvals that may be required for clean energy projects, in general, are listed below:

- Clean Water Act Section 404 approval
- Endangered Species Act Incidental Take Statement Section 7(a)(2) and Incidental Take Permit Section 10(a)(1)(B)
- Groundwater and Drinking Water Permit
- Historic and Archeological Resource Protection, Section 106 process
- Land and Water Conservation Fund Act Section 6(f)
- Marine Protection, Research, and Sanctuaries Act Section 103 approval
- National Ambient Air Quality Standards (NAAQS)
- National Pollutant Discharge Elimination System (NPDES) permits
- NEPA compliance
- New Source Performance Standards
- Notice of Proposed Construction or Alteration in Airspace
- Outer Continental Shelf Renewable Energy Project Leases, Rights-of-Use and Easement, and Rights-of-Way
- Prevention of Significant Air Quality Deterioration Determination
- Rivers and Harbors Act Section 9 and 10 approvals

NMFS and USFWS share responsibility for implementing ESA. Generally, the USFWS regulates activities that may impact threatened and endangered terrestrial and freshwater species, while the NMFS regulates activities that may impact marine and anadromous species. Federal agencies must consult with NMFS and USFWS, under Section 7(a)(2) of the ESA on Federal activities, including Federally funded activities, that might affect a listed species. These interagency consultations, or Section 7 consultations, are designed to assist Federal agencies in fulfilling their duty to ensure Federal actions do not jeopardize the continued existence of a species or destroy or adversely modify critical habitat. Section 7 consultations may conclude with the issuance of Incidental Take Statements, under which the Federal agency is authorized to incidentally take certain members of a listed species but only under certain conditions.

National Pollutant Discharge Elimination System or other run-off and/or clean water permits are required during construction and potentially throughout facility operation to regulate facility discharges.

The FAA would be involved in reviewing potential airspace conflicts for any proposed site in proximity to civilian airports or navigational aids (navaids). The Obstruction to Navigation Federal Regulation (49 CFR Part 77) requires FAA approval of any project higher than 200 feet above ground level. An FAA Finding of No Hazard to Air Navigation does not address all military airspace and other issues; coordination with the military command responsible for management of the training space (military operating areas, military training areas, and special use airspace) also would be required.

Additionally, developers should consult with NPS on projects that could have direct or indirect impacts on sensitive, cultural, natural, scenic, visual, and recreation resources of the National Park System and other protected resources.

2.2.5.2 General State of Hawai‘i Requirements

Typical State agency permitting and regulatory considerations include approvals to use the seafloor within 3 miles of the coastline; Conservation District Use Permits (for shoreline construction activities); coastal zone management review and approvals; species review and protection approvals; archaeological and cultural review and protection approvals; clean water approvals; approvals to impact local transportation activities; clean air approvals; and solid waste approvals. Examples of State of Hawai‘i clean energy reviews and approvals that may be required for clean energy projects, in general, are listed below. Since these are examples, some of these permits may not be applicable to all potential projects. Further, this list is not an exhaustive list of potential permits that may be required.

- Air Pollution Control Permit (Covered and Non-covered Source)
- Agricultural Burning
- Closed Watershed Entry
- Conservation District Use Permit
- Coastal Zone Management Federal Consistency Review
- Groundwater Control Area
- HEPA compliance
- Historic Preservation Review (HRS 6E)
- Incidental Take License and Habitat Conservation Plan
- Individual Wastewater System Permit
- Noise Permits
- Oversize and Overweight Vehicles
- Special Management Area Use Permit and Shoreline Setback Approval
- Special Use Permit (over 15 acres)
- State Land Use Boundary Amendment
- Transmission Line Approvals
- Underground Injection Control
- Underground Storage Tank
- Use and Occupancy Agreement (Lane Use Permit for Construction Work)
- Variance from Pollution Control
- Water Quality Certification Permit
- Well Construction and Modification Permit
- Wildlife Sanctuary Entry
- Zone of Mixing permit

Hawai‘i’s relatively small electrical grids impact permitting, and the appropriate utility must be contacted early in the planning stages to discuss project interconnection to the electrical grid (DBEDT 2013a).

Contracts such as Power Purchase Agreements (PPAs) with local utility companies may be required to either provide backup power or to sell any excess energy produced. For proposed clean energy projects that would support existing agricultural, industrial, or commercial businesses, the businesses would likely be connected to the local power grid. However, agreements would be required to sell electricity to the utility. Transmission line approvals are required to interconnect a proposed renewable energy project to the existing grid when new transmission lines are required (this approval is in addition to necessary easements or authorizations from property owners).

The project proponent must prepare an EIS under HEPA for certain proposed actions enumerated under HRS 343-5 that would use State or county lands, State or county funds, or have the potential to significantly affect Hawai`i's environment. As part of this process, a cultural impact assessment must be conducted and included in the EIS or EA. Such an assessment considers all the project's impacts to the cultural resources of Hawaiʻi.

An Incidental Take License and Habitat Conservation Plan would be required to allow incidental take of endangered or threatened species while carrying out an otherwise lawful activity. The proponent of a project with the potential to adversely impact threatened or endangered species must develop a State Habitat Conservation Plan in consultation with the State Division of Forest and Wildlife and the USFWS (this process is intertwined with the Federal process described above). The Plan and its supporting information must include sufficient scientific and other information to determine estimated take levels and, if applicable, the project proponent must begin the process of obtaining a State Incidental Take License. This often requires the project proponent to develop and maintain a separate area to support the proliferation of species impacted by the primary project. These management areas generally require their own permits and approvals.

The State of Hawaiʻi regulates historic preservation matters per HRS 6E and has a role in implementing Section 106 of NHPA. SHPO approval from the State Historic Preservation Division within the Hawaiʻi DLNR may be required. Historic places or structures listed (or eligible for listing) on the *National Register of Historic Places* require special consideration.

Proposed sites on presently or previously contaminated sites would need to engage with the Hazardous Evaluation and Emergency Response Office within the Hawaiʻi Department of Health. The Hawaiʻi State Energy Office strongly recommends that renewable energy applicants consult with that office prior to submitting permit applications. The language used in certain applications can trigger other permits or approvals not otherwise required (DBEDT 2013a).

The State of Hawaiʻi established a "Call Before You Dig" program with mandatory participation for excavators (such as installation contractors) and operators (including public utilities). As established under a 2004 State law, the Hawaiʻi PUC created the Hawaiʻi One Call Center (HOCC). The HOCC maintains a single phone number for excavators to call anytime 24 hours a day, 7 days a week for information in locating and marking underground lines, including lines for electric, gas, telecommunications, cable, water, and sewer facilities. The HOCC number is 1-866-423-7287 or 811. Additional information is available at http://www.callbeforeyoudig.org/Hawaiʻi/index.asp.

2.2.5.3 General County Requirements in Hawaiʻi

County permitting and consultation requirements vary by county. Typical county agency permitting and regulatory considerations include building permit approvals, approvals for many construction and operation activities (e.g., grubbing, grading, electrical and water/sewage connections), as well as ensuring county-level land use compatibility reviews. Examples of reviews and approvals common to one or more of the counties and applicable to clean energy projects, in general, are listed below:

- Building permits
- Certified shoreline/shoreline setback variance
- Flood zone variances and approvals
- Grading permits
- Grubbing permits
- Sewer, plumbing, and/or water service connection or tank installation permits
- Special Management Area Use Permit and Shoreline Setback Approval
- Special use permits

County-level departments with permitting and regulatory jurisdiction in these areas would include the Department of Planning and Permitting for the City and County of Honolulu and the Departments of Public Works and the Planning for Kaua‘i, Maui, and Hawai‘i counties (descriptions of the county-level departments and web links for each are provided in Table 2-2 above). The Planning Department plays the major role in permitting larger projects. Once submitted, the process for permits varies by county (e.g., Maui County has building, electrical, and plumbing permits, whereas the City and County of Honolulu issues only building permits).

Potential project developers should view each county’s development plans to ensure the proposed project is sited appropriately and consistent with county zoning purposes and ordinances. For new construction, a series of county-level agency project reviews and approvals may be necessary. In addition to county Planning and Public Works approvals, new construction activities could require approval by other county departments, such as the Departments of Water, Health, Engineering, Wastewater Management, and the Fire Department.

2.3 Activities/Technologies

This section contains a detailed discussion of various aspects of the technologies and activities identified in this PEIS. There are 31 distinct technologies or activities that have been grouped into 5 general clean energy categories: energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electricity transmission and distribution. Table 2-1 above presents these technologies and activities along with the broader clean energy groupings. Activities and technologies were selected for these clean energy categories based on their ability to make a timely contribution to the reduction on Hawai‘i’s reliance on fossil fuels and the specific HCEI goals and their stage of technical development, which makes it more likely to advance to the implementation or commercialization stage. For purposes of this PEIS, the clean energy categories are defined below along with footnotes citing sources.

Energy efficiency refers to reducing the energy needed for a given purpose or service or the act of going without a service in order to save energy. Energy efficiency technologies or activities include technologies that reduce the need for energy (such as ground source heat pumps, sea water air conditioning, and solar water heating) and sets of activities (such as energy efficient buildings, energy conservation, and initiatives and programs) that require less energy or save energy. The activities and technologies in the energy efficiency category were selected to represent those actions that could be taken to achieve improvements in end-use efficiency; one of the key sectors of the energy economy identified in HCEI.

Distributed renewables refer to the use of renewable energy resources in distributed generation, which in turn refers to any electricity generation by a generator that is located close to the particular load that it is intended to serve. The generating capacity of a distributed generation source is significantly smaller than those of centrally located utility-scale plants and can range from generation at a single residence to larger installations for commercial or multi-unit housing applications. Distributed renewable technologies are those distributed generation projects that use renewable energy resources, including biomass, hydroelectric, hydrogen fuel cells, photovoltaic (PV), and (small) land-based wind energy systems. Taken in concert with the utility-scale renewables (below), the technologies in these two categories represent "electricity generation," one of the key sectors of the energy economy identified in the HCEI.

Utility-scale renewables refer to the use of renewable energy resources at the utility scale, meaning at the scale of a centrally located power plant. Utility-scale renewable technologies include the same kinds of renewable energy resources as in the distributed renewables category (biomass, hydroelectric, photovoltaic, and land-based wind) but also include others whose use at the distributed scale is presently impractical (geothermal systems, municipal solid waste, marine hydrokinetic energy, ocean thermal energy conversion, solar thermal, and offshore large-scale wind energy systems). The generating capacities for utility-scale technologies are typically at least an order of magnitude larger than for distributed applications.

Alternative transportation fuels and modes encompass those kinds of fuel and types and methods of transportation that are different than the conventional gasoline-powered private automobile. The technologies associated with this category include the production and use of biofuels; compressed and liquefied natural gas and liquefied petroleum gas; and hydrogen. It also includes electric vehicles and hybrid-electric vehicles. Finally, it also encompasses multi-modal transportation activities such as using mass transportation (bus, rail, and marine), ridesharing, car sharing, biking, walking, and telecommuting. The inclusion of alternative transportation fuels and modes as a clean energy category in this PEIS is in direct response to the "transportation" key sector of the energy economy identified in HCEI.

Electrical transmission and distribution refers to the transmission of power from a point of generation and the means by which it is stored and distributed to electricity users. Electricity transmission and distribution systems form an electrical grid or network that is used to manage and distribute electricity. Electricity transmission and distribution technologies evaluated in this PEIS include on-island transmission, undersea cables (including land-sea cable transition sites), smart grid, and energy storage. While electrical transmission and distribution is not specifically addressed as a key sector of the energy economy in HCEI, these actions would be a direct result of implementing new renewable energy technologies or improving the existing electrical network in Hawaiʻi and are therefore included as an integral element of the Hawaiʻi Clean Energy PEIS.

The remainder of Section 2.3 considers the technologies or activities associated with these five clean energy categories. For each technology and activity, this section contains an in-depth description; a characterization of the feasibility and deployment; activity-specific or technology-specific permitting and consultation requirements (not including general permitting requirements discussed in Section 2.2); and a description of a representative project. Where available, the individual sections also provide a characterization of cost savings potential for the evaluated technologies.

DOE defined "representative projects" for each activity and technology to serve as analytical tools to allow the PEIS to evaluate and present the typical impacts (beneficial and adverse) associated with the respective activity or technology. The representative projects for each activity and technology characterize typical proposed projects that could be implemented in Hawaiʻi by 2030 based on realistic capacity factors and feasibility. The representative projects are hypothetical and not intended to represent any real or proposed project and are provided for analytical purposes only. As stated previously, DOE is not proposing any specific projects as part of this PEIS. An overview of the approach to the representative projects for each energy category is presented in Sections 2.3.1 through 2.3.5, followed by detailed descriptions of activities and technologies for each energy category.

2.3.1 ENERGY EFFICIENCY

Among the HCEI goals is a Statewide reduction in electricity usage of 30 percent through energy efficiency and conservation measures by 2030. The implementing legislation for HCEI (HB 1464) establishes an Energy Efficiency Portfolio Standard (EEPS) for the State of Hawai‘i that is designed to achieve this goal. Specifically, it calls for a demand reduction of 4,300 gigawatt-hours by 2030 – a figure that corresponds to a 30 percent reduction (Braccio and Finch 2011). To meet this requirement, the State of Hawai‘i is seeking to align efficiency regulatory policy framework with clean energy goals, support the retrofitting of existing residential and commercial buildings, strengthen new construction policies and building codes, and identify non-building related energy efficiency measures. The energy efficiency category focuses on activities and technology options that reduce energy use from residential and commercial buildings as well as what agencies and consumers can do to reduce and conserve energy use and increase cost savings. The energy efficiency technologies and activities discussed in this section include the following:

- Energy Efficient Buildings (Activity)
- Energy Conservation (Activity)
- Ground Source Heat Pumps
- Initiatives and Programs (Activity)
- Sea Water Air Conditioning
- Solar Water Heating

For energy efficiency activities, representative projects are based on Hawai‘i’s energy efficiency goals. Representative projects for energy efficiency technologies are based on what is considered a typical project in Hawai‘i. A representative project is not evaluated for Energy Conservation activities since there would be no potential for adverse environmental impacts from those activities. Additionally, there is no representative project evaluated for Initiatives and Programs because environmental impacts from these initiative would also be unlikely. No representative project is defined for Ground Source Heat Pumps because they are unlikely to be deployed in Hawai‘i by 2030.

2.3.1.1 Energy Efficient Buildings

Residential and commercial buildings use energy for cooling, lighting, water heating, and appliances and electronics. Today’s buildings consume more energy than any other sector of the U.S. economy, including the transportation industry (DOE 2008a). In an effort to decrease energy consumption of residential and commercial buildings, energy efficiency measures are incorporated into building construction and retrofits. Much of the information in this section can be found online at the State of Hawai‘i’s Department of Business, Economic Development and Tourism Energy Programs website: http://energy.hawaii.gov/programs.

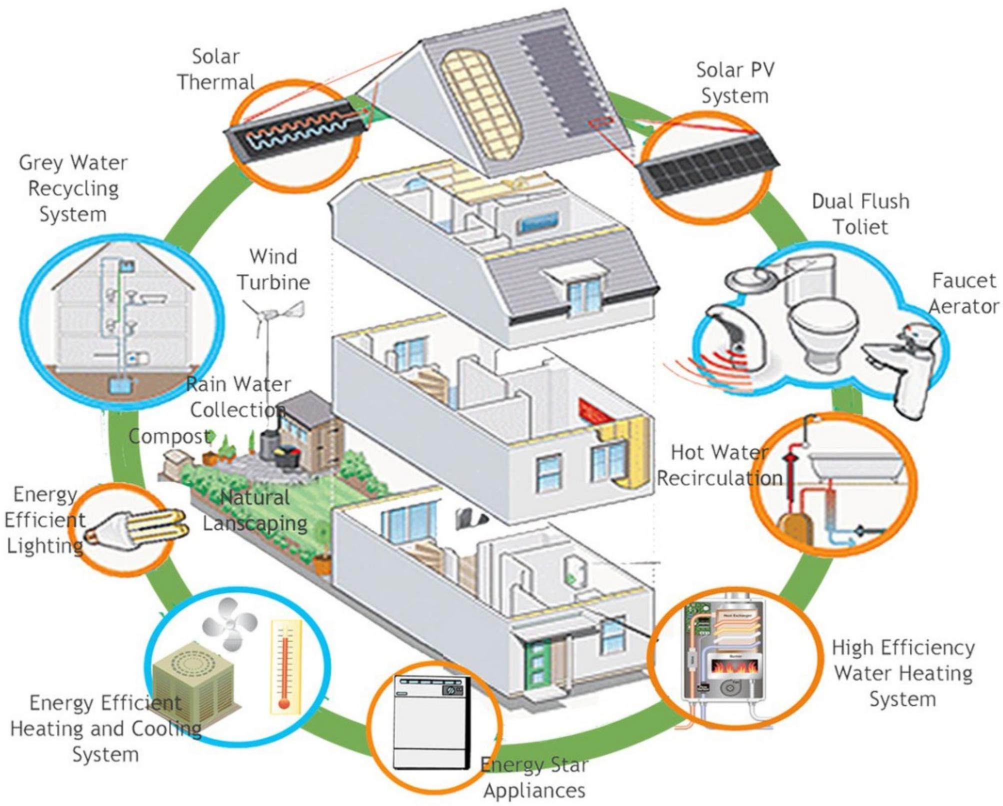


Figure 2-1. Illustration of an Energy Efficient Home

2.3.1.1.1 Activity Description

The State of Hawai‘i is characterized by its mild tropical climate, which experiences very little seasonal variation in day length. The islands are exposed to high sun angles throughout the year, resulting in a relatively constant amount of incoming solar energy annually with very small temperature fluctuations. This presents a unique challenge to designers as incoming solar radiation significantly affects the heat load and increases energy demand on air conditioning systems in buildings. As such, energy efficiency measures in the State focus on balancing the amount of heat gained from the sun and the heat generated internally from lights, people, and equipment, with the demand for air conditioning and electric lighting in buildings (Royle and Terry1990). To help decrease energy usage from buildings, energy efficiency measures are incorporated into building construction and retrofits in the State. Table 2-3 provides a descriptive list of common energy efficient measures applicable to building construction and retrofits in the State.

Table 2-3. Energy Efficiency Measures

Measure	Description
Integrated Building Design	A well-integrated building system design ensures that all of the building's components are designed to work together. This includes solar control strategies, daylighting/visual comfort strategies, thermal comfort strategies, special indoor requirements, indoor air quality strategies, specific building type issues, and commissioning. For example, in the State, this can mean limiting heat build-up in a building by minimizing the area of east- and west-facing walls and windows; providing generous areas of planting and ground cover to help reduce site temperatures; increased use of porous paving materials to reduce thermal mass, heat gain, and glare; shading roofs to prevent heat build-up or integrating cool roofs; and orienting buildings to maximize the cooling potential of prevailing winds. When performing at optimum levels, these components can save money in the long run and provide a durable and comfortable system that can help avoid future maintenance and repair costs.
Daylighting	Daylighting controls the amount of light entering a building by diffusing sunlight across a room through proper window sizing, light colored interiors, higher ceilings, and the use of shutters and skylights/lightwells. In Hawai‘i, the key to daylighting is finding a way to get light into a building while minimizing the amount of heat a building receives (e.g., minimizing the difficult-to-shade east- and west-facing windows and preventing heat gain and glare when installing skylights).
Shading	Shading keeps the sun's heat from entering buildings. This can be achieved via overhangs, awnings, and trees. Overhangs and awnings provide shade and direct water away from buildings; overhangs, specifically, have been used extensively in Hawaiian architectural design. Where possible, energy efficient landscaping can also provide shading.
Natural Ventilation	In the State, gentle trade winds can make air conditioning unnecessary. Summer is the windiest time of the year in Hawai‘i, and capturing cooling breezes can help keep buildings comfortable. As such, outlet vents or exhaust fans that are placed strategically remove moisture and pollutants. A controlled, filtered air intake ensures plenty of fresh air.[a]
Energy Efficient Lighting & Controls	Replacing existing lighting systems or the installation energy efficient lighting systems including ENERGY STAR©-qualified light bulbs and light fixtures (i.e., compact fluorescent light bulbs or light-emitting diode) in homes, buildings, street lights, and park lights can result in energy and cost savings. Proper installation and placement (for effective light delivery) of energy efficient lighting technologies (including controls such as timers, occupancy sensors, and photo sensors) can reduce lighting energy use in buildings by 50 to 75 percent.
Energy Efficient Windows	Windows can have a significant impact on energy consumption in a building's perimeter spaces. Energy efficient windows help to control and reduce ultraviolet light that can keep window areas cooler and improve the comfort of homes or buildings. In the State, it is important to shade windows and other openings and to use high-performance glazing or window film on windows exposed to the sun.
Dehumidification	Ensures that indoor humidity levels are kept at a comfortable level. Dehumidification is an important component of air conditioning loads.
Right-Sized & High-Efficiency Heating, Ventilation, and Air Conditioning System	The installation of a properly sized, high-efficiency heating, ventilation, and air conditioning system costs less than bigger equipment, saves energy, and is designed to comfortably handle heating and cooling loads.

Table 2-3. Energy Efficiency Measures (continued)

Measure	Description
High-Performance Heating & Cooling and Power Systems	The installation, tune-up or upgrade to energy efficient heating and cooling systems results in less energy for operations, decreased indoor humidity, less noise, and improves overall building comfort. When combined with proper equipment maintenance and appropriate insulation, air sealing, and adjusted thermostat settings, a 20 to 50 percent energy savings can result. For maximum energy savings and to prolong the life of these systems, use only when necessary or when natural ventilation is inadequate.
Cool Roof Systems	A cool roof emits the sun's heat back to the sky instead of transferring it to the building below. This can be achieved via ventilating attics, installation of fiberglass or foam board insulation or radiant barriers, the installation of white roofs to keep roof surfaces up to 70°F cooler. These measures can help reduce cooling load, thereby reducing air conditioning needs.
Appliances	When upgrading, replacing, or buying new appliances, ENERGY STAR®-certified appliances or ENERGY STAR® Most Efficient appliances such as air conditioners, ceiling fans, refrigerators, dishwashers, clothes washers, as well as Digital Video Disk (DVD) and Videocassette Recorder (VCR) players, televisions, home office electronic equipment and control panels (to completely shut off entertainment centers) can help reduce energy usage in both residential and non-residential buildings.
Tight Construction/Air Sealing and Sealed Ducts	Advanced techniques for sealing holes and cracks in a building's "envelope" (i.e., floors, walls, ceilings, windows, doors, and fireplaces) and in heating and cooling ducts help reduce drafts and moisture, as well as dust, pollen, pests, and noise. A tightly sealed building improves comfort and indoor air quality while lowering utility and maintenance costs.
Effective Insulation	Properly installed and inspected insulation in floors, walls, crawl spaces, and attics in conjunction with air sealing ensures consistent temperatures with less energy use, resulting in lower utility costs and a quieter, more comfortable building. Insulation is measured by "R-value." The higher the R-value, the thicker and more effective the insulation. For Hawai'i, an R-value of R 30 (about 10 inches thick) is recommended for roofs and a rating of R 13 (13 inches thick) is recommended for walls by DBEDT.
Well-Designed Moisture Barriers:	A well-designed moisture barrier in tropical climates helps avoid expensive structural damage and helps stop humidity, mold, and mildew.
Solar Water Heating/ High Efficiency Water Heating	Solar water heating systems use energy from the sun to heat water and are composed of solar collectors and storage tanks. This can replace conventional water heating, which is a big expense and accounts for approximately 40 percent of a house's utility bill in the State (see Section 2.3.1.6 of this PEIS). As of January, 2010 any newly constructed single-family home must have a solar water heating system, unless granted a variance.[b] Alternatively, the installation of an energy-efficient hot water heater tank, or an on-demand tankless water heater can result in energy savings. For added savings homes can use less hot water, turn down the thermostat on water heaters, or insulate existing water heaters and use timers.
Energy Efficient Landscaping	Energy efficient landscaping involves careful planning to keep buildings and the air surrounding the buildings cool. Landscaping can involve the use of trellises or trees to shade structures and paved areas; the use of light-colored exterior surfaces such as cream colored concrete to keep exterior areas cool; limiting unplanted and paved surfaces; and/or the use of porous paving materials that allow grass to grow in gaps.

Table 2-3. Energy Efficiency Measures (continued)

Measure	Description
Commissioning/Retro-commissioning	Commissioning is the process of verifying that a building's heating, ventilation, air conditioning, and lighting systems perform correctly and efficiently and in accordance with the design intent and owner's project requirements.
	The commissioning process for new construction integrates the traditionally separate functions of design, construction, and operation by bringing the project team together during each phase of the project. Existing building commissioning (retro-commissioning) investigates, analyzes, and optimizes the performance of existing building systems by identifying and implementing measures to improve their performance. Without commissioning, system and equipment problems can result in higher than necessary utility bills and unexpected and costly equipment repairs.

Sources: DOE 2004a; DBEDT and AIA 2001; DBEDT 2004.

a. At this time, the Hawai‘i Natural Energy Institute (HNEI) is proposing to partner with the University of Hawai‘i School of Architecture's Environmental Research and Design Lab (ERDL) and Loisos + Ubbelhode (an architecture and engineering firm) to leverage current research at the Lawrence Livermore National Laboratory to develop ceiling fan controls, hardware, and the prototype to test the controls in facilities HNEI currently monitors. The technology developed will be directly applicable to schools and other State facilities that need to improve comfort and reduce energy costs, and will allow more buildings to be naturally ventilated, thus advancing HCEI goals (HSEO 2013a).

b. A Public Utilities Commission-approved replacement solar water heater is required to qualify for a rebate.

New Construction

Energy efficiency measures can be incorporated during both preconstruction and construction of new buildings, including through scoping and design, procurement, codes and standards compliance, building development, and commissioning. For example, proper site selection and building placement can optimize the use of the existing environment while creating opportunities for energy efficiency. This takes advantage of solar access, natural areas, prevailing wind resources, water resources, and existing landscaping. During the design phase, high-performance building design takes into consideration the entire building—from the building materials used for the foundation and structure, to design elements that include high levels of insulation or reflective surfaces, high-performance windows with solar controls, daylighting, indoor air quality, and high-performance mechanical systems (e.g., direct digital controls, building monitoring systems, and building automation). High-performance mechanical systems can include, ground source heat pumps (see Section 2.3.1.3), sea water air conditioning (see Section 2.3.1.5), solar water heaters (see Section 2.3.1.6) energy efficient lighting, occupancy sensors, low-flow water fixtures, and cogeneration. Where applicable, buildings can also incorporate energy efficient landscaping (for shading/wind protection). Additional research and piloting of new building construction projects are integrating renewable energy resources (e.g., solar panels and small-scale wind turbines) into buildings to achieve *net zero energy demand* (see below and Section 2.3.2 of this PEIS).

Retrofits

Energy efficiency retrofits help ensure that existing buildings meet or exceed their optimal operational needs. Energy efficiency retrofits encompass general energy saving projects and range from energy efficient equipment to controls. These include replacing incandescent light bulbs with compact fluorescent and light-emitting diode light bulbs, installing insulation and duct sealing, and replacing water heaters, air conditioning units, roofs, floors, windows, boilers, heat pumps, and other appliances and features with energy efficient models and material. Historically, replacement of aging and outdated equipment has been cost-prohibitive. Today, however, energy efficient retrofits in a building can result in a 15 to 30 percent energy savings through improved operations and maintenance. So while the initial investment to retrofit buildings may be high, given Hawai‘i's high electricity prices, payback times are often less than three years.

Net Zero Building

Net zero-capable building, or zero energy-capable building, is the term of art for highly efficient new building construction or retrofits where energy efficiency is supplemented by renewable energy, resulting in zero fossil fuel energy consumption.. The Building Industry Association of Hawai‘i, the Hawai‘i State Energy Office, the Department of Hawaiian Home Lands, and residential military community developers in Hawai‘i have built and monitor zero energy-capable homes and communities. Private home owners also have designed and built their own net zero homes. Regardless of their energy efficiency, net zero homes can only achieve zero energy consumption if the occupant maintains and operates the home in an efficient and optimal level. Therefore, continued public education and outreach are key to the success of this concept.

2.3.1.1.2 Feasibility and Deployment

Existing Buildings

Buildings in the State have been developed in compliance with the State’s building energy code requirements, which vary by county. The basis for the code was set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Illuminating Engineering Society Standard 90.1 (the first standard in the nation to set requirements for energy efficiency in buildings in the early 1980s). Since its initial adoption, the code has been amended and changed several times to incorporate measures that help the State meet its energy efficiency goals. The current code was approved in February 2012, with the State Building Code Council (SBCC) approving the 2009 International Energy Conservation Code (IECC) with State-specific amendments. The SBCC is charged with adopting the International Code Council (ICC) suite of codes and follows the ICC cycle which is updated every three years. The new Hawai‘i Model Energy Code code applies to new and renovated buildings, and requires that all equipment and products be commissioned by a third party. The counties in the State are free to modify the code, as long as the codes that are adopted are at least as stringent. At this time, the 2009 IECC has only been locally adopted by Kaua‘i. Adoption in Honolulu, Maui, and Hawai‘i is still in progress. The SBCC is also currently proposing amendments to the 2012 IECC.

DBEDT is in the process of developing a “Tropical Energy Code” to address conditions unique to the tropical climate. This new code will draw substantially from the Guam Energy Code (available from http://www.guamenergy.com), and is being shared with the Pacific and Caribbean islands. A proposal to add a Tropical Climate Zone to the existing eight climate zones was approved at the October, 2013, International Codes Council final hearings.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

LEED is a national voluntary program developed by the U.S. Green Building Council that promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, materials selection, indoor environmental quality, and overall energy efficiency. The program provides performance ratings that range from the lowest, LEED certified, to the highest, LEED Platinum.

Refer to http://www.usgbc.org/leed for more information and to get the latest certification requirements.

HRS 196-9 (a and b) requires that all State buildings (including facilities receiving State funds) achieve Silver certification under the Leadership in Energy and Environmental Design program to the extent practicable. The statute allows for alternative certification under other nationally recognized standards that meet State approval, if necessary. The Statute further requires that counties also meet Silver certification for both new construction and retrofits unless deemed not feasible, inappropriate, or the resulting system would interfere or conflict with the use of the building or facility as an emergency shelter.[1,2] Pursuant to HRS 46-19.6, the State has the authority to prioritize construction and development permits for those project that achieve LEED Silver certification. Further, each county is allowed to prioritize permit applications submitted by private parties in the same manner.

LEED version 4 was adopted in the fall of 2013 and includes a prerequisite that buildings must be designed to meet ASHRAE 90.1-2010. Other energy-related pre-requisites are that fundamental Commissioning and Measurement and Verification, along with an Operations and Maintenance Plan will be required. In 2010, the State mandated that solar water heating systems be installed on all State facilities and newly constructed single-family homes, with some exceptions (DBEDT 2013c; HSEO 2013a).[3]

Hawaiʻi Clean Energy Initiative

As part of the HCEI, HSEO created a 30-percent Energy Efficiency Portfolio Standard to reduce electricity consumption by 4,300 gigawatt-hours in the State by 2030 by the use of clean, renewable energy.

In an effort to meet this goal, the State initiated and supports several programs, including the following:

- Energy savings performance contracts for government buildings. These contracts use guaranteed future energy and water utility bill savings to pay for the upfront capital costs of facility improvements;
- A public benefits fund to help finance retrofitting of building energy technologies;
- Lead by Example initiative, a retrofitting program for State-owned facilities, fleets, and personnel practices;
- Adoption of new, highly efficient building codes [such as the 2009 (and forthcoming 2012) International Energy Conservation Code 06 and higher]; and
- Funding of net zero-capable building pilot projects that incorporate renewable energy technologies, such as PVs, to achieve a goal of zero energy consumption.

The State also supports the Green Sun Hawaiʻi Loan Program, a public-private partnership with the potential to save energy via energy efficiency and renewable energy equipment installation Statewide (see https://hcrc-hawaii.org/community-development/financing-programs2.html). These loans help fund ENERGY STAR refrigerators to lighting retrofits and upgrades, energy efficient windows, cool roofs, and many other projects. DOE has also provided low-income households with assistance through its Weatherization Assistance Program, and the State has a homestead program (HSEO 2013a). Section

[1] H.B. 2175, which was codified in HRS 196-9, applies to all new State-owned or -funded construction of 5,000 square feet or greater, including K-12 public schools.
[2] H.B. 1464, also codified in HRS 196-9, addresses energy efficiency requirements for existing public buildings. By the end of 2010, State agencies had to evaluate the energy efficiency of all existing public buildings larger than 5,000 square feet or that use more than 8,000 kilowatt-hours annually. Furthermore, the bill required that opportunities for increased energy efficiency be identified by setting energy benchmarks for these buildings using ENERGY STAR Portfolio Management. The bill also requires buildings to be retro-commissioned every five years.
[3] This is a requirement for State facilities and single-family homes as long as life-cycle cost-benefit analyses determine it to be cost-effective; the State exempts single-family residential clients of the Department of Hawaiian Home Lands or any agency that can take advantage of utility rebates from this requirement.

2.3.1.4 of this PEIS provides additional information about the State's energy efficiency initiatives and programs.

Net Zero Buildings

Several pilot projects involving net zero-capable buildings have been conducted in the State (Braccio and Finch 2011), as listed below.

- The Hawai'i Gateway Energy Center in Kailua-Kona on Hawai'i island - Completed in 2005, this new construction visitor complex was designed to house research, development, and demonstration facilities for energy and technological fields (DOE 2013a). The building incorporates aggressive energy efficiency design including extensive daylighting, a passive thermal chimney (which captures heat and creates air movement), a cooling system that uses seawater to reduce energy consumption, and a 20-kilowatt PV system on its copper rooftop. The PV system produces all the energy required by the building, including the power needed for the cooling pumps. For more information about this pilot project. http://zeb.buildinggreen.com/overview.cfm?projectid=592.

- The Kaupuni Net-Zero Energy Village - a LEED-Platinum net zero community comprising 19 homes and a community center for low-income Hawaiian families. The village integrates cultural sustainability concepts of an ahupuaa with solar water heating and solar modules for electricity. Energy efficiency measures incorporated into the project include dual-pane windows, composite roofing, fully insulated walls and ceilings, ENERGY STAR appliances and lighting packages, and a porous concrete driveway for drainage. The village is also equipped with outlets for charging electric vehicles. Based on actual measured average consumption in a study conducted thereafter, the village came within 1 percent of its net zero energy goal, which proves the pilot a success in that the community performed near-net zero during its first year of use (Norton et al. 2013).

- The Energy Lab at Hawai'i Preparatory Academy - the first of its kind in the world—a facility for students, by students, that will connect young people and their schools, allowing them to collaborate and develop sustainable living. The lab is located in Kamuela, on the island of Hawai'i where a variety of renewable resources are readily available and accessible. The design team and head of the Hawai'i Preparatory' s Science Department have furthered these goals; expanding the mission to include a great number of building systems that employ sun, water and wind. The project has achieved LEED Platinum and Living Building Challenge certification. http://www.hpa.edu/academics/energy-lab/about-lab and http://living-future.org/case-study/hpaenergylab

- Kuykendall Hall - The University of Hawai'i at Manoa is currently retrofitting this building to reduce energy consumption by at least 30 percent and achieve net zero energy use. The retrofit design uses the prevailing winds to aid ventilation and cooling and incorporates lighting elements that reduce the need for cooling. Planned for completion during 2014, this project is on track to use about 50 percent less energy than the current building, exceeding the 30 percent savings goal. With the addition of building-mounted solar modules, the retrofitted building is projected to achieve net zero annual energy use. Altogether, the project is expected to result in a 49-percent energy savings (EERE 2013a).

Existing Energy Demand

Few studies and energy audits have been conducted of existing buildings in the State and their respective energy footprints. Therefore, the baseline energy demand from buildings discussed herein is based on the most current study available, the *State of Hawaiʻi Energy Efficiency Potential Study*, which was prepared for the Hawaiʻi Public Utilities Commission (PUC) in January 2014. The study provides quantitative estimates regarding baseline energy usage across residential, commercial, water/wastewater, military, and street lighting sectors. This PEIS limits its analysis to those sectors mainly affecting buildings in the State, such as building energy demand from the residential and commercial sectors.[4] According to the study, total electricity use for residential and commercial buildings in the State of Hawaiʻi in 2012 was 8,119 gigawatt-hours. This continues the trend in reduced energy usage in the State since it peaked in 2004, which was likely due to a combination of factors, including the recession, the State's ongoing energy efficiency goals and programs, and increasing use of renewable energy (Evergreen Economics 2013).

According to the PUC study, electricity usage in 2012 was largest in the commercial sector at 52 percent, or 4,983 gigawatt-hours, followed by the residential sector at 32 percent, or 3,136 gigawatt-hours. The highest amount of energy intensity among the building usage categories in the commercial sector included retail/services, offices, and miscellaneous or various building types including manufacturing facilities. Primary end uses for the commercial sector included lighting and cooling. In the residential sector, energy intensity was mostly concentrated in single-family homes. This was due to larger sized single-family homes when compared to multi-family homes, and includes higher air conditioning saturation and more appliances and electronics. The largest end-uses identified in the residential sector were appliances, water heating, and lighting (EnerNOC 2014).

Projected Energy Demand

As noted above, there are a limited number of studies and audits of existing buildings in the State and their respective energy footprints. Therefore, projected energy demand was modeled using projections from 2012 energy usage demand estimates.[5] Also, as noted above, actual energy usage rates have decreased since 2004. Whether or not future economic factors affect these demand estimates is still unknown.

According to the *State Energy Efficiency Potential Study*, the projected baseline energy demand for residential and commercial buildings in 2030 is estimated at 10,907 gigawatt-hours, or an increase of 2,788 gigawatt-hours from 2012 energy demand. This estimate includes an increase in energy usage from 3,136 gigawatt-hours in 2012 to 4,463 gigawatt-hours in 2030 (a 42 percent increase) for the residential sector, and an increase in energy usage from 4,983 gigawatt-hours in 2012 to 6,444 gigawatt-hours (a 29 percent increase) for the commercial sector (EnerNOC 2014). These estimates do not take into consideration potential energy efficiency savings from appliance standards or building codes since 2008, market-driven conservation measures, and other energy efficiency programs. Therefore, increased demand resulting from increased building activity may be partially offset by energy code compliance and aggressive retrofits. Table 2-4 shows the projected baseline energy usage for buildings until 2030 below.

[4] Due to the challenging nature of data collection and sensitivity of information of the military sector, existing and projected energy demand and savings for the military sector were omitted from this discussion.

[5] Baseline projections were utilized from the *State Energy Efficiency Potential Study* which used EnerNOC's Load Management Analysis and Planning tool (LOADMap) and data gathered from the HECO residential appliance saturation survey (RASS), KIUC RASS survey, the non-residential baseline study for HECO companies, the non-residential billing analysis by KEMA for KIUC, and various secondary data, as well as electricity sales information.

Table 2-4. Energy Usage Baseline Projection Summary for Buildings, Statewide (gigawatt-hours)

Sector	2012	2015	2020	2025	2030
Residential	3,136	3,398	3,698	4,047	4,463
Commercial	4,983	5,373	5,765	6,123	6,444
Total	**8,119**	**8,771**	**9,463**	**10,170**	**10,907**

Source: EnerNOC 2014.

The PUC projects that there is substantial potential to reduce energy usage in the State including via adoption of a “best-in-class” energy efficiency program to achieve the majority of potential energy savings. In order to achieve these savings, current programs would need to continue to increase awareness of the value of energy efficiency and accelerate energy savings (Hawai‘i PUC 2013) including for both new construction and retrofits.

New Construction

It is forecast that new construction would occur as a result of increased housing and commercial demand and as a result of replacing existing buildings with newer (more efficient ones). The energy consumption of new buildings is projected to increase with the adoption of more extensive air conditioning units and more energy-intensive appliances. According to a report released by the Energy Information Administration, while new homes and buildings have become more energy-efficient, new homes and buildings actually use slightly more energy than older ones as most buildings today are bigger and are used differently, i.e., use more electronic gadgets (EIA 2013a). However, as noted above, the State’s overall goal for energy efficiency is to attain a 30-percent reduction of electricity demands by 2030. In order to meet this goal, the State plans on strengthening new construction policies and building codes. As such, new building construction will be code-compliant and designed and constructed in accordance with LEED Silver certification requirements. This would include incorporation of the energy efficiency measures listed above (Section 2.3.1.2.1). Building owners and managers should evaluate the most cost-effective efficiency improvements and develop a priority list of retrofits to meet their specific circumstances.

Based on the *State Energy Efficiency Potential Study*, assuming the adoption of future equipment standards and building codes (known as of September 2013), an energy savings of 17 percent or 761 gigawatt-hours could be achieved in the residential sector, and a savings of 11 percent or 714 gigawatt-hours could be achieved in the commercial sector over 2030 baseline projections. These energy savings would primarily result from lighting, as a result of Federal lighting standards, increasingly stringent energy codes, rebate programs, and the falling cost of energy efficient lamps. However, these savings are not absolute as additional codes and standards could be adopted in the future.

Finally, the State goals for future new building construction are poised to shift toward the development of more zero energy-capable buildings to eliminate the State’s reliance on imported energy. As such, new building construction (where feasible) is anticipated to incorporate renewable energy to supplement energy code requirements and energy efficiency measures to meet a building’s energy demand. With additional research and development of zero energy-capable buildings, it is anticipated that the State will continue to progress toward its end goal of zero net energy consumption for new construction. Furthermore, with DOE’s ongoing support to help the State achieve its HCEI goals, including NREL’s continued feasibility studies and assessments of zero energy-capable buildings, it is anticipated that zero energy-capable buildings will be deployed to the extent feasible in the future. Altogether, these policies will help provide flexibility and permit innovation to further increase energy savings for new building construction.

Retrofits

Energy efficiency retrofits provide more potential energy savings when compared with the energy savings from new building construction because new construction requires, among other things, new building material and land disturbance (such as clearing and grading), which consumes energy. Therefore, from an energy footprint standpoint, building retrofits provide greater energy savings.

In order to maximize the amount of electricity savings from building retrofits, the least viable candidates for retrofit must first be identified and confined to low-cost retrofits with short payback times. Retrofits, on the other hand, should be targeted at the buildings that are capable of being cost-effectively retrofitted. This is due to the fact that most buildings that operate in the lower 20 percent of the energy efficiency curve may be slated for demolition in the not-distant future. If the buildings are not replaced, they would continue to act as a drag on the State's energy load reduction efforts. Therefore, those buildings that can be retrofitted in a cost-effective manner should be upgraded, while those that would not be cost-effective to retrofit should be replaced entirely. This would generate the maximum efficiency savings from both existing buildings (more retrofits will happen) and from new construction (highly efficient new construction replaces the worst of the energy users) (Finch and Potes 2010).

Assuming all feasible cost-effective energy savings measures for buildings are adopted in the State, it is projected that a potential energy savings of 5,462 gigawatt-hours of "economic potential" (or cost-effective) savings could be achieved (EnerNOC 2014). This would exceed the HCEI goal of 4,300 gigawatt-hours of electricity demand reduction with new construction. Specifically, this would include an energy savings of 2,115 gigawatt-hours from the residential sector and an energy savings of 3,347 gigawatt-hours from the commercial sector (EnerNOC 2014).

Lighting retrofits in the State would provide the greatest energy savings potential for both residential and commercial sectors.[6] Specifically, energy savings from lighting in the residential sector would result from the conversion of interior and exterior lamps to LED lamps, the installation of solar water heaters or heat pump water heaters, the installation of low-flow showerheads and faucet aerators, and the use of ENERGY STAR electronics and appliances. In the commercial sector, the majority of energy savings could come from the use of LED lamps and the installation of heat pump water heaters (EnerNOC 2014).

In addition to retrofits, proper building *retro-commissioning*, operation, and maintenance are anticipated to achieve the full savings potential of building retrofits, as building operators may be unfamiliar with new technologies. In particular, focus should be on the proper operation of building controls, as properly installed and operating equipment can have a large impact on building energy use for minimal cost. As such, energy retrofits are encouraged to help residents and businesses save energy, as well as save money, support job growth, and reduce pollution.

While building energy retrofits may provide ample energy savings reduction, consumer behavior should also be taken into account. Most energy use can simply be reduced via small behavioral changes to avoid wasted energy. This PEIS addresses such issues in Section 2.3.1.2.

Furthermore, it is anticipated that continued research and development of zero energy-capable buildings can help existing building retrofits achieve the State's HCEI goals of increased energy savings. With existing buildings, this can be done via efficiency and the installation of PV systems or other renewable energy systems to help offset energy demand. This presents a feasible scenario for buildings but would require extensive investment, including private funding.

[6] For example, ENERGY STAR LED lamps are rated to remain in service for at least 25,000 hours (approximately 23 years in residences), which is longer than typical incandescent lamps (1,000 hours) or compact fluorescent light bulbs (6,000 to 10,000 hours) (DOE 2012a).

2.3.1.1.3 Permitting and Consultation Requirements

Permitting and consultation requirements for new building construction and building retrofits across the State of Hawaiʻi are likely to be more general in nature (see Section 2.2.5 above). In an effort to accelerate energy efficiency implementation, the Hawaiʻi State Legislature passed a bill to promote a priority permitting process for construction projects that are certified LEED Silver, two Green Globes, or other comparable program. As mentioned in Section 2.3.1.1.2, counties are in the process of implementing their respective priority permitting programs. Certain projects (such as re-roofing) may not require a permit.

Careful consideration should be given when retrofitting historic buildings since not all energy efficient retrofits are appropriate for historic buildings (e.g., replacing historic windows may be inappropriate to retain the building's historic integrity). Specifically, consultation with the State Historic Preservation Division would be required if a retrofit were to involve a residential or commercial building listed in the *National Register of Historic Places*. Retrofits of historic buildings should follow the *Secretary of the Interior's Standards for Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings* (see http://www.nps.gov/tps/standards/rehabilitation/sustainability-guidelines.pdf).

2.3.1.1.4 Representative Project

The representative project focuses on energy retrofits as opposed to new construction to allow for specific impact analysis of retrofit projects. As such, this representative project is for all existing homes in the City and County of Honolulu beginning in 2015. This includes the retrofit of homes to bring them into compliance with the 2009 International Energy Conservation Code (which is expected to result in a greater than 15-percent energy savings when compared with the 2006 Code) and replacement of the remaining 50 percent of incandescent light bulbs inside a home with LED lamps to reduce energy loads in a typical single-family residential home.[7][8] Based on incorporation of these energy efficiency measures, the estimated energy savings from these retrofits would result in a total energy savings of approximately 1,550 kilowatt-hours per home, per year, as shown in Table 2-5. This total energy savings of approximately 129 kilowatt-hours per month of the estimated 561 kilowatt-hours per month (6,700 kilowatt-hours per year)[9] represents an approximately 23-percent energy savings for a residential home in the City and County of Honolulu. Assuming energy usage remained constant, when multiplied by the projected 402,321 residential units in Honolulu County in 2030, this would result in a total countywide energy savings of about 620,000 megawatt-hours per year (620 gigawatt-hours per year). This would represent approximately 14 percent of HCEI's goal of 4,300 gigawatt-hours per year for 2030. With adoption of future updates to the IECC code, it is anticipated that energy savings would be greater in the future when compared with existing energy savings. However, as energy demand from more energy-efficient homes decreases in the future, so would potential energy savings.

Investment in the energy efficiency measures for the representative project likely would result in decreased loads on the grid and subsequently decreased air pollution and greenhouse gas emissions. However, adoption of such measures would require extensive investment from homeowners, as these retrofits are costly. Investments may further be hampered by recent economic conditions. As such, subsidies and/or State incentives would be required to increase the success of the representative project.

[7] The representative project includes both single- and multi-family residential homes.
[8] The 2009 IECC requires that 50% of bulbs inside a home be replaced with energy efficient bulbs. Therefore, the representative project requires that the remaining bulbs inside a home be replaced.
[9] Recent figures for the City and County of Honolulu show a decrease in average residential electricity use to 561 kilowatt-hours per month. This is based on Hawaiʻi Facts & Figures: Electric Utilities, Residential Electricity Use, Rates, and Average Bill, 2012.

In addition, waste materials may increase as a result of building retrofits, which should be recycled to the extent feasible and disposed of appropriately if containing hazardous materials (e.g., asbestos insulation). As noted above, consultation with the State Historic Preservation Division would be required if the retrofit involved a residential or commercial building listed in the *National Register of Historic Places*.

Table 2-5. Projected Energy Savings with the Representative Project

Energy Efficiency Measure	Estimated Energy Savings (kWh/yr)
Update State Building Code to IECC 2009	Equal to or greater than 15% of 7,827 kWh/yr = ~1,175 kWh/yr
Replace 50% of 50-watt incandescent light bulbs with 12-watt LED light bulbs = 38 W/hr (0.038 kWh)	0.038 kWh × 17 sockets × 1.6 hours a day × 365 days a year = ~377 kWh/yr[a]
Total Energy Savings per Home	**~ 1,552 kWh/yr**

a. Estimate based on the assumption that half of the light sockets utilize high-efficacy lamps to be compliant with IECC 2009, and based on half of the average number of light sockets inside a home in Hawai‘i (based on an average of 34 lamps per household) (Evergreen Economics 2013). Estimate assumes light bulb is on for 1.6 hours a day (DNV et al. 2012).

IECC = International Energy Conservation Code; kWh/yr = kilowatt-hours per year; LED = light-emitting diode; W/hr = watts per hour.

2.3.1.2 Energy Conservation

Energy efficiency is using less energy to perform the same service or task. Energy conservation is the act of reducing or going without a service or task in order to save energy. For example, turning off a light is energy conservation; replacing an incandescent light bulb with a different type of light bulb that uses less energy to produce the same amount of light is energy efficiency. However, both conservation and efficiency can reduce the amount of energy used. Using less energy generally has positive potential environmental consequences.

2.3.1.2.1 Characterization of Activity Feasibility and Implementation

There are numerous initiatives and programs in place and funded that support energy conservation and efficiency in Hawai‘i. Many of these programs were established and have evolved over more than two decades. Others are new to the State and in the pilot stage. They all support Hawai‘i’s current and evolving energy initiatives and include relevant updates to the State Building and Energy Code, the GreenSun Hawai‘i Loan Loss Reserve Program, Hawai‘i Green Business Program, Lead By Example Initiative, Energy Savings Performance Contracts, Department of Hawaiian Homelands Energy Policy, net-zero energy homes, and the many DBEDT energy efficiency programs. Section 2.3.1.1 of this PEIS discusses these initiatives and energy efficiency programs.

Table 2-6 contains energy conservation measures from HECO, also available online at http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=7c4e5e658e0fc010VgnVCM1000008119fea9RCRD&vgnextfmt=default. Table 2-7 lists energy saving measures that Hawaii Energy’s rebate program supports for residents on O‘ahu, Maui, and Hawai‘i when they purchase energy efficient equipment and appliances for their home. Information on this program is available at http://hawaiienergy.com/tips-to-save-energy. On Kaua‘i, Kaua‘i Island Utility Cooperative (KIUC) supports Energy Wise Programs with solar rebates and loans, lighting and energy efficient appliance replacement and rebates for more energy efficient appliances and equipment. Information on this program is available at http://website.kiuc.coop/content/energy-wise-programs-0.

Table 2-6. Energy Conservation Measures

Measure	Results / Savings[a]
Light with Compact Fluorescents (new programs include light-emitting diodes)	Changing just one regular 100-watt bulb to an energy-saving 26-watt compact fluorescent light bulb can save 81 kWh and more than $24 per year per bulb, when used 3 hours a day.
Use Fans instead of Air Conditioners[b]	Use fans instead of air conditioners, a savings of $71 per month. A ceiling fan on for eight hours per day uses 24 kWh per month, or $7. An air conditioner (12,000 Btu/H, EER 10.8) running eight hours per day uses 26 kWh or $78 per month.
Shorten Showers	Cutting just 2 minutes per shower could save up to 463 kWh and $139 a year.
Repair Leaky Faucets	One drop each second can waste about 1,661 gallons of water a year. A leaking hot water faucet wastes water and up to $79 in energy costs a year.

Table 2-6. Energy Conservation Measures (continued)

Measure	Results / Savings[a]
Wash Clothes in Cold Water	Switching from hot wash/warm rinse to the cold/cold cycle on a standard, top-loading washing machine for just two loads a week can save 225 kWh and $68 per year.
Eliminate Energy Sneakers (Phantom Load)	Use a power strip to eliminate energy sneakers (phantom loads) by turning off devices not in use, such as cell phone chargers, camera battery chargers, and computers. Such devices use standby power when not in use. Using a power strip to turn off your computer can save 50 kWh and $15 per year.
Air Dry Dishes	Letting dishes air dry instead of using a dishwasher's heated drying cycle saves 110 kWh and $33 per year.
No Peeking	Limiting how often and how long you open the refrigerator will save electricity and protect the appliance. Also limit opening the oven while cooking or baking to save electricity, protect the appliance, and speed up cooking times, too.
Install Motion/Occupancy Detectors Indoors and Out	Cutting use of a 150-watt, outdoor flood light from six hours to one hour per night with a motion sensor saves up to 270 kWh and $81 per year. Switching off a 100-watt light for just one, eight-hour day per week, can save 41 kWh and over $12 per year.
Use ENERGY STAR Appliances	When it is time to replace or add appliances, look for the ENERGY STAR symbol on refrigerators, ovens, dishwashers, DVD and VCR players, televisions, and home office equipment.

a. All savings are based on industry averages and 30 cents per kilowatt-hour.
b. Use natural ventilation and open your windows to take advantage of the trade winds first and foremost.
kWh = kilowatt-hour; Btu/H = British thermal units per hour.

Various agencies and industry groups have developed many programs to train students, faculty, and residents in energy efficiency, auditing, and assessments. Cumulatively, all of these efforts are providing positive contributions to educating and increasing the awareness of residents and businesses in energy conservation and energy efficiency; helping toward achieving the HCEI goals.

Hawai‘i Energy's Educational and Training – Programs drive capabilities for the Building Operators and decision makers such as Building Operator Certification training, International Facility Management Association local technical training seminars, Association of Energy Engineers certification classes and testing for Certified Energy Managers and Certified Energy Auditor, Energy Efficiency Funding Group Selling Energy Efficiency seminars http://www.Hawai‘ienergy.com/media/assets/2013Hawai‘iEnergy2013AnnualPlan.pdf.

Table 2-7. Hawaii Energy's Residential Rebate Program – Measures, Savings, Cost, and Payback

Measure	Annual Savings	Install Cost	Payback
Put in a solar water heater	$500 to $1,600 after credits and rebates	$1,000 - 2,000	4 years
Energy savings, rebates, and tax credits will pay for a solar water heater for a family of four on O‘ahu in as little as four years.			
Switch to compact fluorescent light (CFL) bulbs	$240	$1 - 100	1 year
CFLs use up to 75 percent less energy and last up to 10 times longer than incandescent light bulbs. Switch 10 incandescent bulbs to CFLs and save $240. Each CFL could save about $24 a year.			
Use fans and not air conditioning	$560	$1 - 100	1 year
Use fans along with air conditioners to circulate cold air and save energy and money. Savings based on O‘ahu electric rates for an 8,000 Btu/H; air conditioner replaced by an oscillating ceiling fan, both running for 8 hours a day.			
Replace your 10-year-old or older refrigerator	$300	$501 - 1,000	3 years
Replace old, less-efficient refrigerator with a new ENERGY STAR model and pay back within two to three years (depending on the model) with electric bill savings. Average savings for a 19- to 21-foot refrigerator/freezer built before 2001 when replaced by an ENERGY STAR model.			
Take shorter showers and install low-flow showerheads	$38 - 57	FREE	
Save money for every minute deducted from a hot shower – electricity and water.			

CFL = compact fluorescent light bulb; Btu/H = British thermal units per hour.

HECO recognizes that the majority of the State's population struggles to understand energy usage in their daily lives. In working toward the goals of the HCEI, the ignorance of energy consumption or *energy illiteracy* presents a significant impediment to progress, especially in the context of personal behavior and its impact on energy efficiency and conservation. HECO holds the position that to affect behavior, the State's population must improve its *energy literacy*.

Behavior modification will be built upon the foundation of energy literacy. The program will be developing an offering that will not only serve to develop future green employees through great internships, but will do so through an in-home mentoring program. This offer is envisioned to provide an educational experience to families while conducting a simple home energy assessment http://www.Hawai‘ienergy.com/media/assets/2013Hawai‘iEnergy2013AnnualPlan.pdf.

The UH Community College and Department of Labor and Industrial Relations Training: Home Energy Survey Professional – The Home Energy Survey Professional provides participants with training in small business and residential energy auditing. Participants received hands-on experience using state-of-the-art building performance equipment and will leave with an understanding of appropriate technologies and strategies for improved energy performance in Hawai‘i. Topics include building envelope features and performance, mechanical equipment types, renewable energy uses, and appliance and lighting characteristics. This course is appropriate for contractors, architects, inspectors, or anyone looking to pursue a career in an emerging industry in Hawai‘i.

The E^2U Program and KUPU (formerly the YEAH Program) - The E^2U Program is centered on energy conservation and vocational training in the sustainability field. E^2U is designed for young adults who are interested in learning how to conserve energy and want to help others learn how to conserve energy too. The E^2U Program provides members the latest training in how to conserve energy while providing members hands-on experience, conducting energy assessments of O‘ahu residences. E^2U members also learn about conservation and health issues related homes.

KANU - Completed an energy assessment for a home in Manoa Valley. From the Rewarding Internships for Sustainable Employment (RISE) Program, interns and crew went through HECO's "Power To Save: An Energy Conservation Guide for Your Home" curriculum to assess the home's energy use. The goal from this was to take a look at overall energy usage and behavior. Throughout the assessment they focused on different areas of energy consumption, including lighting, water heating, cooling, electronics, clothes washer and dryer, refrigerator and freezer, and kitchen appliances such as microwave ovens and toasters.

Based on what KANU learned working with hundreds of families to save energy, the organization is developing a free energy efficiency course. The course is designed to help anyone better manage modern devices including video game systems, Digital Video Recorders (DVRs), and other devices that lack energy efficiency information. KANU will be testing a new energy savings concept centered on a KANU lending library in partnership with HECO http://www.kanuHawaiʻi.org/story/?id=137048591724533426.

Rewarding Internships for Sustainable Employment – This program is centered on sustainability and the development of Hawaiʻi's green-collar workforce. It is designed for college students and recent college graduates interested in gaining entry-level experience in areas such as clean energy, pollution, sustainable development, and greenhouse gas reduction. This internship experience allows individuals to work on projects addressing various sustainability issues http://www.risehi.org.

HECO's Home Energy Challenge - HECO and the Hawaiʻi State Department of Education team for this annual event. Students learn about conserving energy while helping the environment and their families http://www.heco.com/portal/site/heco/menuitem.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=fbdebcb8b9109310VgnVCM10000005041aacRCRD&vgnextfmt=default. All homes participating in the Home Energy Challenge who reduce their energy use during the Challenge period of October to March are automatically included in the drawing to win a free 2-kilowatt Kumu Kit PV system, courtesy of Hawaiʻi Energy Connection. All of the families who participated last year saved almost $100,000.

Teacher's Energy Resource Center - http://www.heco.com/portal/site/heco/menuitem.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=7600bcb8b9109310VgnVCM10000005041aacRCRD&vgnextfmt=default.

Hawaiʻi Student Energy Ambassador Development - The mission of the Hawaiʻi Student Energy Ambassador Development Program is to empower students to create a bright energy future for Hawaiʻi through sustainability education and energy audit training http://www.Hawaiʻisead.org/about/.

U.S. Green Building Council Hawaiʻi Chapter's Green Schools Committee - The committee's goal is to develop and support green school champions by creating a resource clearinghouse in support of Hawaiʻi Green Schools, collaborating and partnering with organizations that promote and advocate for green schools, and reaching out to the public on the benefits of Green Schools http://www.usgbcHawaiʻi.org/index.php?page=green-schools.

2.3.1.2.2 Permitting and Consultation Requirements

Energy conservation measures are not typically subject to permitting and consultation requirements. However, the appropriate county and State agencies should be consulted prior to commencement of work to ensure all installations are done properly and as required by law.

2.3.1.2.3 Representative Project

Because of the speculative nature of this activity and that adverse environmental impacts would be unlikely, this PEIS is not analyzing associated impacts (that is, Chapter 4 will not include an impacts analysis for energy conservation). However, the following examples and tips are provided to characterize the types of environmental consequences that could occur as a result of conservation and efficiency activities.

Typically, lighting accounts for about 11 percent of a home's and 38 percent of a business's total electric bill. If the total watts of light used in the home or business were reduced by 50 percent by either reducing the wattage of the bulbs used, reducing the amount of time the lights were turned on, or replacing the types of bulbs used with more efficient types of bulbs, the total energy reduction would be about 5.5 and 19 percent, respectively (NEED 2012a).

Other similar examples include the following:

- Walking, riding a bicycle, or driving a more efficient vehicle to work or for other travel needs;
- Raising the thermostat setting for the air conditioner;
- Installing a more energy-efficient cooling system in a home; and
- Buying a smaller or more energy-efficient refrigerator for a home or office.

As another reference point, buying a larger home, appliance, or other item that is more energy efficient might not result in a reduction in energy use if the increased efficiency is offset by the larger size.

2.3.1.3 Ground Source Heat Pumps

Underground temperatures are more stable than air temperatures, with temperatures 10 feet below the ground holding nearly constant between 50° and 60°F regardless of seasonal temperature extremes. A ground source heat pump, also known as a geothermal heat pump or geoexchange, is an electrical-powered heating and cooling system that takes advantage of the relatively constant ground or groundwater temperature to transfer energy for space heating/cooling and water heating. Ground source heat pumps provide heating, cooling, and domestic hot water for homes, schools, and government and commercial buildings.

There are many benefits to installing a ground source heat pump. They can be installed in homes and buildings of any size. They can be installed under lawns, landscaped areas, driveways, or the structure itself. Ground source heat pumps are energy efficient; they use 25 to 50 percent less electricity than conventional heating or cooling systems and up to 72 percent less compared with electric resistance heating with standard air-conditioning equipment (DOE 2012b). Compared to conventional heating and cooling systems, ground source heat pumps cost more initially but provide long-term cost savings. Ground source heat pumps can be used to preheat water tanks, thereby reducing water-heating costs. Installing a ground source heat pump in a residence or building can be particularly cost-effective for newly constructed homes or building or if replacing an existing heating and cooling system. Ground source heat pumps maintain about 50 percent relative indoor humidity, and are more efficient and use less electricity than conventional heat pumps. Relative to air source heat pumps, ground source heat pumps are quieter, last longer, need less maintenance, and do not depend on the variable temperature of outside air.

Barriers to using ground source heat pumps include the costs and difficulty of evaluating the suitability of individual installation sites, the need for installation-specific design and engineering of the ground loop, and space requirements for ground coupling in densely built areas (Navigant 2009). Technical knowledge and equipment expertise is necessary to properly design and size a ground source heat pump system. Although ground source heat pumps offer long-term energy cost savings, they initially cost more than conventional heating and cooling systems.

2.3.1.3.1 Technology Description

Ground source heat pumps use the earth as a heat source and transfer heat from the ground source to a building when in the heating mode (typically in the winter). In the cooling mode, ground source heat pumps use the earth as a heat sink and heat is transferred from a building to the ground source (typically in the summer). Figure 2-2 illustrates this heat exchange process. Some systems are designed to operate in one mode only (that is, heating or cooling). Space-heating typically is not used in Hawai‘i; whereas, space-cooling is widely used in commercial and government buildings and in residences, albeit less often. Hence, the single-mode operation is the only one likely to be used in Hawai‘i.

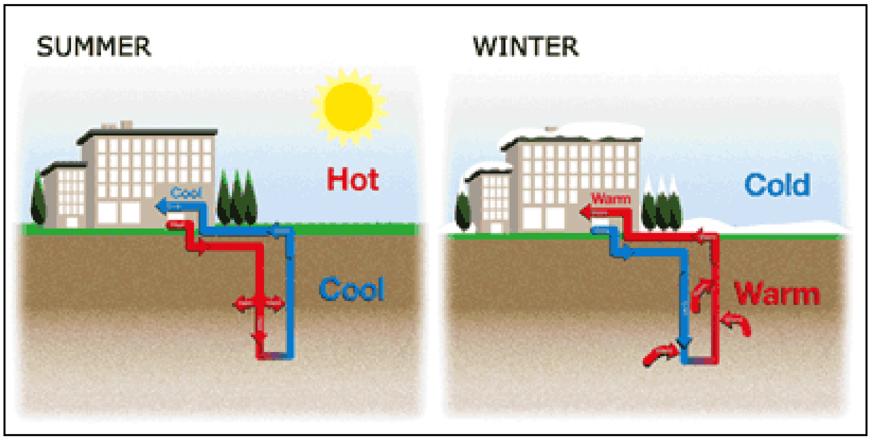


Figure 2-2. Ground Source Heat Pump Heat Exchange (Source: EnergyBible.com 2013)

Since first developed in the 1940s, the ground source heat pump technology’s efficiency has considerably improved. Ground source heat pumps are one of the fastest growing applications of renewable energy in the world, with an annual growth rate in the United States of 12 percent between 1999 and 2009 (Lund et al. 2009). The regions of the U.S. that have the largest implementation of ground source heat pumps are the Midwest and South. Ground source heat pump system warranties, similar to conventional heating and cooling system, are usually offered. Most ground source heat pumps can be added to existing home insurance policies (DOE 2012b).

Components

Ground source heat pumps consist of three main components: an earth connection loop; a heat pump; and the heating, ventilation, and air conditioning distribution system. The components are maintained through routine inspections and cleaning. Ground source heat pumps are expected to last about 25 years for the indoor components and more than 50 years for the earth connection loop (DOE 2012c). Hybrid systems combine ground source heat pump technology with geothermal, solar, or air source technologies.

Earth Connection Loop

The earth connection loop is a series of connected pipes buried in the ground that circulate a fluid (water or a mixture of water and antifreeze) that absorbs heat from, or relinquishes heat to, the surrounding soil, depending on whether the ambient air is colder or warmer than the soil (DOE 2013b). The loop is buried either vertically or horizontally in the ground near the building to receive the air conditioning/heat. Vertical systems are the most common because they have the smallest area of disturbance.

There are four types of earth connection loops (see Figure 2-3). Earth connection loops can be either closed-loop or open-loop. Closed-loop configurations typically circulate heat exchange fluid, usually water or a water-antifreeze solution, through a closed loop of pipes buried underground or submerged in a body of water. As shown in the figure, the closed-loop system can be horizontal or vertical in the ground or in a nearby body of water. Open-loop systems use ground or surface water as the heat exchange fluid that circulates directly through the system and then returns to the ground through a well or surface discharge (DOE 2012c). All types work for residential and commercial buildings; the type selected is based on site-specific climate, soil conditions, available land, and installation costs.

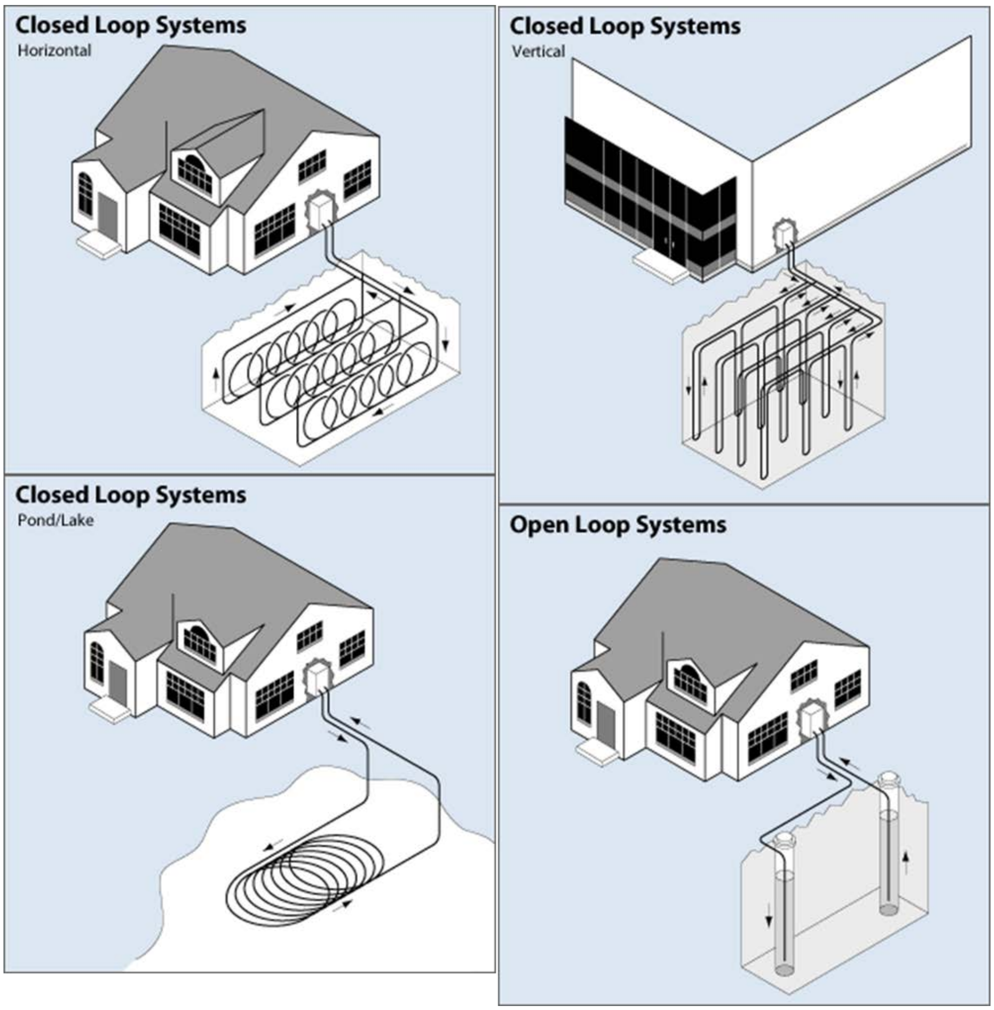


Figure 2-3. Types of Earth Connection Loops (Source: DOE 2012c)

Heat Pump

A heat pump removes heat from a fluid and transfers it to a building for heating; the process is reversed for cooling. The heat pump operates in a similar fashion as a refrigerator or air conditioning unit. A heat exchanger transfers heat between the refrigerant in the heat pump and the fluid in the earth connection loop. Alternatively, a direct exchange system can pump the refrigerant through copper tubing buried in a horizontal or vertical configuration instead of using a heat exchanger, which is better in areas with moist soils that are not corrosive to copper tubing. Most residences can sufficiently us a heat pump as small as a typical washing machine (IGSHPA 2010). Heat pumps require a small amount of electricity to run the heat pump compressor; however, the energy output is 4 times the input (Lund et al. 2009).

Heating, Ventilation, and Air Conditioning Distribution System

The heating, ventilation, and air conditioning distribution system uses conventional ductwork to distribute the heated or cooled air throughout a building. An air handler contains the indoor coil and fan and moves the building air through the heat pump for heating or cooling, and contains a blower and a filter exactly like conventional air conditioners. Heating, ventilation, and air conditioning distribution systems can be used in existing houses by retrofitting the existing ductwork. No external venting is required (hybrid systems excluded) and there is no associated noise.

2.3.1.3.2 Characterization of Technology Feasibility and Deployment

Ground source heat pumps have not been used in Hawai‘i, likely because of Hawai‘i’s moderate climate. The benefits of ground source heat pumps may not be as substantial as they would be in areas where climate variation is more extreme (HREDV 2009a). However, there is no technical reason that ground source heat pumps could not be used in the future. Hybrid systems, where PVs provide power for ground source heat pump operation, have deployment potential in Hawai‘i. Regardless of hybrid or standard, the high upfront costs likely would prohibit wide-scale use of ground source heat pumps in Hawai‘i by 2030.

2.3.1.3.3 Permitting and Consultation Requirements

Permitting and consultation requirements for ground source heat pumps in Hawai‘i are likely to be more general in nature (see Section 2.2.5).

Ground source heat pump installations require the services of a trained professional. Installation of ground source heat pumps also run the risk of damaging or otherwise interfering with existing subsurface utility infrastructure. All projects must use the area HOCC (see Section 2.2.5).

2.3.1.3.4 Representative Project

Ground source heat pumps currently are not deployed in Hawai‘i and unlikely to be in any notable amount by 2030; therefore, this PEIS does not present a representative project against which to evaluate impacts for this technology.

2.3.1.4 Initiatives and Programs

Utility- and government-sponsored clean energy initiatives and programs can help to make renewable energy, efficiency, and conservation practices attractive to communities. The State of Hawai‘i’s energy efficiency and renewable energy objectives are intended to reduce Hawai‘i’s high reliance on imported fossil (primarily petroleum) fuels.

There are several ways to provide incentives to individuals, businesses, and communities that will result in a reduced overall demand for imported fossil fuels, ranging from education and training to financial incentives for using energy efficient appliances and equipment at home and in commercial operations. Examples include energy savings compensation from street-lighting retrofits and underwriting the cost of compact fluorescent bulbs or providing interest subsidies for the purchase of highly efficient, but more expensive, household appliances (e.g., energy efficient refrigerators) and equipment for industry. The State of Hawai‘i, island utilities, counties, and the Federal Government have employed several energy efficiency and renewable energy (i.e., clean energy) initiatives and programs for specific State-, island-, and community-level projects.

A combination of Federal, State, and county (including utility) initiatives and programs can influence the use of energy efficiency and renewable energy technologies in general, or of certain technologies in particular.

2.3.1.4.1 Activity Description

There are many clean energy initiatives and programs throughout the United States. The DOE and North Carolina State University maintain the Database of State Incentives for Renewables and Efficiency found online at http://www.dsireusa.org/. The database is a comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States.[10] A large majority of this section summarizes information from the database and associated websites, references, and other related information sources.

2.3.1.4.2 Characterization of Activity Implementation and Deployment

Financial Incentives

Federal financial incentives and implementing policies and regulations are applicable and available to all residents of the United States, and provide a component for achieving renewable energy and energy efficiency goals in Hawaiʻi. This PEIS focuses on State renewable energy programs and initiatives and, therefore, discusses only those programs sponsored by the State of Hawaiʻi and counties therein. Financial incentives administered by the State of Hawaiʻi and local jurisdictions are varied and can be grouped in the following incentive categories: taxes, loans, rebates, green building, and performance-based.

Tax Incentives

State corporate tax incentives include tax credits, deductions, and exemptions. These incentives are available in Hawaiʻi to corporations that purchase and install eligible renewable energy or energy efficiency equipment, or construct green buildings. In a few cases, the incentive is based on the amount of energy produced by an eligible facility. Tax credit may only be allowed for a corporation that has invested a minimum amount in an eligible project. Typically, there is a maximum limit on the dollar amount of the credit or deduction. There is a corporate solar and wind energy credit available in Hawaiʻi.

Personal tax incentives include income tax credits, deductions, and exemptions. The percentage of the credit or deduction varies by state, and in most cases, there is a maximum limit on the dollar amount of the credit or deduction. The same solar and wind energy credit that is available to the corporate sector is available to the personal and residential sector.

Property tax incentives include exemptions, exclusions, abatements and credits. Most property tax incentives provide that the added value of a renewable energy system be excluded from the valuation of the property for taxation purposes. There is one property tax exemption program in the State of Hawaiʻi that is applicable to corporate and residential sectors and consists of a real property tax exemption for a period of 25 years for alternative energy improvements associated with a variety of renewable energy technologies (excluding geothermal) that are installed in the City and County of Honolulu.

[10] The North Carolina Solar Center at the North Carolina State University operates the Database of State Incentives for Renewable and Efficiency with support from the Interstate Renewable Energy Council, Inc. DOE provides partial funding. The Database of State Incentives for Renewables and Efficiency does not include incentives and policies that promote alternative transportation fuels and vehicles.

Loan Incentives
Loan incentives provide financing for the purchase of renewable energy or energy efficiency systems or equipment. Low-interest or zero-interest loans for energy efficiency projects are a common demand-side management practice for electric utilities. At the Hawai‘i State level, loans are available for farm and aquaculture alternative energy applications and other eligible efficiency and renewable technologies. From a local standpoint, the City and County of Honolulu and Maui County offer solar loan programs to eligible residents. On the island of Kaua‘i, KIUC administers a solar water heating loan program.

Enabling legislation for an innovative financing program passed the 2013 Hawai‘i State Legislature and is expected to be implemented in 2014, once enacted into law. This program aims to bring together a more traditionally industrial financing mechanism to issue low-interest bonds to acquire a pool of low-cost money to fund a clean energy financing program such as on-bill financing. While each specifically designed loan program will have to file a Green Infrastructure Program Order with the Hawai‘i PUC for approved use of funds, the legislation enables the use of funds for clean energy technology, demand response technology, and energy use reduction and demand side management infrastructure, programs, and services. Electric utility customers will be able to finance these approved installations and the repayment obligation will be tied to the meter and repaid via the participating customers’ electric bills.

The GreenSun Hawai‘i program works with various lenders throughout Hawai‘i to offer financing for renewable energy and energy efficiency upgrades. Through the program, and using Federal funds (via the *American Recovery and Reinvestment Act of 2009*; ARRA), homeowners may be eligible to finance ENERGY STAR refrigerators and air conditioners, solar water heating systems or heat pumps, insulation installed with an ENERGY STAR air conditioner, and PV (solar module) systems. Multi-family residential/commercial property owners may be eligible to finance lighting retrofits or upgrades, air conditioning, solar water heating systems, solar PV systems, and windows. An energy assessment is required for multi-family residential/commercial property owners.

Green Energy Market Securitization (GEMS) is a financing model designed to make clean energy improvements, such as PV systems, affordable and accessible to underserved community members, including low- and moderate-income homeowners, renters, and nonprofit organizations. GEMS will take a proven rate-reduction bond structure and use it to provide low-cost financing to utility customers. Payment for the devices would be made over time through the customer’s electric utility bill and paid for with energy savings. As of early 2014, the GEMS program, which will be facilitated by DBEDT, was awaiting approval from the PUC. For more information, see http://energy.hawaii.gov/testbeds-initiatives/gems.

Rebate Incentives
Rebate programs for the islands of Hawai‘i, Lāna‘i, Maui, Moloka‘i and O‘ahu are administered by Hawai‘i Energy, which is a ratepayer-funded conservation and efficiency program under contract with the Hawai‘i PUC. Utilizing electricity ratepayer funds, Hawai‘i Energy offers cash rebates and other incentives to residents and businesses to help offset the cost of installing energy efficient equipment. In addition to rebates, the program conducts education and training to residents, businesses, and contractors to encourage the adoption of energy conservation behaviors and efficiency measures (Hawai‘i Energy 2013). Hawai‘i Energy offers rebates for three programs: (1) commercial energy efficiency, (2) residential energy efficiency, and (3) solar water heating. As part of the commercial energy efficiency incentive, Hawai‘i Energy offers a Whole Building Assistance program that includes energy audits, energy study assistance, energy study project implementation, and design assistance.

KIUC offers two rebates for the island of Kaua‘i: the Energy Wise Commercial Energy Efficiency program and the Solar Water Heating program.

Green Building Incentives

Green buildings are designed and constructed using practices and materials that minimize the impacts of the building on the environment and human health. Several organizations issue certification for green buildings, including the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED certifications) program, the Green Building Initiative (Green Globes certification), and the National Association of Home Builders Research Center (National Green Building Certification). HRS 46-19.6 requires each county agency in Hawai'i that issues building, construction, or development-related permits to establish a procedure to give priority to permit applications for construction projects that incorporate green building designs.

Many cities and counties offer financial incentives to promote green building. The most common form of incentive is a reduction or waiver of a building permit fee. This had been in place in Honolulu until the PV installation permits grew to over 25 percent of total construction activity, and the lack of fees interfered with the permitting agency's ability to hire the staff necessary to process the permits in a timely manner (Honolulu 2013).

Performance-Based Incentives

Performance-based incentives, also known as production incentives, provide cash payments based on the number of kilowatt-hours or British thermal units a renewable energy system generates. A *feed-in tariff* is an example of a performance-based incentive. To ensure project quality, payments based on a system's actual performance are generally more effective than payments based on a system's rated capacity. In September 2009, the Hawai'i PUC issued a decision that established a feed-in tariff in Hawai'i. The feed-in tariff is offered by the three investor-owned utilities providing service on O'ahu, Maui, Moloka'i, Lāna'i, and Hawai'i. The rates for the feed-in tariff, schedule, and standard interconnection agreements were approved on October 13, 2010 (Hawai'i PUC 2010). Several renewable energy technologies are eligible for the feed-in tariff, including PV, concentrating solar power, land-based wind, and in-line hydropower (Hawai'i PUC 2009).

A State facility incentive with a performance-based requirement is provided for ethanol production facilities. In accordance with HRS 235-110.3, in order to receive the income tax credit/payment, the facility must produce at least 75 percent of its *nameplate* capacity.

Rules, Regulations, and Policies

In addition to financial incentives, several rules, regulations, and policies in Hawai'i further enhance the State's ability to achieve renewable energy and energy efficiency goals.

Building Energy Codes

Building energy codes adopted by states (and some local governments) require commercial and/or residential construction to adhere to certain energy standards. While some government entities have developed their own building energy codes, many use existing codes (sometimes with State-specific amendments), such as the International Energy Conservation Code. A few local building energy codes in Hawai'i require certain commercial facilities to meet green building standards. The State has adopted its Hawai'i Model Energy Code, and in February 2012, the Hawai'i State Building Code Council approved Hawai'i's adoption of the 2009 International Energy Conservation Code. The counties of Hawai'i are free to modify the Statewide code, as long as the codes they adopt are at least as stringent. Hawai'i County adopted the 2006 version of the International Code in October 2010, Maui County adopted the 2006 Code in October 2009, Honolulu County adopted the 2006 Code in November 2009, and Kaua'i County adopted the 2009 Code in May 2010. The 2009 Code gives options for roof insulation including cool roofs, advanced ventilation, and low-emitting roofs by testing or specification.

A second building energy code program consists of legislation enacted in June 2008 (HRS 196-6.5) with the intent to require solar water heating systems to be installed on all single-family new home construction, with a few exceptions. Section 2.3.1.2 of this PEIS presents a more detailed discussion of energy efficient new building construction and building retrofits.

Energy-Efficiency Portfolio Standards

Hawai‘i’s Energy Efficiency Portfolio Standard sets a goal of reducing electricity use by 4,300 gigawatt-hours by 2030 through the use of energy efficiency and renewable displacement and offset technologies.

Energy efficiency resource standards are State of Hawai‘i policies that require utilities to meet specific targets for energy savings according to a set schedule. These standards set policies that establish separate reduction targets for electricity sales, peak electric demand and/or natural gas consumption. In most cases, utilities must achieve energy savings by developing demand-side management programs, which typically provide financial incentives to customers to install energy efficient equipment. An energy efficiency resource standard policy is sometimes coupled with a state’s renewables portfolio standard. In these cases, energy efficiency typically is included as a lower-tier resource.

Energy Standards for Public Buildings

Many states and local governments, as well as the Federal Government, have chosen to lead by example by requiring new government buildings to meet strict energy standards. In May 2006, the State of Hawai‘i established a standard that requires renewable energy, energy efficiency, and alternative fuels in State facilities and operations. Enacted in June 2009, H.B. 1464 addressed energy efficiency requirements for existing public buildings. By the end of 2010, State agencies had to evaluate the energy efficiency of all existing public buildings larger than 5,000 square feet or that use more than 8,000 kilowatt-hours annually. Agencies must identify opportunities for increased energy efficiency by setting benchmarks for these buildings using Energy Star Portfolio Management or another similar tool. Buildings must be *retro-commissioned* every five years.

The Database of State Incentives for Renewables and Efficiency includes green building standards, energy-reduction goals, equipment-procurement requirements, and the use of onsite renewable energy in other locations. Many of these policies require that new government buildings (and renovated buildings, in some cases) attain a certain level of certification under the LEED program. Equipment procurement policies often mandate the use of the most efficient equipment, including equipment that meets ENERGY STAR criteria. Policies designed to encourage the use of onsite renewables generally establish conditional requirements tied to life-cycle cost analyses.

Interconnection Standards

Interconnection standards specify the technical and procedural process by which a customer connects an electricity-generating system to the electrical grid. Such standards include the technical and contractual terms by which system owners and utilities must abide. State PUCs typically establish standards for interconnection to the local distribution grid, while the Federal Energy Regulatory Commission has adopted standards for interconnection to the more-encompassing transmission grid. While many states have adopted interconnection standards, some state standards apply only to investor-owned utilities (i.e., not to municipal utilities or electricity cooperatives). Hawai‘i has established simplified interconnection rules for small renewables and separate rules for all other distributed generation. In May 2010, a Hawai‘i PUC decision and order created a standard three-party interconnection agreement.

The State’s largest electric utility, HECO, which owns Hawai‘i Electric Light Company (HELCO) and Maui Electric Company (MECO), uses a set of simple interconnection guidelines (HECO 2013a). The State’s only other utility, KIUC, has a similar set of rules for interconnection. The HECO companies are taking a proactive approach to implementing interconnection of customer-sited electricity generation. The current interconnection tariff (Rule 14H) screens for two penetration-based potential impacts: 15 percent of peak circuit load and 75 percent of minimum daytime circuit load for PVs; exceeding these conditions triggers an interconnection requirements study. Although such a requirement does not necessarily mean a project will not go forward, it can act as a significant barrier and process bottleneck, since the system proposer must pay for the interconnection requirements study, it could take months to complete, and once reviewed, may not even result in approval of the proposed interconnection. The HECO's proactive approach is intended to more precisely identify and target system constraints through more accurate understanding of specific conditions on measured and observed conditions on the specific feeder system, rather than the use of proxy figures (i.e., "15 percent peak" or "75 percent minimum daytime"); allow project developers to check online for current feeder capability to accept the system's output; enable better understanding of the need and scope of any interconnection requirements study; and direct utility actions to foresee potential circuit and system issues through comprehensive analysis, data, modeling, and mitigation (IREC 2013).

Net Metering

For electricity customers who generate their own electricity, net metering allows for the flow of electricity both to and from the customer—typically through a single, bi-directional meter. When a customer's generation exceeds the customer's use, electricity from the customer flows to the grid, offsetting electricity consumed by the customer at a different time during the same billing cycle. In Hawai‘i, net metering is available on a first-come, first-served basis to residential and small commercial customers (including government entities) that generate electricity using solar, wind, biomass or hydroelectric systems. Third-party owned and operated systems (leased systems and systems with a third-party power purchase agreement) can participate in net metering. Hawai‘i's three investor-owned utilities (HECO, HELCO, and MECO) and sole electric cooperative (KIUC) have slightly different programs but achieve similar results.

Public Benefits Fund

Most public benefits funds were developed by states during the electric utility restructuring era (the late 1990s) to ensure continued support for renewable energy, energy efficiency and low-income energy programs. These funds are commonly supported through a very small surcharge on electricity consumption (e.g., less than $0.01 per kilowatt-hour). This charge is sometimes referred to as a "system benefits charge." Public benefits funds commonly support rebate programs, loan programs, research and development, and energy education programs. In June 2006, the Hawai‘i State Legislature enacted legislation to create a public benefits fund for energy efficiency and demand-side management. This legislation granted authority to the Hawai‘i PUC to develop the details of the third-party administered public benefits fund. In July 2009, Hawai‘i Energy was created, and administration of the public benefits funds programs transitioned from the utilities to Hawai‘i Energy, a third-party administrator. The public benefits fund is available through Hawai‘i Energy for energy efficiency programs and technologies on the islands of Hawai‘i, Maui, Moloka‘i, Lāna‘i, and O‘ahu.

Renewable Portfolio Standards

Hawai‘i's Renewable Portfolio Standard law (HRS 269-91 *et seq*.) requires each electric utility company that sells electricity for consumption in Hawai‘i to establish the following percentages of renewable electrical energy sales:

- 10 percent by the end of calendar year 2010 (standard achieved);
- 15 percent by the end of 2015;
- 25 percent by the end of 2020; and
- 40 percent by the end of 2030.

Generation from existing renewable energy facilities may be counted in the total. In addition, an electric utility company and its electric utility affiliates may aggregate their renewable portfolios in order to achieve the Hawaiʻi Renewable Portfolio Standard (i.e., HECO and affiliated utilities may add together their renewable energy numbers to meet the goal). Before December 31, 2015, energy efficiency and renewable energy displacement can be counted toward meeting the Portfolio Standards. Beginning in 2016, only renewable generation (including customer-sited PVs) will count toward the meeting the Standards; efficiency (including domestic solar water heating and sea water air conditioning) will count toward the Energy Efficiency Portfolio Standard.

According to the Hawaiʻi Renewable Portfolio Standard law, "renewable energy" is energy from:

- Sun (i.e., solar);
- Wind;
- Falling water (i.e., hydropower);
- Bioenergy, including biomass (e.g. crops, agricultural and animal residues, municipal and other solid waste), biofuels, and biogas;
- Geothermal;
- Ocean water, including ocean thermal energy conversion and wave energy; and
- Hydrogen produced from renewable energy sources

Most states have established a renewable portfolio standard law. Some laws in other states require utilities to use or procure renewable energy or renewable energy credits to account for a certain percentage of their retail electricity sales—or a certain amount of generating capacity—according to a specified schedule. The term *set-aside*, or *carve-out*, in this context refers to a provision within a renewable portfolio standard that requires utilities to use a specific renewable resource (usually solar energy) to account for a certain percentage of their retail electricity sales (or a certain amount of generating capacity) according to a set schedule. Hawaiʻi's Renewable Portfolio Standard does not have credits or carve-outs.

Solar and Wind Access Policy

Solar and wind access policies are designed to establish a right to install and operate a solar or wind energy system at a home or other facility. HRS 196-7 prohibits the creation of any covenant or restriction contained in any document restricting the installation or use of a solar energy system on a residential dwelling or townhouse. Furthermore, Hawaiʻi requires homeowners associations to adopt rules that provide for the placement of solar energy systems and do not unreasonably restrict the placement.

Some solar access laws also ensure a system's access to sunlight. In some states, access rights prohibit homeowners associations, neighborhood covenants, and local ordinances from restricting a homeowner's right to use solar energy. At the local level, communities use several policies to protect solar access, including solar access ordinances, development guidelines requiring proper street orientation, zoning ordinances that contain building height restrictions, and solar permits.

Solar and Wind Contractor Licensing

Some states have established a licensing process for solar energy and/or wind energy contractors. These requirements are designed to ensure that contractors have the necessary knowledge and experience to install systems properly. Solar licenses typically take the form of either a separate, specialized solar contractor's license, or a specialty classification under a general electrical or plumbing license. Hawaiʻi offers several specialty licenses for solar contractors through Hawaiʻi's Department of Commerce and Consumer Affairs; Hawaiʻi does not require specialty licenses for wind power contractors at present.

2.3.1.4.3 Permitting and Consultation Requirements

The financial incentives and rules, regulations, and policies in the State of Hawaiʻi associated with renewable energy and energy efficiency do not require typical environmental permits or consultations (see Section 2.2.5). They do, however, require research and understanding of the requirements for the application and approval process for initiatives and programs. The DOE Database of State Incentives for Renewables and Efficiency provides links to specific websites and other documents that outline additional detail, eligibility criteria, requirements, and forms for participating in each program (see http://www.dsireusa.org).

2.3.1.4.4 Representative Project

The Initiatives and Programs discussion presents government- and utility-sponsored efforts to provide incentives to individuals, communities, municipalities, and businesses to make it easier or financially beneficial to support renewable energy technologies and energy conservation and efficiency in Hawaiʻi. As such, the incentives presented are not typically viewed as technologies or programs that could have the potential to cause adverse impacts to an environmental resource, and therefore, this PEIS does not present a representative project against which to evaluate impacts for this activity. The information is provided to the reader for general knowledge and a more complete understanding of the available incentives.

2.3.1.5 Sea Water Air Conditioning

2.3.1.5.1 Technology Description

District cooling systems provide cooling from a centralized location to a large number of end users—typically a group of buildings. In district systems, the heating or cooling can come from any source, such as coal- or gas-generated electricity, combined heat and power, nuclear power, or renewable energy sources. Sea water air conditioning, or deep water cooling, uses the temperature gradients between deep and surface water to chill water for individual buildings or district cooling air conditioning systems. This energy efficiency technology replaces the conventional electric chiller component of a cooling system with a significantly less energy-intensive deep, cold sea water cooling station or heat exchanger to cool a closed-loop air conditioning system (State of Hawaiʻi 2002, Konan 2012a). The heat exchanger transfers heat from the closed-loop fresh water to the cold sea water. Pumps circulate the warmed sea water (effluent) back into the ocean at higher depths than where retrieved to ensure the effluent is introduced into an environment of similar temperature to minimize impacts. Sea water and fresh water never mix because of the closed-loop system. The newly chilled water in the closed-loop air conditioning system cools the facility in the same manner as a standard district cooling system, whereby the chilled water is distributed via insulated pipes to the various buildings connected to the chilling station (Figure 2-4). Sea water used for this process is generally below 45ºF, and found at depths that vary based on location. It does not require any working fluids other than sea and fresh water, as opposed to conventional cooling which may employ refrigerants. To maximize economic benefits, sea water air conditioning systems generally operate at a "district" level, with one system cooling a specified geographical district or grouping of buildings. Depending on the availability of cold water, and the length of the intake pipe, sea water air conditioning can meet or exceed the cooling capacity of a standard district cooling system. Sea water air conditioning systems could replace an existing conventional district cooling system used to supply electrically chilled air to a population center or facilities that require significant cooling requirements. Alternatively, a sea water air conditioning system can be developed for end-users with no existing conventional district cooling or centralize cooling systems in place.

From an operations and maintenance perspective, the intake pipes can be designed for maintenance "recovery" thus eliminating the need for deep-water diving for repairs (Makai 2013). Comparing operations and maintenance costs, a study conducted by the State University of New York found that chilled deep water facilities are comparatively less expensive to operate and maintain than conventional electric chiller systems (State of New York 2011).

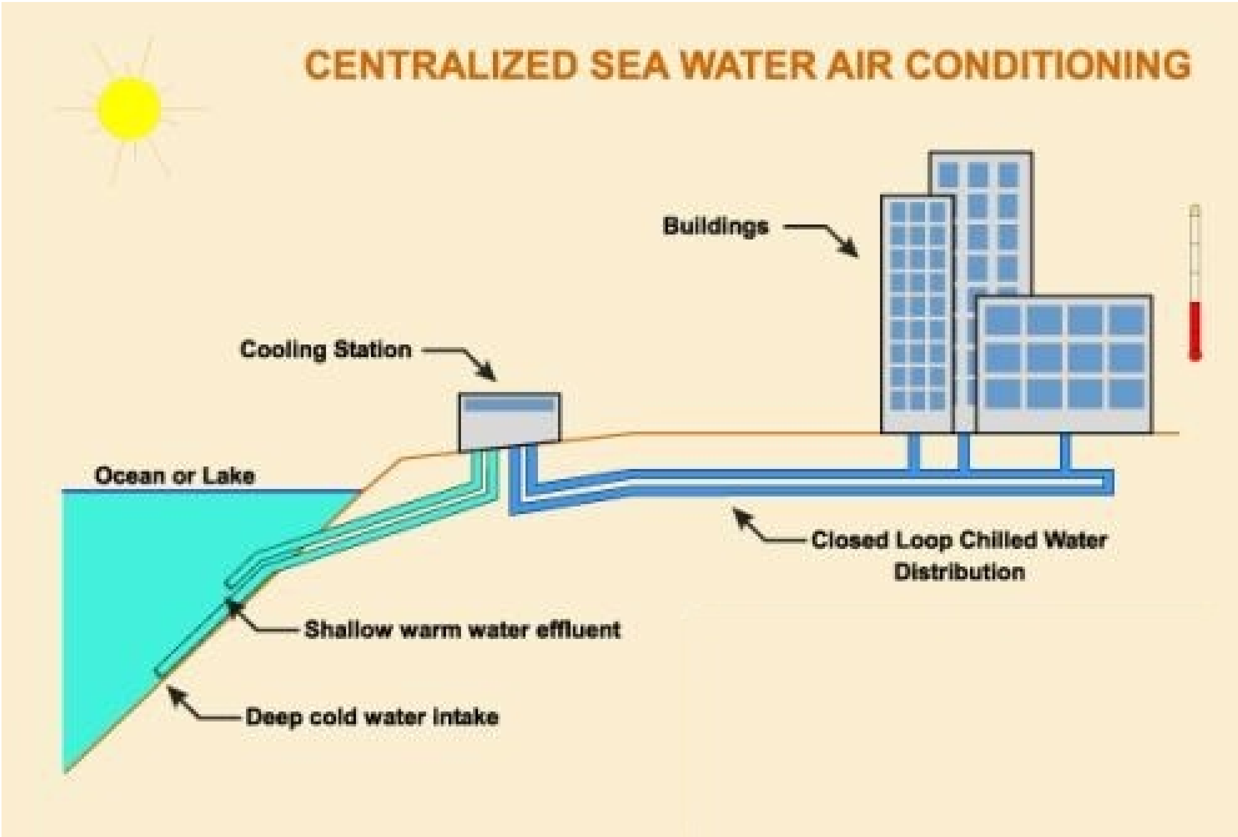


Figure 2-4. Illustration of a Deep Water Cooling Facility (Source: Makai 2013)

2.3.1.5.2 Characterization of Technology Feasibility and Deployment

The potential economic benefit of energy efficient sea water air conditioning is directly related to two main factors: access to deep sea water and the distance the cold sea water must be pumped from the ocean to the cooling station. In general, the deeper the intake pipe depth, the higher the initial costs (due to installation materials); the shallower the intake pipe, the higher the eventual operating cost (due to warmer water). Owing to their volcanic geology, the Hawaiian Islands generally present an ideal environment for easily accessible, cold, deep sea water. As is standard in district cooling systems, local water resources, or treated waste/grey water can supply the fresh water used in the closed-loop system, which carries the heat from buildings and transfers it to the sea water through the heat exchanger. Because it is a closed loop, the utility does not need to continuously supply the fresh water.

Industry sources indicate that financially feasible sea water air conditioning operations require ocean temperatures between 40° and 68°F (Makai 2013; Konan 2012a). In the Hawaiian Islands, the Pacific Ocean averages 46°F at a depth of 1,650 feet (NREL 2013b). Water at 46°F can be found at depths ranging from 330 to 1,315 feet off the northwestern shore of Hawaiʻi island. Similarly, offshore waters near Maui, Lānaʻi, Molokaʻi, and Oʻahu are at a depth and temperature to facilitate a sea water air conditioning operation. With such abundant thermal resources available, deployment of such an operation in Hawai‘i is feasible. The basic considerations would be the distance of the cooling facility (heat exchanger) from the shore and the required cooling capacity (size of district).

The cost of sea water air conditioning is typically cheaper than conventional cooling systems because it replaces electricity costs associated with conventional chillers (Makai 2013; Hawai‘i 2002). Previous case studies on O‘ahu have shown that a district sea water air conditioning system can save more than 75 percent (77.5 million kwh/year) of the yearly energy cost of operating a conventional cooling system (Konan 2012a, State of Hawai‘i 2002). Honolulu Seawater Air Conditioning, LLC expects to have an operational 25,000-ton seawater cooling facility online by 2014 (Honoluluswac 2013). In Hawai‘i's warm climate, this capacity can provide cooling for about 10 million cubic feet, sufficient for a number of high rise buildings, office spaces, and other commercial air conditioning applications.

On Hawai‘i island, temperature conditions in Kona require roughly 12,000 British thermal units per hour (3.5 kilowatts) to cool an average hotel room (Josey 2008); most of the island's resorts are on the Kona and Kohala coasts. While Hilo, on the opposite side of the island, is the second largest city in the State, its population is only 20 percent of Honolulu's, with considerably fewer large buildings that would benefit from such a system (Grant 2012). Smaller-scale systems could be designed for more localized cooling needs, such as the small-scale system the Natural Energy Laboratory of Hawai‘i Authority (NELHA) deployed in 1986, which supplements the Authority's use of deep water for other research interests including agriculture and irrigation (Makai 2013). Additionally, the Kahala Resort on O‘ahu makes use of a small sea water air conditioning system saving 380,000 kilowatt-hours and 4.5 million gallons of water annually (Konan 2012a).

The use of sea water air conditioning systems replaces the need for conventional chillers that use refrigerants that have chemicals known to damage the ozone layer (Cornell University 2013). In addition, using a renewable energy source, such as wind or offshore wave energy, to power a sea water air conditioning system's pumps can reduce the system's energy consumption to effectively zero. As such, this technology has the potential to address many of HCEI's energy-savings goals. Furthermore, these systems can be designed to last up to 100 years (Cornell University 2013).

Despite the benefits of sea water air conditioning, one potential issue is a lack of information on how ocean microbes would respond to the return of nutrient-dense deep water at, or closer to, the surface of the ocean (Konan 2012b). Based on the findings of preliminary field experiments conducted by the Center for Microbial Oceanography Research and Education (C-MORE), the deeper and more diffuse the effluent the better. However, placing the outflow pipe beneath the euphotic zone (the depth that receives enough sunlight for photosynthesis to occur) increases the cost of a sea water air conditioning system.

The immediate feasibility of sea water air conditioning technology can be facilitated by the presence of chilled-water air conditioning systems in commercial buildings, which typically produce their own chilled water through onsite electric chillers (Honoluluswac 2013). A building or complex can easily connect to a planned or existing district system by removing its chillers and retrofitting its existing cooling system (i.e., closed-loop system) to connect to the district cooling system. By connecting to an existing cooling system, the building or complex would avoid the capital investment of installing a new cooling system by tapping into the sea water system. However, if no existing system is in place, building developers would have the flexibility of installing a bigger (or smaller) cooling system depending on their current and future needs, considering future development in the area that could tap into the same cooling system.

The Honolulu Seawater Air Conditioning project represents what may be possible on other islands at a similar scale. Several feasibility and environmental impact studies have been done on the site. The *Honolulu Seawater Air Conditioning Final Environmental Impact Statement* included an analysis of four components of the project's operation and installation (Hawai‘i 2009):

- Seawater intake and return pipes would be deployed offshore of Honolulu,
- A cooling station would be built on a site in Kakaako,
- Freshwater distribution pipes would be installed beneath streets in the downtown area, and
- A shoreline site in Keehi Lagoon would be used for staging and pipeline assembly.

Other locations could use this project as a model for a similar system, but would only be economically feasible in locations with larger building cooling needs (Konan 2012a). Densely populated areas with many district cooling subscribers, particularly commercial buildings such as hotels and large apartment residences, are desirable in order to mitigate startup costs. While the system operation would be similar, the physical aspects would be different; primarily, the depths at which seawater is at optimal temperature would determine the depth of the intake and discharge components. However, as was noted above (Section 2.3.1.5.1), water temperatures around the Hawaiian Islands do not vary widely.

For a direct comparison, readers are directed to a study prepared about a sea water air conditioning project in Waikiki that potentially would employ similar parameters as the Honolulu Project (Lilley 2012). This study also gauged public opinion on use of the technology in O‘ahu, showing that 62 percent of the island’s residents support its use.

2.3.1.5.3 Permitting and Consultation Requirements

In addition to general permitting and regulatory requirements described in Section 2.2.5, technology-specific requirements for installing a sea water air conditioning system (land-based with off-shore piping) would include complying with environmental regulations involving water quality and marine habitats. These facilities generate large volumes of effluent (in other words, heated water) and “Zone of Mixing” considerations are especially important. Sea water cooling systems might also require a lease for submerged State lands from the Hawai‘i DLNR; a process that may be subject to public auction or competitive bidding.

Water quality impairment and cooling water intake for ocean thermal energy conversion facilities is regulated by the CWA Sections 316(b), 402, and 403. Section 316(b) provides a means to demonstrate to EPA that the location, design, construction, and capacity of cooling water intake structures for facilities reflect the best technology available for minimizing adverse environmental impacts (33 U.S.C. §§ 1326(b), 1342, and 1343). Under CWA Section 402, any discharge of a pollutant or combination of pollutants into a waterway requires a valid NPDES permit, and Section 403 provides for the promulgation of guidelines applicable to NPDES permits for discharge of pollutants into oceans and territorial seas (NOAA 2013a).

2.3.1.5.4 Representative Project

The representative project would replace an existing conventional district cooling system with an energy efficient district sea water air conditioning system. The intake pipe and cooling station would be located close to a population center and would supply electricity chilled air to facilities that require significant cooling requirements. Cooling towers used in conventional cooling towers would be removed and conventional chiller machinery would be substituted with heat exchangers.

The system would use a screened pipe, 63 inches in diameter, 4 to 5 miles long, with intake at a depth of 1,770 feet to access water at 44º to 45ºF. The pipe would be made of high-density polyethylene for its strength, impact resistance, corrosion resistance, and biofouling resistance. In order to minimize wear on the pipe and impacts to shoreline ecosystems, installation crews would bury the pipe on land a certain distance from the shoreline, using one of several available trenchless technologies: (1) horizontal directional drilling, which involves drilling underneath obstructions and pulling the pipe through the tunnel; (2) microtunneling, which uses a remote-control boring machine to drill tunnels and generally is used for smaller-diameter pipes; or (3) conventional tunneling, which involves personnel entering the tunnel on a boring machine. The project developer will determine the drilling method based on local geotechnical conditions and the proposed pipe route.

Using bathymetric analysis, it is possible to determine the shortest distance to the desired depth, while avoiding sensitive habitats such as coral reefs. Analysis must be done to mitigate impacts on all ocean-floor benthic zones along the shore and into the ocean depths. Additional care would need to be taken to ensure the pipe did not interfere with recreational or fishing activities in the area.

For the representative project, the effluent pipe would be constructed with the same material as the intake pipe and placed where the average water temperature at depth is closest to the temperature of the effluent exiting the cooling station, approximately 53ºF. This depth could be fairly close to the surface, possibly as high as about 150 feet below the surface, or as deep as 650 feet, depending on location (NREL 2013b). A sea water air conditioning developer would need to conduct site specific studies to determine the depth that would be most appropriate to most effectively minimize localized temperature gradient impacts. In other words, the effluent sea water would be pumped back into the ocean at a depth that provides temperatures closest to the discharging sea water to avoid altering the local temperature gradient (Makai 2013). The main concern is related to the impacts on offshore water quality. Therefore, the project would qualify as a "zone of mixing," which requires diluting the return seawater to a specified water quality standard. Maintenance of the pipe and screen would be performed regularly to prevent excessive biofouling and clogging. Automated systems are available for the pipe itself, thus eliminating the need for deep-water diving for repairs.

The cooling station would be built close enough to the shoreline to ensure minimal change in the incoming seawater's temperature. The representative project would take into account exposure to waves and tsunamis, soil conditions, and availability of tunneling to connect to both the seawater and freshwater loops. Potential sites can include parking lots and unused buildings. Two sets of pumps located in the cooling station would be connected to the electrical grid; each would require between 300 and 450 kilowatts of power. For comparison, the Honolulu Sea Water Air Conditioning project proposes a 25,000-square-foot station, two stories tall. Finally, the representative project may also spur the construction of more distribution lines, which would be installed beneath the city's streets.

2.3.1.6 Solar Water Heating

Solar water heating is an energy efficiency technology that uses the sun to heat water. It is generally considered for use in residential rooftop applications. This section focuses on its use in single-family homes; however, it is scalable to multi-family residences. Solar water heating technology has the potential to reduce household energy consumption by up to 40 percent (NREL 2011a).

2.3.1.6.1 Technology

Residential solar water heating systems consist of two main parts: a solar collector and a storage tank (NREL 2013c). The solar collector is usually a flat, black plate made of metal, which absorbs the sunlight, enclosed in a weatherproof insulated metal box with a transparent cover. The collector is located on the rooftop, and angled for maximum exposure to sunlight. Water flows from the storage tank into small metal tubes, coated black for maximum heat absorption located in the collector and is warmed by the absorber plates (DOE 2012d). The heated water then flows back to the storage tank for use. The tank is similar to, or may even be a modified version of, a standard home water heater and is well insulated to maintain the water's temperature (Figure 2-5). Solar water heating systems can scale to provide hot water to bigger, commercial facilities, such as convention centers or even small communities. These larger systems generally consist of an array of smaller heating units, connected in parallel, to provide the desired amount of hot water

Solar water heating technology can be an active or passive system. Active systems, which are more efficient (ANL 2013), utilize pumps to move the water between the collector and storage tank. Passive systems rely on natural convection to circulate the warm water. Active systems rely on fluid circulated by pumps to provide a building's hot water (DOE 2012d). *Direct circulation* systems of the type used in Hawai'i pump water throughout the system, directly heating it for use in the home. Solar water heating systems typically require a backup system, such as a gas or electric water heater, for use during times of minimal sunlight. A solar heating system can replace an existing gas or electric system to provide an efficient means of maintaining a hot water supply. In some cases, solar modules are installed behind the collectors to provide electrical power for the pumps and (DBEDT 2002a).

2.3.1.6.2 Characterization of Feasibility and Deployment

Solar water heating systems are commonly used on houses in Hawai'i; there are more than 100,000 systems installed Statewide (InSynergy 2012). The systems range in size depending on the family's needs and resources. Over the life of the solar water heating system, the initial cost of the system is returned to the homeowner by the savings in energy, and it will continue to provide monetary savings while the home uses less energy to heat water.

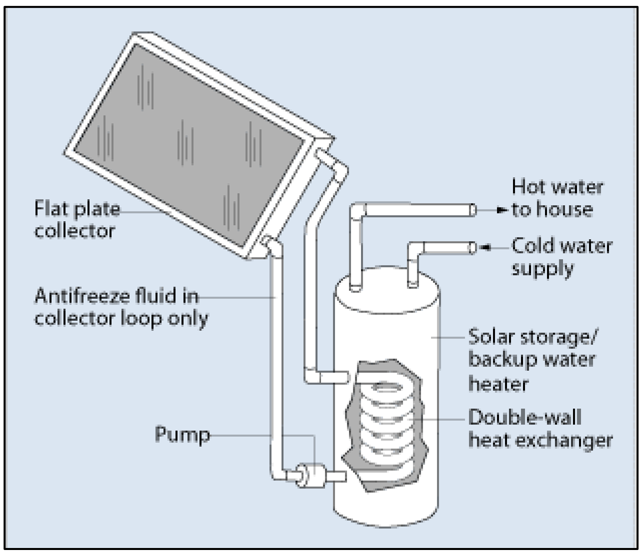


Figure 2-5. Basic Solar Water Heater (Source: DOE 2012d)

As much as 40 percent of home energy use in Hawai'i is directly related to the water heater (DBEDT 2002a). The success of solar water heating is proportional to the amount of solar radiation received in a given area. That is, the more direct sunlight that strikes a rooftop, the more water a system can heat, and for longer periods of time. Because many parts of Hawai'i receive direct, year-round sunlight for long durations of the day, solar water heating is a feasible, if not ideal, energy-efficiency solution.

The productivity of solar water heating systems depends on the amount of sunlight. Most places in Hawai'i receive ample sun to heat a household's water. For example, a home near Ala Manoa in Honolulu might receive approximately 570 watt-hours per square foot of solar energy (sunlight) every day (DOE 2012e), equivalent to 6.1 hours of peak sunlight (defined as 1 kilowatt per square meter [0.09 kilowatt per square foot]). Therefore, even a small system with a south-facing, 40-square-foot collector in Honolulu would receive 22.8 kilowatt-hours per day of solar energy, or 683 kilowatt-hours per month. For comparison, a conventional electric water heater for a typical household of four people consumes 8.7 kilowatt-hours per day, or 260 kilowatt-hours per month (DBEDT 2013e). Under this scenario, a solar water heating system provides a sufficient amount of energy required to heat the home's water. If properly sized and oriented, the percentage energy provided by the solar heating system, the solar savings fraction, can be as high as 90 percent (DBEDT 2013e). The remaining heat is provided by a backup system, usually electric resistance heating.

Solar radiation levels vary widely across the State, depending on localized weather patterns; however, according to solar radiation maps produced by the State of Hawai'i (Hawai'i 2013a) and DOE (DOE

2012e), most locations in Hawai‘i receive between 3.5 to 6 hours of peak sunlight every day, enough to supply sufficient solar heat for domestic uses. Other factors can affect a system's efficiency, including whether or not the home currently uses conventional heating and the amount of hot water it consumes. All things remaining equal, an average four-person home would require around 4 hours of peak sunlight to make a solar water heating system an economic replacement for a gas or electric water heater, lower levels of solar radiation would require larger collectors (DBEDT 2013f).

Most major cities and towns on the islands receive sufficient sun. On the sparsely populated islands of Lāna‘i, Moloka‘i, and Kaua‘i, the areas of greatest peak sunlight roughly align with population centers. The windward slopes of the eastern half of Moloka‘i is mostly high forest and receives large amounts of rain. The western half of the island is more low-lying and drier; the town of Kaunakakai receives approximately 6 hours of peak sunlight a day (Hawai‘i 2013a). Lāna‘i's main town, Lāna‘i City, also is located in an area that receives large amounts of sunlight; that is, approximately 6 hours of sunlight a day (DOE 2012e). Coastal cities on Kaua‘i receive a smaller, but still considerable, amount of peak sunlight: Hanapepe and Poipu each receive about 5.8 hours and Lihue and Kapaa each receive 5 hours of peak sunlight.

The island of Hawai‘i receives a significant amount of peak sunlight. However, its largest city, Hilo, is located on the coast at a lower elevation and receives only 4.6 hours of direct sunlight.

On Maui, the areas with the highest amounts of solar radiation occur along the coast (all but its northeastern coast), including Kahului and Wailuku, both of which receive between 5 and 6 hours of peak sunlight (Hawai‘i 2013a).

On O‘ahu, coastal parts of Honolulu receive more than 6 hours of peak sunlight, as do other cities along the southern coast, all of which are heavily populated areas. For Honolulu, most homes could completely replace conventional heating systems. Because of the amount of direct sunlight, some homes even need to use temperature control schemes to prevent their water from becoming too hot (Hawai‘i 2013a)

Hawai‘i has significant market penetration of solar water heating compared with other states; between 1977 and 2011, over 103,000 solar water heating systems were installed in Hawai‘i, resulting in a current savings of 152,800 megawatt-hours per year for the State (InSynergy 2012).In 2010, the State of Hawai‘i instituted a mandate requiring that all new single-family homes be built with solar water heaters (DBEDT 2013c). The Hawai‘i PUC, through the Public Benefits Fee Administrator, provides rebates for qualified retrofit solar water heating systems on homes built before the mandate was enacted.

Because of the abundance of sunlight, the new State mandate, and its ease of use, solar water heating is on track to becoming a significant part of the HCEI's goals of meeting 30 percent of Hawai‘i's energy goals through energy efficiency and conservation. Solar water heating is appealing to many homeowners and is seen as a substantial "first step" in energy efficiency and saving money in the near future.

2.3.1.6.3 Permitting and Consultation Requirements

Although a residential solar water heating system is fairly non-invasive, some general permitting and consultation may still be required (see Section 2.2.5). Residential rooftop projects, such as solar heat, generally only require county-level permits for electrical and plumbing work. Federal or State permits generally are not required for a residential-scale rooftop renewable energy project (DBEDT 2013a).

2.3.1.6.4 Representative Project

For purposes of this PEIS, the representative project is an active solar water heater system with a 40-square-foot collector and 120-gallon storage tank for a single-family residence. The water would circulate between the collector and the 120-gallon storage tank located in the home, in place of the conventional water tank. Since freezing is not a concern, the system utilizes direct circulation, where the water itself is heated, rather than indirect circulation, which uses a heat-transfer fluid and a heat exchanger. Because the system itself would require electricity to run its pumps and control system, the collector would use a PV cell to power the pumps. The components for the representative project would be on the roof and interior of the house. Pipes would run from the rooftop collector to the tank through existing crawlspaces or under the eaves of the roof, and the tank would connect with existing plumbing. Residential systems can typically be installed in one day with limited onsite construction by a small team of several contactors and without any disruptions to the property.

2.3.2 DISTRIBUTED RENEWABLES

Renewable energy technologies produce sustainable, clean energy that can be incorporated via a range of uses including residential, commercial, and industrial uses. Although similar to utility-scale technologies, distributed energy is designed primarily for local use as opposed to providing electricity to an electrical grid for distribution to multiple electricity users (utility-scale). Additionally, distributed energy sources are often connected to the electrical grid and can provide a financial incentive for local electricity producers. Distributed technologies discussed in this section harness energy from renewable energy sources such as the sun, wind, falling water, and biomass, as well as hydrogen produced from renewable energy sources:.

- Biomass
- Hydroelectric
- Hydrogen Fuel Cells
- Photovoltaic
- Wind (land-based)

As mentioned previously, distributed scale projects could range from single family residences to larger commercial uses. Representative projects were defined based on technology-specific capacity factors, uses, and feasibility in Hawai‘i. The description of each technology within Section 2.3.2 includes a discussion of the differences between nameplate capacity and actual capacity based on efficiency and the range of typical capacity factors for that technology. Chapter 5 discusses how the impacts would scale (for example, linearly, exponentially, or not at all) for the range of potential technology applications to explain the effects of smaller or larger projects and how impacts could change based on the size of the technology implemented.

2.3.2.1 Small-Scale Biomass

Biomass energy encompasses multiple energy production technologies that use organic matter from trees, agricultural crops, and animal waste as well as biogenic material in urban waste streams to produce a variety of potential energy end products (EPA 2007; Bain et al. 2012; HNEI 2012a). Because biomass resources (i.e., feedstock) represent a wide variety of biochemical material such as sugars, starch, fiber, and oils, different conversion technologies can be used to produce electricity and heat or used as alternative transportation fuel (i.e., biofuels such as ethanol and biodiesel). For the purposes of analysis, this PEIS discusses biofuels as alternative transportation fuel in Section 2.3.4.1. Biomass energy products produce electricity and heat are discussed under both distributed renewable and utility-scale renewable energy.

2.3.2.1.1 Description of Technology

A biomass energy system is composed of several interdependent components including: (1) biomass or feedstock production, (2) feedstock logistics or handling of the biomass source, (3) energy technology conversion system, (4) distribution, and (5) end use (HNEI 2009a, 2012a). For example, to produce electricity from sugar cane bagasse (milling waste), a supply of bagasse must be produced and then delivered to an operating generating station. The electrical power is then generated and delivered to an existing market of users. The pathway analysis of each component is important for understanding potential environmental impacts from developing a biomass energy industry (HNEI 2012a).

Feedstock Production

Production of biomass feedstock in Hawaiʻi occurs through three primary sources: agriculture, forestry, and urban waste streams. Agriculture could potentially produce feedstock through three processes: (1) crop residues, (2) dedicated energy crops, and (3) animal waste (Bain et al. 2012; Turn et al. 2002a, 2002b; Khanal et al. 2009). The forest industry produces potential feedstock in wood residues from timber harvest and processing and possibly through dedicated timber stands planted to produce wood biomass. Urban waste streams represent a diversity of feedstock as byproducts of human activity. These include municipal solid waste, sewage sludge, food wastes, and fat/oil/grease.

Agriculture Biomass

Crop Residues

Crop residues are unused plant parts left in the field after harvesting or leftover material after crop processing. In Hawaiʻi, sugar and pineapple historically have been two of the largest agricultural industries, but have greatly declined over the past two decades because of the production and market economy (DBEDT 2012a). Sugar cane has been grown commercially in Hawaiʻi for more than 170 years and the technology for producing and processing sugar cane is well established in the State (Khanal et al. 2009). Sugar cane has high fertilizer requirements and optimally requires about 70 inches of water annually (Khanal et al. 2009). Irrigation, in addition to natural precipitation, is normally required to meet sugar cane's annual water needs.

The commercial milling of sugar cane produces two byproducts, bagasse and molasses (Turn et al. 2002a). Bagasse is a fibrous residue left after the milling and extraction of sugar from the sugar cane stalks, and molasses is the liquid stream remaining after normal sugar extraction. Sugar cane production and processing also produces sugar cane trash fiber (i.e., leaves, plant tops, and ground trash) (Turn et al. 2002b). There is only one operating sugar mill in Hawaiʻi, the Puunene factory operated by Hawaiian Commercial & Sugar Co. (HC&S) at Puunene on Maui. The Gay and Robinson (G&R) factory located at Kaumakani on Kauaʻi closed in 2009. As reported in Turn et al. (2002a), in 2002, HC&S produced about 550,000 tons of bagasse at 50 percent moisture (about 275,000 tons of fiber) and 80,000 tons of molasses. Also in Turn et al. (2002), during the same year, G&R produced about 147,000 tons of bagasse at 50 percent moisture (about 74,000 tons of fiber) and 15,000 tons of molasses. In addition, HC&S and G&R produced 137,000 and 37,000 tons of cane trash fiber, respectively. Both mills at the time produced electricity using conventional steam boiler technology with bagasse as fuel. Currently, HC&S fires coal and Bunker C fuel oil to satisfy the terms of its power contract with Maui Electric Company. HC&S operates three boilers in total with an installed generating capacity of 44 megawatts. G&R operated one boiler with an installed capacity of 4 megawatts. A decrease in sugar cane production has potentially made land available for the production of biomass crops.

Pineapples were once a major industry in Hawaiʻi (Turn et al. 2002a). However, major pineapple growers have ceased operation. The pineapple industry did not produce biomass that was used for biomass energy production. Pineapple residues left in the field (about 10 dry tons per acre) were typically turned into the soil or burned before replanting. Pineapple processing produced a residue byproduct (dewatered skins) that was used by cattle producers as feed. The decrease in pineapple production has potentially made land available for the production of biomass crops.

Nutshells are a byproduct of Hawaiʻi's macadamia nut industry. From 2011 through 2012, growers harvested 15,000 acres of macadamia nut trees, producing 49 million pounds on a wet-in-shell basis (NASS 2012). (No estimate of nut shell production was provided.) Turn et al. (2002a) estimated that about 19,000 tons of nutshells, industry-wide, were produced during this same time period. Macadamia nut shells have a heating value of 21.1 mega-Joules per kilogram, a value higher than sugar cane bagasse. Macadamia nut shells also are lower in nitrogen content than other biomass sources, which lowers the potential for the formation of nitrogen oxides (an air pollutant) during combustion (Turn et al. 2002b). Nut shells are used as boiler fuel to generate steam for drying processes (nuts and coffee) and to generate electricity (Turn et al. 2002a).

Crop residues are ideally suited for *distributed generation* of renewable energy because the crop production technology and harvesting and handling infrastructure are already established and the energy production from the residue can be integrated into existing agricultural or processing facilities or marketed as an energy commodity. Crop residue availability is a function of the economic viability of the industry. For example, as the sugar industry in Hawaiʻi has decreased, the amount of bagasse feedstock also has decreased. This effect is often mitigated in distributed renewable energy applications because the energy requirement also decreases with the industry. It should be recognized that agricultural residues have other uses including animal feed, soil amendments, industrial feedstock, and other commercial products that also have economic value; therefore, not all residues are available for use in energy generation.

Energy Crops

Although not commercially developed in Hawaiʻi, dedicated *energy crops* are a potential source of feedstock for biomass energy. Research has been conducted for many years on potential energy crop plant species that are adapted to Hawaiʻi's soils and climate (Khanal et al. 2009;Turn et al. 2002a; Poteet 2006). Energy crops are grown specifically for use in biomass energy production. With the significant decline in both the sugar and pineapple industries, land formerly used for sugar cane and pineapples could potentially support energy crops and improve the agricultural industry and local economies. Approximately 136,000 acres suitable for growing biomass are estimated to be available in the State without displacing any current farming (DBEDT 2013h).

HEATING VALUE

The heating value of a biomass fuel is a measure of the amount of heat energy released during combustion of a unit mass of material. The heating value is often expressed as energy per unit mass such as mega-Joules per kilogram.

Sugar cane could be grown as an energy crop because of significant amounts of fiber and sugar that are produced. The agronomic practices for growing, harvesting, and milling cane are well established although some changes in agronomic procedures (e.g., frequency of harvest, burning) may be changed when growing for energy opposed to sugar production. Banagrass is a tropical grass that has been studied for fiber production. Because of the similarities between sugar cane and banagrass, production strategies and harvest techniques have been based on experience with sugar cane. However, work remains on developing superior banagrass cultivars with characteristics adapted to Hawaiʻi's growing conditions, establishing management practices specific to banagrass, and improving harvest and transportation systems. Other potential energy crops that industry has considered but not extensively tested are sweet sorghum, guinea grass and industrial hemp. A major concern with any plant species (herbaceous or woody) tested for use as biomass crops is their potential to be an invasive species (HNEI 2012b; Buddenhagen et al. 2009; Daehler et al. 2012). Banagrass is considered a potential risk as an invasive species; however, based on field evidence from recent plantings (less than 10 years old), green banagrass has not yet become invasive or shown signs of becoming a serious invader (HNEI 2012b). Guinea grass is a weedy grass established in Hawaiʻi (HNEI 2012b).

Another group of potential energy crops are oil crops (Poteet 2006). These crops are primarily grown for their oil-producing seeds and fruits. The plant oils are extracted and processed to produce a biodiesel fuel that can be used as a fuel to generate electricity in a steam boiler and combustion engine power plant. Poteet (2006) identified a variety of plant species that have potential as oil crops. Although some of these species have been used in other countries to produce biodiesel, oil crops have not been widely developed in Hawaiʻi but are being studied.

Dedicated energy crops face a dilemma described in the 2009 *Hawaiʻi Bioenergy Master Plan* as the "chicken and egg problem" (HNEI 2009a). Without an established market for biomass crops, biomass producers are reluctant to invest in production. Conversely, without a reliable supply of energy biomass, energy producers are reluctant to invest in biomass conversion facilities. This issue is less of a concern for distributed biomass energy systems that are typically integrated into existing commercial operations, which often produce their own biomass. Distributed biomass energy systems may be the way to develop the market for commercial energy crops, which could eventually supply utility-scale biomass energy production. Establishing production contracts between biomass producers and electrical power producers is another means by which to establish a market for biomass fuels.

A concern in developing biomass energy crops in Hawaiʻi is the availability of land and water resources necessary to produce the crops. Because of both spatial and seasonal variation in precipitation, biomass energy crops in Hawaiʻi may require significant amounts of irrigation water in addition to natural precipitation. Questions remain regarding allocation of water resources to competing needs. Hawaiʻi also has limited lands suitable for the production of agricultural crops. Extensive development of energy crops could compete with other agricultural crops or grazing lands. However, recent decreases in sugar cane and pineapple production has opened land area that could be used for biomass crops without using lands dedicated to other agricultural products (DBEDT 2013d). Energy crops may be a means to offset the economic impacts associated with declines in the pineapple and sugar industries and provide an alternative agricultural industry. As part of the 2009 Hawaiʻi Bioenergy Master Plan, the University of Hawaiʻi at Manoa (College of Tropical Agriculture and Human Resources) evaluated the land and water resources issues associated with the potential development of bioenergy crops in Hawaiʻi (CTAHR 2009).

The potential development of energy crops in Hawaiʻi also introduces the possibly of using genetically modified organisms (GMO) for the production of biomass. Genetic engineering could be used to enhance plant characteristics such as productivity and oil content of seeds. The use of genetic engineering in Hawaiʻi agriculture is an active area of research. GMO crops (e.g., corn and papaya) are currently grown on the islands. For additional information on GMO in Hawaiʻi, the reader is referred to the biotechnology website of the University of Hawaiʻi College of Tropical Agriculture and Human Resources (http://www.ctahr.hawaii.edu/biotech/).

Animal Waste

Livestock production produces animal waste (i.e., manure), which is a potential biomass feedstock. Animal waste, with its high moisture content, is amenable to anaerobic digestion to produce a biogas that is largely methane gas. The main domesticated livestock populations in the State are dairy and beef cattle, hogs, and chickens. However, animals must be raised at high density to produce sufficient manure accumulation with low collection costs to serve as a biomass resource. The beef industry in Hawaiʻi largely uses dispersed pasture and rangeland grazing and therefore does not produce a concentrated supply of animal waste. Several large livestock production operations exist in Hawaiʻi that would have sufficient numbers and concentrations of cows, hogs, and chickens to produce large accumulations of manure (Turn et al. 2002a). However, animal waste has competing uses. Manure from dairy operations currently is either spread on fields as fertilizer or disposed of as waste. Chicken manure is high in nitrogen and is often mixed with mulch and composted and sold as fertilizer. Oʻahu has the largest concentration of large livestock producers. In the past, two anaerobic digesters operated at swine production facilities and one at the University of Hawaiʻi Waialee Livestock Experiment Station on Oʻahu (Turn et al. 2002a) but all have been decommissioned. Additional labor for maintenance and operation of the digester system is the primary reason this technology has not been adopted.

Forest Residues and Energy Forests

Hawaiʻi's forest industry is a potential source of biomass feedstock. The forestry industry produces biomass either through wood residues generated as a byproduct of timber harvesting and wood processing or potentially through the development and production of dedicated forest biomass crops. The island of Hawaiʻi has the largest inventory of timber resources in the State, while Maui and Kauaʻi have smaller acreages. Hawaiʻi's timber resource comprises native and nonnative species. Eucalyptus trees were brought to Hawaiʻi as a potential commercial timber species and are commonly grown in Hawaiʻi. There are many species of eucalyptus trees and different species have adapted to the variety of growing conditions found on the islands (Khanal et al. 2009). Research continues to evaluate a variety of woody species as potential dedicated wood biomass feedstock, including eucalyptus species adapted to different microclimates and soils, leucaena, and albizia (Khanal et al. 2009). Wood residues include slash (waste timber after harvesting), bark, sawdust, and mill residues (slab wood and trimmings). In dedicated energy forests, the entire timber harvest would be processed into wood residues or chips. Wood residues are used to generate electricity or produce steam heat for lumber drying, typically in steam boiler generator systems. Similar to herbaceous crops, there are concerns about invasive characteristics for some of these species, such as jatropha and leucaena (HNEI 2012b; Buddenhagen et al. 2009).

Urban Waste Streams

The third primary source of biomass is urban waste streams, which include municipal solid waste, sewage sludge, food wastes, and fat/oil/grease (urban grease). Similar to animal waste, urban waste streams need to be sufficiently large and concentrated, such as at landfills, to provide an adequate biomass source.

Municipal Solid Waste

Municipal solid waste includes biogenic waste materials that are intended for disposal in landfills but can be burned in a steam-cycle power plant (Turn et al. 2002a). Landfills can provide a secondary source of biomass through the decomposition of waste following landfill closure. Anaerobic mesophilic bacteria in the landfill produce a biogas that is about 50 percent methane, which can be collected and extracted from wells bored into the landfill. This PEIS discusses municipal solid waste in Section 2.3.3.4.

Sewage Sludge

Sewage sludge or biosolids are a byproduct of wastewater treatment facilities and are generated at primary and secondary stages of treatment. Sludge is often further stabilized prior to disposal, typically by digestion, to reduce the volume, dewater the sludge, reduce the organic content, and reduce odor (Turn et al. 2002a). Smaller treatment facilities often do not have this capability, in which case the sludge is often transported to public facilities thus consolidating the sludge from several locations.

Food Waste

Food waste is produced by restaurants, food courts, hotels, markets, food manufacturers and processors, caterers, and hospitals. Food waste has multiple uses including mixing with other biogenic municipal solid waste, hog feed, and anaerobic digestion (methane production). Hog feed is the current primary use of food waste in Hawai‘i (Turn et al. 2002a). Food waste generation is largely a function of the concentration of people.

Urban Grease Waste

Urban grease waste is generated as byproducts from food preparation activities. Urban grease can be classified into two categories, yellow grease and grease trap waste. Yellow grease is derived from used cooking oil and waste greases that are separated and collected at the point of use by the food preparation facility. Yellow grease is normally picked up by a company that consolidates it and either uses it or sells it for manufacturing into tallow, animal feed supplements, fuels, or other products. Grease traps are located in the drain lines from restaurant and food service facility sinks and dishwashers and serve to accumulate grease, thereby preventing it from entering the sewage system. Grease trap waste is collected and treated and used similar to yellow grease.

Biomass Logistics

Biomass logistics includes two primary components: the transportation and delivery of the biomass from the point of origin to the point of use and the preparation of the biomass material for use in an energy conversion technology. Transporting biomass differs from transporting fossil fuels in two ways (Jorgenson et al. 2011). First, biomass has a significantly lower energy density and higher fuel moisture content compared with fossil fuels, such as coal. Therefore, the cost per unit of energy to transport biomass is higher. Second, biomass resources are more spatially distributed than fossil fuels, which are typically extracted from a mine or well. Increasing the biomass collection radius may increase the available biomass but also may increase the related transportation costs. Availability of a biomass resource within a reasonable distance is an important consideration in determining the feasibility of a distributed biomass energy application (EPA 2007; Jorgenson et al. 2011). However, each of the islands in Hawai‘i is relatively small, and transportation costs for distributed biomass projects likely would not be prohibitive. Commercial industries that produce biomass waste as part of their operation are ideally suited for distributed biomass energy production because transportation costs are minimal and energy production can be scaled to match their energy requirements and the available biomass. The sugar and macadamia nut industries in Hawai‘i are two examples that have used self-produced crop wastes to produce their own electricity.

The preparation of the biomass material for use in an energy conversion technology typically includes receiving, processing, storing, and then feeding the biomass into the energy production facility (i.e., furnace/boiler or gasifier) (EPA 2007; Jorgenson et al. 2011). There are three primary considerations in biomass preparation: moisture content, particle size, and storage. Moisture content varies with the type of biomass material and season. Higher moisture content decreases boiler efficiency because of energy required to evaporate the water (Jorgenson et al. 2011). However, drying biomass either requires additional costs or longer storage times for biomass to dry to equilibrium moisture content (i.e., moisture content in balance with surrounding air temperature and relative humidity).

Particle size and particle size distribution are important for efficient use of the biomass material and the application of different conversion technologies. Biomass materials of more uniform particle size burn more efficiently (i.e., combust more completely per unit time). Different energy conversion technologies may require particles of a different size.

Biomass energy systems will require some amount of storage to ensure an available biomass supply. Biomass materials will eventually decay (i.e., compost), are a potential fire risk, and are a possible source of stormwater contamination. Proper storage and management of the biomass material will minimize loss. Dryers, grinders, conveyors, separators, and storage bins may be necessary depending on the feedstock and the energy conversion technology being used. Biomass preparation does not necessarily have to be part of the energy production system. For a distributed biomass energy system, a fully processed and prepared biomass material could be procured from a biomass producer. However, securing a reliable source of cost-competitive biomass fuel is essential for implementing a biomass energy system. Commercial industries that produce biomass material as a byproduct of their operations have a distinct advantage and are prime candidates for implementing distributed biomass energy production systems.

2.3.2.1.2 Characterization of Activity Implementation and Deployment

Biomass energy generation is a valuable distributed renewable energy source in areas where it can fulfill the power supply needs of local agricultural and industrial operations and other residents. Because of the lower energy content of biomass materials compared with fossil fuels, it is important to locate the energy production facility near the biomass source to offset the transportation costs (see above discussion). The economic value of agricultural and forest waste residues and crops as fuel sources makes biomass conversion a potential benefit to agricultural and forest product producers, enhances energy security, and reduces strain on the electrical grid. Use of urban waste streams minimizes waste disposal.

Because biomass energy sources include a variety of materials with different chemical constituents (e.g., fiber, oils, sugars, starch), a number of different technologies are being used to convert biomass energy into a useable product that can then be used to produce electricity and heat. Biomass energy conversion technologies can be broadly grouped into two categories; thermochemical processing, and biochemical processing (HNEI 2012a). Thermochemical processing is accomplished in different steps by altering the amount of air or oxygen available. The most common and familiar thermochemical process is direct combustion or burning of biomass with excess air in a boiler furnace to produce steam to drive a steam turbine or supply steam heat (e.g., drying and facility heating). Other forms of thermochemical processing involve heating but not burning (i.e., restricted air) biomass to convert it into an intermediate gas or liquid (i.e., biofuel) that is then used to produce heat and electricity (Bain et al. 2012). Intermediate conversion technologies include thermal gasification (gaseous products) and thermal pyrolysis (liquid products). Another process is transesterification of plant oils that is mostly a chemical process performed at much lower temperatures (~50ºC) to produce biodiesel. The liquid and gaseous energy products are then used in steam turbine (i.e., furnace/boilers), gas turbine, or internal combustion engine generators (Bain et al. 2012).

Biochemical processing involves the use of bacteria, yeasts, and enzymes to ferment or digest biomass (e.g., anaerobic digestion) to produce a methane-rich gas. The analysis in this PEIS includes combustion (direct fire, co-fire), pyrolysis, gasification, and anaerobic digestion technologies. The following sections briefly describe these technologies and potential uses in Hawai‘i. Section 2.3.4.1 of this PEIS discusses the production of transportation biofuels such as ethanol and biodiesel.

Combustion (direct fire and co-fire)

Combustion technology uses biomass fuel, typically those high in fiber such as bagasse, wood products (sawdust, chips, mill residues), and municipal solid waste, in conventional steam boilers and turbines to produce electrical power (EPA 2007). Depending on the supply, both the amount and seasonality, biomass fuel may be co-fired with other energy sources such as coal or fuel oil to replace part of the fossil fuel. The impact of biomass co-firing on capacity and heat rate is facility-specific and a function of co-firing rate and boiler control characteristics (Bain et al. 2012). Direct fire, steam-based biomass power plants are a proven, simple, and mature technology (EPA 2007; Peterson and Haase 2009; Bain et al. 2012; Khanal et al. 2009). The oxidation of biomass with excess air produces hot flue gas to generate steam in boilers. The steam is then used in a standard steam generator to produce electricity. The conversion efficiency typically is 15 to 35 percent depending on the system being used (Peterson and Haase 2009). The overall conversion efficiency can be increased to as much as 85 percent if operated as a combined heat and power system, where a portion of the steam is used as process heat for industrial applications such as drying (e.g., nut processing or lumber drying). Because heating requirements are limited in Hawaiʻi, use of a combined heat and power system most likely would be limited to distributed industrial heating applications.

Biomass combustion technology is particularly suited for distributed energy production where biomass energy can be integrated into existing facilities near the biomass source. The sugar industry in Hawaiʻi has long produced electricity using biomass combustion technology primarily to meet internal energy needs and also for export to utility companies. Direct combustion biomass technology is scalable by using different sized boilers and generators and is adaptable to various distributed energy applications as long as a reliable biomass source exists that can be economically acquired (Khanal et al. 2009; Jorgenson et al. 2011). Construction of conventional combustion steam-cycle generating stations involves land disturbance and building of structures to house the boilers and turbines, an emission stack, and electrical distribution lines. However, for distributed applications, the generating stations are often co-located near the biomass source (e.g., agricultural production or processing plant, landfill, or lumber mill) adjacent to or in existing disturbed sites.

Transesterification

Transesterification is a chemical process in which plant oils and animal fats are reacted with an alcohol (typically methanol) to yield a fuel (methyl esters) with properties (e.g., density, flash point, viscosity, and pour point) similar to diesel fuel (Berchmans and Hirata 2008; Raja et al. 2011). The processing of oil crops begins with an extraction process that separates the plant oils from the oil-producing plant part (i.e., seeds, fruit). In addition to the plant oils, the processing of oil crops produces several byproducts that have potential value. Following the transesterification process, approximately 10 to 15 percent of the final product is glycerin or glycerol, a sugar alcohol that is used in soap-making and other cosmetics (Poteet 2006). The seedcake that remains after oils are extracted has potential uses as an organic fertilizer, animal feed, or even combusted for energy. However, some plant species contain natural botanical toxins (e.g., Jatropha and castor bean), and the seedcake cannot be used as animal feed unless it is detoxified (Poteet 2006).

Pyrolysis

Pyrolysis and gasification are thermochemical conversion processes that use a controlled destruction of the biomass material to produce solids, liquids, and gases (Overend 2004; Verma 2012). Differences in the two processes (temperature, rate of heating, amount of air) will favor the production of more or less solids, liquids, and gases. The reader is directed to Overend (2004) and Verma (2012) for a more detailed technical discussion about thermochemical processes.

Pyrolysis is a process in which biomass material is heated to about 450 to 500ºC in the absence of oxygen (Khanal et al. 2009). Pyrolysis is actually an old process that is used to produce charcoal and cooking coal. However, for biomass energy production, fast pyrolysis (rate of heating is increased) is designed to maximize the production of pyrolysis oils, or bio-oils (Overend 2004; Verma 2012). Bio-oil, as a liquid fuel, has a heating value similar to most solid biomass fuels and about 55 percent of fuel oil (Khanal et al. 2009). With additional processing, bio-oil can be used in combustion turbines, but bio-oils have seen limited application as a boiler fuel for either power or heat production. In boilers, bio-oils provide no energy advantage over direct firing of biomass except in situations where it is necessary to transport fuel from the point of production to point of use because bio-oil has a higher energy density and therefore a lower transportation cost. Bio-oils also might be advantageous and the preferred option when existing fuel-oil-fired boilers are being converted to biomass fuels. Although research, testing, and development continues on combustion turbines that burn bio-oils and on portable pyrolysis units, the use of pyrolysis-produced bio-oils for distributed renewable energy has potential but currently limited application (Khanal et al. 2009).

Gasification

Gasification is an extension of the pyrolysis process designed to give the highest yields of carbon and energy in the gas phase. This is achieved by reacting the biomass material at high temperatures (greater than 700°C) with a controlled amount of oxygen and possibly steam (partial oxidation). The resulting gas mixture is called *synthetic gas* (syngas) or *producer gas*, which is processed (i.e., cleaned and upgraded) into a variety of fuels that can be combusted at a higher temperature than the original biomass material to produce electricity (i.e., having a higher heating value) (EPA 2007; Jorgenson et al. 2011). Different types of gas reactors are available for performing the gasification process including fixed bed, atmospheric and pressurized bubbling-fluidized bed, and circulating fluidized-bed technologies (Kinoshita et al. 1997; Khanal et al. 2009).

Several approaches exist for using the gases produced (Khanal et al. 2009). Smaller-scale gasification using internal combustion systems are at the commercial stage (EPA 2007; Bain et al. 2012; Khanal et al. 2009). Another approach is the more complex biomass integrated gasifier, combined-cycle application where the product gas from the biomass conversion is fired in a combustion gas turbine to generate electricity (topping cycle) (Khanal et al. 2009). The hot exhaust products then pass through a heat recovery steam generator and the steam produced is used in a steam turbine to generate additional electricity (bottoming cycle). The combined cycle system is at the demonstration stage (Bain et al. 2012). A third approach is removal of the combustion turbine from the combined cycle system and directly fire the product gas in a steam cycle boiler system (Peterson and Haase 2009). This approach has commercial application. Gasification technology has potential application for distributed renewable energy production. However, the technology is not yet widely applied, although available in different forms. One of the disadvantages of gasification for distributed energy is the larger scale required to capture cost and efficiency benefits (Bain et al. 2012). Gasification also requires fuel of uniform size and with low moisture content (Peterson and Haase 2009).

Anaerobic Digestion

Anaerobic digestion is a biological process in which microorganisms degrade biomass material into a methane and carbon dioxide gas mixture in an oxygen-free environment. Anaerobic digestion, or decomposition, is a complex process and occurs in three basic stages from the activity of a variety of microorganisms. Initially, a group of microorganisms converts organic material to a form that a second group of organisms utilizes to form organic acids. Methane-producing (methanogenic) anaerobic bacteria use these acids and complete the decomposition process. Generally, 1 kilogram (2.2 pounds) of organic matter generates about 0.35 cubic meter (0.46 cubic yard) of methane gas (Khanal et al. 2009).

Anaerobic digestion typically is used to produce biogas in two ways. One is the natural anaerobic fermentation that occurs in closed landfills, which produces methane as a byproduct of the breakdown of municipal solid waste. The second approach is the use of constructed anaerobic digesters —also known as biodigesters— which typically consist of an air-tight tank into which the biomass material is placed. The advantage of an anaerobic digester is environmental conditions can be managed to optimize the gas production. Optimal digestion occurs around 98°F. Efficient operation requires maintaining the appropriate pH and proper ratios of water to solids and carbon to nitrogen, mixing the digesting material, selecting the best particle size of the material being digested, and identifying the optimal retention time. Although many types of biomass materials can be used in a biodigester, livestock manures are a common feedstock as well as sludge from water treatment facilities. Anaerobic digesters are constructed with concrete, steel, brick, or plastic. They are shaped like silos, troughs, basins, or ponds, and may be placed underground or on the surface. All anaerobic digestion system designs incorporate the same basic components: a pre-mixing area or tank, digester vessel(s), system for using the biogas, and a system for distributing or spreading the effluent (the remaining digested material).

Gas collected from an anaerobic digester or landfill can be used as fuel gas or in a power plant to generate electricity. Biogas produced in anaerobic digesters consists of methane (50 to 80 percent), carbon dioxide (20 to 50 percent), and trace levels of other gases such as hydrogen, carbon monoxide, nitrogen, oxygen, and hydrogen sulfide. The relative percentage of these gases in biogas depends on the feed material and management of the process (Khanal et al. 2009). Impurities must be removed prior to use as fuel. Carbon dioxide is not an impurity but does reduce the heating value of the fuel. Hydrogen sulfide is an extremely reactive corrosive gas that must be removed. Biogas has traditionally been used as a boiler fuel for steam generation for electricity production or process heat production (Khanal et al. 2009). However, it also could be used in internal combustion engine generators, gas turbine generators, fuel cells, and as vehicle fuel.

Anaerobic digestion is a mature technology and could easily be implemented in Hawai‘i’s tropical climate. The 85-acre Kapaa landfill operated a successful landfill gas recovery system. In 1998, the landfill produced 2.3 million cubic feet of gas per day that was used in a gas turbine generator system (Khanal et al. 2009). The turbine exhaust also was used to dry rock aggregate. The operation terminated in 2002 because of operating difficulties with the combustion turbine. No landfill gas recovery systems are currently operating in Hawai‘i. Constructed anaerobic digesters have been used in Hawai‘i but none is currently operating. Two digesters operated at swine production facilities. A third digester was operated at the University of Hawai‘i Waialee Livestock Experiment Station on O‘ahu but was subsequently decommissioned (Turn et al. 2002a). The primary reason for abandoning this technology was the lack of maintenance and operations personnel. Anaerobic digestion is suitable for distributed energy development. However, adoption and development of the technology by private industry will depend on the economic benefits. Landfill gas is less likely to be used as a distributed energy source because of the gas recovery infrastructure required. However, the *Clean Air Act* requires many landfills to manage landfill gas either by collecting and flaring it or using it (http://www.epa.gov/lmop/faq/lfg.html#07).

2.3.2.1.3 Permitting and Consultation Requirements

As discussed in Section 2.2.5, the number of permits required for a biomass energy project can vary depending on the scope of the project, the anticipated environmental and social impacts, and location within certain zoning districts or special management areas (Zapka 2009). The number of required permits, uncertainty regarding approval or denial of important permits, and potential lengthy appeal processes may impact the implementation of biomass energy projects. The Hawai‘i Bioenergy Master Plan provide a review of potentially applicable laws, permits, and permitting issues with respect to the biomass energy industry in Hawai‘i (Zapka 2009).

Technology-specific permitting and consultation requirements for a biomass energy project need to consider not only the construction and operation of an energy conversion facility such as a power plant or gasification facility, but also the feedstock production component and bioenergy distribution system. Permits required for the production and collection of common biomass feedstock such as agricultural residues, crops, forest and mill residues, and municipal waste should be in place as part of existing production operations. However, additional permitting may be required for the handling and transportation of feedstock such as municipal solid waste or animal waste. The development of new feedstock production operations or the expansion of existing operations may require new permits or modification of existing permits.

2.3.2.1.4 Representative Project

A representative biomass energy project would involve the direct combustion of biomass in a steam boiler to produce steam for electricity generation and industrial steam. This is a proven technology and has been used on the Hawaiian Islands for many years. For example, the sugar industry has long used bagasse as a fuel source to generate electricity to operate its mills, irrigation pumps, wells, and facilities (http://hcsugar.com/keeping-maui-green/energy-through-agriculture/). Similarly, a high-producing nut processing plant uses nut shells in a steam boiler to generate electricity for the nut processing plant and steam heat for the nut drying tanks (http://www.maunaloa.com/about/sustainability.asp).

The representative project would produce about 50 kilowatts (0.05 megawatt) of electricity. The boiler unit(s) would use a fibrous residue biomass material from either an agricultural or forest source. Biomass feedstock would be supplied by nearby sources either produced as part of the commercial or industrial operation for which the power is being produced or procured from local biomass producers. In either case, transportation of the biomass feedstock would be local and for relatively short distances (up to 5 miles).

The biomass steam generator would provide baseload electricity with a capacity factor of 80 percent, or 350,400 kilowatt-hours of electricity per year (Aabakken 2006). Biomass fuels such as bagasse, wood, straws, and nut shells all have essentially the same gross heating value on a moisture and ash free basis, about 20 mega Joules per kilogram (Kaupp 2013; Turn et al. 2005). Higher moisture and ash content reduce the heating value. For purposes of calculating the amount of biomass required to operate a representative 50-kilowatt biomass steam generator and the land area needed to produce the biomass, bagasse would be fired at 50 percent moisture with 3 percent ash content. Therefore, 1.53 kilograms of bagasse would need to be fired to produce each kilowatt-hour of electricity. This translates into an annual requirement of about 590 tons of bagasse to operate a 50-kilowatt plant at 80 percent capacity.

The average sugar cane production from 2010 to 2012 (24-month harvest cycle) was about 82 tons per acre (NASS 2013). The general ratio of bagasse to cane production is about 0.3, or about 12.3 tons of bagasse per 1 acre of sugar cane. Production of 590 tons of bagasse biomass would require about 48 acres of sugar cane. For the representative project, the sugar cane bagasse would be a byproduct of an existing agricultural operation; therefore, this PEIS does not consider existing agricultural conditions, related to water, fertilizer runoff, pesticide and herbicide use, or air emissions from burning cane fields.

Construction of the representative project would require clearing, grading, and leveling an area of about 2 to 4 acres for the boiler and turbine building, biomass handling and feed system, and temporary construction space. Construction would require approximately 30 workers for about 9 months. Operations would require 2 employees per shift. The energy facility would be adjacent to the commercial or industrial facility where the electrical power would be used. Therefore, road access and utility services such as water and sewer would exist nearby. Approximately 1 to 2 acres of land would be disturbed for the extension of water and sewer lines and also possibly new road access. Depending on the configuration of the power plant, electrical distribution lines could be either above or below ground but would be relatively short (less than 200 feet) because the power would be used close to the point of generation. The electrical steam generator would be connected to the local power grid to deliver excess power to the local electrical utility. This connection would be made through existing electrical utility services and would allow purchases of power when the steam generator is not operating.

The buildings would be about 20 feet tall with an emission stack height of approximately 60 feet. The steam boilers would produce carbon dioxide, nitrogen oxide, particulate matter, carbon monoxide, and sulfur dioxide emissions. Biomass combustion would produce ash waste, and ash-handling facilities would be integrated into the generating station. The representative project would produce about 18 tons of ash per year based on 590 tons of biomass fuel burned per year with 3 percent ash content. It is assumed that ash waste would be used on nearby agricultural fields as fertilizer, with some disposal in a landfill. Industrial noise would be produced from operation of the biomass handling facilities and removal of ash waste. Noise from the steam boilers and turbines mostly would be contained within the buildings.

Table 2-8 summarizes the specifications and capacities for the representative project.

Table 2-8. Steam Boiler Electricity Generation

Power Plant Specifications	Value
Production Capacity	50 kilowatt
Capacity Factor	80%
Energy Efficiency	25%
Kilowatt-hours per year	350,400
Construction Area (acres)	3 - 6
Construction Crew (9 months)	30
Operations Crew/shift	1 - 2
Biomass (50% moisture, 3% ash)	
Annual Requirement (tons)	590
Land Production Area (acres)	48
Ash Produced (tons)	18

2.3.2.2 Small-Scale Hydroelectric Systems

Hydroelectric power, or hydropower, utilizes the energy in flowing water to spin a turbine attached to a generator to produce electricity. The potential extractable energy in the water is determined by the product of the *head* and *flow* characteristics of a given hydro system. Head, measured in feet or units of pressure, is the vertical distance that water drops and, in the case of a conduit system, is a characteristic of the channel or pipe that water flows through before it interacts with the turbine. Flow measures the quantity of water, in cubic feet per second, flowing in a system (DOE 2001). Together, these factors determine the type of hydropower plant suitable for a given location.

Hydropower plants require a water source in a geographic area generally characterized by uneven terrain, such as hills or mountains, to have sufficient power-generation potential. There are three common types of hydropower plant designs: impoundment, diversion, and pumped storage hydropower (the latter is discussed in Section 2.3.5.5 of this PEIS). Ultimately, regardless of design, hydropower plants can be scaled to meet the size of a given hydro system, but the type of hydropower turbine technology used to generate electricity is dependent on the head and flow characteristics of the hydro system in question.

An impoundment hydropower plant captures water, via dam or other means, to store water in a reservoir and generate head. The annual downstream flow characteristics of rivers with impoundment plants are very stable compared to water availability upstream of the power plant, which can fluctuate greatly across seasons due to rainfall variations. The flow function of an impoundment is determined by the amount of water flowing into the reservoir. Diversion hydropower plants utilize the water flowing in a river to generate electricity without significantly impounding water, and are, therefore, subject to annual variations in rainfall. The flow, and thus the power-generating potential, is determined by the water available in the river. Any system where the water flowing into a hydropower plant is equal to water flowing out of the hydropower plant is known as run-of-the-river.

In general, impoundments utilize dams that control outflow to stabilize variations in inflow, while diversions are run-of-the-river. While there are exceptions, for the purposes of analysis, this PEIS approaches the technology from this general understanding.

2.3.2.2.1 Technology Description

The technical description for this section focuses on diversionary hydropower and hydropower from conduit systems made up of the pipes used to transport water in and around cities or towns. Typically, a diversion system falls into the DOE's small hydropower category, with a capacity between 0.1 to 30megawatts (DOE 2011a). While these power plants are not designed to store or regulate water flow like a dam, they typically have a component, known as a forebay tank (DOE 2001), for stabilizing short-term water availability, filtering sediments, and ensuring that only water enters the power plant, as air and debris can damage the turbine through cavitation, a phenomenon where bubbles formed by pressure in a liquid implode, damaging the turbine blades over time (BOR 2009).

In simplified terms, a diversion system works by redirecting a small portion of water from a river into a holding tank, forcing it through a pipeline, and then using the water to move turbines to generate power. The technical components of most diversion systems include an upstream intake, a forebay tank, a penstock for transporting the water to the powerhouse, the powerhouse itself (which includes all the necessary power generation and conversion equipment), and an outlet (or tailrace), where the water returns to the river (Figure 2-6). Distance from the water intake to the powerhouse can vary depending on the site and the desired head. Some sites may require the use of a penstock (pipeline for transporting water directly into the powerhouse) that is a mile or longer to optimize head, while some penstocks may be shorter when natural head created by a high waterfall is available. Typically, however, the powerhouse for a diversion system is close (i.e., using a short penstock) to the intake.

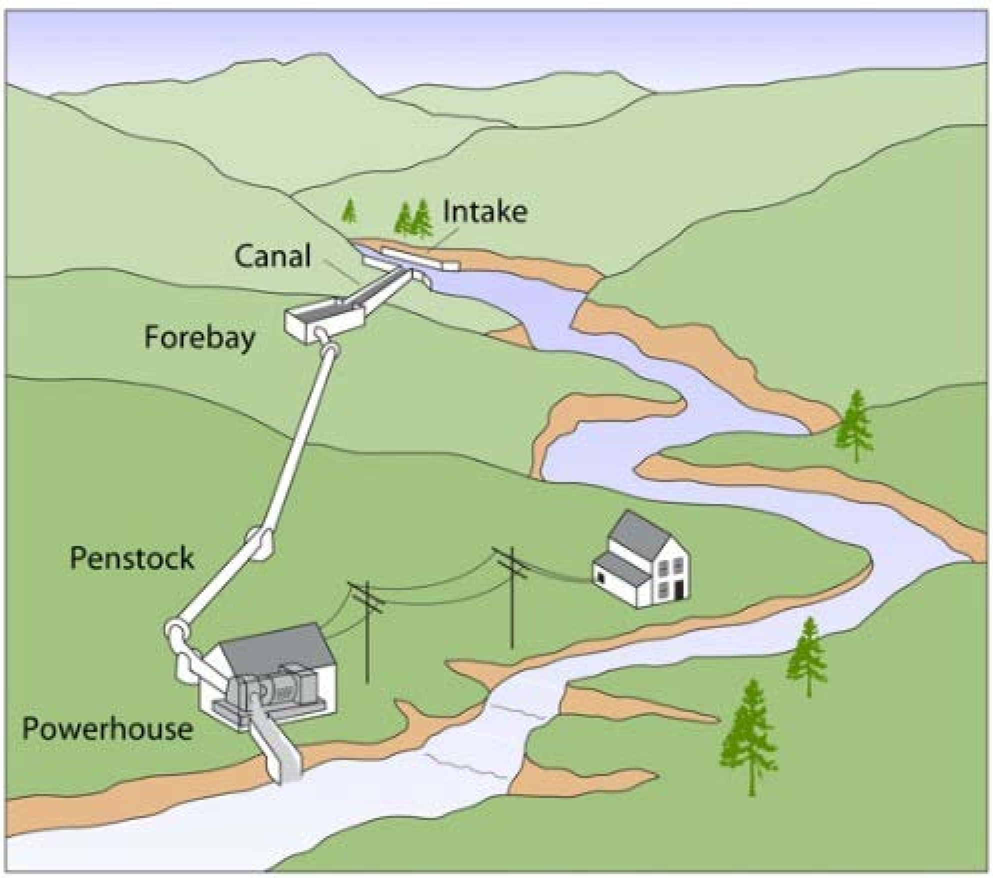


Figure 2-6. A Microhydropower System with Water Diverted into a Penstock (Source: DOE 2001)

There are two main types of turbines used to generate electricity in any size hydropower plant: impulse and reaction turbines. Impulse turbines rely on a high-velocity water jet striking the turbine, or runner blades, to spin the generator. Common types of impulse turbines include the pelton wheel and the turgo wheel. Ideal for low-flow, high-head application, pelton and turgo wheel designs have narrow nozzles that direct high-pressure (high-head) jets of water at a wheel with scooped-bucket-shaped blades.

Reaction turbines resemble propeller blades and, essentially, are submerged in a sealed housing filled with water. The runner speed is controlled by the pressure of the water on the runner within the housing. Typically, due to complexity and cost, reaction turbines are used in large hydropower applications, but can be scaled for smaller projects (DOE 2001).

As noted above, hydropower plants can be scaled to the size of the river and desired application; the footprint of the intake, forebay, penstock, powerhouse, and tailrace likewise can scale with the size and site requirements. As a point of reference, a powerhouse for a 4-megawatt generator and associated equipment would be roughly the size of a 1-room cabin (16 × 28 feet). In addition to the plant footprint, a hydropower facility may require the construction of transmission or distribution to connect to the power grid. For remote locations, new access roads may be required to transport equipment and power plant workers. Development of small, non-grid connected systems used for local power generation would not require extensive transmission lines; however, access roads and cabling may be required to connect electricity from the powerhouse to the house, farm, or small business using the power.

Separate from diversion systems, conduit hydropower systems can be installed in existing systems used for water transportation. Such systems use turbine technology that generates power based on flow of water, rather than requiring an impoundment for creating potential energy in the form of stored head (DOE 2004b). In conduit hydropower systems, power-generating equipment is installed within the water system, utilizing the existing flow. Such systems are cost- and time-effective by making use of an existing municipal or irrigation system that delivers water in and around cities.

2.3.2.2.2 Characterization of Technology Feasibility and Deployment

Hawai‘i’s geography is characterized by variations in elevation, high levels of rainfall, numerous waterways, and uneven terrain. While not conducive to utility-scale hydropower (Section 2.3.3.3), such conditions can be suitable for diversion hydropower generation. To that point, the islands of Hawai‘i and Maui currently operate systems ranging from 0.5 megawatt to 11 megawatts (HECO 2013b). Furthermore, there are eight small hydroelectric plants in operation on the island of Kaua’i, ranging from 0.13 megawatt to 1 megawatt. Developers have also conducted additional feasibility assessments on sites that can generate between 4 megawatts and 8 megawatts, if constructed. Due to availability of hydroelectric resources, future development interest has primarily been directed at the islands of Hawai‘i and Kaua‘i. Along with Maui, these islands have an extensive irrigation system that is no longer used for agriculture, but has been highlighted as upgradeable for use with diversion hydropower and pumped storage (USACE 2011). Furthermore, many plantations currently use hydropower systems for irrigation. While many have fallen into disrepair, they could be revitalized and used to support new hydropower facilities.

Constructing and successfully operating new power plants depends on a number of technical and political factors. A 2011 assessment by the Army Corps of Engineers investigated the various elements that could affect the feasibility of a diversion hydropower system in the Hawaiian Islands (USACE 2011). Finding:

- A site is considered potentially economically feasible if it can produce energy comparable with the O‘ahu HECO rate of $0.25 per kilowatt-hour.

- The degree of feasibility for hydropower is largely determined by the available locations.
- Ideally, hydropower would be installed in an area with adequate transmission line connectivity and proper land use rights.

Additional feasibility issues related to environmental and social concerns over land use may present large socio-political factors to consider. Along with the State's contentious water rights, issues regarding protected lands and tourism considerations may block access to otherwise ideal water resource sites.

The USACE's report identified the Waimea Canyon ditch system on Kauaʻi as a viable location for a diversionary hydropower plant. It is the site of two small hydropower plants and has an extensive network of irrigation and reservoirs. Like many potential projects, it can be combined with additional existing or planned public works projects such as flood control and sediment management. A renewal of hydropower, especially on the small scale, could contribute much to HCEI's goals. Small hydropower can boost production in isolated areas.

2.3.2.2.3 Permitting and Consultation Requirements

Permitting and consultation requirements for distributed hydroelectric in Hawaiʻi are likely to be more general in nature (see Section 2.2.5). In-stream flow is heavily regulated and monitored by the State of Hawaiʻi Department of Land and Natural Resources, Commission on Water Resource Management, when multiple users are accessing the same waterway. To minimize conflict, it is recommended developers consult all potential waterway users and regulators prior to any type of use or diversion for hydropower. In addition, various State agencies now control or maintain old water ditches, which can further impact the siting and permitting of in-stream hydropower as use of State facilities triggers other processes (e.g., public auction) and permits (e.g., environmental assessment or environmental impact statement).

2.3.2.2.4 Representative Project

Diversion

A representative project would be located at a site identified with sufficient head and flow characteristics to sustain regular power generation, ideally on a steep slope or close to a waterfall. Typically, this would be a rural area, on a farm, park, or similar site. The hydropower plant would be designed to generate up to 10megawatts of electricity, utilizing either pelton wheel or turgo wheel technology, and require a shorter penstock due to the relative slope of the ideal deployment location. System configuration sizes may vary, depending on the river resource as well. Depending on the location, these power plants may also require construction of transmission or distribution lines to ensure grid connectivity.

Conduit Hydro

A conduit hydropower system would be composed of a kinetic turbine and generator system rated from small kilowatt sizes up to 6megawatts to meet the municipal water flow of the chosen site. This technology would be installed at a water distribution/pressure control facility. The representative project would be located in an existing site; therefore, no new transmission or distribution lines would be needed.

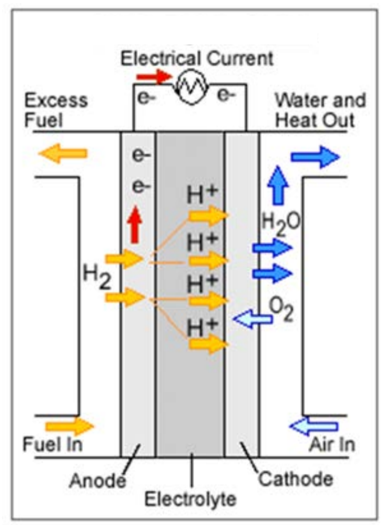
2.3.2.3 Hydrogen Fuel Cells

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. A hydrogen fuel cell uses the chemical energy of hydrogen to react with oxygen to produce electricity. Fuel cells can be used for almost any application typically powered by batteries or internal combustion engines, and can scale to provide energy to a laptop computer or to a utility power station. Fuel cells produce no criteria air pollutants or greenhouse gas emissions at the point of operation. While there are associated byproducts from manufacturing and decommission fuel cells, the scope of this PEIS is construction and operation of renewable energy projects and, therefore, it does not address this topic. Readers are directed to the many available Internet resources on fuel cell byproducts (e.g., http://www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/systems.html).

The following sections focus on hydrogen fuel cell use as a potential replacement for traditional electricity generation. This PEIS discusses hydrogen-powered vehicles in Section 2.3.4.4.

2.3.2.3.1 Technology Description

A single fuel cell consists of an electrolyte and two catalyst-coated electrodes. Electricity is generated when hydrogen feeds to the negative electrode (anode) where a catalyst, often platinum, separates hydrogen's negatively charged electrons from positively charged protons (Figure 2-7). The electrons from the anode cannot pass through the electrolyte to the cathode and must travel around it via an electrical circuit to reach the other side of the cell. The movement of electrons is an electric current (DOE 2010a). At the positively charged electrode (cathode), the positively charged protons and the negatively charged electrons combine with oxygen to form water and heat. The amount of power produced by a fuel cell depends on the fuel cell type, cell size, temperature at which it operates, and pressure at which the gases are supplied. Combining individual fuel cells into *fuel cell stacks* increases the amount of electricity generated The scalability of a fuel cell stack enables fuel cells to operate a wide variety of applications, including laptop computers (20 to 50 watts), homes (1 to 5 kilowatts), vehicles (50 to 125 kilowatts), and central power generation (1 to 200 megawatts) (DOE 2010b).



Source: DOE 2011b

Figure 2-7. Illustration showing Chemical Reaction of a Fuel Cell

Fuel cells can provide stationary power for buildings and power for transportation applications. Stationary fuel cells provide backup power, power for remote locations, distributed power generation, and cogeneration. This section focuses on fuel cell use for stationary application.

In general, all fuel cells have the same basic configuration, an electrolyte, an anode, and a cathode; the difference is the type of electrolyte used. The electrolyte determines the kind of chemical reactions that take place within the fuel cell, the temperature range of operation, and other factors that determine its most suitable applications. Each fuel cell type has its own advantages, limitations, and potential applications (DOE 2011b), as the following addresses:

- Polymer Electrolyte Membrane Fuel Cells - Also called proton exchange membrane fuel cells, these fuel cells have a high *power density* (amount of power delivered by volume) due to their low weight and volume. They use a solid polymer as an electrolyte and porous carbon electrodes containing a platinum catalyst. They need only hydrogen, oxygen from the air, and water to operate. They are typically fueled by pure hydrogen supplied from storage tanks or on-board *reformers*, devices that extract hydrogen from hydrocarbon or alcohol fuels.

  Polymer electrolyte membrane fuel cells operate at relatively low temperatures (around 176°F), which allows them to start quickly and results in less wear on system components. However, the low temperature requires a noble-metal catalyst, such as platinum, to separate the hydrogen's electrons and protons. Not only is platinum expensive, it is extremely sensitive to carbon monoxide in the fuel gas. However, the platinum can be recovered at the end of the fuel cell's operating life.

Polymer electrolyte membrane fuel cells are used primarily for transportation applications and some stationary applications. However, due to their fast startup time and high power density, they are particularly suitable for use in passenger vehicles such as buses and cars.

- Alkaline Fuel Cells – This type of fuel cell was one of the first fuel cell technologies to be developed and was widely used in the U.S. space program to produce electricity and water on spacecrafts. They use a solution of potassium hydroxide in water as the electrolyte and can use non-precious metals as a catalyst. These older, high-temperature alkaline fuel cells operate between 212° and 482°F, while newer designs operate at lower temperatures of 74° to 158°F.

  Alkaline fuel cells are easily poisoned by carbon dioxide, even that occurring in the air, and thus need to purify the oxygen in the atmosphere before use. The susceptibility to carbon dioxide also reduces the cell's lifetime. As a result, this type of fuel cell would not be competitive in commercial applications.

- Phosphoric Acid Fuel Cells – Phosphoric acid fuel cells use liquid phosphoric acid as an electrolyte and porous carbon electrodes containing a platinum catalyst. Considered the first-generation modern fuel cells and the first to be used commercially, the phosphoric acid fuel cell typically generates stationary power, but has been used to power large vehicles such as city buses.

  Phosphoric acid fuel cells are more tolerant of impurities in fossil fuels that have been converted into hydrogen than polymer electrolyte membrane cells. They are 85 percent efficient when used for the cogeneration of electricity and heat, but only about 40 percent efficient when generating electricity alone. This is only slightly more efficient than combustion-based power plants. They are less powerful than other fuel cells of the same weight and volume, and the expensive platinum catalyst raises the cost of the fuel cell.

- Molten Carbonate Fuel Cells - Currently being developed for use in natural gas and coal-based power plants, molten carbonate fuel cells are high-temperature fuel cells that use an electrolyte composed of a molten carbonate salt mixture suspended in a porous, chemically inert ceramic lithium aluminum oxide matrix.

  Molten carbonate fuel cells can operate at very high temperatures, about 1,200°F, which is advantageous because non-precious metals can be used as a catalyst and the fuel cell can convert hydrogen to fuel without an external reformer. When coupled with a turbine, these fuel cells can reach efficiencies of about 65 percent. Further, molten carbonate fuel cells are not susceptible to carbon monoxide or carbon dioxide poisoning and can thus be fueled with gases made from coal.

  The primary disadvantage of these fuel cells is durability. The high temperatures and corrosive electrolyte cause increased component breakdown and corrosion, which decreases cell life compared to other types of fuel cells.

- Solid Oxide Fuel Cells – Solid oxide fuel cells use a hard, non-porous ceramic compound as the electrolyte and are expected to be about 50 to 60 percent efficient. Similar to the molten carbonate fuel cells, these fuel cells operate at very high temperatures of about 1,830°F and can use a non-precious metal catalyst and reform fuels internally.

The high operating temperatures results in a slow startup and requires significant thermal shielding. Durability of components is also an issue.

- Direct Methanol Fuel Cells - Unlike most fuel cells that are powered by hydrogen fed into the system directly or generated within the fuel cell system, as the name implies, direct methane fuel cells are powered by pure methanol, which is mixed with steam and fed directly to the fuel cell anode.

  This technology is relatively new compared with that of pure hydrogen-powered fuel cells, and its research and development is about four years behind that of other fuel cell types, which means it is not yet suitable for commercial development.

Hydrogen Production

The development of processes that can produce clean and cost-competitive hydrogen is one of the keys to the successful implementation of the hydrogen fuel cell. The following are some basic facts about hydrogen that affect its usability for energy production (DOE 2011d):

- Hydrogen combines readily with other elements and is almost always found as part of another substance, such as water, biomass, or hydrocarbons. Therefore, it must be separated from compounds that contain it.

- Hydrogen can be produced using domestic resources, including fossil fuels (such as natural gas and coal) and biomass, or by using nuclear energy and renewable technologies such as geothermal, wind, and solar to split water. This diversity of supply is an important reason why hydrogen has a large potential as an energy carrier.

- Hydrogen can be produced at either large central plants or in small distributed units located at or very near the point of use.

Hydrogen can be produced via a range of different technologies, each with its own advantages, disadvantages, and environmental impacts.

- Renewable Electrolysis - Electrolysis uses an electric current to split water into hydrogen and oxygen. Although the electricity can be generated from any source, as its name implies, renewable technologies that utilize wind, solar, geothermal, and hydroelectric power are preferred. Because of the variable nature of wind and solar electricity production, excess electricity produced during times of high wind or sunshine can generate hydrogen that can be stored and used to produce electricity during times of low wind or low sun.

- Natural Gas Reforming – Natural gas can produce hydrogen by using high-temperature steam in a process called “steam methane reforming.” This process accounts for about 95 percent of the hydrogen used today in the United States (DOE 2010c). Another method, called “partial oxidation,” produces hydrogen by burning methane in air. Both steam reforming and partial oxidation produce a “synthesis gas,” which reacts with additional steam to produce a gas with higher hydrogen content.

  Solid oxide fuel cells and carbonate fuel cells often use an internal reformation process due to their high operating temperatures. As a result, fuels convert to hydrogen within the fuel cell itself and do not require an external reformer. Larger commercial operations often use this technology so they can use natural gas as a fuel. Although the conversion of natural gas to hydrogen within the fuel cell would result in some greenhouse gas emissions, the amount of greenhouse gas released would be less than that from the combustion of natural gas in a conventional engine.

- Gasification - Gasification is a thermal process in which coal or biomass is converted into gaseous components by applying heat under pressure in the presence of oxygen and steam. The biomass is broken apart to produce a synthesis gas, which then reacts with steam to produce a gas stream with an increased hydrogen concentration that can be separated and purified. With carbon capture and storage, hydrogen can be produced from coal with only minor greenhouse gas emissions. Because growing biomass consumes carbon dioxide in the atmosphere as part of the natural growth process, biomass can produce hydrogen with near-zero net release of greenhouse gas emissions.

- Renewable Liquid Reforming - Biomass resources can be converted to ethanol, bio-oil, or other liquid fuels that can be relatively easily transported to the point of use and then reformatted with steam at high temperatures to produce hydrogen.

- High-Temperature Thermochemical Water-Splitting - High temperatures generated by solar concentrators (mirrors that focus and intensify sunlight) or nuclear reactors can drive a series of chemical reactions that split water into hydrogen and oxygen.

- Biological Processes - Certain microbes, such as green algae and cyanobacteria, produce hydrogen as a byproduct of their natural metabolic processes by splitting water in the presence of sunlight. Other microbes can produce hydrogen directly from biomass.

- Photoelectrochemical Processes - Sunlight and a special type of semiconductor material can produce hydrogen from water. The highly specialized semiconductors absorb sunlight and use the light energy to separate water into hydrogen and oxygen.

Hydrogen Delivery

Hydrogen produced at centralized locations requires infrastructure to move the hydrogen to where it is used in a fuel cell. This infrastructure can include pipelines, trucks, ships, and barges to carry the fuel and the facilities and equipment to load and unload the hydrogen. Producing the hydrogen at the site of the fuel cell rather than at a centralized location (known as distributed production) can reduce the potentially high costs of transportation.

Readers are directed to the DOE website on hydrogen fuel cells for more detailed information about the above topics: http://www1.eere.energy.gov/hydrogenandfuelcells/

2.3.2.3.2 Characterization of Technology Feasibility and Deployment

The major challenges facing the commercialization of fuel cell technology include a reduction in production costs, improved durability (DOE 2011c), and creation of a distribution infrastructure. In order to be a viable alternative, fuel cell systems must be cost-competitive with, and perform as well or better than, traditional power technologies over the life of the system. Ongoing research is focused on identifying and developing new materials that will reduce the cost and extend the life of the systems without decreasing performance.

In 2001, the State of Hawaiʻi commissioned the Hawaiʻi Natural Energy Institute (HNEI) to prepare a hydrogen and fuel cell feasibility study, with a revision in 2004. The study, as revised, concluded that geothermal-electricity-produced hydrogen on the Island of Hawaiʻi and biomass-produced hydrogen on

Hawaiʻi, Maui, and Kauaʻi could eventually compete with the price of gasoline and that liquefied natural gas-produced hydrogen on Oʻahu could also be cost competitive, but that the lack of infrastructure for liquefied natural gas could prohibit development (HNEI and Sentech 2004). Although the study concluded that hydrogen produced from wind electricity on Hawaiʻi, Maui, and Kauaʻi would not be cost effective due to the intermittency of the wind resource, curtailed wind might be a source for producing hydrogen economically. An island-by-island technical feasibility for producing hydrogen, as determined by that study, follows (HNEI and Sentech 2004):

- Hawaiʻi - Possesses the greatest diversity of renewable resources, including solar, wind, biomass, and geothermal. It is the only island with a geothermal power plant, and off-peak electricity is often available from which to produce hydrogen. The island contains airports, commercial resorts, commercial agriculture, and a tourist industry that potentially could use electricity made by fuel cells. Although the study concluded that the limited population and large size of the island would limit the application of hydrogen, there is potential to convert the island's bus system to hydrogen. The hydrogen could be produced from electricity generated from geothermal or curtailed wind.

- Oʻahu - Contains the greatest population, including the urban center of Honolulu. The large population represents the greatest opportunity to use hydrogen and fuel cells. Urban issues such as electricity transmission limitations, power quality, and commercial peak power create a potential market for fuel cells, but electricity demand patterns and limited availability of renewable resources decrease the ability to produce hydrogen. Sources of hydrogen from imported oil are available from the existing refinery and synthetic natural gas capability, but this source of hydrogen still requires the importation of fossil fuel products and is not considered a renewable resource.

- Maui and Kauaʻi - Both islands have biomass, solar, and wind resources. Maui also has geothermal resources that are being developed. The large biomass availability makes hydrogen gasification an option.

No large-scale use of stationary hydrogen fuel cells exists within the State of Hawaiʻi. This is due, in part, to the high cost of producing hydrogen as a fuel source. Although natural gas is used as a primary fuel for fuel cells in the continental United States and other countries, natural gas is not readily available in Hawaiʻi and synthetic natural gas derived from fossil fuels is not a renewable resource (HCEI 2010). Consequently, HNEI has been conducting hydrogen research since 1983 and is making advances in hydrogen production using biological techniques, gasification of biomass, and the solar splitting of water into hydrogen and oxygen using photoelectrochemical devices (HNEI 2013a). In addition, private companies are working to develop processes and procedures to produce gaseous products from renewable feedstock, such as plant oils and animal fats, that could be used to produce hydrogen (HREDV 2013).

Hawaiʻi's emphasis in hydrogen fuel cell use has been with transportation vehicles rather than in stationary power plants. A modular hydrogen production and fueling station for hydrogen vehicles has been in operation at Hickam Air Force Base since 2006. (Section 2.3.4.4 of this PEIS discusses hydrogen vehicles and their hydrogen production and fueling systems.) The United States military recently began developing and deploying stationary hydrogen fuel cells. In 2012, Joint Base Pearl Harbor-Hickam announced that it will build a 100-kilowatt power system using polymer electrolyte membrane fuel cells. Although the energy system will not account for the base's entire energy needs, it will provide the base with additional stationary power flexibility and energy security capabilities (Hydrogen Fuel News 2012).

Hydrogen produced by electrolysis of water from geothermal, solar or wind electricity, biological techniques, and gasification of biomass could contribute to HCEI goals of meeting 40 percent of the

State's energy needs through renewable energy by 2030. Electrolysis technologies are commercially viable today, but biological technologies are still mainly in the research phase and are not yet commercially available at a scale that would greatly impact the State's renewable energy needs. Gasification of biomass is still in the research phase, but getting close to commercial availability (DOE 2012f). Using natural gas, including renewable natural gas produced from renewable feedstock, to fuel the fuel cells could be a bridge to a renewable hydrogen future and could thus help meet HCEI's goals of using renewable energy.

The potential to reform fuel cell grade hydrogen from natural gas in Hawaiʻi is currently limited to areas that can be supported by infrastructure for natural gas in urban Oʻahu. As natural gas infrastructure expands, so would the technical feasibility of hydrogen production for use in fuel cells.

Outside of Hawaiʻi, hydrogen fuel cells are being installed as part of commercial and public policy. The world-wide developments include:

- Within the continental United States, a growing number of Fortune 500 and other companies are purchasing fuel cells for backup electrical power and for distributed electricity generation. Depending on the company that is building and selling the fuel cell, the fuel cell systems are usually sold in modules of 200 or 300 kilowatts, 1.4 megawatts, or 2.8 megawatts. The technology is usually either solid oxide fuel cells or molten carbonate fuel cells and utilizes natural gas, wastewater treatment gas, propane, coal gas, and biogas as the fuel source. Existing commercial fuel cells do not normally use purified hydrogen gas as their fuel source, but rather generate the hydrogen within the fuel cell from the other fuel sources. Fuel cell systems totaling greater than 32 megawatts were purchased in the year 2012 (Fuel Cells 2000 2012). Some of the top fuel cell power users in the continental United States include AT&T (17.1 megawatts at 28 sites), Wal-Mart (10.4 megawatts at 26 sites), eBay (6.5 megawatts at 2 sites), and Apple (5.3 megawatts at 2 sites) (Fuel Cells 2000 2012). The fuel cell systems are compatible with, and complement, other energy technologies such as natural gas, biogas, solar, wind, and batteries.

- Other countries, most notably Japan, Germany, and South Korea, have policies in place to promote fuel cell technology. Japan is focusing primarily on small, 1-kilowatt fuel cell units primarily for single-family homes. The fuel cells run on either liquefied petroleum gas or natural gas, but the majority uses natural gas as fuel (ORNL 2011). Germany is still largely in the research and development phase due to limited funds. South Korea, which is 97 percent dependent on imported energy, has committed to a low-carbon energy future and selected hydrogen and fuel cells as one of the new energy sources. South Korea is implementing 1-kilowatt fuel cells for both home systems and larger systems for power generation (ORNL 2011). Construction on a 58.8-megwatt stationary fuel cell plant using molten carbonate fuel cell technology and natural gas for fuel was scheduled to begin in late 2012 (Fuel Cell Today 2012).

In an effort to increase the feasibility of hydrogen fuel cell technology in Hawaiʻi, DOE awarded DBEDT a contract to develop a hydrogen power park project in the State of Hawaiʻi in October 2002. DBEDT in turn contracted with HNEI to implement the project (HNEI 2013b). The power park provides an opportunity for operating integrated hydrogen energy systems (including providing stationary power and dispensing hydrogen for hydrogen-fueled vehicles), measuring operational results, and evaluating technical and economic performances. The project has completed initial testing of various full-scale components and installed and tested an integrated wind-solar hydrogen production and fuel cell power system at Kahua Ranch, which is near the north end of the Island of Hawaiʻi. The State chose this location because it has excellent wind and solar resources and has been used to test wind-to-hydrogen and solar-to-hydrogen hydrogen generation systems (HNEI 2013b).

The Hawai‘i power park project expanded to include the building of a hydrogen production and fueling station (HNEI 2013b). Under this expansion, DOE and the State of Hawai‘i provided additional funding to HNEI to build a hydrogen production and dispensing station that was originally intended to be installed at Hawai‘i Volcanoes National Park to support its Hydrogen Shuttle Bus project. However, delays in the acquisition of shuttle buses, the arrival of a fleet of General Motors Equinox fuel cell electric vehicles on O‘ahu, and the start of a new project to produce hydrogen at the Puna Geothermal Venture power plant on Hawai‘i island resulted in relocating the hydrogen production and dispensing station to the Marine Corps base Hawai‘i on O‘ahu. Originally built as a 350 bar (5,000 psi) system, the hydrogen dispensing system on the Marine Corps base is being upgraded to 700 bar to support the General Motos Equinox fuel cell electric vehicles deployed on O‘ahu. The Puna Geothermal plant will produce the hydrogen for the Hawai‘i Volcanoes National Park hydrogen dispensing system and deliver the hydrogen by road to the Park, providing the hydrogen requirements for the Hydrogen Shuttle Bus project (HNEI 2013b).

Centralized hydrogen production using electricity generated by geothermal, wind, or solar would need to be located near those geothermal, wind, and solar sources for hydrogen production to be economical. Hydrogen could be produced during times of low electricity demand, stored, and delivered to distributed fuel cells when needed. The hydrogen generated from centralized production would require an infrastructure to transport the hydrogen from the point of production to the point of use. Depending on scale, this could include pipelines or truck transportation. HNEI anticipates installing a hydrogen production facility at the Puna Geothermal plant. The electrolyzer is being tested as a grid management tool to help regulate grid frequency while at the same time producing hydrogen as a value-added product to support transportation (HNEI 2012c). Trucks will transport the hydrogen produced at the plant via road to support fuel cell electric buses the County of Hawai‘i Transit Agency and the Hawai‘i Volcanoes National Park are operating. The hydrogen could also be used to provide peak power support to the grid utilizing stationary fuel cells.

Distributed hydrogen production could use smaller wind or solar resources at the site of the fuel cell to generate electricity to produce hydrogen from water via electrolysis.

2.3.2.3.3 Permitting and Consultation Requirements

Even as a distributed energy source, most hydrogen fuel cells likely would be constructed in areas that already contain buildings and an existing electrical grid. Construction within existing developed areas likely would not need environmental permits such as protected species, sensitive environments, and cultural and archaeological impacts (see Section 2.2.5).

2.3.2.3.4 Representative Project

This PEIS analyzes a representative project to provide a perspective of the potential environmental impacts that could be expected from a distributed-scale fuel cell project. The representative project is hypothetical and is not intended to reflect actual or planned proposals at any specific location. In general, fuel cells have a small footprint, produce little noise or hazardous waste, and produce fewer criteria air emissions than a comparable generator.

A representative hydrogen fuel cell project in Hawai‘i would possibly be different than a representative fuel cell project in the continental United States. Whereas fuel cell projects on the mainland tend to be fueled by natural gas, near-term hydrogen fuel cell projects in Hawai‘i likely would be powered directly by hydrogen produced from electrolysis processes using geothermal, solar, or wind electricity; from biomass; or from biological production methods if existing research proves to be commercially viable.

5-kilowatt Fuel Cell Power System

The representative project is a 5-kilowatt fuel cell power system designed for use by a single-family residence. The power system would be housed in a container either inside or outside the residence and would use stacks of fuel cells in a modular system to produce the power output specified. The hydrogen would be produced onsite as part of the modular system using water and electricity for the electrolysis process or be purchased from a centralized hydrogen production facility. Electricity for the electrolysis process could be supplied either via the existing electrical grid or via renewable resources at the site such as solar or wind.

Different manufacturers have different specifications for their fuel cells and hydrogen generators. The specifications this PEIS uses represent approximate consumptions and fuel uses and are not intended to reflect any actual project or product.

Individual hydrogen fuel cells are stacked together in racks as part of a modular system. According to various product specifications, the rack for a hydrogen fuel cell system that produces 5 kilowatts of electricity would be about 5 × 2.5 × 7 feet in size and weigh about 2,300 pounds. Assuming that a fuel cell produces 15 kilowatt-hours of electricity per kilogram of hydrogen consumed, about 0.33 kilogram (0.73 pound) of hydrogen would be required per hour for a 5-kilowatt fuel cell system.

Enough hydrogen would need to be produced at the site of the fuel cell power system to meet the consumption requirements of the fuel cells if the hydrogen is produced onsite by electrolysis. The electrolyzer would have to be 6 × 3 × 6 for the fuel cell to produce sufficient kilowatt-hours for the project. The unit would require about 28 kilowatt-hours of electricity and about 1 gallon of deionized water per hour. Table 2-9 provides a brief description of operational parameters for a 5-kilowatt fuel cell power system.

Table 2-9. Operational Parameters for a 5-kilowatt Fuel Cell Power System

Project Parameters (associated with resource areas)	Operational Parameter
Site disruptions (cultural, biological)	None. Built in developed areas next to (or inside of) existing buildings
Air emissions	None
Noise generated	Depending on the technology, less than 60 dBA at 3 feet for fuel cell, 80 dBA at 3 feet for hydrogen electrolyzer system
Waste generated	None
Infrastructure	Hydrogen production uses electricity and water
Size of facility	Small indoor or outdoor containers (fuel cells grouped in racks)
Visual aesthetics	Small indoor or outdoor containers
Location	Next to existing facilities

Scaling of the Representative Project

The representative project could be scaled up to a larger fuel cell power system designed for use in the average commercial system. Existing hydrogen fuel cell systems and hydrogen-production systems are modular and stack individual fuel cells and hydrogen-production units together to produce the desired power output. Consequently, the operational parameters for fuel cell systems of increasing size tend to be linear with respect to size. For example, each individual 5-kilowatt fuel cell system would produce the same amount of electricity, consume the same amount of hydrogen, and have the same emissions, whether a single fuel cell system is used or 10 fuel cell systems are grouped for a 50-kilowatt system.

Likewise, the space required for the fuel cell stacks of a 5-kilowatt system would increase linearly for larger systems (even though the required space may vary slightly due to specific system layouts).

2.3.2.4 Photovoltaics

Photovoltaic cells convert sunlight to electricity. Photovoltaic cells are assembled into a solar *module*, or group of PV cells. Solar modules are placed in an area or added to a larger system to generate and supply electricity for homes and businesses. A system typically includes one or more solar modules (sometimes referred to as an *array*), equipment to convert direct current (DC) electricity to alternating current (AC) electricity (i.e., inverters), and connecting wiring. Some systems are designed with batteries to store the generated electricity for later use and/or sun tracking devices to increase the amount of solar energy collected.

Photovoltaic systems can be located on rooftops or mounted on racks on the ground. The systems can connect to the local electrical transmission grid or can operate as stand-alone systems. Stand-alone systems can be used with or without batteries. Solar modules have a typical life span of 20 to 30 years. The National Renewable Energy Laboratory determined that life-cycle greenhouse gas emissions from solar modules were significantly less than fossil and nuclear electricity generation, as well as many other renewable energy technologies (NREL 2012a).

2.3.2.4.1 Technology Description

When sunlight shines on a PV cell, the cell absorbs a portion of the light. The energy of the absorbed light transfers to some of the electrons in the atoms of the PV cell’s material. Those electrons escape from their normal positions in the atoms and become part of the electric flow, or electricity. The amount of energy from the sunlight that converts to electricity depends on a number of factors, including the wavelength of the light, the amount of light absorbed, the temperature of the photovoltaic cell, and the resistance of the materials to the electrons’ flow. Capacity factors among the different photovoltaic cell materials and designs range from about 6 to 40 percent. Typical commercially available modules used in distributed, or small-scale, installations range from 15 to 20 percent.

The generated electricity is Direct Current (DC) and must be converted with one or more inverters to Alternating Current (AC) before use. The electricity can either be used onsite or transmitted to the local utility grid and used in nearby homes and businesses. Stand-alone systems without batteries produce electricity only when there is a light source. Stand-alone systems with batteries produce electricity when there is light and will store the excel electricity in the battery for later use. Users can draw electricity from the batteries with or without a light source.

Distributed photovoltaic systems connected to the grid will produce electricity during the day, and send excess electricity to the local utility distribution grid. During periods when the photovoltaic system is not operating (i.e., no light source), the photovoltaic customer’s electricity needs can be met from the local utility distribution grid. Depending on the local regulations, the utility either buys the excess electricity or provides offset credits that can be used when a customer draws energy from the local grid. Figure 2-8 is a diagram of the major items of a distributed photovoltaic system connected to a local utility distribution grid, and Figure 2-9 is a diagram of a stand-alone system with battery storage.

A less-common but possible configuration is a grid-tied distributed PV system that includes batteries and the ability to disconnect from the grid during outages. This allows the customer to power the residence using stored electricity when the grid is down, without endangering utility personnel.

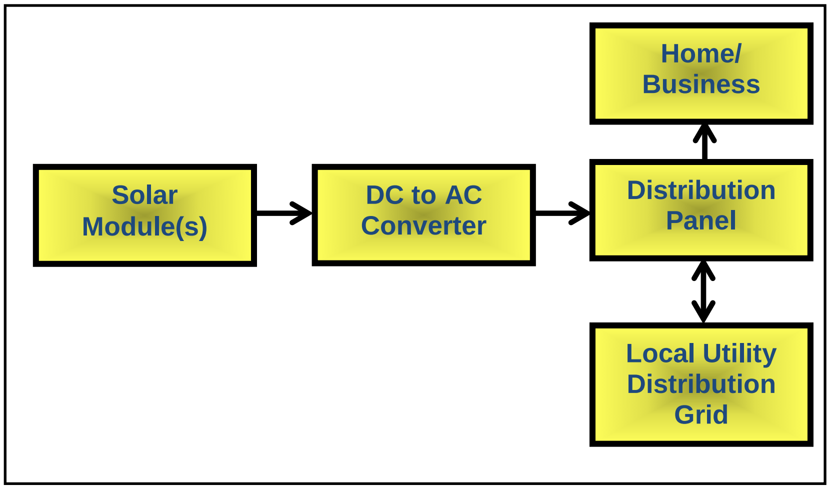


Figure 2-8. Diagram of the Major Items of a Distributed PV System Connected to a Local Utility Distribution Grid

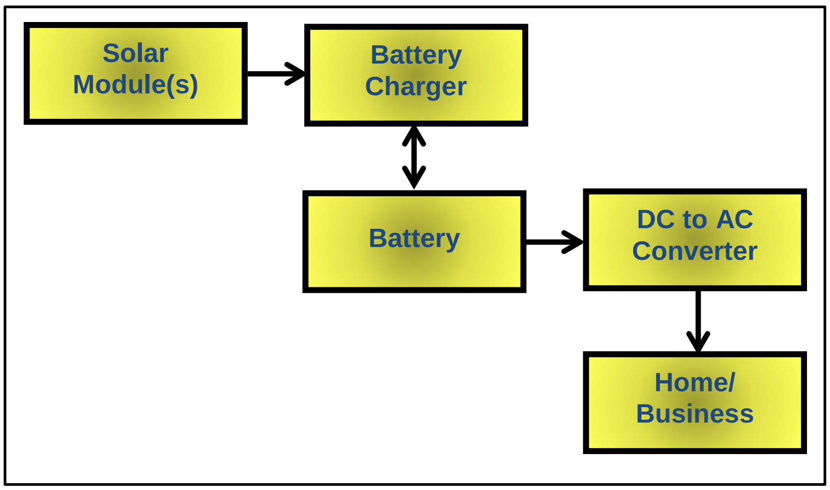


Figure 2-9. Diagram of the Major Items of a Stand-Alone Distributed PV System with Battery Storage

There are a multitude of distributed photovoltaic system designs derived from the basic systems to meet individual customers' needs. Additional information and resources on solar can be found online at the following sites: http://energy.hawaii.gov and http://energy.gov.

2.3.2.4.2 Characterization of Technology Feasibility and Installation

Distributed photovoltaic systems are a mature and reliable renewable energy technology. The DOE SunShot Initiative is a national collaborative effort to make solar energy cost-competitive with other forms of electricity by the end of this decade (DOE 2013c). The State of Hawai‘i has ideal sun conditions for distributed photovoltaic systems. The HECO website provides additional information on site considerations for solar systems: http://www.Hawaiianelectric.com/portal/site/heco/menuitem.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=3b0ac44a75709310VgnVCM10000005041aacRCRD.

The number of photovoltaic systems in Hawai‘i has increased exponentially over the last five years. As of 2011, the State of Hawai‘i is third in the Nation for the amount of installed photovoltaic capacity; most of which is distributed solar. Homes and businesses have roofs that are large enough for installation of these systems.

HECO has established limits for the percentage of distributed electricity (for all sources not just solar) that can be generated for a distribution circuit. This maximum percentage was established to protect the local grid from electricity overload from the distributed electricity generation sources. Once this percentage is reached, no additional installations would be permitted until adequate feasibility studies were conducted to determine if the distribution circuit could maintain stability with a higher distribution load. This effectively halted additional installations on those circuits that were at the maximum percentage. HECO recently raised the percentage, which nearly doubled of the amount of distributed electricity generation allowed before requiring a costly and time-consuming study. However, as photovoltaic and other distributed electricity generation systems are added to the grid, the new maximum percentage could be reached again. This could result in a requirement for feasibilities studies and possibly further revision of the limit (IREC 2013).

2.3.2.4.3 Permitting Requirements

General permits requirements are discussed in Section 2.2. Many solar modules contain substances that could pose a risk to the environment and potentially to public health if not properly disposed of or recycled. There are industry initiatives to develop recycling guidelines and processes for solar modules. Currently some discarded solar modules may need to be managed and disposed of as hazardous waste. Batteries and electrical equipment also may need to be managed and disposed of as hazardous waste. State law requires that battery sellers accept and recycle used batteries. More information on the management of used batteries and electrical/electronic equipment can be found at http://www.opala.org/solid_waste/eWaste.html.

There have been issues with delays and costs associated with installations in areas that are near their distribution percentage maximum (see previous discussion). However, HECO’s recent action should mitigate such delays and additional costs.

2.3.2.4.4 Representative Project

The representative project involves a typical distributed photovoltaic project for a home or business installation. Regardless of home or business, the system would be mounted on the rooftop. The representative project assumes a typical home 5-kilowatt installation would cover about 350 square feet, and a typical business 50-kilowatt installation would cover about 3,500 square feet or about one-tenth of an acre. The number of solar modules depends on the wattage of the modules selected, their efficiency, the desired load, the solar resource, and the orientation of the array. Depending on the type of system there may also be batteries for storage or the system may be tied into the local utility distribution grid.

2.3.2.5 Small-Scale Wind Power

2.3.2.5.1 Technology Description

Wind turbines convert the kinetic energy of the wind to mechanical power. The wind turbine blades are designed to act like an airplane wing; the wind causes a pocket of low-pressure air on one side of the blade, which generates “lift” and pulls the

> **WIND CURTAILMENT**
>
> Occurs when wind plants are required to reduce their electric generation output. Typically occurs when there is excess electric production in an area and there is insufficient transmission capacity to move that electricity to where it is needed.

blade toward it, causing the blade to move and the rotor to turn. The rotor turns a shaft and, through a gearbox, spins a generator to make electricity. Small wind turbines generally are those with capacities ranging from 20 watts to 100 kilowatts. At the low end of this range, units with capacities of 20 to 500 watts are often referred to as micro-turbines (DOE 2007). At the high end of the range, small wind turbines can have a similar configuration and appearance to utility-sized wind turbines. Figure 2-10 provides a group of drawings showing several views of a typical small wind turbine, its primary components, and the component names.

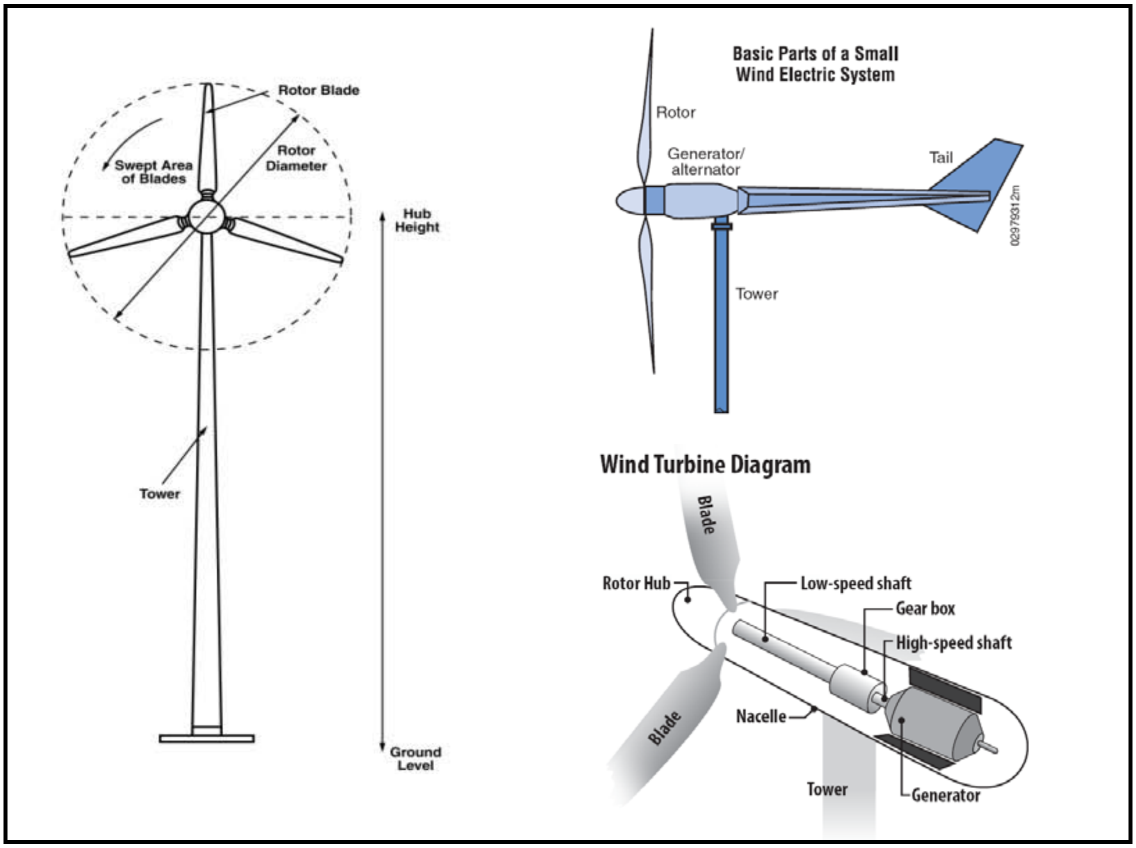


Figure 2-10. Illustrations of Typical Small Wind Turbines (Sources: DOE 2007; NEED 2012b)

Small wind turbines manufactured today generally are horizontal-axis, *upwind* machines, such as depicted in Figure 2-10. Upwind refers to the direction of the rotor; specifically, during operation, the rotor faces into the wind and the nacelle and tail are positioned behind (downwind). The other primary type of wind turbine is the vertical-axis machine in which the axis or shaft that spins is in a vertical orientation and the blades, which can be of several different configurations, are basically arranged in a horizontal plane. The vertical-axis wind turbine has the advantage of intercepting wind from any direction without changing its own orientation. However, the vertical-axis wind turbine is not yet as cost-effective as the conventional horizontal-axis turbine (Boyd 2013). Figure 2-11 provides examples of several vertical-axis wind turbine and blade configurations. While not as cost effective, there are still numerous manufacturers that promote and sell vertical-axis wind turbines, and research to find and develop different configuration continues (DOE 2010d).

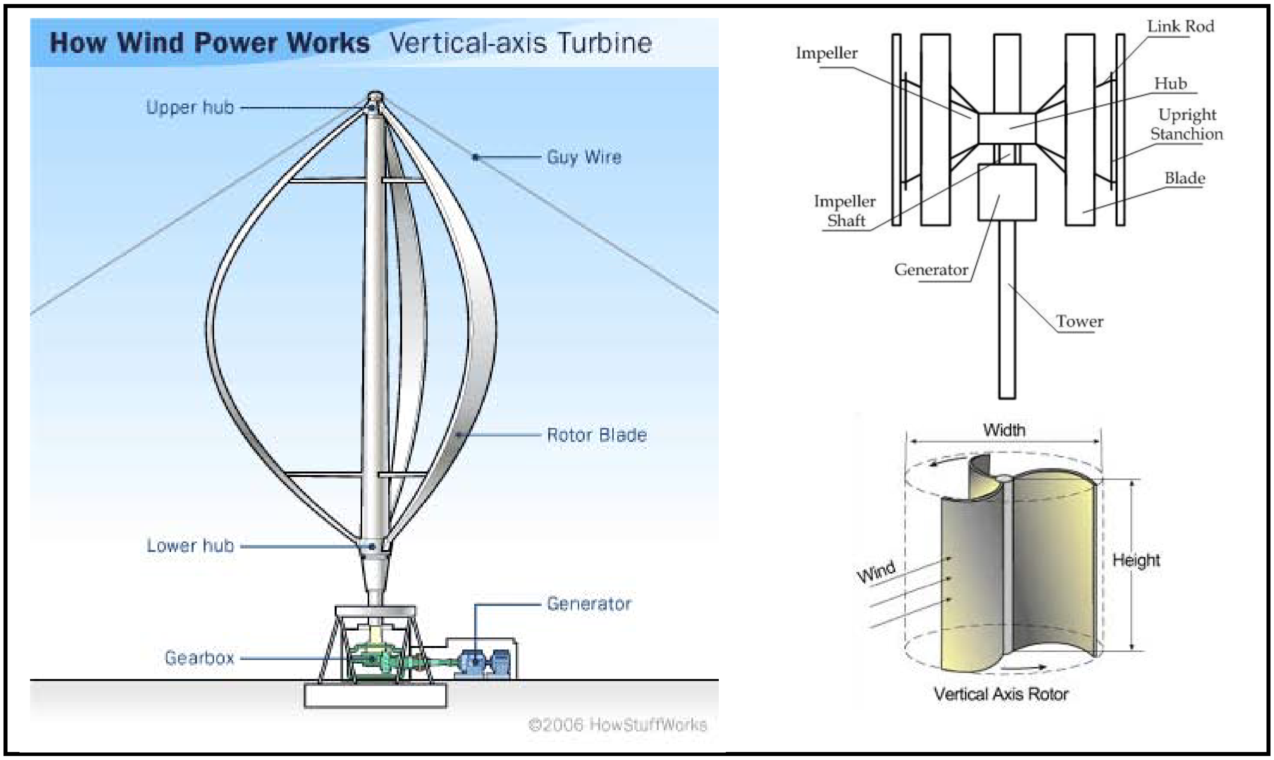


Figure 2-11. Illustrations of Various Vertical-Axis Wind Turbines and Blade Configurations

In simple terms, the primary components of a horizontal wind turbine can be described as follows:

- Rotor and Blades (where the rotor is formed by two or three blades mounted on a shaft) – The rotor, attached to a shaft and being turned by the wind, converts the energy to rotational shaft energy. The power that can be produced by the wind turbine is a direct function of the swept area of the blades (Figure 2-10), so if the swept area increases by a factor of two, the power generating capacity basically doubles (all other factors staying equal). This also means the power generating capacity increases by the power of two with increases in blade length. For example, increasing the blade length by a factor of about 1.4 results in roughly doubling the wind turbine's power capacity (DOE 2007), because 1.4 squared is approximately 2. For comparisons, a 2-kilowatt wind turbine requires a rotor diameter of about 12 feet, while 5- and 10-kilowatt machines require 18- and 25-foot diameter rotors, respectively (AWEA 2013). As the machines increase in size, particularly at the higher end of the small wind turbine category, they have slightly shorter blades than would be assumed from the above discussion. This is because manufacturers generally rate the turbines at increasing wind speeds as the size of the turbine increases, which is consistent with larger systems being able to take advantage of the fact that wind speeds increase with elevation above the ground. As an example of a rating being based on a higher wind speed, 100-kilowatt wind turbines generally have rotor diameters of about 60 feet (AWEA 2013) (whereas, following the discussion above, the required diameter would be almost 80 feet).

- Drive Train – The drive train, which includes the gearbox and generator, as well as the low- and high-speed shafts (Figure 2-10), carries the rotational energy through gears to control and change the revolution speed that is put to the generator for production of electricity. Small wind turbines generally generate DC electricity (DOE 2007), although in the upper range of the category, wind turbines can produce AC. In small, stand-alone system applications, such as recharging batteries or for some home uses, there may be direct uses of DC electricity, but in most instances *balance-*

of-system components (see below) need to include equipment to convert to AC. The conversion is required for any wind turbine connected to the electrical power grid. An alternate drive train approach, the direct-drive is also worthy of note. This approach eliminates the gear box and links the rotor shaft directly to the generator. Direct-drive wind turbine technology is advancing in the larger, utility-scale category, particularly with regard to off-shore wind power and, accordingly, is described further in Section 2.3.3.10.

- Housing and Tail – The housing, or nacelle in larger wind turbines, provides protection for the gearbox and generator, as well as a more streamlined structure. The tail is designed to keep the turbine facing into the wind. Wind turbines in the upper range of the small category generally have no tails, but rather have internal motors and electronic controls that turn and maintain the turbine into the wind just like the larger utility-scale wind turbines.

- Tower – The tower supports the rotor and drive train with the objective of putting the rotor blades into a zone of higher wind velocity and lower wind turbulence than occurs near the ground. The average height of small wind turbines is about 80 feet, which is twice the height of a standard telephone pole, and the range of heights is from 30 to 140 feet. As a general rule, the bottom of the wind turbine blade should be at least 30 feet above any obstacle within 300 feet of the tower (DOE 2007). Therefore, the bigger the rotor diameter, the higher the tower must be. Otherwise, there is no required relationship between the height of the tower and the size of the wind turbine. The higher the tower, however, the greater the wind speed and the more power produced from the same turbine. As an example, raising a 10-kilowatt turbine from 60 feet to 100 feet is estimated to add about 10 percent to the overall cost of the system, but results in a 25-percent increase in power production (DOE 2012g). As described above, the power that can be produced by a wind turbine is a direct function of the swept area of the blades, but the power production also varies exponentially, by the power of three, with increases in wind velocity. So if the wind speed is doubled, or increased by a factor of 2, the potential power production increases by a factor of 8 [or 2 to the power of 3 (2^3)].

  There are two basic types of towers: self-supporting and guyed. The towers can be either of monopole or lattice design. Guyed towers are the least expensive, but because of the guy wires, they require more area. Various configurations of tilt towers, either guyed or self-supporting also are available, but generally only for the lighter and smaller wind turbines of 10 kilowatts or less (DOE 2012g). The tilt towers allow the wind turbines to be easily brought down to ground level for maintenance or during hazardous weather conditions.

- Balance-of-System Equipment – Balance-of-system refers to additional equipment needed to condition the electricity produced by the wind turbine, to safely transmit it to the load, and, if desired, to store it for future use. The type of additional equipment needed primarily depends on whether the wind turbine is a stand-alone system or to be connected to the electrical grid.

  – Stand-Alone System. The simplest system would be one connected directly to the equipment using the power, and if a battery was need for times the system was not operating, the balance-of-system equipment could be as simple as batteries and associated charge controller. If the wind turbine system was intended to power equipment or appliances in a home or other building, the balance-of-system equipment would be more complicated and likely would consist of batteries (or accumulators), charge controller, power conditioning equipment (including a converter), safety equipment, and meters and instrumentation (DOE 2012h) (Figure 2-12).

– Connected to the Grid. If the wind turbine system connected to the electrical grid, the balance-of-system equipment would include that necessary to safely accommodate the local loads and whatever was needed to comply with area power provider's grid requirements. The equipment would be similar to that described above for a home or building, and likely would involve equipment meeting certain manufacturing and installation specifications and codes to give the power provider assurance that neither the grid nor other clients would suffer any harm. Inclusion of batteries with a charge controller would be appropriate if that fit with the local needs (DOE 2012h).

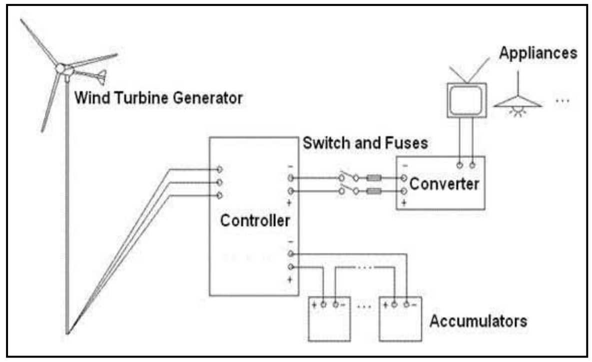


Figure 2-12. Stand-alone System Providing Power to a Home or Other Building

Vertical-axis wind turbines have many of the same components as described above for the horizontal axis variety with the following exceptions: The rotor and blades would be different, there would be no tail, and a vertical-axis turbine likely would have nothing resembling a housing positioned up in the air, but the necessary functions would still be there.

It should also be noted that entrepreneurs are pursuing alternative approaches to harnessing wind energy. For example, it is relatively easy to find websites describing various means of using tethered devices similar to kites, wind sails, or even rigid wing-like items to generate power from wind. Some of these devices may hold great promise as future distributed or even utility-scale energy producers; however, these devices are too early in development for this PEIS to address in any detail.

Small Wind Turbine Uses

Micro-turbines (20- to 500-watt machines) are often used for charging batteries for recreational vehicles or sailboats. Wind turbines in the range of 1 to 10 kilowatts are often used for dedicated uses such as pumping water. The average U.S. home uses about 10,000 kilowatt-hours of electricity per year, so a wind turbine capacity in the range of 5 to 15 kilowatts, depending on the average wind speed, would be needed to make a significant contribution to powering an average home (DOE 2007); smaller units would support some of the electrical demands. Wind turbines in the upper range of the small wind turbine category, such as 50- to 100-kilowatt machines, are considered too large for a single home, but could be used to support multiple homes or larger facilities such as public buildings, businesses, or industries. Such larger wind turbines, as well as any of the other sizes, can be connected to the area's electrical grid as long as the wind turbine system includes the appropriate power conditioning and safety equipment as part of its balance-of-system equipment and otherwise meets the local utility's connection requirements.

Provided the small wind turbine is located in proximity to the electrical grid and the utility's requirements for connection are not prohibitively expensive, connection to the grid presents an almost ideal situation for the small wind turbine owner. If the wind turbine does not generate enough energy to meet the owner's needs, the utility would provide the remainder; if the wind turbine generates more energy than the owner can use, the utility would buy the excess. Utilities are required to connect with and purchase power from small wind energy systems in accordance with the *Public Utility Regulatory Policies Act of 1978* (PURPA) (DOE 2007). If the utility allows *net metering* as the means to satisfy this requirement, the owner's electricity meter basically turns backwards when producing more energy than the owner uses. This means the wind system owner receives credit for electricity at the full retail rate for the energy generated; that is, the same price the owner pays when the wind turbine is not operating. In Hawaiʻi, the PUC has established a slightly different approach, termed feed-in tariffs. Under this program, standardized pricing, terms and conditions, and procedures are established that allow small renewable energy producers to easily enter into simple contracts with the utility that includes a pre-set level of compensation (Hawaiʻi PUC 2010).

Utilities implement net metering programs differently, often with specific limits on the size of the power system that can be connected to the grid and limits on the amount of net metering allowed over a certain period of time. DOE tracks the various net metering programs across the United States as part of the Database of State Incentives for Renewables and Efficiency program, which can be found online at http://www.dsireusa.org/. Information in this database shows that all utilities in Hawaiʻi offer net metering to wind systems, albeit the three investor-owned utilities (HECO, HELCO, and MECO) as well as the sole electric cooperative (KIUC) have slightly different programs (NCSU 2012).

Wind turbines considered "distributed renewables" often are deployed as small single units to produce energy for individual homes, farms, and small businesses. Although the category of small wind turbines is generally associated with this type of application, there would be no reason that a larger wind turbine, even into the megawatt range, could not be deployed in a manner consistent with a distributed energy source.

Locations for Small Wind Turbine Systems

Guidelines suggest wind turbines large enough to provide a significant portion of a single home's energy demand require about 1 acre of property (DOE 2007) and, as indicated previously, the blade should have a 30-foot clearance above any obstacle within 300 feet of the tower. Local, county requirements specify that turbines be set back from the property line by a distance at least as great as the tower height. Manufactures and installers of small wind turbines generally recommend that a site have average wind speeds of at least 12 or 13 miles per hour at the hub height to be feasible (AWEA 2013; NEED 2012b). According to the American Wind Energy Association, less than 1 percent of existing small wind turbines are located in urban settings. This is attributed to zoning issues and also to the poor wind quality associated with heavily built-up areas (AWEA 2013).

2.3.2.5.2 Characterization of Technology Feasibility and Deployment

Feasibility of Small Wind Resources Deployment by Island

Figure 2-13 shows areas within Hawaiʻi where small wind turbines may be appropriate based on average wind speeds at 30 meters, or about 100 feet, above the ground. It can be seen that the wind speed categories shown in the map are in units of meters per second. As a point of reference, 12 miles per hour, the minimum average wind speed for most small wind turbines, equates to 5.4 meters per second. Based on this conversion, the areas of the islands shown in green or yellow likely would not be appropriate for locating small wind turbines.

Characterization of Existing Deployment

Table 2-10 shows existing small wind turbine projects identified by the Hawaiʻi State Energy Office. As can be seen in the table, the wind turbine size planned for the Lalamilo Wind Farm Project, at 2 megawatts, is well over the size considered for the small wind turbine category. It is listed in the table because the intended use for this system is consistent with that of a distributed renewable project.

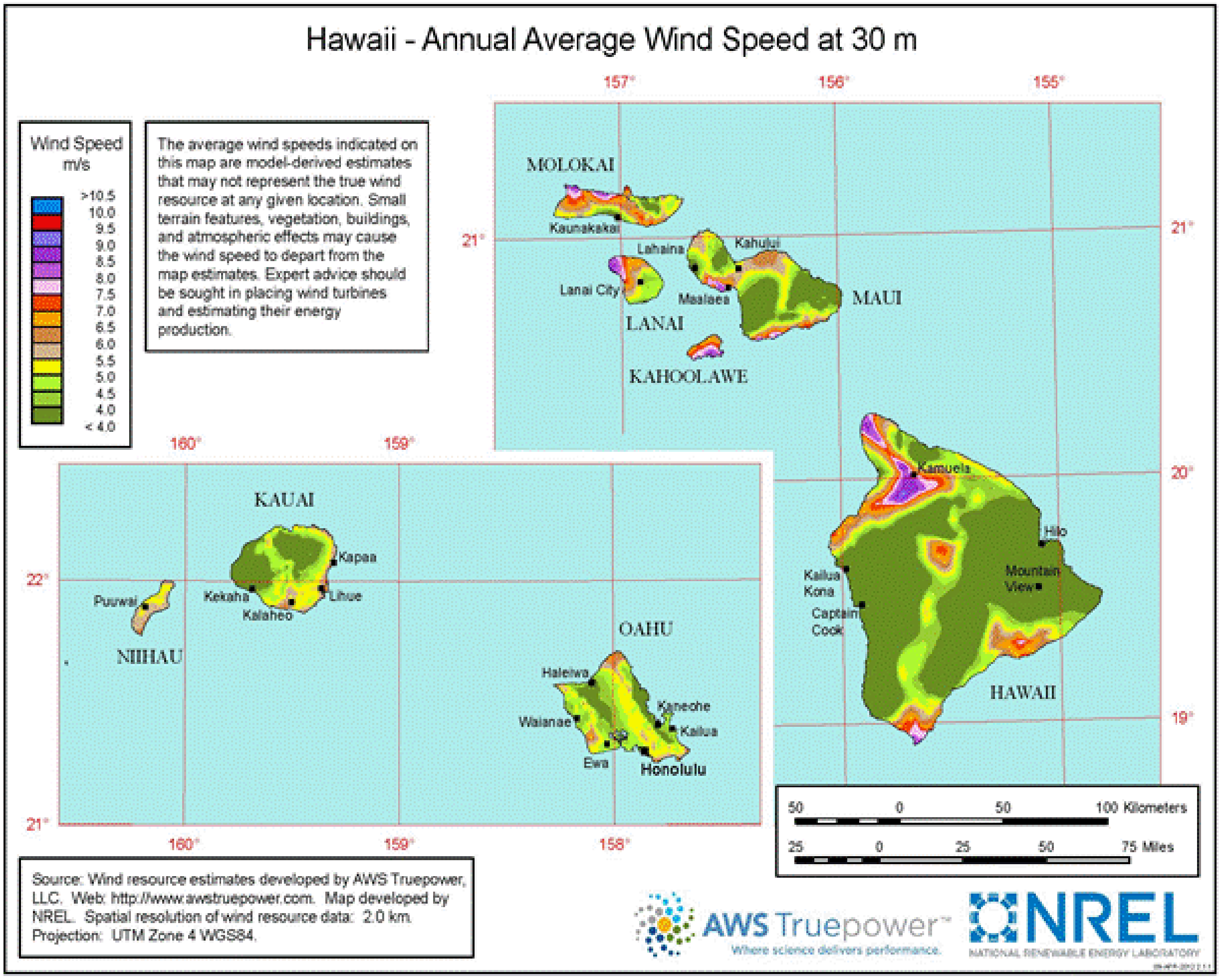


Figure 2-13. Average Wind Speeds at 30 Meters, or about 100 Feet, Above the Ground (wind speed in meters per second multiplied by 2.24 equals miles per hour) (Source: DOE 2012i)

Table 2-10. Small Wind Turbine Projects

Project Name	Location	Wind Turbine Size	Status	Purpose/Description
Big Island Beef Community Wind Project	Paauilo, Hawai‘i island	100 kW	Planning	Power the Big Island Beef facility.
Lalamilo Wind Farm Repowering Project	South Kohala, Hawai‘i island	2 MW	Planning	County Department of Water Supply is seeking bids for a wind energy system large enough to supply power to four existing water wells.
Off-Grid Powered Agricultural Operation	Hawi, Hawai‘i island	100 kW	Active	Power for a water pumping system for diversified agricultural operation. Partially funded by the DOE.
Waikoloa Water Community Wind Project	Waikoloa, Hawai‘i island	100 kW	Active	Power for the Waikoloa water treatment facility.

kW = kilowatt; MW = megawatt.

a. Source: Hawai‘i 2013b.

2.3.2.5.3 Permitting and Consultation Requirements

In addition to the general permitting requirements discussed in Section 2.2.5, there are several noteworthy requirements specific to wind projects. Those requirements associated with bird and bat species are included here since wind projects generally have a higher-than-average likelihood of impacting flying species compared with other renewable energy technologies.

- A USFWS Incidental Take Permit is required to conduct any activity that might incidentally "take" a terrestrial or freshwater aquatic species listed as a threatened or endangered species pursuant to ESA. With limited exceptions, USFWS will require the applicant for an Incidental Take Permit to submit a Habitat Conservation Plan to the USFWS.

- USFWS also implements the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712) and the Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c). The unauthorized take of species protected under these statutes is prohibited. As such, the project proponent may need to discuss with USFWS necessary mitigation, minimization, or avoidance measures that would limit the risk of the project proponent violating the statutes. The project proponent may also need to obtain a permit under the applicable statute.

- The State may require a Habitat Conservation Plan (HCP) and Incidental Take License (ITL). These permits are issued by the Hawai‘i Department of Land and Natural Resources (DNLR) and are required in order to allow the incidental take of endangered or threatened species while carrying out an otherwise lawful activity.

- The project may require a "Notice of Proposed Construction or Alteration of Airspace" from the FAA for structures taller than 200 feet above the ground (this is higher than would be expected for small wind turbine systems) and within 20,000 feet of the nearest point of the nearest runway.

- It is worth noting that county zoning designations often carry height restrictions that would be applicable to wind turbines and, as identified previously, counties have established setback requirements for wind turbines.

Some unique challenges to permitting a distributed wind facility in Hawai‘i include:

- ESA compliance and consultation for smaller wind facilities can be a significant portion of overall costs and may be too burdensome financially to pursue the project.

- Hawai‘i's limited land areas often result in increased project visibility, particularly for wind projects. Thorough community outreach is needed in constructing a structure that can be seen from a distance at day and night (via red lights).

- Hawai‘i's strong military presence warrants DoD consultation to determine if the wind project would be in or near military fly zones.

- Proximity to cultural, historic, and scenic resources, including National Parks; any NPS park units within the viewshed of the proposed wind resource development (and associated facilities and transmission corridors) should be consulted early in the planning process.

2.3.2.5.4 Representative Project

A representative small wind project for purposes of evaluation in this PEIS is assumed to consist of the construction and operation of a single 100-kilowatt wind turbine. It is further assumed that the turbine is a horizontal-axis unit, with a 60-foot rotor diameter (that is, it has blade lengths of about 30 feet), and is mounted on a 120-foot monopole. Noise produced by the wind turbine is 55 dBA at a distance of 130 feet. Connection to the grid is a distance of 300 feet from the wind turbine.

A 100-kilowatt wind turbine is at the top of the range generally considered for the category of small wind turbines. Potential environmental impacts would be expected to decrease in a linear manner in some resource areas as the size of the wind turbine decreased. For example, noise production would be expected to decrease steadily with decreases in its rated power capacity. The tower height, however, can be independent of generator size, often being determined by such factors as zoning, wind characteristics, or surrounding terrain and obstacles. Other resource areas such as biological resources could have decreasing impacts with decreasing wind turbine size, but this would depend on the location and the types of wildlife involved. Impacts associated with land disturbance would likely decrease with wind turbine size, but not linearly because things like new access roads and power line installation would involve land disturbance amounts largely independent of the wind turbine size, and if the tower height did not change, there might be little, if any, change in land disturbance. Access roads and power line construction associated with wind turbines also would impact viewsheds.

2.3.3 UTILITY-SCALE RENEWABLES

Utility-scale renewable energy technologies are similar to distributed energy technologies but involve medium-to-large scale installations designed to generate larger amounts of electricity for distribution to an electrical grid for eventual distribution to multiple end users. The utility-scale technologies discussed in this section harness energy from renewable energy sources such as the sun, wind, falling water, the ocean, geothermal, and biomass, as well as waste-to-energy:

- Biomass
- Geothermal
- Hydroelectric
- Municipal Solid Waste
- Marine Hydrokinetic Energy
- Ocean Thermal Energy Conversion
- PV systems
- Solar Thermal
- Wind (land-based)
- Wind (offshore)

Representative projects were defined based on technology-specific capacity factors, uses, and feasibility in Hawai‘i. The description of each technology within Section 2.3.3 includes a discussion of the differences between nameplate capacity and actual capacity based on efficiency and the range of typical capacity factors for that technology. Table 2-11 presents acre per megawatt estimates for surface disturbance using nameplate values for energy output associated with each technology. These estimates are based on the listed capacity factors, which are an important element. Higher capacity factors result in a smaller potential footprint. As an example, if a land-based wind turbine installation had a 50 percent capacity factor instead of 25 percent, the number of turbines and affected land area would be cut in half. Chapter 6 discusses how the impacts would scale (for example, linearly, exponentially, or not at all) for the range of potential technology applications to allow the reader to understand the effects of smaller or larger projects and how impacts could change based on the size of the technology implemented.

Table 2-11. Estimated Acreage of Permanent Surface Disturbance for Utility-Scale Renewable Technologies for the Representative Project by Nameplate Capacity, Total Acreage, and per Megawatt

Utility-Scale Renewable Energy Technology	Nameplate Capacity (megawatts)	Total Permanent Surface Disturbance (acres)	Acreage of permanent surface disturbance per MW (ratio)	Notes
2.3.3.1 Biomass	10	5,100	510	**Type: Direct combustion steam boiler project** **Permanently disturbed land area:** 12 to 16 acres including: • 6 to 8 acres for boiler and turbine building; biomass handling and feed system, and any electrical transformer station; • 2 to 3 acres for landscaping acres and parking lots; • 2 to 5 acres for road access and utility services such as water and sewer. **Total permanently disturbed land: 10 to 16 acres.** **Land production area: 5,100 acres.** **Typical capacity factors range from 75 to 85 percent.**
	10	14,000 – 27,000	1,400 – 2,700	**Type: Biodiesel project** **Total permanently disturbed land: 10 to 16 acres** in the same manner as for the direct combustion steam boiler facility. **Land production area: 14,000 to 27,000 acres.** **Typical capacity factors range from 75 to 85 percent.**
2.3.3.2 Geothermal	25	58	2.3	Exploration including slim holes or coring wells: 5 acres Drilling operations and utilization Total: 53 acres **Total permanently disturbed land: 53 acres (excludes exploration phase)** **Typical capacity factors range from 75 to 95 percent.**
2.3.3.3 Hydroelectric	-	-	-	*No representative project*
2.3.3.4 Municipal Solid Waste (MSW)	5	10	2	**Permanently disturbed land for an MSW-to-energy direct combustion facility designed to produce 5 megawatts: 10 acres** (Facility requires 165 tons of solid waste per day.) **Typical capacity factors range from 75 to 85 percent.**
2.3.3.5 Marine Hydrokinetic Energy (MHK)	Various	-	-	**Representative project assumes no surface disturbance.** Different generation capacities were given in Section 2.3.3.5 based on the type of MHK technology including 5 to 10 megawatts for facilities using overtopping devices and 0.5 megawatt for a shore-based facility using an oscillating water column. **Typical capacity factors are uncertain due to developing nature of the technology but are estimated at about 25 percent.**

Table 2-11. Estimated Acreage of Permanent Surface Disturbance for Utility-Scale Renewable Technologies for the Representative Project by Nameplate Capacity, Total Acreage, and per Megawatt (continued)

Utility-Scale Renewable Energy Technology	Nameplate Capacity (megawatts)	Total Permanent Surface Disturbance (acres)	Acreage of permanent surface disturbance per (ratio)	Notes
2.3.3.6 Ocean Thermal Energy Conversion	50	-	-	**Representative project assumes no surface disturbance.** However, based on the platform size in the representative project, its surface area would be 83,200 square feet, or 1.9 acres. This would yield a permanent on-water "surface disturbance" ratio of: **1.9/50 = 0.04**. This figure does not include any other components associated with the technology. **Typical capacity factors are uncertain due to developing nature of the technology but are estimated at about 25 percent.**
2.3.3.7 Photovoltaic	50	250	5	Ratio refers to aerial extent of a 200,000-module array; General rule: 5 acres per megawatt **Typical capacity factors range from 18 to 26 percent.**
2.3.3.8 Solar Thermal	5	20 to 45	4 – 9	**Ratio refers to aerial extent of the solar mirror array.** According to NREL, a typical land parabolic trough plant would require between 5 and 10 acres of land per megawatt generation capacity (NREL 2013d). **Typical capacity factors range from 22 to 65 percent.**
2.3.3.9 Land-Based Wind	25	17.5	0.7	**Ratio is based on the permanently disturbed land acreage figure of 17.5 acres stated in the description of the representative project.** • Array size: Ten 2.5-megawatt turbines with 42.5 acres of temporarily disturbed land; • Land required for the entire project: 250 acres or 10 acres per megawatt. **Typical capacity factors range from 19 to 50 percent.**
2.3.3.10 Offshore Wind	50	-	-	**Representative project assumes no surface disturbance.** As described in the text, an array of ten 5-megawatt turbines, meaning the total affected surface area of the sea would be 3.9 square miles, or about 2,500 acres. This would yield a ratio of 2,500/50 = ~50. **Typical capacity factors range from 26 to 55 percent.**

Note: Capacity factors obtained from NREL website http://www.nrel.gov/analysis/tech_cap_factor.html.

2.3.3.1 Utility-Scale Biomass

2.3.3.1.1 Activity Description

Biomass energy sources for utility-scale projects are the same as those for distributed renewable energy projects (see Section 2.3.2.1 of this PEIS). Some types of biomass resources are more or less suited for utility-scale projects and those limitations are discussed in this section. The cost-effective acquisition (i.e., collecting, processing, and transportation) of biomass resources is a key component to implementing a utility-scale biomass energy system.

Biomass Production

Agricultural and forestry residues and dedicated energy crops and forests are well suited to utility-scale biomass electrical power and heat production. These biomass resources are distributed across the Hawaiian Islands. The islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i all have established agricultural and forestry resources that could be used. Biomass resources on the islands of Moloka‘i and Lāna‘i are less developed. Dedicated energy crops have not been developed extensively in Hawai‘i, although considerable research has been done. Development of utility-scale biomass energy projects would provide an opportunity to the bioenergy sector of the Hawai‘i agriculture and forestry industries. Recent estimates indicate about 136,000 acres of land could be available for developing biomass resources without competing with existing agricultural food production (DBEDT 2013d). Another potential source of biomass is from efforts to eradicate invasive plant species, such as albizia. Utility-scale biomass power production requires a reliable biomass resource to produce constant electricity. Energy crops have the potential to provide the long-term reliable biomass resource that agricultural and forestry residues may not be able to provide. One of the concerns with developing dedicated energy crops is the potential use of plant species that could escape cultivation and become invasive in undisturbed areas (Buddenhagen et. al 2009; Daehler et al. 2012). The native flora and fauna of Hawai‘i have been greatly impacted by the introduction of invasive species. Hawai‘i has established a weed risk assessment system to screen and evaluate potential risks of particular species (https://sites.google.com/site/weedriskassessment/home). Nonnative energy crops should be thoroughly screened and evaluated prior to commercial production.

Animal waste has less potential as a biomass resource for utility-scale production of electricity. The cost-effective availability of animal waste (i.e., transportation cost) and competing uses (e.g., fertilizer and composted mulch) limits it potential. Components of urban waste streams such as grease waste, food waste, and sewage sludge have potential as biomass resources for utility-scale energy production but are limited to areas that have sufficient concentration of waste streams to make it cost effective. Municipal solid waste, because of its concentration in landfills, offers potential use as biomass fuel (either solid waste material or landfill gas production) for utility-scale projects (see Section 2.3.3.4 of this PEIS).

Biomass Logistics

Biomass logistics includes two primary components: the transportation and delivery of the biomass from the point of origin to the point of use and the preparation of the biomass material for use in an energy conversion technology. As discussed in Section 2.3.2.1, transportation of biomass material is more costly because the energy density is lower than fossil fuels, bio-oils, and biodiesel. However, each of the islands in Hawai‘i is relatively small, and the transportation distances for biomass resources are even smaller when considering those island areas suitable for producing biomass material and locating potential power generation facilities. Intra-island transportation costs likely would not be prohibitive. Utility-scale biomass power generation projects, by virtue of their larger scale, would require a larger biomass resource produced over a larger area. As with distributed biomass production, the location of power production in relation to the biomass resource is an important consideration. Initial study of interisland marine transportation of liquid and bulk biofuels feedstock (pyrolysis oil versus bagasse) indicate that transportation of liquid feedstock is considerably cheaper. It should be noted that cost estimates for potentially cheaper open dry bulk barge transport of bagasse were not available (HNEI 2012d). In the near term, use of bulk biomass (agriculture and forestry products) for generation of electrical power most likely would be developed on an island-by-island basis using locally produced biomass.

The preparation of the biomass material includes receiving, processing, storing, and then feeding the biomass into the energy production facility (i.e., furnace/boiler or gasifier) (EPA 2007; Jorgenson et al. 2011). Biomass handling and preparation for utility-scale power production is similar to that discussed for distributed biomass energy. The mass and volume of biomass handled and processed for utility-scale power production would be significantly larger. However, in many cases, the biomass could be prepared (e.g., ground, chipped, dried, and sorted) offsite as part of the biomass production process and delivered to the power plant as a finished product. Onsite handling of biomass would then be limited to storage and furnace/boiler feeding systems.

2.3.3.1.2 Characterization of Technology Feasibility and Deployment

The energy conversion technologies available to utility-scale production of biomass energy are the same as those for distributed energy applications: combustion, pyrolysis, gasification, and anaerobic digestion. A description of these technologies is given in Section 2.3.2.1. The following sections discuss application of each of these technologies to utility-scale biomass energy production. One primary difference between utility-scale and distributed renewable energy with respect to biomass is distributed applications typically are installed in close proximity to where the electrical power or heat is being used. Because energy from utility-scale facilities is distributed through power grids, energy production facilities may face a tradeoff between locating near a biomass resource or a power distribution grid.

Combustion (direct- or co-fired)

Combustion technology (burning of biomass material) to produce steam to generate electricity or industrial and commercial heat is a well-developed technology and has a long history in Hawaiʻi (Khanal et al. 2009). The technology is well suited to utility-scale production of energy and is similar to steam turbine generators that use coal, natural gas, and diesel fuel technology. Combustion technology is scalable by using different sized steam boilers and turbines and can be sized to match the available biomass. Because of the island geography of Hawaiʻi, utility-scale implementation of biomass combustion technology is most feasible on an island-by-island basis because of the interisland transportation cost of unprocessed biomass material (HNEI 2012d). Agricultural and forest residues, energy crops, and municipal solid waste are potential biomass sources that could support utility-scale production of electricity and heat. The technology has been deployed on the islands using crop residues from the sugar industry. Increased production of dedicated energy crops could support increased development of utility-scale projects. Currently, several utility-scale biomass power projects are in different stages of planning and development (HECO 2013c; KIUC 2013).

Pyrolysis

Pyrolysis is a thermochemical process that converts biomass material such as crop and forest products into bio-oils which can then be used in combustion turbines or steam-cycle generators to produce electricity and heat. In boiler systems, bio-oils do not provide significant energy advantages over direct combustion of the biomass material because any increased efficiency is offset by the energy to produce the bio-oil (Khanal et al. 2009). The potential advantage of bio-oils in utility-scale steam boilers lies in the greater energy density (energy/unit volume) compared with the unprocessed biomass material. Bio-oils may create a means to more cheaply transport biomass energy between islands or to a centrally located power plant by first converting the less energy dense biomass material and then transporting the more energy dense bio-oil (HNEI 2012d; Khanal et al. 2009). While technically feasible, production of bio-oils by pyrolysis and use as fuel for utility-scale generation of electricity has not been widely implemented.

Gasification

Gasification is a thermochemical conversion process for biomass materials that produces gas products rather than the liquid bio-oils produced by pyrolysis. The gases produced can then be combusted in a combustion gas turbine or traditional gas-fired steam boiler to produce electricity and heat. This technology is suited to utility-scale power production, probably more than for distributed energy applications because of investment in technology. While still an emerging technology for commercial energy production, one integrated biomass gasification and steam-cycle turbine project to produce electricity is planned on O‘ahu (HECO 2013d).

Transesterification

Transesterification is a chemical conversion process that is used to convert plant oils and animal fats into a biodiesel fuel (methyl esters) that have properties similar to petroleum diesel fuel. The chemical process reacts the oils with methanol using a catalyst (e.g., sodium hydroxide) at temperatures (~50ºC) much lower than those used in the pyrolysis or gasification processes (Berchmanns and Hirata 2008). The biodiesel produced can be used as a partial (blended mix) or complete substitute for petroleum diesel fuel in steam boiler systems or combustion engines to generate electricity.

Anaerobic Digestion

Anaerobic digestion is a biological process in which microorganisms degrade biomass materials into gaseous fuel (i.e., biogas), especially methane gas, in an oxygen-free environment. As discussed in Section 2.3.2.1.2, biogas can be produced either through specially designed anaerobic digesters or under natural anaerobic conditions in closed landfills. Biogas has been traditionally used in steam boilers to produce electricity but also can be used in combustion gas turbines and engine generators (Khanal et al. 2009). Biogas is a suitable utility-scale technology that was been implemented at the Kapaa landfill on O‘ahu. However, that project was shut down in 2002 because of problems with the combustion turbine. See Section 2.3.3.4 for a discussion of municipal solid waste and landfill gas. Anaerobic digesters have been used in the past for distributed renewable energy but all have been decommissioned. Future use of digesters for utility-scale energy production may depend on the cost-effective acquisition of sufficient waste streams such as animal waste, food waste, sewage sludge, and possibly green silage produced from crops. However, these waste streams have competing uses such as fertilizer, animal feed, and other biomass energy technologies and may not be economically viable for production of biogas, at least for utility-scale power production.

2.3.3.1.3 Permitting and Consultation Requirements

As discussed in Section 2.2.5, the number of permits required for a biomass energy project can vary depending on the scope of the project, the anticipated environmental and social impacts, and location within certain zoning districts or special management areas (Zapka 2009). The number of required permits, uncertainty regarding approval or denial of important permits, and potential lengthy appeal processes may impact the implementation of biomass energy projects. The Hawai‘i Bioenergy Master Plan provides a review of potentially applicable laws, permits, and permitting issues with respect to the biomass energy industry in Hawai‘i (Zapka 2009).

Technology-specific permitting and consultation requirements for a biomass energy project need to consider not only the construction and operation of an energy conversion facility such as a power plant or gasification facility, but also the feedstock production component and bioenergy distribution system. Permits required for the production and collection of common biomass feedstock such as agricultural residues, crops, forest and mill residues, and municipal waste should be in place as part of existing production operations. However, additional permitting may be required for the handling and transportation of feedstock such as municipal solid waste or animal waste. The development of new feedstock production operations or the expansion of existing operations may require new permits or modification of existing permits.

2.3.3.1.4 Representative Projects

To illustrate potential utility-scale renewable biomass projects that could be developed in Hawai‘i for the generation of electricity and heat, two representative biomass energy projects are described in the following sections. These representative projects were selected to provide a perspective of the potential environmental impacts that could be expected from utility-scale biomass projects. Because of the diversity of biomass resources and potential energy conversion technologies, a variety of different types of biomass projects are possible but generally involve using the biomass as a solid (direct combustion), converting it to a liquid (bio-oils and biodiesel), or producing a gas fuel (gasification and anaerobic digestion). For the purposes of evaluating potential environmental impacts, it was assumed that the biomass was produced specifically for the electrical energy project. Therefore, potential impacts from the biomass production process are explicitly considered part of the project. These representative projects are hypothetical and are not intended to reflect actual or planned proposals at any specific location but include a range of project types that are similar to biomass energy projects being planned or could be developed on the islands. The potential environmental impacts of these types of utility-scale renewable biomass energy projects are discussed in Chapter 6.

Direct Combustion Biomass Fueled Steam Turbine Generator

The direct combustion of biomass in a steam boiler to produce steam for electricity generation and industrial process steam is a proven technology and one that has been used on the islands for many years. Although designed as a distributed renewable application, the HC&S Company on Maui generates electrical power to operate its mills, irrigation pumps, wells, and facilities using bagasse in a steam generator system. HC&S sells excess power to the Maui Electric Company. Similar technology could be implemented in utility-scale projects using a variety of biomass resources that are locally available as crop or forestry residues or from dedicated energy crops.

The representative project would use a typical direct combustion biomass steam generating station built for utility-scale applications to produce 10 megawatts of electricity (Table 2-12). The steam boiler unit(s) would use a fibrous biomass source such as sugar cane, banagrass, or wood from dedicated crops or forests. The representative project assumes local sources (i.e., less than10 miles from the generating site) would supply the biomass feedstock to minimize transportation costs.

Table 2-12. Biomass Steam Boiler Electricity Generation

Power Plant Specifications	
Production Capacity	10 megawatts
Capacity Factor	80%
Energy Efficiency	25%
Megawatt-hours per year	70,080
Construction Area (acres)	6 – 8
Construction Crew (18 months)	250
Operations Crew	25
Biomass	
Biomass Supply Chain jobs	30 – 40
Sugar cane (50% moisture, 3% ash)	
Annual Requirement (tons)	118,200
Land Production Area (acres)	3,340
Ash Produced (tons)	3,540
Wood (25% moisture, 1% ash)	
Annual Requirement (tons)	74,940
Land Production Area (acres)	5,100
Ash Produced (tons)	740

Biomass fuels such as bagasse, wood, straws, and nut shells all have essentially the same gross calorific value on a moisture- and ash-free basis, about 20 mega Joules (MJ) per kilogram (Kaupp 2013; Turn et al. 2005). On an energy basis, 1 kilowatt-hour is equivalent to 3.6 mega Joules. However, biomass steam generator systems are only 20 to 35 percent efficient (Aabakken 2006; McHale & Associates 2010). Therefore, generating 1 kilowatt-hour of electricity at 25 percent efficiency would require 14.4 mega Joules of moisture- and ash-free biomass (i.e., 3.6 mega Joules divided by 25-percent efficiency equals 14.4 mega Joules, the equivalent of 1 kilowatt-hour). Although biomass materials have similar calorific values on a moisture- and ash-free basis, the moisture and ash content varies among different types of biomass. Higher moisture and ash content reduce the heating value. Therefore, the representative project looks at two cases when calculating the amount of biomass needed to operate a 10-megawatt biomass steam generator project and the land area needed to produce the biomass: sugar cane and wood chips. Estimating the amount of land required for either the sugar cane or wood chips requires dividing the weight of biomass fuel required by the average biomass produced per acre (see below).

The first case assumes use of energy cane (sugar cane grown for biomass), which would be fired at 50 percent moisture with 3 percent ash content. Thus, approximately 1,500 kilograms (1.7 tons) of processed sugar cane would need to be fired to produce each megawatt-hour of electricity. The biomass steam generator would provide baseload electricity with a capacity factor of 80 percent, or about 70,000 megawatt-hours of electricity per year (Aabakken 2006). This translates to an annual requirement of about 120,000 tons per year of processed cane material to operate the 10-megawatt plant.

Land required for sugar production is based on cane production at about 82 tons per acre (average for years 2010-2012) per 2 years (24-month harvest cycle), or 41 tons per acre per year (NASS 2013). The representative project assumes that energy cane would be harvested annually with some loss during processing but with fuel characteristics of bagasse. The project further assumed a production value of 35 tons per acre. Production of the 120,000 tons of processed cane biomass for the 10-megawatt plant would require about 3,300 acres of sugar cane.

The second case assumes that wood chips from dedicated eucalyptus forest plantations would fire the biomass steam generator at 25 percent moisture and 1 percent ash. Approximately 970 kilograms (1.1 tons) of wood chips would need to be fired to produce each megawatt-hour of electricity. At 80-percent capacity, or about 70,000 megawatt-hours, operation of the 10-megawatt plant would require about 75,000 tons of wood chips per year.

Wood production from dedicated biomass forests varies based on harvest rotation length, species mix, planting density, and fertilization rate (Whitesell et al. 1992). The representative project assumes a single-species (*Eucalyptus saligna*) forest with a 6-year harvest rotation and a production rate of 66 tons of dry biomass per acre (Whitesell et al. 1992, Table 11). Because the wood chips are fired at 25 percent moisture, the production per acre would be 88 tons per acre including the moisture. Production of the required 75,000 tons of wood chips would require harvesting approximately 850 acres of forestland each year. However, because of the 6-year harvest rotation (i.e., 850 acres multiplied by 6 years), maintaining a sustainable annual harvest would require about 5,100 acres of dedicated forestland. The estimated acreage assumes all harvested wood biomass is used for biomass fuel. In a forest production system, some logs could be marketed for timber rather than used for biomass fuel; this would require an increase in the acreage required for biomass production. Approximately 50,000 acres of forest land has been planted for the management and natural regeneration of tree species for the purpose of possible harvest (http://www.Hawai‘iforestinstitute.org/Hawai‘is-forests/healthy-and-productive-forests-campaign/healthy-and-productive-forests-campaign-fact-sheet/).

Biomass energy crops differ from the use of agriculture or forest residues in that the biomass production is part of the biomass energy production system. Potential environmental impacts of producing the dedicated energy crops should be considered along with other potential impacts of biomass energy production. In addition to acres of arable land, biomass crops may require varying amounts of irrigation water, fertilizers, herbicides, and pesticides. Sugar cane requires about 50 to 70 inches of annual precipitation for optimal growth and typically requires supplemental irrigation because either total annual precipitation or seasonal precipitation is insufficient (http://www.sugarcanecrops.com/agronomic_practices/irrigation_water_management/) (Khanal et al. 2009). Annual water requirements are about 180,000 to 250,000 cubic feet per acre, part of which is met with naturally occurring precipitation. The amount of irrigation water needed varies across the islands by location (i.e., windward versus leeward) and season (summer versus winter) (Fares 2008). Sugar cane is drip irrigated in Hawaiʻi, allowing more efficient control over the amount of water that needs to be applied. The representative project assumes no irrigation for the production of the wood chips.

Sugar cane has relatively high fertilizer requirements for nitrogen (about 200 pounds per acre) and potassium (about 200 pounds per acre) and significant requirements for phosphorus (about 50 to 250 pounds per acre). Weeds are controlled through applications of pre-emergent herbicides and inter-row herbicides prior to canopy closure. Fertilizer for improving forest production is primarily nitrogen. Studies indicate that approximately 300 to 400 pounds of nitrogen per acre should be applied over a 4 to 5 year growing period for pure stands of eucalyptus (Whitesell et al. 1992). Nitrogen fertilizer requirements can be reduced by inter-planting nitrogen-fixing trees, such as albizia, with eucalyptus (Whitesell et al. 1992; Binkley et al. 1992). However, albizia is considered an invasive species in Hawaiʻi and out-competes native `ohi`a trees.

Construction of a utility-scale biomass-fueled steam turbine generating plant would require clearing, grading and leveling an area of about 6 to 8 acres for the boiler and turbine building, biomass handling and feed system, possibly an electrical transformer station, and construction space. On final grading, approximately 2 to 3 acres maybe landscaped or used for worker parking lots. Construction would require approximately 250 workers for about 18 months. Operations would require about 25 employees. The energy facility would be near existing biomass sources (0 to 10 miles) such as agricultural fields or forests. Biomass production operations would require an additional 35 workers in agriculture or forestry type jobs. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Aboveground electrical distribution lines would be constructed to connect the power plant to the local electrical grid. Approximately one mile of high voltage distribution would be required.

The buildings would be 30 feet tall with an emission stack height of approximately 80 feet. The steam boilers would produce air emissions with nitrogen oxides, particulate matter, carbon monoxide, and sulfur dioxide. Ash waste would be produced from biomass combustion, and ash handling facilities would be integrated into the generating station. It is assumed that ash waste would be used on nearby agricultural fields or forest plantations as fertilizer with small quantities disposed of in a landfill. Industrial noise would be produced from truck deliveries of biomass, operation of the biomass handling facilities, and removal of ash waste. Noise from the steam boilers and turbines would be mostly contained within the buildings.

Biodiesel Plant and Electric Power Plant

Another approach to generating electricity would be to produce biodiesel from oil crops, which is then used as fuel in a power plant. A representative biodiesel energy system would comprise an oil crop production system, a facility to extract and process the plant oils into biodiesel, and an electrical power plant. The power plant would be a 10-megawatt-capacity facility that could use either diesel combustion engines or biodiesel-fired steam boilers to generate electricity (Table 2-13).

A variety of plant species have been identified as potential crops for oil production in Hawaiʻi such as soybean, flax, rapeseed, African oil palm, and Jatropha tree (Poteet 2006). Most of the species identified as potential oil crops are species not native to Hawaiʻi. Because Hawaiʻi's native flora has been greatly impacted by the introduction of invasive nonnative species, the use of any introduced plant for oil crop production would have to be carefully evaluated prior to cultivation. This PEIS assumes an oil crop production system with Jatropha trees. The Jatropha tree is a small tree with a shrubby growth form that produces an oil-rich seed (43 to 59 percent) (Poteet 2006). The Jatropha tree grows under a variety of conditions, being tolerant of high temperatures, drought, poor soils, and varied pH levels. Growing Jatropha trees under moist conditions (natural or irrigation) could allow more than one seed crop per year. The selection of Jatropha tree as an example of an oil crop in this PEIS is only for illustrative purposes. A specific plant species was selected to allow estimation of the amount of land area that may be needed to produce biodiesel and the potential environmental impacts that could occur.

Table 2-13. Biodiesel Production Plant and Electrical Power Plant

Biodiesel Production Facility	
Production Capacity (gallons/day)	30,000
Construction Area (acres)	6 – 8
Construction Crew (12 to 18 months)	150 to 200
Operations Crew	20
Power Plant Specifications	
Production Capacity	10 megawatt
Capacity Factor	80%
Energy Efficiency	25%
Megawatt-hours per year	70,080
Construction Area (acres)	6 – 8
Construction Crew (18 months)	200
Operations Crew	20
Biodiesel Fuel (125 MJ/gallon)	
Biomass Supply Chain jobs	25 – 30
Annual Requirement (gallons/year)	8 million
Land Production Area (acres)	14,000 – 27,000

On an energy basis, 1 kilowatt-hour is equivalent to 3.6 mega Joules. However, biomass conversion systems are only 20 to 35 percent efficient (Aabakken 2006; McHale & Associates 2010). Therefore, generating 1 kilowatt-hour of electricity at 25 percent efficiency would require 14.4 mega Joules or 14,400 mega Joules per 1 megawatt-hour of electricity production. A 10-megawatt electrical power plant operating at 80 percent of annual capacity would produce approximately 70,000 megawatt-hours of electricity per year. Biodiesel produced from Jatropha seed oil has an energy value of approximately 125 mega Joules per gallon (Prueksakorn and Gheewala 2006). Therefore, the 10-megawatt power plant would need approximately 8 million gallons of biodiesel per year.

The production of oil per acre from the Jatropha tree varies based on the growing conditions. Jatropha trees are capable of growing in low rainfall areas and would be adaptable to the leeward side of the islands and in lower-quality soils. However, production increases (through multiple seed crops per year) with higher amounts of precipitation or supplemental irrigation. Poteet (2006) used a production value of 300 gallons of oil per acre from one Jatropha seed crop per year. To produce the 8 million gallons of biodiesel, approximately 27,000 acres of land would be needed assuming one seed crop but could be reduced to about 14,000 acres if the production location had higher annual precipitation or agronomic practices were adopted that would increase production to two seed crops per year. Some inputs of fertilizers and supplemental irrigation would be anticipated but the amounts are uncertain based on the site conditions. Jatropha grows well with 35 to 50 inches of annual precipitation (Prueksakorn and Gheewala 2006). Because some arable lands in Hawai‘i receive about 20 inches of precipitation, it was assumed that on average about 20 inches of supplemental irrigation would be applied. The oil extraction process produces a seedcake that could be returned to the fields as a fertilizer and reduce the input of inorganic fertilizers. However, water and fertilizer inputs are likely to be less for other energy crops such as sugar cane or banagrass. Some inputs of herbicides and pesticides are possible depending on the agronomic conditions.

The development of a biodiesel production system would require an industrial facility for extraction of the seed oil and processing of the oil (transesterification) into biodiesel. Storage tanks and bulk liquid handling facilities would be included. Construction of the biodiesel production facility would require approximately 6 to 8 acres. Construction would require 150 to 200 workers for approximately 12 to 18 months. The facility would require road access, electrical, sewer, water, and communications utilities. If the biodiesel production facility and the power plant were not co-located, tanker truck transportation would be required to transport the biodiesel from the production facility to the power plant. Assuming the use of 7,500-gallon tanker trucks, approximately 1,066 deliveries would be required to transfer the biodiesel from production plant to power plant.

Construction of a 10-megawatt generating plant would require clearing, grading, and leveling an area of about 6 to 8 acres. On final grading, approximately 2 to 3 acres may be landscaped or used for worker parking lots. Construction would require approximately 250 workers for about 18 months. Operations would require about 25 employees. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Aboveground electrical distribution lines would be constructed to connect the power plant to the local electrical grid. Approximately one mile of high voltage distribution line would be required. The power plant would produce air emissions with nitrogen oxides, particulate matter, carbon monoxide, and sulfur dioxide.

2.3.3.2 Geothermal

2.3.3.2.1 Technology Description

Geothermal energy recovery systems use heat from the earth. Heat radiates from the center of the earth where temperatures are greater than 7,200°F (greater than 4,000°C) (Green and Nix 2006) and often compared to temperatures on the sun's surface (GEA 2012), which is about 10,000°F. This radiating heat, which is maintained by the constant decay of radioactive particles (EIA 2012b), equates to an estimated 42 million megawatts of power flowing from the earth's interior (GEA 2012). It results in a gradient of increasing temperature with depth that is often referred to as the *geothermal gradient*, which averages about 13.7° to 16.5°F per 1,000 feet in the upper 30,000 feet of the earth's crust (Dickson and Fanelli 2004). In some areas, geothermal gradients are lower and in some instances, such as Hawai‘i, gradients are controlled by unique and localized conditions. In Hawai‘i, it is common for geothermal resources to be constrained by igneous (volcanic) dikes and cooling water from infiltrating precipitation and the nearby ocean. As a result, shallow geothermal gradients are often not present despite the geothermal resource. In general, however, the geothermal gradient can be more than 10 times the average value over large areas of the earth's surface. This is particularly the case in areas along the margins of the earth's tectonic plates where the crust is constantly (on a geologic timescale) shifting and characterized by densely fractured zones, a large number of volcanoes, the ascent of very hot magmatic materials toward the surface, such as in Hawai‘i, and high heat flow. In general, these are areas of important geothermal resources and often the location of natural geothermal systems, which consist of a heat source, a reservoir of hot, permeable rocks, and a fluid to transfer the heat.

Natural geothermal systems can be in the form of hot water or steam reservoirs that are deep in the earth and accessed by drilling, or they can be in geothermal reservoirs located near the earth's surface. In the United States, geothermal reservoirs near the earth's surface are limited to the western states, including Alaska and Hawai‘i. Geothermal systems are often characterized by their temperature. For example, the U.S. Geological Survey classifies geothermal systems as follows: low temperature [less than 90°C

(194°F)], moderate temperature [90° to 150°C (194° to 302°F)], or high temperature [greater than 150°C (302°F)] (USGS 2008). Often, systems are simply classified as high temperature [above 150°C (302°F)] or low temperature [below 150°C (302°F)] (NREL 2012b). On a large scale, these geothermal systems can be used directly for heating buildings or in industrial processes, or they can be used to generate electricity. Because it is difficult to transport heat over any large distance, both direct use and electricity production must take place at, or very near, the geothermal system. Once converted to electricity, the energy can be transported great distances over transmission lines.

Geothermal energy projects generally begin with exploration to find the areas with high potential for geothermal resource development. This is followed by drilling into the reservoir and performing tests to determine if the reservoir has the appropriate characteristics to support development. The success or failure of each step determines the nature of the next step or if the next step is even taken. Exploration includes analyzing existing data (for example, aerial and satellite imagery, geologic surveys, and geologic mapping); conducting geophysical, geochemical, and seismic surveys; drilling temperature gradient wells; and using other means to determine where the higher-temperature gradients may occur. The specific exploration actions vary by site. For example, in Hawaiʻi where temperature gradients are often not present at shallow depths, slim-hole drilling is used to reach greater depths and collect subsurface materials, such as cores, and data from down-hole instrument surveys. Drilling performed during exploration is usually done with relatively small truck-mounted rigs that can go to depths of more than 4,000 feet. These drill holes are not intended to reach the geothermal reservoir, are not large enough for use in producing geothermal fluids if a developable resource is identified, and the rigs do not require construction of a drill pad. The rigs and other equipment, however, do require road access in most instances and, depending on the areas to be drilled or surveyed, may require construction of temporary access roads and the drill sites may require clearing and leveling. Drilling muds and additives are used in drilling temperature gradient wells and slim holes, and sumps and tanker trucks are generally used to capture the fluids (BLM and USFS 2008).

Drilling to the geothermal reservoir is a more significant undertaking and requires larger drill rigs that need constructed pads for operations. Once the reservoir is reached, operations include flow testing, producing and evaluating geothermal fluids, and possibly injecting fluids into the reservoir. These activities require construction of sumps and pits to hold fluids and sludges as well as development of the necessary infrastructure to support the testing. If a viable geothermal reservoir is determined through this testing, then the site is further developed for commercial operations. This includes construction of more permanent access roads and infrastructure; drilling and developing well fields; and building power production facilities, substations, and transmission lines (BLM and USFS 2008).

More detail on the general actions involved in developing a geothermal resource can be found in the Bureau of Land Management's and the U.S. Forest Service's *Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States* (BLM and USFS 2008). Table 2-14, taken from this same document, provides estimates of the typical amount of land disturbance associated with development of a geothermal resource. As indicated in the table and as would be expected, the amount of disturbance can vary greatly depending on site conditions and the nature and size of the development. Much of the land disturbed during exploration and even some of that disturbed during large-scale drilling and facility construction would be reclaimed after those initial actions, so the amount of land dedicated to the facility during long-term operations would be less than that shown in the table (BLM and USFS 2008). For example, the Puna Geothermal Venture on Hawaiʻi island is a well-established geothermal power production facility, and the total amount of property not revegetated is less than 50 acres.

Table 2-14. Typical Land Disturbances Associated with Geothermal Resource Development (Source: BLM and USFS 2008)

Development Phase and Activity	Disturbance Estimate per Plant
Exploration	**2 – 7 acres**
Geologic mapping	Negligible
Geophysical surveys	30 square feet[a]
Gravity and magnetic surveys	Negligible
Seismic surveys	Negligible
Resistivity surveys	Negligible
Shallow temperature measurements	Negligible
Road/access construction	1 – 6 acres
Temperature gradient wells	1 acre[b]
Drilling Operations and Utilization	**51 – 350 acres**
Drilling and well field development	5 – 50 acres[c]
Road improvement/construction	4 – 32 acres[d]
Power plant construction	15 – 25 acres[e]
Installing well-field equipment including pipelines	5 – 20 acres[f]
Installing transmission lines	24 – 240 acres[g]
Well work-overs, repairs, and maintenance	Negligible[h]
TOTAL	**53 – 367 acres**

a. Calculated assuming 10 soil gas samples, at a disturbance of less than 3 square feet each.
b. Calculated assuming area of disturbance of 0.05 to 0.25 acre per well and six wells. Estimate is representative average disturbance of all well sites. Some wells may require a small footprint (for example, 30×30 feet), while others may require larger rigs and pads (for example, 150×150 feet).
c. Size of the well pad varies greatly based on the site-specific conditions. Based on a literature review, well pads range from 0.7 acres up to 5 acres. Generally a 30 to 50 megawatt power plant requires about five to 10 well pads to support 10 to 25 production wells and five to 10 injection wells. Multiple wells may be located on a single well pad.
d. One-half (½) mile to 9 miles; assumes about one-quarter mile of road per well. Estimates 30-foot wide surface disturbance for an 18- to 20-foot road surface, including cut and fill slopes and ditches.
e. 30-megawatt plant disturbs approximately 15 acres; 50 megawatt plant disturbs approximately 25 acres.
f. Pipelines between well pad to plant assumed to be one-quarter mile or less; for a total of 1½ to 7 miles of pipeline in length, with a 25-foot corridor.
g. Five to 50 miles long, 40-foot-wide corridor.
h. Disturbance would be limited to previously disturbed areas around the well(s).

For purposes of this PEIS, DOE assumes that any sizeable, future geothermal resource development in Hawaiʻi would be for the purpose of generating electricity. To a large extent, the nature of the geothermal system, including the physical state of the fluid and its temperature, dictates the type of geothermal plant that would be feasible for converting the geothermal energy to electricity. Geothermal power plants are variations or combinations of three types of power plants:

Dry Steam. Dry steam power plants draw from a steam reservoir and the steam is piped directly to a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in California and Yellowstone National Park. Since Yellowstone is protected, The Geysers represents the only system of dry steam plants in the country. In 2012, geothermal power plants in the United States had an installed capacity of about 3,200 megawatts; approximately 1,590 megawatts of which was attributed to dry steam plants, all in California (GEA 2012).

Figure 2-14 is a simplified schematic of a dry steam power plant. Steam directed through the turbine causes its blades and shaft to spin, which in turn spins the attached generator producing electricity. Discharge from the turbine is cooled and condensed before being injected back to the geothermal reservoir. The efficiency of a condensing steam turbine depends on the difference in temperature between the vapor entering the turbine and leaving the turbine, so the temperature of the geothermal fluid and the reduction in temperature achieved by the condenser system are both critical (CGS 2012). As the exhaust steam from the turbine condenses, its volume decreases by several orders of magnitude. Because this is occurring in a closed vessel, it creates a vacuum on the condenser side of the turbine and essentially an additional force in moving the steam through the turbine.

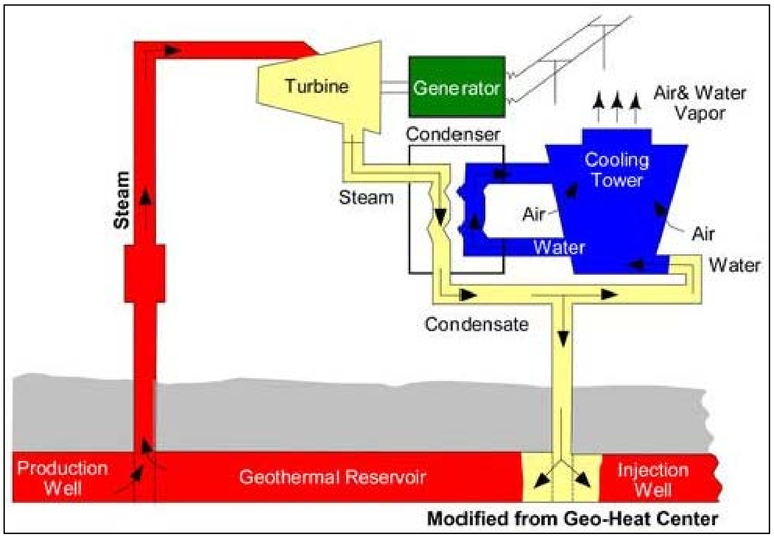


Figure 2-14. Simplified Schematic of a Dry Steam Geothermal Power Plant (Source: CGS 2012)

Important considerations for a dry steam power plant are the types and concentrations of any naturally occurring gases or minerals in the steam produced by the geothermal reservoir. Geothermal fluids (steam or hot water) generally contain gases, such as carbon dioxide, hydrogen sulfide, and methane as well as dissolved minerals, such as sodium chloride, boron, arsenic, and mercury (Dickson and Fanelli 2004). Concentrations of the dissolved constituents usually increase with the temperature of the reservoir. Since the condenser cooling system associated with a dry steam power plant is an open system, and the gases do not condense at standard temperature and pressure, there is the potential for these materials to be released to the environment. The gases can leave with the cooling air and the minerals can leave in any small water particles carried out by the air. Depending on the concentrations of these gases and minerals in the extracted steam, additional air pollution control equipment may be required.

Flash Steam. Flash steam power plants (Figure 2-15) are the most common types of geothermal plants worldwide and use geothermal reservoirs of water with high temperatures (NREL 2012b). The water, which must be under pressure to remain liquid at the temperatures involved, flows up through wells and a portion boils into steam as pressure decreases. The steam is separated from the water and used to power a turbine/generator unit. Separated water and condensed steam are generally injected back into the reservoir; however, as shown in the figure, the separated wastewater has elevated temperature and could be put to other uses. In 2012, flash steam power plants comprised about 900 megawatts of the 3,200 megawatts of installed geothermal capacity in the United States (GEA 2012).

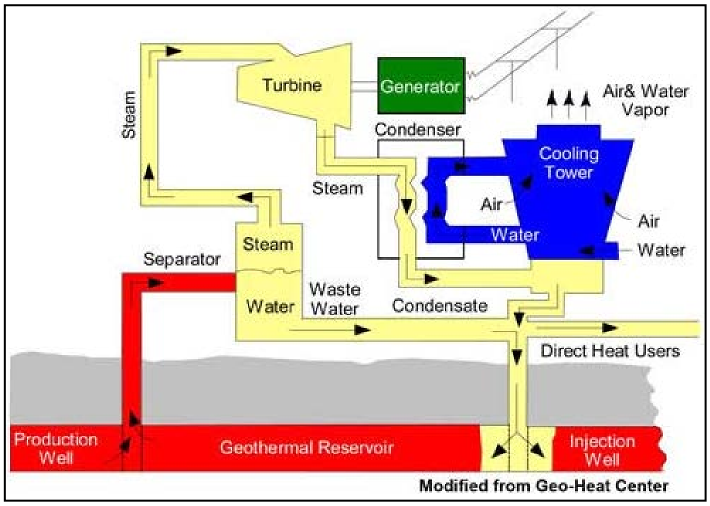


Figure 2-15. Simplified Schematic of a Flash Steam Geothermal Power Plant (Source: CGS 2012)

As with a dry steam plant, when the exhaust steam from the flash steam turbine is condensed, any noncondensable gases that were originally in the geothermal fluid must be vented, directed to air pollution control equipment (depending on their concentrations), or collected for reinjection with the geothermal fluid going back to the reservoir.

Binary Cycle. The development of binary cycle power plants has made it possible to produce electricity from water reservoirs of only moderate temperatures, with current binary plants generally working with geothermal fluids of temperatures of about 225° to 360°F (NREL 2012b). In a binary power plant (Figure 2-16), the hot water is piped to a heat exchanger and its heat is transferred to a working fluid with a low boiling point (usually an organic compound such as isobutane or n-pentane), causing the working fluid to boil. The working fluid vapor is used to power a turbine/generator unit. Both the working fluid and the geothermal water basically are in closed loops (though minor leakage may occur); the working fluid stays in the powerhouse and the geothermal water is injected back into the subsurface reservoir. Since the working fluid is a pure material, there are no noncondensable gases that need venting during the cycle. Correspondingly, the condenser's cooling system fluid, which can be either air, as shown in the figure, or water, does not come into contact with the working fluid. In 2012, binary power plants made up about 700 megawatts of the installed geothermal capacity in the United States (GEA 2012).

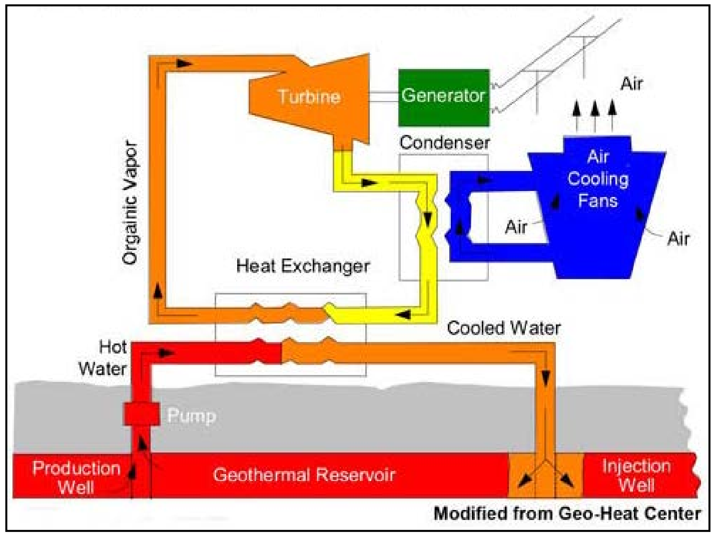


Figure 2-16. Simplified Schematic of a Binary Cycle Geothermal Power Plant (Source: CGS 2012)

Combination System. As noted previously, geothermal power plants may also be variations or combinations of the plant types described above. One such combination is worthy of note because it is used in the Puna Geothermal Venture Power Plant on Hawai'i island. Figure 2-17 is a simple line schematic of a "flash-binary," which combines primary elements of a flash steam system and a binary system. As shown in the figure, the geothermal fluid is first separated into steam and water, with the steam going directly to a turbine as shown in Figure 2-15. However, the separated hot water is then used as the heat source for binary cycle (such as is shown in Figure 2-17), driving a second turbine. The hot water stays in a closed system from the separator to the injection well, but the steam side is generally open to some degree and noncondensable gases naturally occurring in the thermal fluid still have to be removed from the system. The Puna Geothermal Venture Power Plant is designed to maintain a closed system, using only non-contact air cooling, and sends even the noncondensable gases to the injection well.

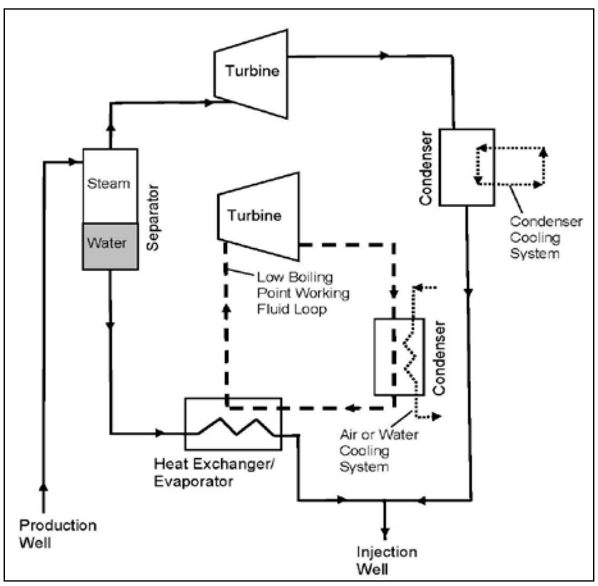


Figure 2-17. Simple Schematic of a Flash-Binary Geothermal Power Plant

Enhanced Geothermal Systems

Conventional hydrothermal power plants are associated with naturally occurring reservoirs with sufficient fluid, heat, and permeability to support power production. *Enhanced geothermal systems* (EGS) are engineered hot water reservoirs that are created where subsurface fluid and permeability are lacking. In an EGS, one or more of several subsurface techniques is used to stimulate pre-existing fractures to re-open, increasing permeability and allowing fluid to circulate for power production (DOE 2012j). Hydraulic stimulation, which consists of injecting water under relatively high pressure into a rock formation, is the primary type of reservoir stimulation technology used in EGS development projects to date. EGS is still an evolving technology, but it is now focusing on an approach often referred to as hydro-shearing, in which the goal is to use enough stimulation pressure to open existing fractures and fissures without breaking up the formation with new fractures. This provides a high ratio of contact surface (for optimum heat exchange) to the amount of water that can push through. This is different than the oil and gas industry, where stimulation is done at higher pressures and the goal is to generate new fractures (that is, hydro-fracturing) that will allow rapid draining of the formation. The oil and gas industry also frequently adds materials to the stimulation fluid to aid the fracturing process, while EGS generally relies on just water.

A basic premise of EGS is that it expands the areas where geothermal energy might be exploited to well beyond those where there is a naturally occurring hydrothermal circulation system. This includes subsurface areas at the greater depths that can be reached with today’s drilling technologies and where there may be higher temperature gradients and low potential for any significant amounts of permeability or groundwater. Although the potential for EGS in the United States and around the world is great, the technology is not yet economical on a large scale. However, in April 2013, DOE announced the Ormat Technology Desert Peak 2 Project in Nevada, partially funded by the DOE, as the first commercial EGS project to supply electricity to the electrical power grid. Ormat used EGS to expand power production at an operating geothermal field by 1.7 megawatts of power, an increase of almost 38 percent (DOE 2013d). There have been several smaller-scale field tests in the United States and abroad that have shown promise, including a project in France that currently is operating a pilot-scale power plant from an engineered reservoir (GEIE EMC 2012). If EGS can be used to develop geothermal reservoirs with recoverable heat, they would generally be paired with a binary system to generate electricity, as is the case for the French pilot-scale plant.

Additional information on EGS can be found in an MIT study on the potential for the technology, *The Future of Geothermal Energy, Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century* (MIT 2006), and two DOE reports, *An Evaluation of Enhanced Geothermal Systems Technology* (DOE 2008b) and *Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems* (DOE 2012k). The latter document addresses an effect associated with EGS projects. The slippage along an existing fault or fracture, or other change in the stress patterns in the rock that occurs during hydraulic stimulation, although small, is a seismic event. The inducement of seismic events, such as those caused by hydraulic stimulation, is a common characteristic of several different types of activities that involve deep injection or extraction of large volumes of subsurface fluid (DOE 2012k), and is a consideration that must be addressed for any planned EGS project.

Hawai‘i’s geothermal resources are less permeable than most areas of the world where such resources have already been developed. As a result, EGS may possibly be used in future development in Hawai‘i even though the existing geothermal power plant in the State is associated with a conventional hydrothermal system. However, Hawai‘i’s geothermal resources have not yet been characterized to the degree required to support any estimate of the potential of EGS or, more pertinently, to provide any accurate estimate of the State’s hydrothermal resources of any temperature (PICHTR 2013).

Typical Capacity Factors of Geothermal Power Plants

Geothermal power plants, tapping a relatively constant source of energy, are developed primarily as baseload power plants. Consistent with this intent and corresponding design, they typically operate at high capacity factors (the ratio of actual power output to potential output). It is reasonable for geothermal plants to have utilization up to 96 percent, and financial planning for geothermal plants often assumes capacity factors in the area of 85 percent (NREL 2012b). In 2012, the Puna Geothermal Venture Power Plant on Hawai‘i island produced 266 gigawatt-hours of electricity (DBEDT 2013h). With a plant capacity of 38 megawatts, this equates to a capacity factor of 80 percent.

2.3.3.2.2 Characterization of Technology Feasibility and Deployment

Feasibility of Geothermal Resource Deployment by Island

Figure 2-18 shows areas within Hawai‘i where geothermal resources are expected to exist. Additional areas may be identified through state-of-the-art resource assessments. As shown in the figure, only the islands of Maui and Hawai‘i are expected to contain high-temperature resources. Because of the older age of volcanic activity on the other islands, geothermal resources that could support electricity production are not likely (MIT 2006). Figures 2-19 and 2-20 provide additional detail on the geothermal resources for Maui and Hawai‘i counties, respectively. The highlighted areas in the figures are areas where there are reasonable expectations of high-temperature geothermal resources, which in this case represents temperatures of 125° C (257° F) or greater. This temperature is based on an estimate of the lower temperature limit at which a binary power plant could produce electricity (GeothermEx 2005). Because the amount of subsurface data actually available is limited, evaluations of the geothermal resources included statistical simulations to develop estimates of the probability they would be present at usable temperatures and conditions. The calculated probability values vary greatly by island and, for the island of Hawai‘i, by area within the island. The two highlighted areas on Maui are each associated with a 25 percent or less chance of finding a high-temperature geothermal resource. On Hawai‘i, however, there is up to 90 to 95 percent probability that high-temperature resources are present in the large highlighted area around the Kilauea rift zones. The other three highlighted areas (the two Mauna Loa rift zones and Hualalai) each have a 35 percent probability of containing high-temperature geothermal resources (GeothermEx 2005).

Characterization of Existing Deployment

The Puna Geothermal Venture Power Plant on Hawai‘i island is the only active geothermal power plant in the State. The Puna plant, located near the eastern-most tip of the island, has a 38-megawatt capacity, is connected to the Hawai‘i Electric Light Company (HELCO) grid, and provides about 20 percent of the Big Island’s electrical needs (Hawai‘i 2013b). As identified in the preceding discussion, the Puna plant consists of a hybrid flash and binary system.

The only other geothermal project listed in the State Energy Office’s online database is the Ulupalakua Geothermal Project and is in the exploration stage. Under this project, Ormat Technologies, owner of the Puna Geothermal Venture Power Plant, is determining whether a resource exists sufficient to support development of a geothermal power plant facility on land on or adjacent to the Ulupalakua Ranch on Maui. In the third quarter of 2013, ORMAT reported it was in the process of developing an EIS with a goal of filing it with the State by the end of 2013, followed by pursing necessary leases and permits for exploration activities (Recovery.gov 2013). The future viability of this project will be determined based on data obtained from exploration wells. Ormat is assumed to be planning for a geothermal power plant similar in scale and design to that in Puna (Hawai‘i 2013b).

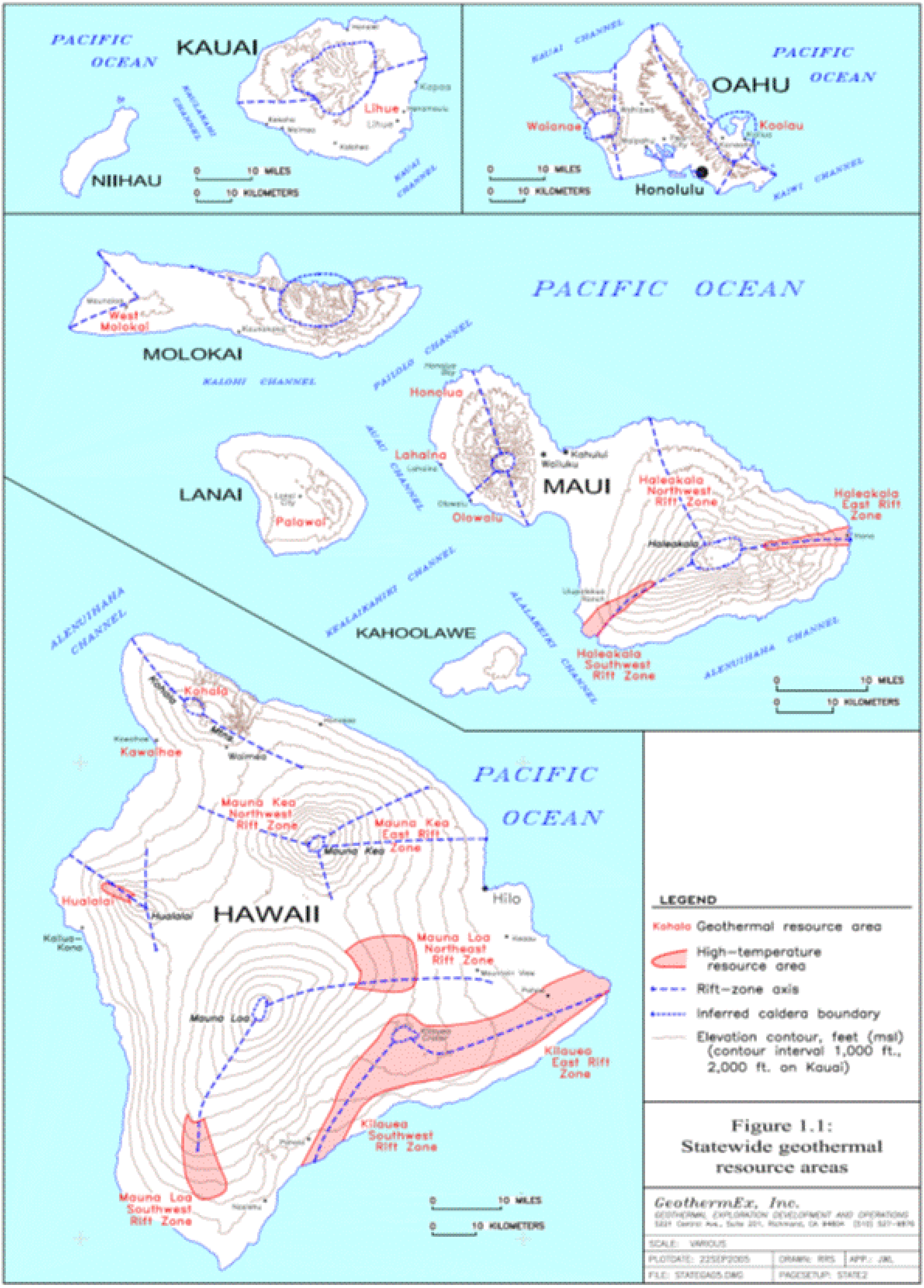


Figure 2-18. Geothermal Resource Areas Within the State <u>**(Source: GeothermEx 2005)**</u>

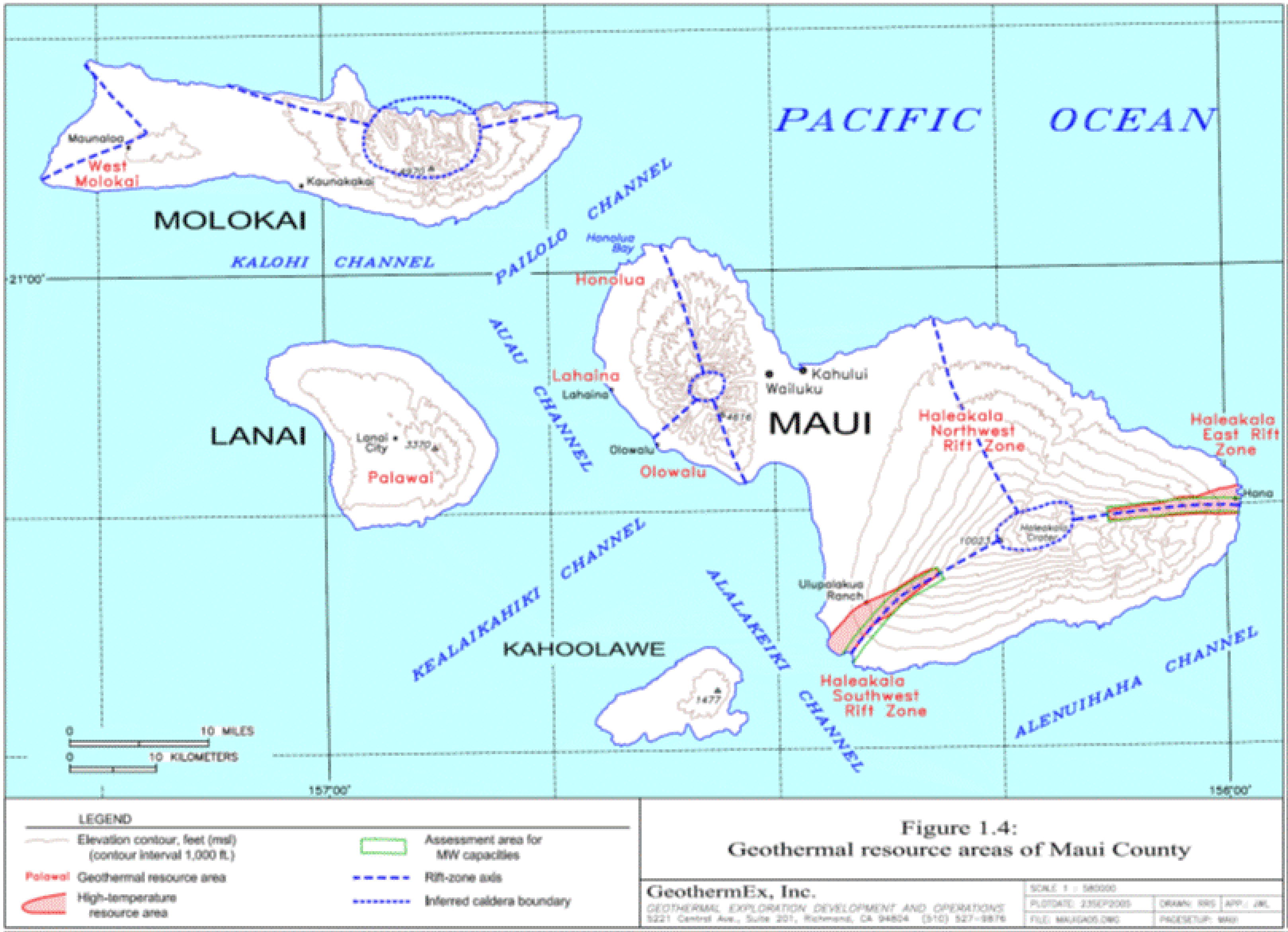


Figure 2-19 Geothermal Resource Areas for Maui County **(Source: GeothermEx 2005)**

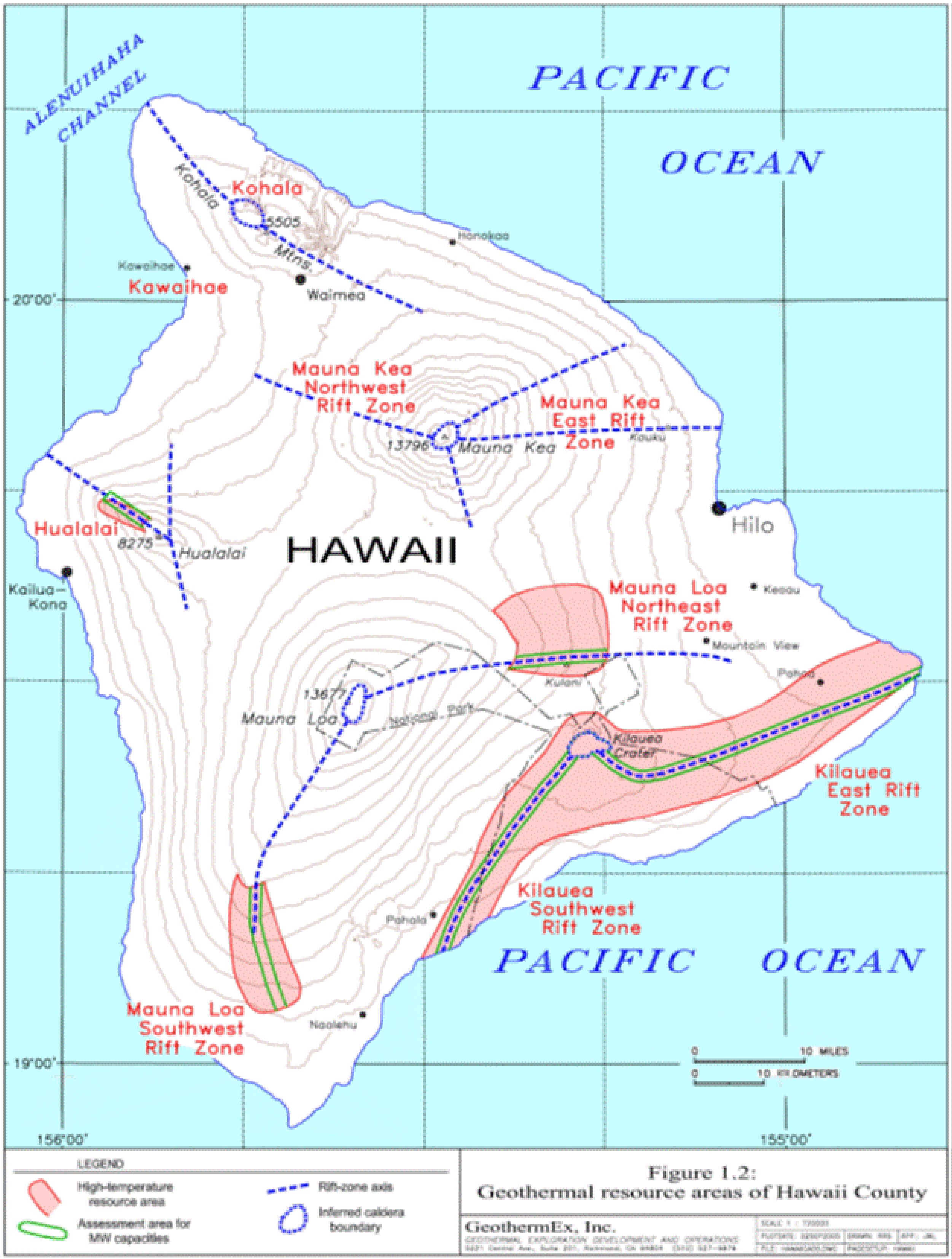


Figure 2-20. Geothermal Resource Areas for Hawai'i County (Source: GeothermEx 2005)

HELCO has solicited bidders for development of additional geothermal resources on the Island of Hawai‘i. The proposals are for an expansion of geothermal energy by up to 50 megawatts. In January 2013, HELCO requested PUC approval to solicit bidders by issuing a Request for Proposals (RFP) (Smith 2013). Approval was obtained and HELCO issued the Geothermal RFP on February 28, 2013, and requested proposals by the end of April (HELCO 2013). Six responses to the RFP were received. A possible location for any future geothermal wells will not be released until the bids are made public.

A Statewide evaluation estimates that geothermal resources on Hawai‘i island (see Figure 2-20 for areas assessed) have a combined minimum capacity of 488 megawatts and a most likely capacity of 1,396 megawatts. The comparable numbers for Maui (see Figure 2-19 for areas assessed) are a minimum capacity of 38 megawatts and a most likely capacity of 139 megawatts. These estimates are intended to reflect the amount of recoverable heat energy, but not necessarily whether that energy can be exploited commercially (GeothermEx 2005).

Based on scoping performed for this PEIS as well as news releases and posted records of public meetings, there is both public opposition to and support for geothermal energy development in the State. Opposition has been well documented on Hawai‘i island where the existing geothermal power plant is located. Opposition is based primarily on public health and safety concerns, including the potential for emissions of toxic gases and dangerous accidents. There are also concerns with noise, seismicity, and lighting. Some mention also has been made of financial damage due to decreasing property values. Other members of the public have expressed support for geothermal energy development, provided it is done safely. Such concerns, either for or against, also play a significant role in the overall feasibility of future geothermal energy development within Hawai‘i.

In September 2012, Hawai‘i County initiated actions to form a fact-finding group to examine the type and extent of health impacts from geothermal operations on the island. This study group released a draft report, *Geothermal Public Health Assessment, Findings and Recommendations*, for public review and comment on July 27, 2013 (http://www.accord3.com/pg68.cfm). Among the recommendations contained in the draft study were the undertaking of additional, specific health studies, establishment of a better monitoring system, and strengthening of communications with the public, including improved alert systems.

2.3.3.2.3 Permitting and Consultation Requirements

In addition to the general permitting requirements discussed in Section 2.2, there are several noteworthy requirements specific to geothermal projects that are listed below. They are grouped into State and county permitting requirements.

- State permits – A Geothermal Exploration Permit is required to conduct any exploration activity on State or reserved lands for evidence of geothermal resources. A Geothermal Drilling and Well-Modification Permit is required to conduct geothermal development and/or drilling activities. These permits are issued by the Hawai‘i Department of Land and Natural Resources. Permit applications may be reviewed for impacts to endangered species and archaeological resources prior to issuance.

- County permits – A County Zoning or Geothermal Resource Permit is issued by the affected county. This permit is required to conduct geothermal activities within a State agricultural, rural, or urban district.

From a permitting perspective, geothermal development in Hawai‘i faces many challenges; some unique to Hawai‘i, some common throughout the world. These challenges include:

- Cultural significance,
- Proximity to residential areas and health concerns raised by residents,
- Proximity to scenic resources, including national parks,
- Evolving regulatory roadmap (county permitting, permitting for exploration), and
- Injection of effluent.

2.3.3.2.4 Representative Project

A representative geothermal energy project for purposes of evaluation in this PEIS is assumed to consist of the exploration, development, and operation of a 25-megawatt power plant. Similar to the existing Puna Geothermal Venture Power Plant on Hawaiʻi island, the representative power plant would consist of a combined flash and binary system, so the fate of noncondensable gases would have to be addressed, but all geothermal liquids and condensable gases would be re-injected into the subsurface reservoir. It should be emphasized that this representative project is hypothetical in nature, used only for analytical purposes, and is not intended to represent any actual or planned geothermal project.

Considering the information in Table 2-14 (above), estimates of ground disturbance are as follows:

- Exploration (Total = 5 acres)
  - 5 acres for exploration – There would be a moderate amount of access road work and slim holes or coring wells. Given the relatively confined area of the islands, long access roads would not be expected.

- Drilling Operations and Utilization (Total = 53 acres)
  - 15 acres for drilling and well-field development – Six well pads (at 2.5 acres each) to support four injection wells and five production wells.

  - 8.2 acres for road improvement/construction –2.25 mile of road (0.25 mile per well) would be needed and assuming a 30-foot wide disturbance.

  - 15.5 acres for power plant construction – About 0.5 acre per megawatt.

  - 4.5 acres for well field equipment and pipelines – This is based on each well pad being about 0.25 mile from the power plant and a 25-foot-wide disturbance corridor for each pad.

  - 10 acres for transmission lines – This is based on 2 miles of new transmission line with a 40-foot-wide disturbance corridor.

Water, not necessarily potable, needed during construction (drilling wells, cementing wells, pipeline construction, and plant construction) is estimated at 7 million gallons (Clark et al. 2011). Consumptive use of water during plant operations primarily would be due to evaporation loses of the geothermal fluid in the cooling system in the flash process. All other geothermal fluids would be re-injected.

Air emissions during construction would consist of fugitive dust and equipment exhausts. During operations, the noncondensable gases in the geothermal fluid going to the flash system would be lost or controlled. This might be done by injecting the noncondensable gases into the subsurface with the used geothermal fluids or having off-gas treatment systems as scavenger or regenerable catalyst systems. These types of systems involve passing the off-gas through beds of materials designed to react with and remove the gas of concern.

If the scope of the representative project were increased (by a factor of two for example), it is reasonable to assume the associated impact elements (for instance, amount of land disturbance and water needs) would increase by a similar factor.

2.3.3.3 Hydroelectric Systems

Utility-scale hydroelectric power systems operate similarly to small-scale systems (see Section 2.3.2.2), albeit on a larger scale. In general large-scale facilities use dams to regulate water flow and generate energy, while small-scale facilities use a water diversion design, which is most often run of the river (e.g. water in equals water out, no long term [greater than one hour's worth of power generation] water storage. While there are exceptions, for the purposes of analysis, this PEIS approaches the technology from this general understanding.

2.3.3.3.1 Technology Description

The technical description for this section focuses on impoundment dam hydroelectric facilities. Typically, impoundment facilities fall into DOE's "Large Hydro" category, which is defined as any facility with a capacity larger than 30 megawatts (DOE 2011b). Impoundment facilities are suitable on a river system with low head and a high flow rate. As shown in Figure 2-21, the main components of an impoundment facility include a dam for water storage, a penstock to carry water from the reservoir to the powerhouse, and a powerhouse containing the turbines and generators. Large impoundment hydroelectric facilities must connect to the electrical power grid, and thus require access to transmission lines.

Traditional impoundment dam systems span the width of a given river system to control the flow of water. These dams vary in size and height depending on the characteristics of the river valley. Dammed rivers then cause the valley behind the dam to fill with water and form a manmade lake, which provides the hydropower system with a regular source of water for power generation.

As described in Section 2.3.2.2, the two main types of turbines used to generate electricity in a hydropower facility are impulse and reaction turbines. Because of the complexity and high cost, reaction turbines are generally limited to large hydropower applications (DOE 2001), such as those associated with commercial-scale operations.

There are two main reaction turbine designs: the Kaplan and the Francis (Figure 2-22). The main difference between these two designs is how the water flows around the blades. The Francis turbine, commonly known as a water wheel, spins as water flows through it, and the Kaplan design is basically a boat propeller with adjustable blades that accommodate changes in water levels. Both turbines are in contact with water at all times (DOE 2011a).

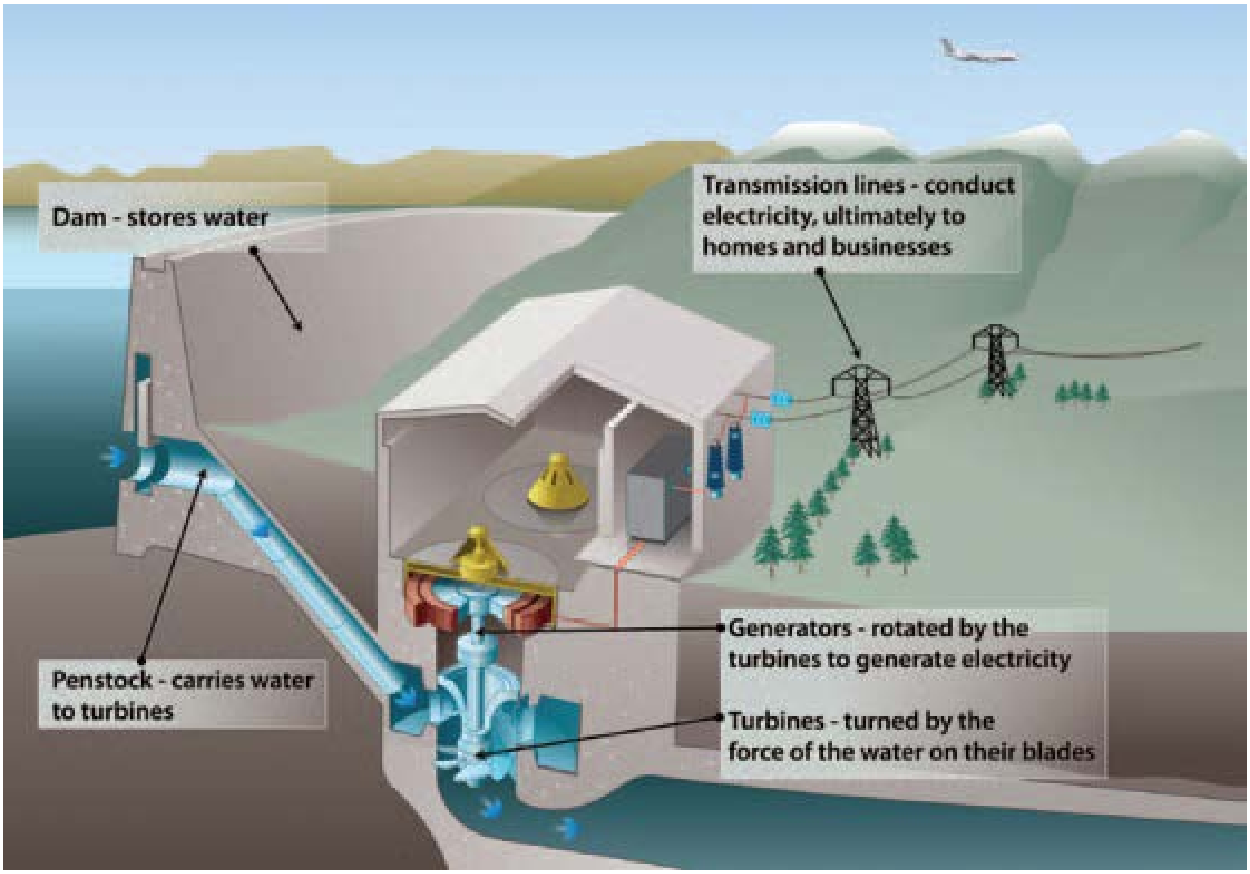


Figure 2-21. Cross Section of an Impoundment Hydropower Facility that Uses an Impoundment Dam (Source: DOE 2011a)

Figure 2-22. Illustration of Francis (left) and Kaplan (right) Turbines (Sources: Topomatika 2013; Orengine 2013)

2.3.3.3.2 Characterization of Technology Feasibility and Deployment

Hydropower has a long history of use in Hawai‘i for agriculture and small-scale power generation; however, according to HECO, the river resources in Hawai‘i are not suitable for large hydroelectric impoundments, as there are no major low-head, high-flow rivers in Hawai‘i, and building major dams would have a significant environmental impact (HECO 2013b). Furthermore, the porous nature of soils in Hawai‘i would necessitate lining the entire reservoir of an impoundment to prevent water losses. As such, even small-scale impoundments would have significant added costs. A renewal of hydropower can contribute much to HCEI’s goals; however, only certain technologies are viable on the Hawaiian Islands, such as those associated with small-scale diversion or in-stream hydropower facilities (Section 2.3.2.2).

2.3.3.3.3 Permitting and Consultation Requirements

As noted above, utility-scale hydroelectric facilities are not feasible on Hawai‘i. General permitting requirements are discussed in Section 2.2. Technology-specific permitting requirements for small-scale facilities are discussed in Section 2.3.2.2.

2.3.3.3.4 Representative Project

Because utility-scale hydroelectric power generation has been determined not feasible in Hawai‘i (HECO 2013b), DOE has chosen not to select a representative project and will not evaluate this technology in the impacts chapter (Chapter 6).

2.3.3.4 Municipal Solid Waste

Municipal solid waste, more commonly known as trash or garbage, consists of everyday items used and then thrown away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. These come from our homes, schools, hospitals, and businesses. The municipal solid waste industry has four components: recycling, composting, landfilling, and waste-to-energy via incineration. This section provides technical descriptions of options available for converting municipal solid waste and other forms of waste (e.g., construction and demolition, green waste) to energy. Municipal solid waste-to-energy projects use similar technologies as those described for biomass facilities (see Sections 2.3.2.1 and 2.3.3.1).

2.3.3.4.1 Technology Descriptions

Currently, more than 30 percent of municipal solid waste generated in the United States is recycled annually. For the State of Hawai‘i, about 25 percent of municipal solid waste is recycled (Columbia University 2013). The majority of municipal solid waste that is not recycled is typically sent to landfills after it is collected (EPA 2013b). As an alternative to landfills, waste-to-energy facilities can convert municipal solid waste to electricity. Because no new fuel sources are used other than the waste that would otherwise be sent to landfills, municipal solid waste is often considered a renewable power source. This section discusses technologies used in such facilities: combustion or incineration, pyrolysis and thermal gasification, and landfill gas.

Combustion or Incineration

Mass burn technology involves the combustion of unprocessed or minimally processed refuse. The major components of a mass burn facility include refuse receiving, handling, and storage facilities; a combustion and steam generation system (a boiler); flue gas cleaning system; power generation equipment (steam turbine and generator); condenser cooling water system; and residue hauling and storage system (fly and bottom ash).

Incoming trucks deposit the refuse into pits, where cranes then mix the refuse and remove any bulky or large non-combustible items (such as large appliances). The refuse storage area is typically maintained under pressure less than atmospheric in order to prevent odors from escaping. The cranes can also move the refuse into the hopper to feed the boiler.

Heat from the combustion process generates steam, which is routed to a steam turbine-generator for power generation. The steam is then condensed via traditional methods (such as wet cooling towers or once-through cooling) and routed back to the boiler. The wet cooling towers or once-through cooling are the largest water uses of the project. Wet cooling towers require make-up water for any water that is lost to evaporation during the cooling process. Other large water uses for the combustion processes includes steam generator blowdown, where the water system is flushed to remove impurities that can accumulate in the steam generators. Other residues produced include bottom ash (which falls to the bottom of the combustion chamber), fly ash (which exits the combustion chamber with the flue gas), and residue from the flue gas cleaning system.

The combined ash and air pollution control residue ranges from 20 to 25 percent by weight of the incoming refuse processed. The ash residue may or may not be considered hazardous, depending on the makeup of the municipal waste. Typical control technologies for controlling air emissions and greenhouse gas emissions include electromagnetic precipitators and/or baghouses (primarily for particulate capture), and scrubbers for removal of acidic gases and some particulates. Fly and bottom ash is surveyed for hazardous materials and disposed of in appropriately certified landfills. If the material is not hazardous, it can be reused as supplements to cement, roadbed construction, landfill cover, and many other uses. Scrubber waste can be a liquid, paste, or powder. Its waste is also disposed of; in some cases, it can be reused for products such as drywall (CEC 2013).

The processed municipal solid waste can be further processed to produce refuse-derived fuel, which removes incombustible materials such as dirt, glass, metals, and very wet organics, and it makes the waste more uniform in size than raw municipal solid waste. The remaining material is then used or sold. The refuse-derived fuel processing facility and municipal solid waste combustion facility are normally located in the same facility or near each other. The major components of a refuse-derived fuel process are the same as those in a mass burn facility.

Key steps in these processes include:

- Size reduction (shredding)
- Air classifying/screening (methods of separating materials and particle sizes)
- Magnetic separation
- Glass and non-ferrous metal separation (mostly aluminum)
- Drying

Pyrolysis and Thermal Gasification

Pyrolysis and *thermal gasification* technologies are not yet as common as combustion in waste-to-energy systems. Pyrolysis is the thermal decomposition of organic material at elevated temperatures in the absence of gases such as oxygen. The process requires heat and produces a mixture of combustible gases (primarily methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids, and solid residues. The pyrolysis process starts at about 390° to 570°F.

With thermal gasification, thermal decomposition takes place in the presence of a limited amount of oxygen. The generated gas can then be used in boilers or cleaned up and used in combustion turbines or generators. Gasification converts organic or fossil-based material into carbon monoxide, hydrogen, and carbon dioxide at temperatures greater than 1,290°F.

From a benefits standpoint, pyrolysis and gasification offer more opportunities for recovering products from waste than combustion. When waste is burned in a modern incinerator, the only practical product is energy; whereas, the gases, oils, and solid char from pyrolysis and gasification can not only be used as fuel but also purified and used as a feedstock for petrochemicals and other applications. The processes can also produce a stable granulate instead of an ash, which can be more easily and safely utilized. In addition, processes can target producing specific recyclables, such as metal alloys and carbon black. From gasification, in particular, it is feasible to produce hydrogen, which is becoming an increasingly valuable resource (Jupiter 2013). Section 2.3.4.4 of this PEIS discusses how hydrogen can be used in the transportation arena.

From a challenge standpoint, pyrolysis and gasification are not among the more economical alternatives. The pyrolysis process needs improvements in the quality and consistency of the bio-oil that is produced. With gasification, the main challenge is to reach an acceptable (positive) gross electric efficiency. The high efficiency of converting synthetic gas to electric power is counteracted by significant power consumption in the waste preprocessing, the consumption of large amounts of pure oxygen (which is often used as a gasification agent), and gas cleaning. Another challenge is maintaining long service intervals in the plants to avoid closing down the plant every few months for cleaning (HTCW 2013; Thermoselect 2013).

Key steps in these thermal processes include:

- Materials Transport – Transport the materials to and from the conversion facility.

- Shredding and Separating - The municipal solid waste runs through multiple shredding and separation steps to get to an appropriate size and to remove items such as metals, glass, and dirt.

- Pyrolytic Converter - From the shredding and separating processes, the waste goes through a pair of air lock valves and into the pyrolytic converter (or pyrolysis unit). The air locks are necessary to keep air out because the objective is to decompose organic material at an elevated temperature with no, or minimal, oxygen.

- Scrubber - Gases pulled from the pyrolytic converter first go through a scrubber to wash out carbon particles that may have traveled with the gas from the converter and to remove some of the condensable gases.

- Condenser and Demister - From the scrubber, the gas goes through a condenser to remove the rest of the condensable gases, which consist primarily of steam/water but could also include some hydrocarbons. The non-condensable gas then goes through a demister to ensure no liquid remains in the stream (DOE 2014a).

Landfill Gas

Landfill gas utilization is a process of gathering, processing, and treating the gas typically released from landfills to produce heat, fuels, and various chemical compounds. The number of landfill gas projects, which convert the methane gas that is emitted from decomposing garbage into energy, is growing. The EPA's Methane Outreach Program lists active landfill gas-to-energy projects and landfills with the potential characteristics to sustain recovery operations (http://www.epa.gov/lmop/).

Landfill gas is generated through the degradation of municipal solid waste by microorganisms. The quality (higher percent methane gases) is dependent on the composition of the waste, presence of oxygen, temperature, physical geometry, and time elapsed since waste was disposed (DOE 2014b). Aerobic conditions (presence of oxygen) leads to the generation of predominately carbon dioxide. Anaerobic conditions (no oxygen), as is typical of landfills, produce methane and carbon dioxide in approximately equal amounts. Methane is the important component of landfill gas.

Landfill gas is gathered from landfills through trenches and/or extraction wells (roughly one well per acre is typical) and a collection system (EPA 2009a). The following are key steps in the process.

- Landfill gas Collection System – Landfill gas can be extracted through horizontal trenches or vertical wells. Both systems are effective. Once extracted, a blower or pump blows or draws gas from the collection wells to a main collection header. The blower/pump then sends the gas to be treated or flared (burned off). The main collection header can connect to a collection system to collect condensate forming in the pipes.

- Flaring – If gas extraction does not warrant direct use or electricity generation, the gas can be flared off. The purpose of flaring is to dispose of the flammable constituents of landfill gas, particularly methane, safely and to control odor nuisance, health risks, and adverse environmental impacts (UK Environment Agency 2013). Flares can also help control excess spikes and maintenance down periods. Flares can be either open or enclosed.

- Landfill Gas Treatment – Landfill gas is treated to remove impurities, moisture, and particulates. The treatment system depends on the end use. Gas that will be used directly in boilers, furnaces, or kilns requires minimal treatment. Using the gas to generate electricity typically requires more in-depth treatment. Treatment systems are divided into primary and secondary treatment processing. Primary processing systems remove moisture and particulates. Gas cooling and compression are also common in primary processing. Secondary treatment systems employ multiple cleanup processes, physical and chemical, depending on the specifications of the end use. Adsorption and absorption are the most common technologies used in secondary treatment (EPA 2009a).

- Gas Distribution – In some cases, the collected gas goes to a pipeline for distribution to a gas truck line or to a direct serve customer. The pipelines typically are 10-inch high-density polyethylene pipeline (Three Rivers 2013).

Capacity Factors for Renewable Energy Sources

The various solid waste-to-energy technologies can produce base-load or reliably constant capacities based on an even stream of solid waste entering the facility. Base-load capacity is the minimum amount of power that a utility or distribution company must make available to meet minimum demands for its service area. There are several reasons why a plant would have a capacity factor lower than 100 percent. The most common reason is a plant is out of service or operating at reduced output due to equipment failures or routine maintenance.

2.3.3.4.2 Characterization of Technology Feasibility and Deployment

Feasibility

The H-POWER facility on O‘ahu has been converting municipal solid waste to energy since 1990 and recently expanded its capacity to 90 megawatts (meeting approximately 8 percent of O‘ahu’s energy needs) (Covanta 2013).

On April 25, 2013, Maui County awarded the contract to construct and operate the Maui County Landfill Waste-to-Energy Facility, which will be located on a 10-acre site next to the existing landfill in Puunene. The facility, expected to begin operations in 2017, will generate up to 15 megawatts of power. The landfill currently accepts about 450 tons of waste daily. The County may decide to sell the generated electricity to MECO. The County is also exploring landfill gas collection opportunities.

The BioEnergy Hawaiʻi Waste Conversion facility currently is in the planning stages. The facility would be located on about 25 acres at the National Energy Laboratory of Hawaiʻi Authority in Kailua-Kona on Hawaiʻi island. The facility plans to use thermal gasification on waste from the Puuanahulu landfill to generate up to 11 megawatts of electricity. The facility would use the resultant carbon dioxide to feed algae beds, which the facility would convert to biofuel (Hawaiʻi State Energy 2010). The State of Hawaiʻi prepared the *Environmental Assessment/Environmental Impact Statement Preparation Notice for the BioEnergy Hawaiʻi Waste Conversion Facility* in December 2010 (DBEDT 2010). The proposed bioconversion facility will use gasification technology to divert up to 75 percent of the 400 tons generated per day of municipal solid waste from West Hawaiʻi's landfill.

EPA's Landfill Methane Outreach Program has developed a variety of analyses profiling specific landfill sites that it considers candidates for landfill gas projects Considerations include gas recovery estimates and feasibility assessments conducted to evaluate the landfill gas generation and recovery potential at specific landfills and potential end uses. Table 2-15 lists eight candidate landfills in Hawaiʻi for gas recovery.

Table 2-15. Candidate Landfill Gas-to-Energy Landfills in Hawaiʻi

Landfill Name	City	County	Waste in Place (tons)	Opening Date	Closure Date	Owner
Central Maui LF	Puuene	Maui	3,666,000	1987	2030	Maui County
Kailua LF	Kealakhe	Hawaiʻi	500,000	1975	1993	Hawaiʻi County
Kalaheo LF	Waimanalo	Honolulu	1,310,000	1987	1990	Honolulu
Kapaa LF Site No. 2	Kailua	Honolulu	2,122,147	1982	1998	Honolulu
Kekaha LF Phase II	Kekaha	Kauaʻi	1,492,886	1953	2015	Kauaʻi County
South Hilo LF	Hilo	Hawaiʻi	1,396,049	1965	2016	Hawaiʻi County
Waimanalo Gulch LF	Kapolei	Honolulu	5,070,000	1989	2045	Honolulu
West Hawaiʻi LF/Puuanahulu	Waikoloa	Hawaiʻi	900,000	1992	2070	Hawaiʻi County

Source: EPA 2012.

Developers are exploring three of the landfills: Waimanalo Gulch, Central Maui, and West Hawaiʻi (Hawaiʻi Energy Futures 2013).

In determining the suitability of a project, the first step for the landfill proponent would be to determine if the landfill is likely to produce enough methane to support an energy recovery project. Screening criteria include whether the landfill contains at least 1 million tons of municipal solid waste, has a depth of 50 feet or more, is still in operation or recently closed, and receives at least 25 inches of precipitation annually. Landfills that meet these criteria are likely to generate enough gas to support a landfill gas project. These are ideal conditions, but success has also occurred at older, smaller, and more arid landfills (EPA 2013c).

Deployment

The City and County of Honolulu owns the Covanta Honolulu Resource Recovery Venture, locally known as H-POWER (which stands for Honolulu Program of Waste Energy Recovery). The facility is located at Kapolei on Oʻahu on 28 acres of land in the Campbell Industrial Park. The facility processes up to 3,000 tons of municipal solid waste per day and can generate up to 90 megawatts of electricity.

Initially, the facility had two 845-ton-per-day furnace/boilers using refuse-derived fuel. In 2012, the facility added a 900-ton-per-day expansion using the mass burn (combustion) technology, which included the third combustion unit, turbine/generator, and associated air pollution control equipment (Covanta 2013).

There are no existing landfill gas-to-energy projects in Hawaiʻi. During the 1990s, the Kapaa landfill on Oʻahu burned the methane that collected to produce electricity; the landfill dried gravel with the heat from the turbine exhaust.

2.3.3.4.3 Permitting and Consultation Requirements

Municipal solid waste and landfill gas energy projects can be subject to the general permits and regulations discussed in Section 2.2.5, including air quality, solid waste, and water quality regulations and permitting requirements. H.A.R. Chapter 58.1, "Solid Waste Management Control," regulates facilities designed to reduce volume of solid waste by the use of an enclosed device using controlled combustion. Solid waste used for incineration must not include materials contaminated with hazardous waste as defined in the rules. All solid waste incinerators or refuse-derived fuel processing facilities require a permit and must comply with Sections 11.58.104 and 11.58.1-12(a). A site plan and analysis are required.

From a larger Federal and State permit perspective, proposed mass burn facilities would require compliance with permitting regulations, including:

- New Source Performance Standards promulgated under Section 111 of the Clean Air Act(CAA);
- National Ambient Air Quality Standards (NAAQS) promulgated under Sections 108 and 108 of the CAA;
- Prevention of Significant Air Quality Deterioration regulations under Section 165 of the CAA;
- Standards for Residual Disposal (Fly and Bottom Ash) and potential hazardous waste management promulgated under Subtitle C, in accordance with Section 306 of the CAA, of the *Resource Conservation and Recovery Act* at the Federal level and under HRS 342H and 342J at the State level;
- Permits for waste water treatment and disposal and cooling water blow down promulgated under the CWA Sections 104 and 316 and HRS 342D ; and
- Transmission line tie-in regulations promulgated under Section 216 of the *Federal Power Act* (FPA) and HRS 269.

A comprehensive discussion of permitting requirements for municipal waste combustion facilities can be found at http://www.combustionportal.org/mswi.html.

Pyrolysis and thermal generation would have many of the same requirements summarized above.

Landfill gas energy projects may need to obtain National Pollutant Discharge Elimination System permits for discharging wastewater that is generated during the energy recovery process. This wastewater, as well as wastewater from the system maintenance process, must be removed from the collection process. Subtitle D of the *Resource and Conservation Recovery Act* is specific to landfill gas mitigation control. Since October 1979, regulations have required controls on migration of methane gas from landfills. Subsequently, in October 1993, EPA issued landfill standards requiring methane monitoring and performance standards for methane migration control.

Under the New Source Performance Standards of the *Clean Air Act*, EPA requires affected landfills to collect and control landfill gas. The standard targets reductions in the emissions of landfill gas due to odor, possible health effects, and safety concerns. Landfills meeting certain design capacity and emission criteria are required to collect landfill gas and either flare it or use it for energy.

It is important for prospective municipal solid waste and landfill gas developers to consider the feedstock facility when assessing overall facility requirements. Feedstock facilities are often subject to heavy regulation, so the municipal solid waste/landfill gas developer should ensure all current permits are valid and that any new proposed activities do not adversely impact existing facility permits. New activities such as shredding onsite or transporting feedstock materials can trigger additional approvals, including for air emissions, traffic impacts, noise, and run-off.

2.3.3.4.4 Representative Project

For purposes of this PEIS, the representative project is a municipal solid waste-to-energy direct combustion facility designed to produce 5 megawatts of energy on 10 acres of land. Freshwater or saline (saltwater) can be used for cooling (National Water Commission 2009). This was chosen as a representative project because it is the type most commonly used in the United Sates and Hawaiʻi. The operation of a direct combustion facility would result in potentially higher levels of air emissions and water usage for cooling purposes than the other technologies used to covert municipal waste to energy.

Power plants that burn municipal solid waste are normally smaller than fossil fuel power plants but typically require a similar amount of water per unit of electricity generated. Assuming a 100-percent capacity factor, the 5-megawatt representative project would use about 4 million gallons per month for make-up water and about 1.3 million gallons per month for blow-down water (EPRI 2009).

The representative project would employ approximately 25 construction workers for an 18 to 24 month period, and 14 full-time equivalent operations staff (Hawaiʻi 2010).

The representative project would require 165 tons of solid waste per day. This is based on 33 tons of solid waste required to generate 1 megawatt of energy per day.

To minimize transportation-related impacts, the representative project would be co-located with or near a municipal solid waste landfill that supplies the feedstock. Site infrastructure would include those services that are typical of a processing facility (e.g., utilities, waste and wastewater, construction laydown yards, and parking). The facility would provide electricity to the electrical grid or otherwise offsite, and would require 1-mile-long transmission lines to connect the plant to the physical grid (or to any direct serve customer).

2.3.3.5 Marine Hydrokinetic Energy

2.3.3.5.1 Technology Description

Marine hydrokinetic technologies use the *kinetic energy* from moving water (such as waves, tides, and ocean currents) to generate electricity. The amount of energy that can be extracted from a wave is a function of the wave's height and frequency. That is, the higher and more frequent the waves, the more power that can be extracted. Marine hydrokinetic devices can be situated on the shoreline or offshore, depending on the technology (NREL 2009a). This technology is in the early stages of development; consequently, there are numerous designs in various stages of viability for commercial deployment or product testing (Pew 2011). It is expected that over the course of the next decade or so, some of these technologies/designs will emerge as superior energy conversion devices, setting a commercial standard for marine hydrokinetic technologies. The costs associated with development, deployment, and maintenance are largely unknown. Further, much research is still needed on existing devices to determine reliability, optimal siting, commercial operational parameters, and impacts to marine environments (DBEDT 2002b).

Wave Power Technology Types

Wave power, measured in units of kilowatts of power per meter, is the amount of power between wave crests. Each wave power technology category utilizes distinct designs to capture energy based on the kinetic properties of the water. Wave energy generators take advantage of the *oscillation* of surface waters to produce energy. The devices include attenuators, overtoppers, oscillating water columns, point absorbers, and oscillating wave and surge converters (DOE 2013e). Unless otherwise noted, the following illustrations and explanations are from the DOE's Marine and Hydrokinetic Technology online glossary, http://www1.eere.energy.gov/water/marine_hydro_glossary.html. The intent of this section is simply to introduce the known wave power technologies. More detailed descriptions of the individual technologies, including design specifics, use scenarios, and entities involved with such, are available on the Internet.

Attenuators

Attenuator technology designs are based around a central hinge connecting separate moving arms floating on the surface of the water (Figure 2-23). The device is positioned so that the end of an arm faces the oncoming waves. The force of the waves move the arms, which bend the hinge, which in turn pumps fluid between the arms. The fluid drives a generator, producing electricity. Underwater transmission lines bring the generated power to the grid onshore.

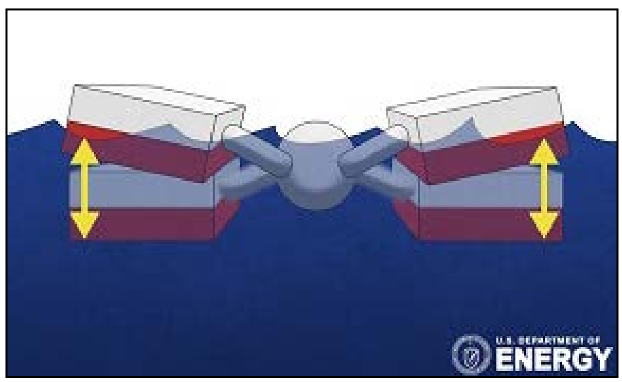


Figure 2-23. Illustration of Attenuator Technology

Resembling semi-submerged cargo containers, a device like that in Figure 2-23 is about 400 feet long by 11 feet wide, rise about 10 feet out of the water, and comprise multiple segments, depending on technology design (OSU 2013a). Such a device has the capacity to generate 750 kilowatts of electricity. These devices are based offshore, requiring mooring lines to keep them tethered to the seabed.

Overtopping

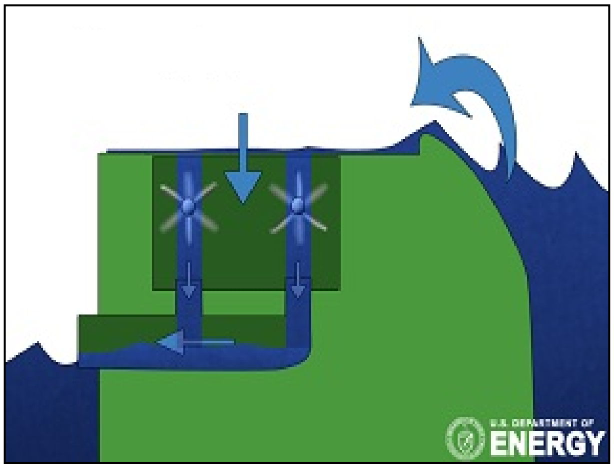


Figure 2-24. Illustration of Overtopping Technology

Overtopping devices are designed to capture and funnel waves over the top of the device through a system of turbines back out to the source water (Figure 2-24). These devices can be semi-submerged in the water and moored to the ocean floor, or be shore-based to capture waves on the shoreline. Currently, deployed prototype devices range in size, but commercially viable units likely will be about 1,000 feet long by 600 feet wide, and rise about 10 to 30 feet out of the water. Such units will have the capacity to generate 5 to 10 megawatts of electricity. A 10-unit array of overtopping devices could be staggered across a 2.5-mile transect of ocean. As with an attenuator, underwater transmission lines would bring the generated power to the grid onshore.

Oscillating Water Column

Oscillating water columns are partially submerged structures that enclose a column of air above a column of water. The movement of the waves causes the water column to rise and fall, driving the cycling air pressure through a turbine generator (Figure 2-25). As a wave enters the column, it forces the air in the column up the closed column past a turbine, and increases the pressure within the column. As the wave retreats, the air is drawn back past the turbine due to the reduced air pressure on the ocean side of turbine.

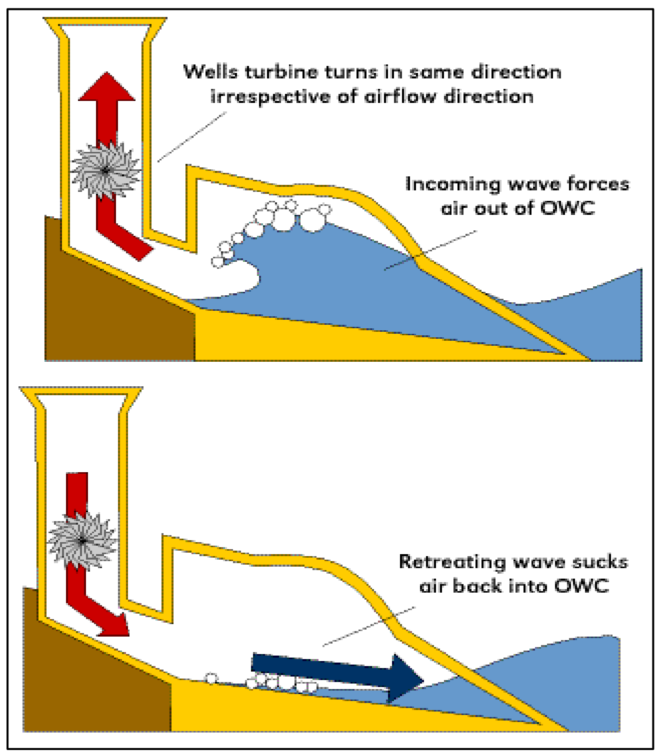


Figure 2-25. Illustration of Oscillating Water Column Technology (Source: Earthscience.org 2013)

The water columns are housed in very large concrete structures that can be built into the shoreline or moored at sea. A shore-based facility with a capacity to generate 500 kilowatts of electricity could be the size of a two-story, 3,000-square-foot structure , positioned half on the shore, half in the water (Figure 2-26). At-sea designs are still in the development phase; however, current designs range from 0.5 to 3 megawatts and about 100 feet long by 30 feet wide, with the surface floating about 8 feet above water level. At-sea devices would increase in size, depending on capacity (Oceanlinx 2013). Transmission and electrical distribution requirements would be dependent on proximity to existing infrastructure.

Point Absorber

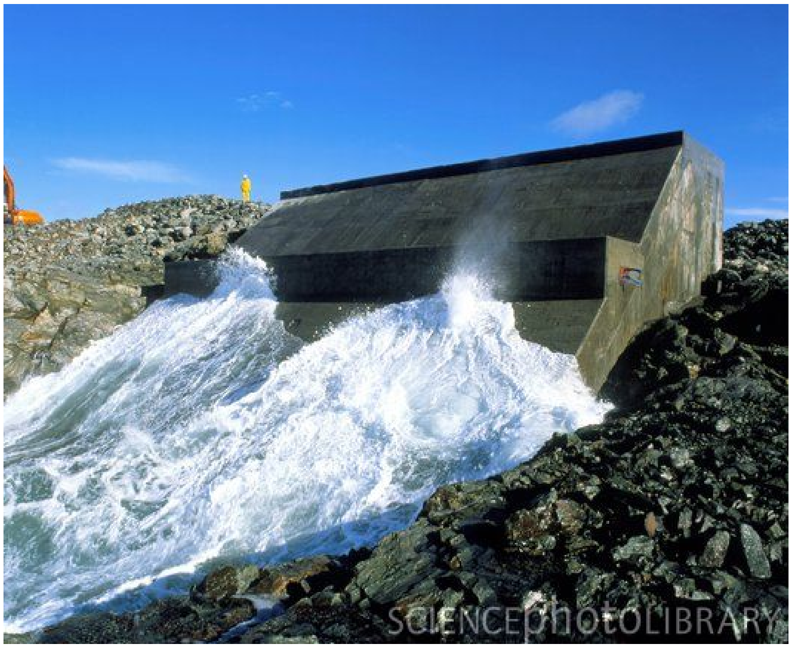


Figure 3-26. The Limpet Wave Power Station in the Isle of Islay, Scotland (Credit: Martin Bond/Science Photo Library

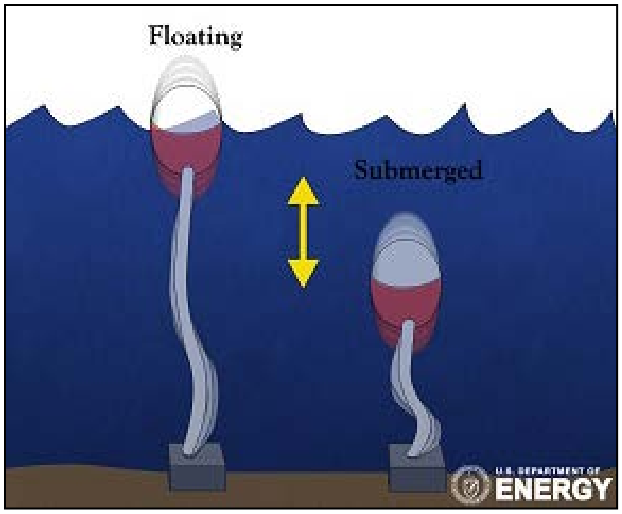


Figure 2-27. Illustration of Point Absorber Technology

Point absorber technology involves harnessing wave energy from a single, or array of wave energy "absorbers." The absorber can be a floating (buoyant) or submerged device (Figure 2-27). The rising and falling of the ocean swells cause the device to rise and fall, facilitating the movement of electromagnets inside a coil of wire to generate electricity. Other designs use the ocean's movement to generate pressure in a cylinder within the device to pump water to a powerhouse onshore. In all cases, associated infrastructure would include underwater transmission cables to carry the generated electricity to a power converter onshore.

Devices generally are the size of a lighthouse submerged 75 percent underwater and currently generate around 150 kilowatts per device, with large-capacity devices proposed for future development. For the devices that generate electricity via water pressure onshore, the size and capacity of the system is dependent on the number of buoys and onshore electricity-generating equipment. Technologies currently under development range from tens to hundreds of kilowatts (OSU 2013b). Transmission and electrical distribution requirements are dependent on proximity to existing infrastructure.

Oscillating Wave Surge Converter

Oscillating wave surge converters utilize the relative back and forth motion of waves near shore to move a large paddle-like flap (Figure 2-28). This device produces electricity by converting mechanical energy from the horizontal motion of the paddle into power, or by pumping water to shore, similar to the point absorber technology above, to generate electricity via hydropower turbine (Folley et al. 2004;

Figure 2-28. Illustration of Oscillating Wave Surge Converter Technology

Aquamarine 2013). Based on images of deployed devices in the United Kingdom, these wave surge converters are roughly the size of a small airplane hangar, and the power conversion station likely the size of a two-story structure that is between 5,000 and 10,000 square feet (Figure 2-29).

Water Current/Tidal Power Technology Types

Technologies that rely on the flow of water (that is, currents, free-flowing rivers, and predictable tidal flow) to generate electricity are similar to wind turbines and include axial flow turbines, cross-flow turbines, and reciprocating devices (DOE 2013e). However, these are not viable in Hawai‘i due to insufficient water current, and tidal ocean current resources (NREL 2009a). Therefore, this PEIS does not address these technologies further.

Figure 2-29. Oscillating Wave Surge Converter
(Source: http://www.computescotland.com/images/ibRJzFJ2p4I0OYrXxfUD0ff0bh.jpg)

2.3.3.5.2 Characterization of Technology Feasibility and Deployment

Despite the technological barriers that some of these technologies face, in terms of commercial scale development, Hawai‘i has one of the most consistent wave regimes in the United States, making it a superior location for wave power deployment (DBEDT 2002b). DOE estimates that Hawai‘i’s theoretical wave energy resource is 130 terawatt-hours per year (EPRI 2011). Aside from ocean thermal energy conversion (discussed below in Section 2.3.3.6), wave energy is the only type of marine hydrokinetic power feasible in the Hawaiian Islands (NREL 2009a). According to NREL’s Marine and Hydrokinetic

Atlas (http://maps.nrel.gov/mhk_atlas), the greatest wave power resources exist along the northern coasts of the Hawaiian Islands. According to Hawai‘i’s 2006 Wave Map, there are numerous areas in and around the islands’ shorelines that have competing uses—military, marine mammal sanctuaries, and fisheries management areas (Hawai‘i 2006)—which may limit the deployment of marine hydrokinetic technologies.

Economically feasible wave resources occur in water around 250 feet deep; shallower depths affect waves due to sea-floor friction reducing wave power. Around the Hawaiian Islands, wave power potential at 250-foot-deep water averages from 10 to 15 kilowatts per meter; however, proximity of the islands to each other creates sheltering from waves and reduces potential power around O‘ahu and Hawai‘i (DBEDT 2002b). There is a total of 30 gigawatt-hours ocean energy potential on both O‘ahu and Maui, totaling 60 gigawatt-hours for the State (DBEDT 2012b). As a renewable energy power source located in an area with ample wave resources, deployment of wave power conversion devices would aid in addressing the goals of the Hawai‘i Clean Energy Initiative.

In 2012, DOE ran a $500,000 solicitation to assist in the testing of a marine hydrokinetic device at the Wave Energy Test Site (WETS) in Kaneohe Bay, O‘ahu (DOE 2012l). As a result of this solicitation, a wave device is expected to arrive in Hawai‘i mid-2014 to utilize the shallow, grid-connected berth at WETS. An EA and Finding of No Significant Impact (DoD 2014) for two deeper WETS berths were completed in early 2014. WETS will host pre-commercial, pilot-scale projects. According to the DOE’s Marine and Hydrokinetic Technology database (http://www1.eere.energy.gov/water/hydrokinetic/default.aspx), there are no commercial, grid-connected marine hydrokinetic devices operating in Hawai‘i.

Marine hydrokinetic technology designs are still emerging. Specific representative deployment details are also unclear with respect to the size of the technologies, the expanse of the deployment array, the capacity of the devices, or which devices will ultimately be economically or technically viable in the Hawaiian Islands. However, if deployed, the selected technology likely would fall into one of two categories: onshore and offshore. Generally, the construction of onshore technologies would require the deployment of one or more semi-submerged devices at the shoreline (see descriptions above for oscillating wave surge converter, overtopping, and oscillating water column for ranges of project sizes and technical descriptions), along with the construction of transmission lines, closed-loop water piping, and any necessary power conversion structures on land, and likely would be the size of a small warehouse. Offshore devices, either floating or submerged, would need to be tethered to the sea floor with anchors, and would connect to a power cable running back to shore. Alternatively, such devices may require connection to water piping to transfer pressurized water in a closed loop to and from a powerhouse onshore to drive a turbine.

In almost every case, marine hydrokinetic technology installations will require moorings to secure devices in a given marine location. Moorings can have a single or multiple legs (that is, cables connected to anchors made of chain, wire, or synthetic material), and vary in length depending on the depth of water. Cables can be slack and allow for movement of the device or taut and restrict movement, such that the device is stationary in the water. Depending on the design, buoys may also be attached to some mid-point of the line and be present above or below the water. Anchors would attach cables to the sea floor. The type of anchors needed are dependent on environmental conditions of the installation area including depth, expected forces on the device from wave activity and/or weight of attached device, and seabed composition. There are many different types of anchors to consider, including deadweight, drag-embedment, pile, and plate anchors. More complex designs intended for minimal site impacts have greater interaction with the seabed (e.g., buried or driven into the seabed rather than just sitting on top of the seabed, like a giant weight). Such designs can also be more expensive due to complexity of the technology and deployment considerations (OWET 2009).

Deadweight anchors are heavy objects made from steel or concrete and can vary in size depending on how much resistance is needed. Drag anchors are dragged along the sea floor until they penetrate the sea floor, but offer little in the way of resistance to vertical movement because of how the anchor is oriented to the sea floor once it is secured. Piles are metal shafts driven into the sea floor and require specialized equipment for installation. If the seabed is rock (rather than loose sediment), installers must pre-drill holes prior to pile installation. Anchor plates are similar to piles, but instead of cylinders, are flat, like plates with barbs, so they keep in place after installation. Anchor plates are driven into position via pile driver, vibration, or dragging, and then re-oriented perpendicular to the sea floor to prevent the anchor from coming lose if needed. In hard seabed, reorientation is not always necessary, as the friction around the installed anchor may be sufficient (depending on the load requirements of the anchor installation) (OWET 2009).

The sea floor in waters around Hawaiʻi less than 1000 feet deep is composed primarily of a hard surface of active coral reef or compact sand, whereas the sea floor in deeper waters has a generally softer composition of mud and between 20 and 30 percent sand (DBEDT and SOEST 2010). However, during project development, a detailed site analysis would show that this is not a uniform rule, and sea floor composition varies from site to site. Considering the sea floor characteristics, sensitive environmental conditions (i.e., marine life and coral reefs) in Hawaiʻi, and limited resistance to uplift, drag anchors would not be suitable for marine hydrokinetic applications. In addition, if the seabed slope is greater than 10 degrees, deadweight anchors would not be suitable (OWET 2009). However, all other anchoring options could be utilized, depending on the technical application and size of the device, where the size of the anchors directly correspond to the size of the device being tethered to the sea floor (OWET 2009).

Offshore devices likely would be connected in large arrays if the deployment was intended for commercial-scale power generation. Array configurations, size, and space requirements are dependent on technology design. In many cases, further testing and investigation are needed to determine optimal placement.

2.3.3.5.3 Permitting and Consultation Requirements

For a discussion of general permitting and regulatory requirements, including requirements for marine-based projects, see Section 2.2.5. In accordance with the provisions of EPAct 2005, FERC is responsible for licensing, inspecting, and overseeing hydrokinetic activities. However, EPAct 2005 also amended the *Outer Continental Shelf Lands Act* to grant the Secretary of the Interior discretionary authority to regulate the production, transportation, or transmission of renewable energy on the Outer Continental Shelf (OCS). In April 2009, the Secretary of the Interior and the Chairman of FERC signed an MOU, clarifying the scope of each agency's respective responsibilities for regulating renewable energy projects on the OCS. Under the agreement, FERC has authority to issue licenses for all hydrokinetic projects (including those on State submerged lands and on the OCS), and the DOI has authority to issue leases and easements for hydrokinetic projects located partially or wholly on the OCS. For projects within the 3-mile buffer, the project developers need to seek a variety of permits from Federal, State, and county regulatory entities. If a project is located near a protected marine habitat, the developers must also consult with the NOAA NMFS for permits relating to those concerns (DOE 2009a). The developers also would consult with the USFWS and the NOAA NMFS on projects impacting protected species, critical habitat, and essential fish habitat. Additionally, developers should consult with NPS on projects that could have impacts on sensitive resources of the National Park System and other protected resources. With the abundance of marine recreational and commercial activities in Hawaiʻi, project siting and stakeholder outreach for marine hydrokinetic projects are critical. Project developers must identify and consult with key stakeholders early in the planning stage. The procedures for authorizing marine hydrokinetic energy projects involve rigorous environmental review and a substantial level of agency and stakeholder consultation (DOE 2009a).

2.3.3.5.4 Representative Project

Due to the uncertainty of marine hydrokinetic technology readiness, it is difficult to describe with any accuracy what a representative project might look like, and would ultimately depend on the type of wave technology selected. For the purposes of this PEIS, the potential environmental impacts of marine hydrokinetic technologies (presented in Chapter 6) will consider the range of potential applications identified in Section 2.3.3.5.2 that address potential impacts to the shoreline, near-shore, and offshore environments.

2.3.3.6 Ocean Thermal Energy Conversion

Ocean thermal energy conversion is a renewable energy technology that relies on temperature gradients in the ocean to generate electricity. By utilizing cold deep water and warm surface waters, it is possible to alternately condense and evaporate a fluid to drive a turbine. In general, the larger the temperature diference between the shallow and deep water, the more power a system will be able to produce.

2.3.3.6.1 Technology Description

There are three primary methods of converting ocean thermal energy. The needs of the energy system it is serving and the local ocean characteristics help determine the best method (DOE 2013f):

- Closed-cycle ocean thermal energy conversion uses warm seawater and a low boiling-point working fluid such as ammonia, propane, or Freon to generate electricity. Pumps draw warm, shallow seawater from the ocean and transfer it to a heat exchanger where it heats the working fluid. The working fluid vaporizes and drives a turbine to produce electricity. The working fluid is then pumped through a second heat exchanger, where it mixes with cold seawater brought up from the ocean depths, condenses back into a fluid, and cycled back through the process.

- Open-cycle ocean thermal energy conversion uses warm seawater to generate electricity directly, rather than through a working fluid. Pumps draw warm, shallow seawater from the ocean and transfer it to a heat exchanger, where it vaporizes into steam. This steam is used to drive a turbine, which produces electricity. The steam is then pumped through a second heat exchanger, where it mixes with cold seawater brought up from the ocean depths and condenses back into a fluid. The resulting liquid is almost completely desalinated and can be used in other applications.

- Hybrid ocean thermal energy conversion combines these methods. Warm seawater vaporizes into steam in a heat exchanger and the steam heats a working fluid. The working fluid vaporizes, which drives a turbine to produce electricity. The working fluid is then pumped through a second heat exchanger, where it mixes with cold seawater brought up from the ocean depths, condenses back into a fluid, and cycled back through the process.

The first documented reference to the use of ocean temperature differences to produce electricity is found in Jules Verne's *Twenty Thousand Leagues Under the Sea* published in 1870 (Vega 2002). Small-scale ocean thermal energy conversion projects have been demonstrated since the 1970s; there are no large-scale commercial ocean thermal energy conversion systems in operation. However, the world's first commercial-scale ocean thermal energy conversion power plant, a 10-megawatt offshore facility, is under development and will be located off the coast of Southern China (OTEC News 2013).

Ocean thermal energy conversion facilities can be located either onshore or offshore. Land-based facilities have a higher internal energy demand relative to offshore plants due to the pumping load required to bring large volumes of water onshore through long intake pipes (NELHA 2012). Offshore facilities would be located in deep ocean water several miles from the shore. First generation commercial OTEC facilities in Hawaiʻi would likely be offshore facilities (NELHA 2012; Vega 2002). Figures 2-30 and 2-31 illustrate onshore and offshore ocean thermal energy conversion facilities. Figure 2-30 also shows co-production facilities.

Figure 2-30. Onshore Open-Cycle Ocean Thermal Energy Conversion Facility with Desalination Co-production (Source: NOAA 2013b)

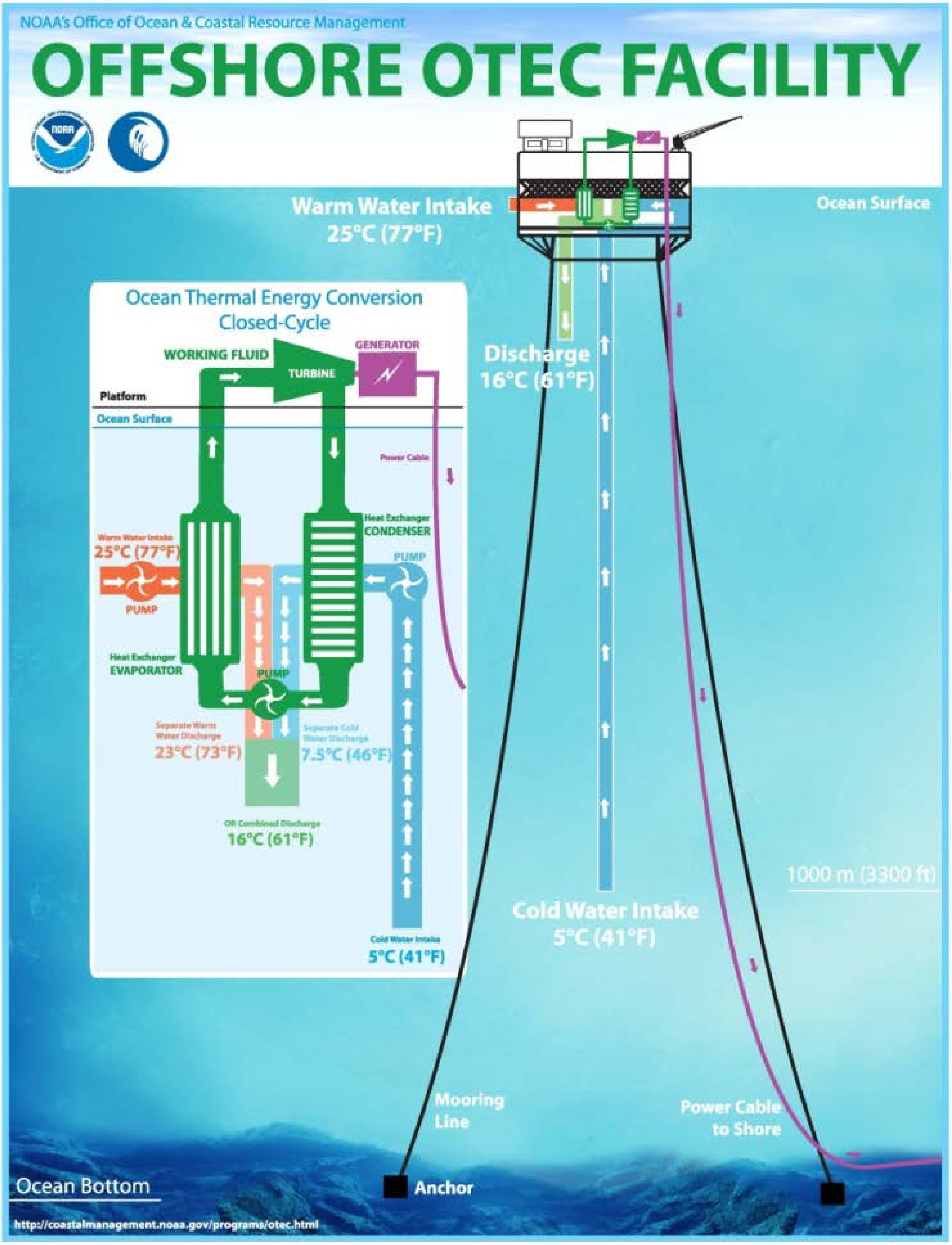


Figure 2-31. Offshore-based Closed-Cycle Ocean Thermal Energy Conversion Facility (Source: NOAA 2013c)

2.3.3.6.2 Characterization of Technology Feasibility and Deployment

Ocean thermal energy conversion technology depends largely on accessible ocean temperature gradients. Although in theory there is a vast amount of energy contained in the ocean's temperature gradients, in reality, a temperature difference of over 36ºF between deep and shallow water must exist for an economically viable system (DOE 2009b). Seawater temperature differences of less than 36ºF require ocean thermal energy conversion systems with relatively large seawater flow rates, on the order of 100 cubic feet per second per megawatt of net electricity produced (Nihous 2013). However, suitable temperature gradients exist in tropical regions such as the Hawaiian Islands with access to deep (i.e., greater than 3,000 feet) ocean water (Vega 2010a).

According to the NREL Marine and Hydrokinetic Technology atlas, the annual average temperature difference between deep and shallow water off the coasts of the Hawaiian Islands is 68ºF (NREL 2013b). A larger temperature difference is found on the southwestern coasts, compared with a slightly smaller temperature difference on the northeastern coasts. Sufficiently deep waters are found close to the Hawaiian Islands, due in part to the area's geology, which provides a steep slope to ocean depths that provide the required water temperature variance. Siting considerations include the distance to centers of greatest electricity demand from feasible sites. However, ocean temperatures surrounding the islands are relatively consistent, indicating that a potential developer would have their pick from a number of viable site locations.

The main benefit of ocean thermal energy conversion is that ocean temperatures are relatively stable, and can provide a consistent source of power without downtime. Unlike some renewable energy technologies, the electricity generated can be distributed at utility scales with little intermittency. There are also potential beneficial applications for co-products that can be implemented within a system's distribution range (DOE 2013f). Cold, deep seawater used to condense the working fluid can be distributed throughout a district cooling system to provide air conditioning to buildings within range (Section 2.3.1.5 of this PEIS addresses sea water air conditioning technologies). The cold, deep seawater can also be used in agriculture, aquaculture, and potable water applications. For open-cycle and hybrid systems, desalinated water can be used. High capital costs may be an initial barrier to implementation of commercial OTEC systems. However, ocean thermal energy conversion facilities benefit from economies of scale, with larger-scale systems being more viable.

The following potential environmental issues related to ocean thermal energy conversion facilities require further research (NOAA 2013d):

- Withdrawal and Discharge Water – A 100-megawatt facility would use 10 to 20 billion gallons per day of warm sea water from the surface and cold water from a depth of approximately 3,300 feet. The large volume of water discharged from ocean thermal energy conversion facilities will be cooler, denser, and more nutrient rich due to the composition of the deep cold water being different from the receiving waters. Nutrient rich water (with nitrogen and phosphorus) would be discharged at a depth where the ambient water is warmer and oligotrophic (nutrient poor).

- Impingement and Entrainment – Screens would be used for both the warm and cold water intake systems to prevent debris and larger species from entering.

- Biocide Treatments – The warm water used in the facility would need to be treated with a biocide (e.g., chlorine) to prevent biofouling (the accumulation of microorganisms, plants, algae, or animals on wetted surfaces) and maintain the efficiency of the heat exchangers. The amount of biocide needed would likely be less than the maximum discharge allowed under the CWA.

Several pilot-scale ocean thermal energy conversion projects have been executed in Hawaiʻi since the 1970s. Large-scale ocean thermal energy conversion electricity generation, however, has been slow to emerge. NELHA at Keahole Point in Kona achieved major milestones in ocean thermal energy conversion in the 1980s and 1990s, including a 1-megawatt floating pilot plant, Mini-OTEC (the world's first demonstration of net power output from a closed-cycle plant) and other demonstrations in both open- and closed-cycle configurations (DBEDT 2013h). A 1-megawatt onshore demonstration project at NELHA is currently the planning stages, and there is interest in 5- to 10-megawatt and 100-megawatt offshore demonstration projects off Oʻahu (BOEM 2012). NELHA presently hosts an ocean thermal energy conversion heat exchanger test facility, and there are plans to add a 100-kilowatt generator in 2014 (DBEDT 2013h).

2.3.3.6.3 Permitting and Consultation Requirements

NOAA's Office of Ocean and Coastal Resource Management is responsible for licensing the construction and operation of commercial ocean thermal energy conversion systems, while DOE's Office of Energy Efficiency and Renewable Energy Water Power Program is responsible for designating ocean thermal energy conversion demonstration projects (NOAA 2013c). The majority of Federal, State, and county requirements would be handled through the NOAA licensing process (HNMREC 2013). See Section 2.2.5 for a discussion on general permitting and regulatory requirements, including marine-based technologies.

Primary environmental risks from ocean thermal energy conversion facilities include the high volume of discharge into the ocean and the impacts of laying a large pipe on the seafloor and coastline. Facility modeling to determine effluent volume, temperature, and composition is needed to provide the permitting agencies the information necessary to assess and mitigate project impacts. Projects would need to conduct extensive biological exploration within the project footprint, both above and under water, to identify protected marine species that potentially could be impacted by the project.

Water quality impairment and cooling water intake for ocean thermal energy conversion facilities is regulated by the CWA Sections 316(b), 402, and 403. Section 316(b) provides a means to demonstrate to EPA that the location, design, construction, and capacity of cooling water intake structures for facilities reflect the best technology available for minimizing adverse environmental impacts (33 U.S.C. §§ 1326(b), 1342, and 1343). Under CWA Section 402, any discharge of a pollutant or combination of pollutants into a waterway requires a valid NPDES permit, and Section 403 provides for the promulgation of guidelines applicable to NPDES permits for discharge of pollutants into oceans and territorial seas (NOAA 2013a).

2.3.3.6.4 Representative Project

A representative ocean thermal energy conversion project in Hawaiʻi would consist of a 50-megawatt closed-cycle system located in deep water 3.5 miles offshore from a land-sea cable transition site. A deep-water pipe 30 feet in diameter and about 3,300 feet deep would draw deep, cold seawater. Deep water would be retrieved at a temperature of 39º to 41ºF and surface water at 75º to 82ºF. Warm sea water would be drawn through two 33-foot diameter pipes. Seawater flow rates would be 70,000 gallons per second of warm water and 36,300 gallons per second of cold water. The effluent sea water (both warm and cool waters combined) would be returned via two 40-foot-diameter pipes at a depth of 200 feet, in accordance with environmental standards and Zone of Mixing regulations to prevent alteration of natural ocean temperature profiles or disruption of thermohaline cycling.

The floating platform would be 650 feet long with a 128-foot beam and an operating draft of 53 feet. The closed-cycle system would use pressurized anhydrous ammonia as the working fluid, which would pass through evaporating and condensing plate-fin heat exchangers. These exchangers would be located on the floating platform anchored to the ocean floor via mooring lines. The facility would use the anhydrous ammonia at a rate of about 6,100 pounds per second. The project would use chlorine to protect the heat exchangers from biofouling. It has been determined that biofouling from cold sea water is negligible and that evaporator fouling can be controlled effectively by intermittent chlorination (50 to 100 parts per billion of chlorine for 1 hour per day) (Vega 2010b).

An undersea power cable no more than 5 inches in outside diameter would run approximately 6 miles to an onshore land-sea cable transition site, which would connect to the power grid to power the pumps and to deliver electricity to the entire facility. The floating platform would use auxiliary diesel-powered generators to provide backup power to maintain operation of the ocean thermal energy conversion system.

2.3.3.7 Photovoltaic Systems

As Section 2.3.2.4 covered, photovoltaic cells convert sunlight to electricity and are grouped into solar modules. Solar modules for utility-scale systems are part of a larger system, or array, to generate and supply electricity for the utility grid. A system typically includes a number of modules, equipment to collect and convert the electricity generated, sun-tracking devices to improve the ability of the module to collect solar energy regardless of the location of the sun throughout the day, and, in some cases, energy storage capacity. For comparison purposes, a typical distributed photovoltaic system generates up to 50 kilowatts of electricity, uses relatively few solar modules, and covers a few hundred square feet. The Anahola Solar Project on Kaua‘i, one of the more recent utility-scale photovoltaic projects under construction in Hawai‘i, will generate 12 megawatts of electricity, use approximately 50,000 modules, and take up about 67 acres of land.

Generally speaking, a utility-scale system ties into the grid close to where the power is produced, which travels to the consumer via the grid. *Energy storage* allows excess electricity to be stored and used at times when the demand for electricity on the grid exceeds the amount generated. It also facilitates grid stability, allowing for regulating, or smoothing, intermittency. Energy storage is one of a group of technologies that can contribute to a *smart grid*. A smart grid is designed to improve the efficiency and overall reliability of the utility distribution grid. This PEIS discusses smart grids and energy storage in Sections 2.3.5.4 and 2.3.5.5, respectively. More information on both topics can be found online at http://energy.gov/oe/technology-development/smart-grid.

The National Renewable Energy Laboratory determined that life-cycle greenhouse gas emissions from solar modules were significantly less than fossil and nuclear electricity generation, as well as many other renewable energy technologies (NREL 2012a).

2.3.3.7.1 Technology Description

The technology behind PV systems is basically the same whether with a small, distributed system or a utility-scale system. When sunlight shines on a photovoltaic cell, the cell absorbs a portion of the light. The energy of the absorbed light transfers to some of the electrons in the atoms of the photovoltaic cell’s material. Those electrons escape from their normal positions in the atoms and become part of the electrical flow, or electricity. The amount of energy from the sunlight that converts to electricity depends on a number of factors, including the wavelength of the light, the amount of light absorbed, the temperature of the photovoltaic cell, and the resistance of the materials to the electrons’ flow. Capacity factors among the different photovoltaic cell materials and designs range from about 6 to 40 percent. Typical commercially available modules used in utility-scale installations range between 15 and 20 percent.

The generated electricity is DC and must be converted to AC before use. One or more inverters convert the generated electricity onsite at the utility-scale photovoltaic installations or at other locations where the electricity is going to be used. If the former, the local utility transmits the electricity via distribution grid to the consumer. As with a distributed system, a utility-scale system may or may not include energy storage capabilities, albeit a higher capacity storage system. Figure 2-32 is a diagram of the major items of a utility-scale photovoltaic system connected directly to a local utility distribution grid and Figure 2-33 is a diagram of a utility-scale photovoltaic system with energy storage capabilities.

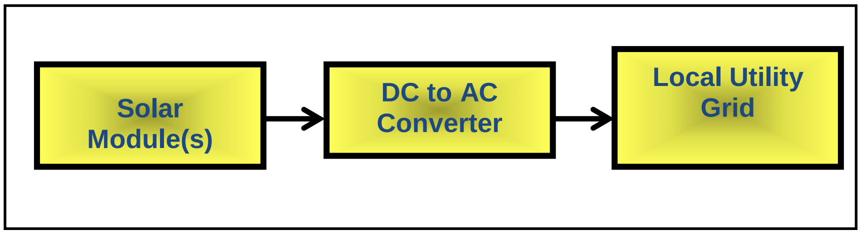


Figure 2-32. Diagram of the Major Items of a Utility-Scale Photovoltaic System Connected Directly to a Local Utility Distribution Grid

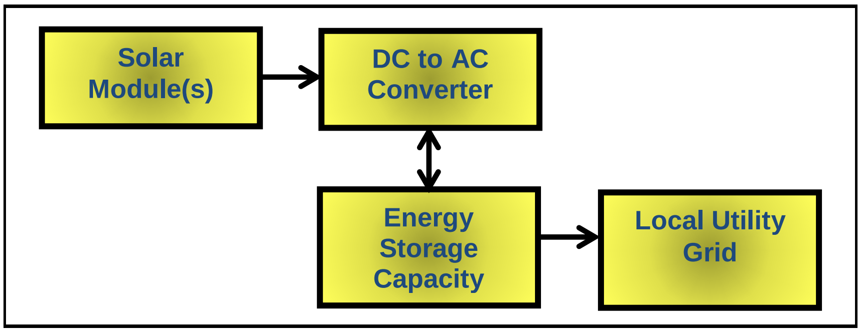


Figure 2-33. Diagram of the Major Items of a Utility-Scale Photovoltaic System with Energy Storage Capacity

2.3.3.7.2 Characterization of Technology Feasibility and Installation

Utility-scale photovoltaic systems are a mature and reliable renewable energy technology. The DOE SunShot Initiative is a national collaborative effort to make solar energy cost-competitive with other forms of electricity by the end of this decade (DOE 2013c). The State of Hawai‘i has ideal sun conditions for the development of electricity from PV systems. Currently 2.6 percent of electrical energy consumption in the State is produced by solar facilities including utility-scale photovoltaic systems. There are approximately 23 megawatts of capacity operating or close to starting operations in the State, with about 49 megawatts of capacity under development (SEIA 2013).

2.3.3.7.3 Permitting Requirements

General permitting requirements are discussed in Section 2.2. Many photovoltaic modules contain substances that could pose a risk to the environment and, potentially, public health if not properly disposed of or recycled. There are industry initiatives to develop recycling guidelines and processes for PV systems. There is also research being conducted on photovoltaic cells that are made from plant materials and while the conversion efficiencies for these cells are currently low-- a few percent--future advances could partially address future disposal considerations. Currently some discarded solar modules may need to be managed and disposed of as hazardous waste. There has been recent discussion regarding the use of agricultural lands for renewable energy development in Hawai‘i. Given the State priorities on energy and food independence, careful siting and planning must occur to ensure these priorities are taken into consideration.

2.3.3.7.4 Representative Project

The representative project involves utility-scale facility with 50 megawatts generating capacity that ties directly into the electrical distribution grid. The representative project would have a footprint ranging from approximately 250 acres, with about 200,000 modules. In general, solar photovoltaic projects require about 5 acres of land per megawatt generated. The type and amount of electrical equipment and wiring associated with collecting, converting the DC electricity to AC electricity, and tying the system into the utility grid would be proportional to the size of the project. For purposes of analysis, the representative project transmits electricity directly to the distribution grid and does not have energy storage capabilities.

2.3.3.8 Solar Thermal Systems

2.3.3.8.1 Technology Description

Solar thermal energy converts solar energy into thermal energy (heat) that can be used for thermal loads or for the production of electricity. One big difference from solar photovoltaic technology is that solar thermal power plants generate electricity indirectly. Heat from the sun’s rays is collected and used to heat a fluid. The steam produced from the heated fluid powers a generator that produces electricity. This is similar to the way fossil-fuel-burning power plants work except the steam is produced by the collected heat rather than from the combustion of fossil fuels. Solar thermal facilities are capable of producing one or a few to hundreds of megawatts of power (Solar Thermal 2013). Solar PV systems directly convert the sun’s light into electricity. Sections 2.3.2.4 and 2.3.3.7 of this PEIS discuss PV systems for distributed and utility-scale projects, respectively.

High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for larger-scale electric power production. Utility-scale thermal systems use high-temperature collectors (up to and over 400°F) and are often called concentrating solar power systems (EIA 2013b).

Solar thermal units use concentrated sunlight to produce electricity by capturing heat using mirrors or lenses, which turn to follow the course of the sun during the day. The mirrors focus the reflected sun’s heat on a heat-absorbing working liquid. The heat is then transferred from the working fluid to a conventional steam generator or organic rankine cycle generator. A thermal energy system can store heat, thus allowing electricity production into the evening and after the sun goes down or on cloudy days (EIA 2013b).

Solar thermal power technology uses concentrator systems to achieve the high temperatures needed to heat fluid. The three main types of solar thermal power systems are parabolic trough with linear concentrations, solar power tower, and solar dish (EIA 2013b). Although solar dish technology has the potential to become one of the least expensive sources of renewable energy, this technology is still in the engineering development stage and faces challenges concerning the solar components and commercial availability (SolarPACES.org 2013). Therefore, this PEIS does not analyze that technology further.

Parabolic Trough Power Plants

Parabolic trough power plants (the most common type of solar thermal plant in the United States) use curved, mirrored modules shaped like a trough to reflect the direct sun’s rays onto the receiver (a glass tube containing a fluid), which runs the length of the trough (Figures 2-34 and 2-35). The trough is parabolic, or U-shaped, along one axis and linear along the axis of the receiver. The trough tilts east to west so that direct sunlight hits the receiver at all times. Seasonal changes in the angle of sunlight do not require adjustment of the mirrors, since the light concentrates on the receiver.

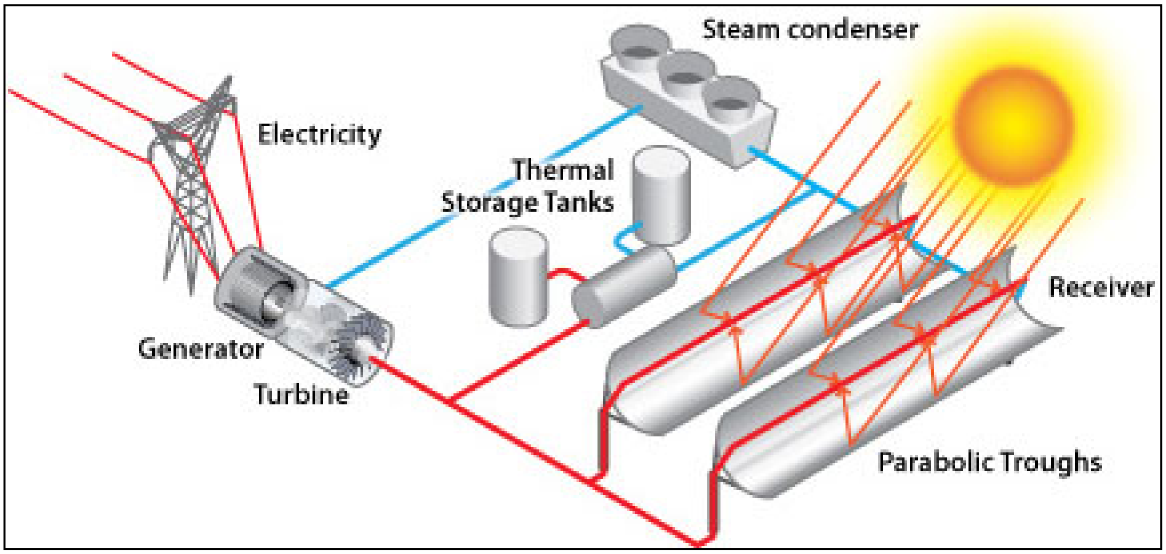


Figure 2-34. Depiction of a Parabolic Trough Solar Thermal Power System

A heat transfer fluid passes through the receiver and becomes very hot. Common fluids are synthetic oil, mineral oil, molten salt, and pressurized steam. Using gravity, the fluid containing the heat flows to a heat engine, where about one-third of the heat converts to electricity (EERE 2013b). Located at NELHA at Keahole Point is the world's first Concentrating Solar Power project based on the MicroCSP technology using a regenerative Rankine Cycle Engine (see Section 2.3.3.8.2) (Sopogy 2013). The Rankine Engine uses refrigerant as its working fluid rather than steam (Northwestern University 1997).

Figure 2-35. Parabolic Trough Solar Farm with High-Temperature Solar Collectors and Support Facilities, Cooling Towers, White Water Tanks, and Generation Equipment (Source: EERE 2013b)

If the receiver contains oil or molten salt as the heat-transfer fluid (HTF), then the thermal energy can be stored for later use (EERE 2013b). The HTF is supplied to the power plant where it passes through a series of heat exchangers, turning water into high-pressure steam that drives a Rankine steam turbine. The HTF is then returned to the solar collector field to be heated once again, creating a closed-loop system. Heat storage allows a solar thermal plant to produce electricity at night and on overcast days. This enables the use of solar power for baseload generation (backed up by liquid or gaseous fuels) as well as peak power generation. Several thermal storage technologies are in use, including the two-tank direct system, two-tank indirect system, and single-tank thermocline system.

Two-tank direct systems store solar thermal energy in the same fluid used to collect it. The fluid is stored in a closed loop in two tanks, one at high temperature and the other at low temperature. Fluid from the low-temperature tank flows through the solar receiver, where solar energy heats it to a high temperature, and then continues to the high-temperature tank for storage. Fluid from the high-temperature tank flows through a heat exchanger, where it generates steam for electricity production. The fluid exits in the heat exchanger at a low temperature and returns to the low-temperature tank (EERE 2013b).

Two-tank indirect systems function the same as direct systems, except the fluids used for heat collection and heat storage are different. In addition, with indirect systems, the fluid from the low-temperature tank flows through a heat exchanger before flowing to the high-temperature tank. Storage fluid from the high-temperature tank generates steam in the same manner as a direct system (EERE 2013b). Indirect systems require an additional pump to circulate the fluid through the closed-loop system, and therefore, may be more costly than a direct system.

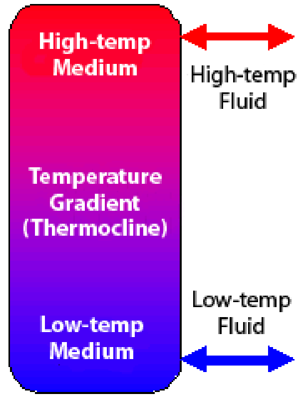


Figure 2-36. Graphic Presentation of the Single-Tank Thermocline System (Source: EERE 2013b)

The single-tank thermocline system (Figure 2-36) stores thermal energy in a solid medium, most commonly silica sand, in a single tank. Inside the single tank, parts of the solid are kept at low to high temperatures, in a temperature gradient, depending on the flow of fluid. For storage purposes, hot heat-transfer fluid flows into the top of the tank and cools as it travels downward, exiting as a low-temperature liquid. This process moves the thermocline, or transition layer, downward and adds thermal energy to the system storage. Reversing the flow moves the thermocline upward and removes thermal energy from the system to generate steam and electricity. Buoyancy effects help to stabilize and maintain the thermocline (EERE 2013b).

Parabolic trough systems require 5 to 10 acres of land to generate 1 megawatt of power (NREL 2013d).

Solar Power Towers

Power towers (also known as central power plants or heliostat power plants) capture and focus the sun's thermal energy with thousands of tracking mirrors (called heliostats) in approximately a 2-square-mile field (Figure 2-37). Heliostats focus concentrated sunlight on a receiver that sites atop a tower, which is positioned in the center of the heliostat field. Within the receiver, the concentrated sunlight heats salt to more than 1,000°F. Like the parabolic trough systems, HTF is an integral part of the power tower system. The HTF is composed of either water or molten nitrate salt and as it moves through the receiver it is heated to temperatures over 500°C. The heated HTF is then sent to a heat exchanger where the water is turned into steam, which then drives a turbine generator. More advanced systems that use molten salt as the HTF can take advantage of the higher heat capacity of the fluid and can store the heat energy, which allows the system to continue to generate electricity for several hours longer compared with those without storage capability, which effectively increases a power tower's capacity factor (UM School of Natural Resources 2010).

The advantage of this design compared with the parabolic trough design is the higher temperature attained. Thermal energy at higher temperatures can be converted to electricity more efficiently and is less expensive to store for later use. Furthermore, solar power facilities are not limited by the topography of a prospective site. The mirrors can move independently so they point at the receiver. However, the fact that the mirrors make the design more complex, in that each mirror must have its own dual-axis control; whereas, in the parabolic trough design, a single array of mirrors can share single axis tracking.

Figure 2-37. Operating Solar Power Facility in Spain

The land-to-power ratio is estimated at 44 acres per 1 megawatt. NREL has estimated that by 2020, electricity could be produced from power towers for 5.47 cents per kilowatt-hour and for 6.21 cents per kilowatt-hour from parabolic troughs. The capacity factors are estimated to be 72.9 and 25 percent for solar towers and parabolic troughs, respectively, to greater than 40 percent for plants with thermal storage (NREL 2013d). Tower heights can range from approximately 300 to 650 feet. Tower height and field size vary depending on individual project economics. An economic optimization analysis takes into consideration the capacity factor and capital costs. The amount of solar energy collected is a function of the number of heliostats installed. However, as the number of installed mirrors increases, the height of the tower must also increase. Determining the optimal tower height and field size is driven by the economies of scale (UM School of Natural Resources 2010).

2.3.3.8.2 Characterization of Technology Feasibility and Deployment

Hawai‘i’s tropical location provides a lot of sun energy that is poised to be utilized more effectively in the future. Basic site location considerations for a utility-scale solar thermal energy plant include proximity to the electrical grid, sufficient sun light, and topography. For utility-scale parabolic trough plants, project siting would generally avoid environmentally sensitive areas and population centers. The use of public lands can offer suitable sites (DOE and BLM 2003). Level land with a southern exposure is generally preferable (Ownergy 2011) because it provides the longest duration of sunlight.

There are two solar thermal energy projects under development in Hawai‘i; both are parabolic trough systems: the 2-megawatt Holaniku facility in Keahole Point on Hawai‘i island and the 5-megawatt Kalaeloa Solar Power 1 facility in Kalaeloa on O‘ahu.

2.3.3.8.3 Permitting and Consultation Requirements

Additional information on more general permitting requirements can be found in Section 2.2.5. There are several requirements specific to solar thermal energy projects of potential interest in terms of environmental evaluations:

- Due to potential reflectivity issues, the Federal Aviation Administration recommends all solar projects with reflective potential consult them early in the planning stages.
- For solar power towers more than 200 feet tall, the Federal Aviation Administration guidelines for marking and lighting facilities could require warning lights that flash white during the day and twilight and red at night (BLM and DOE 2010). Daylight lighting might be avoided in some cases by painting the power tower orange and white according to the Administration guidelines, but this practice could result in large increases in visual contrast for the tower during the day (resulting in a negative visual resources impact; see Section 6.8).
- Proximity to cultural and scenic resources, including national parks; any NPS park units within the viewshed of the proposed solar power facility (and associated facilities and transmission corridors) should be consulted early in the planning process.

2.3.3.8.4 Representative Project

The representative solar thermal facility would be a parabolic trough facility with 5-megawatt capacity on 20 to 45 acres of land (GWU 2011). The construction and operation of solar collectors and support structures would be confined to that acreage and spaced to avoid shading the collector modules.

A 5-megawatt facility would use about 230,000 gallons of water per year (Basin and Range Watch 2013). Construction of a 5-megawatt facility would result in about 10 construction jobs for a period of up to one year; operational full-time jobs would range from 10 to 15 employees (IndyStar 2013).

The facility would include the key elements discussed in Section 2.3.3.8.2 and depicted on Figure 2-34, in addition to road access, parking, and maintenance facilities. During construction, the site would experience land clearance activities and require lay-down yards. The project also assumes a transmission tie-in of at least 1 mile.

2.3.3.9 Land-Based Wind Power

2.3.3.9.1 Technology Description

As described in Section 2.3.2.5 for small wind turbines, utility-scale wind turbines convert the kinetic energy of the wind to mechanical power. In the typical horizontal-axis wind turbine, wind flowing over the airplane-wing-like blade causes a pocket of low-pressure air on one side of the blade and the low-pressure generates “lift” and pulls the blade toward it, causing the blade to move and the rotor to turn, which spins a generator to make electricity. The category of utility-scale, land-based wind turbines is generally considered to encompass turbines with capacities greater than 100 kilowatts and includes units with multiple megawatt capacities (DOE 2013g). The two basic groups of wind turbines are the horizontal- and vertical-axis varieties. Representative configurations for these two groups are depicted in Figure 2-38. The horizontal axis wind turbine shown in the figure is the most common type; however,

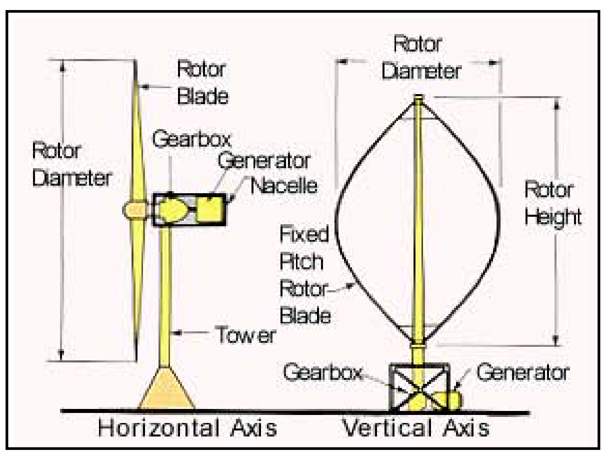


Figure 2-38. Basic Wind Turbine Configurations

there is a wide variety of potential blade configurations for vertical-axis wind turbines, particularly in smaller wind turbine sizes (see Section 2.3.2.5).

Utility-scale, horizontal-axis wind turbines are designed to face into the wind and they contain internal equipment and controls that automatically rotate the turbine housing and rotor to keep the rotor in an upwind position. The vertical axis wind turbine has the advantage of being able to intercept wind coming from any direction without changing its own orientation. A primary limiting factor for the vertical axis turbine is the rotating shaft must remain rigid and stable, which requires the lower barring to be very solid or the top of the unit be fixed with an upper barring and guy wires. Either option typically limits the size and suitable installation locations. In comparison to horizontal axis wind turbines, the vertical axis wind turbines are less efficient and are generally installed at lower elevations where wind is less energetic and more often subject to turbulence caused by other structures or topography changes. The increased turbulence decreases energy production and increases wear (DOE 2012m). Utility-scale wind turbines and the associated wind farms are dominated by horizontal-axis machines and, accordingly, the technology description presented in this section will focus on this configuration.

Figure 2-39 shows the primary components of a utility-scale, horizontal-axis wind turbine. Several of these elements are described as follows:

- Rotor (Hub and Blades) – The rotor consists of the hub and blades. The majority of utility-scale wind turbines have three blades made of composite laminates. The blades, designed to be moved by wind, rotate the hub, which is connected to a shaft; thus, converting wind energy to rotational shaft energy. The amount of power that can be produced is a direct function of the swept area of the blades. Since the swept area increases by the square of the blade length, to double a wind turbine's capacity, the blade length would have to be increased by a factor of about 1.4. For example, a 1.5-megawatt wind turbine requires a rotor diameter of about 216 feet (DOE 2011e), so a wind turbine with twice the power capacity, or 3.0 megawatts, needs a rotor diameter that is 1.4 times greater in size, or about 300 feet. That is, provided both machines were designed for the same wind velocity (see Tower description).

- Tower – The tower supports the rotor and nacelle (the housing that contains the gear box, shafts, generator, controller, and brake) with the objective of putting the rotor blades into a zone of higher wind velocity and lower wind turbulence than occurs near the ground. Towers can be made from tubular steel, concrete, or steel lattice (DOE 2013h), but the most common towers on modern utility-scale wind turbines are of tubular steel. There is no required relationship between the height of the tower and the size of the wind turbine, but power production varies by wind speed, which increases with height about the earth's surface. Wind turbines in the 2.5 to 3 megawatts range are offered with towers heights of 260 feet or slightly higher, but may be 330 feet and higher.

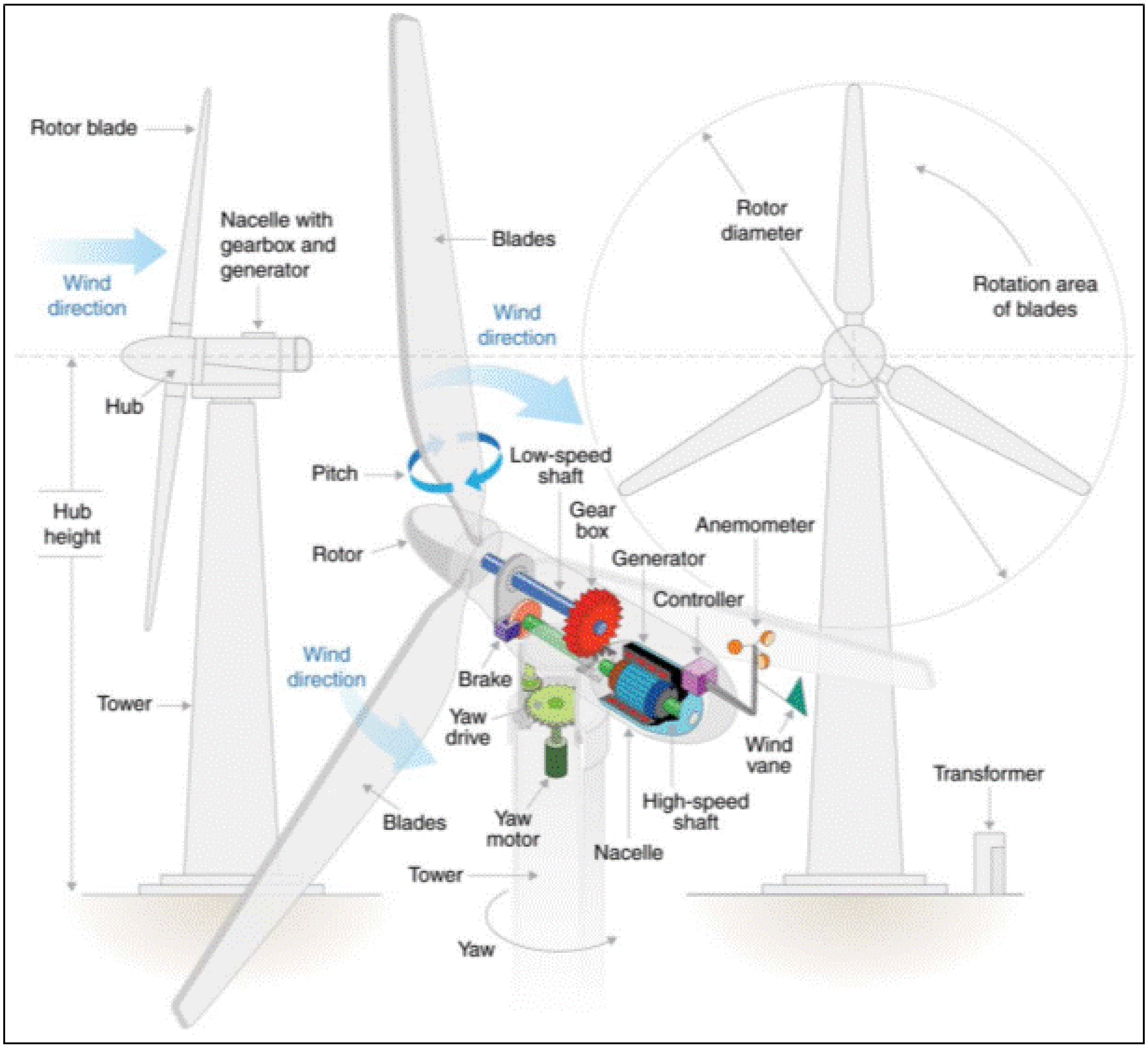


Figure 2-39. Schematic of the Primary Components of a Utility-Scale, Horizontal Axis Wind Turbine (Source: NREL 2012c)

- Drive Train – The major mechanical components inside the nacelle are part of the drive train that includes the following:

  – Gear Box – The gear box contains a multi-stage series of gears that convert the 8 to 15 rpm of the slow shaft to about 1,200 to 1,800 rpm for the high-speed shaft and which is the rotational speed required by most electric generators (NREL 2012c). The gear box is a heavy and expensive component of the wind turbine and ongoing research and development is pursuing generators that can operate directly from the low-speed shaft, which would eliminate the need for the gear box (DOE 2013b). It is estimated that more than 10 percent of the global turbine supply already consist of direct-drive drivetrains and the technology is already found among the wind turbines in Hawai‘i. To date, the direct-drive generators are larger and heavier than their high-speed counterparts (NREL 2012c), so some of their advantage is lost.

– Generator – The electric generator produces AC electricity, at 60 hertz in the U.S., and is generally an off-the-shelf induction generator.

Additional detail on the components of a typical horizontal wind turbine can be found in NREL's *Renewable Electricity Futures Study*, available only from http://www.nrel.gov/analysis/re_futures/.

Vertical-axis wind turbines have many of the same components as described above for the horizontal axis variety. The rotor and blades would be different and a vertical-axis wind turbine likely would have nothing resembling a housing positioned up in the air, but the necessary functions would still be there.

Various entrepreneurs are pursuing alternative approaches of horizontal and vertical wind turbines to harnessing wind energy. It is relatively easy to find websites describing various means of using tethered devices similar to kites, wind sails, or even rigid wing-like items to generate power from wind. Some of these devices may hold great promise as future utility-scale energy producers, but for purposes of this document they are considered to be too early in development to address in any detail.

Evolution of Wind Turbine Sizes

Utility-scale wind turbines are intended to provide electricity to a distribution system, therefore their design is not centered around any specific power level. Rather, it is basically driven by a desire to provide as much output as possible, as efficiently as possible. In order to maximize turbine performance, manufacturers have pursued more advanced turbine components and larger turbines. As a primary example, the development of stronger and lighter blades has facilitated design of wind turbines with larger rotor diameters. The current, state-of-the-art turbine produces about 1.5 to 3.5 megawatts. In 2011, the average installed turbine size in the United States was about 2 megawatts (DOE 2013i). At least one manufacturer is already promoting a land-based wind turbine with a capacity of 4.5 megawatts (Gamesa 2012).

Wind Needs and Typical Capacity Factors

It is generally preferred that candidate sites should have average wind speeds of at least 14 miles per hour at the hub height for these large turbines to be economically feasible (DOE 2011f). The relationship between wind speeds and wind turbine operations can be grouped into four wind speed regions explained further in Table 2-16. As noted in the table, the wind turbine does not operate in regions I and IV; region I being too low and region IV being too high.

Capacity factor is a terminology often used in describing power generating technologies. It is defined as the ratio of a technology's actual output over a period of time (typically a year) to its potential output, where the potential output is the device operating continuously over that period of time at its rated, or nameplate, capacity. For a wind turbine to operate at or near a 100 percent capacity factor, the wind speed would have to be constantly in the region III category shown in Table 2-16. The capacity factor that can be achieved by a single wind turbine is dependent on its location and the wind available at that location, as well as other influences such as curtailment and maintenance periods. The higher the average wind speed, the more time the wind turbine would be expected to spend in region III and the upper end of region II. Capacity factors have increased as wind turbine hub heights have increased because of the better wind resources at greater distances from the ground. Along with the average wind speed, the characteristics of the site's wind consistency are also very important. If a site has a high average wind speed primarily because of the amount of time it's at 55 miles per hour or higher, that could easily be a poorer candidate site than one with a lower, but more consistent average wind speed, with less time of excessive wind.

Table 2-16. Wind Speed Regions in Comparison with Wind Turbine Operations

Wind Speed Region	Wind Speeds (in mph)[a]		Description of Wind Turbine Operation
	Lower Limit	Upper Limit	
I	0	7	Below a cut-in wind speed of about 7 mph the wind turbine's controller keeps the rotor from turning.
II	7	27	Between the cut in speed and the wind speed at which the wind turbine is rated (27 mph in this case), the rotor turns at a rate that varies with the wind speed.
III	27	55	By changing the pitch on the blades, the wind turbine's controller keeps the rotor turning at a constant rate, independent of the wind speed, producing the wind turbine's rated output.
IV	55	> 55	Once a cut-out wind speed of about 55 mph is reached, the wind turbine's controller fully furls the blades and stops the rotor from turning.

Source: NREL 2012c.

a. These are representative values for utility-scale wind turbines that can change by minor amounts by manufacturer and wind turbine model. For example, cut-in wind speeds are generally in the range of 7 to 9 mph, fully rated powers are generally achieved at wind speed ranges of 27 to 29 mph, and cut-out wind speeds are generally in the range of 55 to 65 mph.

mph = miles per hour (meters per second = mph × 0.447)

Although capacity factors are largely site specific, evaluating data over a large number of turbines provides a good indication of what can be expected. According to evaluations performed by U.S. Department of Energy's National Renewable Energy Laboratory (NREL), capacity factors for wind plants installed from 2004 through 2010 in the United States have ranged between 30 and 35 percent. This is compared to an average capacity factor of 25 percent for the wind plants installed in 1999 (NREL 2012c).

Site-specific capacity factor data for several Hawai‘i wind farms are as follows: 65 and 45 percent, respectively, for the Pakini Nui and Hawi wind farms, both on Hawai‘i island, and 47 percent for Kaheawa I on Maui. These capacity factors were based on 2011 data and the high values were attributed to the "robust and consistent" wind regimes available within the State (DBEDT 2013h).

Land Needs for Utility-Scale Wind Turbines

NREL has also collected and evaluated information on the amount of land required for wind farm projects (NREL 2009b). Theoretical evaluations propose optimum land requirements of about 30 to 50 acres per megawatt of wind turbine capacity. However, data on 161 wind farm projects representing about 25 gigawatts of proposed or installed capacity within the United States were considered to characterize typical "real world" land requirements. This evaluation determined an average land requirement of 84 acres per megawatt.

As a comparison to the above land area requirements, Table 2-17 provides a summary of land areas associated with wind projects in Hawai‘i. The acreage per megawatt installed ranges from 3.2 to 23.8, with an average for the seven projects of 9.7 acres per megawatt. These low values in comparison to the NREL study are likely attributed to the limited size of the data sets, but may also be due to the fact that very few Hawai‘i wind farms have multiple strings of wind turbines so projects in the table may not include spacing between rows.

Table 2-17. Summary of Land Areas Associated with Hawai‘i Wind Project[a]

Project Name	Year Installed	Island	Developer	Capacity (MW)	Acres	Acres per MW
Hawi Renewable Development	2006	Hawai‘i	Hawi Renewables	10.5	250	23.8
Kaheawa I Wind Farm	2006	Maui	First Wind	30	200	6.7
Pakini Nui Wind Farm[b]	2007	Hawai‘i	Tawhiri Power	20.5	67	3.3
Kahuku Wind Farm	2011	O‘ahu	First Wind	30	578	19.3
Kawailoa Wind Farm	2012	O‘ahu	First Wind	69	650	9.4
Kaheawa II Wind Farm	2012	Maui	First Wind	21	143	6.8
Auwahi Wind	2012	Maui	Sempra Generation	21	68	3.2

a. Source: DBEDT 2013h.
b Actual footprint is 26 acres. Personal communication, Steven Pace, 4/26/13. Parcel size is 67 acres.
MW = megawatt.

The NREL study also looked at the amount of land that would actually be disturbed as part of wind turbine projects. This is a much smaller amount of land than described above because most surrounding land uses, for example agriculture or ranching, can coexist with both the installation and operation of a wind farm. The study analyzed both permanent impacts from such items as the turbine area, access roads, and substations and temporary impacts such as staging areas, temporary roads, and construction disturbances outside the structure footprint. The study concluded the average permanent direct impact was about 0.7 acres per megawatt of capacity and the average temporary direct impact was about 1.7 acres per megawatt of capacity (NREL 2009b). Although this study was based on mainland wind turbine projects where more land was probably available to be disturbed, it is assumed these are reasonable, rough estimates for Hawai‘i because projects on the mainland likely would choose sites where construction of ancillary items such as substations and access roads could be minimized.

2.3.3.9.2 Characterization of Technology Feasibility and Deployment

Feasibility of Utility-Scale Wind Resources Deployment by Island

Figure 2-40 shows average wind speeds within the State at an elevation of 80 meters, or about 260 feet above the ground. This is the wind map typically used in evaluating the potential for utility-scale wind turbines because of their heights. It can be seen that the wind speed categories shown in the map are in units of meters per second. As a point of reference, 14 miles per hour, the lowest generally accepted average wind speed for utility-scale wind turbines, equates to 6.3 meters per second.

The NREL has also developed wind maps for each of the primary islands based on average wind speeds at 50 meters, or about 160 feet, above the ground, so they are slightly different than what is shown in Figure 2-40. The 50-meter wind maps can be found at http://www.nrel.gov/gis/mapsearch/.

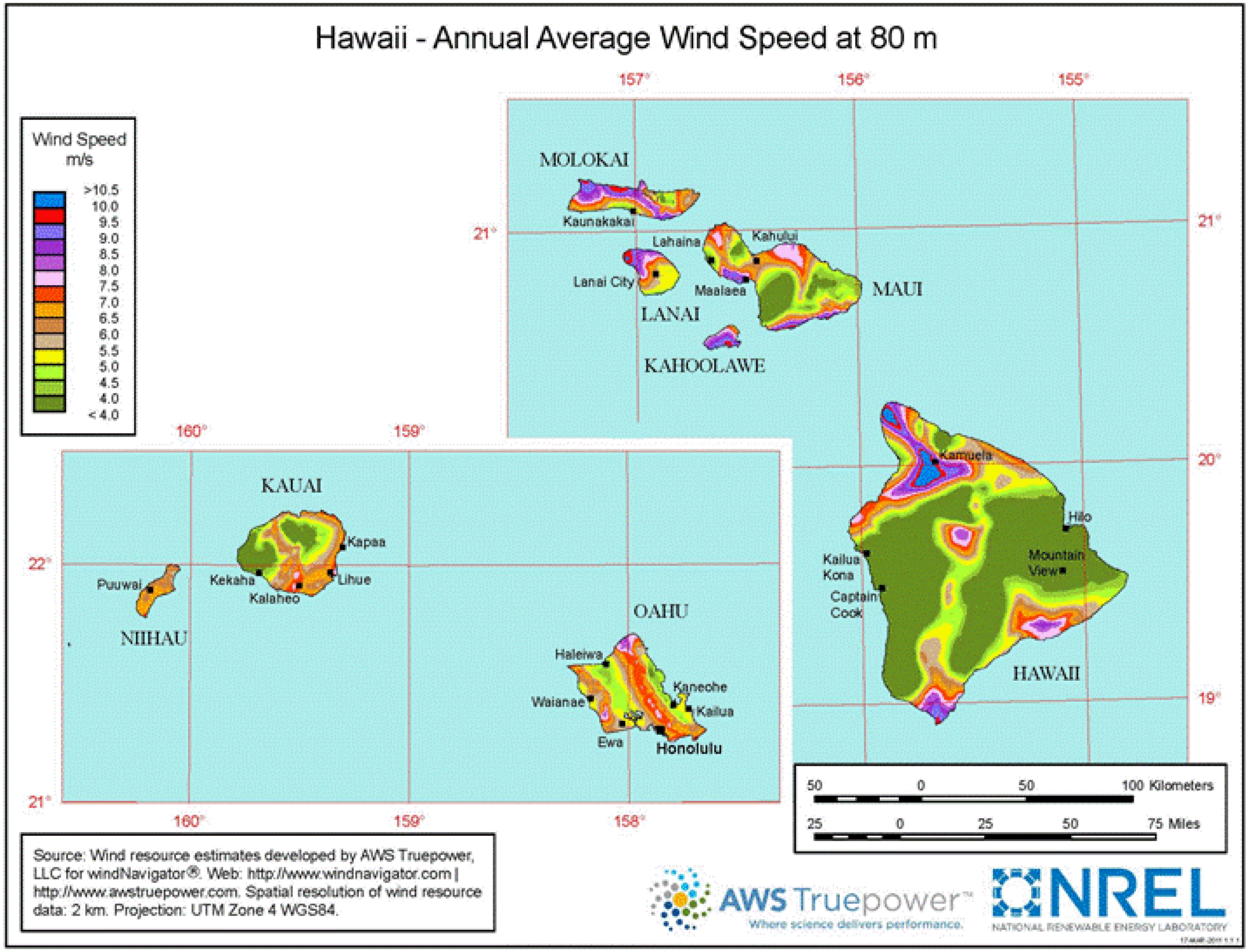


Figure 2-40. Average Wind Speeds at 80 Meters, or about 260 Feet, Above the Ground (wind speed in meters per second multiplied by 2.24 equals miles per hour)

Results of the wind resource evaluation were presented in the *HIREP Planning Information Study* in the form of Figures 2-41, 2-42, and 2-43, for Molokaʻi, Lānaʻi, and Maui, respectively (AECOM 2012a). Areas in the figures shown in blue hatching and outline are the areas not screened out; that is, the area deemed suitable (based on the identified criteria) for wind farm consideration.

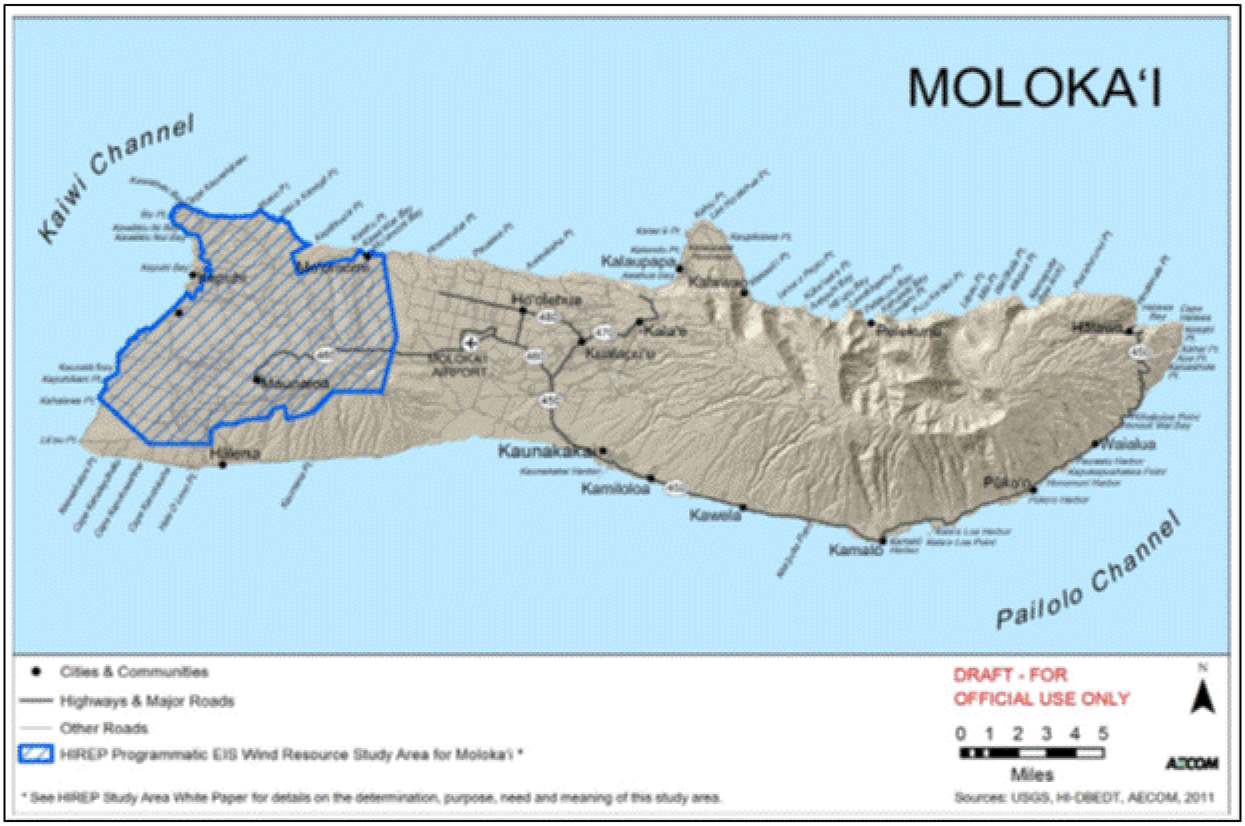


Figure 2-41. Molokaʻi Areas Meeting Wind Resource Criteria

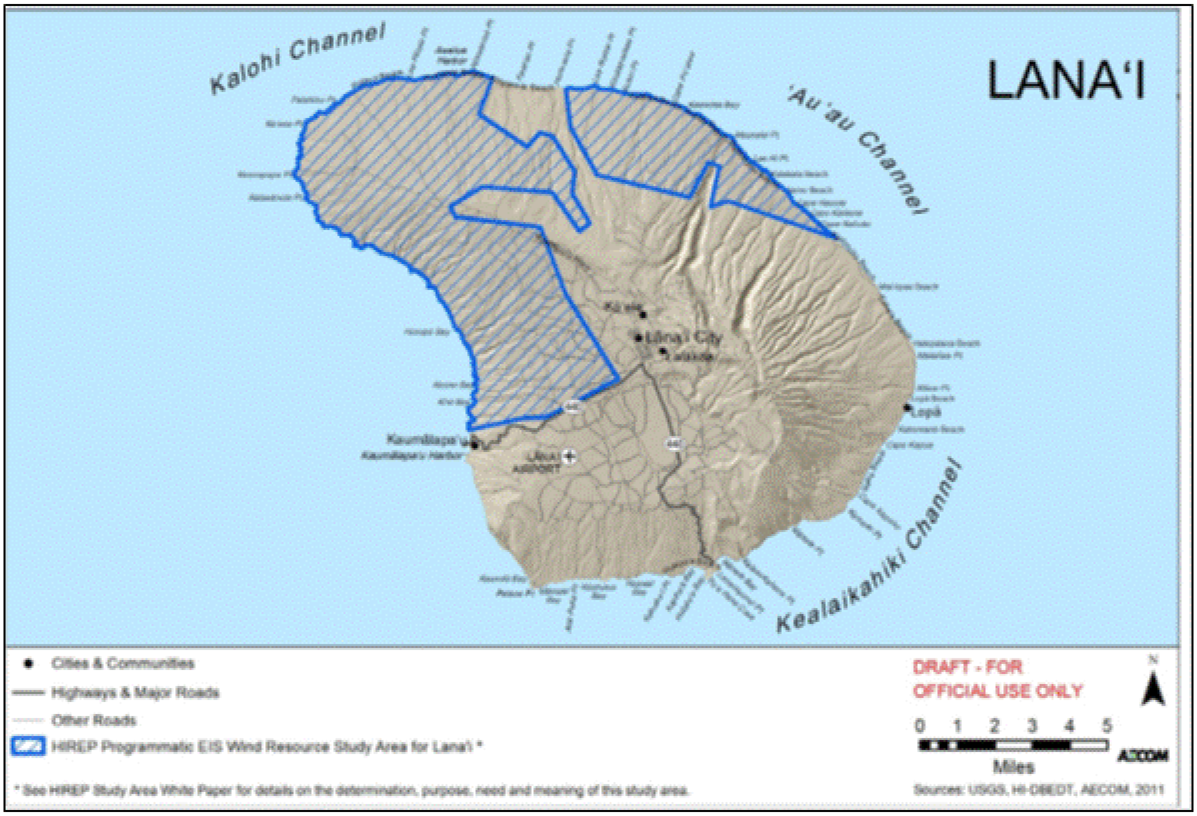


Figure 2-42. Lānaʻi Areas Meeting Wind Resource Criteria

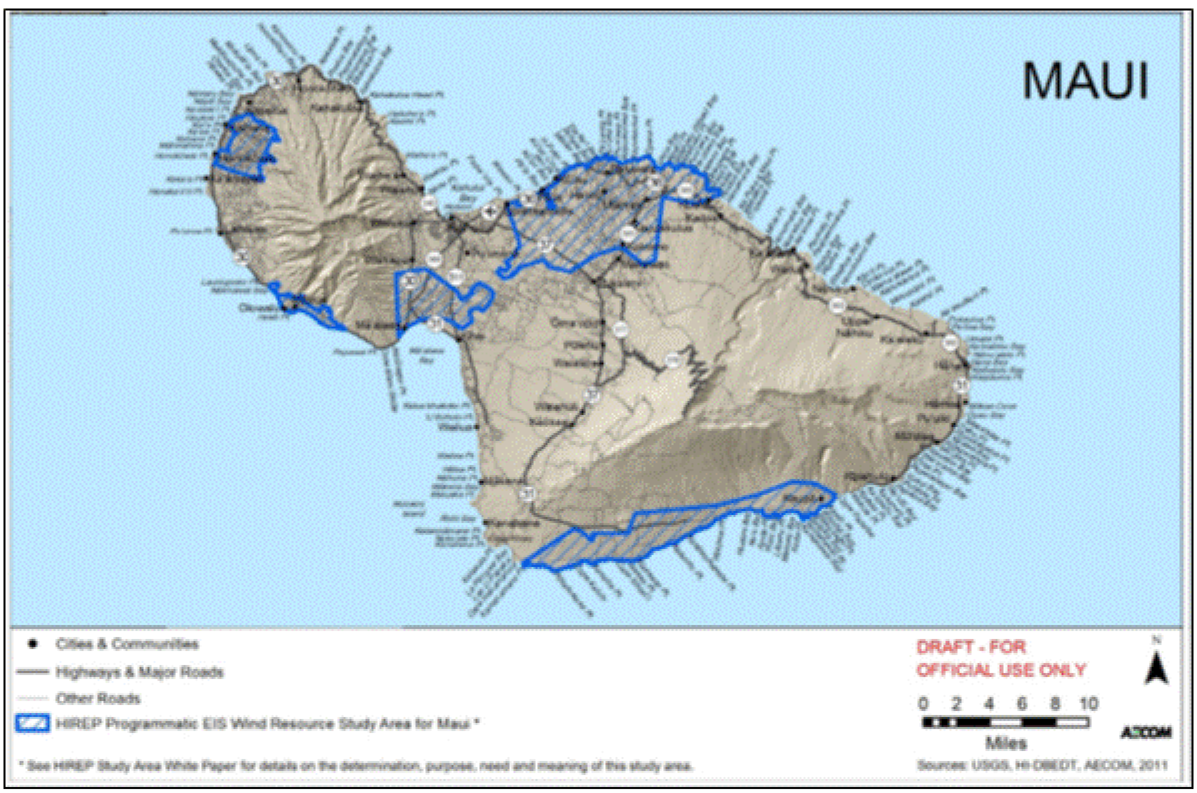


Figure 2-43. Maui Areas Meeting Wind Resource Criteria

The *HIREP Planning Information Study* (AECOM 2012a) includes an evaluation of wind resources on the islands of Molokaʻi, Lānaʻi, and Maui. This evaluation started with the 50-meter wind maps, then established land use, topography, and other factors that would or would not be appropriate for a wind farm. In this manner, the evaluation screened out portions of each of the three islands it deemed unacceptable (based on the criteria) for wind farm consideration and thereby identifying the acceptable portions. The specific criteria used in the evaluation are as follows:

1. Technical Feasibility – Using 50-meter wind map data, locations with average wind speeds of about 14 miles per hour or higher (corresponding to Wind Power Classes of 3 and above) were retained.

2. Size – A 50-megawatt power facility minimum size.

3. Topography – Excluded areas with slopes greater than 20 percent.

4. Census Designated Area – Excluded census tracts with greater than 10 percent of the island population.

5. Conservation zones – Excluded officially designated reserves (except game management areas), national parks, preserves, and sanctuaries.

6. Land Use Designations – Excluded State land use areas zoned "Urban."

7. Hawaiian Homelands – Excluded Department of Hawaiian Home Lands areas with documented development restrictions.

It should be noted that use of different screening criteria would be expected to change the configuration of the land areas shown in Figures 2-41 to 2-43. Also, more detailed planning for potential wind farm locations would have to consider other criteria such as military training areas or operations, which would require consultation with the DoD Clearinghouse.

2.3.3.9.3 Characterization of Existing Deployment

Table 2-18 shows existing utility-scale wind turbine projects in Hawaiʻi. Information in the table is a "snap shot in time," but updated information can be found at the HSEO website, https://energy.ehawaii.gov/epd/public/re-projects-home.html.

Table 2-18. Utility-Scale Wind Turbine Projects

Project Name	Island	Year Installed	Capacity (MW)
Existing Projects (Source: DBEDT 2013h)			
Hawi Renewable Development	Hawaiʻi	2006	10.5
Kaheawa I Wind Farm	Maui	2006	30
Pakini Nui Wind Farm	Hawaiʻi	2007	20.5
Kahuku Wind Farm	Oʻahu	2011	30
Kawailoa Wind Farm	Oʻahu	2012	69
Kaheawa II Wind Farm	Maui	2012	21
Auwahi Wind	Maui	2012	21
TOTAL			**202**

MW = megawatt.

2.3.3.9.4 Permitting and Consultation Requirements

In addition to the general permitting and regulatory requirements discussed in Section 2.2.5, there are also several permit-related issues associated with land-based wind projects that should be noted, as follows:

- Given Hawai‘i’s heavy military presence, one of the first things a wind developer must do is consult with local Department of Defense installations to see if the targeted project site conflicts with any military training areas or flight paths.
- An FAA Notice of Proposed Construction or Alteration in Airspace would be required to construct any structure more than 200 feet in height above the ground, with additional requirements for structures closer than 20,000 feet to the nearest point of the nearest runway of specified airports. The notice must be submitted to the FAA in accordance with 14 CFR Part 77.
- Local community outreach is also a priority for wind turbines, given Hawai‘i’s scenic beauty and limited landscapes that increase wind farm visibility. Proper outreach includes providing accurate visual simulations of the project to local community groups, leaders, and neighborhood boards. Developers may need to adjust their project. This could include visuals for night and day operations, as the required aviation safety (red) lighting has been described as an environmental impact. In addition to visual impacts, large wind farms that obstruct access to frequently visited areas or that could involve cultural or archaeological implications would be expected to garner community opposition, so finding a solution to satisfy all stakeholders requires early consultation.
- Because of Hawai‘i’s smaller, more winding roadways, approval from the Hawai‘i Department of Transportation may be required for turbine transport. In certain instances, roadways would require closure to all other traffic and traffic lights may need to be temporarily removed to achieve the necessary width or turning radius. Although harbor facilities would typically be designed to deal with movement of large items, tower components and particularly rotor blades could require advanced planning and authorizations.
- With regard to Kaua‘i, it would be extremely difficult to develop utility-scale wind power with today’s technology due to the island’s extremely high population of endangered sea birds.
- Developers should consult with NPS on projects that could have direct or indirect impacts on sensitive, cultural, natural, scenic, visual, and recreation resources of the National Park System and other protected resources.

2.3.3.9.5 Representative Project

A representative utility-scale wind project for purposes of evaluation in this document is assumed to consist of the construction and operation of a 25-megawatt facility consisting of ten 2.5-megawatt wind turbines. It is further assumed that the each turbine is a horizontal axis unit, with a 390-foot rotor diameter (the blade lengths are about 190 feet), and mounted on a 360-foot monopole. Noise produced by each wind turbine is 106 dBA at the source at standard power. Air emissions would be limited to fugitive dust and heavy equipment use during construction activities. Water use would be relatively minor, consisting of dust control measures plus that used in the formulation of concrete for footings. A spread footing foundation for a 2.5-megawatt wind turbine could require about 450 cubic yards of concrete (Morgan and Ntambakwa 2008). At about 35 gallons of water per cubic yard of concrete, that equates to about 16,000 gallons of water per wind turbine. Land required for the entire project, at an estimated 10 acres per megawatt (based on the identified examples within the State), is 250 acres. Within the 250 acres, the amount of land permanently disturbed (under turbine, road, and other structure foot prints), at 0.7 acre per megawatt, is 17.5 acres and the amount of land that would be temporarily disturbed, at 1.7 acres per megawatt, is 42.5 acres. Connection to the grid is assumed to be at a distance of one mile from the edge of the wind farm property (that is, from the edge of the 250-acre property). In 2010, the average installed cost for a land-based wind turbine project in the U.S. was about $2.2 million per megawatt of which 70 to 75 percent was attributed to the cost of the wind turbine (NREL 2012c).

If the scope of the representative project were increased by some factor (for example, by a factor of two), the number of wind turbines, the land required for the entire project, the land permanently disturbed, and the land temporarily disturbed would all be expected to increase by about the same factor. However, there may be some project aspects that would not require scaling up; for instance, the same access road into a site might serve a project of either size. However, this is, to a large extent, site specific, so for purposes of evaluation, this PEIS based the estimates of land disturbance solely on the “acres per megawatt” values discussed previously.

2.3.3.10 Offshore Wind Power

Offshore, utility-scale wind turbines function in the same manner as land-based wind turbines. That is, they convert the kinetic energy of the wind to mechanical power and the turning rotor spins a generator to make electricity. As of early 2013, no offshore wind projects have begun construction in the United States. There are 33 announced projects in various stages of development, but only 9 have advanced to a stage where they have any of the following: (1) a lease approved for State or Federal waters, (2) conducted baseline studies at the proposed site, or (3) signed a power purchase agreement with a power off-taker. Of these nine more mature projects, five are to be along the northeastern coast (one off Rhode Island, one off Massachusetts, and three off New Jersey), three along the gulf coast (all off Texas), and one on a Great Lake (in Ohio). The one with the smallest proposed capacity (a 25 megawatt wind farm off New Jersey) also has the nearest target completion date, which is 2013. The other eight projects have target completion dates of 2014 to 2018. The combined target capacity for all nine projects is 3,380 megawatts from 646 to 746 wind turbines (Navigant 2013). Since there are no offshore wind projects currently in the United States, the technology elements described in this section are based on what has been employed in other parts of the world, what is being promoted by manufacturers, and what is being planned and projected for the United States.

2.3.3.10.1 Technology Description

Early in the history of offshore wind turbines, which were pioneered in Denmark in the late 1990s and early 2000s, the devices were basically land-based machines with adaptations to make them more survivable in a marine environment. In more recent years, however, offshore wind turbines have been designed and manufactured exclusively for offshore placement, incorporating features to better withstand the demands of the marine environment and to reflect fewer limitations on size. For example, transporting large wind turbine blades is not constrained by the ability to maneuver long loads over existing roads, and the sound levels generated at locations well away from the shore is less likely to be of concern. The fact that wind quality is generally better offshore and at lower elevations (depending on the distance from shore, there is little, if any affect from nearby surface irregularities) has allowed use of lower towers, also providing impetus for development of larger wind turbine capacities (NREL 2010a) because it is easier and less expensive to create a lower tower that will hold the additional weight. Across the world, the typical operating offshore wind turbine (new and old) has a capacity greater than 1 megawatt. Offshore wind turbines installed between 2007 and 2010 had average capacities ranging from about 3 to 3.3 megawatts and in 2011 the average size of newly installed machines was almost 4 megawatts (Navigant 2013); that’s 2 megawatts larger than the average utility-scale, land-based wind turbine installed in the United States in 2011 (see Section 2.3.3.9.1). Most manufacturers of offshore wind turbines are currently testing prototypes with capacities of 5 to 7 megawatts, with rotor diameters roughly 400 to 500 feet and more. In addition, some manufacturers and research facilities have started to develop devices with capacities of 10 to 15 megawatts (Navigant 2013).

Consistent with their evolution from land-based devices, today's offshore wind turbines are predominantly of a horizontal-axis configuration with three-bladed, upwind rotors. As such, their workings and primary components are the same as shown in Figure 2-39 and described in the accompanying discussion (see Section 2.3.3.9.1). Descriptions of the primary components are not repeated here, with one exception regarding direct-drive generators. While direct-drive generators are being deployed in a small portion of land-based machines, they have advantages that make them particularly attractive for offshore systems; namely, they hold the promise of increased reliability by eliminating the gear box, having fewer moving parts, and operating at low rotational speeds. Since one of the challenges for offshore wind turbines is accessibility for repair and maintenance, the possibility of reducing the frequency of such needs is very attractive. Direct-drive turbines are already being used globally in about 18 percent of operating offshore wind turbines (Navigant 2013). Research and development is focused on reducing the size and mass penalties often associated with the technology. However, the direct-drive technology does not yet have an extensive performance record, so the promise of superior performance and reliability is not yet proven (Navigant 2013).

Both horizontal-axis and vertical-axis turbines are applicable to offshore wind technology. There are ongoing research and development efforts specific to vertical-axis wind turbines and there are proponents of vertical-axis turbines that believe they have characteristics that make them particularly well suited to offshore deployment. These characteristics include having the drive train located near the surface. This provides a lower center of gravity, which improves stability for floating platforms; reduces gravity fatigue on key structural components; and makes most maintenance easier. The reduced complexity of the vertical-axis wind turbine should also act to reduce maintenance needs. There are also recognized challenges in pursuing offshore deployment of these wind turbines. These include cost effective production of the complex blades needed for vertical-axis wind turbines and development of an aerodynamic breaking system (such as provided by the blade pitch control system in horizontal-axis wind turbines) (Sandia 2012a). Section 2.3.3.9.1 discussed other limiting factors associated with vertical axis wind turbines.

Offshore Wind Turbine Substructures

A primary difference between land-based and offshore wind turbine technology is the substructure upon which the wind turbine and tower is mounted. The substructures, or pads, for land-based turbines are based on traditional construction techniques, such as compacted foundations or piers and concrete pads; whereas, offshore wind turbines are supported by a variety of devices and systems, many of which are only in the testing and development stages. Because of their complexity, substructures currently used in offshore wind turbine applications account for roughly 20 percent of the total project costs (Navigant 2013). Offshore substructures comprise the area beginning at the lower flange of the tower and extending to the structural elements that attach it to the seabed. Categories of substructures are generally grouped by the depth of water for which they are designed (which in general corresponds to the maturity of the systems' development), as follows (NREL 2010a):

- Shallow-water substructures – These substructures are used in water depths of less than about 100 feet (30 meters).
- Transitional technology substructures – These are used in water depths between about 100 and 200 feet (30 and 60 meters).
- Floating technology substructures – These are envisioned for water depths greater than about 200 feet (60 meters).

As can be seen in Figure 2-44, wind turbines deployed in shallow and transitional depths generally rely on rigid substructures reaching all the way to the seabed. At the deeper depths, however, it is generally believed that offshore wind turbines will have to move to floating platforms held in place with guys or cables that are anchored to the seabed. The following discussion provides additional detail on the categories of substructures being used or planned for offshore wind turbines.

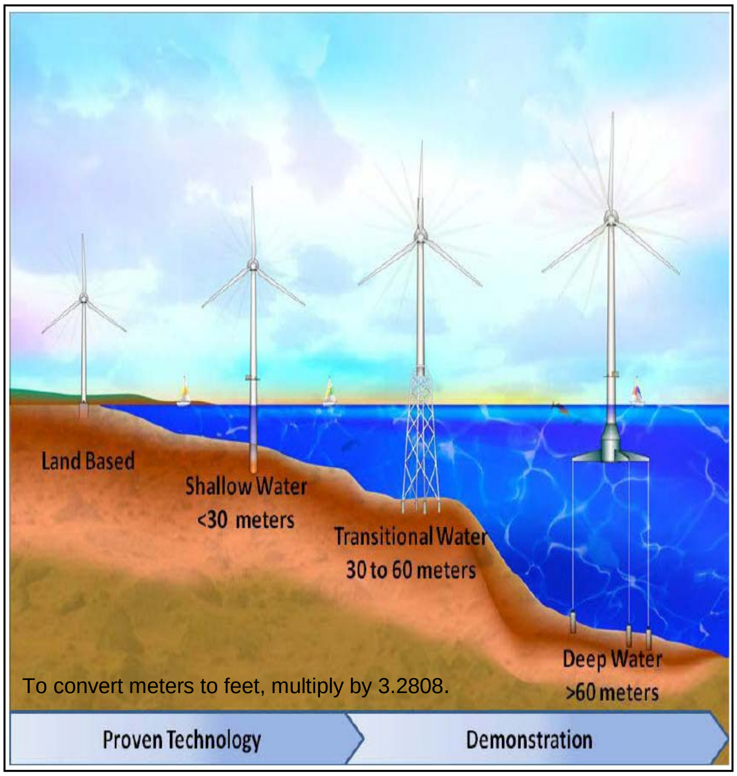


Figure 2-44. Categories of Substructures Deployed for Offshore Wind Turbines (Source: NREL 2010a)

Shallow-Water Substructures – Figure 2-45 provides typical configurations for five different substructures used in the shallow and transitional depth categories. The monopile, suction caisson, and gravity base types are those typically used in shallow water (suction caisson is currently being developed for shallow water). A monopile substructure consists of a long cylindrical steel tube driven into the seabed and a transitional piece that connects it to the wind turbine tower. In order to maintain the necessary monopile stiffness and avoid resonance issues, the monopole diameter and thickness must increase with water depth. This, coupled with the increased difficulty in driving the monopile, makes this substructure less feasible than alternatives at about 100 feet in depth (NREL 2010a).

The gravity base and suction caisson configurations are also intended for shallow depths, but in areas that are more protected and particularly where seabed geology makes it difficult to drive monopiles. The gravity base system relies on a conical or cylindrical casing constructed onshore and, once placed on the seabed, filled with ballast (for example, concrete, sand, rock, or iron ore). The mass and force of gravity are the only elements providing stability for the wind turbine and substructure. In the case of the suction caisson, the primary stabilizing element is a large-diameter cylindrical structure fixed to the seabed by pumping the water out of the structure to create a vacuum and seating the substructure by hydrostatic

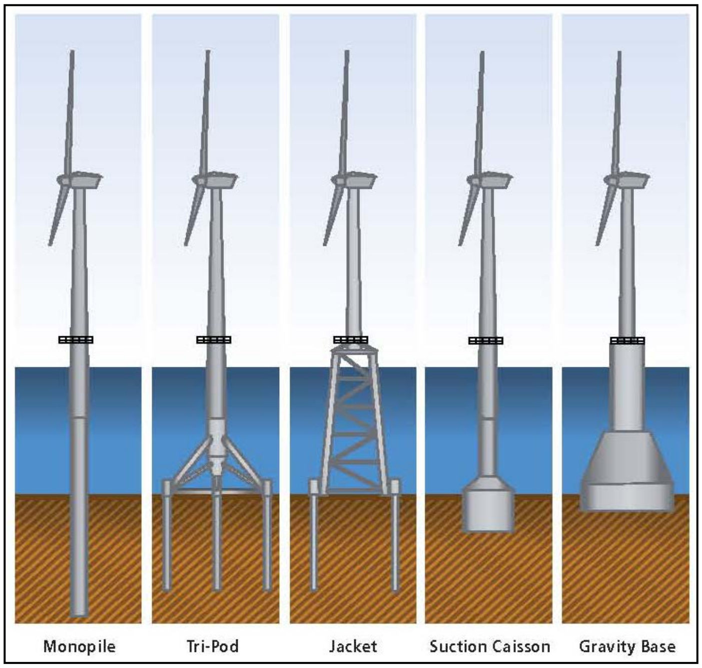


Figure 2-45. Typical Offshore Wind Turbine Substructure Configurations used at Shallow and Transitional Depths (IPCC 2011)

pressure (NREL 2010a; Navigant 2013). In a 2010 report, it was noted that the suction caisson system had not yet been used in a commercial project (NREL 2010a).

The global wind power capacity of installed offshore wind turbines was about 4,100 megawatts at the end of 2011; of this, the vast majority, about 94 percent, is in Europe (the remainder is in China and Japan). In terms of the number of wind turbines installed, there were 1,472 at the end of 2011; again, about 94 percent of those are in Europe. Of all the European offshore wind turbines, 75 percent were constructed with monopile substructures and 21 percent were constructed with gravity base systems (Navigant 2013). That is, as of 2011, about 96 percent of Europe's offshore wind turbines have been deployed at relatively shallow depths of roughly 100 feet or less.

The European offshore wind projects under construction in 2012 indicate a trend change, with only 62 of the wind turbines using shallow-depth substructures (all monopile). The remaining 38 percent were designed with transitional depth systems (Navigant 2013). While substructures suitable for transitional depths also would be suitable for shallow applications, associated costs make it unlikely such systems would be used in shallow water.

Eight of the nine U.S. projects in mature development phases are at depths of less than 100 feet. Most of these, however, have not yet identified which type of substructure they plan to use (Navigant 2013).

Transitional Technology Substructures – The tripod and jacket systems shown in Figure 2-45 are primary examples of substructures designed for the deeper transitional water depths, though there are variations. These substructures are still attached directly to the seabed but require a wider base to counteract overturning forces and to meet stiffness requirements. The jacket or lattice substructure is derived from the common fixed-bottom offshore oil rig and consists of a four-sided, framed structure that is pinned or anchored with an individual piling at each corner. The tripod substructure consists of a three-legged structure assembled from steel tubing connected to a central shaft and is anchored to the seabed with multiple pilings similar to the jacket system. The jacket system entails more fabrication and assembly, but uses less material than the tripod system (Navigant 2013).

Only three European wind farm projects have been deployed at transitional water depths and they represented about 4 percent of Europe's operating offshore wind turbines at the end of 2011. The substructures for these wind turbines were basically split evenly between jacket and tri-pod configurations. As noted previously, 38 percent of the offshore wind turbines under construction in Europe in 2012 were designed with transitional depth substructures; 20 percent jacket systems and 18 percent tri-pod systems (Navigant 2013).

Floating Technology Substructures – Floating wind technology was recently given approval on February 5, 2014, by the Secretary of the Interior to proceed with plans for a 30-megawatt pilot project that uses floating wind turbine technology off the coast of Coos Bay, Oregon. Figure 2-46 shows renderings of three conceptual designs for floating wind turbines: spar-buoy, tension leg platform, and semi-submersible. The spar-buoy consists of a buoyant structure, or spar, stabilized by a large ballast in its lower portion and maintained in a general location by mooring lines and drag-embedded anchors. The buoyancy and ballast of the spar structure provide stability during the pitching and heaving of wave action and loading; the mooring lines maintain position. A semi-submersible substructure is stabilized by a group of interconnected buoyant structures, generally three in a triangular form, and again is held in its general location by mooring lines and drag embedded anchors. The tension leg platform consists of a buoyant platform-like structure below the water surface and is fixed to the seabed with taut mooring lines. In this case, the mooring lines provide the source of stability and the platform provides buoyancy.

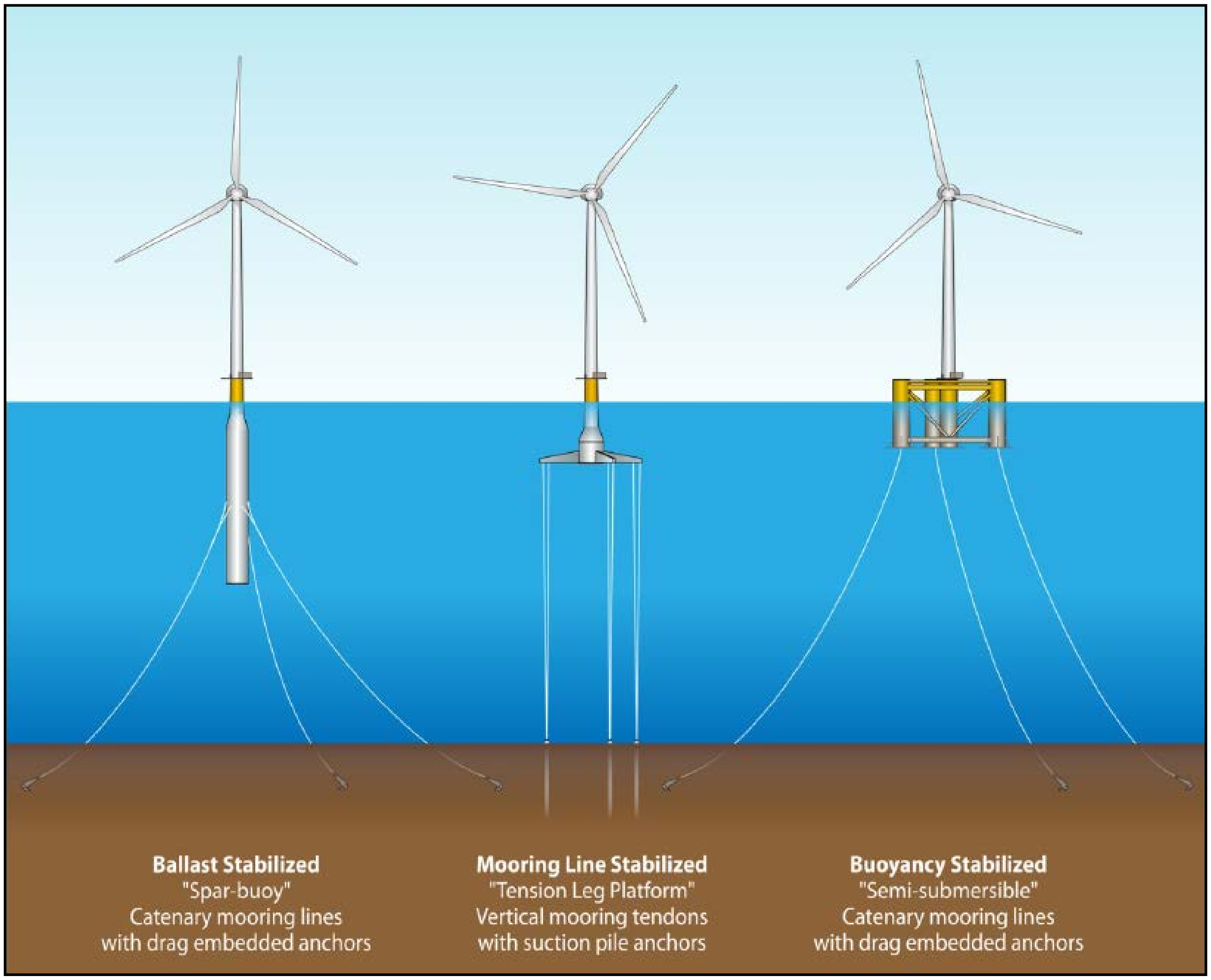


Figure 2-46. Renderings of Three Conceptual Designs for Floating Wind Turbines (Source: Navigant 2013)

Although the preceding descriptions of floating technologies were based on the configurations shown in Figure 2-44, the various wind turbine platforms could use different mooring devices, particularly the way they are fastened to the sea floor, based on what would work best given the characteristics of a specific site.

Application of floating technologies has currently gone no further than full-scale tests. A spar-buoy with a 2.3-megawatt wind turbine was installed off the coast of Norway in 2009. This device is designated the

Hywind concept by Statoil, an international energy company headquartered in Norway, and was deployed in water about 660 feet deep. Statoil reports that based on two years of data, the concept has been verified and performance has been better than expected (Statoil 2012). The only other full-scale test implemented is a semi-submersible platform with a 2-megawatt wind turbine deployed off the coast of Portugal by Principle Power in late 2011 (Navigant 2013).

In late 2012, DOE announced funding to seven offshore wind turbine technology demonstration projects. These initial awards were for engineering, site evaluation, and planning phases of projects targeted at demonstrating offshore wind technologies with a credible potential for lowering the levelized cost of energy and developing viable and reliable options for the United States. Depending on the results of the initial effort, DOE will select up to three of the projects for additional funding to implement full-scale wind turbine projects, with the goal of commercial operation by 2017. Three of the seven initial projects proposed to use innovative floating platform technologies. The other four tentatively proposed new approaches to bottom-mounted substructures, but specific elements of all the projects are yet to be finalized (DOE 2013j).

Although the development of floating platforms for offshore wind turbines is generally expected to be a long-term process, the timeframe under which they will be commercially viable will ultimately depend on whether prototypes or other concepts continue to show promise and if industry continues to receive or make significant investment.

Other Offshore Considerations

In addition to the wind turbine hardware, other offshore wind farm needs include the electrical system infrastructure to move electricity from the wind turbines to the onshore grid. Wind farms typically are arranged in arrays that take advantage of prevailing winds, with individual turbines spaced far enough apart to minimize losses from array turbulence, while balancing the cost of electrical cabling between the turbines (NREL 2010a). Depending on the size of the array and the distance from shore, a substation or electrical service platform may be collocated with the wind farm. Power from each wind turbine would be collected at the substation and transmitted through a number of buried high-voltage lines to an interconnection point on the shore from which transmission lines would then run to the regional electrical grid. Technologies such as horizontal directional drilling could be used to get the electrical lines from the offshore wind farm through the sea-land transitional area with minimal disturbance if necessary to avoid sensitive resources (see Chapter 7, Section 7.9). (Note: Discussions of sensitive resources or community issues that might be involved with the deployment of offshore wind are part of the potential environmental impacts sections.) Horizontal directional drilling and when it might be used is only mentioned here as an associated technology. Section 2.3.5.2 of this PEIS, also considers use of this type of drilling in the land-sea transition zone and provides additional detail on the technology.

If the wind farm is small or close to shore, the substation likely would be onshore. If the substation or electrical service platform were at the wind farm site, it would be designed to function as a central service facility that includes such items as a helicopter landing pad, control and monitoring equipment rooms, a crane, a rescue boat, communications station, firefighting equipment, emergency generators, and staff and service facilities. Costs for these electrical infrastructure systems extend beyond those for comparable components of a land-based wind farm.

Electrical cables running from the offshore wind turbines to the shore and, as applicable, between wind turbines are a significant element of an offshore project. In order to protect them from damage that can be caused by such things as dropped anchors or fishing (a fishing method of particular concern in this regard is bottom trawling, but such fishing is not allowed in Hawai‘i waters), it may sometimes be necessary for these cables to be buried into the sea floor. High-voltage direct current (HVDC) cable installation may occur in two primary ways: laying on the surface of the ocean floor or burial through shallow trenches on the ocean floor. Burial depths of about 3 feet may be sufficient to protect from damage in some cases, but depths of 6 to 15 feet may be necessary in some situations, such as areas where large ships may anchor (Sharples 2011). If required to be buried, cables can be installed using a variety of trenching methods and in most cases equipment is designed and operated to be a one-pass operation, such that the cable is placed immediately behind the trenching device and the sea floor materials fill- or settle-in once the device has moved on. Mechanical plows, which look and work much like an agricultural plow, are one type of device commonly used in the placement of undersea cables. Mechanical plows are towed from the surface, across the sea floor with the electrical cable being fed down the inside of the blade device, behind the cutting edge. The cutting depth is varied by raising or lowering the hydraulically controlled skids on either side of the blade. The skids drag along the floor as the blade cuts into the sediments. Jet plows are another example of trenching devices. These use pressurized sea water to cut a trench as they are being towed. The cable is fed down through a slot behind the water nozzles much like the mechanical plow and the suspended sediments settle back into the trench to cover the cable. Jet plows have also been configured to operate on remotely operated vehicles that can move along the sea floor. Dredging and rock saws have also been used to facilitate cable laying and burial, although rock sawing generally has to be at depths that are within diver limitations. In instances where burial is not feasible or in areas with a high likelihood that the cable could eventually be exposed, concrete could be used to lay over the cable for protection. Sharples (2011) includes additional descriptions of cable installation (available from http://www.bsee.gov).

Wind Needs and Typical Capacity Factors

In addition to having basically the same components, offshore wind turbines operate at basically the same wind regimes as described for land-based wind turbines in the preceding sections. Further, the same wind speed categories apply to offshore wind turbine operations (see Table 2-19); that is, the wind turbines operate in speed regions II and III (which begins at the turbine's rated wind speed) and not in wind regions I and IV. Because the offshore wind turbines typically are larger machines (larger rotors and larger capacities), the cut-in wind speeds may be 1 or 2 miles per hour higher and similarly for the rated wind speeds. Correspondingly, evaluations of wind resources for offshore wind farms generally start at minimum acceptable wind speeds that are slightly higher (at about 16 miles per hour) than for onshore winds (at about 14 miles per hour).

Capacity factors for offshore wind turbines are measured in the same manner as described for land-based wind turbines. That is, for a wind turbine to have a capacity factor of 100 percent, wind speeds would have to be in region III (Table 2-19) constantly so that the wind turbine could operate at its rated capacity constantly. Since wind turbine capacity factors are primarily a function of the wind characteristics, they are largely site specific. However, evaluating data over a large number of turbines provides a good indication of what can be expected. Based on reports from a number of European projects, typical offshore capacity factors have ranged from 29 to 48 percent (NREL 2012c). As another data point, evaluations for the Cape Wind Energy offshore project in Massachusetts, one of the nine planned U.S. projects, use a 40-percent capacity factor that is based on the average wind speed of their site (DOI 2009).

Spacing Needs for Offshore Wind Turbines

There is no consensus on the optimum spacing between wind turbines in an offshore wind farm. The wind disturbance or wake generated by a wind turbine can adversely affect operation of a nearby downwind turbine. This adverse effect is primarily in the form of reduced efficiency in the downwind device, and the further away it is the less severe the effect. While the tendency is to optimize efficiency by spacing the wind turbines further apart, wind farm configurations must be balanced with space limitations (or the desire to make efficient use of space) and the added costs for interconnecting electrical cables and even installing and maintaining wind turbines that are farther apart. Logically, spacing also depends on the configuration of the water area available and the nature of the wind at the site. For example, if the space available supports a single row of wind turbines perpendicular to the prevailing wind, there would be much less concern for effects on downwind devices, and wind turbines within the row could reasonably be spaced closer together than under other circumstances.

The spacing of wind turbines in wind farm arrays is often described in terms of the number of rotor diameters between the wind turbines and literature often describes arrays being designed to maintain 5 to 10 rotor diameters between the devices. For evaluation purposes, this PEIS assumes that an offshore wind farm array might be designed to maintain 8 rotor diameters between wind turbines. For a typical 5-megawatt wind turbine, this equates to roughly 1 square kilometer (or 0.39 square miles) per wind turbine (NREL 2010a). Restated, this equates to about 0.08 square mile per megawatt.

2.3.3.10.2 Characterization of Technology Feasibility and Deployment

Feasibility of Offshore Wind Resources Deployment by Island

Figure 2-47 shows average offshore wind speeds in the vicinity of the Hawaiian Islands at an elevation of 90 meters, or about 295 feet above the water surface. This is the type of wind map typically used in evaluating the potential for offshore wind turbines. If the minimum wind speed for economic feasibility of an offshore wind turbine is about 16 miles per hour, only those areas of the figure showing yellow or green would be excluded from being viable offshore wind turbine locations based on wind speed, and the dark green would be marginal.

The figure also provides water depth contours (indicated by a number followed by “m” for meters) close to the islands and shows the rapid drop just beyond the land areas. This characteristic of the islands acts to limit the amount of area beyond the land surface that would be grouped in either the shallow (less than 100 feet) or transitional (100 to 200 feet) water depths. This is further highlighted by the information presented in Table 2-19, which shows results of an NREL evaluation (NREL 2010b) of Hawai‘i’s offshore wind resources. The table shows estimates of the potential for wind turbine installed capacity, in gigawatts, by wind speed interval, water depth, and distance from shore. As shown in the table, the estimated total installed capacity for the State, out to 50 nautical miles (57.5 miles) is 637.4 gigawatts. It can also be seen that only about 1.2 percent of this total would be from wind turbines deployed in water depths of 200 feet or less, and almost 90 percent of the capacity is at water depths greater than 200 feet at distances of 3 to 50 nautical miles (3.5 to 57.5 miles) from any shoreline.

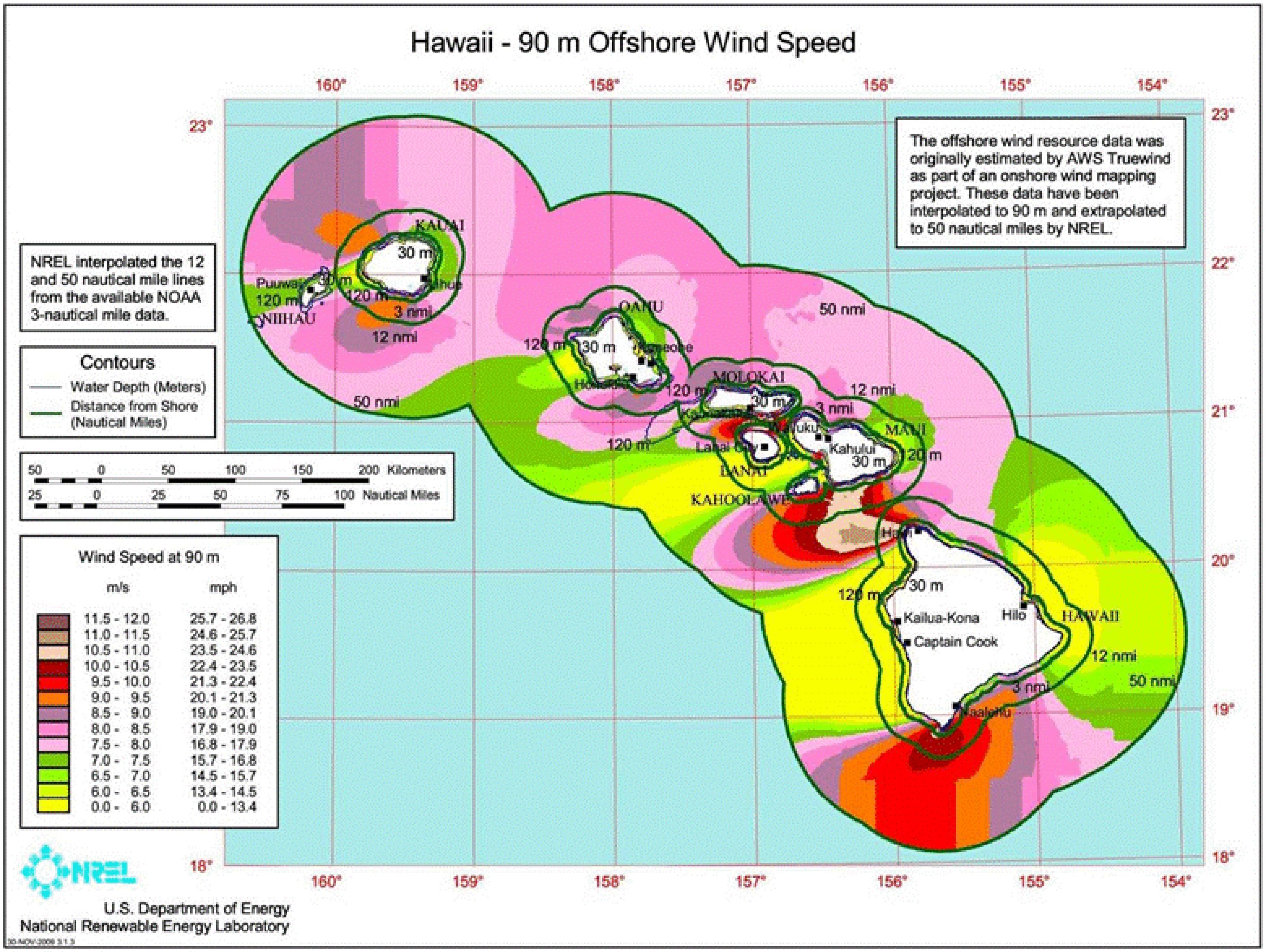


Figure 2-47. Average Offshore Wind Speeds at 90 Meters, or about 300 Feet, Above the Water Surface

Table 2-19. Hawai‘i Wind Resource Potential (in gigawatts of installed capacity) by Wind Speed Interval, Water Depth, and Distance from Shore

Average Wind Speed Groups[a] (mph)	Distance from Shoreline: 0 to 3 nm, Depth Category (feet) 0-100	100-200	>200	3 to 12 nm, Depth Category (feet) 0-100	100-200	>200	12 to 50 nm, Depth Category (feet) 0-100	100-200	>200	Total Resource (GW)
15.7 to 16.8	0.6	0.5	13.2	0.0	0.2	11.1	0.2	0.6	68.1	94.4
16.8 to 17.9	0.3	0.5	12.0	0.0	0.7	25.3	0.0	1.3	171.3	211.5
17.9 to 19.0	0.5	0.6	11.8	0.0	0.1	23.8	0.0	0.0	128.5	165.2
19.0 to 20.1	0.3	0.3	10.5	0.0	0.0	13.1	0.0	0.0	45.3	69.6
20.1 to 21.3	0.1	0.2	5.0	0.0	0.0	9.3	0.0	0.0	24.3	38.9
21.3 to 22.4	0.1	0.2	3.3	0.0	0.0	5.3	0.0	0.0	24.6	33.6
>22.4	0.1	0.4	6.7	0.0	0.0	10.1	0.0	0.0	6.9	24.3
Totals	**2.0**	**2.7**	**62.5**	**0.0**	**1.0**	**98.0**	**0.2**	**1.9**	**469.0**	**637.4**
Percent of Resource Total	0.3	0.4	9.8	0	0.2	15.4	0	0.3	73.6	100

Source: NREL 2010b.

Note: Values may not sum to totals due to rounding.

a. The values here were converted from “meters per second” used in the reference. In the reference, the wind speed groups are present in spans of 0.5 meter per second increments starting with 7.0 to 7.5.

mph = miles per hour; nm = nautical miles (nm times 1.15 equals miles); GW = gigawatts.

Characterization of Existing Deployment

As noted previously, there currently are no offshore wind farms in the United States. Several potential offshore wind developers have indicated an interest in Hawai‘i, but are still in early site identification and planning stages as of August 2013.

The vast majority (almost 99 percent) of the State’s wind resources are at locations where the water depth is greater than 200 feet. Although the remaining potential (7 to 8 gigawatts of installed capacity) is still significant, it appears (Figure 2-47) to be well distributed over the islands, so should projects arise that pursue deployment of offshore wind turbines at shallow or transitional depths, they likely would be relatively small wind farms. Any substantial projects to take advantage of State’s overall offshore wind resource may be delayed until floating platform technologies become more mature.

2.3.3.10.3 Permitting and Consultation Requirements

See Section 2.2.5 for a discussion on general requirements, including marine-based technologies. This section presents additional permitting and consultation requirements specific to offshore wind projects and judged to be of possible concern in environmental evaluations. Given the high use of Hawai‘i’s marine waters for recreation, commercial activities, and military operations, finding a suitable location for an offshore wind farm could be a challenge. A prospective offshore wind farm operation would require intensive outreach with various sectors of stakeholders (e.g., military, NPS, commercial fishers, commercial marine operations, recreational marine groups, aviation agencies, airlines, environmental groups and agencies, species protection groups/agencies). Hawai‘i’s rough seas and hurricanes also would require projects to be designed, manufactured, and constructed in a manner to withstand such conditions. For purposes of evaluating proposed offshore wind facilities, the pertinent standards of 49 CFR 77.17 require that any structure 200 feet above ground level be considered an obstruction to air navigation and requires that an aeronautical study be conducted by the FAA to determine what marking and lighting may be required to ensure safety of the airspace. FAA airspace jurisdiction extends to 12 nautical miles from shore, while U.S. territorial seas extend to 24 nautical miles. Offshore wind farms located between 12 and 14 nautical miles from shore would have to contact the DoD Clearinghouse and request a formal review rather than submit a notice to FAA. In accordance with the provisions of EPAct 2005, FERC is responsible for licensing, inspecting, and overseeing marine hydrokinetic activities. However, EPAct 2005 also amended the *Outer Continental Shelf Lands Act* to grant the Secretary of the Interior discretionary authority to regulate the production, transportation, or transmission of renewable energy on the Outer Continental Shelf (OCS). In April 2009, the Secretary of the Interior and the Chairman of FERC signed an MOU, clarifying the scope of each agency's respective responsibilities for regulating renewable energy projects on the OCS. Under the agreement, FERC has authority to issue licenses for all hydrokinetic projects (including those on State submerged lands and on the OCS), and the DOI has authority to issue leases and easements for hydrokinetic projects located partially or wholly on the OCS. In addition, the visual impacts from the land must be addressed through stakeholder outreach early in the process.

2.3.3.10.4 Representative Project

A representative offshore wind project for purposes of evaluation in this PEIS is assumed to consist of the construction and operation of a 50-megawatt facility consisting of ten 5-megawatt wind turbines. It is further assumed that the turbine is a horizontal-axis unit with a 420-foot rotor diameter (the blade lengths are about 205 feet), and mounted on a 280-foot-long monopole. The wind turbines would be deployed about 4.3 nautical miles (5 miles) from the shoreline and away from the nearshore environment in water with a depth greater than 200 feet on floating platforms with a semi-submersible design. Noise produced by the representative wind turbine would be 108 dBA at the source at standard power. Air emissions would be limited to heavy equipment use during installation and construction activities. Water use would be minor. Area required for the entire project, in terms of limiting the installation of other wind turbines in the area is assumed to be 3.9 square miles (0.39 square mile per wind turbine). Connection to the electrical grid is assumed to be approximately 1 mile from the nearest shoreline. The representative project would use a mechanical or jet plow towed from the surface to install and bury the electrical cable leading onto the shore, so there would be a pathway of disturbed sea floor into the nearshore area where the horizontal direction drilling would exit. Three catenary mooring lines (i.e., hanging freely) and electrical cables would hang near each wind turbine, all extending from the floating platform to the sea floor. Such mooring lines typically are long enough so they would drape onto the sea floor near the anchor much of the time. The electrical cable extending down from each platform would generally have ballast- or buoy-type devices to control the cable's angles at the transition point to the buried cable. Assumed costs are based on 2010 data, with the average installed cost for an offshore wind turbine project at about $4 million per megawatt, of which 30 to 50 percent was attributed to the cost of the wind turbine (NREL 2012c).

If the scope of the representative project were increased by some factor (for example, a factor of two), the number of wind turbines and the area required for the entire project would all increase by the same factor. The larger array of wind turbines would provide economies of scale associated with the electrical components. Power from each turbine would collect at one of the platforms, which would contain a substation, allowing the run of a single cable (or group of cables placed together) to shore.

2.3.4 ALTERNATIVE TRANSPORTATION FUELS AND MODES

In addition to State-mandated renewable energy and energy efficiency goals for electricity generation, the HCEI includes a goal to reduce oil used for ground transportation by 70 percent by 2030, and a goal to meet as much of in-State demand for renewable fuels as feasible by 2030. These goals will be accomplished through a combination of fuel economy improvements, accelerated deployment of electric vehicles and hybrid-electric vehicles, reduced vehicle miles traveled, and incorporation of renewable fuels. Alternative fuels such as natural gas and liquefied petroleum gas are also being analyzed to help achieve HCEI transportation goals, as these fuels would be a substitute for oil and may be considered transitional fuels (until a more commercially viable renewable fuel is available). However, unlike the electricity generation sector, transportation does not have statute-mandated goals, so strategies to reduce the use of petroleum fuel for ground transportation in Hawaiʻi currently rely heavily on influencing personal behavior. In the future, marine and aviation biofuel alternatives may be substituted to help meet the goal by displacing the equivalent of 70 percent of ground transportation demand with non-fossil fuels (Braccio and Finch 2011). The alternative transportation fuels and modes discussed in this section include:

- Biofuels
- Electric Vehicles
- Hybrid-Electric Vehicles
- Hydrogen
- Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas
- Multi-Modal Transportation (Activity)

A common representative project was developed to assess the potential impacts (positive and negative) of all alternative transportation fuels and modes technology options. The common alternative transportation fuels and modes representative project was structured to deliver an annual petroleum reduction of 20 million gallons of gasoline or diesel in 2030. The potential to scale up some of the fuel and technology options is much higher than 20 million gallons, but a lower volume was selected because not all of the evaluated transportation fuel and vehicle technologies are currently available at a commercial scale in the State.

2.3.4.1 Biofuels

Biofuels are fuels derived from biomass or waste feedstocks. Biomass includes wood, agricultural crops, herbaceous and woody energy crops, and municipal organic wastes such as manure. Through various conversion technologies, such as hydrolysis, fermentation, gasification, pyrolysis, or transesterification (discussed in more detail below), these feedstocks can be transformed into conventional biofuel products (such as ethanol and biodiesel), and advanced biofuel products (such as cellulosic ethanol, biobutanol, Green Diesel, synthetic gasoline, and renewable jet fuel). The following sections discuss the conversion technologies, the feasibility, and existing and future deployment of the technologies in the State of Hawaiʻi.

2.3.4.1.1 Technology Description

Conventional Biofuels

Conventional, or first-generation, biofuels are produced mainly from agricultural crops traditionally grown for food and animal feed purposes.

- Ethanol – Ethanol is a fuel also known as ethyl alcohol, grain alcohol, and EtOH traditionally produced by fermentation of sugars. On the mainland, fuel-grade ethanol primarily comes from corn, but can also be made from sugar cane. After production and prior to transport for use, refineries denature the ethanol, typically by blending in 5-percent gasoline, and distributing it in the same manner as gasoline or diesel (Siah & Associates and Zapka 2009). The use of ethanol is widespread—almost all gasoline in the U.S. contains ethanol in a low-level blend. E10 or "gasohol" is a blend of 90 percent gasoline and 10 percent ethanol. For perspective, one gallon of E10 has 96.7 percent of the energy of one gallon of gasoline (DOE 2013l). Also available is E85, a gasoline-ethanol blend containing up to 85 percent ethanol, depending on geography and season, used in flex-fuel vehicles. The energy content of one gallon of E85 is approximately 73 - 83 percent of the energy of one gallon of gasoline (DOE 2013l).

- Biodiesel - Biodiesel is a renewable fuel that can be manufactured from new and used vegetable oils, animal fats, and recycled restaurant grease through a process called transesterification. The production process converts oils and fats into chemicals (fatty acid methyl esters), also called long-chain mono alkyl esters, or biodiesel. In general, oil or fat reacts with short-chain alcohol (usually methanol) in the presence of a catalyst (usually sodium hydroxide or potassium hydroxide) to form biodiesel. The production of biodiesel results in a glycerin byproduct that can be used for various applications. While oils, animal fats, and restaurant waste are currently being used to produce biodiesel in Hawai‘i, additional research is currently being conducted to study the potential of developing algae as a biodiesel feedstock. The development of algae as a potential feedstock can produce high yields from a smaller area of land or water when compared to vegetable oils.

  Biodiesel's physical properties are similar to those of petroleum diesel, but it is a cleaner-burning alternative. It differs from diesel because it contains oxygen atoms, giving it different physical properties. Compared with petroleum diesel, biodiesel substantially reduces tailpipe emissions (DOE 2013k). Similar to ethanol, biodiesel comes in several blends, including B5 (5-percent biodiesel and 95-percent petroleum diesel), B20 (20-percent biodiesel and 80-percent petroleum diesel), and B100 or pure or neat biodiesel. No vehicle modifications are required for using B5 in diesel engines since the standard specification for diesel fuel used in vehicles allows up to 5-percent biodiesel (ASTM D975).[11] However, vehicles that use more than 5 percent biodiesel require vehicle modifications that need to be certified by a vehicle manufacturer for safe use.

Advanced Biofuels

The biofuel market is rapidly advancing and continuously evolving. Compared with conventional biofuels, advanced biofuels are expected to be better in terms of energy balances, greenhouse gas reduction, land use requirements, and competition for food, fiber, and water. However, some conversion technologies are still in the research and development stages and not yet commonly produced at a commercial scale. The following discussion focuses on those fuels that potentially offer distinct advantages to a future fuel distribution system in Hawai‘i (Siah & Associates and Zapka 2009).

- Cellulosic Ethanol - Cellulosic ethanol comes from cellulose, hemicellulose, or lignin— all nonfood-based feedstocks. Technologies to convert cellulose-based crops into ethanol include acid hydrolysis, enzymatic hydrolysis, and thermal gasification (which produces a synthetic gas that can be further converted into ethanol and other fuels, including substitutes for diesel and jet fuel). Cellulosic ethanol is anticipated to be the most commercially viable biofuel in the near future. In fact, the Renewable Fuel Standard targets that approximately 16 out of 36 billion ethanol gasoline equivalents or 44 percent of all total biofuels in 2022 be produced from cellulosic biofuels; this however is still subject to EPA ruling(Gruenspecht 2013). In Hawai‘i, major feedstocks that have been identified for potential production of ethanol include banagrass *(Pennisetum pupureum)*, guinea grass *(Panicum maximum)*, sugar cane *(Saccarum officinarum)*, sweet sorghum *(Sorghum vlugare)*, varieties of eucalyptus *(Eucalyptus sp.)*, and leucaena *(Leucaena leucoephala)*(Turn 2012). Many other additional feedstocks are still being explored, including algae.

- Biobutanol - Biobutanol is produced from biomass feedstock and is currently used as an industrial solvent in many wood finishing products (DOE 2013l). New technological advances and the discovery of new microbes have improved the efficiency and cost of the biobutanol production process. It has a greater energy density than ethanol, with an energy content that is 10

[11] ASTM D975, "Standard Specification for Diesel Fuel Oils," allows up to 5-percent biodiesel in petroleum-based diesel.

percent less than that of gasoline (S.K. Ritter 2013). Although biobutanol is not currently an EPA approved additive, biobutanol is more chemically similar to gasoline than ethanol, which means it can be integrated into internal combustion engines more easily than ethanol and in higher ratios. Existing ethanol production plants also can be retrofitted to produce biobutanol, avoiding the need for a separate liquid fuels infrastructure.

In a life-cycle cost analysis of biobutanol funded by the EPA, gasoline emits 2.17 kilograms of carbon dioxide more than biobutanol produced from food waste.[12] When compared with corn ethanol, the process for producing biobutanol produced less carbon dioxide. The life-cycle cost analysis confirmed that biobutanol is more sustainable and better for the environment than both gasoline and ethanol (EPA 2009b).

FISCHER-TROPSCH PROCESS

The Fisher-Tropsch process produces liquid transportation fuels by converting syngas—a mixture of carbon monoxide and hydrogen produced from biomass or fossil fuels, such as natural gas and coal—into Fischer-Tropsch (F-T) diesel. F-T diesel can substitute for conventional petroleum diesel to fuel diesel vehicles without modifying the engine or fueling infrastructure. The key to F-T synthesis is the catalysts—substances that facilitate chemical reactions without being consumed by the reaction. The process includes three steps that occur in the presence of catalysts:

1. **Syngas Formation**
   Old Hydrocarbon + Oxygen → Syngas
2. **Fischer-Tropsch Reaction**
   Syngas → New Hydrocarbon + Water
3. **Refining**
   New Hydrocarbon → Fuels, Chemicals

Source: DOE 2013m.

- Hydrogenation-Derived Renewable Diesel (Green Diesel) – Green, or renewable, diesel is a fuel chemically similar to traditionally refined oils in that it is a pure hydrocarbon without ester bonds (i.e., oxygen). The production methods, similar to oil refining technologies, include hydrotreating, thermal conversion, and biomass-to-liquid. In hydrotreating (or hydrodesulfurization), feeds are treated with hydrogen to remove impurities. Conversion temperatures range from 600° to 700°C, with pressures ranging from 40 to 100 standard atmosphere. During thermal conversion, biomass converts into bio-oil at temperatures ranging from 570° to 660°C, with pressure sufficient to keep the water primarily as a liquid (i.e., at 100 to 170 standard atmosphere), and then refined into a diesel-like fuel. In both methods, reaction times vary depending on the catalysts used in the process. The biomass-to-liquid process is a multi-step process that uses a high-temperature gasification system to convert biomass into a synthetic gas, and then uses a Fischer-Tropsch process to catalytically convert the synthetic gas into a fuel.

  Green Diesel is a “drop-in” fuel or a fuel that can be used in existing fuel tanks without changes to the existing infrastructure. Four of the most commonly used feedstocks to produce Green diesel include soybean oil, palm oil, waste grease, and canola, and rapeseed oils. Byproducts during the production of Green Diesel include *naphtha* and liquefied petroleum gas (this PEIS discusses liquefied petroleum gas in Section 7.5).

[12] The basis for the assessment was the energy content of 1 kilogram of butanol, 33.3 mega Joules per kilogram.

- Pyrolysis Oils – Pyrolysis is the process of heating biomass to 450° to 500°C in the absence of oxygen. As the biomass feedstock decomposes, and when products are brought to ambient conditions, the result is a mixture of solid char, permanent gases, and a liquid referred to as bio-oil or pyrolysis oil. Pyrolysis oil is 50-percent dissolved water weight and the remaining mass, but the actual chemical compositions vary based on the feedstock and the processing conditions (i.e., the particle size of the biomass, the residence time, and the reactor type). Biomass-derived pyrolysis oil is rich in carbon and can be refined in ways similar to crude petroleum.

- Hydrotreated Renewable Jet Fuel – Hydrotreated renewable jet fuel is a synthetic liquid fuel produced by hydroprocessing biomass feedstocks such as plant/bio oils (i.e., carbon-based jatropha, camelina, and algae oils), animal fats, or waste grease. The fuel produced is chemically identical to conventional petroleum-based jet fuel and is therefore considered a "drop – in" fuel. As such, hydrotreated renewable jet fuel is compatible with the existing petroleum infrastructure. Further, renewable jet fuel can provide a 65- to 80-percent reduction in greenhouse gas emissions relative to petroleum-based jet fuels.

2.3.4.1.2 Characterization of Technology Feasibility

Biofuels have the potential to replace a significant volume of petroleum fuels in the State of Hawai‘i. Liquid fuels are essential to the State since they are the primary fuel source of ground, air, and marine transportation. Different biofuels are produced by different processes, all of which have merits in terms of physical properties (such as net energy and impacts on the environment) or economic and feedstock considerations.

Conventional Biofuels

Ethanol

While ethanol is widely used, it is not yet routinely transported in pipelines over long distances. As mentioned above, lower ethanol blends such as E10 are mixed with gasoline and transported, stored and dispensed in existing infrastructure. Higher ethanol blends, such as E85, however, would require separate infrastructure because it cannot be used in all vehicles, and can corrode some materials. The challenge of a future ethanol distribution system is dealing with its strong tendency to attract and absorb water from the atmosphere, strong solvent characteristics, and stress corrosion in storage and transport containments. Ethanol's properties require special materials for tanks, pipelines, transport containments, sealants, pipe fittings, and fuel transfer equipment and other components. While the handling of ethanol is an established operation in the chemical and petrochemical industry, the handling of large volumes of fuel-grade ethanol could present operational challenges, such as the potential for large ethanol fires and large ethanol spills.

Biodiesel

Unlike petroleum diesel, biodiesel has a higher flashpoint, or temperature at which it gives off vapor to ignite in air, which makes it safer to handle. It is also a stronger solvent than petroleum diesel, which enables it to dissolve accumulated particulates and sediments found in diesel storage and engine fuel systems. The dissolved impurities, however, can cause problems in distribution and equipment infrastructure. Biodiesel can also degrade and break down certain plastics with prolonged exposure. Certain gaskets, hoses, seals, and O-rings found in older fuel systems may experience leaks or seepage problems.

Biodiesel has a greater chemical attraction to water than petroleum diesel, which can result in operational problems when water contaminates the fuel, such as corrosion and filter plugging in fuel systems. Storage tanks, transport containers, and pipelines that contain certain compounds, such as soft metals (brass, bronze, copper, lead, tin, or zinc) can be subject to operations problems due to corrosion and creation of sediments. Unfortunately, such compounds are found in many fuel systems, causing material incompatibility problems with existing distribution infrastructure. As such, pure biodiesel (B100) should be transported and stored only in fuel systems that are designed for or known to be compatible with the fuel.

Given Hawai‘i’s temperate climate, biodiesel flow and mixing problems would not be an operational concern. However, biodiesel may be susceptible to impurities from contaminants, particulates, and water sources. As such, storage and transport vessels must be thoroughly cleaned and dried before being used for biodiesel. A dedicated distribution infrastructure would be preferable to avoid material incompatibility, cross contamination, and operational complications.

Biodiesel contains no hazardous materials and is considered safe for use. Typically, methyl esters biodegrade much more rapidly than conventional fuel, which mitigates fuel spills and decreases the environmental impacts of the fuel.

Advanced Biofuels

Cellulosic Ethanol

While corn and sugar cane can produce conventional ethanol, high production costs and increased land value are major barriers to their use in Hawai‘i. As such, cellulosic ethanol, which uses lignin (plant material) rather than extracting sucrose from plants, is currently being explored as a feasible alternative to conventional ethanol production. However, cellulosic ethanol is in the research stages and there are limited commercial-scale facilities in operation (e.g., the Abengoa biorefinery near Hugoton, Kansas, which has a capacity of 10 million gallons per year of ethanol). Current estimates of cellulosic ethanol yield and production are based on field-scale studies and in controlled conditions. As such, additional studies are still required to identify the best feedstocks for commercial-scale production.

Denatured ethanol, or ethanol mixed with additives to render the alcohol undrinkable, has about 70 percent of the energy density by volume of neat gasoline. Therefore, about 40 percent more volume has to be stored and transported to supply the same amount of energy content of motor gasoline (BP 2009).

Biobutanol

Butanol is currently produced using propylene, a petrochemical, but, as noted above, the same raw materials that produce ethanol (corn and sugar cane) can also produce biobutanol.

Biobutanol has a higher toxicity than ethanol, and can give off a bad odor when hydrolyzed, or chemically broken down by water. The capital costs for production and operation including all the equipment and labor has made biobutanol an expensive process. Currently, biobutanol is in the piloting stages for scaled up commercial production. At this time, there is a major focus to increase early adopters by retrofitting ethanol plants. Additional push for biobutanol is underway to help producers meet the Renewable Fuel 2 Standards (RFS2) and as ethanol subsidies decline.

Green Diesel

Green Diesel is a renewable fuel that can be produced using the same types of feedstock oils as biodiesel. Green Diesel is an aromatic and sulfur-free diesel fuel, has a very high cetane blending value[13], and good cold flow properties. It is as stable as petroleum diesel, and does not require special precautions or handling/dispensaries. As such, it can be widely used for any type of oil feedstock to produce a diesel substitute and is compatible for blending with the standard mix of petroleum-derived diesel fuels. Despite

[13] A high cetane value indicates that the fuel will ignite faster than those with a lower value.

its low production costs, feedstock costs remain high. Therefore, while green diesel has been demonstrated for use on commercial and military flights, few companies are producing Green Diesel on a commercial scale. This is expected to change as more second-generation renewable feedstocks (such as camelina, jatropha, and algae) become available. As an alternative to conventional transportation fuels, Green Diesel has the smallest carbon dioxide footprint when compared with petroleum and biodiesels.

Pyrolysis Oils

There is currently ongoing research and development to produce pyrolysis oils of sufficient quality for transportation applications. Plant operations face challenges from feedstock particle size and plugging of process parts during operation, and reducing the amount of solids in the oil. In addition, the various types of feedstock that can be used to produce pyrolysis oils introduce challenges related to quality control and feedstock traceability. Although pyrolysis oils can be more cost competitive than other biofuels and show great potential for market penetration, the cost of feedstock and operational materials can still be relatively expensive (VTT 2012).

Transportation and handling of pyrolysis oils are subject to the American Society for Testing and Materials requirements, specifically, ASTM D7544. Caution is urged due to both acid content and the risk of static electricity generation and dissipation. Pyrolysis oil is stable at the ambient temperature experienced in Hawai‘i. Nonetheless, due to the acidity of pyrolysis oil, tanks would have to be stainless steel or polymer, but need not be pressurized, heated, or cryogenic. As such, pyrolysis oils are not flexible with the existing infrastructure.

Hydrotreated Renewable Jet Fuel

Hydrotreated renewable jet fuel is in the research and development stages for scaled-up commercial production. Due to the limited feedstock availability, including feedstock competition with biodiesel producers, production capacity of renewable jet fuel is limited. A limited number of test, demonstration, commercial, and military flights have been conducted using drop-in hydrotreated renewable jet fuel at a 50-percent blend with standard jet fuel including in 2012, when the Navy demonstrated a 50-percent blend during the Rim of the Pacific Exercise in Hawai‘i. On the mainland, commercial airlines such as United Airlines are starting to purchase hydrotreated renewable jet fuel for anticipated flight use in 2014 (Sapp 2013).

2.3.4.1.3 Characterization of Future Deployment

The amount of land available for feedstock production is the key metric to measuring the biofuel technology’s potential. Studies conducted regarding the availability and feasibility of biofuel technology for the State show that approximately 136,000 acres of arable land could be available to maximize production of biofuel (combination of biodiesel and ethanol) feedstocks in order to reduce imports and associated costs (Braccio et al. 2012). In particular, there is space on O‘ahu, Maui, Kaua‘i, and Hawai‘i to grow biofuel feedstock; however, various economic, social, and environmental issues would need to be considered. Additional consideration should also be given to the amount of water resources available; such is the case on the islands of Moloka‘i (limited land and competing crops for water resources) and Lāna‘i (which receives very little precipitation). Additional information regarding the different types of crops available as feedstock biofuel production, and the land available (including maps) for use in the State is available in the following resources. Other studies are currently being conducted to assess the biofuel potential of other crops for use in the State.

- *Hawai‘i Natural Energy Institute Bioenergy Master Plan – Land and Water Resources Section* (HNEI 2009b)
- *Biofuels Assessment* prepared for the State of Hawai‘i DBEDT (Black and Veatch 2009),
- *Rocky Mountain Institute - Hawai‘i Biofuels Summit Briefing Book* (RMI 2006).

In addition to local production of biofuels, the future biofuel supply for the State would most likely require imports of refined biofuel and feedstock, and the development of a future distribution system similar to Figure 2-48.

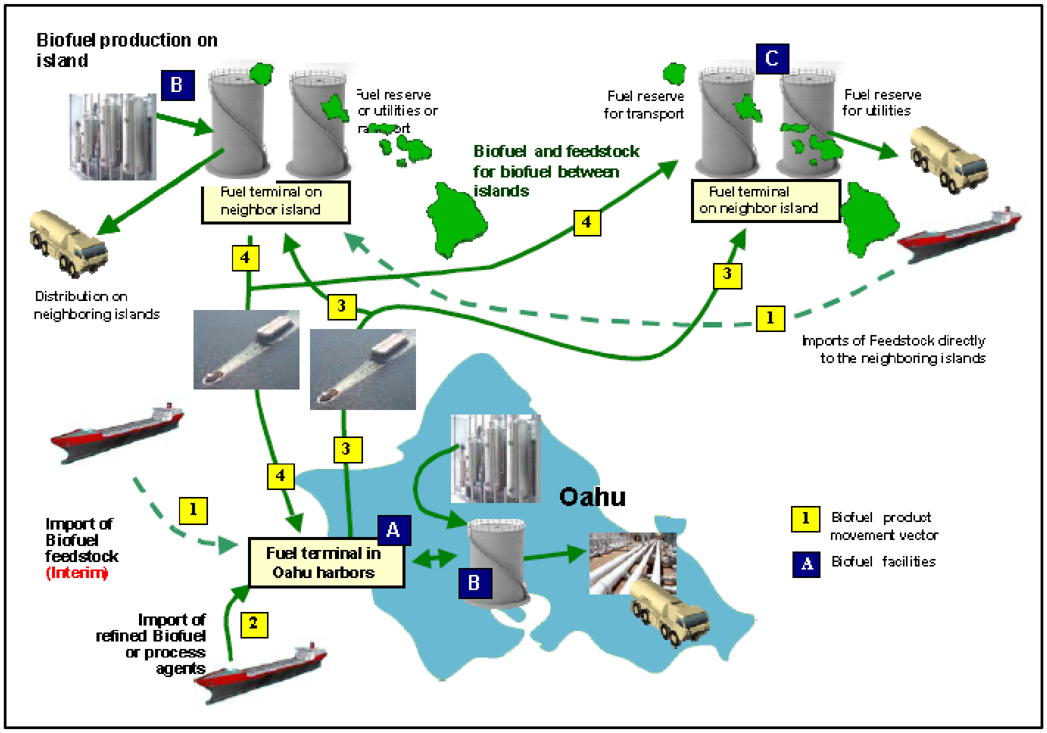


Figure 2-48. Biofuel System Supply for Hawai‘i (Source: Siah & Associates and Zapka 2009)

As shown in Figure 2-48, biofuels would likely would continue to be imported through O‘ahu, with direct imports of biofuel products and/or feedstocks to neighboring islands. Biofuel producers in O‘ahu would distribute the biofuel in O‘ahu via truck and the neighboring islands using marine transport modes. Alternatively, neighboring island feedstock production and biofuel conversion plants could satisfy local demand and export volumes of refined biofuels to O‘ahu or other neighboring islands; or neighboring islands without biofuel conversion plants would have facilities to unload fuel transported from fuel production inside the State and from direct biofuel imports to Hawai‘i (Siah & Associates and Zapka 2009). However, as port facility capacity is currently tight, the State would need to make adjustments to schedules and implement port expansion plans (HNEI 2012d).

Biofuels can be transported as liquid or solid feedstock. However, the State of Hawai‘i has not updated material regulations to consider the various types of biofuels and biofuel feedstock. The State treats the materials as “chemicals,” which triggers special requirements when being transported via ocean barge or vessel[14] (HNEI 2012d).

[14] Transport via isotainer is a currently approved method for chemicals and thus for biofuel feedstock; the gap in regulation is for transportation via bulk liquid vessel.

2.3.4.1.4 Characterization of Existing Deployment

Production and Distribution

Biofuel supply in the State is largely composed of imports of ethanol for blending with gasoline to produce an E10 blend. Ethanol is not currently being manufactured in the State, and E85 fuel has yet to be sold for public use.[15] Ethanol is imported from the mainland to Oʻahu, and delivered to and blended with gasoline terminals on Oʻahu, Maui, and the island of Hawaiʻi then sold through regular gasoline stations.

Biodiesel produced in the State at this time is mainly used for power plants, such as the Campbell Industrial Park Generating Station. Some volume of the biodiesel is produced in the State by Pacific Biodiesel a company that has built several production facilities in other states and countries. However, the company's local production of biodiesel comes primarily from waste oil feedstock on Oʻahu, Maui, and Hawaiʻi island (Pacific Biodiesel 2013; RMI 2006). Some of this biofuel has been contracted to HECO and the HDOT for a biofuel-powered emergency generating power plant at Honolulu International Airport (DBEDT 2012c). Some fuel is also used in local fleets, including by the City and County of Honolulu. Local biodiesel production may change as technological shifts continue to change the biofuels outlook through improved agronomic and conversion technologies for feedstocks, the continuous and rapid evolution of production of cellulosic ethanol, and further improved biofuels chemistry overall. In 2012, Hawaiʻi Electric Light Company (HELCO) asked the Hawaiʻi PUC to approve a new biofuel supply contract with ʻĀina Koa Pono, LLC. The ʻĀina Koa Pono processing facility (Kaʻū Project) is anticipated to provide approximately 16 million gallons of biofuel per year. According to ʻĀina Koa Pono, approximately 8 million gallons of bio-gasoline would be sold to Mansfield Oil Company, a mainland distributor of transportation fuel, as part of the Kaʻū Project (ʻĀina Koa Pono 2013).

The infrastructure currently available to support biofuel technology largely exists for ethanol on Oʻahu where storage, transport, and blending of petroleum and ethanol fuels has been handled successfully by the local fuel industry. However, future increases in the volume and range of renewable fuels will likely present additional scaling challenges for the State. Increased volumes of biofuels will require modifications to the existing distribution infrastructure to meet the growing demand, including the addition of new infrastructure to expand the State's biofuel industry. This includes expansion of the following components: storage tanks, pipelines, fuel installations in the harbors (for marine transport), tanker trucks, and blending facilities.

Vehicle Systems

Despite the State's ability to produce various biofuels, vehicle sales patterns in Hawaiʻi show a relatively low turnover of vehicles, with approximately 50,000 vehicles replaced per year (Braccio et al. 2012). This is supported via vehicle registration data show in Figure 2-49. Given the approximately 1 million vehicles in the State and an average of 50,000 vehicles being replaced each year, the average life of a vehicle in Hawaiʻi is estimated to be approximately 20 years, hindering the State from replacing older, less efficient cars on the road with newer, more sustainable vehicles (Braccio et al. 2012; DBEDT 2012d).

[15] There currently are three E85 fueling stations in the State. However, the E85 fueling stations are limited to Navy use.

This is further complicated as alternative-fueled vehicles require alternative fueling infrastructure. For example, flex-fuel vehicles represent approximately 5 percent of the light duty vehicles in use in the Nation (EIA 2012c). In Hawai‘i, this percentage is estimated to be less than 1 percent due to the limited amount of fuel and fueling stations currently available.[16] Therefore, although E85 ethanol is considered a possible petroleum fuel reduction strategy to help meet the State's transportation goals, the actual existing penetration rate of E85 ethanol (in particular) as a transportation biofuel is projected at this time to be minimal in the State. Although these numbers are projected to continue to increase, for large impacts to truly be realized, one study recommended that drop-in replacement fuels (e.g., Green Diesel or green gasoline which can be easily utilized in existing standard vehicles) would likely be better candidates for deployment in the future for the State (RMI 2006).

To help facilitate biofuel support and usage, Federal and State and incentives are available and discussed in Section 2.3.4.1.5 below.

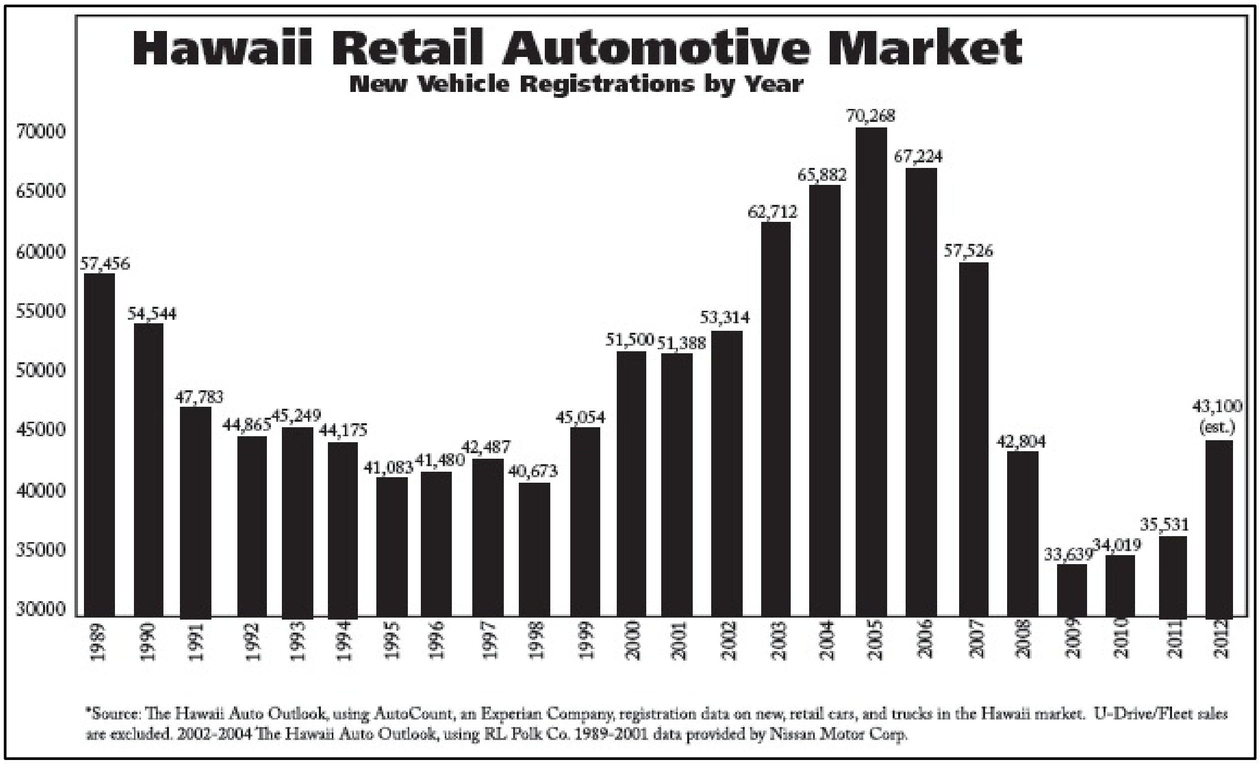


Figure 2-49. Hawai‘i Vehicle Registration Data, 1989-2012

Other Transportation Systems

It is noted that several U.S. Government agencies, including the DoD and NOAA, have used biofuels in ground transport and aboard marine vessels to spur initiative and for testing. However, while biofuels have performed relatively well for ground transportation, there are no pending specifications or large-scale fueling facilities for marine-grade biofuels (Nayar 2010). The DoD is currently researching biofuel for jet fuel use. In August 2011, the secretaries of Agriculture, Energy, and the Navy announced a memorandum of understanding to develop or retrofit domestic commercial- or pre-commercial-scale

[16] Information based on 2011 data, the latest information available, Source: the U.S. Energy Information Administration, Independent Statistics and Analysis, Renewable & Alternative Fuels – Alternative Fuel Vehicle Data, 2011 Yearly Estimates of User & Fuel Data by Weight Class, Accessed November 26, 2013. Available online at: http://www.eia.gov/renewable/afv/index.cfm

biofuel plants and refineries to support the Navy's goal of deploying a Green Strike Group and a Great Green Fleet by 2016 with a 50/50 blend of drop-in hydrotreated renewable jet fuel (DBEDT 2012c).

2.3.4.1.5 Incentives and Programs

As noted above, the Federal Government and State of Hawaiʻi have created laws and incentives to help increase biofuel support and usage. These include the following:

- An alternative fuel standard requiring that alternative fuels provide 15 percent of highway fuel demand by 2015, 20 percent by 2020, and 30 percent by 2030;
- A biofuel land use allowance and exemption where lands originally zoned for agricultural land use may be used for renewable energy production, storage, distribution, and the production of biofuels—the exemption releases biofuel production facilities from subdivision requirements for leases and easements within agricultural land use districts until July 1, 2020 (HRS 201N-14, 205-2, and 205-4.5);
- A biofuels procurement preference where State and county agency contract awards give preference to bids for biofuels and biofuel blends for the purchase of diesel fuel;
- A discounted tax rate for alternative fuels, an ethanol production incentive;
- Advanced vehicle acquisition requirements for the State and county; and
- An energy feedstock program that includes feedstock to produce biofuels.

2.3.4.1.6 Permitting and Consultation Requirements

Project permitting would be required for the production, conversion, and distribution activities and networks with accompanying infrastructure for the construction and operational phases of the project from various Federal, State and county agencies. See Section 2.2 for a discussion on general permitting and regulatory requirements.

Because of the nature of the biofuel technologies, projects would have to comply with the *Hawaiʻi Emergency Planning and Community Right-to-Know-Act* Chemical Inventory Reporting permitting requirements. Further details can be found in the *Guide to Renewable Energy Facility Permits in the State of Hawaiʻi – Version 1* (DBEDT 2013a).

Proper facility siting is critical to facility permitting and biofuel facilities should be sited in industrial areas or far away from residences. The following are some biofuel facility permitting nuances in Hawaiʻi:

- The regulatory requirements associated with import of certain microorganisms can be complex and time-consuming and could require compliance with Hawaiʻi's environmental assessment/environmental impact statement law (HRS 343).
- Approval of a traffic impact assessment is required for feedstock or product trucking and may require mitigation measures (e.g., restrictions on truck volume and transport times, load security/cover requirements).
- Some feedstocks host the many endangered avian species found in Hawaiʻi. Feedstock harvest cycles may need to be adjusted to accommodate species mating or birthing seasons.

- A project could potentially trigger HRS 343 under "oil refinery" or "waste-to-energy" facility.
- Project should include a rigorous regulatory review of facility effluent to ensure no invasive species are exhausted from the facility (e.g., genetically modified crops and algae).
- Competition for water, perceived pollutions risks, increased traffic, and use of agricultural land for nonfood crops can increase public opposition to the project.

There are also a few laws specific to biofuel facilities:

- City and County of Honolulu, Table 21-3, Revised Ordinances of Honolulu, includes a special use category called "Biofuel processing facilities," making it clear where such a facility can be permitted.
- HRS 205-2(d)(5) and 205-4.5(a)(16) state which biofuel facilities are permitted in State Agricultural Districts.

2.3.4.1.7 Representative Project

Due to the uncertainty of biofuel technology readiness, it is difficult to describe with any accuracy what a representative project might look like, and would ultimately depend on the type of biofuel technology selected. For the purposes of this PEIS, the potential environmental impacts of biofuel technologies (presented in Chapter 7) considers the range of potential applications identified in Section 2.3.4.1.2 and the potential impacts resulting from the development and utilization of biofuels from feedstock production and processing, to the slow integration of biofuels into the market, the fueling infrastructure, and vehicle use.

2.3.4.2 Electric Vehicles

Electric vehicles operate with an electric motor (or motors) powered by rechargeable battery packs. Some electric vehicles run solely on electrical power from the grid, others use a combination of gasoline and electricity. There are definite advantages and disadvantages of electric vehicles compared to internal combustion engine (DOE and EPA 2013a):

ELECTRIC VEHICLES

Battery Electric: Operates without internal combustion engine or fuel tank and relies solely on power from electrical grid.

Hybrid-Electric: Operates with a combined internal combustion engine and energy storage system; refuels with gasoline.

Plug-in Hybrid-Electric: Operates with a combined internal combustion engine and energy storage system; primarily uses grid-supplied electricity.

Advantages

- Energy efficient – Electric vehicles convert about 59 to 62 percent of the electrical energy from the grid to power at the wheels—conventional gasoline vehicles convert only about 17 to 21 percent of the energy stored in gasoline to power at the wheels.
- Environmentally friendly – When operating on battery power, electric vehicles emit no tailpipe pollutants, although the power plant producing the electricity may emit them. Electricity from nuclear-, hydroelectric-, solar-, or wind-powered plants causes no air pollutants.
- Performance benefits – Electric motors provide quiet, smooth operation and stronger acceleration and require less maintenance than cars with internal combustion engines.

- Reduce energy dependence – Electricity produced from renewable resources is domestically produced.

Disadvantages

- Driving range – Most currently available electric vehicles can only go about 100 to 200 miles before recharging—gasoline vehicles can go over 300 miles before refueling.
- Recharge time – Fully recharging the battery pack can take from 4 to 8 hours. A “quick charge” to 80-percent capacity typically takes 20 minutes.
- Battery cost – The battery packs are expensive and may need to be replaced one or more times throughout the life of the vehicle.
- Bulk and weight – Battery packs can be heavy and take up considerable vehicle space.

The DOE Alternative Fuels Data Center website (http://www.afdc.energy.gov), the joint DOE/EPA Fuel Economy website (http://www.fueleconomy.gov), and the Electric Drive Transportation Association (http://www.electricdrive.org) are all very good resources for learning more about electric drive technologies.

Electric vehicles are currently available in light-duty, such as passenger cars (from microcars to large sedans), and in medium-duty vehicles, such as delivery vans, transit buses, and shuttle buses. Battery electric vehicles do not have an internal combustion engine or fuel tank (e.g., gasoline, diesel, or compressed natural gas). Instead, battery electric vehicles solely use power stored in a battery pack and an electric powertrain to propel the vehicle. Hybrid-electric vehicles combine a combustion engine and an energy storage system to provide power. The engine is typically an internal combustion gasoline engine, but any engine/fuel combination is possible. Plug-in hybrid-electric vehicles are hybrid-electric vehicles with a larger-energy capacity battery pack, a higher-power capability electric powertrain, and the ability to plug into an electrical power source to charge the battery pack.

This section discusses technologies specific to electric vehicles that primarily use grid-supplied electricity for propulsion: battery electric vehicles and plug-in hybrid-electric vehicles. Section 2.3.4.3 discusses hybrid-electric vehicles.

2.3.4.2.1 Technology Description

Vehicle Types

Full-Speed Battery Electric Vehicles

Full-speed battery electric vehicles are capable of replacing a conventional gasoline vehicle and can use any road with any speed limit, assuming the driving range is sufficient. While any battery chemistry can be used (e.g., lead-acid, nickel metal hydride, zinc-air, lithium-ion, and lithium-air), lithium-ion is the only battery type in commercial use because of its power, cost, life, and safety, among other factors. However, as batteries improve in range, power, cost, and life, improved lithium-ion batteries or other battery chemistries likely will join, or replace, lithium-ion at some time.

These vehicles are fully functional and are potential replacements for conventional gasoline and diesel vehicles. However, due to battery cost the vehicles can typically only drive for about 100 miles between charges. The Federal Highway Administration data and General Motors Company internal data determined that 40 miles meets 86 percent and 100 miles meets 100 percent of the daily driving demands of more than 90 percent of passenger vehicle trips in the United States (FHWA 2008; Savagian 2011). So, while this means the 100-mile travel range would be adequate, smaller, lighter, and larger-capacity batteries undoubtedly would make these vehicles that much more competitive.

Neighborhood Battery Electric Vehicles

Neighborhood electric vehicles are small battery-powered, low-speed vehicles. Their performance and vehicle safety equipment must conform to Federal Motor Vehicle Safety Standard 500 “Low-speed Vehicles” (USDOT 2011a). The standard requires a minimum set of safety equipment (e.g., safety belts, windshield, headlights, taillights, stop lamps, front and rear turn indicators, a horn, and a parking brake). These standards and Hawai‘i State law restrict neighborhood electric vehicle operation to a maximum speed of 25 miles per hour and only on roads with speed limits up to 35 miles per hour. Neighborhood electric vehicles have a much simpler powertrain than a full-speed electric vehicle and typically run with a lead-acid battery pack of 48 or 72 volts DC that can be replaced at a relatively low cost (less than $1,000). Neighborhood electric vehicles have an onboard charger, which can plug into any standard 3-pronged, 120-volt AC outlet.

Plug-In Hybrid-Electric Vehicles

Plug-in hybrid-electric vehicles use grid-supplied electricity for the majority of daily driving trips. As a result, a plug-in hybrid-electric vehicle displaces more petroleum than a hybrid-electric vehicle, but less than a battery electric vehicle. Plug-in hybrid-electric vehicles refuel by both filling the fuel tank and plugging into an electrical power source to charge the battery pack. Plug-in hybrid-electric vehicles also recover braking energy to recharge the battery while driving. Most plug-in hybrid-electric vehicles can drive between 10 and 40 miles solely on electricity (without the use of the gasoline-powered combustion engine) between charges. Plug-in hybrid-electric vehicles are often referred to by their all-electric driving range. For example, a type PHEV-10 is a plug-in hybrid-electric vehicle with a 10-mile all-electric driving range.

Plug-in hybrid-electric vehicles have the potential to cost less than battery electric vehicles because they have a lower-energy capacity battery and may have lower electric-power throughput on the electric drive components, which result in lower powertrain costs. This is especially true for plug-in hybrid-electric vehicles with lower electric range. However, in today’s marketplace, the purchase price for some plug-in hybrid-electric vehicles is more than that of battery electric vehicles depending on the make and model. Battery electric vehicles cost less to operate than plug-in hybrid-electric vehicles because they operate solely on grid-supplied electric power. Even so, because the per vehicle petroleum savings does not scale linearly with battery capacity, having a larger-capacity battery pack [e.g., a battery electric versus a plug-in hybrid-electric vehicle with a 40-mile electric range (PHEV-40), or a PHEV-40 versus a PHEV-10] does not necessarily result in significantly lower petroleum use. In 2008, the Deputy Assistant Secretary for the DOE Office of Renewable Energy and Energy Efficiency stated that plug-in hybrid-electric vehicles with a 10-mile range (PHEV-10) with financial incentives seemed to be a better option than PHEV-40 (Rodgers 2008). This was because the PHEV-10 battery pack was less expensive, which resulted in earlier market penetration and a much larger amount of fuel being saved. The result is more consumers may be attracted to plug-in hybrid-electric vehicles and more inclined to purchase them.

Extended Range Electric Vehicles

Extended range electric vehicles is a term coined by General Motors Company to describe the Chevrolet Volt in an attempt to differentiate it from other plug-in hybrid-electric vehicles. Under most conditions, the Volt operates as an electric vehicle. It switches to conventional hybrid-electric vehicle operation when the battery is depleted (i.e., a charge-depleting plug-in hybrid-electric vehicle). Since an extended range electric vehicle is simply a different name for a plug-in hybrid-electric vehicle, this PEIS does not address it separately.

Electric Vehicle Charging Equipment

Electric vehicles must be connected to a supply of electricity using specialized equipment to recharge the battery. All currently available vehicle chargers use conductive charging, which is the same method used by most electric devices in the United States. All electric vehicle chargers must be installed by a licensed electrician and must comply with local, State, and Federal codes and regulations to ensure proper and safe installation. The following sections briefly describe relevant charging equipment. For more detailed information, readers are directed to the DOE's Alternative Fuels Data Center (http://www.afdc.energy.gov/) and HECO's electric vehicle technologies website (HECO 2013e).

Level 1 Electric Vehicle Chargers

Level 1 electric vehicle chargers are the lowest power output, least expensive, and slowest method to charge a battery pack. Level 1 electric vehicle chargers connect to a 3-pronged, 120-volt AC circuit (a standard household electrical outlet), and deliver between 1.3 and 1.7 kilowatts of power. Most commercially available, on-road electric vehicles include an integrated onboard Level 1 electric vehicle charger to ensure they are always able to charge as long as a 120-volt outlet is available. A special cordset connects the vehicle to a proper outlet.

A general rule of thumb is a Level 1 charger provides a full-speed battery electric vehicle between 2 and 5 miles of driving range per 1-hour of charging. (The actual mileage depends on the particular vehicle's energy consumption.) Because of this slow recharge rate, electric vehicles with a large battery pack would take a long time to recharge (e.g., it could take about 20 hours to charge a fully depleted battery), and may need a higher charge rate to meet consumer demand. The decision will be user and vehicle dependent. Plug-in hybrid-electric vehicles, however, have a lower-capacity battery pack and, thus, a shorter charge time. Level 1 charging is likely to be used primarily for overnight or workplace charging when the vehicle would be connected for many hours for both battery electric and plug-in hybrid-electric vehicles. Level 1 charging is not suited for public charging locations where vehicles would be connected for much shorter durations, since it would not replace much charge.

Level 2 Electric Vehicle Chargers

Level 2 electric vehicle chargers have a higher power output than Level 1 chargers and connect to either a 240-volt AC, two-phase circuit (typical in residential applications) or a 208-volt AC, three-phase circuit (typical in commercial applications). Level 2 electric vehicle chargers are installed on a dedicated circuit with a current capacity between 20 and 80 amps and deliver between 3.3 kilowatts and 6.6 kilowatts of power (roughly 2 to 4 times the power of Level 1). This power output allows all currently available electric vehicles to recharge overnight. Most homes in Hawai‘i have 240-volt AC electrical service for operating appliances such as clothes dryers. The service can also be used for a Level 2 electric vehicle charger. Plug-in hybrid-electric vehicles have lower battery capacities than electric vehicles, so Level 2 charging may not be necessary for home charging since the less-expensive Level 1 charger will likely be able to charge the battery overnight. A general rule of thumb is a Level 2 charger provides between 10 and 20 miles of driving range per 1-hour of charging. (The actual mileage depends on the particular vehicle's energy consumption.)

Direct Current Fast Chargers

Direct current fast chargers use a 480-volt DC input. Direct current fast charger units are much more expensive than Level 2 chargers (on the order of $20,000 to $40,000) (Plug In America 2014). The typical total installed cost (charger hardware and labor) ranges from $75,000 to $100,000. The low cost range is $40,000 to $50,000, but total installed costs can be as high as $150,000 (T. Ritter 2014). The wide cost variation results from site-specific differences, As a result, this type of charger is only applicable to public recharging such as a charging station (the electric vehicle equivalent of a gasoline/diesel station). A general rule of thumb is a direct current fast charger provides between 60 and 80 miles of driving range in a 20-minute charging session. (The actual mileage depends on the particular vehicle's energy consumption.)

Wireless Charging

Wireless charging, also known as inductive charging, does not use a direct physical connection between the vehicle and charger to transfer power. Rather, the charger transfers power to the vehicle via an inductive coupling through a magnetic field. In the 1990s, General Motors used inductive charging for the EV-1. In this application, a paddle was inserted into the charger slot at the front of the car to charge the battery. Today, wireless charging technology, still under development, uses a charging pad installed in the ground (Figure 2-50). The vehicle parks so the vehicle-mounted charging pad is over the ground-installed pad.

Figure 2-50. Wireless Charging Concept Demonstrator Concept (Source: HECO 2013f)

2.3.4.2.2 Characterization of Technology Feasibility and Deployment

Feasibility of Technology

Electric vehicles have been used and promoted in Hawai‘i since the mid-1990s. The Hawai‘i Electric Vehicle Development Program (now the Hawai‘i Center for Advanced Transportation Technologies) implemented a program to demonstrate electric vehicles in service at HECO and State agencies. In 1999, the Center extended the program to make Hawai‘i the first electric-vehicle-ready state by installing a network of direct current fast chargers. The Electric-Vehicle-Ready State program expanded with the addition of 15 Hyundai electric vehicles as the company saw Hawai‘i's unique climate and operations opportunity related to the geography and short typical driving distances (ENOVA 2001). All of these efforts showed that electric vehicles were a practical transportation option for Hawai‘i. The vehicles involved with the program used battery technology of the day (lead-acid and nickel metal hydride), which had limited driving range and power. Current electric vehicles have much higher driving range and power, so are expected to be accepted by a wider range of drivers.

Vehicle usage data provided by DBEDT show that the average annual vehicle miles travelled per vehicle has been relatively steady at 9,050 miles per year (1990 to 2011). U.S. Department of Transportation, Bureau of Transportation Statistics data show the vehicle miles travelled to be lower, at 7,014 (2000 data) (USDOT 2002). Regardless of the difference, these data correlate to low daily driving distances of about 20 to 25 miles per day, which is well below the driving range for all production battery electric vehicles and within the all-electric driving range for many commercially available plug-in hybrid-electric vehicles (e.g., Chevrolet Volt). It should be noted that these data are for the State of Hawai‘i; island-specific data are not available, so a more refined discussion was not possible. While it is not possible to quantify at this point, given the available data, one could assume that battery electric vehicles and the all-electric driving range of plug-in hybrid-electric vehicles could satisfy trips with double or triple the average daily mileage. Ultimately, it is not anticipated that there will be a significant differences in the applicability and use of electric vehicles between the islands. Electric vehicles on the island of Hawai‘i likely will be driven longer distances than on the smaller islands, but the use would not exceed normal usage on the mainland, so electric vehicles are still a viable technology.

Existing Deployment of the Technology

Vehicles

Figure 2-51 shows the vehicle registration trend for electric vehicles (HSEO 2013b). The Hawai‘i EV Ready program, funded by the *American Recovery and Reinvestment Act of 2009* (Public Law 111-5, 123 Stat. 115), provided additional financial incentives for purchasing electric vehicles and chargers to promote electric vehicles and jump start the wider public adoption (HSEO 2013c; DBEDT 2013i). The program ran from August 2010 through December 2012 and increased the number of registered electric vehicles by more than 700 percent, ending with a total of 1,182 registered vehicles.

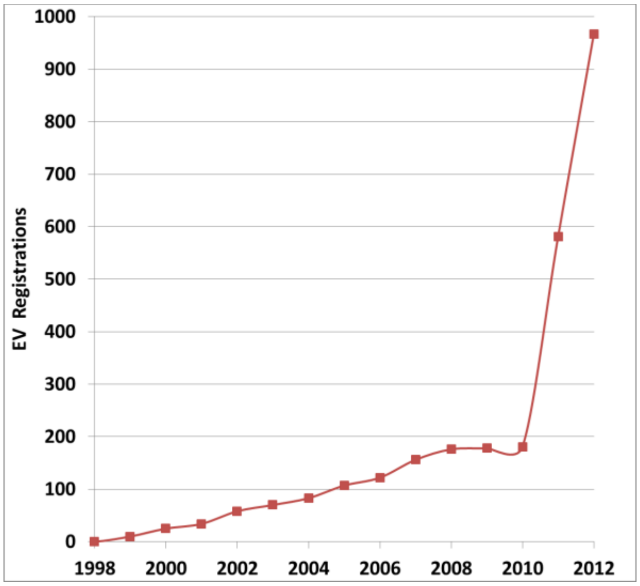


Figure 2-51. Electric Vehicle Registration in Hawaii

Charging Infrastructure

The Hawai‘i EV Ready program also awarded funds to several awardees (AeroVironment, Better Place, the County of Kaua‘i, the City and County of Honolulu, GreenCar Hawai‘i, and Plug in America) to install publicly available charging infrastructure. The program was responsible for installing 277 Level 2 charging spots and six direct current fast chargers at 98 locations across Hawai‘i.

HSEO compiles and makes available locations of public electric vehicle charging stations (HSEO 2013d, HSEO 2013e); the same information for public and private commercial stations is compiled by the Alternative Fuels Data Center (http://www.afdc.energy.gov). Figure 2-52 summarizes the distribution of chargers and charging ports installed across the State. (Note: chargers can have multiple charging ports.) Private residential charging locations are not included in either reference.

2.3.4.2.3 Electric Vehicles in 2030

The HCEI transportation sector goal is to reduce petroleum use for ground transportation by 70 percent by 2030. One way of achieving this is to replace conventional gasoline vehicles with electric vehicles across the State.

2030 Electric Vehicle Definition

The Hawai‘i vehicle fleet predominantly comprises light-duty vehicles (e.g., passenger cars and light trucks), so transitioning this class of vehicles to more energy-efficient vehicles is key to reducing petroleum and energy use. In addition, there are many current and near-term electric vehicle options for light-duty vehicles (mainly passenger cars).

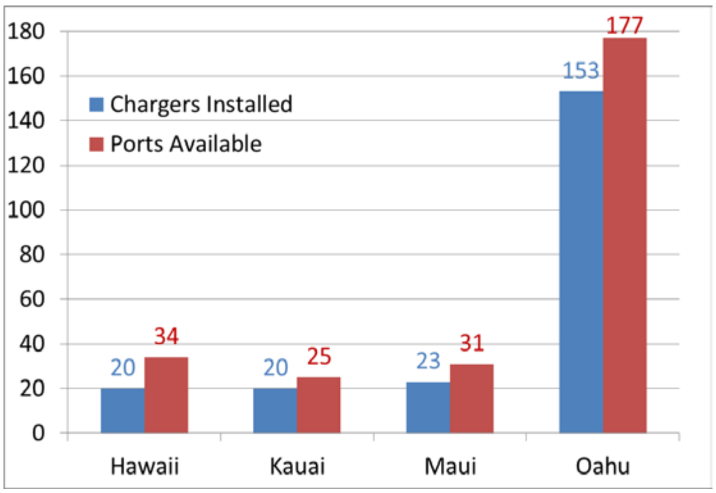


Figure 2-52. Electronic Vehicle Charging Infrastructure bv Island

Annual Hawai‘i light-duty vehicle sales data show that the Statewide light-duty vehicle mix is approximately 50 percent passenger cars and 50 percent light trucks (includes sport utility vehicles, crossover utility vehicles, and pickup trucks). The average annual sales in Hawai‘i is approximately 50,000 vehicles per year, which roughly equates to a 20-year fleet turnover rate for the State's approximately 1 million vehicles. This means that most of the fleet's current vehicles will be replaced by the 2030 HCEI target year.

VEHICLE FLEET

For this PEIS, the term "fleet" has two purposes:

1. The general usage refers to the entire vehicle population in Hawai‘i.

2. When used in the discussion about the representative project, fleet refers to the collective group of all electric vehicles included in the electric vehicle population needed to achieve the 20-million-gallon gasoline use reduction.

Average driving distance data available from HSEO show that the annual per vehicle driving distance has remained very steady since 1999; slowly decreasing from 9,058 miles to 9,020 miles in 2011. Assuming a constant 9,020 miles per year and an average gasoline passenger car fleet combined fuel efficiency of 25 miles per gallon (includes a combination of highway and city driving), the average vehicle consumes 361 gallons of gasoline per year.[17,18]

One study compared the fuel economy improvement of plug-in hybrid-electric vehicles with that of an electric vehicle; the study did not include a comparison with conventional vehicles (NRC 2010). The fuel economy improvement of hybrid-electric vehicles compared with plug-in hybrid-electric vehicles varies by manufacturer, vehicle, battery capacity, what the baseline vehicle used for comparison, and other factors. Table 2-20 summarizes these results.

Table 2-20. Per Vehicle Fuel Consumption Comparison of Conventional, Hybrid-Electric, and Electric Vehicles

Vehicle Type	Current Commercial Examples	Average Annual Gasoline Consumption (gallons)	Annual Fuel Consumption Reduction Relative to Conventional Gasoline Vehicle (gallons)	Annual Fuel Reduced Compared with Conventional Gasoline Vehicle (%)
Conventional Gasoline	Toyota Camry, Toyota Corolla	361	0	0
HEV	Toyota Prius, Honda Civic Hybrid, Ford Fusion	216	144	40
PHEV-10	Toyota Prius Plug-In Hybrid	173	188	52
PHEV-20	Ford Fusion Energi, Ford C-Max Energi	148	213	59
PHEV-40	Chevrolet Volt	97	263	73
BEV	Nissan Leaf, Ford Focus Electric, Fiat 500e, Chevrolet Spark EV, Honda Fit EV, Mitsubishi i-MiEV	0	361	100

BEV = battery electric vehicle; HEV = hybrid-electric vehicle; PHEV = plug-in hybrid-electric vehicle.

[17] The 2030 passenger car fleet average fuel economy will be higher, but is not yet known. So data from various model years of Toyota Camry and Toyota Corolla were used as the basis to develop 25 miles per gallon.
[18] Light-duty diesel vehicle penetration is currently very low. Even though this may change by 2030, the fuel savings from diesel were not included in this example.

Potential Benefits

The primary benefit of the 2030 electric vehicle fleet will be a dramatic reduction of petroleum use and exhaust emissions, assuming renewable energy is the primary energy source. The electrical energy demand for the electric vehicles accounts for 5.2 percent[19] of current firm power potential. By the 2030 target date, it may be possible to meet the demand with renewable generation. Using current system efficiencies, even if the electricity was generated primarily from fuel oil there would be about a 30 percent reduction in petroleum energy use for an electricity-powered mile compared with a gasoline-powered mile (DBEDT 2012d).

Potential Initial Issues

Electric vehicle charger installations for commercial or residential use may require trenching to run electrical cable conduit from the circuit panel to the electric vehicle charging equipment and/or to run additional electrical service to the building if the existing service cannot accommodate the additional load. A study of commercial properties on Oʻahu showed that only 3 of the 22 properties required trenching to install their chargers. Of the locations that needed trenching, the trenching distance ranged from 10 to 150 feet per charger (HCC 2012a). Electrical work crews initially would require more time to install the chargers; however, installation times would decrease as crews became more familiar with the new equipment.

Potential In-Use Issues

Electrical Grid Issues

The combined power capacity required to charge a large number of electric vehicles could pose a challenge to the utility and could increase petroleum use. Hawaiʻi electrical energy consumption has decreased by 7 percent (770 gigawatt-hours) since it peaked in 2004 (HSEO 2013f) (Figure 2-53). There may be electrical generation and distribution capacity for adding electric vehicle loads, especially if the time of electricity use for electric vehicle charging is controlled. HCEI energy conservation programs will continue to result in decreased electrical energy usage. Increased renewable electricity generation will only improve the power availability for electric vehicles.

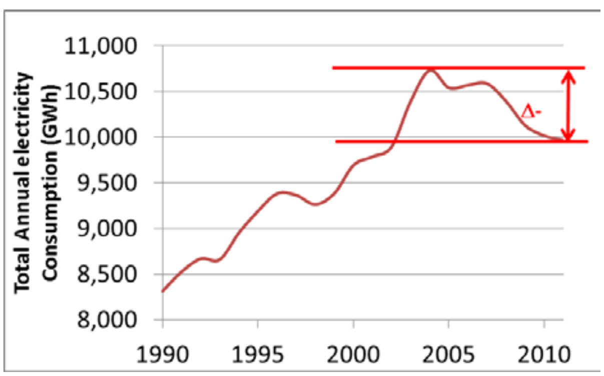


Figure 2-53. Electricity Use Decrease since 2004 Peak

The Hawaiian Electric Companies (HECO in Oʻahu; MECO in Maui, Lānaʻi, and Molokaʻi; and HELCO on Hawaiʻi island) have pilot programs for residential and business customers that provide incentives when users charge electric vehicles during off-peak hours (9 p.m. to 7 a.m.) (HECO 2013g and HECO 2013h). The rate structure varies somewhat depending on whether the electric vehicle charger is metered separately. For commercial accounts, the rate ranges from $0.05 below to $0.02 above typical rates; for residential accounts, the rate ranges from $0.06 below to $0.05 above typical rates. The Hawaiian Electric Companies also recently began offering two new electricity rate schedules intended to facilitate the deployment of a direct current fast charging infrastructure to alleviate range anxiety. (Range anxiety is the concern that an electric vehicle has insufficient driving range to reach its destination, leaving the occupants stranded.) The new Schedule EV-F rate is a time-of-use rate without a demand

[19] This figure is based on the assumption that the estimated daily total energy required to charge the total number of 2030 electric vehicles of 800,000 kilowatt-hours would require generation capacity of roughly 133 megawatts and a Statewide total firm generation power capacity of 2,484 kilowatts (discussed further below).

charge. Without this rate structure, fast charging could dramatically increase demand charges, while also potentially occurring at peak electricity usage periods. The second rate schedule allows the Hawaiian Electric Companies to install up to 25 publicly accessible direct current fast charging facilities on Oʻahu, in Maui County, and on Hawaiʻi island (DBEDT 2013j). Information for the Kauaʻi Island Utility Cooperative was not available.

First Responder Issues

First responders (e.g., fire, police, and ambulance) have been properly trained to safely help electric vehicle drivers who are involved in accidents. The National Alternative Fuels Training Consortium has a First Responder Safety Training class that can be used by local emergency responders.

Potential End of Vehicle Life Issues

Electric vehicle powertrain components (e.g., batteries, electric motors, power electronics, and cabling) have a potential negative impact if they reach a landfill. The materials are all recyclable and should be captured through municipal and corporate reuse and recycling processes. Recycling practices and protocols for lithium-ion batteries have been in place for decades and are being further developed to handle the various types of lithium-ion batteries used in vehicles (Coy 2011, 2012). Batteries in electric vehicles are considered to have reached their end-of-life when a battery charge provides only 80 percent of the new battery's energy capacity. At this point, technicians can recondition and use the batteries for non-vehicle applications, such as an energy storage buffer for solar or wind generation and utility grid support. Such reuse avoids costs and energy to produce new batteries, as well as costs associated with recycling. Batteries that cannot be reconditioned or repurposed ultimately will be recycled.

2.3.4.2.4 Permitting and Consultation Requirements

Electric vehicles are purchased in the same manner as a conventional vehicle. However, installation of the electric vehicle chargers is the new aspect that must be addressed. The Hawaiʻi EV Ready program included the development of the *Guidebook for Commercial Vehicle Charging Station Installations* (Plug In America 2012). This detailed reference describes the complete electric vehicle charger installation process, including planning, permitting, installation, and operation.

General permits are required before installation activities begin to ensure project conformity to Federal, State, and county laws, codes, and standards, as well as industry codes and standards (see Section 2.2). This section summarizes required permitting and provides references for more information if required.

All commercial electric vehicle charger installations require a permit. All permanently installed residential electric vehicle chargers require an electrical, building, and/or plumbing permit (the specific permitting requirements differ by county). Level 1 electric vehicle chargers likely do not require a permit since they can use any 120-volt AC outlet. Portable Level 2 electric vehicle chargers designed to plug into a 240- or 208-volt AC outlet likely do not require a permit, provided a dedicated outlet is in place. The "County Permitting Agencies for Charger Installations" section of the guidebook provides contact information for the permitting agencies for each county (Plug In America 2012). County planning and permitting contact information is provided in Section 2.2.5.

The majority of early electric vehicle charger permits for installations on commercial properties on Oʻahu took between two and three weeks to receive approval (HCC 2012a). Should a more comprehensive zoning permit be required, permitting timelines and costs would increase. In many cases, a third-party electric vehicle charger installer, if used, handles the permitting process. DBEDT prepared a report that included a summary of the permitting issues and suggestions for improving and streamlining the permitting processes among the islands. One specific suggestion was to extend online electric vehicle charger installation permits for commercial installations (DBEDT 2012d). The City and County of

Honolulu used funding from the Hawai‘i EV Ready program to make residential building permits available online for the installation of charging stations to help expedite residential charging station installations. Residential installation permits are attainable online for electric vehicle chargers that have been approved by the City and County of Honolulu.

2.3.4.2.5 Representative Project

The representative electric vehicle project is to increase the light-duty electric vehicle population to avoid use of 20 million gallons of gasoline fuel by 2030. This fuel avoidance amount is being used across all relevant sections in this PEIS to provide a consistent basis for comparison.

Using the 2030 electric vehicle discussion above (see Section 2.3.4.2.3), the representative project assumes that the Statewide vehicle mix remains 50 percent passenger cars and 50 percent light trucks. The representative project also assumes that only passenger cars will transition to electric vehicles (i.e., no light trucks). This assumption is based on two factors: (1) high vehicle costs, primarily related to battery costs, which scale with vehicle size, and (2) light-trucks are more likely to be used to transport loads (materials, people, towing), which would either decrease the driving range or require a larger, more expensive battery pack. Reinforcing this assumption, currently no EV sport utility, crossover utility vehicles, or pickup trucks are available for sale in Hawai‘i. Only one model of battery electric compact crossover utility vehicle is commercially available. No plug-in hybrid-electric or any battery electric vehicles are available in the other light truck classes.

The representative project includes a mixture of battery electric vehicles and different levels of plug-in hybrid-electric vehicles (e.g., PHEV-10, PHEV-20, and PHEV-40) to mimic a potential future fleet mix. Using data from Table 2-20, the representative project uses the following values:

- PHEV-10 – PHEV-10 reduces fuel consumption by 20 percent compared with a hybrid-electric vehicle (52 percent compared with a conventional gasoline vehicle) (NRC 2010).
- PHEV-40 – An average PHEV-40 reduces fuel consumption by 45 percent compared with a hybrid-electric vehicle (73 percent compared with a conventional gasoline vehicle) (NRC 2010).
- PHEV-20 – The PHEV-20 category was not included in the study, but is included here since this is the logical middle ground and PHEV-20 vehicles are currently available. Interpolating between the estimated PHEV-10 and PHEV-40 gives an estimated 32 percent lower fuel consumption compared with a hybrid-electric vehicle (59 percent compared with a conventional gasoline vehicle).

2030 Electric Vehicle Fleet to Meet Fuel Reduction Target

The representative project assumes the 2030 electric vehicle fleet mix will be:

- 40 percent PHEV-10
- 30 percent PHEV-20
- 20 percent PHEV-40
- 10 percent battery electric vehicle

The weighting takes into account higher adoption rates of less-expensive vehicles and conversely lower adoption rates of more-expensive vehicles. As Table 2-21 shows, reaching the 20-million-gallon petroleum reduction would require adoption of approximately 88,000 electric vehicles (roughly 6 percent of the total number of 2030 vehicle fleet).

Table 2-21. Estimated 2030 Electric Vehicle Fleet Composition and Gasoline Reduction Potential

Vehicle Type	Percentage of 2030 Electric Vehicle Fleet	Number of 2030 Electric Vehicle Fleet	Total Annual Gasoline Consumption Reduction (gallons)
PHEV-10	40	35,139	6,592,676
PHEV-20	30	26,354	5,610,304
PHEV-40	20	17,570	4,627,552
BEV	10	8,785	3,169,556
TOTALS	**100**	**87,848**	**20,000,088**

BEV = battery electric vehicle; PHEV = plug-in hybrid-electric vehicle.

Table 2-22 shows the installed battery capacity and estimated daily energy required to charge the batteries. The National Academy of Science report stated a PHEV-10 would require about 2 kilowatt–hours of installed battery capacity and a PHEV-40 would require about 8.0 kilowatt-hours. These numbers are roughly half of that used in the commercialized vehicles mentioned in Table 2-21.

Table 2-22. Summary of Electricity Capacity Required To Charge the 2030 Electric Vehicle Fleet

Vehicle Type	Installed Battery Capacity Per Vehicle (kilowatt-hour)	Estimated Daily Battery Capacity Used Per Vehicle (kilowatt-hour)	Estimated Daily Total Energy Required (kilowatt-hours)
PHEV-10	4.4	4.4	210,000
PHEV-20	8.0	8.0	285,000
PHEV-40	16.0	10.0	235,000
BEV	24.0	6.0	70,000
TOTALS	**NA**	**NA**	**800,000**

BEV = battery electric vehicle; NA = not applicable; PHEV = plug-in hybrid-electric vehicle.

So to be more accurate, the representative project uses representative battery capacity values from current commercially available vehicles. Data from HSEO show the average daily trip distance in Hawai‘i is roughly 25 miles. Because of this, vehicles with an all-electric driving range greater than 25 miles (e.g., PHEV-40 and battery electric vehicles) will not be fully depleted at the end of the day, so the battery pack will not require a full charge. The total daily energy required to charge the electric vehicle fleet was estimated using the usable battery capacity, an overall 75 percent battery charging efficiency. The battery charging efficiency includes transmission and distribution efficiency (about 94 percent) (EIA 2010), battery charger efficiency (about 90 percent) (Chae 2011), and battery-level losses (about 90 percent).

Electrical Energy Required to Charge the 2030 Electric Vehicle Fleet

Assuming a 6-hour charge, 800,000 kilowatt-hours would require generation capacity of roughly 133 megawatts. This equates to 5.2 percent of the firm generation power capacity in Hawai‘i for each avoided 20 million gallons of gasoline (Table 2-23). This is additional demand on the grid that would have to be included in energy use forecasts. The majority of electric vehicle charging loads will occur off-peak when sufficient production is available. It is critical that the vehicles charge after the evening peak (typically 9 p.m.), otherwise electric vehicle charging will increase the demand on the grid. This is one of the reasons that the utilities have pilot time-of-use electric vehicle charging rate programs that provide incentives for off-peak charging (see the Potential In-Use Issues section above). The additional electric vehicle charging loads would require that sufficient renewable power generation is available to meet the HCEI goals. There are currently 202 megawatts of wind power, 31 megawatts of hydroelectric power, and 38 megawatts of geothermal power generation capacity (271 megawatts total), which, combined, have the potential to charge the electric vehicle fleet in this representative project. Some of these loads face curtailment, especially at night, so would be available for electric vehicle charging. The renewable generating capacity would be higher in 2030, so may be able to meet the electric vehicle charging demand.

Table 2-23. Power Generation Capacity in Hawai‘i

Utility Company (Islands)	Firm Generation Power (megawatt)	Non-Firm Generation Power (megawatt)[a]
HECO (O‘ahu)	1,783	88
MECO (Maui, Lāna‘i, Moloka‘i)	284	48
HELCO (Hawaii)	292	32
Kaua‘i Island Utility Cooperative (Kaua‘i)	125	NA
TOTALS	**2,484**	**>168**

Source: DBEDT 2013h.
a. Source: HECO 2011.
NA = not applicable.

Electric Vehicle Charger Installations to Support the 2030 Electric Vehicle Fleet

The typically short average driving distances and the island geography mean that home charger installations could meet a significant portion of the regular charging infrastructure need, especially for plug-in hybrid-electric vehicles. It is reasonable that Level 1 chargers will be sufficient for PHEV-10 and PHEV-20. It was assumed that Level 2 chargers will be required as the primary (i.e., home) charging method for PHEV-40 and battery electric vehicles given the larger battery capacity. This results in a scenario where approximately 62,000 Level 1 chargers and 27,000 Level 2 chargers would be installed where the vehicles park overnight.

Even with Hawai‘i’s limited geographic boundaries, range anxiety serves as a major impediment to purchases and public acceptance of battery electric vehicles. (Range anxiety is not a concern for plug-in hybrid-electric vehicles since they switch over to operating as a conventional hybrid-electric vehicle when battery charge reaches certain threshold.) This is true for residents and tourists who could rent or lease electric vehicles. Range anxiety will be the biggest concern for atypical, longer distance, trips, such as driving from town centers to major beaches and remote popular destinations. Range anxiety could also be an issue for residents with commutes that are close to the maximum driving range, especially if they encounter side trips, road construction detours, or unexpected traffic delays. As a result, public charging stations will be needed in frequented locations (e.g., work, shopping malls, major beaches, and popular tourist attractions) to encourage electric vehicle acceptance for residents and tourists. Level 1 or Level 2 chargers could be used for workplace charging since the vehicles would remain idle for sufficient time to replace a useful amount of battery capacity. High-power Level 2 chargers could be installed in public locations where the vehicles park for only an hour or two (e.g., shopping malls, colleges, civic center, major beaches, medical complexes, and popular tourist attractions). A network of direct current fast chargers also likely would be necessary for electric vehicle users who do not park their vehicles for long periods during the day (e.g., pick up/drop off at bus terminal/airport, scenic drive around the island), or to give the battery a boost charge to ensure the vehicle gets home. A properly designed combined solution of Level 1, Level 2, and direct current fast charge stations will enable the electric vehicle market to grow by removing a significant potential detractor for vehicle purchaser and renters.

2.3.4.3 Hybrid-Electric Vehicles

Hybrid-electric vehicle powertrains combine a conventional combustion engine (gasoline or diesel), a battery, and an electric motor. The wheels are driven by the internal combustion engine, the electric motor, or a combination of the two. There are various hybrid powertrain configurations. In a parallel hybrid-electric car, the conventional engine and the electric motor are mechanically connected to the driveshaft and the wheels of the car. In a series hybrid-electric car, the combustion engine is only used to generate electricity, which then powers an electric motor that drives the wheels. Hybrid-electric vehicles reduce fuel use mainly by recovering braking energy, an approach called *regenerative braking.*

Regenerative braking converts the vehicle's kinetic energy into electrical energy to charge the battery, rather than wasting it as heat energy as conventional brakes do. All hybrid-electric vehicles also have an idle-stop feature, which turns the engine off when the vehicle stops to save more fuel.

Section 2.3.4.2 of this PEIS discusses electric vehicles which includes battery electric vehicles and plug-in hybrid-electric vehicles. This PEIS addresses hybrid-electric vehicles separately because they all use an internal combustion engine so rely more on conventional fuel than electricity to propel the vehicle. Hybrid-electric vehicles are currently available in light-duty vehicles, such as passenger cars (from microcars to large sedans) and sport utility vehicles/crossover utility vehicles), and in medium- and heavy-duty vehicles, such as delivery vans, transit buses, and shuttle buses.

The DOE Alternative Fuels Data Center website (http://www.afdc.energy.gov), the joint DOE/EPA Fuel Economy website (http://www.fueleconomy.gov), the Electric Drive Transportation Association (http://www.electricdrive.org), and the joint EPA/USDOT National Highway Transportation Administration documentation supporting the 2017-2025 Corporate Average Fuel Economy legislation (EPA and USDOT 2012) are all very good resources for learning more about hybrid-electric vehicle technologies.

2.3.4.3.1 Technology Description

Vehicles Types

Not all hybrid-electric vehicles are equal; there is a wide range of types of hybrid-electric vehicles. This section defines the different levels of vehicle "hybridization". While definitions differ somewhat depending on the data source (e.g., government agency, vehicle manufacturer, and research study), The definitions provided in the following sections, and summarized in Table 2-24, are from a recent Society of Automotive Engineers symposium (Anderman 2013), and provide practical guidelines for the types of hybrids. All hybrid-electric vehicles are full-function vehicles and are direct replacements for conventional gasoline or diesel internal combustion engine vehicles.Table 2-24. Comparison of Hybrid System Types

Hybrid Type	Battery Type	Battery Voltage (VDC)	Electric Assist Power (kW)	Electric Range (miles)	Fuel Use Savings (%)	Benefits
Micro-0	Advanced lead-acid	14	0	0	2 - 6	Engine stop-start, some idle loads
Micro-2	Advanced lead-acid and Li-ion	14+	0	0	8 - 20	More idle loads for longer engine off
Mild	Advanced lead-acid and Li-ion	48	7 - 12	~0		Engine off during coasting
		100 - 140	10 - 16	~0		Launch assist
Moderate	NiMH and Li-ion	100 - 150	10 - 20	~0		Limited power assist
Full/ Strong	NiMH and Li-ion	>200	25 - 50	1 - 3 (at low speeds)	15 - 50	Extended power assist

Source: Anderman 2013.
kW = kilowatts; Li-ion = lithium-ion; NiMH = nickel-metal hydride; VDC = volts direct-current.

Micro-Hybrid-Electric Vehicles

Micro-hybrid-electric vehicles (micro-hybrids) are sometimes referred to as stop-start hybrids since their primary purpose is to shut the engine off when the vehicle is stopped (e.g., traffic lights, stop signs, or stop-and-go traffic). Micro-hybrids also are referred to as 12-volt stop-start hybrids, idle-stop hybrid, or

12-volt direct current micro-hybrid (EPA and USDOT 2012). The Micro-0 level of micro-hybrids uses a single 12-volt direct current battery (primarily advanced lead-acid). Micro-0 hybrids are the least sophisticated, capable, and costly of the hybrids. Integration with the combustion engine is typically via a belt-alternator starter arrangement, where a drive belt delivers power to start the engine, rather than using a conventional starter motor (EPA and USDOT 2012). Micro-0 systems cannot adequately power all vehicle electrical loads (e.g., radio, power windows, air conditioner) when the engine is stopped for long periods, so the engine will restart automatically when needed to ensure the loads are met even if the vehicle is still stopped. The Micro-2 level of micro-hybrids uses a more capable single 14-volt direct current battery that enables limited regenerative braking and the ability to power all electrical loads when the engine is off.

The fuel use reduction of micro-hybrids is low (from 2 to 8 percent, depending on the drive cycle and the number of stop-start events); however the system cost is also very low (about $250 for Micro-0 up to about $525 for the Micro-2). The low cost is anticipated to result in a large number of vehicle purchases (especially light-duty vehicles) to use micro-hybrid systems. The resulting combined fuel savings would be appreciable. Current micro-hybrids use either advanced lead-acid or lithium-ion batteries. Other battery types and energy storage configurations are being tested to improve performance and lower cost. There are no commercially available micro-hybrids currently available in the Unite State; however, they are becoming common in light-duty vehicles in Europe and Japan. No medium- or heavy-duty micro-hybrids have been produced or are expected to be produced in the future.

Mild Hybrid-Electric Vehicles

Mild hybrids, also referred to as “higher voltage stop-start” and “belt integrated starter generator,” use an advanced lead-acid or lithium-ion battery between 48 and 140 volts direct current and a low-power, 10- to 15-kilowatt, electric motor to improve on the Micro-2 hybrid’s performance to increase the regenerative braking performance (higher power and energy capture rate) and allow for limited electric-only driving (for instance, driving out of a parking garage). Some examples use the belt-alternator starter configuration (discussed earlier). Mild hybrids cost more than Micro-2 systems, but are still an affordable option, so are anticipated to be widely used. European automakers are leading the development of the 48-volt direct current hybrid systems (Anderman 2013; PSA 2013). For instance, PSA Peugeot Citroën has stated a goal of producing a system that has reasonable performance (from 10 to 15 percent fuel use reduction) that is affordable by the largest number of customers (PSA 2013). Higher-voltage mild hybrid systems are available in a limited number of models in the United States, currently in mid-sized passenger cars from both mass market and luxury brands. No medium- or heavy-duty micro-hybrids have been produced or are expected to be produced in the future.

Moderate Hybrid-Electric Vehicles

Moderate hybrids, also referred to as “integrated motor assist” and “crank integrated starter generator,” systems (EPA and USDOT 2012) have higher electrical power capabilities than mild hybrids and provide electric launch and power assist (i.e., do not supply full launch or propulsion power) functionality. Moderate hybrid systems use an integrated motor/generator located between the engine flywheel and transmission to capture and deliver power to the driveline. Honda is the only light-duty vehicle manufacturer currently producing moderate hybrid-electric vehicles. Lower-power vehicles (e.g., Honda Fit and Insight) use nickel metal hydride batteries, while higher-power vehicles (e.g., Honda Civic and CR-Z) use lithium-ion batteries (Anderman 2013). Moderate hybrids are available from several commercial vehicle manufacturers or propulsion system manufacturers.

Full Hybrid-Electric Vehicles

Current full hybrid-electric vehicles, also referred to as “strong” hybrids, have higher electric motor and battery capabilities and performance than moderate hybrids. They can operate solely on electric power for speeds up to 60 miles per hour. As with other hybrids, the combustion engine turns on once the power demand is above what the hybrid system can deliver. In general, full hybrids improve fuel consumption by between 16 and 50 percent compared with a comparable conventional vehicle. Most mass-market passenger car full hybrids reduce fuel consumption between 40 and 50 percent. Full hybrid pickup trucks, sport utility vehicles, and luxury cars reduce fuel consumption by 12 to 20 percent.

Light-duty full hybrid-electric vehicles are available in passenger cars (from subcompact to large sedans), sport utility vehicles/crossover utility vehicles, and pickup trucks. Current light-duty full hybrids primarily use nickel metal hydride batteries. Lithium-ion batteries recently entered the full hybrid market; however, not all manufacturers are making the switch right away (e.g., Toyota says it will continue to use nickel metal hydride battery in its hybrid vehicles (Takahashi 2013). According to Anderman (2013), all new light-duty full hybrid models will use lithium-ion batteries, as related costs are expected to decrease by 2016/2017. Commercially available full hybrids are also available in medium-duty (e.g., utility trucks, package delivery trucks, school buses, and shuttle buses) and heavy-duty vehicles (e.g., refuse trucks, delivery trucks, and transit buses). As with electric vehicles, battery development is the key focus for improving hybrid-electric vehicles for power, cost, weight, and battery pack life; therefore, improved lithium-ion batteries or other battery chemistries, such as lithium-air or lithium-sulfur, likely will join, or replace, lithium-ion at some point.

Vehicle Fuel Consumption

This PEIS compares fuel consumption for mild, moderate, and full hybrids with their respective internal combustion engine model. Table 2-25 summarizes the results of this comparison, where an average representative fuel consumption was used. Table 2-25. Per Vehicle Fuel Consumption Comparison of Conventional and Hybrid-Electric Vehicles

Vehicle Type	Current Commercial U.S. Vehicle Model Examples	Fuel Reduced Compared to Baseline Vehicle (%)	Average Annual Petroleum Use (gallons)	Fuel Use Reduction Relative to Baseline (gallons)
Baseline	Toyota Camry, Toyota Corolla, Ford F-150, Toyota Tacoma	0	462	0
Micro-Hybrid[a]	NA	4	444	18
Mild Hybrid	Chevrolet Malibu eAssist, Mercedes-Benz E400 Hybrid	12	407	55
Moderate Hybrid[b]	Honda Civic Hybrid, Honda CR-Z	21	366	96
Full Hybrid	Toyota Prius, For Fusion Hybrid, Hyundai Sonata Hybrid, Volkswagen Touareg Hybrid, Chevrolet Silverado 15 Hybrid	27	339	123

Source: DOE and EPA 2013a.

a. Micro-hybrids are not commercially available in the United States, so fuel consumption reduction was estimated based on current information on systems in Europe and Japan from Anderman (2013).

b. No moderate hybrids for trucks currently exist. This value estimates the potential moderate hybrid performance for trucks, using the difference between car and truck fuel reductions for full hybrids as a gauge.

Vehicle Fueling Infrastructure

Hybrid-electric vehicles refuel in exactly the same way, and at the same fuel stations, as conventional internal combustion engine vehicles. Hybrid vehicles can use any fuel, but as mentioned earlier all hybrid-electric vehicles currently sold in the United States use gasoline. One could conclude that as more hybrid vehicles are in use, the amount of gasoline consumed will decrease, Furthermore, the fuel consumption reductions from hybrid-electric vehicles and other vehicle fuel efficiency improvements will mean an overall decrease in the consumed fuel. So over time the number of fueling stations will likely decrease since per station fuel throughput will decrease.

2.3.4.3.2 Characterization of Technology Feasibility and Deployment

Feasibility of Technology

Hybrid-electric vehicles have been available and used in Hawai‘i since Honda released the original 1999 Insight. Because they are operated the same as conventional vehicles, there is no learning curve to dissuade potential users. On the infrastructure side, all hybrid-electric vehicles are fueled the same as a conventional internal combustion engine vehicle, so no special fueling station is required.

Existing Deployment of the Technology

As can be seen in Figure 2-54, hybrid-electric vehicle sales (as indicated by registration trend) in Hawai‘i were low in the first several years, but picked up as consumers became more familiar with the technology, vehicle prices decreased, the price of gasoline increased, and Federal tax incentives became available (from 2005 to 2010) (DOE and EPA 2013b). The current number of hybrid-electric vehicles in Hawai‘i through July 2013 is about 15,500. The majority of these are full hybrids, followed by moderate hybrids.

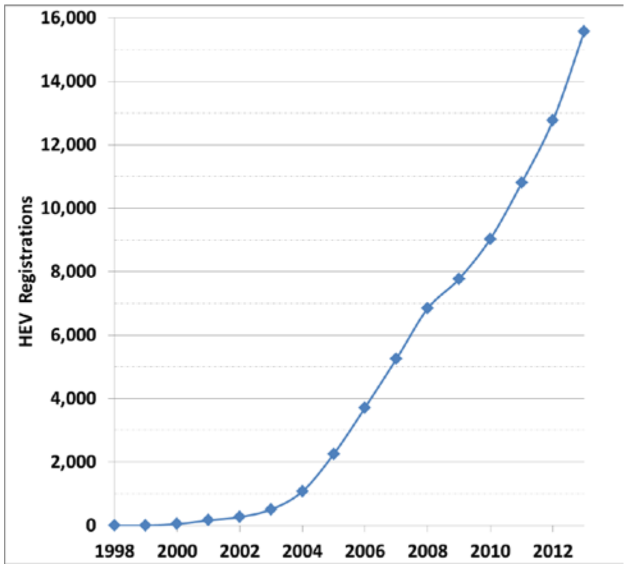


Figure 2-54. Hybrid-Electric Vehicle Registration Trend in Hawai‘i (Source: HSEO 2013b)

As discussed above, hybrid-electric vehicles are available for light-duty passenger vehicle and medium- and heavy-duty commercial vehicle applications. Medium- and heavy-duty vehicles use significantly more fuel on a per-vehicle basis than light-duty vehicles, which makes them good candidates for hybridizing. Further, the vehicle’s application (e.g., refuse truck, transit bus, or longer-distance delivery) is important because frequent stop-starts maximizes the hybrid system’s benefits. The incremental vehicle costs (price above a conventional vehicle) are also much higher than light-duty vehicles, and options for medium- and heavy-duty hybrid-electric vehicles currently are much fewer. Commercial fleets purchase vehicles based on a business case analysis and vehicle purchase decisions typically are made based on the lowest total cost of ownership (e.g., vehicle purchase, fuel costs, maintenance costs, labor costs, insurance, and salvage value). Medium- and heavy-duty hybrid-electric vehicles have lower fuel saving potential, but offer a better business case (when compared with plug-in hybrid-electric vehicles) because of their lower incremental cost. Overall, the medium- and heavy-duty vehicle population [roughly 1,000 vehicles out of 1 million vehicles (0.1 percent)] is very small compared with light-duty vehicles, so the cumulative fuel savings potential is much lower than for the light-duty fleet.

Conversely, as discussed earlier, there are many current and near-term options in most light-duty classes. Light-duty vehicles use less fuel, but light-duty hybrid systems have much lower incremental costs (as low as a few hundred dollars for micro-hybrids). The high fuel costs in Hawai‘i make a compelling case for increased adoption of light-duty hybrid-electric vehicles of all types.

2.3.4.3.3 Hybrid-Electric Vehicles in 2030

An HCEI goal is to reduce the petroleum used for ground vehicles by 70 percent by 2030. One way to achieve this is to replace conventional gasoline vehicles across the State with hybrid-electric vehicles.

2030 HEV Vehicle Definition

Vehicle usage data provided by DBEDT show that the average annual vehicle miles traveled per vehicle has been relatively steady at 9,050 miles per year (1990 to 2011); USDOT, Bureau of Transportation Statistics data show this number to be lower, at 7,014 (USDOT 2002). Regardless of the difference, these annual numbers correlate to low daily driving distances of roughly 20 to 25 miles per day. Note that these data are based on the population of the State; island-specific data are not available.

Benefits

As discussed above, the primary benefit of the 2030 hybrid-electrical vehicles will be a reduction of petroleum use. Exhaust emissions also will be reduced due to the lower petroleum use.

Potential Initial Issues

Hybrid-electric vehicles are a known technology and are already successfully integrated into the public and private automobile marketplace. Increasing the number of registered hybrid-electric vehicles to meet the 2030 goal (on average 23,700 sales per year, or roughly 2,000 per month, based on the data in Figure 2-54) may sound aggressive based on historical sales. However this projection includes a large percentage of significantly lower cost options, micro-hybrids and mild-hybrids (60 percent and 10 percent, respectively, in the representative project discussed in Section 2.3.4.3.5). Micro-hybrid adoption is expected to be nearly universal on most non-hybrid vehicles due to the cost-effective fuel reduction. The high adoption rates will be driven by wider availability, hybrid system costs bring driven lower by sales volume (for all hybrid configurations), and by reaching a value point for consumers for reducing fuel costs. Vehicle manufacturers will commercialize and sell all types of hybrids to first meet their consumers' expectations, but also to comply with Corporate Average Fuel Economy requirements.

Maintenance and Service

The vehicles are serviced at the dealer in the same manner as a conventional vehicle, except that new and unique service is done for hybrid system components. Many vehicle manufacturers already have hybrids on the market so already have this capability in place.

First Responder Issues

First responders (e.g., fire, police, and ambulance) have been properly trained to safely help distressed drivers of hybrid-electric vehicles. Many departments likely have these training programs and requirements in place since hybrids have been on the market for more than ten years. In addition, the National Alternative Fuels Training Consortium has a First Responder Safety Training course that local emergency responders can take.

Potential End of Vehicle Life Issues

Hybrid-electric vehicles have additional components compared with conventional vehicles (e.g., batteries, electric motors, power electronics, and cabling). Each of these has a potential negative impact if they were to reach a landfill. Many of the materials are high value so should be captured through municipal and corporate reuse and recycling processes. Recycling practices and protocols for lead-acid, nickel-metal hydride, and lithium-ion batteries have been in place for decades and are being further developed to handle the various types of lithium-ion batteries used in vehicles (Coy 2011, 2012). Batteries in hybrid-electric vehicles are considered to have reached their end-of-life when the battery capacity after a full charge is 80 percent of the new battery's capacity. At this point, technicians can recondition and use the batteries for non-vehicle applications, such as an energy buffer for solar or wind generation and utility grid support. Such reuse avoids costs and energy to produce new batteries, as well as costs associated with recycling. Batteries that cannot be reconditioned or repurposed ultimately will be recycled.

2.3.4.3.4 Permitting and Consultation Requirements

Hybrid-electric vehicles are purchased in the same manner as conventional vehicles, so no new or different processes or permits are required. The vehicles are fueled using existing conventional fuel stations, so no additional infrastructure or permitting is needed to fuel or operate them.

2.3.4.3.5 Representative Project

The representative hybrid-electric vehicle project in the State is to increase the light-duty hybrid-electric vehicle population to avoid use of 20 million gallons of gasoline fuel by 2030. This fuel avoidance amount is being used across all relevant sections in this PEIS to provide a consistent basis for comparison.

The representative project assumes that the Statewide vehicle mix remains at 50 percent passenger car and 50 percent light truck (see Section 2.3.4.2.3).

Average driving distance data available from the Hawai‘i Energy Office show that per vehicle driving distance has remained very steady since 1999 (slowly decreasing from 9,058 miles to 9,020 miles per year). The representative project assumes 9,020 annual travel miles per vehicle. Using the Toyota Camry, Toyota Corolla, Toyota Tacoma, and Ford F-150 as representative baseline vehicles, the representative project further assumes an average conventional passenger vehicle fuel efficiency of 25 miles per gallon (based on 80 percent urban driving), for a calculated fuel consumption of 361 gallons of gasoline per year. The representative project does not include light-duty diesel vehicles because they are not used enough to affect the outcome. Using the same baseline vehicles, the representative project assumes an average conventional pickup truck fuel efficiency of 16 miles per gallon, for a calculated consumption of 564 gallons of gasoline per year. Applying the 50 percent passenger car to 50 percent light truck ratio, this equates to an average of 462 gallons of gasoline consumed per year. This is within the range indicated by actual fuel and vehicle data for Hawai‘i (on-highway gasoline demand in calendar year 2012 was 444,268,297 gallons, which fueled a vehicle population that included 998,883 gasoline and 12,141 hybrid-electric vehicles, for an average gasoline fuel consumption of 439 gallons per vehicle; DBEDT 2013k).

The representative project assumes that only passenger cars and light trucks will transition to hybrid-electric vehicles. Further, the representative project assumes 60 percent of the hybrids will be micro-hybrids and 25 percent will be full hybrids. This is based partly on the lower cost of micro-hybrids and DOE's forecast that 85 percent of all hybrid sales in 2030 will be of micro-hybrids (Chase 2013). Moderate hybrids are assumed to account for only 5 percent of hybrid sales. This is because moderate hybrids are currently only available from one manufacturer and they are expected to be replaced by other, more cost-effective hybrid configurations (EPA and USDOT 2012). As shown in Table 2-26, reaching the 20-million-gallon petroleum reduction would require roughly 383,000 hybrid-electric vehicles (meaning hybrid-electric vehicles would account for roughly 30 percent of all light-duty vehicles in 2030).

Table 2-26. Estimated 2030 Hybrid-Electric Vehicle Statewide Composition and Petroleum Reduction Potential

Vehicle Type	2030 HEV Fleet (%)	Number of Vehicles in 2030 Fleet	Total Annual Petroleum Consumption Reduction (gallons)
Micro (0 and 2)	60	113,441	4,250,000
Mild	10	18,907	2,120,000
Moderate	5	9,453	1,850,000
Full	25	47,267	11,780,000
TOTALS	**100**	**383,242**	**20,000,000**

2.3.4.4 Hydrogen

This section discusses hydrogen as a transportation fuel. Section 2.3.2.3 addresses hydrogen fuel cells.

2.3.4.4.1 Technology Description

Hydrogen is the simplest and most abundant element in the universe and can be produced from fossil fuels including oil, coal, or natural gas as well as biomass, organic waste, water, or salt water. Hydrogen is obtained through various methods including chemical processes, electrolysis, steam reforming, methanol cracking, and hydrogen purification. The versatility and ability to produce hydrogen from several resources is a key element in the development of hydrogen as a transportation fuel. When produced from renewable resources, hydrogen is often touted as the sustainable transportation fuel of the future. As a transportation fuel, the energy content in 2.2 pounds of hydrogen gas is about the same as the energy content in 1 gallon of gasoline. Due to its low volumetric energy density compared with gasoline, however, hydrogen fuel on a vehicle requires larger storage tanks than most conventional vehicles to achieve the same vehicle range between refueling stops.

The following discussion describes various ways that hydrogen can be used to power vehicle systems.

Hydrogen Internal Combustion Engine Vehicle

Hydrogen can be used in internal combustion engines that are modified with hardened valves and valve seats (for longer life on dry fuels), stronger connecting rods, non-platinum-tipped spark plugs (platinum is a catalyst causing hydrogen to oxidize with air), a higher-voltage ignition coil, fuel injectors designed for a gas instead of a liquid, larger crankshaft damper, stronger head gasket material, modified (for supercharger) intake manifold, positive pressure supercharger, and a high-temperature engine oil. When hydrogen is burned in an internal combustion engine, the only byproducts are water vapor and nitrogen oxide exhaust (when combined with air). The energy efficiency is 20 to 25 percent higher than that of a gasoline internal combustion engine (Ogden 2002). Maintenance is similar to a gasoline internal combustion engine.

Hydrogen Fuel Cell Vehicle

Hydrogen can be used in fuel cells to power electric motors. Hydrogen fuel cells used in vehicles consist of an electrolyte and two catalyst-coated electrodes, providing electricity in a manner similar to that provided by batteries in an electric vehicle (see Section 2.3.4.2). However, rather than having batteries recharged, a fuel cell vehicle has its hydrogen tank refilled. When used in fuel cells, hydrogen does not produce air pollutants or greenhouse gases. Hydrogen fuel cell vehicles also have an efficiency rate that is two to three times higher than a gasoline vehicle (DOE and EPA 2013c). However, as noted above, it is important for a fuel cell vehicle to store enough fuel onboard to have a driving range sufficient to meet the required range of the vehicle. Section 2.3.2.3 of this PEIS provides a general tutorial on hydrogen fuel cells. The following discussion is specific to hydrogen fuel cells for transportation applications.

- Proton Exchange Membrane Fuel Cells – Proton exchange membrane fuel cells, or polymer electrolyte membrane fuel cells, are the most common type of fuel cells used in transportation applications. Proton exchange membrane fuel cells use a solid polymer as an electrolyte and porous carbon electrodes containing a platinum catalyst and need only hydrogen, oxygen from the air, and water to operate. Section 2.3.2.3 of this PEIS provides further discussion on proton exchange membrane fuel cells. Figure 2-55 provides a schematic diagram of a hydrogen fuel cell vehicle.

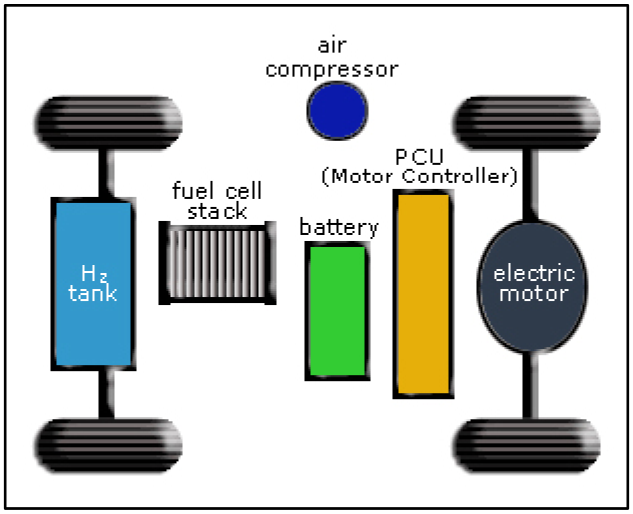


Figure 2-55. Hydrogen Fuel Cell Vehicle Schematic
(Source: DOE and EPA 2013c)

- Hybrid-Electric Fuel Cell Vehicle – Hybrid-electric fuel cell vehicles combine the powertrain of an all-electric, battery-powered vehicle with fuel cells. This configuration allows vehicle designers to cost-effectively size energy (battery and hydrogen) storage systems and fuel cells without sacrificing vehicle performance. The combined powertrain offers an extended operating range, which is especially crucial in early phases of deployment (DOE 2013n).

As with other vehicles, fuel cell vehicles can be equipped with other advanced technologies to increase efficiency, such as regenerative braking systems, which capture the energy lost during braking and store it in a large battery. These vehicles are still at an early stage of development; however, research and development efforts are bringing them closer to commercialization (DOE and EPA 2013c).

2.3.4.4.2 Characterization of Technology Feasibility and Deployment

Although hydrogen is abundant and versatile, hydrogen fuel is not a primary energy source and requires energy from other sources for production. In Hawai‘i, hydrogen fuel can potentially be produced economically from indigenous resources and incorporated directly into the State’s energy economy. Figure 2-56 shows the potential future energy system with hydrogen incorporated. As shown, hydrogen can be stored and distributed using methods similar to the existing utility gas and propane infrastructure.

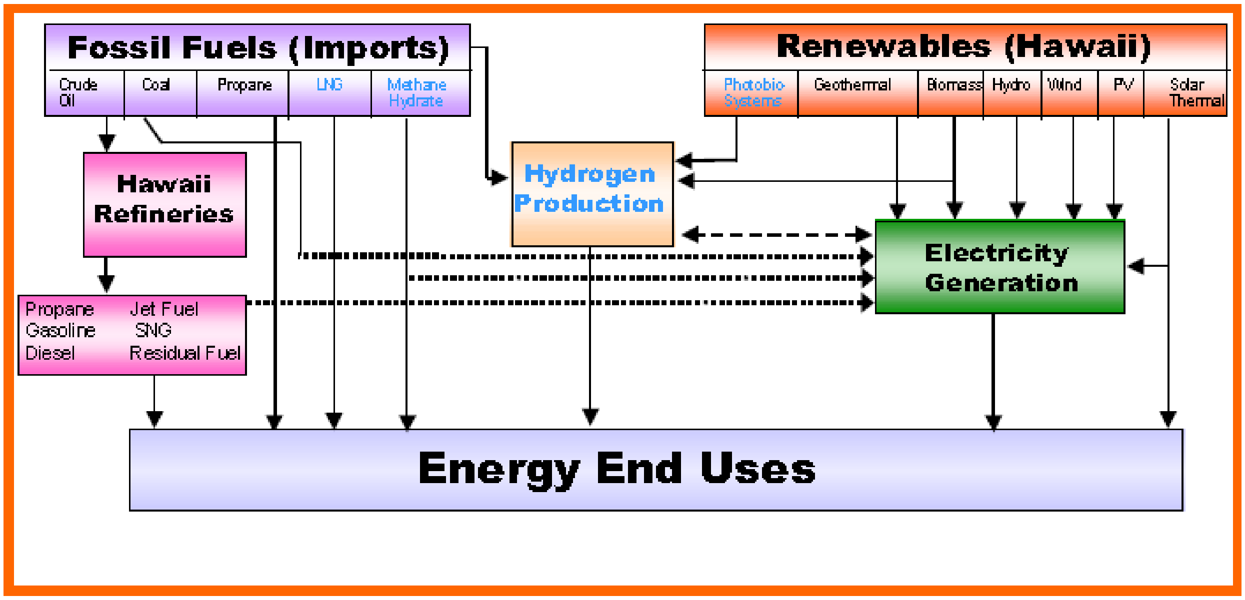


Figure 2-56. Hawai‘i's Potential Future Energy System Incorporating Hydrogen (Source: HNEI and Sentech 2004)

Of the fossil fuels, a study conducted in 2007 for the State of Hawai‘i showed natural gas as the least expensive feedstock for hydrogen. Unfortunately, as with other fossil fuels, natural gas supplies are not indigenous to the island and need to be imported from the mainland. In addition, natural gas is not emissions free, may be subject to price volatility, and may face competing demands (FGE 2007).

Hydrogen can be produced several ways via renewable sources but would be most cost-effective if produced via geothermal, solar and—despite the hurdles discussed above—natural gas. Wind energy can produce hydrogen, but its intermittent nature results in low- capacity factors and higher-cost hydrogen. Other renewable energy technologies are still too early in the deployment stage to be considered for the production of hydrogen fuel (HNEI and Sentech 2004).

The following discussion addresses the potential production of hydrogen on each Hawaiian Island and its contribution to HCEI goals.

- Maui/Kaua‘i - Both Maui and Kaua‘i offer tremendous potential for biomass and solar resources to produce hydrogen. A dispersed population makes transportation and utility uses the highest likely value (Sentech 2008). However, the feasibility of importing hydrogen to these islands still needs to be explored.

- O‘ahu - O‘ahu represents the greatest opportunity to use hydrogen and fuel cells, as it is the most populous of the Hawaiian Islands and includes the urban center of Honolulu. Transportation applications on O‘ahu include tourist transport, military transport, airport support vehicles, and other fleet applications, creating a large potential opportunity for a clean hydrogen-fueled fleet. However, there is limited availability of renewable resources on the island, which limits potential hydrogen production. Hydrogen from imported oil is available from existing refineries, but this does not offer a secure long-term solution to meet transportation fuel demands on O‘ahu (HNEI, Sentech, 2008). As such, the import of hydrogen to the island may be required.

- Molokaʻi/Lānaʻi - The most promising renewable energy technology available in Molokaʻi and Lānaʻi include wind and solar, both of which could be utilized to produce hydrogen. However, at present, hydrogen production from wind and solar is very costly since the hydrogen is produced via electrolysis (see Section 2.3.2.3 for hydrogen fuel cells). Furthermore, hydrogen production and distribution on both islands does not appear feasible due to the small populations in both islands.

- Hawaiʻi island – Renewable energy resources present on Hawaiʻi island include solar, wind, biomass, and geothermal. Hawaiʻi island is the only island with a geothermal power plant and the electricity demand patterns typically able to yield available off-peak electricity from which to make hydrogen (HNEI and Sentech 2004). As such, the island has been specifically favored as a unique and ideal location to test and validate the potential for a hydrogen-fueled transportation system. In 2008, an analysis of geothermal- produced hydrogen on Hawaiʻi island was conducted for the State. According to the study, only 3.3 percent of Hawaiʻi island's transportation requirements could be served by the existing geothermal plant. Further, this would be possible only if 24 megawatts of the geothermal capacity was used in producing hydrogen (Sentech 2008). In order to provide a geothermal hydrogen future for the State, a three phased approach was recommended: (1) test and validate the infrastructure; (2) conduct an expanded demonstration; and (3) implement an aggressive expansion, investment, and commercialization of hydrogen as a fuel (Sentech 2008). Figure 2-57 shows the hydrogen capacity required to meet Hawaiʻi island's transportation needs.

Hydrogen as a transportation fuel is ideal for use in fuel cells, which would provide a highly efficient energy conversion system for vehicles. It is anticipated that hybrid-electric fuel cell vehicles may cost-effectively compete with conventional internal combustion engine vehicles in 2025. However, as noted in Section 2.3.4.1 of this PEIS vehicle sales patterns in the State show a relatively low turnover of vehicles and an average vehicle life of approximately 20 years, hindering the replacement of older, less fuel-efficient cars with newer, more sustainable vehicles. As such, only fuels that could be used in existing vehicles (e.g., biodiesel and green gasoline) would be useful to the State in meeting HCEI goals. As such, the future deployment of hydrogen transportation fuel would be dependent on consumer marketability and reduced vehicle turnover ratio. Additional concerns noted in Section 2.3.4.1 that also apply here include the increased electricity generation required for electricity production if renewable energy is developed or used to generate electricity for hydrogen production.

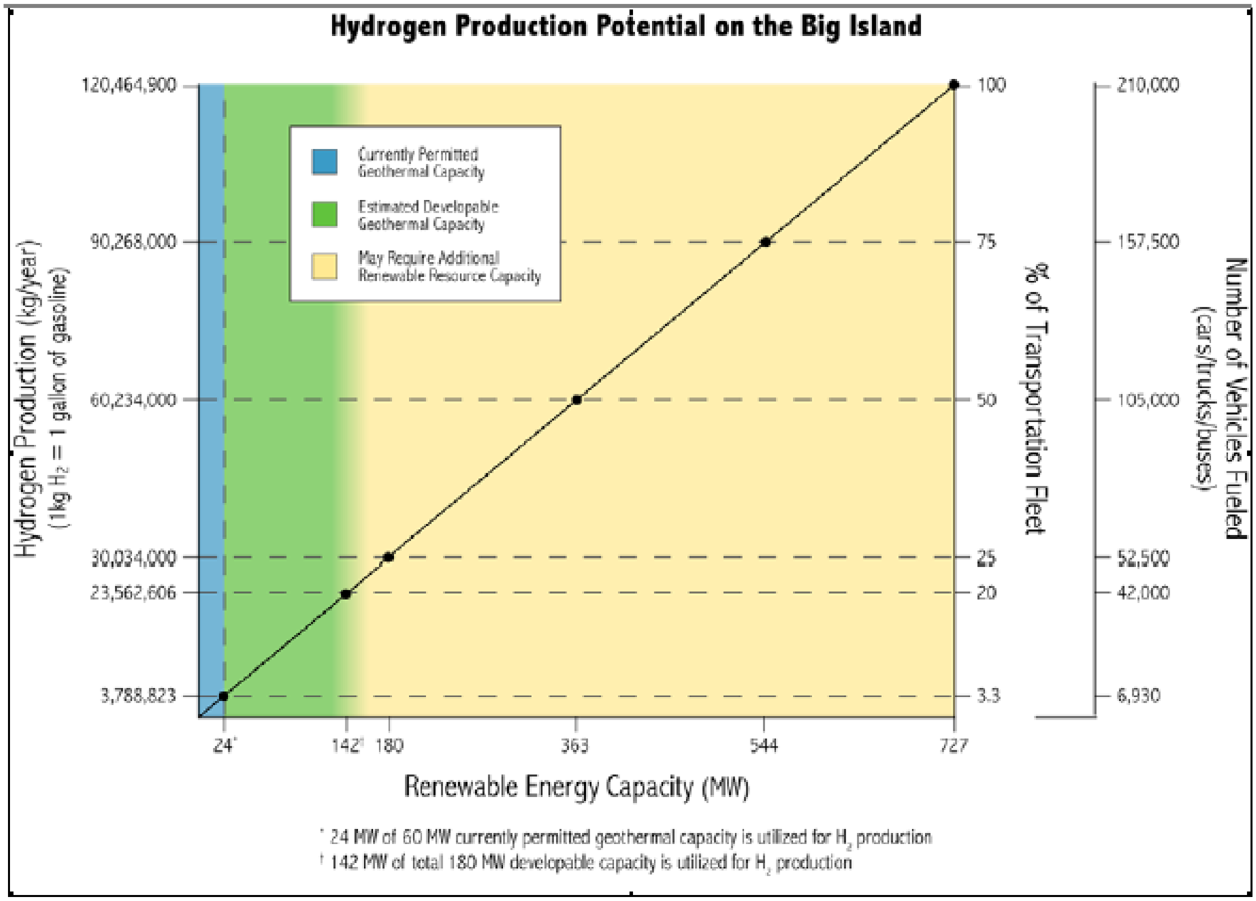


Figure 2-57. Capacity Required to Meet Hawai‘i island’s Transportation Needs (Source: Sentech 2008)

2.3.4.4.3 Existing Deployment of the Technology

Hydrogen production, distribution, and deployment are still in the research and development stages in the State. However, the State and industry have undertaken major efforts to test and develop the technology for implementation. The following sections discuss some of the key efforts taken to date.

- The Hawai‘i Center for Advanced Transportation Technology – The mission of the Hawai‘i Center for Advanced Transportation Technology is to develop and demonstrate technologies for future military and commercial transportation systems. The Center has a list of accomplishments and ongoing projects to further develop a hydrogen future for the State. These include the development and introduction of fuel-cell-powered demonstration vehicles, the development and installation of a modular/deployable hydrogen production and fueling station, the development and installation of a photovoltaic-powered fueling station, the evaluation of hydrogen internal combustion engine Ford Escapes, supplementing the fueling station with wind turbine power, and, most recently, working on a hydrogen-powered tug and hydrogen-powered weapons loader for the military (HCATT 2013).

- Hawai‘i Hydrogen Initiative – The Hawai‘i Hydrogen Initiative is an innovative partnership among 13 agencies, companies and universities that seeks to develop hydrogen infrastructure in

Hawaiʻi with the goal of displacing petroleum imports by operating vehicles with renewable hydrogen (H2I 2013).

- Hawaiʻi Natural Energy Institute – The Hawaiʻi Natural Energy Institute is a research arm of the University of Hawaiʻi at Manoa. The Institute performs research, conducts testing and evaluation, and manages public-private partnerships across a broad range of renewable and enabling technologies to reduce the State of Hawaiʻi's dependence on fossil fuel. The Institute conducts specific research and deploys pilot projects for the production and deployment of hydrogen in the State, including the Hawaiʻi Hydrogen Power Park, photoelectrochemical hydrogen production, biological hydrogen production, hydrogen for Hawaiʻi Volcanoes National Park vehicles, hydrogen for General Motors Equinox vehicles, and hydrogen from biomass. Several of these are discussed in more detail below. For more information, readers are directed to the Institute's recently completed draft environmental assessment for a project that will demonstrate the use of hydrogen as a potential energy storage technology (HNEI 2012).

Production

Hydrogen is produced through various methods including chemical processes, electrolysis, steam reforming, methanol cracking (splitting methanol and steam in the presence of a copper-zinc catalyst), and hydrogen purification. With the exception of electrolysis, most production methods still result in smog and greenhouse gas emissions, albeit less than conventional vehicles. Proponents of hydrogen as a fuel indicate that the most promising production pathway would be hydrogen produced through electrolysis of water using renewable energy (e.g., solar or wind power). While this would eliminate carbon emissions, the challenge lies in the high costs associated with hydrogen production. At this time, the Office of Naval Research is currently researching water desalination techniques using energy-efficient microbes to produce hydrogen. Others, such as Virginia Tech, have developed a way to extract hydrogen from sugars using any kind of plant (VT News 2013). Other research includes the production of hydrogen from wastewater or brackish water. However, this technology is not ready for commercial production/use.

HawaiʻiGas, formerly The Gas Company, LLC, currently produces approximately 50 percent of its hydrogen supply using reverse osmosis recycled water from the Honolulu Waste Water Treatment Plant. The water combines with methane and carbon monoxide in two separate reactions to produce hydrogen in a chemical conversion process. The other half of hydrogen HawaiʻiGas produces is from petroleum feedstock (The Gas Company 2012). HawaiʻiGas is also piloting a renewable natural gas plant, which would convert various types of renewable feedstocks into fuels, including hydrogen.

Vehicle Systems Technology

Fuel cell vehicles are still too expensive for most consumers to afford. Until the associated technology costs are lower, no light-duty hydrogen fuel cell vehicles have been commercially produced for sale to the public. Ford, Mercedes-Benz, and Nissan have indicated a target year deployment of fuel cell vehicles by 2017; however, this news remains speculative (Cunningham 2013). Currently, Hyundai is the first carmaker to start manufacturing fuel cell vehicles on a production line, and intends to be the first automaker to offer a fuel cell vehicle to the general public. Hyundai estimates it will build approximately 1,000 fuel cell cars by 2015 at its factory in Korea (Sunderland 2013). Test vehicles, mainly heavy-duty hydrogen fuel cell vehicles, are available in limited numbers to demonstration fleets with access to hydrogen fueling stations. As discussed in Section 2.3.2.3 of this PEIS, DOE awarded the State of Hawaiʻi several contracts to develop a hydrogen power park, operating an integrated hydrogen energy system including hydrogen fueling stations and the deployment of hydrogen-fueled vehicles.

Infrastructure

In addition to the high production and technology costs to develop hydrogen-powered vehicles, the existing infrastructure in the State is not set up for hydrogen fuels. A viable hydrogen infrastructure requires the ability to deliver hydrogen from where it is produced to where it will be used, such as a dispenser at a refueling station or stationary power site. Infrastructure includes the pipelines, trucks, storage facilities, compressors, and dispensers involved in the process of delivering fuel.

There are plans for installation of a hydrogen fueling station at a location near the Hawaiʻi Volcanoes National Park. Future plans for the State include the use of hydrogen plug-in hybrid-electric buses in coordination with the Hawaiʻi Volcanoes National Park[20], as well as a Hawaiʻi hydrogen highway on Hawaiʻi island (HNEI 2013a). Additional fueling stations are planned for future phased deployment on Hawaiʻi island as the hydrogen economy on the island expands. Additional detail can be found in the *Analysis of Geothermally Produced Hydrogen on the Big Island of Hawaiʻi: A Roadmap for the Way Forward* (Sentech 2008).

In Oʻahu, there are currently plans to deploy hydrogen through the existing 1,100-mile Hawaiʻi Gas pipeline (in Oʻahu) using pressure swing adsorption technology as part of the Hawaiʻi Hydrogen Initiative. The pressure-swing adsorption process removes carbon dioxide and other impurities from the gas stream, leaving essentially pure hydrogen. This can be made possible at the point of use, i.e., once the gas is distributed to 20 to 25 hydrogen refueling stations in Oʻahu for fuel-celled vehicles. Full-scale production is anticipated to commence in approximately 2015. As part of the Hydrogen Highway Initiative General Motors also operates a service center in Honolulu to test and maintain a fuel-cell vehicle fleet (Hawaiʻi Hydrogen Initiative, 2013), (Char 2012). Plans to deploy hydrogen to the other islands are not available at this time.

According to the Sentech study, the hydrogen-related policies and financial incentives currently in place in the State have helped initiate the necessary business and infrastructure growth for hydrogen as a fuel; however, additional, larger incentives will be required in the future, depending on the level of expansion in the State (Sentech 2008). Major policy considerations must include the following: (1) siting, permitting, and land-use planning to accommodate geothermal and other renewable electricity development on a scale to produce hundreds of megawatts of renewable electricity; (2) an electricity policy that will result in electricity pricing that supports alternative fuel (i.e., a transportation tariff); and (3) an incentive strategy for early purchasers of hydrogen vehicles and fleet operators. This would also require large involvement from partners such as geothermal renewable electricity developers and providers, hydrogen production and refueling infrastructure providers, hydrogen and hybrid vehicle providers, and users (Sentech 2008).

2.3.4.4.4 Permitting and Consultation Requirements

Hydrogen projects in Hawaiʻi would be part of a regulatory environment that is administered by Federal, State, and county agencies. See Section 2.2 for a discussion on general permitting requirements.

Permits would be required before construction activities could begin to ensure project conformity to Federal, State, and county laws, codes, and standards concerning construction and pollution control. During operations, the production, transport and distribution of hydrogen fuel would require compliance with storage, handling, and dispensing requirements by Federal, State, and county agencies including the local county departments of planning and public works, and other departments.

[20] The 2008 Sentech study indicated that due to high sulfur levels experienced at the Hawaiʻi Volcanoes National Park site and the susceptibility of fuel cells to sulfur, the demonstration would use hydrogen internal combustion engine buses instead of hydrogen fuel cell buses. However, according to HNEI, these buses would be hydrogen plug-in hybrid-electric buses (Sentech 2008; HNEI 2013a).

2.3.4.4.5 Representative Project

The representative project involves the production and distribution of hydrogen as an alternative transportation fuel source to displace approximately 20 million gallons per year of gasoline. This would require the production of approximately 44 million pounds of hydrogen, or 20 million kilograms per year of hydrogen. The representative project assumes production of hydrogen via a combination of two sources: (1) the 38-megawatt Puna Geothermal Venture Plant (depending on resolution of the independent power producer contract expirations on the HELCO system) on Hawai‘i island; and (2) 50 megawatts of solar energy on O‘ahu. This would require the installation and development of distribution infrastructure including pipelines, storage tanks, and fueling stations on Hawai‘i and O‘ahu. The representative project would have the option of using tanker trucks instead of distribution pipelines, or a combination of both.

Assuming a heating value of 52.5 kilowatt-hours per kilogram of hydrogen (assumes a 75 percent efficiency system based on the higher heating value of hydrogen), the representative project would require approximately 1,050,000 megawatt-hours, or 1,050 gigawatt-hours (1,050,000,000 kilowatt-hours) of electricity production to generate 20 million kilograms of hydrogen per year; half of which (525,000 kilowatt-hours) would be produced annually via the Puna Geothermal Venture Plant and the other half (525,000 kilowatt-hours) annually via solar energy. Marine transport would distribute the hydrogen to the other Hawaiian Islands, such as Maui and Kaua‘i.

2.3.4.5 Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas

Natural gas is an odorless, nontoxic, gaseous mixture of hydrocarbons—consisting primarily of methane. Most natural gas is domestically produced on the mainland from wells, or extracted in conjunction with crude oil production. Natural gas can also be mined from subsurface porous rock reservoirs though extraction processes, such as hydraulic fracturing. As such, most natural gas that is produced is not considered renewable. Renewable natural gas is an emerging fuel produced from decaying organic materials, such as waste from plants, landfills, wastewater, and livestock (DOE 2013o).

Natural gas as an alternative transportation fuel for vehicles comes in two forms: compressed natural gas and liquefied natural gas. The fuel is used in natural gas vehicles (NGVs), more commonly in compressed natural gas- powered vehicles, which are similar to gasoline or diesel vehicles with regard to power, acceleration, and cruising speed. However, natural gas vehicles generally have less driving range than comparable gasoline and diesel vehicles because less overall energy content can be stored in the same size tank of natural gas vehicles than the more energy-dense gasoline or diesel fueled vehicles. While emissions generally vary with engine design, natural gas vehicles generate no evaporative emissions and less exhaust and greenhouse gas emissions when burned compared to comparable gasoline or diesel powered vehicles; this is the reason why natural gas is viewed as a cleaner-burning fuel. However, it is noted that natural gas primarily consists of methane, which is the second most prevalent greenhouse gas emitted in the United States from human activities. In 2011, methane accounted for about 9 percent of all U.S. greenhouse gas emissions from human activities (EPA 2013d). However, it is noted that natural gas primarily consists of methane, which has a global warming potential 21 times that of carbon dioxide.

Propane is the primary component of, and the name commonly used for, liquefied petroleum gas. When stored under pressure inside a tank, liquefied petroleum gas is a colorless, odorless liquid. As pressure is released, the liquid vaporizes and turns into gas that is used for combustion. While liquefied petroleum gas is a fossil fuel and, therefore, not considered a renewable resource, it is considered an alternative fuel for transportation that could reduce the State’s dependence on imports of foreign oil. Liquefied petroleum gas is beneficial from the standpoint of fuel diversification and produces lower level of carbon emissions than other hydrocarbon fuels such as coal or oil. When used for transportation applications (i.e., vehicles), it is referred to as liquefied petroleum gas (rather than propane). Liquefied petroleum gas can also be used in construction equipment, ground maintenance and service equipment, such as forklifts.

Detailed descriptions of these gases and associated topics can be found online at the DOE's Alternative Fuels Data Center, http://www.afdc.energy.gov/fuels/.

This PEIS addresses natural gas and propane as potential transportation fuels and not for electricity generation as they do not meet the definition of "renewable" or "clean" energy source, in accordance with HCEI guidelines[21].

2.3.4.5.1 Technology Description

Compressed Natural Gas

Compressed natural gas-powered vehicles store natural gas under high pressure (typically 3,000 to 3,600 pounds per square inch). Compressed natural gas is used in light-, medium-, and heavy-duty applications (DOE 2013o). Auto manufacturers offer a variety of both dedicated (operates exclusively on natural gas) and dual-fuel (can operate on both natural gas and gasoline) compressed natural gas vehicles. These vehicles get about the same fuel economy as a conventional gasoline vehicle on a *gasoline gallon equivalency* basis; the gasoline gallon equivalency for compressed natural gas is 5.66 (i.e., 1 gallon of gasoline gets the same mileage as 5.66 pounds of compressed natural gas). Most natural gas fueling stations dispense compressed natural gas, which is compressed onsite in most cases. Since compressed natural gas is odorless, colorless, and tasteless, an odorant is added to give the natural gas a smell for safety reasons.

Liquefied Natural Gas

Liquefied natural gas is produced by purifying natural gas and super-cooling it to -260°F to turn it into a liquid. This reduces the space natural gas occupies by more than 600 times, making it more practical to store and transport (FERC 2012). When liquefied natural gas reaches its destination, it is regasified and distributed as pipeline natural gas, primarily used for heating and cooling on the mainland. Because it must be kept at cold temperatures, LNG is stored in double-walled, vacuum-insulated pressure vessels.

Liquefied natural gas is a hazardous liquid because of three of its properties: cryogenic temperatures (related to its low temperatures), dispersion characteristics, and flammability characteristics. Because of these characteristics, the following hazards can occur: Extremely cold liquefied natural gas can directly cause injury or damage such as frostbite; a vapor cloud formed by a liquefied natural gas spill could drift downwind into populated areas; and natural gas in vapor form can be combustible when in the concentration range of five and 15 percent in the air if it encounters an ignition source. If in a confined space, combustible mixtures will burn explosively (CEC 2013). A large array of laws, regulations, standards, and guidelines from the National Fire Prevention Association[22], the USDOT, and other agencies is currently in place to prevent and reduce the consequences of liquefied natural gas releases. These requirements affect LNG facilities' design, construction, operation, and maintenance.

Liquefied natural gas is typically used in medium- and heavy-duty vehicles due to its complex storage requirements; not only is installation of liquefied natural gas tanks and engines expensive, but the ideal

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[21] DBEDT believes that LNG could also play a limited, transitional role in the power generation market. LNG, rather than the more expensive diesel, could provide generation for peak load demand.

[22] The National Fire Prevention Association is an international nonprofit leading advocate of fire prevention and is an authoritative source on public safety. The Association develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks (see http://nfpa.org).

vehicle for liquefied natural gas is one where the natural tendency of liquefied natural gas to result in vapor loss is countered by heavy use. As such, liquefied natural gas is considered appropriate for trucks requiring a longer range because liquid is more dense than gas and, therefore, more energy can be stored by volume in a given tank. One gasoline gallon equivalency equals about 1.5 gallons of liquefied natural gas (DOE 2013o; FGE 2012).

Liquefied Petroleum Gas

Liquefied petroleum gas, composed primarily of propane, butane, or a mixture of the two, is a by-product of petroleum refining and natural gas processing. Liquefied petroleum gas is a gas at atmospheric temperatures and, like liquefied natural gas, is pressurized for storage in liquid form. The propane fuel grade used in vehicles is called HD-5. Aboard a vehicle, propane is stored in a tank pressurized to about 150 pounds per square inch—about twice the pressure of an inflated truck tire. Under this pressure, propane becomes a liquid with an energy density 270 times greater than the gaseous form. Propane stores less energy per gallon than gasoline, requiring more gallons to drive the same distance.

There is currently a limited availability of propane-powered light-duty passenger vehicles. On the mainland, most propane light duty vehicles are limited to custom-ordered law enforcement vehicles (PERC 2013). For a list of currently certified propane gas vehicles, see http://www.autogasusa.org/uploadedFiles/Fuel/Fueling_With_Propane/Feb%202013%20OTR%20Manufacturer%20Listing%20Public%20View.pdf.[23] However, existing internal combustion engine vehicles can be converted relatively inexpensively. Conversion kits include a regulator/vaporizer that changes liquid propane to a gaseous form and an air/fuel mixer that meters and mixes the fuel with filtered intake air before the mixture is drawn into the engine's combustion chambers (DOE 2003). Vehicle conversions must occur via licensed technicians associated with vehicle manufacturers and must be certified to meet EPA requirements. This ensures that equipment is properly installed, is safe and durable, and meets the emissions standards of the vehicle model year (PERC 2013).

2.3.4.5.2 Characterization of Feasibility and Deployment of Technology

Existing Production/Distribution and Infrastructure Systems

To date, only about one-tenth of 1 percent of natural gas is used for transportation fuel in the United States. In the State of Hawai‘i, even less than that is used since it has to be manufactured from refined products, and is very expensive to produce.

Natural gas used in the State is synthetic natural gas produced by Hawai‘i Gas (formerly The Gas Company), the local utility supplier. Hawai‘i Gas transforms naphtha, a byproduct of oil refining, into synthetic natural gas at the Synthetic Natural Gas Plant in Campbell Industrial Park and distributes the synthetic natural gas to the greater Honolulu area through 1,000 miles of underground utility pipeline. The synthetic natural gas is used by residential, commercial, and industrial customers primarily for water heating, cooking (range and oven), and dryers (HawaiiGas 2013a).

Compressed and Liquefied Natural Gas

Vehicle Systems - As there is currently no compressed and liquefied natural gas production/distribution/fueling station infrastructure available for natural gas vehicles, no natural gas vehicles utilize compressed natural gas or liquefied natural gas for transportation applications in Hawai‘i.

Marine Vessels - At this time, no marine vessels in Hawai‘i run on natural gas because there is very limited experience with conversions of marine vessels to run on natural gas in the State. Assuming the

[23] The Propane Education and Research Council maintains a list of propane autogas vehicles that have earned certifications from the EPA or the California Air Resources Board.

State imported large volumes of natural gas, ships could convert their engines to run on natural gas, but this would be expensive due to storage tank requirements. There are currently three natural gas engine technologies available for large marine vessels including: (1) spark-ignited lean burn, (2) dual-fuel diesel pilot ignition with low-pressure gas injection, and (3) dual-fuel diesel pilot ignition with high-pressure gas injection) (FGE 2012).[24]

Liquefied Petroleum Gas

Propane in Hawai‘i is either purchased and shipped from local refinery operations on O‘ahu, or from foreign sources to bulk distribution terminals in Hawai‘i, Kaua‘i, and Maui via tanker ships. Propane is also moved between islands by propane barges and stored in tanks for distribution. Propane is then distributed to non-utility customers via truck delivery to individual tanks (HawaiiGas 2013a). Hawai‘i Gas, O‘ahu Gas Service, and other propane suppliers serve all the islands with propane (FGE 2012). As a transportation application, liquefied petroleum gas is used as for passenger vehicles and specialty vehicles, such as forklifts (The Gas Company 2012). There are three public propane fueling stations in the State of Hawai‘i, two in Honolulu and one in Hilo (DOE 2013p).

Vehicle Systems - As noted above, the availability of liquefied petroleum gas-fueled light-duty passenger vehicles is limited across the United States. Propane vehicles are available in Hawai‘i, but due to the limited infrastructure, are few in numbers.

Marine Vessels - As noted above, no marine vessels are currently known to operate on propane; although future research and development may be in progress.

Future Projected Production/Distribution and Infrastructure Systems

As noted in Section 2.3.4.1 of this PEIS, the vehicle sales patterns in the State show a relatively low turnover of vehicles, with approximately 50,000 vehicles being replaced per year. As indicated therein, the average vehicle life of a vehicle in the State is approximately 20 years, hindering the State from replacing older, less-efficient cars with newer, more sustainable vehicles (Braccio et al. 2012). As such future deployment of compressed and liquefied natural gas and propane gas as a transportation fuel in the State will be dependent on consumer marketability and reduced vehicle turnover ratio. The following discussion addresses the import and production of natural gas, propane and associated infrastructure Hawai‘i.

Compressed and Liquefied Natural Gas

DBEDT believes that LNG could play a limited, transitional role in the power generation market[25]. Therefore, it is anticipated that natural gas likely would be imported to Hawai‘i to supplement electricity generation first.[26] Bulk natural gas supplies are anticipated to be imported in the future by utility companies, pending Federal, State and other regulatory approval, a portion of which could be used for transportation fuel. Based on a study conducted for the State, the potential natural gas demand for ground transportation in the State ranges from 30 to 90 kilotonnes (2.4×10^{-3} to 7.2×10^{-3} million tons) in 2030, increasing to 50 to 200 kilotonnes (4.0×10^{-3} to 1.6×10^{-2} million tons) by 2035 (FGE 2012).

[24] Spark-ignited engines operate exclusively on natural gas, while diesel pilot ignition engines can operate on a range of fuels including natural gas (FGE 2012).
[25] DBEDT believes that LNG, rather than the more expensive diesel, could provide generation for peak load demand.
[26] On March 6, 2014, the Hawai‘i Public Utilities Commission approved Hawai‘i Gas’s proposal to import natural gas into the State. Natural gas is anticipated to be imported to Hawai‘i in several phases starting in 2014 (Hawai‘i PUC 2014).

As the natural gas production and distribution infrastructure is limited in the State, so is the vehicle fueling infrastructure. Therefore, once the import source and shipment logistics are determined, liquefied natural gas would need to be regasified to compressed natural gas and the installation of natural gas fueling stations would be required. Fueling stations for both compressed natural gas and liquefied natural gas vary considerably. Compressed natural gas stations require more equipment and configuration, while liquefied natural gas stations require less equipment, but more safety precautions during fueling.

There are two types of compressed natural gas stations, including fast-fill and time-fill stations[27]. The type of station that would be required is dependent on the application. Typically, retail stations use fast-fill, and fleets with central fueling and overnight use capability, use time-fill stations. As natural gas can be a safety hazard, safety guidelines need to be considered when developing natural gas infrastructure, including the National Fire Prevention Association's NFPA 52 Vehicular Gaseous Fuel Systems Code, which applies to the design and installation requirements of compressed natural gas refueling facilities (DOE 2013q).

Liquefied natural gas stations are structurally similar to gasoline and diesel stations since it is a liquid fuel. There are three options for liquefied natural gas fueling including mobile, containerized, and customized large stations. Because liquefied natural gas is stored and dispensed as a super-cooled liquefied gas, protective clothing and gloves are required when fueling a vehicle. In mobile fueling, liquefied natural gas is delivered by a tanker truck that contains metering and dispensing equipment on-board. A containerized station, or a starter station, includes a storage tank, dispensing equipment, metering, and required containment. A custom station has greater storage capacity and is tailored to meet a fleet's needs (DOE 2013q).

To ensure that cost-savings benefits to Hawai‘i are realized, projects must carefully consider sourcing, terminal siting options, and good regulatory controls in developing Hawai‘i's natural gas infrastructure.

Vehicle Systems - The potential introduction of NGVs in the State would make the transportation sector the second (after electricity generation) biggest potential user of natural gas in Hawai‘i by 2035. As noted above, compressed natural gas vehicles are available as light-, medium-, or heavy-duty vehicles. While the number of light-duty NGVs from original equipment manufacturers is limited, it is growing. There is a wide variety of new, heavy-duty natural gas vehicles available from original equipment manufacturers. Fleets and consumers also have the option of economically and reliably converting existing light-, medium-, or heavy-duty gasoline or diesel vehicles to natural gas operation using qualified system retrofitters. All conversions must meet the emissions and safety regulations and standards instituted by the EPA, the National Highway Traffic Safety Administration, and Hawai‘i agencies. However, vehicle conversion to natural gas is still very costly for light-duty vehicles due to the complex storage requirements associated with natural gas. As such, natural gas is practical only for heavy-use vehicles and would likely be desirable only for heavy-duty fleets (e.g., garbage trucks) and public transportation systems (e.g., transit buses) in the State. Section 2.3.4.5 of this PEIS discusses alternative fuels and public/mass transportation. There is also concern that liquefied natural gas-fueled vehicles require more maintenance, but additional study is required to support this concern (DOE 2013r).

[27] Fast-fill stations fuel vehicles from dispensers and are generally suited for light-duty vehicles such as vans, pickups, and sedans where drivers experience similar fill times to gasoline fueling stations—i.e., less than five minutes. Time-fill stations fuel vehicles directly from the compressor (fuels at a lower volume) and are used primarily for fleets and work vehicles with large tanks that refuel at a central location nightly. The time it takes to fuel a vehicle is dependent on the number of vehicles, compressor size, and the amount of buffer storage (DOE 2013x).

Marine Vessels - The conversion of marine vessels to natural gas operation is expensive. Estimated costs to convert a medium-sized tugboat to operate on natural gas are up to $7 million and almost $11 million to convert a large car and passenger ferry. Approximately one-sixth of this cost relates to converting vessel engines, and the rest is for installation of natural gas storage tanks and related safety systems and ship modifications. Given the high costs of conversion, the only viable candidates are those marine vessels used often and that use a lot of fuel relative to its size and power (Bradley 2012).

Liquefied Petroleum Gas

Limited information is available regarding the future production, distribution, and infrastructure systems of liquefied petroleum gas in the State. As liquefied petroleum gas is a byproduct of petroleum and natural gas refining, it is anticipated that refining would continue to occur on Oʻahu, but this would be dependent upon the existing refineries' decision to continue operations. According to FGE (2012), if 50 percent of the HCEI's goals are met in 2020, then liquefied petroleum gas (and synthetic natural gas) demand would be 138 thousand metric tons.

Vehicle Systems - Future propane vehicle use in the State would be dependent on the infrastructure that is made available in Hawaiʻi. At this time, information regarding the projected amount of propane vehicles planned for future use in Hawaiʻi is very limited and speculative.

Marine Vessels - At this time no propane marine vessels are projected for use in Hawaiʻi.

2.3.4.5.3 Permitting and Consultation Requirements

Compressed or liquefied natural gas or liquefied petroleum gas projects in Hawaiʻi would be part of a regulatory environment that is administered by Federal, State, and county agencies (see Section 2.2 above). Additional guidelines regarding natural gas infrastructure should also be adhered to in accordance with NFPA guidelines to ensure safety concerns are addressed.

Permits would be required before construction activities could begin to ensure project conformity to Federal, State, and county laws, codes, and standards concerning construction and pollution control (DBEDT 2013a). A Boiler or Pressure Vessel Installation Permit is likely required from the Hawaiʻi Department of Labor and Industrial Relations (DLIR). Development and distribution of natural gas in the State could require additional agency compliance, including with requirement s from the National Fire Protection Association and the USDOT.

2.3.4.5.4 Representative Project

The representative project for natural gas would involve the import of approximately 10 million gallons per year gasoline gallon equivalency of natural gas, or approximately 15.36 million gallons (10 million gallons per year × 1.5362) of liquefied natural gas per year to Oʻahu from the West Coast, supplemented by approximately 10 million gallons per year gasoline gallon equivalency of liquefied petroleum gas, or approximately 13.5 million gallons per year of liquefied petroleum gas. Combined, the representative project would offset a total of 20 million gallons per year of gasoline. The use of natural gas as transportation fuel would only occur if the infrastructure for import and use of natural gas for electricity generation were already in place. As liquefied petroleum gas is currently produced locally, the representative project assumes existing suppliers would increase liquefied petroleum gas production and that the existing gas distribution network would be modified and/or expanded as necessary.

The representative project assumes natural gas vehicles would not be imported, as car conversions would occur, albeit costly. Passenger vehicles would mostly be converted to compressed natural gas- and propane powered vehicles, while medium and heavy-duty vehicles, including transit buses, waste collection and transfer vehicles, airport shuttles and vehicles, and City and State vehicles would be converted to run on liquefied natural gas.

2.3.4.6 Multi-Modal Transportation

Multi-modal transportation options reduce the number of miles traveled by personal vehicles for work commuting and personal trips. Multi-modal transportation options include mass transit, ridesharing, car sharing, biking, walking, and telecommuting/teleworking. Examples of multi-modal transportation include:

- Mass Transportation – Mass transportation involves the use of shared passenger transportation services, with modes including bus (e.g., transit, commuter, trolley, shuttle, and bus rapid transit), rail (e.g., light rail, commuter/inter-city, and high-speed), and marine (e.g., intra- and interisland ferries).

- Ridesharing – Ridesharing includes carpooling and vanpooling and is focused on increasing the number of passengers in each vehicle to reduce the number of cars on the road to ease congestion as well as reduce the total miles traveled and fuel usage.

- Car Sharing – These services provide a flexible way for people to rent a vehicle for a short period of time (such as a couple hours) to go shopping or visit friends. Available cars are located and reserved online or by phone and are picked up in central, mainly urban locations by an identification card that unlocks the car (the exact process varies by company).

- Active Transit (biking and walking) – Leaving the personal vehicle at home to walk or bike to work or for personal trips eliminates the vehicle miles traveled and fuel used. This type of program is limited for various reasons, such as proximity to work, change in weather, condition of personal fitness, and lack of personal motivation, but can likely be expanded by increasing awareness and incentives.

- Telecommuting/Teleworking – Employees work one or more days per week from home or telework centers located near their home.

- Alternative Work Schedules – Modified employee work schedules from a typical 8-hour day, from 9 a.m. to 5 p.m., 5 days a week while remaining full time. While this option does not remove vehicles from the road, it is intended to put fewer cars on the road at any one time, thereby reducing congestion and decrease total miles traveled. Less congestion results in less energy loss in traffic.

The applicability of each transportation option varies by person and circumstance, but all have the potential for Hawai‘i residents to reduce fuel usage while reducing their commute and increasing personal mobility. All of the multi-modal transportation options reduce the number of vehicles on the road and thus the total vehicle miles traveled, the required fuel usage, and roadway congestion. The primary focus is on decreasing the number of cars on the road during weekday commuting, but many of the options can also be a solution for personal business.

Table 2-27 summarizes the multi-modal options used by commuters in Hawai‘i. The data are presented by county and reflect work-related travel (that is, they do not include personal trips). As can be seen in the table, driving alone is the predominant transportation option. Ride-sharing options (carpool and vanpool) are the second most popular option in all counties. Mass transit is much more prevalent on O‘ahu (both percentage of population and number of individuals). Working from home is popular on Maui and Hawai‘i, and in the City and County of Honolulu. The following sections discuss each commuting option.

Table 2-27. Multi-Modal Option Summary for Commuters by County (2006 to 2010)

County	Total Population	Percentage of Population					
		Drive Alone	Walk	Ridesharing	Public Transit	Work from Home	Other
Kaua‘i	65,460	78.8	1.6	12.1	0.4	4.8	2.4
Honolulu	936,984	64.5	5.5	15.6	7.9	3.4	3.1
Maui	150,711	70.2	3.3	14.7	1.7	7.7	2.4
Hawai‘i	180,382	68.0	2.7	16.6	1.5	8.9	2.3
County	**Number of Individuals**						
	Drive Alone	**Walk**	**Ridesharing**	**Public Transit**	**Work from Home**	**Other**	
Kaua‘i	51,582	1,047	7,921	262	3,142	1,571	
Honolulu	604,355	51,534	146,170	74,022	31,857	29,047	
Maui	105,799	4,973	22,155	2,562	11,605	3,617	
Hawai‘i	122,660	4,870	29,943	2,706	16,054	4,149	
Totals	884,396	62,425	206,188	79,551	62,658	38,383	

Source: USCB, American Community Survey 2013.

2.3.4.6.1 Mass Transportation

Technology Description

Mass transportation involves the use of shared passenger transportation services, with modes including bus (e.g., transit, commuter, trolley, shuttle, and bus rapid transit), rail (e.g., light rail, commuter/inter-city, and high-speed), and marine (e.g., intra- and interisland ferries). Details of the modes are provided in the following sections. There will be increasingly more opportunities for all mass transportation modes to use a higher percentage of alternative fuels or electricity produced from renewable sources as Hawai‘i progresses toward the HCEI goals.

Although the various mass transportation modes utilize various energy sources, the primary source in Hawai‘i is currently fossil fuels. Mass transit uses much less energy per passenger mile than personal vehicles. In addition, the use of transit results in fewer vehicles on the roads, reducing congestion and increasing throughput. Human factors that increase mass transportation usage include concern for the environment, concern for the global climate, a desire to reduce commuting cost, stress, and time, and the cost of owning and operating a personal vehicle.

Characterization of Technology Feasibility and Deployment

Increasing the use of some mass transportation modes would require major construction to develop the infrastructure where it currently does not exist (e.g., the Honolulu Authority for Rail Transit project) (HART 2013a). Other modes will require less (e.g., enlarged or new transit bus facilities and on- or offsite fueling infrastructure).

The following section discusses current and near-term multi-modal transportation modes with potential in Hawai‘i:

Bus Transit

Transit bus services operate on conventional roads, have a relatively low per vehicle passenger capacity, and are ideal for shorter trips such as intra-city travel or commuter transportation between or into urban areas. Bus transit service is subdivided into traditional fixed-route/fixed schedule service and paratransit/demand response service. Fixed-route service operates on a set of fixed routes with designated bus stops for picking up and dropping off passengers. Paratransit service differs from traditional transit service in several ways: it is primarily used by persons with disabilities and the elderly. There are no fixed routes or schedules; rather passengers request service for pick-up and drop-off at requested locations (e.g., a person's home, doctor's office, and shopping center).

Transit buses are the most common mass transportation mode used in Hawai‘i for commuting to work, school, and for personal business. Transit buses are available with a wide range of fuels and powertrains; however, conventional diesel, natural gas, and diesel-fueled hybrid-electric are the most common powertrains across the United States. Transit buses are predominantly custom-designed as heavy-duty buses, are blunt-faced, and have at least two sets of doors (one at the front and one or more in the middle of the vehicle) for passenger access. Somewhat smaller, less-rugged medium-duty cutaway chassis cab buses are used for routes with lower passenger throughput. Smaller, less-rugged heavy-duty van-cutaway type minibuses are the most common paratransit/ demand-response vehicle type; however, taxi cabs and passenger vans also transport on-demand passengers. Figure 2-58 shows the 2011 fuel use mix for transit properties across the United States (USDOT 2011b). Data for Hawai‘i show 99.5 percent of fuel use as diesel and 0.5 percent as gasoline. No natural gas buses are in use in Hawai‘i.

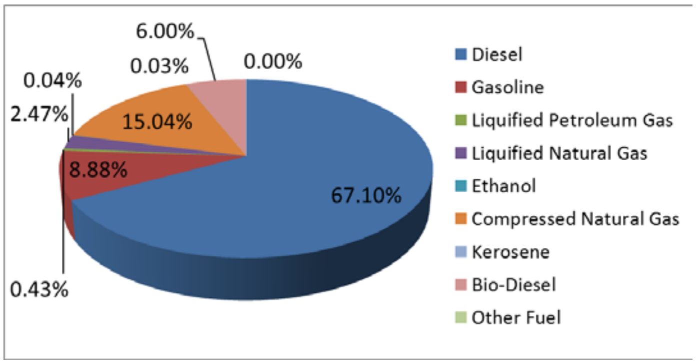


Figure 2-58. U.S. Transit Fuel Usage Mix (non-electric) (Source: USDOT 2011b)

Note that the available hawaii-specific fuel use data only include O‘ahu and did not include any biodiesel use. In late 2012, the bus mass transit agency on O‘ahu, "TheBus," began an initial biodiesel-blended fuel field evaluation (HCC 2012b). Even so, petroleum remains the dominant fuel in the transit market in Hawai‘i.

A brief description of each transit bus fuel and/or powertrain technology (e.g., hybrid-electric) is given below. Many online sources are available for more detailed information. This PEIS uses information from the following sources:

- Appendix G of the *Kaua‘i Bus Multimodal Land Transportation Plan* (Kaua‘i Bus 2012)
- *Guidebook for Evaluating Fuel Choices for Post-2010 Transit Bus Procurements* (TRB 2010)
- *Alternative Fuel Study* (FTA 2006).

Diesel Buses

Diesel-fueled buses are the standard bus in Hawai‘i and across the United States. Of the 45,010 diesel-fueled buses in use in the United States (32 percent of urban transit buses), 689 are used in the State of Hawai‘i (86 percent of urban transit buses in the State) (USDOT 2011c; NTD 2011c). Diesel engines meeting the current 2010 and later EPA emissions regulations are also referred to as "clean diesel" because the exhaust emissions (e.g., particulate matter and nitrogen oxides) are significantly lower compared with earlier-generation engines.

Hybrid-Electric Buses

Hybrid-electric buses combine an internal combustion engine (typically diesel) and an energy storage system (typically electrochemical batteries) to provide propulsion power to the wheels. Hybrid technology can be used with any fuel; however, because diesel-fuel is the standard transit fuel, diesel hybrid-electric buses are the most common.

Of the 3,311 hybrid-electric buses in use on the United States (2.4 percent of urban transit buses), 78 are used in the State of Hawai‘i (10 percent of urban transit buses in the State) (USDOT 2011c). However, gasoline hybrid-electric buses are also in use, albeit not in Hawai‘i (199 on the mainland, or 0.14 percent of all urban transit buses). Hybrid-electric buses reduce fuel use mainly by recovering braking energy, reusing the energy later for accelerations, and by allowing the vehicle’s control system to manage fuel energy use to minimize fuel consumption. See Section 2.3.4.3 of this PEIS for a detailed discussion on hybrid-electric vehicles.

Biodiesel Buses

Biodiesel accounts for 6 percent of transit fuel use nationwide and is used to a very small extent (i.e., less than 1 percent of total fuel usage) in Hawai‘i. Biodiesel fuel is suitable for use in all modern compression ignition engines. Biodiesel can technically be used in engines in its pure, or “neat”, form or in biodiesel blends with petroleum diesel without modifications. Each engine manufacturer has a maximum recommended (or allowed) biodiesel blend percentage. Transit fleets commonly use B20 fuel (20 percent biodiesel/80 percent petroleum diesel blend by volume) because it is a good balance between emission benefits, improved sustainability, fuel cost, and risk of potential field problems. Section 2.3.4.1 of this PEIS includes a detailed discussion of biodiesel. The Honolulu Clean Cities website also provides information about biodiesel fuel use: http://www.honolulucleancities.org/biofuels/biodiesel-biofuels/. Buses with Cummins diesel engines (ISB, ISL, and ISM models) are certified for use up to B20 biodiesel blends. Buses with Detroit Diesel engines are certified for use up to B5 biodiesel blends.

Gasoline Buses

Gasoline accounts for 8.9 percent of transit bus fuel use nationwide and 0.5 percent in Hawai‘i. Of the 5,270 gasoline-fueled buses in the United States (3.8 percent of urban transit buses), 80 are used in Hawai‘i (15.5 percent of urban transit buses in the State) (USDOT 2011c). Gasoline buses are only available in the lighter end of cutaway type buses, ranging from 11,500 to 20,000 pounds gross vehicle weight rating. These buses are primarily built on medium-duty cab chassis that are fit with a bus body. These buses have a shorter minimum useful life (4 to 5 years, 100,000 to 150,000 miles) compared with 12 years and 500,000 miles for a heavy-duty purpose-built transit bus, so are not suitable for heavy use (FTA 2007). More information on gasoline as a transit fuel can be found in the references (TCRP 2011) (FTA 2006).

Natural Gas Buses

Natural gas is the second most commonly used transit bus fuel nationwide (17.5 percent of fuel use). The natural gas can be stored either in compressed or liquefied form. Natural gas is not a natural resource in Hawai‘i. However, Hawai‘i Gas processes synthetic natural gas for residential and commercial use on O‘ahu, so could be used for natural gas-fueled transit buses. Section 2.3.4.5 of this PEIS discusses natural gas as an alternative fuel source.

Of the 9,189 compressed natural gas buses in use in the United States (6.5 percent of urban transit buses), none is used in Hawai‘i (USDOT 2011c). Hawai‘i Gas’ natural gas pipeline serves approximately 28,000 residential customers (HawaiiGas 2013b). The same pipeline could be used to provide renewable natural gas or gasified liquefied natural gas (HawaiiGas 2013c). While the synthetic gas is not used by TheBus, natural gas-fueled buses could be a potential future transit bus fuel if a connection to the pipeline was available at bus fueling locations or offsite fueling stations.

Liquefied Petroleum Gas Buses

Liquefied petroleum gas, also known as propane, is the most commonly used alternative fuel worldwide (CC 2013), typically in light-duty vehicles. In the United States, liquefied petroleum gas accounts for only 0.4 percent of vehicle fuel use. Of the 324 liquefied petroleum gas buses in use in the United States (0.2 percent of urban transit buses), none is used in Hawai‘i (USDOT 2011c). Currently available liquefied petroleum gas-fueled medium-duty engines suitable for transit use range from 5.4 to 8.0 liters. These engines are available on several cutaway chassis that can accommodate small to large cutaway buses, but not heavy-duty transit buses. All liquefied petroleum gas used in Hawai‘i is shipped into the State, which decreases the ease and economic case for its use.

Battery Electric Buses

Battery electric buses are the transit equivalent to light-duty battery electric vehicles discussed in Section 2.3.4.2 of this PEIS. Battery electric buses do not have an internal combustion engine or fuel tank (e.g., diesel, gasoline, and compressed natural gas). Rather, they use energy stored in batteries (all currently available bus models use lithium-ion batteries) to power the vehicle. The battery pack recharges by connecting to an electrical power source. The connection can be physical or wireless (i.e., inductive). The limited range, model availability, high cost, typically long charge times, limited driving range, and other limitations have resulted in a low adoption rate [of the 51 buses in use in the United States (less than 1 percent of urban transit buses), none is used in Hawai‘i] (USDOT 2011c). Battery electric buses can take advantage of 10- to 20-minute “boost” charging, during passenger loading and unloading and other similar wait periods. Such methods are being further refined to improve the daily bus utility (Proterra 2013).

Most battery electric buses require a 20-minute charge every hour, which places limits on the potential applications and routes. However, some applications, such as airport or hotel shuttle buses, are likely good test applications.

Hydrogen Fuel Cell Buses

Hydrogen fuel cell buses are 100 percent electrically propelled. Buses store hydrogen fuel onboard and use it to produce electricity using a fuel cell, which propels the bus. Fuel cell buses typically include a battery pack to perform the same regenerative braking and launch assist functions as in a hybrid-electric vehicle, which improves the energy efficiency and increases the fuel cell stack service life. Fuel cell technology is in the development phase, yet there are a handful of technology demonstrator buses deployed in fleets for use in fare collection service to gather performance and maintenance data. The Hawai‘i Center for Advanced Transportation Technologies operated a fuel cell shuttle bus field demonstration project at Hickam Air Force Base from 2004 to 2009 (http://www1.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/36412.pdf). The DOE National Renewable Energy Laboratory has performed data analysis of in-use fuel cell bus field demonstrations, which also provides relevant information (http://www.nrel.gov/hydrogen/proj_fc_bus_eval.html). The Federal Transit Administration’s National Fuel Cell Bus Program is another good resource about fuel cell buses (http://www.fta.dot.gov/about/14617.html) (FTA 2013). More information can also be found in Section 2.3.2.3 of this PEIS.

Hydrogen Internal Combustion Buses

Hydrogen internal combustion engines are a similar concept to natural gas fueled engines, except that compressed hydrogen gas is used instead of natural gas. Hydrogen internal combustion engines are seen either as an intermediate step to hydrogen fuel cells (developing the fueling infrastructure while fuel cell technology matures) or as the end goal to eliminate the costly fuel cells while still significantly reducing greenhouse gas and other exhaust emissions. There have been many demonstrations of hydrogen internal combustion light-duty vehicles, shuttles, and transit buses from a range of manufacturers. Ford produced a limited number of hydrogen internal combustion shuttle buses in the early 2000s, but ceased after a few years. The Hawai‘i Center for Advanced Transportation Technologies partnered with the U.S. Army to evaluate 10 hydrogen internal combustion Ford Escapes in real-world conditions (http://www1.eere.energy.gov/vehiclesandfuels/avta/pdfs/hicev/ford16v_hice_fs.pdf).

Trolley Buses

Trolley buses are electrically powered buses whose energy is supplied via overhead electric wires. This type of bus has several names, including trackless trolley, electric trolley bus, trolley coach, trackless tram, or trolley. A strict definition of electric trolley buses would allow for the buses to be propelled solely via electric power from overhead wires. However, there are two types of electric trolley buses: electric trolley buses with emergency backup power and dual-mode buses. Buses with an emergency power backup system operate on electricity under normal conditions. The emergency backup power is used in the event of a dewirement (i.e., the catenary poles lose contact with the overhead wires) or if the bus needs to move around an obstacle (e.g., a broken down vehicle, accident scene, or a construction site) beyond the reach of the catenary poles. The backup power source, typically a battery pack or a generator set, provides less power than the primary catenary propulsion power, but is enough to propel the bus so that it can reconnect to the overhead wires, preventing a bus from being stranded (Vossloh 2013). Dual-mode electric trolley buses are capable of full operation on either electric or another power source (such as a diesel engine). One situation where dual-mode trolleys are beneficial is in a long tunnel where diesel exhaust may not be allowed. Boston and Seattle used dual-mode trolleys for this reason.

The number of trolley buses in the United States is low; of the 572 in use in the United States (0.41 percent of all urban transit buses), none is used in Hawai‘i]. Currently in North America, only five U.S. cities and two Canadian cities use trolley buses. The reasons for this include high installation costs for new or expanded electric trolley lines, limited vehicle options, and aesthetic issues related to the visible catenary network.

Rail Transit

Light Rail Transit

The Transportation Research Board defines light rail transit as “a metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally, in streets and to board and discharge passengers at track or car floor level” (TRB 2000). Compared with a heavy rail system, light rail is intended for lighter loads and is designed to be flexible and adaptable to a variety of environments including streets, freeway medians, railroad rights-of-way (operating or abandoned), pedestrian malls, underground or aerial structures, and even in the beds of drained canals. Because of this design flexibility, light rail transit generally is less costly to build and operate than other fixed guideway modes (e.g., heavy rail, commuter rail, trolley buses, aerial tramways, and cable cars. Light rail transit vehicles can fit more passengers than buses and are narrower and shorter than heavy rapid rail or commuter trains since they have to navigate mixed traffic and fit in city streets. The dedicated infrastructure of rails and power wires, typically above the tracks for safety, limit light rail transit’s flexibility for system restructuring and rerouting.

Rapid Rail Transit

Like light rail transit, rapid rail transit (also referred to as heavy rail systems) are electrically powered. Common terms for rapid rail transit include subway, underground, metro, or elevated railway depending on location and where the trains travel. Unlike light rail, rapid rail trains are designed to carry more passengers, stop at each station more frequently, and operate on a grade separation from general traffic (underground, on elevated tracks, or at grade but separated from other traffic). Rapid rail transit trains typically are powered via an electrified third rail (rather than a catenary like a trolley). Rapid transit operates in highly urbanized areas combining high capacity and frequency with minimal land usage. The Honolulu Authority for Rail Transit project (http://honolulutransit.org/hart.aspx) is in this category.

Commuter rail and high-speed rail are other rail transit options available on the U.S. mainland and worldwide. Neither rail variants are feasible options in Hawaiʻi given the combination of the islands' physical sizes and the islands' population and population densities.

Marine Transit – Ferries

Ferries are marine transportation vessels, usually a boat or a ship, that transport passengers and potentially vehicles across a body of water. Ferries are useful for locations where waterways frequently occur or when frequent and lower cost (than air) travel between islands is necessary. Ferries are, or have been, used for intra-island and interisland trips in Hawaiʻi.

Characterization of Existing Deployment

This section summarizes the current and past usage of each multi-modal transportation mode on each of the six main Hawaiian Islands.

Kauaʻi

- Bus – The Kauaʻi Bus operates 55 diesel cutaway buses, two gasoline paratransit vans, six Park & Ride lots, 18 routes, including express, local shuttles, and paratransit/demand response service (USDOT 2011c; Kauaʻi 2013a). The Kauaʻi Bus has no planned route/system expansion. The agency purchased one hybrid-electric bus in 2010 to use in fare collecting route service. Operation, usage, and maintenance data are being collected to evaluate the bus' performance to determine if additional hybrid-electric bus purchases are warranted (Kauaʻi 2010). Kauaʻi's *Multimodal Land Transportation Plan* identified B20 as its near-term transit bus solution (Kauaʻi 2013b). As of October 2012, the County of Kauaʻi has been discussing B20, compressed natural gas, and electrically powered (battery electric and fuel cell) buses for longer-term alternative fuel options for the transit fleet (Kauaʻi 2013c). The B20 would use locally produced biodiesel blended with petroleum diesel.

Oʻahu

- Transit Bus – TheBus (http://www.thebus.org/) is the public transit bus system on Oʻahu. It is operated by Oʻahu Transit Services, Inc. As expected from the island's larger population, TheBus is the largest transit fleet in the State. As of 2011, the entire TheBus vehicle fleet included 516 transit buses, including (USDOT 2011c):

  - 35 diesel transit buses (less than 40-foot),
  - 333, 40-footdiesel transit buses,
  - 40, 40-foot diesel hybrid-electric transit buses,
  - 70, 60-foot articulated diesel transit buses,
  - 38, 60-foot articulated diesel hybrid-electric transit buses

  - B20 biodiesel. Starting in 2012, 20 transit buses began fueling with B20 biodiesel as part of the Honolulu Clean Cities' *Hawaiʻi Clean Diesel Initiative* (HCC 2012b). The City and County of Honolulu has used B20 as the primary diesel fuel for its diesel fleet vehicles since 2004, and began use in transit buses in 2012.

  - Hybrid-electric vehicles. TheBus fleet includes 78 hybrid-electric buses. It had originally planned to convert half of the transit bus fleet to hybrid-electric buses by 2013. High implementation costs and lower than expected fuel savings (20 versus 60 percent) has put the plan on hold (USDOT 2011c).

- Bus Rapid Transit – The City and County of Honolulu implemented limited bus rapid transit service in the early 2000s, with limited routes and limited bus rapid transit features. Performance and support to continue and grow the service waned and attention shifted to rapid rail service. Bus rapid transit service will continue until it is replaced by the rapid rail system currently under development.

- Paratransit/Demand Response – TheHandi-Van (http://www1.honolulu.gov/dts/riders.htm) is the paratransit/demand response service complement to TheBus.

- TheHandiVan – Bus service includes 132 cutaway buses (102 diesel and 30 gasoline). Van service includes 59 sedans and 382 passenger vans, minivans, and sport utility vehicles.

- Rail – There is no rail service currently in Hawai‘i. The concept for commuter rail was first suggested in the 1960s, and was finally approved in 2005. The Honolulu High-Capacity Transit Corridor Project (now known as Honolulu Authority for Rail Transit) is currently planning, developing, and constructing the system including (but not limited to) tracks, stations, parking lots, and larger Park & Ride lots (HART 2013a). The system is projected to open in three phases between 2015 and 2019 with an estimated ridership of 116,300 weekday passenger trips by year 2030. The system is planned to extend 20 miles from Kapolei to Ala Moana Center (Honolulu Clean Cities 2013). The rail system development is being tied to neighborhood Transit-Oriented Development to build up communities (residential, business, and commercial) around rail stations. A good summary of Transit-Oriented Development can be found at the following websites: http://www.honoluludpp.org and http://honolulucleancities.org/vmt-reduction/public-transportation/

- Ferry – A high-speed ferry (the Hawai‘i Superferry) operated for a short time between 2007 and 2009 between O‘ahu, Maui, and Kaua‘i before legal challenges to the environmental review process caused service to terminate (HISF 2013).

  TheBoat commuter ferry service was operated as part of the City and County of Honolulu’s mass transit system between downtown Honolulu at Aloha Tower Marketplace and Kalaeloa Harbor at Barber's Point in Kapolei (CCH 2007). Service ran from 2007 to 2009.

Moloka‘i (Maui County)

- Bus – Maui Economic Opportunity, Inc. provides limited bus service on Moloka‘i via County of Maui grant funds (MEO 2013). The service operates free bus shuttle service for locals and visitors. There is no information regarding hybrid-electric or alternative fuel use.

- Ferry – The Moloka‘i Ferry provides ferry service that connects Moloka‘i and Maui. Moloka‘i residents use the ferry to travel to and from Maui for work, shopping, medical appointments, and pleasure.

Lāna‘i (Maui County)

- Bus – Maui Economic Opportunity, Inc. provides limited bus service on Lāna‘i via County of Maui grant funds (MEO 2013). The service operates some shuttles for rural shopping, senior nutrition, and Medicaid trips, but no traditional public transportation service. There was no information regarding hybrid-electric or alternative fuel use.

- Ferry – Expeditions Maui-Lāna‘i Ferry provides ferry service that connects Lāna‘i and Maui. Lāna‘i residents use the ferry to travel to and from Maui for work, shopping, medical appointments, and pleasure (Expeditions 2013).

Maui

- Transit Bus – Maui County manages the Maui Public Bus Transit System, which is operated by Roberts Hawai‘i (Maui 2013a). The system includes 13 routes that provide service in and between various Maui communities. The fleet includes 12 diesel buses (less than 40-foot), six 40-foot diesel transit buses, and 23 diesel cutaway buses. A review of the *Short Range Transit Plan* indicated no plans for hybrid-electric or alternative fuel use now or in the future. (MAUI 2005).

- Commuter Bus – The Maui Public Bus Transit System’s commuter bus system is also managed by Maui County and operated by Roberts Hawai‘i (Maui 2013b). The commuter bus system includes four routes and picks up passengers at Park & Rides, shopping centers, community centers, the War Memorial Stadium, hotels, and traditional cross-street roadside stops. As with transit buses, there are no apparent plans for hybrid-electric or alternative fuel use.

- Ferry – Expeditions Maui-Lāna‘i Ferry provides ferry service between Maui and Lāna‘i. Residents and tourists use the ferry for shopping and pleasure trips. Moloka‘i Ferry provides ferry service between Maui and Moloka‘i. Residents and tourist use the ferry for shopping and pleasure trips (Expeditions 2013).

Hawai‘i

- Bus – The Hawai‘i County Mass Transit Agency operates the Hele-On Bus (http://www.heleonbus.org) transit bus service. The service includes 18 routes, 36, 40-foot diesel transit buses, 12 diesel transit buses (less than 40-foot), 5 diesel medium-duty cutaway buses, and 3 gasoline-fueled minivans (paratransit/demand response) (NTD 2011c). There was no information regarding hybrid-electric or alternative fuel use.

2.3.4.6.2 Rideshare

Ridesharing includes carpooling, vanpooling, and bus transit. Bus transit was addressed above so this section addresses just carpools and vanpools. The objective of both activities is to reduce the number of vehicles on the road by increasing the number of passengers in a vehicle. Reducing the number of vehicles decreases fuel consumption and exhaust emissions roughly by a factor of the number of people in the vehicle.[28] Removing vehicles from the roadways also decreases congestion, which in turn decreases fuel wasted in traffic and allows vehicles to operate in conditions optimal for maximized fuel economy. Carpools can be formed by any group of people whether they know each other (e.g., neighbors or work colleagues) or not. The carpool group decides the structure, costs, the vehicle(s), the driver(s), and the schedule that will be used.

HDOT operates several programs to encourage ridesharing (HDOT 2013a), including high occupancy vehicle and zipper lanes reserved for buses, carpools, vanpools, and motorcycles and the carpool/school

[28] The reduction would be somewhat less due to additional miles required to pick up and drop off each passenger on either side of the trip.

pool matching service that connects potential groups together for forming a carpool/school pool (HDOT 2013b). People add their contact, commute, and other relevant information to the database. This information is used to locate and create private carpool/school pool groups. Other private rideshare matching services such as eRideshare exist for people to locate and form carpools on their own.

Vanpools operate in a similar way as carpools, except the vehicle is provided by a service rather than a personally owned vehicle. vRide is the commercial vanpool service provider in Hawaiʻi. The vanpool group can be formed by a group of people who know each other, or vRide can assemble the group. The vans are available in 7-passenger (minivan), 10-passenger (traditional van), and 15-passenger (traditional van) sizes, which equates to removal between 6 and 14 cars from the road. The monthly fee is per vehicle, so the per-person costs depends on the number of people in the vanpool. The monthly fee includes the vehicle, fuel, maintenance, parking, and insurance. vRide has a calculator tool to estimate the monthly savings (vRide 2013). The actual savings are situation dependent; for instance, a 30-mile round trip commute in a vehicle that gets 20 miles per gallon @ $4.00 per gallon is estimated to provide a monthly saving of $153. The monthly savings would increase to $274 when parking and reduced personal car insurance rates were included.

The City and County of Hawaiʻi offers a shared ride taxi service in the urbanized areas of Hilo and Kailua-Kona. Six taxi companies participate in the program (Hele-On Bus 2013). Door-to-door service is available for trips up to 9 miles and costs as little as $2 (or as much as $6, depending on the) per person per trip. The taxi operators may combine and consolidate rides.

2.3.4.6.3 Car Sharing

Car sharing services are similar to car rental services, but are intended for use for short periods, for customers who make only occasional use of a vehicle, as well as others who would like occasional access to a vehicle of a different type than what they use day-to-day. Car sharing services target people who do not own a car, but do not restrict car owners from using the service. Most vehicle types are offered, such as cars, trucks, sport utility vehicles, and vans; however, availability in Hawaiʻi and at each location varies. There are two general types of car sharing services: commercial services that provide vehicles and commercial services that help users organize to share their personal vehicle(s). The commercial services include fuel, insurance, mileage, and parking.

Commercial Services Providing Vehicles

ZipCar is the largest car sharing service in the United States but does not operate in Hawaiʻi. Enterprise CarShare operates small fleets on the University of Hawaiʻi at Manoa campus, the Hawaiʻi Pacific University, Windward Campus, and on Kaneohe Bay Marine Base. Green Car Hawaiʻi (https://www.greencarhawaii.com/) is similar to Enterprise CarShare, but caters to tourists; however, it is also available to Hawaiʻi residents. The service is currently only available at one hotel in Waikiki.

The membership and rental process vary by company, but there is generally a one-time membership enrollment fee and may have a reoccurring (monthly or annual) membership charge. Vehicles are rented on an hourly, daily, or overnight basis. For reference, Enterprise CarShare respectively charges $10, $70, and $40. Cars are reserved online and a wireless membership card is used to unlock and lock the car. The keys stay in the car. The car is returned to the same location, in the dedicated parking spot when the user is done.

Commercial Services Not Providing Vehicles

Relay Rides is a car sharing program that provides the reservation, insurance, and operations support for vehicle owners to rent/share their personal vehicles. Similar to the commercial services providing vehicles, Relay Rides rentals can be for various amounts of time (from hours to days). Currently, there are only eight vehicles enrolled in Hawaiʻi: 2 on Hawaiʻi island, 2 on Maui, and 4 on Oʻahu.

2.3.4.6.4 Active Transit

Active transit is human-powered transportation (i.e., walking and biking) that reduces the number of vehicles on the road (DOE 2013t). The impact is decreased fuel consumption and exhaust emissions. Removing vehicles from the roads also decreases congestion, which decreases fuel wasted in traffic and allows vehicles to operate in conditions optimal for maximized fuel economy. The potential per trip impact of biking and walking is logically lower than other modes, such as mass transportation (bus, rail) or carpools since most people would only opt for these modes for relatively short distance. As can be seen in Table 2-27, the potential pool of people who would walk or ride their bike is a small subset of the population. Regardless, both are important options that play a part in reducing vehicle miles. Both require adequate infrastructure including crosswalks, overpasses, sidewalks, and bike lanes or paths to provide a safe environment. State and county laws protecting pedestrians and bicyclists help improve the safety of active transit.

The State of Hawaiʻi developed the *Statewide Pedestrian Master Plan* and *Bike Plan Hawaiʻi Master Plan* to address the infrastructure and safety aspects for enabling and improving both modes (HDOT 2013c, 2013d).

2.3.4.6.5 Telecommute/Telework

Telecommuting involves people working remotely via either a home computer or by driving to a telework center. The term for telecommuting is also known as teleworking, since the name puts the focus on working, rather than the trip to and from work. In a teleworking arrangement, employees work one or more days per week either from home or a business center located near their home (DOE 2013u). Formal agreements are commonly made between employer and employee to determine, among other things, the number of days per week the employee will telework. In general, teleworking has been shown to be a useful tool for retaining employees by allowing for a better balance between work and home life. Worker productivity has also been shown to be higher for teleworkers since they have fewer distractions from co-workers during the day. Teleworking is not universally applicable since some jobs must be done at the company workplace (e.g., car sales, tourism, and restaurants).

Teleworking from home has the highest petroleum use and traffic congestion benefits. Teleworking at telework centers has somewhat lower petroleum use reduction because workers must drive to the telework center; albeit it a shorter distance and oftentimes less congested location than their work office.

As shown above in Table 2-27, the percentage for those working from home (which includes teleworking) is higher than mass transit on all islands except Oʻahu. Overall, across the State, the number of telecommuters almost equals the number taking mass transit. Increasing teleworking can be an important factor to reducing petroleum use and meeting the HCEI goals,.

2.3.4.6.6 Alternative Work Schedules

Alternative work schedules is simply working a non-typical 8-hour day, from 9 a.m. to 5 p.m., 5 days a week while remaining full time. While this option does not remove vehicles from the road, it is intended to put fewer cars on the road at any one time, thereby reducing congestion and decrease total miles traveled. Less congestion results in less energy loss in traffic (DOE 2013u). Example alternative work schedules include the following:

- 9/80 work week – Employees work 80 hours over 9 work days (10 percent reduction in average weekly miles).

- 4/40 work week – Employees work a 40-hour week in 4 days (20 percent reduction in average weekly miles)

- 3/36 work week – Common in health facilities and fire and police departments; employees work three 12-hour shifts (40 percent reduction in average weekly miles).

- Staggered work hours – Work hours are shifted to spread out the traffic density. The benefit to the workers is a shorter driving time and a more consistent commute. Some fuel savings may result, however, higher average speeds may negate that benefit.

- Flexible working hours – Employees are given the flexibility to work the hours they want and can change on a daily basis. Most flex-time programs require employees to be present during a core period of time (such as from 9 a.m. to 3 p.m.) to allow for the necessary interactions with co-workers and clients. Fuel-related benefits include a shorter commute time if driving earlier/later than rush hour(s). However, higher average speeds may negate that benefit.

2.3.4.6.7 Permitting and Consultation Requirements

The permitting and consultation requirements required for multi-modal transportation are general in nature. See Section 2.2 for a discussion on general permitting and regulatory requirements.

2.3.4.6.8 Representative Project

The representative project could include any number of combinations of the above multi-modal transportation options. Aside from mass transportation, the current and potential future petroleum reduction impact is either difficult or impossible to accurately estimate. Therefore, the representative project is specific to increasing transit ridership (bus and rapid rail) to avoid personal vehicle travel and eliminate 20 million gallons of petroleum fuel use in 2030.

2030 Mass Transit Fleet Improvements to Meet 20-Million-Gallon Fuel Reduction Target

Increasing mass transportation use and the sustainability of the operations is important on all islands, but the representative project considers only O‘ahu. As of 2010, O‘ahu accounted for 70 percent of Hawai‘i’s population, and, as such has a greater chance of affecting increased mass transportation use Statewide (Hawai‘i 2011). The representative mass transportation project could include three features: (1) to increase mass transit usage, (2) to transition to more fuel-efficient transit vehicles, and/or (3) to replace petroleum diesel with renewable biofuels and/or electricity. However, such a variety would lend itself to a matrix of impacts; therefore, the project assumes only conventional diesel bus fixed-route service[29] and rapid rail to provide a realistic project analysis later in this PEIS. (Hybrid-electric buses and biodiesel fuel blends are currently used on a limited basis on O‘ahu, but are not included in this analysis.) The project also assumes that the fuel consumption of conventional diesel buses will not improve between now and 2030. While this assumption is not likely, it was accepted for two reasons: (1) any potential improvements likely would not represent a major reduction and (2) the avoided passenger car gasoline use far outweighs the diesel bus fuel consumption. Fuel usage system summary usage data (e.g., annual vehicle revenue miles, annual passenger miles, and annual trips) (USDOT 2011a, 2011d), and average

[29] Traditional transit bus service (i.e., not paratransit/demand response service) accounts for the vast majority (98.5%) of transit service on O’ahu.

passenger trip length (TheBus 2013) were used to calculate the average diesel fuel use per passenger trip (0.0742 gallon). The average fuel use for completing the same trip in a personal vehicle was estimated assuming the same fuel economy and fleet weighting used in Section 2.3.4.3 (Hybrid-Electric Vehicles) (i.e., 0.4195 gallon).[30] The fleet mix and average fuel economy of the 2030 fleet vehicles will be higher because of increasing fuel costs and Federal Corporate Average Fuel Economy requirements. The result is that the savings presented here will be somewhat higher than expected. The fuel saved per transit trip is the difference between the personal car fuel use and the bus transit fuel use (0.3453 gallon).

The Honolulu Rail Authority Transit estimates the system, at its anticipated usage level, would reduce transportation energy demand by the equivalent of 5.9 million gallons in 2030 from avoided personal car travel (HART 2013b). The calculations included the additional energy use for operating the trains, so the 5.9 million gallons is the net fuel savings. The representative project uses this estimation without modification.

The remaining 14.1 million gallons of avoided fuel use would come from increased transit bus ridership. Table 2-28 presents the ridership increase and the number of new trips (assumes the same average bus trip length) that must be added to reach the total 20-million-gallon petroleum use reduction. An estimated number of additional buses needed to provide the increased ridership (assumes the same utilization, ridership, and fuel consumption per bus and per passenger car trip) is also shown.[31]

Table 2-28. Diesel Transit Bus Increases Needed to Meet 20-Million-Gallon Fuel Use Reduction Target

Transit Bus Ridership Increase (%)	Number of New Transit Bus Trips Added (million)	Approximate Number of New Transit Buses Needed
55	40.9	282

The representative project assumes the following:

- Decreased petroleum usage resulting from switching from personal vehicle trips to transit bus and rapid rail trips for people who own vehicles, and providing a robust set of transportation options for those that do not own vehicles;
- Reduced traffic congestion that would occur from increased mass transit use. Exhaust emissions and greenhouse gas emissions for the island overall also would decrease (assuming that as transit bus fleet emissions increase, personal vehicle emissions would decrease at a much higher rate).
- Increased ridership resulting in increased fare revenue for TheBus, which could be invested to accelerate environmentally sound vehicle purchase and facility upgrade plans to enhance energy usage reductions.

Two maintenance facilities and one heavy maintenance facility service the current fleet of transit service buses on O‘ahu (USDOT 2011e). The representative project assumes the maintenance and heavy maintenance facilities are at or near capacity, and therefore, likely would require building one more maintenance facility or expanding one or both of the two existing facilities to meet the 20-million-gallon petroleum reduction.

[30] Passenger cars (25 miles per gallon average, 50 percent of fleet) and light trucks (16 mile per gallon average, 50 percent of fleet).
[31] The current transit bus fleet includes 516 fixed-route transit buses.

2.3.5 ELECTRICAL TRANSMISSION AND DISTRIBUTION

Energy efficiency within Hawai‘i’s electrical transmission and distribution system would contribute to HCEI goals and would benefit both fossil fueled power generation and renewable power generation sources that use the transmission and distribution systems. Proposed projects would proceed with the intent of balancing HCEI goals with utility system stability and reliability.

Even though they are not specifically included in one of the HECI key sectors of the energy economy, the technologies included in this clean energy category are all complementary to the generation and efficient end-use of electricity from renewable sources. The electrical grids on each island in Hawai‘i are operated independently because there are currently no transmission lines or cables that allow transmission between islands (see Sections 2.3.5.1 and 2.3.5.2). In order to provide additional grid stability for the islands and to fully use the renewable energy resources of the State, an undersea transmission cable may be implemented to transmit energy between islands. To improve the efficiency, reliability, and security of the electrical grid, new computerized and other automated technologies are being used to monitor and manage the supply and demand of electricity. These technologies are called a smart grid (see Section 2.3.5.3). Another component of the electrical distribution system is energy storage. Energy storage systems improve the stability and reliability of electricity distribution when variable, renewable sources such as wind or solar are attached to an electrical grid (see Section 2.3.5.4). The electricity transmission and distribution technologies options discussed in this section include the following:

- On-Island Transmission
- Undersea Cables
- Smart Grid
- Energy Storage

Due to their unique features, no common approach was used to develop the representative projects for electrical transmission and distribution technology options. The representative projects developed for each of the above technologies are specifically addressed in each of the following subsections.

2.3.5.1 On-Island Transmission

2.3.5.1.1 Technology Description

On-island transmission of electricity includes connections from the power generation source, transmission over a short or long distance, and connection to the power user. This system is often referred as the island electrical grid or simply “power grid” (see Figure 2-59). The power grid is how the majority of people and companies get their electricity. The generating station shown on the left in the figure may be current fossil fired power plants, auxiliary generators to help regulate power throughout the grid, or any of the various renewable power generation sources (e.g., sun, wind, biomass, hydropower, geothermal) as described in the previous sections of this PEIS. The power source connection may include meters, switchgear, circuit breakers, inverters, transformers, and connection to transmission lines.

The transmission line may be aboveground or buried to distribute the power to customers. At the power user, connections would also include switchgear, circuit breakers, inverters, transformers, meters, and connection to customer facilities. Some customers with renewable power generation capability may be both users and/or suppliers of power to the grid.

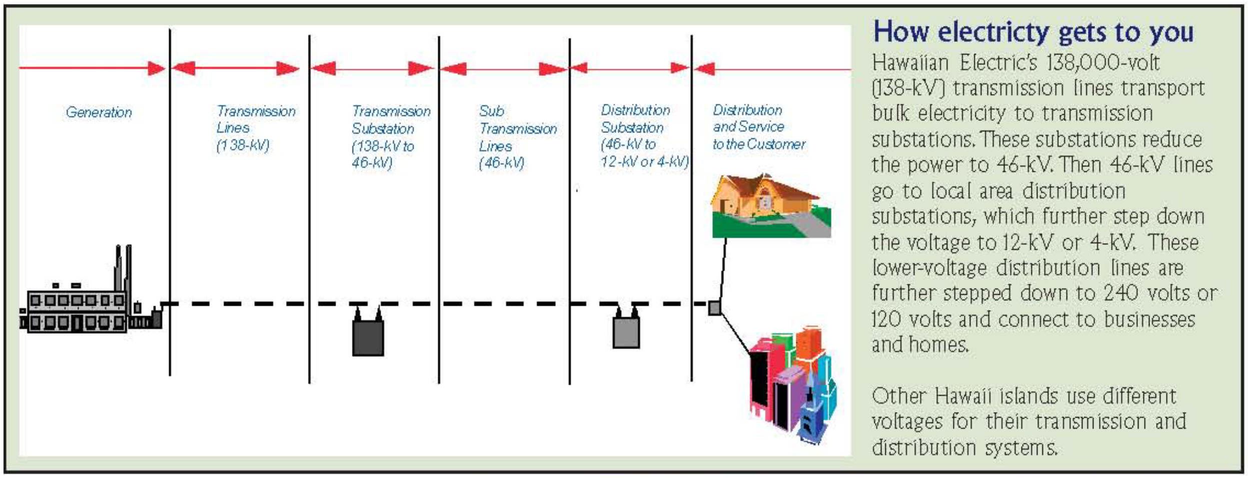


Figure 2-59. Simple Diagram of Electric Power Supply via Transmission Lines to Customers (commonly known as the power grid) (Source: HECO 2009)

2.3.5.1.2 Characterization of Technology Feasibility and Deployment

Power for the six islands of Hawai‘i, Maui, Lāna‘i, Moloka‘i, O‘ahu, and Kaua‘i is supplied by HECO, Hawai‘i Electric Light Company (HELCO), Maui Electric Company (MECO), and Kaua‘i Island Utility Cooperative (KIUC). HELCO and MECO are subsidiaries of HECO and those three companies supply power to about 95 percent of the population of Hawai‘i.

The changes needed to meet the 2030 goals require a commitment of the State of Hawai‘i, the utilities and the residents of Hawai‘i to jointly bring Hawai‘i to a less fossil-fuel-dependent and more renewable-energy-based state. One of the commitments that embody this spirit can be found in the Energy Agreement among the State of Hawai‘i, Division of Consumer Advocacy of the Department of Commerce and Consumer Affairs, and the Hawaiian Electric Companies (Hawai‘i 2008a). The Summary of Key Agreements (Hawai‘i 2008b) states in part:

> “…All parties believe that the future of Hawai‘i requires that we move decisively and irreversibly away from imported fossil fuel for electricity and transportation and towards locally produced renewable energy and an ethic of energy efficiency….”
>
> “…We commit to being open and truthful with our community about the investment necessary to transition to a clean energy future, the importance of making it, and the time it will take to be successful. We accept that the transition to this clean energy future will require significant public and private investment with impacts on Hawai‘i’s ratepayers and taxpayers, and we expect to achieve long-term benefits that outweigh the costs.
>
> As we move from central-station, oil-based power to a much more renewable, distributed and intermittent-powered system, we recognize the need to assure that Hawai‘i preserves a stable electric grid and minimizes disruption to service quality and reliability. In addition, we recognize the need for a financially sound electric utility….”

To address the statement, “recognize the need to assure a stable electrical grid and to minimize disruption to service quality and reliability,” the electrical grid will need to be modified to compensate for the variations in power output from renewable power generation sources (e.g., wind power varies with the wind flow; solar varies with the day/night cycle, clouds, and shading). As added renewable energy begins to reach a larger portion of the State's goals, the old power network will not be able to ensure a stable electrical grid (NREL 2012d; NCEP 2004). Adding new renewable power sources and changing the existing, older fossil-based power sources for any of the Hawaiian Islands will require continuing additions and changes to the existing transmission and power grid infrastructure to properly match the power generation sources and users on the grid. Those changes could include:

- New local connections to the power grid (e.g., residential or commercial customers);
- Transmission lines from new power sources to the existing grid (e.g., connection of solar power plant via above- or belowground transmission line);
- Upgrade of the existing grid to increase capacity to handle added power (e.g., replace sections of transmission lines and substations that become overloaded);
- Better balance of grid to handle new variable renewable power sources [e.g., solar and wind power vary with the weather; therefore, the electrical power supply must constantly be balanced to provide reliable power to all users. Adding power storage devices (Section 2.3.5.5) to the grid may compensate for power spikes by storing power when there is too much and later releasing power to mitigate momentary spikes.]
- Storing energy to address the varying demand for power; energy storage can take electricity that is generated at one point in time and store it for use at a different time in the day (Section 2.3.5.5)
- Interconnection of existing grids (e.g., connect together two independent grids to share power supply resources for better overall power reliability and service) (see Sections 2.3.5.2 and 2.3.5.3).

Currently, the power grid on all six islands is connected to most of the residents and businesses on each island. For those already connected, adding local residential or commercial renewable energy sources may not require extensive change to the existing grid at the point of connection. Programs like net energy metering and feed-in tariff are examples of these changes that are underway. Net energy metering allows residential and commercial utility customers with renewable energy sources to connect to the electrical grid and receive credit for power supplied to offset the cost of power used from the grid (HECO 2013i). The feed-in tariff program provides an opportunity for renewable energy projects to sell electricity to the HECO companies through a tariff payment for the power supplied (HECO 2013i)

Larger utility-scale power sources such as solar farms, wind farms, large biomass generators, hydropower facilities, or geothermal plants will need to be constructed in locations that are favorable to their type of power generation (see Section 2.3.3). In these examples, it is likely that the power source will be some distance (e.g., several miles) from the nearest grid connection location. Typical transmission voltages used throughout the six islands are shown in Table 2-29. The voltages vary from very high at 138 kilovolts to low at 120 volts. The high levels allow for efficient movement of power (e.g., 138 kilovolts, 69 kilovolts); whereas, the lower levels (e.g., 220 volts or 120 volts) allow safer use in household and commercial settings (NCEP 2004). Table 2-30 shows typical transmission line voltage levels, corridor width, and tower or pole height for similar transmission lines. Higher voltage transmission, which is generally more efficient at power transmission, will usually require wider corridors and taller towers, which likely will result in greater impacts (e.g., land disturbance or visual impacts).

Grid modernization plays a strategic role in helping Hawai‘i achieve its 2020 and 2030 clean energy objectives. The State believes grid modernization will encourage private investment and take advantage of both utility-scale and distributed generation resources. The State's grid modernization strategy involves: (1) adopting rules and standards as recommended by the Reliability Standards Working Group established by the PUC, (2) developing sufficient storage capacity and advanced grid upgrades, and (3) connecting the islands through undersea transmission cables.

Table 2-29. Expected Transmission and Interconnection Voltages

	Hawaiʻi (HELCO)	Maui, Molokaʻi, Lānaʻi (MECO)	Oʻahu (HECO)	Kauaʻi (KIUC)
Transmission	69kV	69kV	138kV	57.1kV
Subtransmission	34.5kV	23kV	46kV	-
Distribution varies depending upon location of facility	e.g., 25kV, 12kV, 4kV	e.g., 25kV, 12kV, 4kV	e.g., 25kV, 12kV, 4kV	12.47kV
Household and commercial connection	e.g., 220V, 120V	e.g., 220V, 120V	e.g., 220V, 120V	e.g. 220V, 120V

HECO = Hawaiʻi Electric Company; HELCO = Hawaiʻi Electric and Light Company; KIUC = Kauaʻi Island Utility Cooperative; kV = kilovolt; V = volt.

Table 2-30. Typical Transmission Line Voltage Levels, Corridor Width, and Tower or Pole Height

Transmission Line Voltage (in kilovolts)	Width (in feet)	Height (in feet)
138	100 - 150	70 - 95
69	70 - 100	50 - 70
46	70 - 100	50 – 70

DBEDT believes that an undersea transmission cable is in the public interest due to the benefits it will provide to ratepayers on the connected islands, to the environment, and to the State’s renewable energy goals. More information on this topic is available online at http://energy.hawaii.gov/renewable-energy/grid-modernization and http://energy.hawaii.gov/renewable-energy/Oʻahu-maui-gridtie.

New renewable energy projects will include appropriate connection to the power grid. Issues such as transmission efficiency and losses due to voltage step-up and down-stepping at substations will also be considered (NCEP 2004). The utilities and PUC in Hawaiʻi have processes in place for developing safe and efficient interconnection with the transmission grid. New projects should consult the utilities during their early design phases.

2.3.5.1.3 Permitting and Consultation Requirements

Permits or utility coordination may be needed to construct a particular project would include interconnection with the power grid and permits that maybe required due to specific land used and local environmental characteristics (e.g., cultural surveys, endangered species take permit). General permitting and regulatory requirements are discussed in Section 2.2. Additional permitting considerations include:

- Consultation with the NOAA National Weather Service to avoid interference with weather surveillance radars.
- Consultation with the Federal Communication Commission for microwave or telecom interference.

- Proximity to cultural and scenic resources, including national parks; any NPS park units within the viewshed of the proposed solar power facility (and associated facilities and transmission corridors) should be consulted early in the planning process.

2.3.5.1.4 Representative Project

To illustrate a potential transmission and distribution project that may be encountered on any of the six islands, the analysis in this PEIS considers a representative project that would involve an electrical connection to a large, renewable energy generation project. The representative project is not intended to reflect any known or planned project and is developed for analytical purposes only. The renewable generator maybe a large (100-megawatt) solar farm, wind farm, or geothermal generator. The project assumes that the generation source is 20 miles from the nearest transmission line and the transmission line operates at 69 kilovolts. For this example, the analysis uses a transmission line that would have a 100-foot-wide, 20-mile-long, 0.38-square-mile disturbed area for easement, and a 70-foot pole or structure height. [Not included in this example are other possible requirements at the generator end to convert power to 69 kilovolts. Such equipment may include inverters, transformers, and electrical switchgear. When a project is about to be connected, the utility will require a transmission line approval (see Table 2-30, DBEDT Permit Packet S-50) and any other equipment needs will be determined.]

Characteristics of this representative project are:

- Almost all linear except for small areas for substation or switching yard,
- Aboveground structures (such as poles),
- Easement access (either right of way or roads),
- Construction labor/cost and minimal operational personnel (once constructed, maintenance requirements should be small),
- Construction noise (e.g., heavy equipment),
- Construction use of water (e.g., dust suppression, ground compaction),
- Operational control of the easement (e.g., control of vegetation to avoid interference with the power lines, and
- Little to no operational water use, waste, or hazardous waste streams other than normal human considerations for operational personnel.

2.3.5.2 Undersea Cables

Undersea power cables, also called submarine cables, transmit power across large bodies of water, whether from one island to another, or from an offshore energy facility (e.g., an offshore wind turbine platform) to an on-island electrical network. Undersea cables lay on the sea bed and connect to on-island power grids via a land-sea cable transition site. Any type of electrical power can transmit across undersea cables, including renewable energy sources such as solar, wind, and biomass.

2.3.5.2.1 Technology Description

Undersea cables between islands in Hawaiʻi is not a new concept. Currently, Hawaiʻi has many telecommunications cables running between islands, as Figure 2-60 shows, but no power cables.

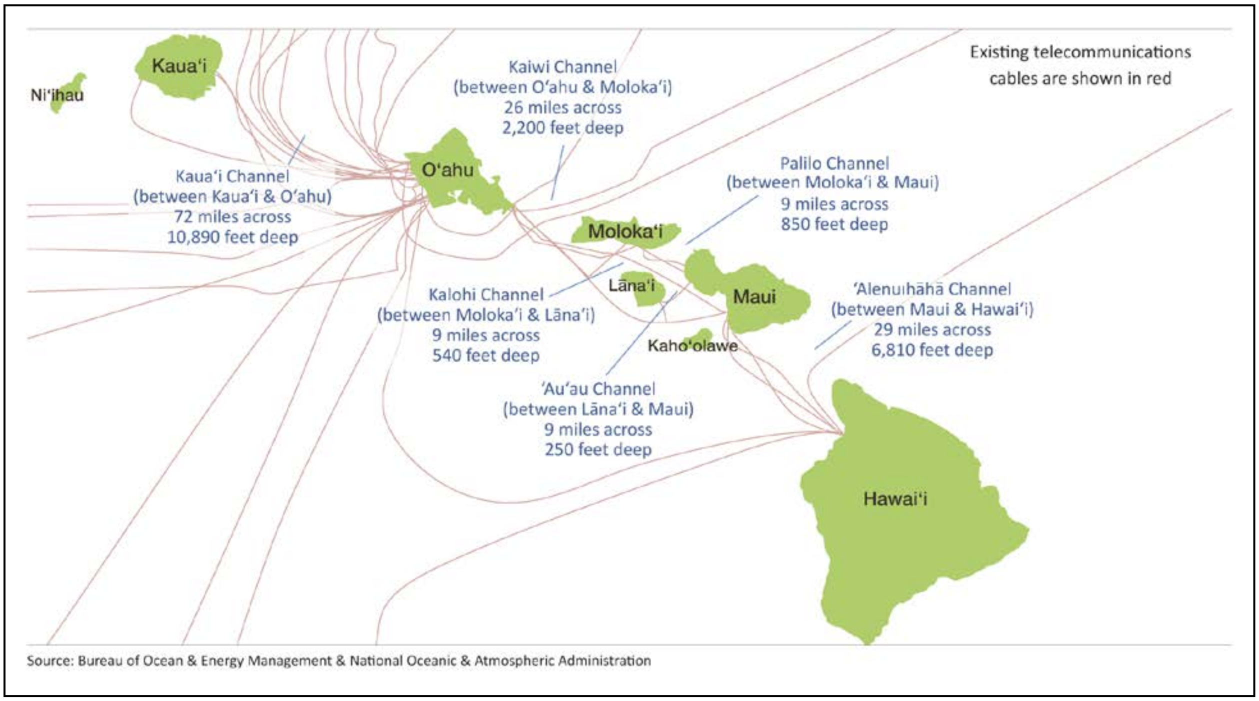


Figure 2-60. Existing Undersea Telecommunications Cables in Hawaiʻi (Source: DBEDT 2013h)

Two undersea cable transmission technology options are available: alternating current (AC) and HVDC. HVDC cables offer the benefit of increasing power system stability when connecting to land-based AC power systems, although this requires additional conversion equipment. Transmission losses are lower for HVDC than for AC, so AC undersea cables are more suitable for transmitting lower power levels over shorter distances. For example, AC undersea cables commonly connect offshore wind farms, which operate at less than 5 miles from shore (see Figure2-44) to onshore power generation stations.

Both AC and HVDC undersea power transmission cables are generally larger and more robust than telecommunication cables. Depending on the current-carrying capacity and insulation, undersea power cables can have a diameter as wide as 12 inches, whereas undersea telecommunications cables typically are 0.5 to 2 inches in diameter (ICPC 2011). A 500-megawatt HVDC transmission cable is about 4 inches in diameter and, when combined with a telecommunication cable and insulation, the bundle, or cable package, is about 10 inches in diameter (DBEDT 2013h). Figure 2-61 illustrates the sizes of a 500-megawatt HVDC transmission cable and insulation, which, when combined, form a typical undersea cable package.

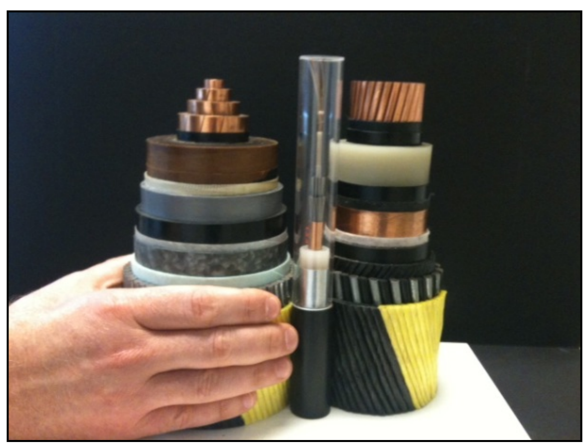


Figure 2-61. HVDC Undersea Cable, 500-megawatt Capacity (Source: DBEDT 2013c)

Several undersea cable systems are currently operational in the United States:

- Cross Sound Cable - Installed in 2002, the 24-mile-long HVDC undersea cable transmits 330 megawatts of electricity between New York and Connecticut.
- The Neptune – Installed in 2007, the 50-mile-long HVDC undersea cable transmits 660 megawatts of electricity between Long Island and New Jersey
- Trans Bay Cable – Installed in 2010, the 53-mile-long HVDC undersea cable transmits up to 660 megawatts of electricity under the San Francisco Bay Area.
- The Hudson Project – Installed in 2013, the 4-mile-long HVDC undersea cable transmits 660 megawatts of electricity between New York and New Jersey.

Undersea cables are common throughout world. The largest undersea cable in the world has a capacity of 2,000 megawatts, which is more than the State of Hawai‘i's entire electricity demand (DBEDT 2013l). For illustrative purposes, Table 2-31 provides statistics of some of the world's major undersea cable systems.

An undersea power cable typically comprises one or more insulated electrical conductors, held together by sheathing, and surrounded by protective layers and armor-encased in a tough outer covering (Figure 2-62 below). The protective layers and armor keep out moisture and protect the cable from abrasion. Screens function to shield the electric field. The electrical conductor is usually copper but can be aluminum, insulation is made from polymer materials (such as high-density crosslinked polyethylene), the metal sheath is made of lead, and the armor is galvanized steel wires. Specific designs vary by manufacturer and seabed conditions, with more armor added where needed, such as where waves and currents are strong (ICPC 2011). The life expectancy for an undersea transmission cable is between 30 and 40 years (DBEDT 2013h). There are systems in Europe that have been in place since the early 1960s and are still functioning.

Electrical charge movement through AC and HVDC undersea cables generate electromagnetic fields (EMF). Electrical fields are proportional to the voltage in a cable, and magnetic fields are proportional to the current (NOAA 2007 and OSPAR 2012). Electromagnetic fields also come from natural sources, such as the earth's magnetic field. Electrical fields are retained within the cabling through industry-standard shielding; however, magnetic fields are not completely retained within an undersea cable..

Table 2-31. Features of Major Undersea Power Cable Systems

Statistic		Name	Location	Cable Type	Voltage (kV)	Capacity (MW)	Length (miles)	Diameter (inches)	Maximum Depth (feet)	Year Installed
Longest AC undersea power cable:	**101 miles**	Martin Linge Field	Northern North Sea-Norway	AC	145	55	101	6.5 – 8.1	1,214	Proposed
Longest HVDC undersea power cable:	**360 miles**	NorNed	Netherlands-Norway	HVDC	450	700	360	Unknown	1,345	2008
Deepest undersea power cable:	**5,380 feet**	SAPEI	Italy	HVDC	500	1,000	261	Unknown	5,380	2011
Highest capacity undersea system:	**2,000 MW**	Cross-Channel	UK-France	HVDC	270	2,000	28	Unknown	5,249	1986
Year of installation of first HVDC undersea power cable:	**1954**	Gotland	Sweden	HVDC	100	20	60	Unknown	Unknown	1954

Sources: ABB 2010, 2012; DBEDT 2013h.
kV = kilovolt; MW = megawatt.

In order to facilitate the distribution of electricity through undersea cables, transition sites between undersea cables and land-based grids must be developed (see Section 2.3.5.1 of this PEIS). Land-sea cable transition sites manage the transfer of electricity between power generation sites and undersea cables, and between cables and on-island grids. Power can be transferred in either direction. An interisland (i.e., island-to-island) undersea cable would require land-sea cable transition sites at both ends of the cable, while an undersea cable from a marine-based alternative energy source, such as an offshore wind turbine or ocean thermal energy conversion facility, would require a single land-sea cable transition site.

LAND-SEA CABLE CHARACTERISTICS

Land-sea cable transition sites would use AC cables to connect to on-island grids.

A typical converter station consists of transformers, switches, and other high-power electrical components. Its function is to convert AC into DC (and vice versa) and to step up or step down cable voltage.

Marine-based alternative energy sources usually connect to land-sea cable transition sites using AC undersea cables. For AC undersea cables, the converter station would only function to step up or step down cable voltage.

The main features of a land-sea transition site are the converter station, which would be built onshore (see Figure 2-62 below), and the connecting cables, which would be installed on land to reach power generation and distribution sources and in shallow water to reach the end point of the undersea cable.

Converter stations typically include rectifiers (which convert AC to DC) and inverters (which convert DC to AC). The conversion equipment is housed inside a building, which provides electromagnetic shielding and noise reduction to the external environment. Transformers and switching gear equipment characteristic of transmission substations would be located adjacent to the building. A chain-link security fence would enclose the entire site, and an access road(s) may be constructed to allow for routine maintenance.

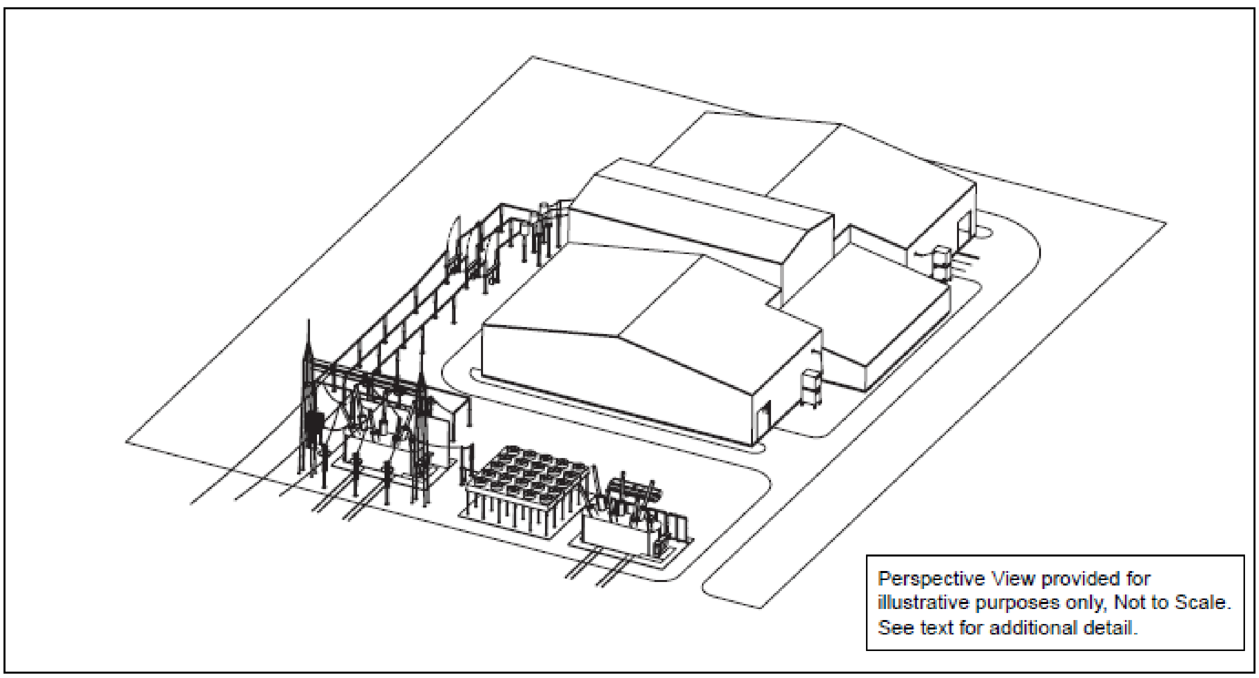


Figure 2-62. Schematic of Typical Converter Station

2.3.5.2.2 Characterization of Technology Feasibility and Deployment

In its current configuration, each island in Hawaiʻi maintains its own isolated power grid. An undersea cable could be used to interconnect these island grids. Power generated on an island where renewable energy potential is high but demand is low (i.e., Molokaʻi, Lānaʻi, Maui, and Hawaiʻi) could be transmitted to Oʻahu, where the demand for energy is high, but viable amounts of renewable energy resources to meet the demand are limited. Additionally, connecting island grids could help prices rise less abruptly than they are expected to without the cable and could also reduce the uncertainty of rates rising with oil price shocks (DBEDT 2013l). This would be achieved by being able to move lower cost power (populated areas with a larger base to recoup costs) to an area of high costs (remote areas with lower populations). Renewable generation facility costs would be spread over a much larger population base. Using undersea cables could allow for more use of renewable resources at predictable energy prices not tied to the price of foreign oil imports. At today's oil prices, an interisland transmission cable would be cost-effective, based on reasonable cost assumptions and renewable resource availability (DBEDT 2013l).An interisland cable also could provide emergency backup electricity between islands because electricity could flow through the cables in either direction.

HVDC or AC undersea cable could be used to connect an island to offshore energy facilities. Interisland cables most likely would be HVDC because more power can be transmitted more efficiently over longer distance with lower losses and at lower capital costs. From a technical perspective, an AC interisland undersea cable could be used to interconnect Molokaʻi and Lānaʻi, and even to Maui, but an AC cable cannot currently be used to efficiently connect Oʻahu to any of the other islands because of the longer distance (NREL 2011b). AC undersea cables are typically heavier than HVDC cables, which could further complicate installation in deeper waters. Figure 2-63 shows the distances and depths for the major channels between the islands, along with a cutaway diagram of an HVDC undersea cable.

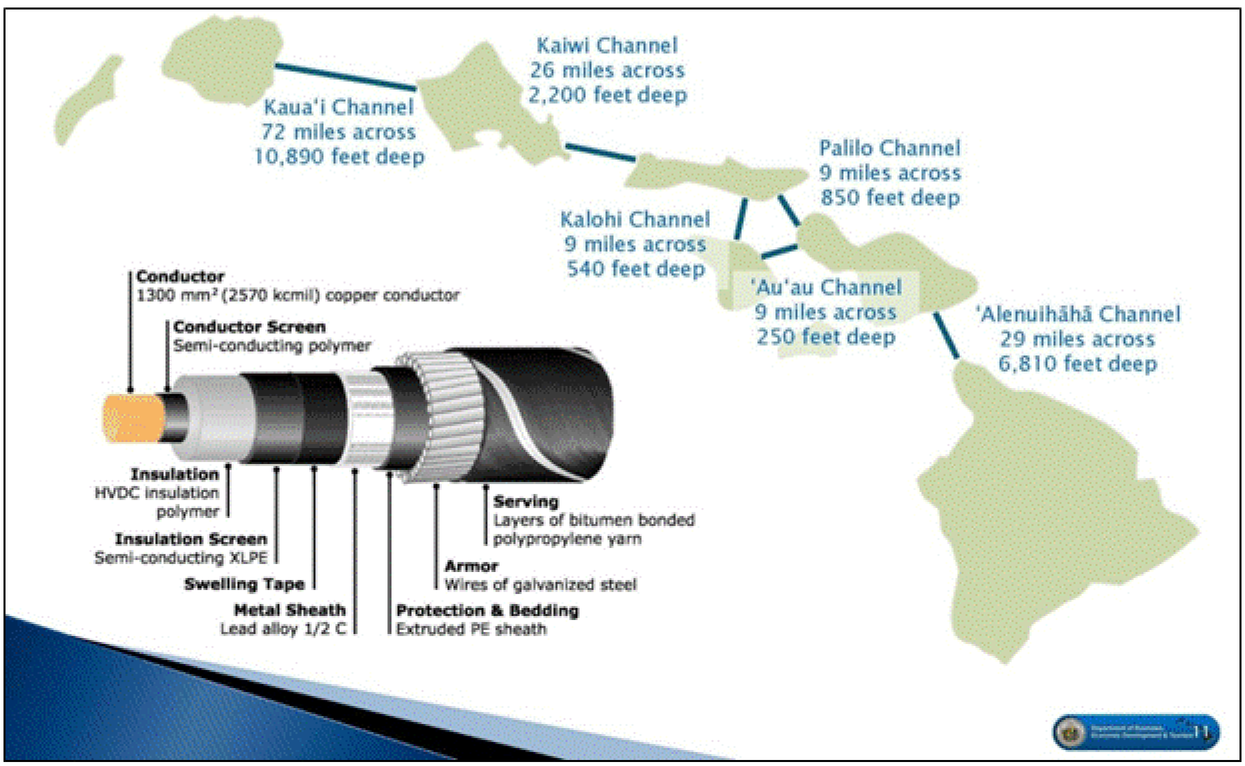


Figure 2-63. Characteristics of Deep Sea Channels in Hawaiʻi and HVDC Undersea Cable Diagram (Source: BOEM 2013)

Potential undersea power cable routes depend on the location of energy generation sources and suitable land-sea cable transition sites. Once the end point areas are identified, existing bathymetry, critical habitats, and seafloor data for the study area are analyzed. The contour of the ocean bottom includes hills, valleys, and plateaus, just like the surface of dry land. Additional ocean floor studies may be necessary to address data gaps. To the extent feasible, cable corridors would be sited to minimize cable length and trenching between end points. Cable length may be extended to avoid sensitive areas. Deep-water areas with a muddy seafloor are often preferred for siting cable corridors, as they would facilitate burial of an undersea cable. Existing and proposed undersea telecommunication cables and pipelines would be avoided to the extent practicable. Future ocean surveys would verify the positions of existing undersea telecommunication cables.

Challenges in siting interisland undersea cable corridors in Hawaiʻi include (DBEDT and SOEST 2010):

- Minimizing corridor length in whale sanctuary and other environmentally sensitive or restrictive areas (connecting Molokaʻi, Lānaʻi, and Maui would require cables in the Hawaiian Islands Humpback Whale National Marine Sanctuary);
- Avoiding deep-water obstacles, such as former reefs, and dumped materials and munitions;
- Avoiding coral reefs, which fringe all the islands and living (including precious) corals and extremely rugged seafloor dominate between east Lānaʻi and west Maui (Kihei);
- Presence of submarine canyons and landslides west of Molokaʻi due to steep slopes; and
- Minimizing crossing existing telecommunication cables, including military telecommunication cables, which will require coordination with DoD.

While there are no undersea power cables or land-sea cable transition site in Hawaiʻi, they are technically feasible. Current substation distribution would play a factor in siting the converter stations, as well as environmental siting considerations. Space requirements would be minimized and potential sites would likely be within 0.5 mile of the shoreline (AECOM 2012a). Specific configurations for the converter station are dependent on the power requirements of the undersea cable.

HSEO has testified in front of the PUC on whether a specific grid-tie interconnection would be in the public interest. The details of this testimony and more information is available at http://energy.hawaii.gov/renewable-energy/Oʻahu-maui-gridtie.

2.3.5.2.3 Permitting and Consultation Requirements

Section 2.2 above discusses general permitting requirements for clean energy projects in Hawaiʻi. A detailed listing of regulatory review requirements, permits, and approvals for an undersea cable is included in Appendix C of the 2012 *HIREP Reference Information Report*, which is available at http://energy.hawaii.gov/hawaii-interisland-renewable-energy-program-hirep-2. The following text regards some of the key permitting and consultation requirements specific to undersea cables.

Permitting an interisland cable and associated generation and conversion facilities would require extensive coordination with many Federal, State, and county agencies (at least two counties would be involved). In addition to the required environmental, land use, and construction permits, cable developers must obtain the right to use the sea floor from BOEM (3 miles and farther from the coastline) and the Hawaiʻi DLNR for seafloor use within 3 miles of the coastline. It is important that developers coordinate with these two agencies to ensure the submerged land use approvals coincide with each other and the proposed cable route. Developers should also consult with DoD and NPS early in the design process to ensure the proposed cable route and construction activities do not impinge on military operations and to avoid conflicts with NPS resources. In addition, projects should be designed to minimize impacts to Hawaiʻi's ocean-based commercial and recreational activities. Developers should consult the Hawaiʻi Office of Planning on proper ocean spatial planning issues.

Planning undersea power cable routes along existing telecommunication cable routes has benefits and drawbacks; for example, adjacent siting of a new cable may minimize environmental and ecological impacts and potentially leverage existing environmental reviews; however, new cables cannot have the potential to interfere with existing cable operations.

Regulations for an Undersea Power Cable

On June 27, 2012, the Hawaiʻi Legislature signed Act 165 into law establishing a regulatory framework for the installation and implementation of proposed interisland electric transmission cable systems (DBEDT 2013d). The PUC was granted review and approval authority for proposed undersea cable systems. In addition, certification criteria for the selection and approval of potential cable developers were established. It is important to note that that the statute does not mandate an interisland cable, or stipulate where the cable goes or the source of the energy that it may carry (Hawaiʻi State Legislature 2012). It only establishes the regulatory structure.

Agency Jurisdictions for Interisland Electrical Power Transmission Cables

Under the *Energy Policy Act of 2005*, BOEM has authority to issue right-of-way grants for proposed undersea cables located on Federal submerged lands of the Outer Continental Shelf located 3 to 200 nautical miles offshore. The right-of-way grants are 200 feet in width, centered on the cable, unless safety and environmental factors during construction and maintenance of the associated cable or pipeline require a greater width (BOEM 2013). BOEM is not authorized to issue right-of-ways within the National Park System, National Wildlife System, National Marine Sanctuary System, or National Monument. Where the prospective project requires access on, across, or through these lands or waters, a special use permit from NPS under 36 CFR 1.6 will be necessary.

The NOAA Office of National Marine Sanctuaries oversees policies and permit guidance for installing and maintaining undersea cables in National Marine Sanctuaries pursuant to Section 304(d) of the *National Marine Sanctuaries Act*. Special considerations apply to the Hawaiian Islands Humpback Whale National Marine Sanctuary, and NOAA's *Policy and Permit Guidance for Submarine Cable Projects* does not apply to the Papahanaumokuakea Marine National Monument, which is governed by other legal authorities including the *Antiquities Act* (16 U.S.C. §§ 431-433) (NOAA 2011).

2.3.5.2.4 Representative Project

As with the other representative projects identified in Chapter 2, the representative undersea cable project has been developed for analytical purposes only and is not intended to represent any real, proposed project by either the DOE or the State of Hawaiʻi. The representative project would involve interconnecting two islands with a 10-inch-diameter HVDC undersea cable. The undersea cable would have two-way transmission capability and would transmit 200 megawatts of renewable energy without grid instability. The cable would be 150 kilovolts.

The undersea cable would transfer power between two islands, bounded by two land-sea cable transition sites with a converter station at each end. Both converter stations would be designed to transmit and receive power. Each station would be designed to receive AC power from a renewable energy generation source (e.g., photovoltaic or wind turbine) or an island grid and convert that power to high-voltage DC for undersea cable transmission, and then receive high-voltage DC power from an undersea cable, convert that power back to AC, and transmit it to the island's electrical grid for distribution. Construction of the converter stations would take approximately 24 months. The grading and foundation work would require 20 construction workers, and building erection would require 10 to 15 construction workers. AC and DC electrical installation would require 20 additional construction workers. The tallest structures of the converter stations would extend up to 40 feet above ground level and be properly shielded and insulated to minimize noise and electromagnetic interference. The stations each would have a total footprint of 6 acres (3 acres plus an additional 3 acres for laydown and future expansion) (AECOM 2012b). They would each be located within 0.5 mile from the shoreline and within 10,000 feet of the endpoints of the cable.

Connection cable lengths and the amount of trenching needed would be minimized; however, cable length may be extended to avoid sensitive areas. Connecting cables from the converter station to the undersea cable connection point is particularly challenging, as the cable route may potentially cross sensitive nearshore coral zones. Horizontal directional drilling (HDD), a form of trenchless drilling that minimizes construction impacts, would be used to install cables in shore crossings (AECOM 2012b):

- HDD is a method of drilling an underground hole from a surface location along a prescribed bore path, suitable for installation of cable conduit. This technology was developed and utilized extensively by the oil and gas industry, making its use for an undersea cable landing safe and tested. Knowledge of the geology along the proposed bore route is extremely important for successful drilling.

- HDD bore diameter will be approximately twice the cable diameter.

- Directionally drilled micro-tunnels used in shore areas to minimize impacts can be up to three-quarter-mile long.

- HDD boring equipment requires a relatively short set-up time and a directional drilling rig can be set up and begin boring within a very short time. Labor requirements are minimal, as it only takes a small crew to operate a directional drilling rig. The temporary land requirement for a directional drilling setup is approximately 1 acre.

- The process starts with the positioning of the drilling rig at the desired start point and a small pilot hole is drilled. The directional drill rig then pushes a small-diameter bore head connected to a hollow steel drill pipe into the ground at an angle, where the rotating drill bit starts to drill. As each section of drill pipe is pushed into the ground a new section is added behind it. This process continues until the drill has reached its destination point.

- The drilling machine pumps a high-pressure jet of drilling slurry, which is generally a mixture of bentonite clay and water, through the pipe to the drill head. Selection of the drilling fluid varies on the soil conditions and geology of the region. Drilling is accomplished through the cutting action of the rotating drill bit and the high-pressure fluid jet. The drilling slurry performs several tasks: cutting the soil, lubricating and cooling the rotating drill pipe, and sealing the inner surface of the bore hole.

- Drilling waste includes the drilling fluid and solids removed from the bore, both of which require disposal. Temporary pits for drilling waste storage are dug at the points where the pilot hole is drilled. The solids suspended in the drilling fluid are separated and removed, and the fluid is then recycled back into the drill pipe. Drilling waste disposal options are determined on a site-specific basis.

- The most commonly used equipment for determining the location of the bore head while it is submerged is a transmitter and receiver system, with the transmitter located behind the bore head and the receiver box located above grade or in a small boat on the water. The transmitter registers the drill bit angle, rotation, magnetic direction, and temperature data and sends an encoded signal to the receiver to decode and relay to the operator. If needed, divers would position a remote antenna over the drill head to send signals back to the surface.

- When the drill bit reaches the exit point, workers remove the drill bit and install a hole-reaming bit. The HDD equipment then pulls the drill bit back through the bore toward the point of entry, rotating the drill pipe with as many passes as required to reach the correct diameter of the hole for installation of the main conduit pipe. Drilling rates for smaller pilot holes can range from 100 to 300 feet per day, depending on how well the location and depth of the drill head can be monitored by divers and how hard the undersea soil or rock conditions are. The longer the hole, the heavier the drill fluid would need to be to seal and lubricate the drill shaft.

- Once the correct size of the bore hole is reached for the cable conduit, workers would remove the reamer bit and reel the cable conduit out, and divers would attach the cable to the end of the drill pipe. Workers would arrange the assembled cable conduit and the HDD would pull it back through the bore hole. Throughout this process, bore fluid is being continually pumped into the hole to ensure that the hole is sealed with no void left between the drill pipe and the native soil.

- The connection point to the undersea cable would be located at least 10,000 feet from the shoreline due to the extent of HDD drilling reach, and endpoint connections are generally covered with rock or concrete to protect the emergence point of the cable.

The undersea cable would connect to the land-sea transition sites 10,000 feet from the shoreline using the HDD drilling method described above. Technical requirements for installing the interisland cable between these connections points are as follows (DBEDT and SOEST 2010):

- The lay rate for the cable-laying ship would be 2 to 3 knots in good conditions.

- Existing cable technology and laying techniques (direct lay or buried) can be used at ocean depths up to one-half mile;

- For cable protection, burial from 3 to 5 feet below the ocean floor is desirable in waters up to 328 feet deep, and may be considered for all water depths; and

- To the extend feasible, cables should route around steep slopes, sharp changes in slopes, suspended spans, sharp turns, or protected area.

General construction activities for the installation of an undersea cable could include the following (AECOM 2012b):

- The cable is laid on the seabed utilizing a cable-laying ship. A large cable reel located at the back of the cable-laying ship lets out the cable onto the ocean floor using a global positioning system.

- Starting at the land-sea cable connection point, the ship lets out the cable using floats, pontoons, or a barge to position the cable for attachment to an anchor point. Once the cable is anchored, the pontoons are removed and the cable is lowered to the ocean floor; the ship moves along its designated path toward the cable endpoint, and the cable continues lowering to the ocean floor.

- Once the ship approaches the end of the cable route, the cable on the ship is attached to the pontoons to enable the cable to be pulled to the point of connection (i.e., a connection point to a land-sea cable site).

- Before the final connection is made at the endpoint, an underwater robotic cable installation machine or remotely operated vehicle buries the cable, usually 3 to 5 feet below the ocean floor. Cables can be installed below the seabed at cable lay time or later after the cable has been laid on the ocean floor surface.

- There may be a need to cross seabed obstructions, especially in areas that are congested with submarine pipelines and other cables. In such case, use concrete mattresses to support the cable over obstructions, and/or cover the obstruction with protective cable sleeves.

- Cable-laying speed is faster in shallow waters than deeper waters because (1) it is easier to control the cable-laying direction and (2) the ship can travel faster and still maintain cable installation location.

- Shallow waters tend to hamper the movement of the ship, requiring that the cables be moved to shore using smaller vessels, such as tugs and barges, to pull the cables to the connection point.

- HVDC cable installation may occur in two primary ways: laying on the surface of the ocean floor or burial through shallow trenches on the ocean floor. For those instances when the cable is buried, the following activities would be implemented:

    - Cables placed and installed at the same time employ a larger robotic cable installer using a plow located at the front of the machine, which simultaneously plows a trench ahead of the cable and lays the cable into the plowed trench.

    - Cables placed onto the ocean floor surface and installed later after the cable is positioned use a remotely operated water jet installer, which is usually smaller and quicker to deploy. The robotic cable installer travels along the cable and lifts it up while high-pressure water jets excavate a trench, just wide enough for the cable. The installer machine then lays the cable back down in the trench as it propels itself along. The trench fills itself in over a short period of time due to natural wave and sediment movement along the ocean floor.

- If large rocks or formations are encountered, the cable installation machine sends a signal back to the operator and halts installation.

2.3.5.3 Smart Grid

Smart grid has become a widely used term-of-art across the utility industry. While specific goals and impacts of smart grid deployment vary from utility to utility, the benefits of investments in smart grid projects generally fall into five areas (ElectricityPolicy.com 2011):

- Projects designed to reduce peak capacity. These range from demand response (turning off loads at designated time) to energy storage (moving demand from on peak to off peak).

- Projects designed to improve operational efficiency. These include smart meters, smart transformers, and relays. All are focused on better and less costly operation of the grid.

- Projects that are designed to improve reliability. These range from micro grids to phasor measurement units. All are focused on reducing or preventing both short-term and long-term outages.

- Projects that are designed to improve the overall efficiency of the grid (i.e., less kilowatt-hours for a given performance). These range from consumer energy management and smart appliances to more efficient cables and devices. All are focused on reducing the amount of energy required and resulting emissions.

- Projects that are designed to integrate new clean technologies into the grid. These include smart electronic vehicles, renewables, and batteries. All are focused on reducing the emissions per megawatt-hour on the grid.

In 2007 the DOE released a study that described the key technologies required to create a smart (modern) grid. The study included the following findings regarding the uses of these technologies:

- Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.

- Dynamic optimization of grid operations and resources, with full cyber security.

- Deployment and integration of distributed resources and generation, including renewable resources.

- Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

- Deployment of ‘‘smart’’ technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.

- Integration of ‘‘smart’’ appliances and consumer devices.

- Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid-electric vehicles, and thermal- storage air conditioning.

- Provision to consumers of timely information and control options.

- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.

- Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.”

National-level policy makers often refer to the “national grid” as having three main interconnections: The Eastern Interconnect, the Western Interconnect, and the Electric Reliability Council of Texas. These are three largely independent and extremely complex systems whose design and operations have their own unique features and challenges. Both Hawai‘i and Alaska have their own unique grids and that both states actually have more than one grid.

In addition to national efforts, on April 23, 2013, the Governor of Hawai‘i signed into law Act 34 of 2013, relating to electric systems and addressing smart grid technologies (Hawai‘i State Legislature 2013) The bill authorizes the PUC to consider the value of implementing advanced grid modernization technology in the State. In addition, local utilities have smart grid programs that vary in scope and timelines with much of the emphasis on grid stability and variable source integration.

2.3.5.3.1 Technology Description

Understanding how the electrical grid works is key to understanding how the abovementioned smart grid technologies work and how they can be deployed. Section 2.3.5.1.1 of this PEIS provides a brief tutorial on the electric power cycle. While new technologies and companies are emerging all the time, the five basic areas of related technology innovation are illustrated in Figure 2-64 and described in the following text.

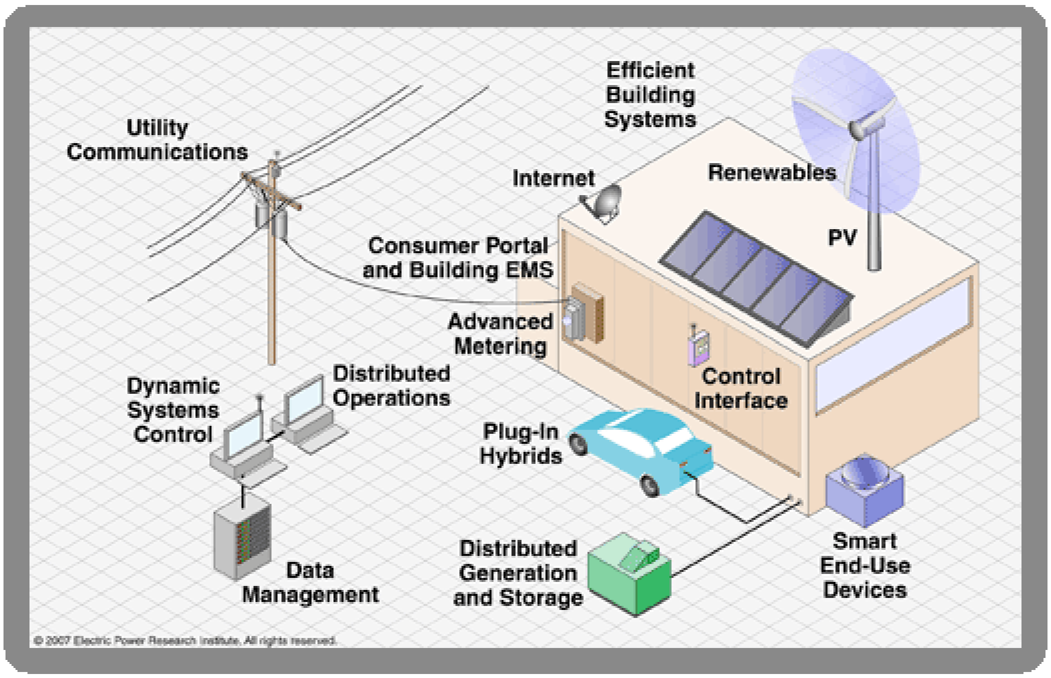


Figure 2-64. Diagram of Smart Grid Integration

- Integrated Communications – High-speed, fully integrated, two-way communication technologies that make the modern grid a dynamic, interactive “mega-infrastructure” for real-time information and power exchange. An open architecture creates a plug-and-play environment that securely networks grid components and operators, enabling them to talk, listen and interact.

- Advanced Components – Advanced components play an active role in determining the electrical behavior of the grid. These power system devices apply the latest research in materials, superconductivity, energy storage, power electronics, and microelectronics to produce higher power densities, greater reliability and power quality, enhanced electrical efficiency that produces major environmental gains and improved real-time diagnostics.

- Advanced Control Methods – New methods and algorithms monitor power system components, enabling rapid diagnosis and timely, appropriate response to any event. They also support market pricing and enhance asset management and efficient operations.

- Sensing and Measurement – Technologies that enhance power system measurements and enable the transformation of data into information. They evaluate the health of equipment and the integrity of the grid, and they also support advanced protective relaying. They enable consumer choice and demand response, and help relieve congestion.

- Improved Interfaces and Decision Support – The modern grid will require wide, seamless, often real-time use of applications and tools that enable grid operators and managers to make decisions quickly. Decision support and improved interfaces will enable more accurate and timely human decisionmaking at all levels of the grid, including the consumer level, while also enabling more advanced operator training.

Many utilities have programs underway as a normal course of business that modernize their systems. For example, utilities replace aging transformers, capacitor banks, and relays at a certain rate each year with state-of-the-art equipment that can be monitored and operated remotely. Utilities are upgrading their information technology infrastructure with more sophisticated communication platforms as well as software that automates various processes including engineering, operations, and customer management.

Smart meters are often thought to be synonymous with smart grid, when they are just one technology (or set of technologies) of a smart grid system. Smart meters remotely measure the amount of electricity a specific customer uses. Many utilities have found that using smart meters at the edge of the grid offers many benefits, including the ability to actively monitor power outages and restorations, remotely connecting and disconnecting customers, and managing line voltages to tighter tolerances.

2.3.5.3.2 Feasibility and Deployment of Smart Grid

Hawaiʻi has several smart grid projects in various stages of deployment. The early successes of many of these projects have already begun to demonstrate the feasibility of implementing smart grid in Hawaiʻi. Four of the most substantial and relevant projects are outlined below.

Maui Smart Grid Project

The Maui Smart Grid Project (http://www.mauismartgrid.com) is a demonstration project that was funded by the DOE's Renewable and Distributed Systems Integration program through the *American Recovery and Reinvestment Act of 2009* (known as the Recovery Act). The total budget for the project was $15 million from 2009 to 2013, with $7 million in DOE funds and $8 million cost share with partners. The HNEI (based at the University of Hawaiʻi at Manoa) and MECO led the project team. The Maui Smart Grid Project tested the feasibility of smart grid technology on Maui and evaluated new smart grid technologies to enable a cleaner, more efficient energy system on the island. This pilot project took place in the Maui Meadows neighborhood in South Kihei on a voluntary, opt-in basis. All participants had a smart meter professionally installed at their house and received access to a personalized energy data website. Through this website, participants can easily monitor and control their energy consumption. The project will collect data for at least one year and submit a report to the DOE, evaluating the technologies and impacts on volunteer energy usage on Maui. Project results will be compared with other demonstration projects throughout the United States and also be used for decisionmaking on future smart grid initiatives in Hawaiʻi.

Project objectives are as follows (HNEI 2009c):

- Reduce distribution circuit peak loading by greater than 15 percent by demand response, switching peak loads to energy storage, and reducing voltage.

- Improve service quality by using integrated voltage/variance control and outage management.

- Enable consumers to manage their energy use to minimize electric bills by using customer portals and advanced home energy gateways for a few homes.

- Support grid stability with controllable loads, storage, and improved voltage/current information.

- Enable greater utilization of as-available renewable energy sources by providing measurement and estimation of distributed PV to the utility operator.

Kauaʻi Smart Grid Demonstration Project (Smart Meter Installation)

In November 2009, pursuant to the Recovery Act, DOE awarded KIUC and 26 other electric cooperatives from 10 states a $33.9 million matching grant for the National Rural Electric Cooperative Association's Cooperative Research Network smart grid project. The total cost of the joint project is $67 million; KIUC's portion is $11 million, of which $5.5 million is being covered by Recovery Act funds. The purpose of the project is to test and develop technologies that operate together to make the electrical power grid more efficient and reliable. The KIUC project involves replacing about 33,000 meters with smart meters, along with communications infrastructure that will allow two-way communication between the meter and KIUC (see http://website.kiuc.coop/content/smart-grid). The 5-year project includes 2 years to replace all 33,000 meters and 3 years to observe and access their functionality and collect energy usage data. Installation of smart meters is almost complete, and the project is expected to continue on time.

Project objectives are as follows (KIUC 2011; Cicotello 2012):

- Enable KIUC to read meters remotely,
- Demonstrate the effectiveness of load control and demand response options within households,
- Manage and detect outages to the household level, and
- Evaluate different rate designs depending on usage.

Jump Start Maui Project

Japan's Hitachi, Cyber Defense Institute, and Mizuho Corporate Bank are working with HECO, the State of Hawaiʻi, the University of Hawaiʻi, and United States national laboratories on a smart grid demonstration project on the island of Maui (see http://maui.com/?p=398). The project is based on the *Japan-U.S. Clean Energy Technologies Action Plan of 2009* and has a projected budget of $37 million. Hitachi, along with the other participants, conducted a feasibility study in 2011. Based on the results, the project is expected to begin in the winter of 2013 and conclude in the winter of 2015. Technologies that will be utilized include power distribution control, demand-side load control, control-information and communication technology platform, electric vehicles operation and charging control, multiple types of rapid chargers, and information and telecommunications technologies (JUMPSmart Maui 2013).

Project objectives are as follows (Peeples 2011):

- Implement advanced load shifting for optimum use of renewables,

- Increase the level of direct control of home appliances and solar generation output to manage quick changes in power supply and demand,

- Integrate electronic vehicle management systems with the grid management system to manage the impacts of high electronic vehicle concentrations,

- Introduce autonomous control architecture (intended to support scalability and rapid response energy control), and

- Increase cyber security.

U.S. Department of Defense SPIDERS Project (Wheeler Army Airfield)

SPIDERS, or Smart Power Infrastructure Demonstration for Energy Reliability and Security, represents the latest Joint Capability Technology Demonstration project involving the DOE, DoD, and DHS. The SPIDERS project demonstrates energy secure micro grids and transitions them as real property improvements at three DoD locations. Phase I was a circuit-sized demonstration at Joint Base Pearl Harbor Hickam followed by a larger Phase II effort at Fort Carson, Colorado. The largest project, an installation-sized micro grid at Camp H.M. Smith in Honolulu, will incorporate the entire base into the micro grid and is still in the initial planning stages (Sandia 2012b). Project objectives are as follows:

- Protect defense-critical infrastructure from power loss due to physical disruptions or cyber attacks to the bulk electrical grid.
- Integrate renewable energy sources and other distributed generation to power defense-critical infrastructure in times of emergency.
- Sustain critical operations during prolonged utility power outages.
- Manage DoD installation electrical power and consumption efficiently to reduce petroleum demand, carbon footprint, and cost.

The Army's Aloha Micro Grid Project: Smart Charging Micro Grid

The Smart-Charging Micro Grid system at the Wheeler Army Airfield base consists of a 25-kilowatt solar array on a carport, 200 kilowatt-hours of battery storage capacity, and four plug-in electric vehicles. The system powers the four electric vehicles and also has the ability to provide instant backup power to support three buildings for 72 hours, including the Garrison headquarters (U.S. Army 2011).

Based on the examples above it is clear that the electrical grid is in the process of evolving to a much different system that supports more real-time optimization, more diverse sources of electricity, more actively managed customer loads, and more dramatic variability. Hawai‘i will continue to invest in a smarter grid to meet all these demands, and while the environmental impact will not be zero, the net impact of integrating more clean-energy sources will have a positive benefit.

Hawai‘i is somewhat unique compared to the rest of the United States because of the large military/ government loads that are served. While infrastructure improvements are paid for by the U.S. government, the infrastructure often must integrate with the local electrical distribution system. While infrastructure improvements represent large opportunities for demand response and other operational strategies, they also represent a very major critical load that has unique reliability requirements.

2.3.5.3.3 Permitting Requirements

See Section 2.2 for a discussion on general permitting and regulatory requirements for proposed clean energy projects in Hawai‘i. Before implementation, smart grid projects must first meet local technical codes and requirements. Furthermore, individual counties within the State may require island-specific permits for construction activities, such as laying new utility lines, that may play a role in any smart grid development (Hawai‘i 2013c, DBEDT 2013a).

In addition, before utilities accept and deploy smart meters, these devices must meet a number of national and industry standards and comply with State and local codes designed to ensure proper operation, functionality, and safety. Smart meters are designed and certified to comply with:

- ANSI C12.1, 12.10, and 12.20: Standards for accuracy and performance;
- NEMASG-AMI 1, "Requirements for Smart Meter Upgradability"; and
- Title 47 CFR 1.1307(b), 1.1310, 2.1091, 2.2093, Federal Communications Commission standards for intentional and unintentional radio emissions and safety related RF exposure: Parts 1 and 2 of the Commission's Rules and Regulations.

The Edison Electric Institute and other industry groups prepared *A Discussion of Smart Meters and RF Exposure Issues*, which provides a relevant summary of key requirements and observations related to potential radio frequency exposure (EEI – AEIC – UTC 2011). The study is available for download at http://aeic.org/wp-content/uploads/2013/07/smartmetersandrf031511.pdf.

2.3.5.3.4 Representative Project

A representative smart grid project is assumed to consist of the following:

- Two-way communicating digital meters for every customer with the ability to control a small number of in-home/in-business devices.

- A comprehensive, robust, secure communications infrastructure capable of near real-time communication to more than 100,000 remote devices. Existing communications infrastructure would be used, including fiber optic cables connecting to radio towers and take out points that receive the signals from the remote wireless devices.

- Digital power equipment throughout 50 percent of the grid capable of real-time monitoring and communication.

- A robust geographic information system-based grid operation platform capable of collecting all remote data, performing real time analysis, and making operational decisions for both normal and emergency operations (including the ability to manage significant variable sources).

- A customer data collection and management system capable of providing near real time feedback to customers and control signals for significant customer loads.

Impacts from construction and operation activities related to the deployment of these smart grid technologies (e.g., replacement of existing meters in the customer facilities, installation of new fiber optic cable using existing structures, and installation of new instrumentation at the utility) would be minimal. However, as technologies advance, the requirements of existing jobs will change. Gridwise Alliance's study on smart grid workforce trends predicts that utility companies and other smart grid stakeholders will need to focus a considerable effort toward both retraining current employees and recruiting new ones as the growing industry creates more jobs (GridWise 2011). Specific workforce classifications that would be affected by smart grid deployment include the following:

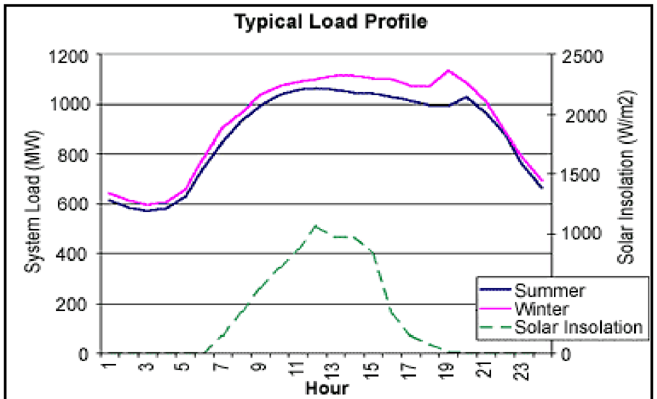
- Line technicians
- Meter readers
- Meter electricians
- Engineer (new construction)
- System operation/dispatch
- Administrative support
- Substation operations
- Engineering support (planning/reliability)
- Management/supervision
- Customer service representatives
- Supply chain
- Meter lab repair
- New hires
- Communications technicians
- Contract construction/engineering labor
- Other support (IT, staffing)

Smart meters are one of the more controversial elements of a representative project and have drawn some concerns from certain public groups primarily focused on wireless radio frequency exposure. Industry has played a role in research and development and has completed a number of reports and studies on the topic, available from the Maui Smart Grid Project website: http://www.mauismartgrid.com/category/news/.

Smart grid projects vary substantially from utility to utility. However, the benefits of a comprehensive smart grid deployment in Hawai‘i are many relative to other places in the United States for several reasons including the high cost of energy, the high penetration of variable power sources, and the small size of the grid(s). Specific technology choices are not critical to assessing the environmental impact of a representative project. Implementing such a project is largely software- and telecommunications-based with minimal impact.

2.3.5.4 Energy Storage

Traditional utility models track electricity from generation to demand but demand variations can be large, resulting in underutilized electricity, as represented in Figure 2-65, resulting in underutilized electric generation and unbalanced loading. Energy storage can take electricity that is generated at one point in time and store it for use at a different time. Incorporating energy storage in the electricity distribution chain allows utilities to decouple generation from demand which has several benefits, including improved use of generated energy. This would help to minimize costs to utilities that, ultimately, would benefit ratepayers. Another benefit is delaying (or eliminating) large capital projects, such as transmission expansion, by using stored energy to alleviate bottlenecks. A third benefit is further integration of electricity from renewable energy resources whose availability may not be aligned with demand (Baxter and Makansi 2002).



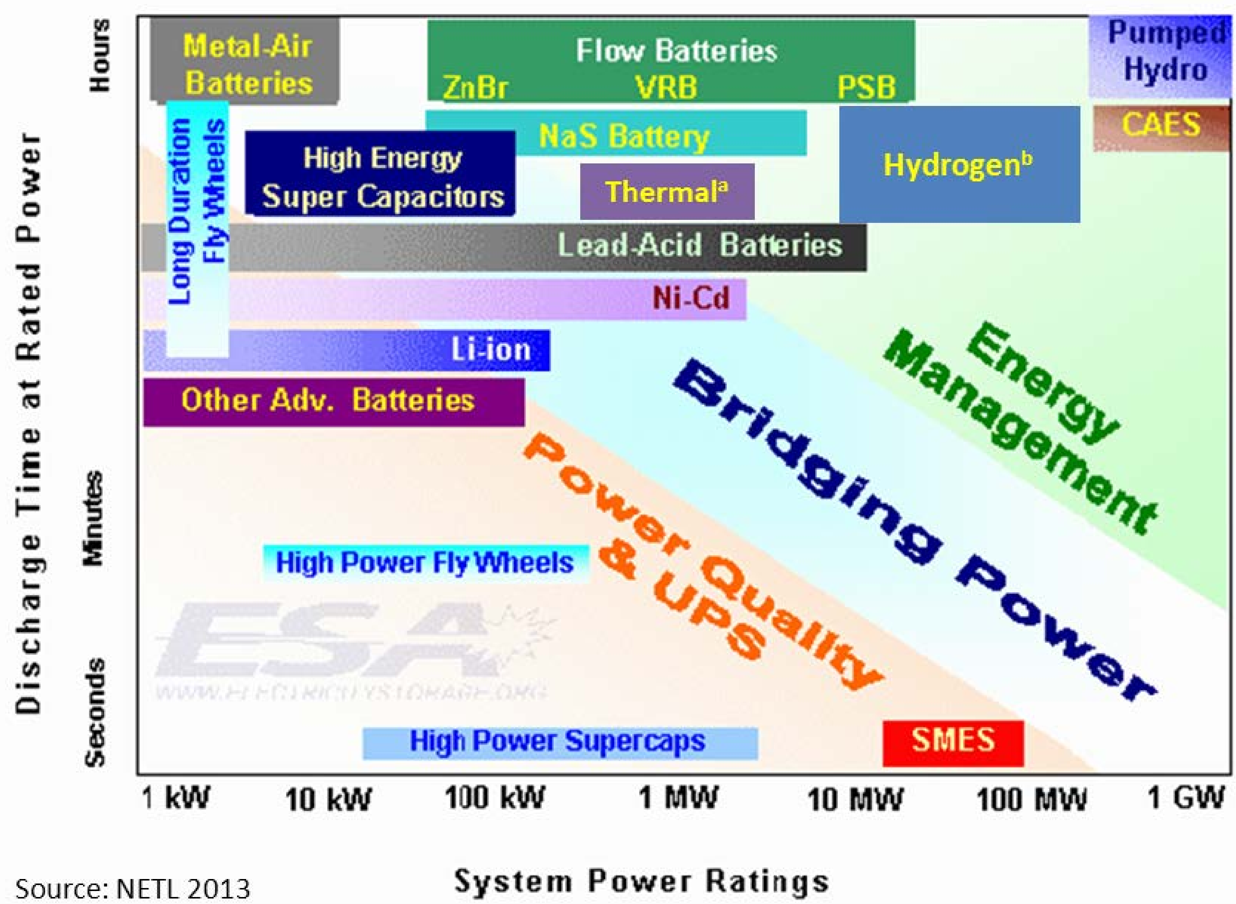
Source: HECO 2013.

Figure 2-65. Typical Weekday Demand for Hawai‘i

Energy storage systems are designed with different energy densities, response times, time of operation, and power depending on the target application. In the electricity distribution chain, the primary applications for energy storage systems are:

- Energy Management – To provide electricity for use during a period other than the one during which it was generated. This energy storage system comes on slowly and lasts several hours.
- Bridging Power – To provide uninterrupted service when the generation source is switched. This energy storage system comes on quickly and lasts just a few minutes.
- Power Quality and Reliability – To ensure that any changes or fluctuations in power quality upstream do not impact sensitive users or equipment downstream. This energy storage system at times operates less than a second in response to the upstream fluctuation providing an uninterrupted power supply (UPS) to the equipment downstream.

Energy storage systems are designed to operate effectively in one or more of these applications. Figure 2-66 shows the different energy storage technologies available by discharge time, amount of power (power rating), and application.



Source: NETL 2013

a. Source: Sopogy 2013.

b. Source: Steward et al. 2010.

CAES = compressed air energy storage; Li-ion = lithium-ion; Ni-Cd = nickel cadmium; NaS = sodium sulfur; PSB = polysulfide bromide; SMES = superconducting magnetic energy storage; VRB = vanadium redox battery; ZnBr = zinc bromide

Figure 2-66. Power Rating vs. Discharge Time for Energy Storage Technologies

2.3.5.4.1 Technology Description

Energy storage can be achieved in a many ways, resulting in either long-term energy supply or short bursts of power depending on the application (Baxter and Makansi 2002). The text that follows briefly describes each of the technologies and their applications. The technologies are listed in alphabetical order.

Source: HECO 2013.

Figure 2-67. Ultra Capacitor Installation

Capacitors

Capacitors store energy electrostatically. They contain two electrical conductors with an insulator, known as a dielectric, between them. When there is voltage across the conductors, an electric field develops with one side becoming positively charged and the other negatively charged. Capacitors can discharge rather quickly, making them ideal for power quality and bridging power applications (Eyer and Corey 2010). Ultra-capacitors essentially are two or more capacitors in series. Figure 2-67 shows a 30-foot trailer housing 640 ultra-capacitors with a maximum power of 263 kilowatts (Schneuwly 2009).

Compressed Air Energy Storage

A gas turbine uses air that is pressurized in the compressor section of the system. This pressurization typically uses two-thirds of the energy produced (Baxter and Makansi 2002). With compressed air energy storage, air is pressurized during low-demand times and stored for use during peak demand periods. In a large system, the air can be stored in natural underground formations such as salt caverns, hard-rock mines, and aquifers (Baxter and Makansi 2002; Eyer and Corey 2010). There are two plants using this technology; one in Alabama and one in Germany (EPRI 2010). For smaller quantities of compressed air, aboveground pressurized storage tanks or pipes can be used. Submerged systems are being considered by NELHA (Gill 2013). Compressed air energy storage systems are used for energy management although the size of this storage is dependent on the turbine system that will use it and the amount of time in which it will operate; however, aboveground storage is typical for capacities on the order of 3 to 15 megawatts (EPRI 2010). Figure 2-68 shows the process diagram for a generation facility with compressed air energy storage.

Flow Batteries

Batteries use electrochemical processes to convert chemical energy to electrical energy. They are composed of two or more electrochemical cells that include two electrodes and an electrolyte. Chemical reactions between the materials cause electrons to flow from one electrode to another, creating a current. Most batteries store the electrodes and electrolyte within a single container; however, with flow batteries the electrolyte is stored separately, outside of the battery container. The electrolyte flows into and out of the battery container during charging and discharging (Eyer and Corey 2010). Although the electrolyte is stored separately, this is still a closed loop system (Baxter and Makansi 2002). Some of the most common chemistries used in flow batteries are polysulfide bromide (PSB), vanadium redox battery (VRB), and zinc bromide (Zn/Br) (Eyer and Corey 2010). Flow batteries are used in energy management applications.

The benefits of flow batteries are the separate storage of the electrolyte, which allows for more of the material to be added, thereby increasing the discharge duration. This configuration also allows for replacement of the electrolyte as it degrades without replacing the other components. Another benefit of flow batteries are their capacity to be customized based on the electrolytic tanks. As of June 2012, there was a 60-kilowatt Zn/Br project on Oʻahu serving as back-up power for an elevator (DOE 2013v).

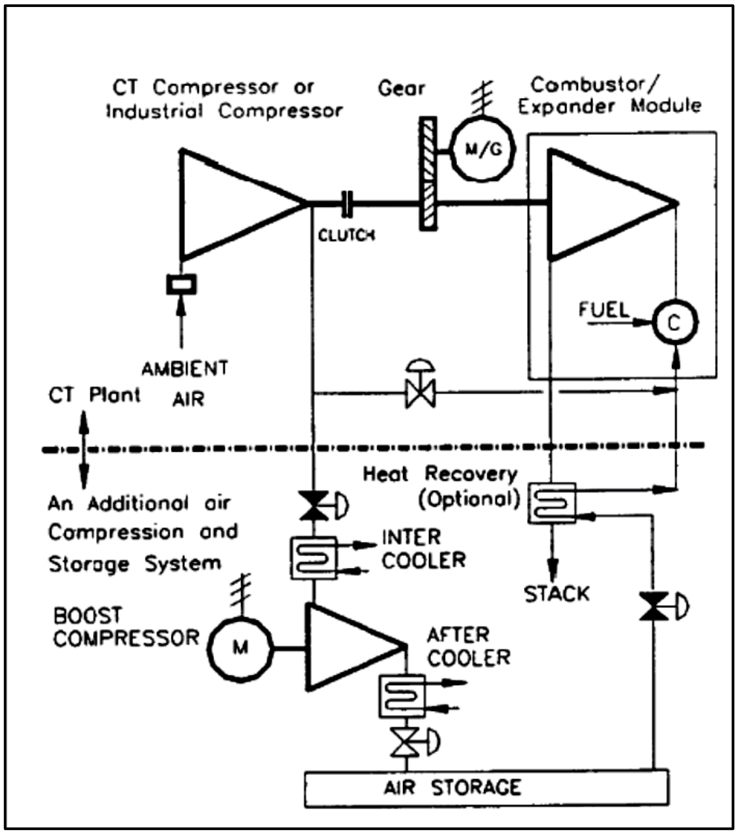


Figure 2-68. Process Diagram for a Turbine Generator System with Compressed Air Energy Storage (Source: NETL 2013)

Flywheels

Flywheels store energy in a spinning mass as inertial kinetic energy. The storage system consists of a cylinder with a rotor that is connected to a motor/generator, which accelerates the rotor to high speeds (Figure 2-69). Magnetic bearings limit friction losses and wear. When the energy is needed, the rotor is decelerated and the kinetic energy through the motor/generator is converted back to electrical energy. A robust enclosure surrounds all the components to protect anything on the exterior should there be a failure of the high-speed components (Baxter and Makansi 2002; Eyer and Corey 2010).

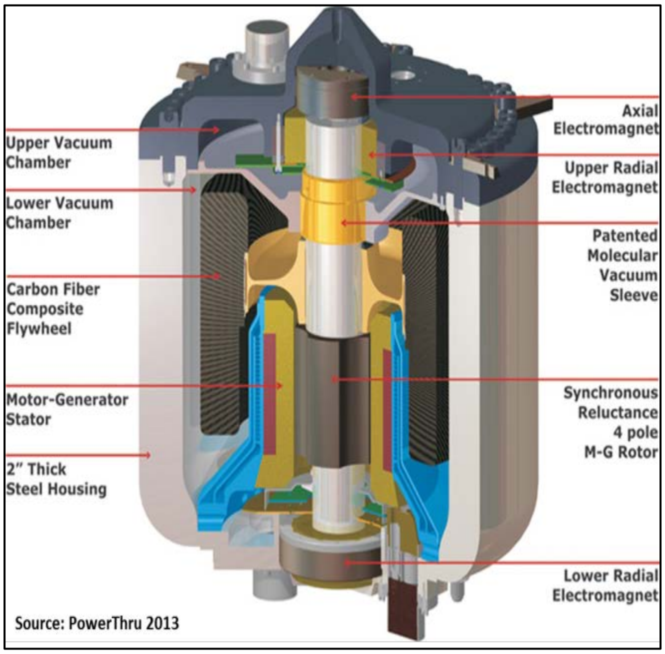


Figure 2-69. Flywheel Cross Section

Flywheels are designed for frequency regulation and reserve power. They have a fast response time, making them more effective than a conventional generator in stabilizing a system (Akhil 2013). For these reasons, flywheels are used in power quality and uninterruptible power supply applications.

Hydrogen

The production of hydrogen involves the conversion of electricity into a gas that can be used in a variety of applications, including fuel cells, internal combustion engines, or in the production of liquids such as hydrogen-treated renewable jet fuel. Although the round-trip efficiency of electricity-to-hydrogen-to-electricity is less than other energy storage options, potential revenue from the sale of hydrogen for other uses, including transportation and biofuel production, could influence specific project size, location, and feasibility (Steward et al. 2010). Hydrogen-related technologies are further discussed in Sections 2.3.2.3 and 2.3.4.4.

Lead-Acid Batteries

Lead-acid batteries have the oldest chemistry of the batteries described here (BCI 2013). Lead-acid batteries are made in the traditional battery configuration of two electrodes and an electrolyte within a single container. Lead-acid batteries are reliable but have a limited operating range, which have kept them from being widely used in the electricity business (Baxter and Makansi 2002). Advanced lead-acid batteries are modern versions of lead-acid batteries that have addressed some of the limitations of traditional lead-acid batteries. These systems have additives like carbon and other additional components for improved performance, high power, or better cycle life (Akhil 2013). Lead-acid batteries are the most commonly used in energy management and bridging power applications.

Advanced lead-acid batteries that operate more efficiently and have an increased cycle life[32] have been paired with solar and wind installations on Maui, Lānaʻi, Oʻahu, and Kauaʻi with some success (DOE 2013v; HNEI 2013c). The sites vary in storage size from 1.5 to 15 megawatts. For example, the battery installation on Lānaʻi is paired with a 1.2-megawatt solar farm. The 1.125-megawatt battery system mitigates the solar generation's variability and allows the facility to sell its full capacity of 1.2 megawatts to MECO's Lānaʻi grid (DOE 2013v).

Lithium-ion Batteries

Like lead-acid and flow batteries, lithium-ion batteries use chemical reactions to store and release energy. There are a variety of slightly different chemistries in this group although all are generally referred to as lithium-ion (Oberhofer 2012). The electrodes of a lithium-ion battery are made of lightweight lithium and carbon. Within lithium-ion batteries there can be various cathode materials such as lithium iron phosphate ($LiFePO_4$) and lithium titanate ($Li_4Ti_5O_{12}$). The chemistry can store several times more watt-hours per kilogram compared with lead-acid batteries, making these batteries popular for portable consumer electronic products (HNEI 2013c). Within the electricity distribution chain, lithium-ion battery systems are still small, making them useful in power quality and uninterrupted power supply applications.

There are several projects in Hawaiʻi where lithium-ion batteries are being used. The Ke Alahele Center, which is part of the Maui Economic Development Board Building, has a 16-kilowatt $LiFePO_4$ battery system in a power quality and grid stabilization application (HNEI 2013c). In addition, the MECO has selected lithium-ion batteries to provide energy storage capabilities to the Maui Smart Grid Project. The 1-megawatt system will deliver power for a full hour to reduce the peak energy load on the substation's transformers thereby increasing grid stability and power quality (MECO 2012).

Pumped Storage Hydroelectric

Pumped storage hydroelectric consists of a lower and upper water reservoir, pumps, and a hydraulic turbine. When power is plentiful and cheap, water is pumped using a non-hydroelectric energy source from a lower elevation to a reservoir at a higher elevation. When energy is needed, water is released from the upper reservoir and passed through the turbine to generate power. Pumped storage units are generally utilized in energy management applications as back-up power generation during times of peak load, to

[32] Cycle life is the life of a facility or unit based on the number of times it is used (Baxter 2002).

stabilize the power grid, and provide clean, reliable, baseload power. These systems are the most commercially viable energy storage available today for large energy storage in the hundreds of megawatts (ORNL 2010). The large capacity comes with a large footprint. In an island application, seawater can be used as the lower water reservoir, thereby reducing the construction time and area. However, the upper reservoir can still be quite large, as is the case with the Okinawa Seawater Pumped Storage Plant upper reservoir, which covers a 14-acre area, has a total storage capacity of 156 million gallons, and provide 30-megawatts of power (IEA 2000). Pumped storage is a proven form of energy storage for electric utilities with over 150 plants in United States. Several natural geological features are needed for this technology, including close land areas divided by adequate elevation, and an adequate water supply. Smaller scale pumped storage is possible requiring less land disturbance but size will vary depending on the power needs, geological features and water available (HECO 2013j).

Sodium-Sulfur Batteries

Like the other previously mentioned batteries, sodium sulfur batteries work based on electrochemical processes. The sodium sulfur battery chemistry consists of molten sulfur on the positive electrode (anode) and molten sodium on the negative electrode (cathode). The electrolyte is a beta-aluminum tube (Baxter and Makansi 2002). The technology requires elevated temperatures (300° to 350°C), which poses a few challenges; however, the battery modules and the sites with sodium sulfur batteries maintain safety systems, such as fire suppression systems, in the event the elevated temperatures or chemistry result in a fire (Akhil 2013). These batteries have been used in commercial applications at the megawatt scale for more than 10 years, and enhancements continue to be made. Most large installations consist of modular units capable of storing 1 or 2 megawatts each. Sodium sulfur batteries are capable of long discharge time, up to 6 hours (Akhil 2013), so they are used in energy management applications.

There are more than 300 megawatts of sodium sulfur battery systems installed globally. Japan is planning to install an 80-megawatt system consisting of 40 sets of 2-megawatt sodium sulfur battery systems at the Noshiro thermal power station to supply energy during peak demand (Hatta 2011). Sodium sulfur batteries currently are manufactured by only one company, with an annual production of 90 megawatts (NEA 2008). Figure 2-70 shows a general battery diagram and a 2-megawatt sodium sulfur battery installation in Bluffton, Ohio (AEP 2013).

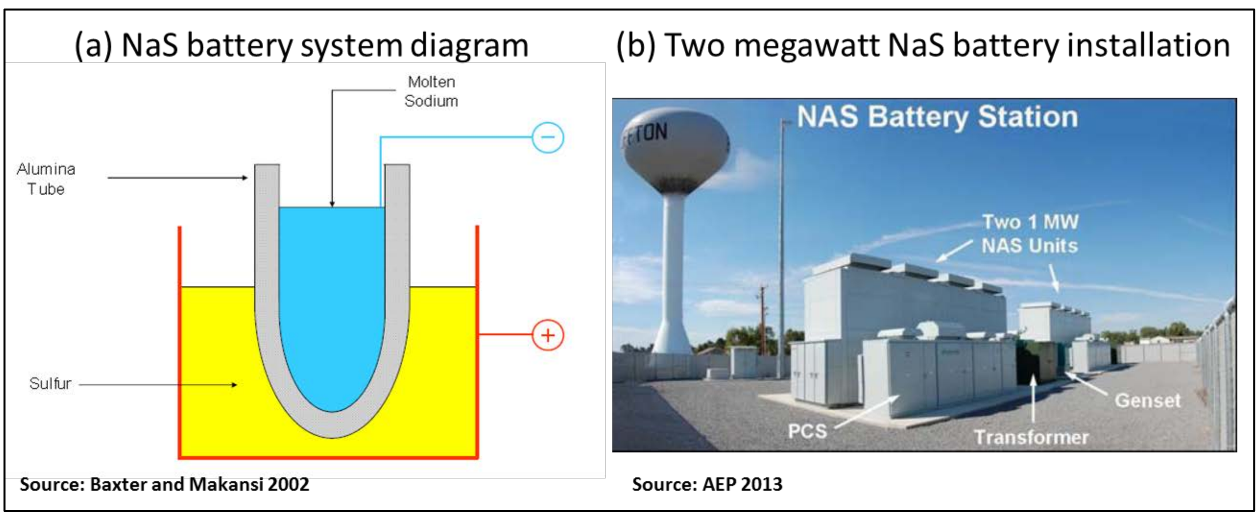


Figure 2-70. Sodium-Sulfur Battery Installation

Superconducting Magnetic Energy Storage

A superconducting magnetic energy storage system stores energy in a magnetic field. The system consists of a superconducting coil, power conditioning equipment, and a cryogenic cooling system, as shown in Figure 2-71. The coil is cooled below the material's critical temperature, and DC is sent through the coil, generating a magnetic field. This method of storage is very efficient and the energy can be held as long as the refrigeration is available. The system provides high power over a short duration and is being designed specifically for grid applications (Baxter and Makansi 2002; Eyer and Corey 2010). Currently, there are about 10 projects worldwide that have implemented this technology. DOE's Advanced Research Project Agency – Energy is funding some supercomputing magnetic energy storage projects, suggesting the technology is still in the infancy stage of development.

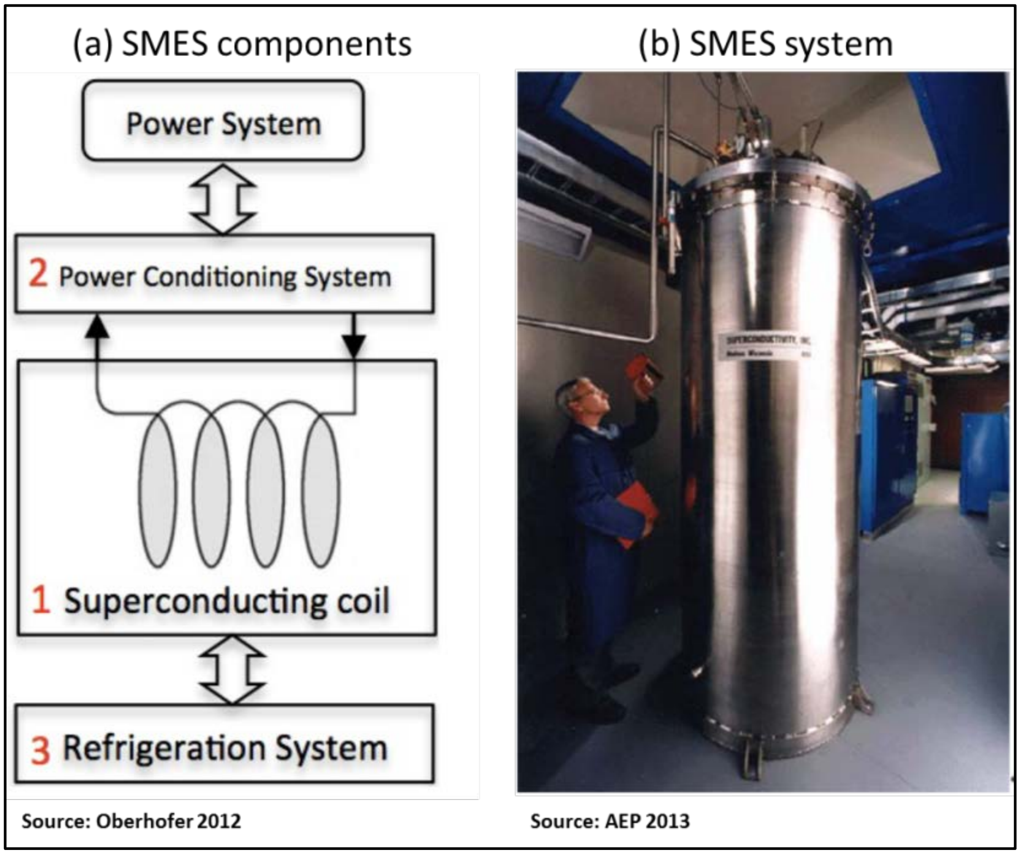


Figure 2-71. Superconducting Magnetic Energy Storage

Thermal Energy Storage

Thermal energy storage includes a number of different technologies. Thermal energy (hot and cold) can be stored at temperatures from -40°C to more than 400°C as sensible heat, latent heat, and chemical energy (thermochemical energy storage) using chemical reactions (IEA 2012). Thermal storage uses off-peak electricity to store cooling energy or heat energy, then during peak demand uses that energy for power needs.

There are two primary ways this can be implemented. The first is via ice-based systems, which are applicable to commercial, residential, and industrial cooling loads at the point of consumption. These systems are for bridging power applications and help shave peak demand. Ice-based thermal energy storage systems are well suited for warm regions like Hawai'i. There are three confirmed projects on O'ahu that use this technology: the Iolani School in Waikiki, the Nordstrom at the Ala Moana Center in

Honolulu, and the Iwilei Costco in Honolulu (Song 2008). The second implementation is via a heat-based system using molten salt. The salt absorbs heat from a solar farm and uses that heat later to make steam for a turbine application. The molten salt systems are still in the development stage but may provide another means of capturing solar energy generation for use during peak demand hours (Baxter and Makansi 2002). The heat-based system can only operate in conjunction with a solar plant. The Holaniku facility at NELHA at Keahole Point is demonstrating a heat-based thermal system (Sopogy 2013). With any thermal storage, the duration of storage may be short, as the ability to insulate the material from the surrounding temperature drives how long the material remains in its useful hot or cold state.

2.3.5.4.2 Characterization of Technology Feasibility and Deployment

Energy storage systems are designed for different applications, making them useful in different parts of the electricity distribution chain. Some are designed to address short power quality issues while others are designed to support peak demand over a longer duration. Table 2-32 summarizes the characteristics of the different technologies described in the previous section.

Table 2-32. Energy Storage Technology Characteristics

Technology	Capacity (MWh)	Power (MW)	Discharge Duration (hrs)	% Efficiency (total cycles)	Response Time[a]	Lifetime (years)[a]
Capacitors[b]	0.5 kWh	200 kW	1–30 seconds	95	4 milliseconds	20 (or 106 cycles)
CAES (above ground)	250	50	5	70[c] (>10,000)	Minutes	30
Flow Batteries	5–50	1–10	5	60–65 (>10,000)	< ¼ cycle	10
Flywheels	5	20	0.25	85–87 (>100,000)	< 1 cycle	20
Hydrogen[d]	300	50	6	35–45	Minutes	40[e]
Lead-acid batteries	200	50	4	85–90 (2,200)	¼ cycle	5
Li-ion batteries	4–24	1–10	2–4	90–94 (4,500)	a few milliseconds[f]	20[g]
Pumped Hydroelectric	1,680–5,300	280–530	6–10	80–82 (>13,000)	Minutes	30
NaS batteries	300	50	6	75 (4,500)	a few milliseconds[f]	5
SMES[a]	0.69 kWh[h]	20 kW[h]	1 second	>85[h]	< ¼ cycle	30
Thermal (heat based system)[a]	4[i]	100	12	50–90[j]	Minutes	*30*[i]

Source: EPRI 2010.

a. Source: Baxter and Makansi 2002 unless otherwise specified.
b. Source: HECO 2013j.
c. Source: Das and McCalley 2012.
d. Source: Steward et al. 2010.
e. Source: DOE 2013w for central production facilities.
f. Source: Divya and Østergaard 2009.
g. Source: Lippert 2013.
h. Source: Li 2012. Targets for superconducting magnet energy storage system with direct power electrics interface for GRIDS project funded by DOE.
i. Source: Sopogy 2013.
j. Source: IEA 2012.

CAES = compressed air energy storage; hrs = hours; kWh = kilowatt-hour; Li-ion = lithium-ion; MW = megawatt; MWh = megawatt-hour; NaS = sodium sulfur; SMES = superconducting magnetic energy storage.

As shown in the table above, energy storage technologies vary by power, discharge duration, and response time, making them useful at many points along the electricity distribution chain. Figure 2-72 illustrates where energy storage can be located and how the location addresses an electricity distribution issue. For example at location "A" energy storage pairs with renewable generation at the utility side to smooth out the variability associated with the wind resources. In location "E" energy storage is located after the distribution at the customer side to address any power quality issues associated with the electricity being delivered. The representative project refers to both of these examples (see Section 2.3.5.4.4).

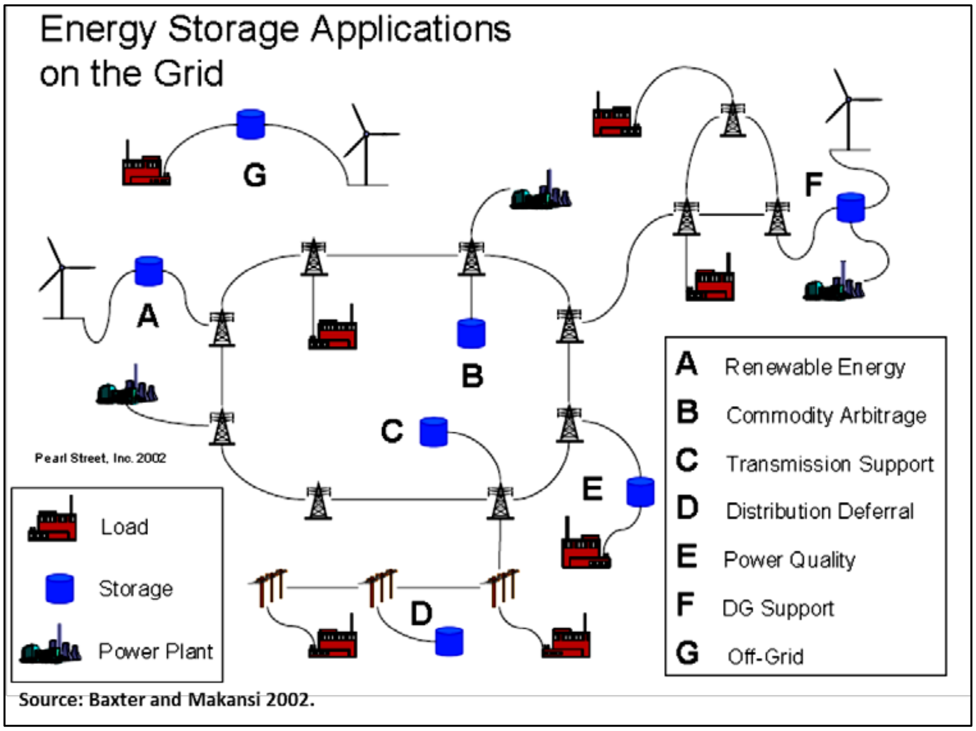


Figure 2-72. Potential Energy Storage Applications in the Electricity Delivery Chain

These technologies are rarely used in isolation, but rather in conjunction with other components in the electricity value chain. Co-location of storage generation, transmission, distribution, or load is typical and each of those locations has certain benefits and drawbacks. These benefits and drawbacks are also a matter of perspective. Many are example-specific, but some of the most common pros and cons of locating energy storage at different points in the value chain are shown in Table 2-33. The table is devised from the perspective of the party maintaining the grid.

Table 2-33. Benefits and Drawbacks Associated with Energy Storage Locations

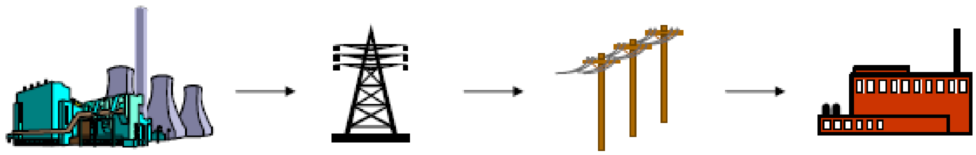


Image taken from Baxter and Makansi 2002.

Storage location	PRODUCTION:	TRANSMISSION:	DISTRIBUTION:	CUSTOMER/LOAD:
Site Description	Co-located with renewable generation on the developer's side of the meter	Located near renewable generation on the utility-side of the meter	Located within the distribution network in proximity to loads (commercial, residential, industrial)	Located at the customer side of the meter
Benefits	Dampen the effect of variability in production, higher generation dispatchability	Can provide additional services: regulation, spinning reserves, load leveling	**Less Risk** - Smaller expenditures over a longer time horizon, multiple vendors/solutions are possible, able to provide local voltage support	Increase customer reliability
	Cost absorbed by plant developer	Generally lower costs per kW for so larger systems are possible	**More Reliability** - Increase distribution system and customer reliability	Peak demand shaving
	Generally lower costs per kW for larger systems are possible		**Flexible control** - Off-load substation transformer during peak times, more discrete dispatching and optimization of resources, integration with Smart Grid communications	Cost absorbed by customer
Drawbacks	Generation takes precedence on the storage dispatch	Dual-use ownership and cost model would need to be defined and agreed upon	Safety hazards & additional equipment requirements associated with locating near population dense areas	Support only user loads
	More complicated business model for utility to access storage	Capital expenditures for distribution upgrades would still be needed.	Land availability & costs for placement	Additional controls needed to allow for backflow into the distribution chain
			Variation in local codes and jurisdictions may have an effect on technology selection or implementation	More complex ratepayer cost & revenue models
				Limited input and information about solutions implemented.

Source: Akhil 2013.

Because the storage feasibility needs to be evaluated with the generation or distribution technology that it helps enable, it is important to understand the advantages and disadvantages of each. Table 2-34 lists some of those but there could be others based on the application.

While some technologies are commercially available today, others are still in the development stage. Table 2-35 summarizes the stages of maturity for the energy storage technologies. Some technologies may be listed in multiple categories. As advancements are made, the technologies mature in more power regions and storage durations.

Table 2-34. Advantages and Disadvantages of Energy Storage Technologies

Storage Technology	Main Advantages	Disadvantages
Capacitors	Long cycle life, high efficiency	Low energy density
CAES	High capacity, low cost	Special site requirement, requires fuel
Flow batteries	High capacity, independent power and energy ratings	Low energy density
Flywheels	High power	Low energy density
Hydrogen[a]	High capacity, low cost	Low efficiency, safety concerns (addressed in design)
Lead-acid batteries	Low capital cost	Limited cycle life when deeply discharged
Li-ion batteries	High power and energy densities, high efficiency	High production cost, requires special charging circuit
Pumped Hydroelectric	High capacity, low cost	Special site requirement
NaS batteries	High power and energy densities, high efficiency	Production cost, safety concerns (addressed in design)
SMES	High power	Low energy density, high production cost
Thermal[b]	High capacity	Insulation requirements

Source: ESA 2011.
a. Source: Steward et al. 2010.
b. Source: IEA 2012.
CAES = compressed air energy storage; Li-ion = lithium-ion; NaS = sodium sulfur; SMES = superconducting magnetic energy storage.

Table 2-35. Energy Storage Technologies and Their Level of Maturity

	Concept Stage		Demonstration Stage		Mature Commercial Product	
	Energy Storage Requirement					
Power	Seconds	Hours	Seconds	Hours	Seconds	Hours
100s of MW			SMES			CAES Pumped Hydro
10s of MW	Capacitors Flywheels		Hydrogen[a]	Hybrid CAES NaS batteries	SMES	Lead-acid batteries
100s of kW to Few MW		Flywheels Li-ion batteries	Capacitors	Flow batteries	Flywheels SMES	Lead-acid batteries Thermal[b]
Several kW			Capacitors	Flywheels NaS batteries Li-ion batteries		Flywheels Lead-acid batteries Thermal[b]

Source: NETL 2013.
a. Source: Steward et al. 2010.
b. Source: IEA 2012.
CAES = compressed air energy storage; kW = kilowatt; MW = megawatt; NaS = sodium sulfur; SMES = superconducting magnetic energy storage.

HECO has demonstrated ultra-capacitors to mitigate short-term voltage and frequency deviations associated with wind power.

Deploying compressed air energy storage systems with aboveground tanks for small turbines is also feasible. Underground storage for compressed air energy storage systems is probably not suitable given the islands' geological characteristics. Due to the island's volcanic origins and active seismicity which create fissures, cracks and air bubbles in the basalt rock, Hawai‘i's lands are highly permeable and not capable of containing pressurized air. The underground lava tube caves that exist are very long and shallow, which does not provide the lithostatic pressure needed for high pressure storage. In addition to the geological limitation, these caves are sometimes used by Native Hawaiians for burials (Hon 2013).

There are manufacturers of indoor and outdoor flywheel systems focused on power quality applications, but the devices are still fairly small and applications somewhat niche. They can be used for frequency regulation and output smoothing of solar and wind energy. Multiple units can be put in series to achieve the necessary storage capacity.

Batteries are appropriately sized for use at generation, distribution, or point of consumption sites on all of the islands. There are battery facilities in Hawaiʻi that are several megawatts in size, demonstrating the technology feasibility for Hawaiʻi.

While there are 31 megawatts of hydroelectric generation in the State of Hawaiʻi, there are no commercial pumped storage hydroelectric facilities (DBEDT 2013g). Studies have explored the possibilities of pumped storage hydroelectric facilities at Koko Crater and Kaʻau Crater; on Hawaiʻi island at Puu Waawaa and Puu Anahulu in North Kona, Puu Enuhe in Kaʻū and at Kaupūlehu-Kūkiʻo. On Maui, pumped storage hydroelectric facilities have been considered at Maʻalaea, Napili-Honokōwai in the Kaʻanapali area, Kohama near Lahaina and upcountry at Ulupalakua (HECO 2013j). There is a record of community opposition to hydroelectric and pumped storage hydroelectric projects on Kauaʻi, Maui, Hawaiʻi and Molokaʻi (HREDV 2009b). Even when the sea could be used as the lower reservoir, pumped storage hydroelectric systems require a large amount of land, which is one of an island's most precious resources. Thus, while seemingly a natural fit for Hawaiʻi, pumped storage hydroelectric may also be the most challenging to implement. Challenges include siting, permitting, water availability, cost and the long lead time for development (HECO 2013j).

Thermal energy storage systems are well suited for warm regions like Hawaiʻi. Ice-based systems have been in operation on Oʻahu as previously mentioned and heat-based systems are still being demonstrated.

2.3.5.4.3 Permitting and Consultation Requirements

Energy storage systems vary by size, technology, and application. These technologies typically are co-located with other equipment such as a wind farm, substation, distribution line, or at the point of consumption. The storage systems can be introduced at the inception of the project or added at a later date. Permit requirements may vary depending on where the energy storage system is put in place and whether it is envisioned at the onset or brought in as an add on to an existing facility.

When the energy storage is considered at the onset of the project, the permit process would reflect the electricity chain that it supports. All components to make a project work, including transmission and storage infrastructure, are included in the original facility permit applications. When energy storage is added later, this may be considered an accessory use to the existing facility or may prompt the need to revisit all existing facility permits. The proper Federal, State, and county permitting authorities must be consulted. General Federal, State, and county permitting and regulatory requirements are discussed in Section 2.2.

Because pumped storage hydroelectric would be constructed as a stand-alone facility, there are specific permits that may be required those Marine-based permits are applicable when the ocean serves as the lower reservoir. One or more of these permits may be required to connect the facility to the grid. On the mainland, FERC would have regulatory authority for these hydroelectric projects; however, in Hawaiʻi, FERC's authority is more limited. The following text is from FERC's Order Dismissing Preliminary Permit Applications (FERC 2011):

> "Given that Hawai'i's electrical generation and transmission system is not connected to the interstate electrical grid, Part I of the FPA applies in a different manner to State of Hawai'i inland hydropower projects than to those located in the contiguous United States. Accordingly, as discussed below, many hydropower projects in Hawai'i do not require a FERC license, and Hawai'i has a long history of authorizing and regulating hydropower projects at the State level. There are no Commission-licensed hydropower projects in Hawai'i."

In addition, there are decommissioning activities associated with the dismantling of batteries and their disposal or the recycling of their chemicals (Eyer and Corey 2010). It is important to note that sodium sulfur battery components are disposed of or recycled by routine industrial processes and lead-acid battery procurement typically has contractual clauses requiring that the batteries be sent to a recycling center at the end of their operational life (Akhil 2013).

2.3.5.4.4 Representative Project

To illustrate a potential energy storage project that may be encountered on any of the islands, the analysis in this PEIS considers two representative projects that would include the energy storage for the following facilities:

- A hotel or resort facility. This project would have an energy storage system for any critical systems. The energy storage system would provide frequency regulation while connected to the grid and reserve power in the event of an outage until a generator could be put in place. It is assumed the hotel has approximately 400 rooms with a peak load of 10 megawatts and a 10 percent critical systems load of about 1 megawatt. Flywheel energy storage was selected because of its small footprint, fast response time, and life cycle.

- A renewable energy generation plant. This project would have an energy storage system that serves a bridging power function. The energy storage system would smooth out variability of the power sent from a renewable generation source to a transmission line. The renewable energy project may be a large (100-megawatt) solar farm or wind farm. The project assumes that one-third of the generation capacity is needed in storage and that the energy storage is co-located with the generation source that is already connected to the transmission line. NaS battery storage was selected because of response time, discharge duration, and modularity allowing for more or less power depending on the generation capability.

The representative project is not intended to reflect any known or planned project and is developed for analytical purposes only. The characteristics of the representative projects are shown in Table 2-36.

2.4 No-Action Alternative

CEQ NEPA implementing regulations require that a PEIS analysis include a no-action alternative, which provides a baseline for comparison against the impacts of the proposed action. Under the no-action alternative, DOE would continue to support, through funding and other actions, the State of Hawai'i to meet its HCEI goals on a case-by-case basis, but without guidance to integrate and prioritize funding decisions and other actions.

Table 2-36. Representative Project Characteristics

Line No.	Project Parameter	Hotel/Resort[a]	Renewable Power Plant[b]
	Technology Selected	Flywheels	NaS batteries
1	Infrastructure support		
	Roads	No	Yes (large, heavy, hazardous material loads)
	Water use	No	No
	Sewer	No	No
2	Size of facility		
	footprint	125 square feet	26,000 square feet
	height	6.5 feet	17 feet
	weight	22 tons	3580 tons
	power generated	1.08 megawatts	34 megawatt (1/3 output)
	number of modules	9 UPS150 units	34, 1,000-kilowatt NAS units
3	Cost of plant	$324,000	$102M
	$/MW or $/kW	$300 per kilowatt[c]	$3M per megawatt[d]
4	Workforce		
	Construction	yes	yes
	Operation	no	no
5	Noise generated	<70 dBA at 3 feet	Low noise
6	Air emissions	no	no
7	Waste generated		
	Type	None	Battery chemicals
	Disposal	Same as electronics	Routine industrial process
8	Electrical Transmission lines	480VAC 3-phase 3-wire plus ground	Grid connections
9	Location	Building utility area	Near intermittent or curtailed renewable power plant

a. Data included is based on the UPS150 unit from Active Power, Inc. (Active Power 2012).
b. Data included is based on a 1,000-kilowatt NAS unit from NGK Insulators, Ltd. (NGK 2013). NAS is a registered trademark for NGK's sodium-sulfur battery system.
c. Source: Baxter and Makansi 2002.
d. Source: HECO 2013j.
dBA = A-weighted decibel; kW = kilowatt; MW = megawatt; NAS = sodium sulfur; VAC = volts alternating current.

Implementation of HCEI in Hawaiʻi will occur whether or not DOE develops guidance to assist in making decision or other actions related to clean energy in Hawaiʻi. Therefore, the potential environmental impacts associated with each of the renewable energy technologies would likely also occur under the no-action alternative; however, there may not be formal guidance in place that would assist DOE in taking actions that maximize the benefits of certain technologies while minimizing the potential environmental impacts in important resource areas. If the goals of the HCEI were not met, the State of Hawaiʻi would remain heavily dependent on fossil fuels and statutory greenhouse gas targets would probably not be met.

The Hawaiʻi State Energy Office will continue taking the following steps to meet its a goal of generating 40 percent clean energy by 2030:

- Align government regulations and policies with clean energy goals,
- Facilitate processes for developing renewable energy,
- Deploy renewable generation and grid infrastructure, and
- Explore next generation technologies and new applications of existing technologies.

2.5 Summary of Potential Environmental Impacts

Chapters 4 through 8 provide a characterization of the potential environmental impacts that could be expected from each of the analyzed energy efficiency activities and renewable energy technologies. As discussed in Section 2.3, these impacts are based on a representative project and do not reflect any actual proposal. These activities and technologies represent potential future actions that could be used to implement HCEI.

The following tables present summaries of the potential environmental impacts and best management practices for the activities and technologies associated with each of the five clean energy categories. Each table presents the following:

- A reference to specific sections in Chapter 3 for those impacts that would be common among most construction or operation activities and are not technology-specific. The potential impacts are identified for each environmental resource area.

- Any potential environmental impacts that would be specific to that activity/technology.

- A reference to specific sections in Chapter 3 for those best management practices that would be common among most construction or operation activities and are not technology-specific. The best management practices are identified for each environmental resource area.

- Any potential best management practices that would be specific to that activity/technology.

Those resource areas with no impacts are shaded and were not carried forward for analysis specific to the activity/technology.

Best management practices and potential mitigation measures are identified in several places in the PEIS. For those impacts mentioned above that would be common among most construction or operation activities and are not technology-specific, best management practices are presented in Chapter 3 for each resource area. For the activity/technology-specific impacts, the best management practices and potential mitigation measures are presented in Chapters 4 through 8 with the impact analysis for that activity/technology. Implementation of these best management practices and potential mitigation measures are important to prevent or minimize the environmental impacts to that resource.

Accompanying each summary table is a tabular illustration of the potential impacts associated with each activity/technology for each resource area. The clear circles represent no potential impacts, the light-gray dots represent impacts that would be similar to those common among construction and operation activities, and the black dots represent those potential impacts specific to an activity or technology.

Tables 2-37 and 2-38 provide the summary of potential environmental impacts and characterization for the activities and technologies in the energy efficiency clean energy category. Tables 2-39 and 2-40 provide the summary of potential environmental impacts and characterization for the technologies in the distributed renewables clean energy category. Tables 2-41 and 2-42 provide the summary of potential environmental impacts and characterization for the technologies in the utility-scale renewables clean energy category. Tables 2-43 and 2-44 provide the summary of potential environmental impacts and characterization for the technologies in the alternative transportation fuels and modes clean energy category. Tables 2-45 and 2-46 provide the summary of potential environmental impacts and characterization for the technologies in the electrical transmission and distribution clean energy category.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Geology and Soils			
	None; retrofitting buildings, would not cause any additional land disturbance that could result in impacts to geology and soils.	**Onshore** Potential soil erosion and contamination during construction (short-term). See Section 3.1.3. **Offshore** Potential disturbance of marine sediments during construction (short-term) and operations.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to geology and soils.
Climate and Air Quality			
Air Quality	Minor impacts during construction. Reductions in criteria pollutants as a result of reduction of electricity generation using fossil fuels.	General impacts during construction (short-term). See Section 3.2.4. The use of a SWAC system would require 75 percent less electricity than a standard cooling system; therefore, there would be a beneficial impact to air quality from a reduction of criteria pollutants resulting from electricity generated by fossil fuels.	Minor impacts during construction. Reductions in criteria pollutants as a result of reduction of electricity generation using fossil fuels.
Climate Change	Minor impacts during construction. Reductions in GHG emissions as a result of reduction of electricity generation using fossil fuels.	Minor impacts during construction. Reductions in GHG emissions as a result of reduction of electricity generation using fossil fuels.	Minor impacts during construction. Reductions in GHG emissions as a result of reduction of electricity generation using fossil fuels.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Water Resources			
	None; retrofitting buildings would not cause any additional land disturbance or increased water demand that could result in impacts to water resources, including surface water, groundwater, floodplains, and wetlands.	**Surface Water – Land Based** General impacts during construction (short-term). See Section 3.3.5. No operational impacts. **Surface Water – Marine-Based** Sediment disturbance/ dispersal and increased turbidity. Potential site-specific impacts may occur to habitats or communities of concern. Potential increase in nutrient levels (nitrate and phosphates). Potential for sea water temperature variability impact. **Groundwater** General construction impacts. See Section 3.3.5. No adverse operational impacts. Potential fresh water (groundwater) savings if wastewater is used as the cooling medium. Potentially beneficial; fresh water savings with an open cooling system.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to water resources.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
		Floodplains and Wetlands Potential short-term impacts during construction. See Section 3.3.5. Potential effects during operations (site specific; i.e., if project were located in a floodplain/wetland).	
Biological Resources			
	None; retrofitting buildings would not cause any additional land disturbance that could result in impacts to biological resources.	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Minimal and localized impacts to marine organisms from water discharge temperature. Potential increase in nutrient levels resulting in increased marine productivity. Potential localized disturbance impacts to benthic communities at discharge point. Potential entrainment of smaller organisms at the intake pipe.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to biological resources.
Land and Submerged Land Use			
	None; retrofitting buildings would not cause any changes to land or submerged land use.	Short-term land disturbance impacts at the cooling station locations and along distribution line routes during construction. Potential land use impacts related to expansions/maintenance of the cooling stations and/or distribution network.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to land use.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Cultural and Historic Resources			
	Potentially adverse visual or architectural context impact to historic properties.	Potential adverse impacts to cultural, historic, and related natural resources during construction and operation (both on and offshore).	Potentially adverse visual or architectural context impact to historic properties.
Coastal Zone Management			
	None; retrofitting buildings would not cause any changes that would have to be reviewed for coastal zone management.	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project- and/or site-specific).	None; installation of solar water heating units would typically be done on rooftops and therefore would be required to comply with CZMA.
Scenic and Visual Resources			
	Potential short-term effects due to visibility of construction activities and personnel. Potential long-term visual impacts (project-specific).	Short-term impacts to visual resources during construction. See Section 3.8.3. Long-term visual impacts associated with the new cooling station.	Potential visual impacts due to visibility including to historic resources (site-specific).
Recreation Resources			
	None; retrofitting buildings, would not cause any additional land disturbance or impacts to recreation resources.	General impacts during construction. See Section 3.9.5. Potential short-term impacts to offshore recreation during installation of the subsurface piping. The short-term impacts could include: (1) restricted access to recreation areas near the area of installation of the underwater piping and on-shore facility, and (2) possible visual impairment from areas near the construction of the facilities that could have a negative effect on the ongoing recreational activities.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to recreation resources.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Land and Marine Transportation			
	None; retrofitting buildings would not cause any changes or impacts to land or marine transportation.	General impacts including localized short term traffic impacts during construction and/or if road crossings are needed. Potential short-term (temporary) impacts on harbor operation, local marine transportation, and military marine operations Potential impacts to military submarine operations.	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to land and marine transportation.
Airspace Management			
	None; retrofitting buildings would not result in any tall structures or other potential impacts to airspace.	None; construction and operation of sea water air conditioning would not require any tall structures and therefore would not impact airspace management.	None; installation of solar water heating units would typically be done on rooftops but not result in any tall structures that could impact airspace.
Noise and Vibration			
	General construction and operation impacts. See Section 3.12.5.	Short-term noise and vibration impacts during construction. Noise levels could temporarily exceed regulatory levels. Exposure to elevated noise and vibration levels may result in temporary impacts to marine & mammal behavior and marine mammal prey species. No long-term ambient noise or vibration impacts are expected during operation. A positive benefit could be the elimination of noise currently generated from cooling towers as buildings convert to sea water air conditioning systems.	General construction and operation impacts. See Section 3.12.5.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Utilities and Infrastructure			
	Potential reduction in energy consumption. See Section 2.3.5.	Potential reduction in energy consumption (may require modification of the utility structure to meet the RPS).	Decrease in energy consumption. No significant impacts to utilities or infrastructure.
Hazardous Materials and Waste Management			
Hazardous Materials	Potential impact from exposure to hazardous materials including: asbestos materials, lead-based paint, polychlorinated biphenyls, arsenic; and/or mercury (site-specific).	General impacts from exposure to hazardous materials during construction. See Section 3.14.4. No adverse operational impacts.	Potential impacts from exposure to hazardous materials encountered during installation including: asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic.
Waste Management	Potential impacts to waste management services could occur during project construction/retrofitting, as special handling and disposal of building materials and retrofits may be required. Retrofit work to bring buildings up to code with the 2009 IECC may result in the discovery of asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. The replacement of incandescent light bulbs and/or compact fluorescent bulbs with LED lamps would require special handling and disposal requirements, as certain fluorescent bulbs contain a small amount of mercury. Potential landfill impacts. After completion, building retrofits would not result in waste management impacts.	General waste management impacts during construction. See Section 3.14.4. No adverse operational impacts.	Potential impacts to waste management services from hazardous demolition debris waste during installation. Potential landfill impacts.

Table 2-37. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Energy Efficiency (continued)

Resource Area	Energy Efficient Buildings	Sea Water Air Conditioning	Solar Water Heating
Wastewater	Common impacts from typical construction activities are identified in Section 3.14.4.	General wastewater impacts during construction. No adverse operational impacts. Potential beneficial impacts may occur if wastewater were utilized in place of sea water. This would minimize the amount of wastewater from other sources that would have to be treated by the local municipality.	No wastewater impacts.
Socioeconomics			
	Beneficial – few jobs created.	Beneficial – few jobs created.	Beneficial – few jobs created.
Environmental Justice			
	No disproportionately high and adverse human health or environmental effects on minority and low-income populations.	Depending on siting, impacts to visual and scenic resources could have the potential to be disproportionately high and adverse with respect to environmental justice communities. The likelihood of significant environmental impacts from this technology is small and therefore, the likelihood for environmental justice impacts would equally be small.	None; negligible adverse impacts to environmental resources. Therefore, no disproportionately high and adverse impacts to minority or low-income population.
Health and Safety			
	General impacts during construction. See Section 3.17.3. During building retrofits, workers may encounter asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. Exposure to such hazardous materials could result in harmful health effects, the severity of which would depend on the level of exposure.	General waste management impacts during construction. See Section 3.17.3.	General waste management impacts during construction. See Section 3.17.3 Potential worker exposure to hazardous materials including: asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic.

Table 2-38. Characterization of the Potential for Environmental Impacts – Energy Efficiency

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Energy Efficient Buildings	○	●	○	○	○	●	○	●	○	○	○	●	●	●	●	●	●
Sea Water Air Conditioning	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●
Solar Water Heating	○	●	○	○	○	●	○	●	○	○	○	●	●	●	●	●	●

○ = No potential impacts.

● = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Geology and Soils					
	General impacts during construction. See Section 3.1.3. No impacts during operation.	**Diversion System** General impacts during construction. See Section 3.1.3. No impacts during operation. **Conduit System** None; the conduit system would be installed at an existing facility and not disturb additional land.	General impacts during construction and operation. See Section 3.1.3.	None; installation and use of rooftop solar modules would not involve land disturbance and therefore would not impact geology and soils.	General impacts during construction. See Section 3.1.3.
Climate and Air Quality					
Air Quality	Burning of biomass at a biomass energy project would emit criteria pollutants. Additionally, the transport of the biomass feedstock would result in emissions from trucks and harvesting equipment	General impacts during construction. See Section 3.2.4.	General impacts during construction. See Section 3.2.4.	General impacts during construction. See Section 3.2.4.	General impacts during construction. See Section 3.2.4.
Climate Change	Potential greenhouse gas impacts pending EPA ruling and dependent on project size (project-specific). Potential reductions in greenhouse gas emissions due to reduced oil consumption by use of renewable energy.	Beneficial; potential reductions in greenhouse gas emissions due to reduced oil consumption by use of renewable energy.	Minimal greenhouse gas emissions (unless supplied from a renewable energy source, in which case impacts would be lower).	Beneficial; potential reductions in greenhouse gas emissions due to reduced oil consumption by use of renewable energy.	Beneficial; potential reductions in greenhouse gas emissions due to reduced oil consumption by use of renewable energy.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Water Resources					
Surface Water	General impacts during construction. See Section 3.3.5. Potential surface water impacts during operations (increased stormwater runoff).	**Diversion System** Potentially adverse impacts to water quality (decreased dissolved oxygen content and increased temperature), water supply, and existing uses (e.g., irrigation fisheries, and recreation). **Conduit System** None; the conduit system would be installed at an existing facility and not incrementally impact surface water.	General impacts during construction and operation. See Section 3.3.5.	None; Installation and use of rooftop solar modules would not involve land disturbance, would involve only minor water demand, and therefore would not impact water resources.	General impacts during construction. See Section 3.1.3.
Groundwater	General impacts during construction. See Section 3.3.5. Potential water resource impacts depending on design and use of groundwater.	**Diversion System** General impacts during construction. See Section 3.3.5. No impacts during operation. **Conduit System** None; the conduit system would be installed at an existing facility and not incrementally impact groundwater.	General impacts during construction and operation. See Section 3.3.5.	None; installation and use of rooftop solar modules would not involve land disturbance, would involve only minor water demand, and therefore would not impact ground water resources.	General impacts during construction. See Section 3.1.3.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Floodplains and Wetlands	Minimal to no potential for common construction impacts. See Section 3.3.5.	**Diversion System** Potential impacts during construction (site-specific). No impacts during operation. **Conduit System** Potential impacts during construction (site-specific) No impacts during operation.	General impacts during construction and operation. See Section 3.3.5.	None; installation and use of rooftop solar modules would not involve land disturbance, would involve only minor water demand, and therefore would not impact floodplain and wetland resources.	General impacts during construction. See Section 3.1.3.
Biological Resources					
	General impacts during construction. See Section 3.4.5. Potential impacts to terrestrial wildlife and protected plants and animals during construction of the boiler, turbine, and local infrastructure. Potential impacts to terrestrial plants and wildlife from biomass production. Potential lighting impacts on flights of marine birds, such as shearwaters and petrels (site-specific).	**Diversion System** General construction impacts. See Section 3.4.5.1. Potential impacts from access roads during construction. Potentially adverse impacts to freshwater fish species. **Conduit System** Impacts are unlikely due to the use of an existing conduit flow system.	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to biological resources.	None; installation and use of rooftop solar modules would not involve land disturbance or sensitive habitat and therefore would not impact biological resources.	General impacts during construction. See Section 3.4.5. Potential adverse impacts to protected avian and bat species

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Land and Submerged Land Use					
Land Use	General construction impacts. See Section 3.5.4 Potential change in land use.	**Diversion System:** Potential land disturbance during construction. Potential land use compatibility impacts. **Conduit System:** General construction impacts. See Section 3.5.4.	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to land use.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact land use.	General construction impacts. See Section 3.5.4 Potential change in land use.
Submerged Land use	None; biomass projects would not involve any off-shore elements.	None; the projects are for installations on the interior of the islands and make use of rivers and stream rather than the ocean.	None; hydrogen fuel cells would not involve any off-shore elements	None; installation and use of rooftop solar modules would not involve any off-shore elements.	None; the wind turbine would be installed on land and would not impact the marine environment.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Cultural and Historic Resources					
	General impacts during construction and operation. See Section 3.6.6.	**Diversion and Conduit Systems** General impacts during construction and operation. See Section 3.6.6.	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to cultural and historic resources.	Potential adverse visual or architectural context impact to a historic property/resource.	General impacts during construction and operation. See Section 3.6.6. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.
Coastal Zone Management					
	Potential coastal zone impacts to special management areas, shorefront access, or shoreline erosion (project/site-specific).	None; the projects are for installations on the interior of the islands and would not affect the shoreline.	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to coastal zone management.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact coastal zone management.	Potential coastal zone impacts to special management areas, shorefront access, or shoreline erosion (project/site-specific).

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Scenic and Visual Resources					
	General impacts during construction See Section 3.8.3. Potential long-term visual impacts from outdoor and security lighting and visual character of project location (site-specific).	**Diversion System** General impacts during construction See Section 3.8.3. Potential long-term visual impacts (site-specific). **Conduit System** None.	None; since there would be no external facilities associated with hydrogen fuel cells, there would be no impacts to scenic and visual resources, the containers would be located either indoor or outdoor adjacent to existing facilities, negligible impacts to visual resources are expected.	Short-term visual resource impacts during installation. Potential long-term visual impacts (site-specific). Potential impacts to natural scenic and visual resources, or historic character of an area.	Short-term visual resource impacts during installation. Potential long-term visual impacts (site-specific). Potential impacts to natural scenic and visual resources, or historic character of an area. Potential lighting and shadow flicker impacts (site-specific)

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Recreation Resources					
	None; the biomass facility would be located near the commercial/industrial electricity users and would be compatible with existing land uses, which would not include recreation.	**Diversion System** General impacts during construction. See Section 3.9.4. Potential impacts to river-based recreation activities, such as fishing and kayaking. **Conduit System** None.	None; since the containers would be located either indoor or outdoor adjacent to existing facilities, no impacts to recreation resources are expected.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact recreation resources	Potential visual impacts to recreation resources (e.g., scenic lookouts and views).
Land and Marine Transportation					
Land Transportation	Potential localized roadway and traffic impacts from increased truck traffic associated with biomass feedstock.	**Diversion and Conduit Systems:** None; construction and operation of hydroelectric facilities would be unlikely to have any impacts to land transportation.	None; since there would be no land disturbance or external facilities associated with hydrogen fuel cells, there would be no impacts to land transportation.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact land transportation.	None; construction and operation of a small wind turbine would not impact land transportation.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Marine Transportation	None; a small distributed biomass energy power generation project would not be expected to require nor effect marine transportation. Biomass would be obtained locally.	**Diversion and Conduit Systems:** None; construction and operation of hydroelectric facilities would be unlikely to have any impacts to marine transportation.	None; since there would be no land disturbance or external facilities associated with hydrogen fuel cells, there would be no impacts to marine transportation.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact marine transportation.	None; construction and operation of a small wind turbine would not impact marine transportation.
Airspace Management					
	None; a small distributed biomass energy power generation facility would not have an emission stack tall enough or produce a thermal plume large enough to cause an aviation hazard.	**Diversion and Conduit Systems** None; construction and operation of hydroelectric facilities would not affect airspace.	None; since there would be no external facilities associated with hydrogen fuel cells, there would be no impacts to airspace management.	None; although installation of rooftop solar modules could cause some glare and reflection, which could be seen by pilots, installations at a distributed scale would typically not require consultations on airspace management.	Potential impacts on airspace including military training airspace (site-specific).

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Noise and Vibration					
	Industrial noise would be produced from operation of the biomass handling facilities and removal of ash waste. Noise from the steam boilers and turbines mostly would be contained within the buildings.	**Diversion System** General impacts during construction. See Section 3.12.5. Potential long-term noise and vibration impacts during operation (site-specific). **Conduit System** General impacts during construction See Section 3.12.5. No impacts during operation	None; since there would be no land disturbance or external facilities associated with hydrogen fuel cells and the fuel cells do not generate noise, there would be no impacts to noise and vibration.	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact noise and vibration.	Minimal noise and vibration impacts during construction. Potential long-term noise and vibration impacts (site-specific).
Utilities and Infrastructure					
	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.	**Diversion and Conduit Systems:** General impacts during construction and operation. See Section 3.13.3.	Negligible impacts to electricity generating capacities.	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Hazardous Materials and Waste Management					
Hazardous Materials	General exposure impacts during construction and operation. See Section 3.14.4.	**Diversion and Conduit Systems:** General exposure impacts during construction and operation. See Section 3.14.4.	No exposure impacts during construction. Minimal exposure impacts during operation.	General exposure construction impacts. See Section 3.14.4. Potential exposure impacts from end-of-life of the photovoltaic system and the battery energy storage.	General construction exposure impacts. See Section 3.14.4. Potential for hazardous material exposure resulting from handling and disposal of batteries (project-specific).
Waste Management	Potential waste management impacts related to ash disposal.	**Diversion and Conduit Systems:** General impacts during construction and operation. See Section 3.14.4.	None; no waste management impacts from construction or operation of hydrogen fuel cells.	General construction impacts. See Section 3.14.4. Potential exposure to hazardous waste (i.e., potential for cadmium). Potential landfill impacts.	General construction impacts. See Section 3.14.4. Potential waste management impacts from toxic and hazardous waste contamination during disposal of batteries at their end-life (project specific)
Wastewater	Potential wastewater contamination from trace chemicals and elevated temperatures.	**Diversion and Conduit Systems:** General impacts during construction. See Section 3.14.4.	None.	Potential impacts from the disposal of PV modules (i.e., potential for cadmium-contaminated wastewater).	General construction and operation impacts. See Section 3.14.4.

Table 2-39. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Distributed Renewables (continued)

Resource Area	Biomass	Hydroelectric	Hydrogen Fuel Cells	Photovoltaic	Wind
Socioeconomics					
	Few operation and construction jobs created and economic benefits.	**Diversion and Conduit Systems** A few operation and construction jobs created. No operational impacts.	None; installation and use of hydrogen fuel cells would result in few jobs and would not impact socioeconomics.	None; installation and use of PV modules would result in few jobs and would not impact socioeconomics.	None; Construction and operation of a small wind turbine would result in few jobs and would not impact socioeconomics.
Environmental Justice					
	Dependent on potentially adverse impacts to other resources in adjacent and nearby areas (site-specific).	**Diversion and Conduit Systems** Dependent on potentially adverse impacts to other resources in adjacent and nearby areas (site-specific).	None; there would be no measurable impacts to the human environment, and there would be no environmental justice impacts.	None; there would be no measurable impacts to the human environment, and there would be no environmental justice impacts.	None; there would be no measurable impacts to the human environment, and there would be no environmental justice impacts.
Health and Safety					
	General impacts during construction and operation. See Section 3.17.3.	**Diversion and Conduit Systems** General impacts during construction and operation. See Section 3.17.3.	Potential impacts related to hydrogen explosions are extremely unlikely.	General impacts during construction and operation. Section 3.17.3.	General impacts during construction and operation. Section 3.17.3.

Table 2-40. Characterization of the Potential for Environmental Impacts – Distributed Renewables

Activity/Technology	Resource Areas																
	Geology and Soils	**Climate and Air Quality**	**Water Resources**	**Biological Resources**	**Land and Submerged Land Use**	**Cultural and Historic Resources**	**Coastal Zone Management**	**Scenic and Visual Resources**	**Recreation Resources**	**Land and Marine Transportation**	**Airspace Management**	**Noise and Vibration**	**Utilities and Infrastructure**	**Hazardous Materials and Waste Management**	**Socioeconomics**	**Environmental Justice**	**Health and Safety**
Biomass	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●
Hydroelectric	●	●	●	●	●	●	○	●	●	○	○	●	●	●	●	●	●
Hydrogen Fuel Cells	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	●
Photovoltaics	○	●	○	○	○	●	○	●	○	○	○	○	●	●	○	○	●
Wind	●	●	●	●	●	●	●	●	●	○	●	●	●	●	○	○	●

○ = No potential impacts.

● = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables

Resource Area	Biomass		Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
	Direct Combustion Biomass-Fueled Steam Turbine Generating Project	**Biodiesel Plant and Electric Power Plant Project**			
Geology and Soils					
	General construction impacts. See Section 3.1.3. Potential soil erosion and degradation from agricultural activities.	General construction impacts. See Section 3.1.3. Potential soil erosion and degradation from agricultural activities.	General construction impacts including land disturbance. See Section 3.1.3. Potential well blowouts during drilling. Potential for increased risk to personnel and equipment from hot fluids and steam and geothermal gases such as hydrogen sulfide. Potential lava flow hazards and risks during operation associated with active volcanoes.	General construction impacts. See Section 3.1.3. No operational impacts.	General construction impacts including soil disturbance. See Section 3.1.3. Potential impacts associated with on-island electrical transmission lines; see Section 8.1.1. Potential impacts to marine sediments and marine communities; see Sections 8.2.1 and 6.4.4. No operational impacts.
Climate and Air Quality					
<u>Air Quality</u>	General construction impacts. See Section 3.2.4 Potential increase in <u>criteria pollutant</u> emissions (including nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) during combustion. Potential increase in criteria pollutant emissions (including carbon dioxide) from biomass production (equipment, fertilizer/ pesticide application, harvest, and transport).	General construction impacts. See Section 3.2.4. Additional criteria pollutant emissions during construction of the biodiesel plant. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) from combustion. Increased criteria pollutant emissions (including carbon dioxide) emissions from biomass production	General construction impacts. See Section 3.2.4. Potential emission of the non-condensable gases during operations. Potential for trace amounts of nitrogen oxides, negligible amounts of sulfur dioxide or particulate matter, and small amounts of carbon dioxide. Potential health impacts from naturally present hydrogen sulfide.	General construction impacts. See Section 3.2.4. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide, as well as carbon dioxide) from combustion. Potential increase in pollutant emissions (including cadmium, carbon monoxide, dioxins/furans, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter, and sulfur dioxide) emissions during project ops.	General construction impacts. See Section 3.2.4. Potential land disturbance and associated fugitive dust at nearby onshore construction related areas. Potential short-term, minor increase in criteria pollutant emissions from construction equipment and marine vessels. Typically, no air quality impacts during operations

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Climate Change	Potential impacts from increased biogenic carbon dioxide emissions and increased greenhouse gas. Decreased greenhouse gas emissions from electricity production using fossil fuels.	Potential increase in carbon dioxide emissions would result in increased greenhouse gas. Decreased greenhouse gas from electricity production using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	Decreased greenhouse gas from electricity production using fossil fuels.	Potential increase in greenhouse gas emissions from construction equipment and marine vessels. Potentially beneficial impacts from greenhouse gas reduction associated with less electricity production using fossil fuels.
Water Resources					
Surface Water	General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff. Increased water demand for crop irrigation (ex: sugarcane crop – more water/acre). Potential adverse impacts from runoff contamination associated with fertilizer/ pesticide applications.	General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff. Increased water supply demand for crop irrigation. Potential adverse impacts from runoff contamination associated with fertilizer/pesticide applications.	General construction impacts. See Section 3.3.5. Potential for minor impacts to surface waters from runoff contaminated with geothermal fluids ("drift") during operation. Potential impacts to surface waters from leaks or releases of low-boiling point organic working fluids (e.g., isobutene or isopentane) during operations.	General construction impacts. See Section 3.3.5. Potential water resource discharge impacts from blowdown chemicals. Potential stormwater contamination from solid waste activities, such as stockpiling, dumping, and moving.	**Onshore** General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff from new building sites (site-specific). **Offshore** Potential ocean sediment disturbance. Potential increased turbidity to communities of concern (site-specific) in marine waters. See Section 8.2.3.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Groundwater	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/ pesticide applications via runoff or local recharge.	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/ pesticide applications via runoff or local recharge.	General construction impacts. See Section 3.3.5. Potential for groundwater contamination/ drinking water supplies from drilling mud used. Potential for increased impacts to water resources from increased water demand (site-specific; i.e., particularly to Maui's Central aquifer sector). Potential groundwater impacts from geothermal fluids removed from the subsurface.	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential increase in water demand.	**Onshore** General construction impacts. See Section 3.3.5. Limited water supply impacts for facility operations. **Offshore** No groundwater impacts.
Floodplains and Wetlands	Potential for general construction impacts. See Section 3.3.5.	Potential for general construction impacts. See Section 3.3.5.	General construction impacts (site-specific). See Section 3.3.5.	Potential for general construction impacts. See Section 3.3.5 (site-specific).	**Onshore** Potential for general construction impacts. See Section 3.3.5 (site-specific). **Offshore** Potential impacts offshore during placement of the MHK device, cables, or pipes.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass		Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
	Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biodiesel Plant and Electric Power Plant Project			
Biological Resources					
	Potential for general construction impacts. See Section 3.4.5. Potential impacts to vegetation or wildlife (including to the wide-ranging Hawaiian hawk and the Hawaiian hoary bat) species (site-specific). Potential beneficial impacts – may create a market for selective harvesting of invasive woody species, such as albizia trees. Potential impacts from the introduction of new, invasive plant species. Potential impacts associated with use of genetically modified plants	General construction impacts. See Section 3.4.5. Potential for loss of wildlife habitat. Potential impacts from the introduction of new, invasive plant species from commercial feedstock production. Potential impacts associated with use of genetically modified plants	General construction impacts. See Section 3.4.5.1. Potential impacts to biological resources including land disturbance and disturbance by human activity. Potential increase in invasive species establishment in disturbed sites. Potential biological impacts on flights of marine birds (such as shearwaters and petrels) from facility lighting (site-specific).	General construction impacts. See Section 3.4.5. Potential for construction impacts including land disturbance to wildlife in adjacent habitats, particularly near important nesting and feeding areas, wetlands, or roost sites (site-specific). See Section 3.4.5.1. Potential for impacts to biological resources during operations (site-specific).	Potential construction impacts include displacement of marine mammals, reptiles, and fish both from physical activity and noise transmission through ocean waters. Potential marine habitat impacts including to marine pools, beaches (both rocky and sand), and coral reefs. Potential loss of beach nesting habitat for sea turtles and marine birds; and resting sites for the Hawaiian monk seal. Potential collision hazards to marine mammals and reptiles during anchor cabling. Potential localized noise (sound waves) impacts (potential auditory injury), avoidance, physical injury to marine mammals, fish, or other species, and alteration of water dynamics from submerged oscillating or rotating components. Potential electromagnetic field impacts from the undersea power cable.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Land and Submerged Land Use					
Land Use	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential conversion of undeveloped land or land under current land uses.	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Undeveloped land or land under current land uses could be converted to energy uses.	Potential change in land use or ownership by purchase or through land leases. Potential impacts to undeveloped land or land with current uses from conversion to an energy facility. Potential land use easement impacts.	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential land use conversion impacts (i.e., the creation of transmission corridors).	Potential land disturbance impacts during construction.
Submerged Land use	Biomass projects would be land-based and not impact submerged land uses.	Biomass projects would be land-based and not impact submerged land uses.	Geothermal projects would be land-based and not impact submerged land uses.	Because the MSW-to-Energy facility would be entirely land-based, there would be no impacts to submerged land use.	Potential localized impacts to the ocean floor from tethering and power cable installation, including obstruction of local marine habitats.
Cultural and Historic Resources					
	General construction and operation impacts. See Section 3.6.6.	General construction and operation impacts. See Section 3.6.6.	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to ethnographic resources as active volcanoes and rift zones are considered sacred by Native Hawaiians. Potential for adverse viewshed impacts from facility development, transmission lines, and other ancillary facilities; particularly to geothermal resources located within and adjacent to the Hawai'i Volcanoes National Park.	General construction and operation impacts. See Section 3.6.6.	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Coastal Zone Management					
	Potential impacts to special management areas, shorefront access, and shoreline erosion (site-specific) through water runoff and sedimentation.	Potential impacts to special management areas, shorefront access, and shoreline erosion through water runoff and sedimentation (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts including land disturbances, structural developments, lighting, and other impacts to special management areas, shorefront access. Potential alteration of shorefront access (site-specific) and alteration of ocean currents.
Scenic and Visual Resources					
	Short-term visual impacts during construction. See Section 3.8.3. Long-term visual impacts from introduction of a new facility. Potential impacts from harvest of biomass. Potential visual impacts from truck traffic during delivery.	Short-term visual impacts during construction. See Section 3.8.3. Long-term visual impacts from introduction of a new facility. Potential impacts during crop harvest. Potential visual impacts from truck traffic delivery.	Potential short-term construction impacts. See Section 3.8.3. Potential long-term visual impacts from the power plant, night lighting, visibility of the transmission line, and the presence of steam plumes at facilities using water-cooled systems.	General visual impacts during construction. See Section 3.8.3. Long-term visual impacts from the MSW combustion facility (site-specific). Long-term visual impacts from truck traffic delivery of MSW (site-specific).	General visual impacts during construction. See Section 3.8.3. Long-term visual impacts (i.e., onshore/ offshore—MHK technology and location specific). Long-term visual impacts from navigation lighting for devices.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Recreation Resources					
	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	General construction impacts. See Section 3.9.4. Potential long-term recreational resource impacts including access restrictions, noise, and visual impacts from the new facilities. Potential permanent loss of recreational values (site-specific). Potential lighting impacts to nearby recreation resources such as campgrounds where dark night sky is valued.	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts including from visual and noise impacts (site-specific). Potential recreational resource impacts from truck traffic. Potential impacts to recreation resources (i.e., nearby campgrounds or areas where a dark night sky is valued) from facility lighting.	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual impacts (site-specific). Potential effects to water-based recreation activities (i.e., swimming, surfing, boating, and fishing) resulting from access restrictions or use alterations to promote recreation user safety and prevent collisions or malfunctions to offshore technologies. Potential wave attenuation impacts at the shore (technology and site-specific; i.e., dependent on the array of devices and location).
Land and Marine Transportation					
Land Transportation	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance.	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance.	Potential short-term impacts on roadway traffic during project construction.	Potential for localized transportation impacts from transporting MSW.	None.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Marine Transportation	None; it is unlikely that bulk biomass would be shipped between islands.	None; it is unlikely that bulk biomass would be shipped between islands.	None identified.	Because the MSW facility would be entirely land-based, there would be no impacts to marine transportation. Transfer of MSW between islands is not anticipated.	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.
Airspace Management					
	Potential hazards to aircrafts from emission stacks for those project locations nearby airports.	Minimal potential hazards to aircrafts from emission stacks for those project locations nearby airports.	None; the development and operation of a geothermal facility would not result in any tall structures or steam exhausts that would require further consultation on airspace management impacts.	Potential impacts if emission stacks are less than 200 feet.	None; MHK would not include any tall structures and therefore would not impact airspace management.
Noise and Vibration					
	Short-term noise and vibration construction impacts. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses. Noise impacts from truck traffic delivery (site-specific).	Short-term noise and vibration construction impacts. Long-term noise and vibration operational impacts (site-specific). Noise impacts from truck traffic delivery (site-specific).	Short-term and long-term noise and vibration impacts would result from exploration, construction, and operation. Potential impacts from noise and vibration would be wholly dependent on sound levels and the proximity of sensitive receptors to the source..	General impacts during construction and operation. See Section 3.12.5.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Utilities and Infrastructure					
	General construction and operation impacts. See Section 3.13.3.1. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction and operation impacts. See Section 3.13.3.1. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, large effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction impacts. See Section 3.13.3.1. Potential for minor to moderate impacts to electric utilities (site-specific, i.e., moderate effects to Maui and minor effects to Hawaii’s utilities).	General construction and operation impacts. See Section 3.13.3.1. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/ management of power grids and overall power production.	General construction impacts. See Section 3.13.3.1.
Hazardous Materials and Waste					
Management Hazardous Materials	General construction impacts. See Section 3.14.4. Potential exposure to high quantities of fertilizers (primarily nitrogen), herbicides, and pesticides.	General construction impacts. See Section 3.14.4. Potential exposure to high quantities of fertilizers, herbicides, and pesticides. Potential hazardous materials exposure impacts from biodiesel leaks or accidents.	General construction impacts. See Section 3.14.4. Potential impact from exposure to hazardous materials if chemicals used during exploration/flow testing or from drilling fluids that were improperly handled or released into the environment. Potential impact from exposure to hazardous materials if an accidental spill or chemical release were to occur during operations from lubricating oils, hydraulic fluids, coolants, solvents, and/or cleaning agents. Potential impact from exposure associated with naturally occurring hydrogen sulfide.	General construction impacts. See Section 3.14.4. Potential exposure to hazardous materials from MSW delivered to the site. Potential impact from exposure to hazardous materials associated with the flammability of syngas production.	General construction impacts. See Section 3.14.4. Potential exposure to hazardous materials including fuels from boats, marine vessels, barges, lubricants and hydraulic fluids contained in the wave or tidal energy devices during operations and maintenance.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Waste Management	General construction impacts. See Section 3.14.4.	General construction impacts. See Section 3.14.4. Potential increase in byproduct waste generated	General construction impacts. See Section 3.14.4. Potentially adverse impacts if additional waste were generated on the island of Hawai'i. Minor amounts of hazardous waste may be generated including paints, coatings, and spent solvents.	General construction impacts. See Section 3.14.4. Potential exposure to of hazardous waste (i.e., infectious waste, electronics, lead acid batteries, firearms, propane tanks, sludge, agricultural wastes, soil, and some noncombustible inorganic materials (such as concrete and stone). Potential waste management impacts from ash waste byproducts. Potentially beneficial impacts resulting from decreased MSW in landfills.	Potential landfill impacts to O'ahu and Hawai'i (pending the resolution of existing landfill capacity constraints) if non-recyclable materials add to existing landfill capacity constraints.
Wastewater	Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during blowdown from the steam cycle and cooling system.	General construction impacts. See Section 3.14.4. Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during the blowdown from the steam cycle and cooling system.	General construction impacts. See Section 3.14.4. Potential wastewater impacts in the event of a leak containing geothermal waste fluids.	General construction impacts. See Section 3.14.4. Potential impacts to wastewater services from blowdown.	Potential impacts to wastewater services from vessel effluent during construction. No operational impacts.
Socioeconomics					
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.

Table 2-41a. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Biomass: Direct Combustion Biomass-Fueled Steam Turbine Generating Project	Biomass: Biodiesel Plant and Electric Power Plant Project	Geothermal	Municipal Solid Waste (MSW) to Energy Facility	Marine Hydrokinetic Energy (MHK)
Environmental Justice					
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	No effects identified. Because of the uncertainty of the MHK designs and the low potential for adverse impacts, there would be no disproportionate high and adverse impacts to minority or low-income populations, there would be no environmental justice impacts from MHK.
Health and Safety					
	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3. Potential health and safety effects from drilling including hydrogen sulfide worker exposure. Potential health and safety impacts from physical, thermal, and chemical hazards such as hydrogen sulfide exposure.	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3. Potential for public health and safety effects including to boats, both civilian and military marine vessels, and to the public onshore in the event the device were destroyed, damaged or if the loss of mooring/ spatial stabilization were to occur.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Geology and Soils					
	None; the only potential impacts to geology and soils would be the interface of the undersea cable to connect the OTEC facilities with the grid. These impacts are addressed in Section 8.1.	General construction impacts from land disturbance/soil erosion. See Section 3.1.3. No operational impacts.	General construction impacts from land disturbance. See Section 3.1.3. Potential for soil contamination in the event of a leak or accidental release of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	General construction impacts from land disturbance/soil erosion. See Section 3.1.3. No operational impacts.	General onshore construction impacts from land disturbance/soil erosion. See Section 3.1.3. Potential impacts to marine sediments (e.g., natural migration of sand) from anchor/mooring devices, undersea cables, and land/sea transition zones. See Section 8.2.1. No operational impacts.
Climate and Air Quality					
Air Quality	General construction impacts. See Section 3.2.4. Limited, intermittent, and short-term air quality impacts during construction. Potential land disturbance and related fugitive dust at nearby onshore construction related areas, including areas where offshore electrical lines connect with the onshore regional electric grid.	General construction impacts. See Section 3.2.4 No operational impacts.	General construction impacts. See Section 3.2.4. No operational impacts.	General construction impacts. See Section 3.2.4. No operational impacts.	General construction impacts. See Section 3.2.4. Potential increased criteria pollutants from construction equipment including marine vessels (powered by fossil fuels i.e., diesel, or gasoline) during construction. Potential for fugitive dust at nearby onshore construction related areas.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
	Potential increase in criteria pollutant emissions during construction from equipment or marine vessels powered by fossil fuels. Potential operational emissions from auxiliary diesel generators on the platform.				
Climate Change	Potential increase in greenhouse gas emissions from construction equipment and operation of diesel generators on the platform. Potential greenhouse gas emissions reduction from a mix of technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of different technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity using fossil fuels.
Water Resources					
Surface Water	Potential ocean sediment disturbance resulting in increased turbidity and impacts to coral or other bottom communities of concern. Potential water quality impacts from discharge not meeting water quality criteria for marine waters (e.g., nutrient levels such as nitrite plus nitrate, phosphate, and phosphorous).	General construction impacts. See Section 3.3.5. Potential stormwater runoff from the site (dependent on the amount of impermeable surface/nature of the preconstruction site).	General construction impacts. See Section 3.3.5. Potential stormwater runoff contamination in the event of leaks or accidental releases of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	General construction impacts. See Section 3.3.5. Potential impacts from power pole installation to the nearest electrical grid are discussed in Section 8.1.3. Potential for increased stormwater runoff as a result of increased impermeable surfaces (wind turbine foundations, electrical support buildings, and paved roads or parking areas) – (site-specific).	General construction impacts including horizontal directional drilling for electrical cables and for the construction of a substation. See Section 3.3.5. No potential onshore effects during operations. Potential for increased turbidity at breakout point from drilling mud or slurries used during horizontal directional drilling.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
	Potential increased algal bloom impacts from increased nutrient levels. Potential impacts from temperature variation and elevated chlorine levels of discharge. See Section 6.5.4 for impacts to biological resources.				Potential impacts to coral or other bottom communities of concern from high turbidity (site-specific).
Groundwater	Minimal groundwater impacts during construction and operation.	General construction impacts. See Section 3.3.5 Potential changes in runoff to the site and potential associated change in groundwater recharge.	Minor groundwater impacts during construction. See Section 3.3.5. Potential changes in runoff to the site and potential associated change in groundwater recharge.	General construction impacts. See Section 3.3.5	General onshore construction impacts. See Section 3.3.5. No operational impacts.
Floodplains and Wetlands	None identified.	Potential impacts during construction (site-specific). See Section 3.3.5.	Potential impacts during construction (site-specific). See Section 3.3.5.	impacts during construction (site-specific). See Section 3.3.5.	impacts during construction (site-specific). See Section 3.3.5.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Biological Resources					
	Potential for short-term and small disturbances during placement of the cabling lines, moors, and anchors. Potential disturbance to deep and shallow marine habitats and shorelines (including marine pools, sandy and rocky beaches, seagrass habitat, shallow benthic communities, and coral reefs at multiple depths) during construction (site-specific). Potential impacts to the marine environment from introduction of an electromagnetic field along the undersea cable. Potential attraction of marine fish, mammals, and seabirds to structures and for biofouling organisms. Potential impacts to marine communities from nutrient rich discharge waters. Potential impacts to marine organisms due to intake pipes. Potential collision hazards to marine mammals from mooring lines.	General construction impacts. See Section 3.4.5. Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	General construction impacts. See Section 3.4.5. Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands) from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	General construction and operation impacts. See Section 3.4.5. Potential impacts to biological resources including loss of vegetation and wildlife (migratory birds, threatened and endangered plants and animals, critical habitat, and other high value areas such as wetlands and native plant communities) from site development (site-specific). Potential for mortality of avian species and bats (site-specific). Potential impacts to seabirds by attracting/disorienting them from onsite lighting.	General construction and operation impacts. See Section 3.4.5. Potential disturbance impacts to the ocean floor and marine communities/ habitats (i.e., coral reefs, shallow benthic communities, seagrasses, beaches, and possibly marine pools) during installation of anchors, undersea cables (site-specific). Potential impacts to marine animals from temporary construction noise impacts. Potential for increase in marine mammal collisions from ships and boats during construction. Potential increase for hazards to marine mammals congregating in marine subsurface structures. Potential for increased collision hazard for large marine mammals (i.e., whales) from mooring cables.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
					Potential hazards (increased risk for mortalities by rotor blade collision) to seabirds in areas surrounding wind turbines due to potential aggregation of forage fish near submarine structures, tower safety lighting, and potential use of aboveground platform structures as resting areas. Potential introduction of an electromagnetic field into the marine environment along the cable resulting in potential impacts to marine mammals with electrosensory systems.
Land and Submerged Land Use					
Land Use	See Section 8.2.5 for typical land use impacts associated with the interface of an undersea cable and the electrical grid.	Potential land use impacts including land disturbance and possible conversion of undeveloped land and land in other current use to an energy generating facility. Potential change in land ownership patterns and/or easements required for the project (i.e., project site, access roads, corridors to the nearest electrical grid). Potential impacts to adjacent land uses (roads, residential/ commercial areas, historic sites, scenic locations, and airports) from the glint and glare of the solar panels.	Potential change in land ownership patterns through purchase and or land use leases for both the solar thermal project site and any linear corridors required to tie-in to the existing electrical grid. Potential impacts to undeveloped land or land currently used for other uses could be converted to energy uses.	Potential land use impacts including land disturbance during site preparation and turbine installation, as well as access road construction and support structures. Potential conversion of undeveloped land or land with other current land uses for energy use. Potential landownership changes and obtainment of land use easements.	Potential change in local landownership patterns. Potential land disturbance during construction of the tie-in to the existing transmission grid.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Submerged Land Use	Potential for large obstructions in the ocean floor from structures.	None; PV projects would be land-based and not impact submerged land uses.	None; solar thermal projects would be land-based and not impact submerged land uses.	None; land-based wind turbines would have no potential effects to submerged land use.	Potential impacts to sea floor requiring a submerged lands lease. See Section 8.2.5.
Cultural and Historic Resources					
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource..	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.
Coastal Zone Management					
	Potential impacts to designated special management areas from the cable crossing the shoreline (site-specific). Potential shorefront access impacts from the cable crossing the shoreline (site-specific). Potential shoreline erosion impacts from the cable crossing the shoreline (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific); Potential for adverse impacts to those locations near the shoreline. Potential for increase in runoff and sedimentation and impacts to coastal water habitats from land clearing.	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Scenic and Visual Resources					
	General visual impacts during construction. See Section 3.8.3. See Section 8.2.8 for potential visual impacts from land/ sea cable transition sites. Potential long-term visual impacts onshore from the introduction of a transition site.	General visual impacts during construction. See Section 3.8.3. Potential long-term visual impacts from solar panels, including in association with new facilities and associated buildings. Potential glinting, glare, and visual effects depending on the panel orientation, sun angle, viewing angle, viewer distance, and other visibility factors; may also be dependent on individual viewer sensitivity. Potential long term visual effects from routine maintenance activities.	General visual impacts during construction. See Section 3.8.3. Potential long-term dynamic visual impacts from parabolic troughs/mirrors (glare/ reflected light), thermal storage tanks, steam condenser, cooling towers (plumes) and generator as well as road access, parking, maintenance facilities, and transmission line tie-in. Potential for individual discomfort from glare effects, depending on viewer sensitivity, viewer location, viewer movement, and time of day. Potential increase in light pollution impacts (skyglow, light trespass, and glare) from security lighting and other exterior lighting around buildings, parking areas, work areas and during maintenance activities (vehicle-mounted lights).	General short-term visual impacts during construction including site preparation activities such as clearing, construction of access and onsite roads, equipment laydown areas, installation of turbine foundations, erection of turbines, and connection to the grid. See Section 3.8.3. Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, movement of the rotor blades, shadow flicker, blade glinting, flashing aviation warning lights, roads, vehicles, and workers conducting maintenance activities. Depending on viewer sensitivity, potential for long-term impacts to viewers nearby due to the strong vertical lines/ large sweep of turbines/ moving blades that can dominate views or command visual attention. Depending on viewer sensitivity, potential for long-term shadow flicker impacts for viewers close enough to fall within the shadows cast by the turbines.	Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, the sweeping movement of the blades, lighting for the marine and aviation navigation, and the land/sea transition site. Depending on viewer sensitivity, potential for long-term impacts to viewers due to the strong vertical lines/large sweep of turbines/ moving blades that can dominate views or command visual attention.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Recreation Resources					
	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts in the vicinity of onshore and offshore facilities from access restrictions and potential visual impacts from the facilities.	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts such as land cover required for the arrays and associated facilities required for the project resulting in access restrictions to area as well as visual impacts created by the presence of the facilities and maintenance activities. Potential impacts to nearby recreation areas from panels and other components that reflect and result in glinting, glare, and other visual effects.	General construction impacts. See Section 3.9.4. Potential long-term impacts to recreation resources from access restrictions to the site and visual impacts associated with the new facilities. See Section 6.7.8 regarding visual effects of solar thermal facilities. Potential impacts to recreation resources from light pollution, particularly those areas where a dark night sky is valued (i.e., campgrounds)	General construction impacts. See Section 3.9.4. Potential long-term recreational resource impacts such as access restrictions due to the presence of wind turbines, movement of the rotor blades, shadow flicker, blade glinting, aviation warning lights, roads, vehicles, and workers conducting maintenance activities. Potential impacts to nearby recreation areas from strong vertical lines of the turbines dominating views and large sweep of moving blades commanding visual attention. Potential intrusion to the natural scenery and viewshed depending on the viewer sensitivity. Potential impacts to the night sky for nearby recreation areas (i.e., campgrounds) from aviating warning lights.	General construction impacts. See Section 3.9.4. Potential long-term recreational resource impacts including access restrictions due to the presence of the wind turbines, the sweeping movement of the rotor blades, lighting for marine and aviation navigation, and the land/sea transition site.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Land and Marine Transportation					
Land Transportation	None.	Short-term transportation impacts associated with construction traffic.	Short-term transportation impacts associated with construction traffic.	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the construction site).	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the harbor for transport to the construction site).
Marine Transportation	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.	None; installation and operation of a utility-scale PV system would not impact marine transportation.	None; installation and operation of a solar thermal system would not have any marine transportation impacts as it would be totally land-based.	Minor impacts on marine transportation from shipment via marine cargo ship.	Potential navigation hazards to domestic and military marine transportation including to military submarine operations from undersea structures (mooring cables and power lines extending down to the ocean floor).
Airspace Management					
	Potential impacts to military transportation operations (marine surface and aviation operations). Potential impacts on approach paths to airports.	Potential hazards to aircraft and pilots from sunlight reflection; dependent on the magnitude of reflection (glint and glare) from solar power systems.	Potential hazards to both military and civilian aircraft from reflections of the concentrated solar power facility. Potential air turbulence hazards to both military and civilian aircraft (likely limited to low altitude aircraft; i.e., helicopters or during take-offs and landings) from concentrated solar power plants employing a dry cooling system.	Potential hazards to airspace navigation, both military (training and operations) and civilian (including tourist industry helicopters/ fix-winged). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor induced turbulence.	Potential hazards to airspace navigation, both military (training and operations) and civilian (including tourist industry helicopters/fix-winged aircraft). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor-induced turbulence.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Noise and Vibration					
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of an OTEC facility 3.5 miles off-shore would be minimal with implementation of best management practices.	General impacts during construction. See Section 3.12.5.	General impacts during construction. See Section 3.12.5.	General impacts during construction. See Section 3.12.5. Operational noise and vibration impacts from land-based wind turbines would occur when wind conditions are favorable, day or night.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of wind turbines located 5 miles offshore would be minimal with implementation of best management practices.
Utilities and Infrastructure					
	General construction impacts. See Section 3.13.3.1. Potentially moderate effects to electric utilities (site-specific).	General construction impacts. See Section 3.13.3.1. Potential minimal impacts to electric utilities (site-specific).	General construction impacts. See Section 3.13.3.1. Potential minimal impacts to electric utilities (site-specific).	General construction impacts. See Section 3.13.3.1. Potential minor impacts to electric utilities (site-specific).	General construction impacts. See Section 3.13.3.1. Potential impacts to electric utilities (site-specific).
Hazardous Materials and Waste Management					
Hazardous Materials	General construction impacts. See Section 3.14.4. Potential exposure to hazardous materials during operations from large quantities of ammonia and/or chlorine gas/liquid, including through accidental releases or leaks.	General construction and operational impacts. See Section 3.14.4. Potential exposure to trace amounts of hazardous materials (i.e., cadmium, selenium, arsenic) if panels were broken.	General construction impacts. See Section 3.14.4.	General construction impacts. See Section 3.14.4. See Section 8.5.14 regarding potential hazardous material exposure impacts resulting from use of batteries for energy storage.	General construction impacts. See Section 3.14.4. Potential hazardous materials impacts associated with construction from MRS sites and the potential use of batteries for energy storage. See Section 8.2.14.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
	Potential for fires or explosions from chorine and gaseous ammonia combinations.				
Waste Management	General construction impacts. See Section 3.14.4.	General construction and operational impacts. See Section 3.14.4. Potential of <u>hazardous waste</u> impacts resulting from trace amounts of cadmium, selenium, or arsenic if solar panels are broken and/or during solar panel decommissioning/disposal.	General construction impacts. See Section 3.14.4.	General construction impacts. See Section 3.14.4. See Section 8.5.14 regarding potential of <u>hazardous waste</u> impacts resulting from use of batteries for energy storage.	General construction impacts. See Section 3.14.4. Minimal construction and demolition waste. Potential impacts during the decommissioning and dismantling of the wind turbine as result of turbine removal.
Wastewater	Potential impacts to wastewater effluent from added chlorine. See Section 6.5.3 for additional discussion on impacts to water resources.	General construction impacts. See Section 3.14.4. Potential impacts from wastewater discharge resulting from disposal of PV modules at their end-life, particularly from potential leaching or contamination from cadmium containing materials.	General construction impacts. See Section 3.14.4.	General construction impacts. See Section 3.14.4.	Minor and limited wastewater impacts from construction and during operations/maintenance activities from personnel and machinery operations.
Socioeconomics					
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.

Table 2-41b. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Utility-Scale Renewables (continued)

Resource Area	Ocean Thermal Energy Conversion (OTEC)	Photovoltaic Systems	Solar Thermal Systems	Wind (Land-Based)	Wind (Offshore)
Environmental Justice					
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. No disproportionately high and adverse impacts to minority populations or to low-income population from solar photovoltaic panels operations.	Minimal potential for environmental justice impacts due to small environmental impacts to general population.	Small environmental justice impacts. Potentially adverse impacts to minority populations or to low-income population associated with potential visual and scenic, noise and vibration, or other resource impacts in the adjunct and nearby areas from development of a utility-scale wind turbine project.	Small potential for environmental justice impacts. Potentially adverse impacts to minority populations or to low-income population associated general environmental impacts in the adjunct and nearby areas from development of a utility-scale offshore wind turbine project.
Health and Safety					
	General construction and operational impacts. See Section 3.17.3. Potential worker exposure to chlorine and ammonia gases.	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3.	General construction and operational impacts. See Section 3.17.3. Potential for public health and safety impacts including to boats, both civilian and military marine vessels, and to the public onshore in the unlikely event the device were destroyed, damaged or if the loss of mooring/ spatial stabilization were to occur.

Table 2-42. Characterization of the Potential for Environmental Impacts – Utility-Scale Renewables

Activity/Technology		Resource Areas																
		Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Biomass	Direct Combustion – Steam Turbine	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Biodiesel Plant/ Electric Plant	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Geothermal		●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●
Municipal Solid Waste		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Marine Hydrokinetic Energy		●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●
Ocean Thermal Energy		○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Photovoltaic Systems		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Solar Thermal Systems		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Wind (Land-Based)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Wind (Offshore)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

○ = No potential impacts.

● = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Geology and Soils						
	Construction impacts would be similar for any of the biofuel technologies and would be consistent with those expected for common construction actions as described in Section 3.1.3. During operation, potential impacts on geology and soils could vary greatly depending on the biofuel technology and <u>feedstock</u>: potential impacts include soil nutrient depletion; contamination from over-application of pesticides; and increased risk of erosion following crop harvest.	Soil disturbances would be limited to instances where minor trenching was required to install chargers at commercial or residential locations.	None; increasing the number of HEVs would not impact geology and soils.	General construction and operation impacts. See Section 3.1.3.	General construction and operation impacts. See Section 3.1.3.	General construction and operation impacts. See Section 3.1.3.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Climate and Air Quality						
Air Quality	General construction and operation impacts. See Section 3.2.4. The production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit criteria pollutants during the production process. These emissions are addressed in Section 6.1.2 for utility-scale biomass projects.	Reduction in air emissions from lowering gasoline usage in passenger vehicles would be partially offset by the amount of air emissions produced from generating electricity.	Potential reduction in criteria pollutants emitted by internal combustion engine vehicles.	General construction impacts. See Section 3.2.4. Potential air emissions associated with distribution of hydrogen.	General construction impacts. See Section 3.2.4. Leaks and air emissions from the liquid natural gas import station would be possible. Potentially beneficial operational air quality and climate change impacts due to replacement of 20 million gallons of gasoline.	General construction impacts. See Section 3.2.4. Using electricity to operate the rail transit would result in criteria pollutants from producing electricity from oil products, unless the generation used renewable sources. Although total transportation energy demand would decrease by 14.1 million gallons per year and reduce passenger vehicle emissions, criteria pollutant emissions still would occur from the operation and usage of diesel buses.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Climate Change	The production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit greenhouse gases during the production process. These emissions are addressed in Section 6.1.2 for utility-scale biomass projects. Gasoline replacement would result in annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	Reduction in greenhouse gas emissions from lowering gasoline usage in passenger vehicles would be partially offset by the amount of greenhouse gas emissions produced from generating electricity.	A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	Potential beneficial impact; A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	General construction impacts. See Section 3.2.4. Leaks and air emissions from the liquid natural gas import station would be possible. Potential beneficial operational benefits due to replacement of 20 million gallons of gasoline.	General construction impacts. See Section 3.2.4. Using electricity to operate the rail transit would result in greenhouse gas emissions from producing electricity from oil products, unless the generation used renewable sources. Although total transportation energy demand would decrease by 14.1 million gallons per year and reduce passenger vehicle emissions, greenhouse gas emissions still would occur from the operation and usage of diesel buses.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Water Resources						
Surface Water	General construction impacts to surface water. See Section 3.3.5. Minimal operational impacts of a biofuel processing plant other than possibly increasing storm water runoff from the site. Potentially significant water use impacts associated with feedstock crops. See Section 6.1. Potential impacts from runoff contamination during feedstock/ agricultural production as a result of fertilizer or pesticide applications. No impacts to surface water resources from use of biofuel as a supplement to, or replacement for gasoline.	None; increasing the number of electric vehicles in Hawai‘i would not impact water resources.	None; increasing the number of HEVs would not impact water resources.	General construction and operation impacts. See Section 3.3.5. Groundwater likely would be required for the generation of hydrogen.	General construction and operation impacts. See Section 3.3.5.	General construction impacts. See Section 3.3.5. Potential improvement to storm water runoff quality from fewer cars on the road (i.e., less contamination).

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Groundwater	General construction impacts. See Section 3.3.5. Long-term operational impacts of biofuel processing plant to groundwater would be limited primarily to the water needs to operate the facilities. Potential operational impact of biofuel agricultural activities due to contamination from fertilizer or pesticide applications reaching groundwater either via runoff or local recharge. Use of biofuel as a supplement to, or replacement for gasoline would not be expected to have any impact on groundwater resources.	None; increasing the number of electric vehicles in Hawai‘i would not impact groundwater resources.	None; increasing the number of HEVs would not impact groundwater resources.	General construction and operation impacts. See Section 3.3.5.	General construction and operation impacts. See Section 3.3.5.	General construction impacts. See Section 3.3.5. Potential improvement to groundwater quality from cleaner runoff.
Floodplains and Wetlands	Potential effects to floodplain and wetland areas during construction if floodplains and wetlands were not avoided.	None; increasing the number of electric vehicles in Hawai‘i would not impact floodplains and wetland resources.	None; increasing the number of HEVs would not impact floodplain and wetland resources.	General construction and operation impacts. See Section 3.3.5.	General construction and operation impacts. See Section 3.3.5.	General construction impacts. See Section 3.3.5.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Biological Resources						
	Impacts common to construction and operations activities are identified in Section 3.4.5. Impacts to terrestrial wildlife and protected plants and animals from construction of the biofuel production plant and local infrastructure (e.g., access roads, water lines, electrical lines) are expected to be relatively minor. Potentially significant impacts associated with agricultural production of some feedstocks posing invasive risk. Minimal potential impacts associated with conversion of land to feedstock production as there is readily available surplus of arable land previously used in agricultural production.	None; increasing the number of electric vehicles in Hawai‘i would not impact biological resources.	None; increasing the number of HEVs would not impact biological resources.	None; the generation of hydrogen and use of hydrogen as a vehicle fuel would not result in impacts to biological resources.	No biological resources impacts anticipated during upgrade and expansion of existing onshore infrastructure as these activities are expected to occur in existing developed areas.	General construction and operation impacts. See Section 3.4.5.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Land and Submerged Land Use						
Land Use	General construction and operation impacts. See Section 3.5.4. Land use impacts could occur from the construction and operation of new production facilities required to generate the biofuels and the infrastructure required to distribute it as an alternative transportation fuel source.	Reduced gasoline demand could result in decreased number of conventional fueling stations; small parcels of land could be converted to other uses and ownership.	None; increasing the number of HEVs would not impact land use.	Potential change in land use from the expansion geothermal facilities on Hawai‘i and a future PV complex on O‘ahu to produce hydrogen. Depending on the actual siting of the facility there could be change in landownership patterns. Potential change in land use in locations where distribution pipeline and storage tanks would be installed and fueling stations constructed. Operation impacts to land use would be limited to facility maintenance activities.	General construction and operation impacts. See Section 3.5.4.	Potential change in land use designation and/or ownership in areas of railway. Reduced demand for gasoline and diesel fuel leading to a decrease in the number of conventional fueling stations, and small parcels of land could be converted to other uses and ownership.
Submerged Land Use	Potential submerged land use impacts if feedstock used to produce the biofuels were harvested offshore (i.e., algae).	None; increasing the number of electric vehicles in Hawai‘i would not impact submerged land use.	None; increasing the number of HEVs would not impact submerged land use.	None identified.	None; increased use of LNG and LPG would not impact submerged land use.	None identified.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Cultural and Historic Resources						
	General construction and operation impacts. Sections 3.6.6.	None; increasing the number of electric vehicles in Hawai'i would not impact cultural or historic resources.	None; increasing the number of HEVs would not impact cultural or historic resources.	General construction and operation impacts. See Section 3.6.6. Additional cultural perspectives and impacts regarding geothermal energy development are described in Section 6.2.6.	General construction and operation impacts. See Section 3.6.6.	General construction and operation impacts. See Section 3.6.6.
Coastal Zone Management						
	General, site-specific impacts dependent on the locations of additional fueling stations.	None; increasing the number of electric vehicles in Hawai'i would not impact coastal zone management.	None; increasing the number of HEVs would not impact coastal zone management.	Potential impacts to designated special management areas and affect shorefront access.	None; increasing the number of vehicles using LPG/LNG would not impact coastal zone management.	None; the representative project does not include locations near the coast.
Scenic and Visual Resources						
	Potential visual impacts from constructing and operating biofuel processing plant described in Section 6.1.8.	None; increasing the number of electric vehicles in Hawai'i would not impact scenic or visual resources.	None; increasing the number of HEVs would not impact scenic or visual resources.	General construction impacts. See Section 3.8.3.	General construction impacts. See Section 3.8.3.	General construction impacts. See Section 3.8.3.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
	Minimal long-term visual impacts typical of agricultural activity, including presence of workers and equipment; lands zoned for agricultural use. Minimal visual impacts associated with truck traffic delivering biomass to processing plant.			Long-term visual impacts would occur from the presence of the new production facilities and distribution infrastructure, including pipelines, storage tanks, and fueling stations, and exterior lighting. Visual impacts would be highly dependent on the location and compatibility with the existing viewshed and land uses.	Potential long-term impacts due to new aboveground storage tanks and fueling facilities (site-specific).	Long-term scenic and visual resource impacts from new infrastructure (site-specific).

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Recreation Resources						
	General construction impacts. See Section 3.9.4. Minimal long-term impacts of feedstock production due to existing agricultural character of the area potentially included in the growing of feedstock and likelihood of growing feedstock in land zoned for agricultural uses as opposed to recreation uses.	None; increasing the number of electric vehicles in Hawai'i would not impact recreation resources.	None; increasing the number of HEVs would not impact recreation resources.	General construction and operation impacts. See Section 3.9.4.	General construction and operation impacts. See Section 3.9.4.	Potential long-term impacts if new infrastructure intersected an area currently used or with potential for future use for recreational purposes.
Land and Marine Transportation						
Land Transportation	Increased truck and employee traffic around processing facilities. Minor increase in truck traffic near biomass collection points.	Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of plug-in electric vehicles increased.	Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of hybrid electric vehicles increases.	General construction impacts. See Section 3.10.3. Potential long-term land transportation impacts from tanker trucks transporting the produced hydrogen if tankers are used with or in place of pipelines.	Land transportation would be required to distribute gas to local fueling stations. Natural gas would likely replace other petroleum-based products; therefore the amount of truck transportation would not increase but change to a different type of vehicle.	Beneficial impacts to traffic congestion by reducing number of cars on the road. Potential for an expanded and/or new maintenance and heavy maintenance facility for increased fleet of diesel buses.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
	Repeated truck traffic could increase wear and tear on road pavement and increase the frequency of road maintenance.					Potential local traffic impacts during construction of infrastructure to support increased fleet of diesel buses and to expand light rail service.
Marine Transportation	Potential impacts on operation of the harbor systems, harbor infrastructure, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations. Potential impact to harbor system if new liquid bulk handling facilities are required.	None; increasing the number of electric vehicles in Hawai'i would not impact marine transportation.	None; increasing the number of HEVs would not impact marine transportation.	Potential long-term marine transportation impacts if produced hydrogen is transported to other islands; would require additional handling facilities at harbors as well as ships with the appropriate storage capability.	Fueling facilities would be constructed consistent with existing traffic patterns	None; while an increase in multi-modal transportation could affect inter- and intra-island ferry use, the representative project addresses bus and rail transportation only.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Airspace Management						
	None; interference with safe air traffic would not occur as a result of the development or use of biofuels.	None; increasing the number of electric vehicles in Hawai‘i would not impact airspace management.	None; increasing the number of HEVs would not impact airspace management.	None; the generation of hydrogen or the use of hydrogen as a vehicle fuel would not result in any tall structures or other impacts to regional airspace.	None; the use of LNG/LPG or the additional fueling stations would not impacts airspace.	None; no impacts to airspace management would be expected from the increased use of multi-modal transportation.
Noise and Vibration						
	General impacts during construction. See Section 3.12.5. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses.	General impacts during construction and operation. See Section 3.12.5.	None; there are no HEVs manufactured in Hawai‘i. Therefore, noise and vibration impacts associated with construction would occur elsewhere.	General impacts during construction. See Section 3.12.5. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses. Increase in marine vessel transport operations would increase noise levels at the harbors.	General impacts during construction associated with construction of fueling facilities. See Section 3.12.5.	General impacts during construction. See Section 3.12.5. Operation of expanded bus and rail systems could potentially result in long-term impacts compared to existing noise and vibration levels, depending on the location of transit corridors and compatibility with the existing noise levels and land uses.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Utilities and Infrastructure						
	Potential impact to local energy utilities by bringing large production facilities online which could affect their load capacity.	Potential impacts on the islands electric utilities would primarily be an increased power demand of 292 gigawatt-hours per year (equivalent to about 33megawatts if operated continuously) to operate charging stations for the required number of vehicles to support the reduction of 20 million gallons of gasoline. This increase would need to be met either by offsetting renewable power generators or continued use of existing power facilities. This additional load would ramp up slowly as the penetration of PEVs increased on the islands.	None; increasing the number of HEVs would not impact utilities and infrastructure.	Impacts from increased hydrogen production would be similar to those in Section 6.2.3 for the geothermal technology and Section 6.7.3 for PV technology. No impacts from hydrogen-operated vehicles because it would not result in a change to electricity demand.	Infrastructure of LNG and LPG fueling stations would need to be expanded to support demand.	None; no impacts to utilities and infrastructure would be expected from increased use of multi-modal transportation.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Hazardous Materials and Waste Management						
Hazardous Materials	Potential impacts from exposure to hazardous materials could result from chemical application (herbicides, pesticides, soil amendments) related to feedstock production. Potential impacts from exposure to hazardous materials associated with biofuel processing. See Section 6.1.14. Potential impacts from exposure to hazardous materials from accidents and spills during handling, storage, and transport of biofuels to fuel stations.	Minimal hazardous material impacts from plug-in electric vehicles during operations. Hazardous material impacts may result at the end-life of the vehicle use from batteries. See Section 7.2.14.1.2.	Potential hazardous material exposure impacts resulting from hybrid electric vehicles at its end-life or during its disposal.	Minimal hazardous material exposure impacts anticipated from increased hydrogen production at the Puna Geothermal Plant. No hazardous material exposure impacts anticipated from hydrogen production via a 50-megawatt utility-scale solar PV system. Minimal hazardous waste exposure impacts during distribution of fuel via tankers or pipelines. Minimal impacts from exposure to hazardous materials during construction and development of hydrogen pipelines and fueling stations. Minimal hazardous material exposure impacts during operation of hydrogen fuel-celled vehicles.	Potential exposure to hazardous material impacts during import and distribution of natural gas if accidental spills or releases occur. Potential short-term construction impacts from exposure to hazardous materials during modifications and/or expansions of natural gas distribution system. See Section 3.14. Minimal impacts from exposure to hazardous materials from increased propane production, distribution and use on O'ahu. The operation of compressed natural gas vehicles and propane-powered vehicles is not anticipated to result in hazardous material exposure impacts.	Potential impact from exposure. Increased fleet size leads to an increased potential for leaks and spills of lubricating oils, hydraulic fluids, coolants, solvents, and cleaning agents.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Waste Management	Minimal waste management impacts from feedstock production and processing. Potential impacts would occur during the construction and operation of the processing facilities to produce biofuels. See Section 6.1.14.	Potential waste management impacts at the end-life of electric vehicles or during its disposal. Potential impacts would result from the import and use of plug-in electric vehicles; replacement of existing internal combustion engine vehicles result in an increase in the amount of waste vehicles.	Potential waste management impacts resulting from the use of hybrid electric vehicles would occur at the end-life of the vehicles or during their disposal.	No new solid waste to be generated by the Puna Geothermal Plant for hydrogen production. Minimal waste management impacts would occur during construction of utility-scale PV system for hydrogen production and associated distribution pipelines and fueling stations; See Section 3.14.4. Minimal impacts would occur during the end life of the PV system; discarded solar panels may need to be managed and disposed of as hazardous waste; it is anticipated that primary waste management impacts resulting from the project would be minimal. Other potential impacts may result from displacement of existing internal combustion **Potential for**	Potential waste management impacts during construction and development of additional natural gas fueling stations. See Section 3.14. Minimal impacts associated with modification and expansion of LPG fueling stations. Minimal impacts associated with retrofitting existing vehicle fleet for natural gas/LPG use.	General construction and operation impacts. See Section 3.14.4.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Wastewater	Refer to surface water impacts.	None; transitioning to a fleet of electric and hybrid electric vehicles would not impact wastewater.	None; increasing the number of HEVs would not impact wastewater.	Potential wastewater impacts associated with hydrogen production from the representative geothermal project would be similar to those impacts discussed in Section 6.2. Potential beneficial impacts to water resources and wastewater services if the project produced hydrogen using wastewater. Wastewater impacts resulting from solar energy produced hydrogen would likely occur during the manufacturing process. These impacts are discussed in Section 5.4.	None; increasing the number of LNG and LPG vehicles in Hawai‘i would not impact wastewater.	General construction and operation impacts. See Section 3.14.4.
Socioeconomics						
	The impact to population and employment variables; to would be very small.	The impact to population and employment variables would be very small.	None; increasing the number of HEVs would not impact socioeconomics.	The impact to population and employment variables would be small.	The impact to population and employment variables would be very small.	The impact to population and employment variables would be very small.

Table 2-43. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Alternative Fuels and Transportation Modes (continued)

Resource Area	Biofuels	Plug-In Electric Vehicles	Hybrid Electric Vehicles	Hydrogen	CNG, LNG, and LPG	Multi-Modal Transportation
Environmental Justice						
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	None; transitioning to a fleet of electric and hybrid electric vehicles would not have environmental justice impacts.	None; increasing the number of HEVs would not have environmental justice impacts.	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Small environmental justice impacts.	Small environmental justice impacts.
Health and Safety						
	None; The development or use of biofuels would not introduce any unique health hazard beyond that already addressed as a function of air quality or standard industrial hazards.	None; transitioning to a fleet of electric and hybrid electric vehicles in Hawai‘i would not introduce any new significant hazards compared with gasoline- or diesel-powered vehicles.	None; increasing the number of HEVs in Hawai‘i would not introduce any new significant hazards as compared to gasoline- or diesel-powered vehicles	No significant accident consequences are anticipated as a result of increased use of hydrogen as a vehicle fuel.	General construction and operation impacts. See Section 3.17.3.	None; no impacts to health and safety would be expected from increased use of multi-modal transportation.

Table 2-44. Characterization of the Potential for Environmental Impacts – Alternative Transportation Fuels and Modes

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
Biofuels	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	○	○
Plug-In Electric Vehicles	●	●	○	○	●	○	○	○	○	●	○	●	●	●	●	○	○
Hybrid Electric Vehicles	○	●	○	○	○	○	○	○	○	●	○	○	○	●	○	○	○
Hydrogen	●	●	●	○	●	●	○	●	●	●	○	●	●	●	●	○	○
Compressed and Liquefied Natural Gas and Liquefied Petroleum Gas	●	●	○	●	●	●	○	○	○	●	○	○	●	●	○	○	●
Multi-Modal Transportation	●	●	●	●	●	●	○	●	●	●	○	●	○	●	●	○	○

○ = No potential impacts.

● = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage: Flywheel	Energy Storage: Sodium-Sulfur Battery
Geology and Soils					
	General impacts during construction. See Section 3.1.3.	**<u>Onshore</u>** General impacts during construction. See Section 3.1.3. **<u>Offshore</u>** Potential disturbance of marine sediments during construction (short-term) with minor impacts: • Sediment disturbance at horizontal directional drilling (HDD) breakout point • Drilling mud/slurry release at HDD breakout point • Sediment disturbance at trenching locations. No impacts to geology and soils during operation.	None; installing electronic equipment and upgrading software for the representative smart grid project would not involve land disturbance and therefore would not impact geology and soils.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	General construction impacts. See Section 3.1.3. No operational <u>effects</u> to geology and soils.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Climate and Air Quality					
Air Quality	General impacts during construction See Section 3.2.4.	General impacts during construction. See Section 3.2.4. Beneficial impacts resulting from higher penetration of renewable generation on each connected island grid.	None; installing electronic equipment and upgrading software for the representative smart grid project would not involve land disturbance and therefore would not impact climate or air quality.	General construction impacts. See Section 3.2.4. No long-term impacts from operation; the flywheel energy storage system would not produce measureable amounts of criteria pollutants. No fossil fuel would be burned and no fugitive dust would be generated.	General construction impacts. See Section 3.2.4. Negligible increase in criteria pollutants during operations. No fugitive dust generated during operation.
Climate Change	General impacts during construction See Section 3.2.4.	General impacts during construction. See Section 3.2.4.	None; installing electronic equipment and upgrading software for the representative smart grid project would not involve land disturbance and therefore would not impact climate or air quality.	General construction impacts. See Section 3.2.4. Negligible increase in greenhouse gas emissions during operation of the flywheel energy storage system.	Negligible increase in greenhouse gas emissions during operation, since fossil fuels would not be burned.
Water Resources					
Surface Water	General impacts during construction. See Section 3.3.5. Operational impacts include possible alteration of stormwater runoff along transmission corridor as vegetation is reestablished. Any single drainage path expected to experience minimal alteration.3	**Onshore** General impacts during construction. See Section 3.3.5. Potential impacts if increase in impermeable surfaces at built up land-sea transition sites.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact water resources.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	General construction impacts. See Section 3.3.5. Potential increase in storm water runoff during operation.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	**Sodium-Sulfur Battery**
	Potential application of herbicides to maintain transmission corridor could produce negative environmental impacts if they reach surface waters.	**Offshore** Sediment disturbance/dispersal and increased turbidity during HDD. Potential site-specific impacts may occur to habitats or communities of concern. No operational impacts.			
Groundwater	General impacts during construction. See Section 3.3.5. No adverse operational impacts unless herbicides applied to maintain transmission corridor.	General impacts during construction. See Section 3.3.5.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact groundwater resources.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	Minimal groundwater impacts during construction of the sodium sulfur battery facility. Potential for increased runoff in the long-term and decrease in groundwater recharge.
Floodplains and Wetlands	Potential impacts during construction. See Section 3.3.5.	Potential short-term impacts during construction. See Section 3.3.5.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact floodplain and wetland resources.	Potential impacts during construction. See Section Section 3.2.5.	Potential impacts during construction. See Section 3.2.5.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Biological Resources					
	General impacts to terrestrial ecosystems during construction, including potential access roads. See Section 3.4.5. Operational maintenance of cleared areas around towers and vegetation height along transmission corridor. Potential bird and bat collisions with towers and lines, especially nocturnal flying species.	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Potential localized disturbance impacts to benthic communities at HDD breakout point and along cable route during construction due to direct displacement or indirect sedimentation. Potential operational impacts on sensitive species by EMF fields along undersea cable route.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact biological resources.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.
Land and Submerged Land Use					
Land Use	Transmission line corridors and location of substations and switching yards could result in changes of land ownership patterns and land use.	General impacts during construction and operation. See Section 3.5.4	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and would not impact land use.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	**Sodium-Sulfur Battery**
Submerged Land Use	None; the on-island transmission project would not extend offshore.	Short-term submerged land disturbance impacts along the undersea cable corridor during construction; Potential temporary impacts during maintenance/ expansion activities. Potential land use impacts along undersea cable corridor.	None; installing electronic equipment and upgrading software for the representative project would not impact submerged land use.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.
Cultural and Historic Resources					
	General impacts during construction and operation. See Section 3.6.6. The visual impact of on-island transmission projects may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	General impacts during construction. See Section 3.6.6.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact cultural or historic resources.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	General impacts during construction and operation. See Section 3.6.6.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Coastal Zone Management					
	General impacts during construction and operation. See Section 3.7.8. Potential impacts to coastal zone resources (site-specific).	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project/site-specific).	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact coastal zone management.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	General impacts during construction and operation. See Section 3.7.8.
Scenic and Visual Resources					
	General impacts during construction. See Section 3.8.3. Long-term visual impacts associated with towers, transmission lines, cleared transmission corridors, substations, and switching yards.	Short-term impacts to visual resources during construction. See Section 3.8.3. Short-term visibility of cable-laying ships. Long-term visual impacts associated with the new transition sites.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact scenic or visual resources.	None; flywheel energy storage would not cause adverse visual impacts as it would be installed in the utility room and would be compatible with the existing setting.	General impacts during construction and operation activities. See Section 3.8.3.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage: Flywheel	Energy Storage: Sodium-Sulfur Battery
Recreation Resources					
	General impacts during construction. See Section 3.9.4. Long-term obstruction to some recreational activities; conversely, some activities could be enhanced by improved access (e.g., from access roads for installed transmission infrastructure).	General impacts during construction. See Section 3.9.4. Short-term impacts during construction; limited to no impacts during operations.	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact recreation resources.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.
Land and Marine Transportation					
Land Transportation	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., towers and tower foundations). Short-term impacts during line stringing. Impacts during construction if transmission line installation required road crossings.	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., cables and installation equipment). General impacts during construction of the land-sea transition sites	None; installing electronic equipment and upgrading software for the representative project would not involve land transportation.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Marine Transportation	None; The on-island transmission project would not extend offshore.	Potential short-term impacts on harbor operations, local marine transportation, and military marine (including submarine) operations.	None; installing electronic equipment and upgrading software for the representative project would not involve marine transportation.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.
Airspace Management					
	Potential air traffic impacts during construction if helicopters are used to transport supplies or for line stringing. Potential construction and operation impacts and hazards to civilian and military aviation due to topography and high presence of low-altitude aviation. Potential long-term impacts from radio frequency interference.	None; construction and operation of undersea cable and land-sea transition sites would not require any tall structures and therefore would not impact airspace management.	None; installing electronic equipment and upgrading software for the representative project would not involve installation of towers and therefore would not impact airspace management.	None; installation of energy storage technologies would not involve any tall facilities; therefore, no impacts to airspace management would be expected.	None; the battery energy storage system would not involve tall facilities and not impact airspace.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	**Sodium-Sulfur Battery**
Noise and Vibration					
	Short-term noise and vibration impacts during construction. Potential vibration and humming noise during operation from loose hardware. Sizzles, crackles, hissing noises possible, especially during periods of higher humidity.	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of undersea cables would be negligible. Noise and vibration impacts from land-based converter stations would be dependent on the location and compatibility with the existing noise levels and land uses.	None; installing electronic equipment and upgrading software for the representative project would not involve construction activities or result in any operational noise.	General construction impacts. See Section 3.12.5. Operational noise levels for the representative flywheel energy storage system would be less than 70 dBA at a distance of 3 feet.	General impacts during construction. See Section 3.12.5. Negligible long-term noise and vibration impacts during operation.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Utilities and Infrastructure					
	Potential impacts related to adding electricity capacity to the grid.	Potential impacts related to adding electricity capacity to the local power grid. Connecting the electrical grids of two or more islands would have the beneficial impacts of: • Enabling the transmission of power and ancillary services in both directions and allow the two networks to operate in a coordinated fashion • Improving the power system economics and reliability on each island • Reducing renewable energy curtailments • A full list of benefits can be found at http://energy.hawaii.gov/renewable-energy/oahu-maui-gridtie.	Power transmission using smart grid technologies assumes that other measures such as energy storage and renewables are also implemented. Potential benefits and concerns are discussed in Section 2.3.5.3.	Beneficial impacts to the utilities and the distributed generator by helping to manage power demand.	Potentially beneficial impacts to utilities by helping to manage power generation.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	Sodium-Sulfur Battery
Hazardous Materials and Waste Management					
Hazardous Materials	General impacts from exposure to hazardous materials during construction. See Section 3.14.4. Potential impacts from exposure to hazardous materials during operation and maintenance from use of herbicides to maintain transmission corridor	General impacts during construction and operation, particularly during development of converter stations. See Section 3.14.4.	Potential impact from exposure to hazardous materials that may be present in old utility meters that are replaced by smart meters.	None; no hazardous materials would be required for the construction or installation of a flywheel energy storage system.	Potential hazardous material exposure impacts during construction and operation due to presence of hazardous chemicals inside the battery.
Waste Management	None; any vegetation cleared likely would be composted or reused.	Any waste generated onboard the construction vessels and barges would be disposed of at the appropriate landfill.	Potential impacts from exposure related to disposal of old utility meters.	General construction and operation impacts. See Section 3.14.4.	General construction and operation impacts. See Section 3.14.4. Potential impacts may occur during disposal of battery at its end of life.
Wastewater	General impacts during construction. See Section 3.14.4.	General impacts during construction and operation, particularly during development of converter stations. See Section 3.14.4.	None; installing electronic equipment and upgrading software for the representative project would not involve wastewater services.	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	None; the battery energy storage system would involve minor land disturbance in previously developed locations.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage	
				Flywheel	**Sodium-Sulfur Battery**
Socioeconomics					
	Minimal beneficial impacts during construction and operation.	Minimal beneficial impacts during construction and operation.	As technologies advance, job requirements will evolve.	Very small impact to population and employment variables.	Very small impacts to population and employment variables.
Environmental Justice					
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	None; installing electronic equipment and upgrading software for the representative project would not result in environmental justice impacts.	None; installation of a flywheel for energy storage would not result in environmental justice impacts.	None; installation of a sodium-sulfur battery for energy storage would not result in environmental justice impacts.

Table 2-45. Summary of the Potential Environmental Impacts, including Resource Areas with No Potential for Impacts – Electrical Transmission and Distribution

Resource Area	On-Island Transmission	Undersea Cables	Smart Grid	Energy Storage: Flywheel	Energy Storage: Sodium-Sulfur Battery
Health and Safety					
	Potential health and safety impacts to workers during installation, maintenance, and repairs of the transmission lines. Typical industrial hazards. Additional health and safety risks specific to electrical generation, transmission, and distribution industry. Potential minor health and safety impacts to the public during operation of the transmission lines as a result of electromagnetic fields generated. Limited to areas immediately adjacent to transmission lines.	General construction and operation impacts. See Section 3.17.3. Potential health and safety impacts to workers during installation, maintenance, and repairs of the undersea cables and transition sites, including increased safety risks associated with the marine environment. Additional health and safety risks specific to electrical generation, transmission, and distribution industry.	General construction and operation impacts. See Section 3.17.3. Minimal potential for health and safety impacts to the public associated with electromagnetic fields and radiofrequency.	General construction and operation impacts. See Section 3.17.3.	General impacts during construction and operation. See Section 3.17.3.

Table 2-46. Characterization of the Potential for Environmental Impacts – Electrical Transmission and Distribution

Activity/Technology	Resource Areas																
	Geology and Soils	Climate and Air Quality	Water Resources	Biological Resources	Land and Submerged Land Use	Cultural and Historic Resources	Coastal Zone Management	Scenic and Visual Resources	Recreation Resources	Land and Marine Transportation	Airspace Management	Noise and Vibration	Utilities and Infrastructure	Hazardous Materials and Waste Management	Socioeconomics	Environmental Justice	Health and Safety
On-Island Transmission	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●
Undersea Cables	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	○	●
Smart Grid	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	○	●
Energy Storage	○	○	●	○	○	●	●	○	○	○	○	○	●	●	●	○	●

○ = No potential impacts.

● = Potential impacts are common among most construction and operation activities.

● = Potential impacts are specific to an activity or technology.

2.5.1 CUMULATIVE IMPACTS

The treatment of cumulative impacts in this PEIS is qualitative in nature. DOE is not proposing any specific project or technology to be implemented as a result of this PEIS; therefore, the proposed action (development of guidance that can be used in making decisions to support the State of Hawaiʻi in achieving the goals established in the HCEI) would not cause any additional, incremental impacts beyond those that are currently part of the affected environment baseline. However, evaluating the potential cumulative effects resulting from future development of activities and technologies to satisfy the HCEI goals would be dependent on a combination of two primary factors: (1) existing deployment and (2) other future development. The identification of the existing deployment or penetration of each of the activities and technologies is presented in Chapter 2 (Section 2.3) of the PEIS. Future development would depend on the degree of implementation of each of the activities and technologies evaluated for environmental impacts in Chapters 4 through 8. Thus, although a detailed discussion of cumulative impacts is not feasible at this stage, information about existing deployment and about environmental impacts presented in this PEIS will likely help analyze cumulative impacts in project-specific environmental reviews.

2.5.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

As required under CEQ regulations (10 CFR 1502.16), this PEIS evaluates the irreversible and irretrievable commitment of resources from implementation of the proposed action. Because the proposed action is to develop guidance and not any specific activity or technology, the only commitment of resources that DOE is making as a result of this PEIS is the financial commitment of funding necessary to prepare the PEIS. Any future Federal involvement in a specific renewable energy project (such as through permitting or funding) would involve additional environmental review under NEPA.

2.5.3 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

As required under CEQ regulations (40 CFR 1502.16), this PEIS evaluates the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity from implementation of the proposed action. Because the proposed action is to develop guidance and not any specific activity or technology, DOE is not altering any current uses of the environment in Hawaiʻi. Any future Federal involvement in a specific renewable energy project (such as through permitting or funding) would involve additional environmental review under NEPA. At that point, each specifically identified project would need to evaluate and disclose the potential long-term effects on productivity of each environmental resource area and discuss potential trade-offs that may be necessary to achieve the goals established by HCEI.

2.5.4 UNAVOIDABLE ADVERSE IMPACTS

As required under CEQ regulations (40 CFR 1502.16), this PEIS evaluates the unavoidable adverse impacts from implementation of the proposed action. Because the proposed action is to develop guidance and not any specific activity or technology, there would be no unavoidable adverse impacts resulting from DOE's current proposal. Any future Federal involvement in a specific renewable energy project (such as through permitting or funding) would involve additional environmental review under NEPA.

2.5.5 PREFERRED ALTERNATIVE

Title 40 CFR 1502.14(e) requires DOE to identify its preferred alternative, if one exists, in this Draft PEIS. DOE plans to incorporate the information presented in this PEIS into draft guidance that could build upon the permitting requirements, best management practices, and potential mitigation measures identified to minimize potential environmental impacts for future development of renewable energy projects and energy efficiency activities. Therefore, DOE's proposed action is also the preferred alternative.

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2.7 Glossary

Affected Environment: In accordance with CEQ NEPA regulations, the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with the environment." The descriptions of the affected environment serve as a baseline – or description of existing environmental conditions – against which the impacts of potential future actions may be evaluated and compared.

Air Pollutant: Generally an airborne substance that could, in high enough concentrations, harm living things or cause damage to materials. From a regulatory perspective, an air pollutant is a substance for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established due to potential harmful effects on human health and welfare. In Hawaiʻi, under HRS Chapter 342B, the term "air pollutant" has the same meaning as under the Clean Air Act. *Related terms: air pollution, air quality, ambient air.*

Air Pollution: Under Hawaii law (HRS Chapter 342B), refers to the presence in the outdoor air of substances in quantities and for durations which may endanger human health or welfare, plant or animal life, or property or which may unreasonably interfere with the comfortable enjoyment of life and property throughout the State and in such areas of the State as are affected thereby, but excludes all aspects of employer-employee relationships as to health and safety hazards. *Related terms: air pollutant, air quality, ambient air.*

Air Quality: The cleanliness of the air as measured by the levels of air pollutants relative to standards or guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150 percent of its standard, even if levels of other pollutants are well below their respective standards). *Related terms: air pollutant, air pollution.*

Alternative Transportation Fuels and Modes: Encompass those fuel types and methods of transportation that are different than conventional gasoline-powered automobiles.

Ambient Air: The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to an emission source. Under Hawaii Administrative Rules (HAR) Title 11 Chapter 59, ambient air is defined as the general outdoor atmosphere to which the public has access. *Related terms: air pollutant, air pollution, criteria pollutant, National Ambient Air Quality Standards (NAAQS).*

Best Management Practices (BMPs): Policies, practices, and measures that reduce the environmental impacts of designated activities, functions, or processes. BMPs are distinguished from mitigation measures because mitigation measures are required as a result of the NEPA/HEPA environmental review process.

Carbon Dioxide Equivalent (CO_2Eq): A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents ($MMTCO_2$Eq)." The carbon dioxide equivalent for a greenhouse gas is derived by multiplying the tons of the gas by the associated global warming potential (GWP):

$$MMTCO_2Eq = (\text{million metric tons of a gas}) * (\text{GWP of the greenhouse gas})$$

Related terms: climate change, global warming potential, greenhouse gases.

Climate Change: (1) Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer. (2) A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Among these human activities are burning fossil fuels as oil, coal, and natural gas (for electricity and transportation); farming (agriculture); deforestation; and other land use changes that result in the release of substantial amounts of greenhouse gases into the atmosphere that most climate scientists believe is contributing to human-induced climate change. The term "global warming" is often used in public discourse when referring to this human-induced climate change. *Related terms: carbon dioxide equivalent, greenhouse gases, global warming potential.*

Council on Environmental Quality (CEQ): A division within the Executive Office of the President that coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. Established under the National Environmental Policy Act (NEPA) of 1969, CEQ is tasked with ensuring that Federal agencies meet their obligations under NEPA by overseeing Federal agency implementation of the environmental impact assessment process and to act as a referee during agency disagreements.

Criteria Pollutant: An air pollutant that is regulated by the Environmental Protection Agency (EPA) under the Clean Air Act through the National Ambient Air Quality Standards (NAAQS) on the basis of specific criteria of human health-based and/or environmentally based criteria. EPA has set NAAQS standards for six criteria air pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter, less than 10 micrometers (0.0004 inch) in diameter, and less than 2.5 micrometers (0.0001 inch) in diameter. *Related terms: air pollutant, air pollution, ambient air, National Ambient Air Quality Standards (NAAQS).*

Critical Habitat: Areas deemed necessary to a species' conservation and officially designated under the Endangered Species Act; provided that the species is legally protected. *Related terms: Endangered species, threatened species*

Demand-Side Management (DSM): A utility action that reduces or curtails end-use equipment or processes. DSM is often used in order to reduce customer load during peak demand and/or in times of supply constraint. DSM includes programs that are focused, deep, and immediate such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programs that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors.

Distributed Generation: Electricity generation by a generator that is located close to the particular load that it is intended to serve. *Related term: Utility-scale generation.*

Distributed Renewables: refer to the use of renewable energy resources for an electricity generator that is located close to the end user or even onsite. The generating capacity of a distributed generation source can range from generation at a single residence to larger installations for commercial or multi-unit housing applications.

District Cooling/Heating: A system that uses chilled or heated fluid to provide cooling or heat, respectively, to a wide group (a "district") of users.

Effect: A changes that is the result or consequence of an action or other cause. As defined in 40 CFR 1508.8, effects include direct effects, which are caused by the action and occur at the same time and place, and indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental (adverse) effects, even if on balance the agency believes that the effect will be beneficial.

Electrical Transmission and Distribution: Refers to the transmission of electrical power from a point of generation and the means by which it is stored and distributed to electricity users. Electricity transmission and distribution systems form an electrical grid or network that is used to manage and distribute electricity in a geographic region. While electrical transmission and distribution is not specifically addressed in the HCEI, implementation of new renewable energy technologies and/or improving the existing electrical network in Hawai‘i would directly affect transmission of such electricity and is therefore analyzed in this PEIS.

Endangered Species: Any species in danger of extinction throughout all or a significant portion of its range. *Related terms: Listed species, threatened species.*

Energy Efficiency: Refers to reducing the energy used for a given purpose or service while maintaining the same results; for example, replacing an incandescent light bulb with a different type of lighting technology that uses less energy to produce the same amount of light. Energy efficient technologies reduce the need for energy while energy efficient activities require less energy or save energy. *Related terms: Hawai‘i Energy Efficiency Portfolio Standard, Renewable Energy.*

Environmental Consequences: Refers to the environmental impacts (effects) of alternatives, including the proposed action, any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment, and any irreversible or irretrievable commitments of resources which would be involved if the proposal should be implemented. *Related term: Affected environment, effect, proposed action.*

Feedstock: Any renewable, biological material that can be used directly as a fuel, or converted to another form of fuel or energy product. Biomass feedstocks are the plant and algal materials used to derive fuels like ethanol, butanol, biodiesel, and other hydrocarbon fuels. Examples of biomass feedstocks include corn starch, sugarcane juice, crop residues such as corn stover and sugarcane bagasse, purpose-grown grass crops, and woody plants. *Related terms: Biofuel, biomass, biomass energy.*

Floodplain: The lowlands and relatively flat areas adjoining inland and coastal waters and the flood prone areas of offshore islands. Floodplains include, at a minimum, that area with at least a 1.0 percent chance of being inundated by a flood in any given year (that is, experiencing a 100-year flood). Floodplains include the base floodplain (those areas subject to 100-year floods) and the critical action floodplain (those areas with at least a 0.2 percent chance of being flooded in any given year, also known as a 500-year flood).

Flow: As used in relation to hydroelectric power, “flow” is a measure of the quantity of water (typically given in cubic feet per second) flowing through a system. Together with head, flow provides information on the potential extractable energy in the water. *Related terms: Head, hydroelectric power.*

Fuel Cell: A device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. A hydrogen fuel cell is thus a specific kind of fuel cell that utilizes hydrogen as its fuel. Fuel cells can be used to for almost any application typically powered by batteries or internal combustion engine, and they can be scaled to provide energy for anything from a laptop computer to a utility-scale power station. A fuel cell produces no criteria air pollutants or greenhouse gas emissions at the point of operation, although there are associated byproducts from manufacturing and decommissioning.

Geothermal Energy: Earth's interior heat made available by extracting it from hot water or rocks for use in generating electricity. Geothermal energy is one of the utility-scale renewable energy technologies analyzed in this PEIS. *Related term: Utility-scale renewables.*

Global Warming Potential (GWP): A measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide. In this way, GWP of a gas provides a relative basis for calculating the equivalent warming it produces as carbon dioxide. For reference carbon dioxide has a GWP of 1, and is therefore the standard by which all other greenhouse gases are measured. The term "global warming" is synonymous with climate change. *Related terms: Carbon dioxide equivalent, climate change, greenhouse gases.*

Greenhouse Gases: Those natural or manmade gaseous constituents of the atmosphere that absorb and re-emit infrared radiation. Such gases allow sunlight to enter the atmosphere freely but absorb the resulting infrared or thermal radiation (heat) that is reradiated by the ground, objects on it, or even the air itself. In this way, such gases "trap" the heat in the atmosphere, causing the air warm. There are many greenhouse gases in nature including water vapor, carbon dioxide, methane, and nitrous oxide, as well certain manmade ones such as aerosols and chlorofluorocarbons (CFCs). Each gas had a specific ability to warm the air that is measured versus the warming potential of carbon dioxide. *Related term: air pollutant, air pollution, climate change.*

Groundwater: Water below the ground surface in a zone of saturation. *Related terms: Watershed, wetlands.*

Hawai‘i Clean Energy Initiative (HCEI): The partnership established through the 2008 Memorandum of Understanding (MOU) between the State of Hawai‘i and the U.S. Department of Energy in furtherance of the provisions of Section 355 of the Energy Policy Act of 2005 (EPAct 2005) in order to transform the way in which energy efficiency and renewable energy resources are planned and used in the Hawaiian Islands. The overarching goal of HCEI is to meet 70 percent of Hawai‘i's energy needs by 2030 through energy efficiency and conservation measures and renewable energy generation, collectively referred to as clean energy. The 70 percent goal includes 30 percent from energy efficiency measures and 40 percent from locally generated renewable sources. *Related terms: Energy efficiency, Hawai‘i Energy Efficiency Portfolio Standard, renewable energy, Hawai‘i Renewable Portfolio Standard.*

Hawai‘i Energy Efficiency Portfolio Standard (EEPS): A policy that sets usage levels as legally mandated targets for the reduction of electricity usage to be achieved through efficiency measures and technologies. Programs and technologies include improvements in energy efficiency of public buildings and creating incentives to achieve electricity use reductions. *Related terms: Energy efficiency, Hawai‘i Renewable Portfolio Standard.*

Hawai‘i Renewable Portfolio Standard (RPS): A policy that requires electricity retailers to provide a minimum percentage or quantity of their electricity supplies from designated or defined renewable energy sources. *Related terms: Renewable Energy, Hawai‘i Energy Efficiency Portfolio Standard.*

Hazardous Material: Any item or agent (biological, chemical, physical) that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. *Related terms: Hazardous waste, solid waste.*

Hazardous Waste: (1) As defined in this PEIS, a hazardous waste refers to any *hazardous material* that can be characterized by ignitability, corrosiveness, reactivity, and toxicity. Those solid wastes that exhibit one or more of these characteristics is are classified as a hazardous wastes, and/or as a hazardous substances, including discarded military munitions. (2) As defined by EPA, a hazardous waste is any waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. *Related terms: Hazardous material, solid waste.*

Head: As used in relation to hydroelectric power, "head" refers to the vertical distance that water drops, and in the case of a conduit system, is a characteristic of the channel or pipe through which water flows before it interacts with the turbine. Head is measured in feet or in units of pressure. Together with flow, head provides information on the potential extractable energy in the water. *Related terms: Flow, potential energy.*

Heating Value: As applied to biomass fuel, a measure of the amount of heat energy released during combustion of a unit mass of material. The heating value is often expressed as energy per unit mass such as mega-joules per kilogram.

Joule: The International System of Units (SI) unit of work or energy equal to the work done by a force of one newton (N) acting through a distance of one meter (m). The joule is abbreviated J.

Kinetic Energy: The energy of motion of an object. That is, the kinetic energy of an object is the energy it possesses because of its motion. Kinetic energy is an expression of the fact that a moving object can do work on anything it hits; it quantifies the amount of work the object could do as a result of its motion. The total mechanical energy of an object is the sum of its kinetic energy and potential energy. *Related term: Potential energy.*

LEED (Leadership in Energy and Environmental Design): A national voluntary program developed by the U.S. Green Building Council that promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, materials selection, indoor environmental quality, and overall energy efficiency. The program provides performance ratings that range from the lowest, LEED certified, to the highest, LEED Platinum Refer to http://www.usgbc.org/leed for more information and to get the latest certification requirements.

Listed Species: Any species of fish, wildlife, or plant determined to be endangered or threatened under Section 4 of the Endangered Species Act. *Related terms: Critical habitat, endangered species, threatened species*.

Low-Income: Individuals who fall below the poverty line are categorized as low-income. The poverty line takes into account family size and the age of individuals in the family. For any given family below the poverty line, all family members are considered to be below the poverty line for analysis. *Related term: Minority.*

Marine Hydrokinetic Energy: The kinetic energy of moving water such as waves, tides, and ocean currents. *Related term: Kinetic energy.*

Minority: Persons are included in the minority category if they identify themselves as belonging to any of the following groups (1) Hispanic or Latino, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander. In addition, individuals who categorize themselves as being of multiple racial or ethnic origins are minorities. *Related term: Low-income.*

Mitigation Measures: Refers to any required plan or course of action (i.e., a measure) for purposes of mitigation. Such measures are required as a result of the National Environmental Policy Act / Hawaiʻi Environmental Policy Act (NEPA/HEPA) environmental review process for future proposed actions to support the State of Hawaiʻi in achieving the goals established in the HCEI.

National Ambient Air Quality Standards (NAAQS): Refers to the standards established under the Clean Air Act (42 U.S.C. §§ 7401 *et seq.*) and implementing Environmental Protection Agency (EPA) regulations (40 CFR Part 50) defining the highest allowable levels of certain pollutants in the ambient air (i.e., the outdoor air to which the public has access). Primary standards are established to protect public health; secondary standards are established to protect public welfare (for example, visibility, crops, animals, buildings). EPA is required to establish the criteria for setting these standards, and therefore the regulated pollutants are called criteria pollutants. EPA has set standards for six principal criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter, less than 10 micrometers (0.0004 inch) in diameter, and less than 2.5 micrometers (0.0001 inch) in diameter. *Related terms: air pollutant, air pollution, ambient air, criteria pollutant.*

National Pollutant Discharge Elimination System (NPDES): A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation. The NPDES permit lists either permissible discharges, the level of cleanup technology required for wastewater, or both.

National Register of Historic Places (NRHP): The official list of the Nation's cultural resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the National Register for their importance in American history, architecture, archeology, culture, or engineering. Properties included on the National Register range from large-scale, monumentally proportioned buildings to smaller scale, regionally distinctive buildings. The listed properties are not just of nationwide importance; most are significant primarily at the state or local level. Procedures for listing properties on the National Register are found in 36 CFR Part 60.

Navigable Waters (of the United States): As defined in section 502(7) of the Clean Water Act (1972 amendments) and 33 CFR 329.4, refers to those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce.

No-Action Alternative: The alternative where current conditions and trends are projected into the future without another proposed action [refer to 40 CFR 1502.14(d)]. CEQ NEPA implementing regulations require that a PEIS analysis include a no action alternative, which provides a baseline for comparison against the impacts of the Proposed Action or other action alternatives. *Related term: Action alternative, proposed action.*

Potential Energy: The energy of an object that results from position or configuration. An object may have the capacity for doing work as a result of its position in a gravitational field (gravitational potential energy), an electric field (electric potential energy), or a magnetic field (magnetic potential energy). The total mechanical energy of an object is the sum of its kinetic energy and potential energy. *Related term: Kinetic energy*

Renewable Energy: For the purposes of this PEIS, renewable energy includes energy derived from renewable sources such as the sun, wind, falling water, the ocean, geothermal, biomass, waste-to-energy, as well as hydrogen produced from renewable energy sources. *Related terms: Energy efficiency, Hawaiʻi Renewable Portfolio Standard.*

Solid Waste: As defined by the U.S. Environmental Protection Agency (EPA), any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. Solid waste includes both hazardous waste and non-hazardous waste. EPA regulations at 40 CFR 261.2 provide the conditions for whether the discarded material meets the "Definition of Solid Waste" (DSW) under RCRA Subtitle C Hazardous Waste. *Related term: Hazardous waste.*

Take (Taking): As defined under the Endangered Species Act in relation to threatened or endangered species, to "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such contact. *Related terms: Endangered species, listed species, threatened species.*

Threatened Species: Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. *Related terms: Listed species, endangered species.*

Utility-Scale Renewable: Refers to the use of renewable energy resources from a centrally located regional power plant. Utility-scale renewable technologies include the same kinds of renewable energy resources as distributed renewables, as well as other resources whose use at the distributed scale is impractical. The generating capacities for utility-scale technologies are typically at least an order of magnitude larger than for distributed applications.

Watershed: An area that drains into a body of water, such as a river, lake, reservoir, estuary, sea, or ocean. It includes the rivers, streams, and lakes that convey the water, as well as the land surfaces from which water runs off. In the Hawaiian Islands, the primary inland surface water features are streams that drain watersheds. By contrast, there are very few natural lakes in the Hawaiian Islands. *Related terms: Groundwater, watershed.*

Wave Power: The amount of power between wave crests. It is measured in units of kilowatts of power per meter. There exist different categories of wave power technology that utilize distinct designs to capture energy based on the kinetic properties of the water. *Related term: Kinetic energy.*

Wetlands: For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" [40 CFR 230.3(t)]. In the case of Hawaiʻi, there are four distinct types of wetlands:

> Riverine wetlands – These are the surface water systems found along the edges of rivers and streams.

Palustrine wetlands – These include marshes and bogs and generally are found in depressions where rain and groundwater collect. Hawai‘i's rare montane bogs, which take millions of years to form, are in this group.

Estuarine wetlands – These include swamps and mudflats that occur on coasts where streams empty to the ocean. These areas typically are influenced by tides, are brackish, and provide habitat for fish, shellfish, and water birds.

Marine wetlands – These include intertidal shorelines, seagrass beds, and tide pools. They are saltwater systems that often provide habitat for many species harvested by humans for food.

Related terms: Groundwater, watershed.

Wind curtailment: Refers to the required reduction in electric generation output by a wind energy facility. This typically occurs when there is excess electric production in an area and there is insufficient transmission capacity to move that electricity to where it is needed.

CHAPTER 3

Affected Environment

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3 AFFECTED ENVIRONMENT

In accordance with Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500 through 1508) for preparing an EIS, the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with the environment." This chapter describes the affected environment to provide the context for understanding the environmental impacts of implementing the renewable energy technologies presented in Chapter 2. Chapters 4 through 8 present the potential impacts of each technology in perspective to the environmental resource areas described herein. The descriptions in this chapter serve as a baseline—or description of existing environmental conditions—against which the impacts of potential future actions may be evaluated and compared. The description of the affected environment is of sufficient detail to support the programmatic nature of the Hawaiʻi Clean Energy PEIS.

This chapter also includes a discussion about the construction and operation impacts that would be expected to typically occur for each environmental resource area for common construction projects, regardless of the renewable energy technology or activity employed. Finally, each section concludes by reviewing the best management practices (BMPs) and/or mitigation measure that would minimize or avoid the common construction and operation impacts of the resource area. These lists are not all inclusive, but, rather, meant to provide the standard BMPs for purposes of analysis. Additional BMPs may be developed for individual projects and would be outlined during that planning and compliance process. Construction and operation impacts and BMPs specific to the renewable energy technologies are analyzed in Chapters 4 through 8. Because of the interconnectedness of the information presented, DOE has published this EIS as an electronic document with bookmarks within and across chapters. The information presented is complete and progresses logically; however, for best results, it is recommended that the document be read via electronic copy—CD or website.

The study area for the affected environment analysis encompasses the State of Hawaiʻi and the six principal Hawaiian Islands of Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi. This chapter provides much of the basic resource information that will be used in shaping the decisions regarding potential development within the study area, including a general description of current conditions and trends for resources and resource uses within the study area that may be affected.

The level of detail presented for the affected environment varies depending on the potential for impacts on a particular resource as a result of implementation of the energy efficiency activities and renewable energy technologies. In addition, the region of influence within the study area varies by resource depending upon the scope of potential impacts on respective resources. For example, air quality would have a broader region of influence because air emissions travel many miles, while soils would have a more restrictive region of influence because impacts are more localized to the areas of physical disturbance. Relevant island-specific information is provided where applicable. During the preparation of this PEIS, analysts used accurate information available to describe existing environments, facilities, activities, and projects. The analysts used recent research, studies, and relevant laws and regulations in describing the existing environment and cite such as appropriate. A listing of reference sources is provided in the back of each chapter where the citation occurs.

This chapter is organized by 17 resource areas, as listed below:

- Geology and Soils – The geologic characteristics of the area at and below the ground surface, the frequency and severity of seismic activity, and the kinds and quality of soils.
- Climate and Air Quality – Climatic conditions such as temperature and precipitation, the quality of the air, and greenhouse gas emissions.

- Water Resources – Marine, surface-water, and groundwater features, water quality and availability, floodplains, and wetlands.
- Biological Resources – Plants and animals that live in the area and the occurrence of special-status species.
- Land and Submerged Land Use – Land and submerged land use practices and land ownership information.
- Cultural and Historic Resources – Cultural, historic, and archaeological resources and the importance of those resources.
- Coastal Zone Management – The existing regulatory process for consistency with coastal zone management plans, special management areas, and shoreline setbacks.
- Scenic and Visual Resources – Scenic and visual resources in terms of land formations, vegetation, and color, and the occurrence of unique natural views.
- Recreation Resources – Existing recreational areas and uses; both on land and in the marine environment.
- Land and Marine Transportation – The existing transportation systems in the area.
- Airspace Management – Existing airport systems and military air bases and operation as well as the processes for managing the safe utilization of the airspace for intended uses.
- Noise and Vibration – Ambient noise and vibration levels, analytical techniques, and the identification of sensitive receptors.
- Utilities and Infrastructure – Existing electric utilities and electrical transmission and distribution services.
- Hazardous Materials and Waste Management – Solid and hazardous waste generation and management practices, wastewater services, the types of waste from current activities, the means by which waste is disposed, and pollution prevention practices.
- Socioeconomics – The labor market, population, housing, public services, and personal income.
- Environmental Justice – The identification of low-income and minority populations that could be subject to disproportionate and adverse environmental impacts.
- Health and Safety (including Accidents and Intentional Destructive Acts) – The existing public and occupational safety conditions, including information on health and safety regulations, , and worker safety and injury data. The impacts chapters will also provide a perspective of potential impacts from accidents and intentional destructive acts.

3.1 Geology and Soils

The affected environment for geological resources is presented in two areas: (1) general geology and physiology (including soils), and (2) geological hazards. As applicable, discussions start with a State overview then move to the individual islands, ordered according to age.

> **GEOLOGY TERMS**
>
> **Lithosphere:** Outer layer of the earth, consisting of the outer crust and the rigid, upper part of the mantle. It is 25 to 125 miles thick under the continents and 30 to 60 miles thick under the oceans.
>
> **Hotspots:** Locations where massive plumes of hot rock have risen through the mantle toward the lithosphere, causing melting along the upper margin as lower pressures are reached at the lithosphere's base. The molten rock, known as magma, can rise into the crust and generate active volcanism.

3.1.1 GENERAL GEOLOGY AND PHYSIOLOGY

3.1.1.1 State Overview

The State of Hawai‘i is part of a chain of 129 volcanoes stretching about 3,800 miles from central to northern Pacific (almost to the Aleutian Islands). The northern, older portion consists of the Emperor Seamounts (mountains rising from the sea floor, but not reaching the water surface) and the southern, younger portion is the Hawaiian Ridge or Archipelago. Collectively, this chain is known as the Emperor Seamounts – Hawaiian Archipelago. As shown in Figure 3-1, this chain of volcanoes changes direction about midway along its path. It is this change that marks the end of the Emperor Seamounts and the beginning of the Hawaiian Ridge or Archipelago. The oldest seamount near the north end of the chain formed about 80 million years ago; the oldest features of the Hawaiian portion, at its northwest end, formed about 30 million years ago (UH Hilo 1998).

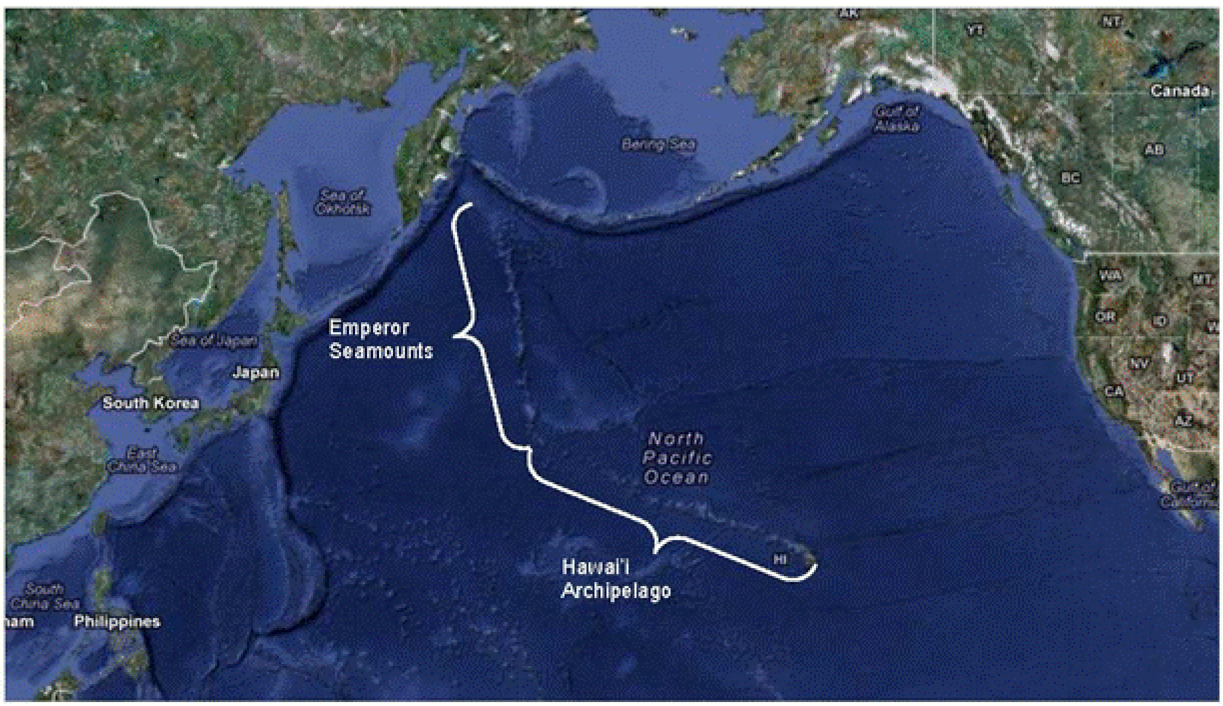


Figure 3-1. The Chain of Volcanoes Making up the Emperor Seamounts – Hawaiian Archipelago

At the southeastern end of the chain are the youngest and currently active volcanoes. These volcanoes formed as the Pacific Plate, one of the moving tectonic plates that make up the earth's lithosphere, passed over a hotspot that has remained in a relatively fixed position over the last 40 million years (UH Hilo 1998). That is, what appears to be a chain of volcanoes moving toward the east-southeast is actually the result of the Pacific Plate moving to the west-northwest over a relatively stationary hotspot.

Each of the volcanoes in the chain has evolved, or is evolving, through a similar sequence of stages (UH Hilo 1998) that together can last several million years. The stages range from the volcano's birth deep underwater, followed by erupting great volumes during the shield stage to reach the surface and to grow thousands of feet above the water, then to go through less active periods, eventually becoming extinct (or near extinct), and go through a phase of erosion and subsidence, slowly retreating back into the ocean. In its last phases the extinct volcano is reduced to sea level and transformed first into a coral atoll and then, with further subsidence, into a guyot, a below-sea level, flat-topped, and coral-capped volcano. As indicated in subsequent discussions, some of the volcanoes go through a late eruptive or rejuvenated stage after significant erosion and subsidence has occurred. The volcanoes that make up the Hawaiian Islands are in various positions in this general sequence of stages.

Geologic maps of the islands presented and addressed in the discussions that follow identify materials in terms of the stage during which they were ejected in volcanic eruptions. Assignment of volcanic materials to the stages is based primarily on the chemical variations that are typical of each and also takes into account their position in the rock layering, or stratigraphy, and their relative ages.

Of the eight large Hawaiian Islands, Niʻihau and Kauaʻi (the northernmost) have undergone a long duration of the rejuvenation stage. The long duration of this stage for these older islands suggests that eruptions of this stage could still occur on each of the younger volcanoes on islands to the southeast, including on the extinct Kohala volcano on Hawaiʻi island. Lōʻihi, located about 3,200 feet below sea level and 18 miles off the southeastern coast of Hawaiʻi island, is the newest volcano of the Hawaiian Ridge and is in transition between the preshield and shield stages. It is estimated that this volcano will emerge as an island within the next 200,000 years (UH Hilo 1998).

Although the islands are of volcanic origin, the thousands and in some cases millions of years involved in their evolution have allowed a constant reworking of the volcanic rocks. This is particularly true of the erosion stage described above during which time the volcanically active island moves off the hotspot and there ensues long periods of time between eruptions. Weathering, gravity, rainwater, and waves erode the volcanic slopes; rock and vegetation decay to form soil; and water, air, and animals contribute to the chemistry that forms organic debris across the volcanic landscape. These processes combined to produce islands with dense forests, streams, watersheds, and broad fringing reefs (Fletcher et al. 2010).

Soils across the islands, although derived from a common source of basalt lavas and volcanic ash, vary based on conditions such as local climate (particularly the amount of precipitation and/or flooding), slope and drainage, and exposures to organic materials and other chemistry-altering factors as well as the amount of time they have been subjected to these conditions. The modern system of soil classification groups soils into 12 Orders at the top of its hierarchy that then includes (in descending order and increasing number of groupings) Suborders, Great Groups, Subgroups, Families, and Series. At the lowest level of the hierarchy—the Series—more than 19,000 have been recognized in the United States (NRCS 1999). Soil surveys of the Hawaiian Islands have identified 11 of the 12 soil Orders. (The only soil Order not identified in the figure is Gelisols, which are soils underlain by permafrost.)

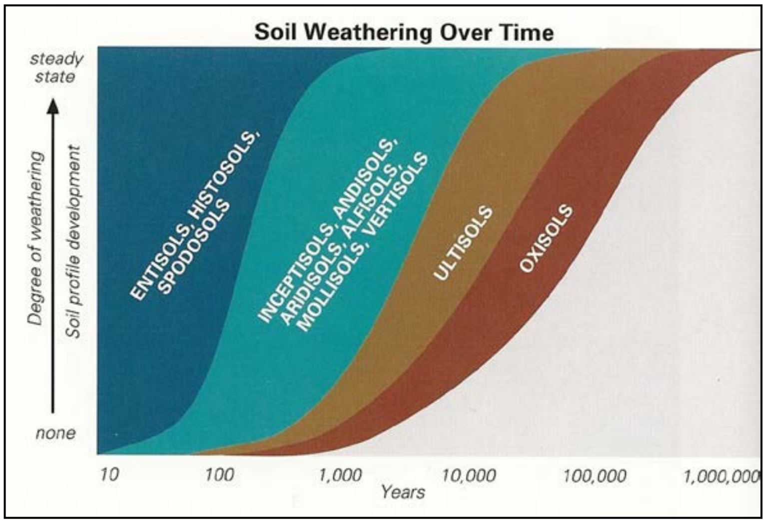


Figure 3-2. General Relationship between Soil Orders and Weathering (Source: UH Hilo 1998)

Figure 3-2 shows a general relationship between the soil Orders and the amount of weathering to which they have been subjected. The figure identifies the 11 soil Orders found on the Hawaiian Islands. Consistent with the relationships shown in Figure 3-2, soil maps show the relatively young Hawai‘i island with large areas of Histosols but no Oxisols. Conversely, soil maps of the older islands of Kaua‘i and O‘ahu show large areas of Oxisols and other soil Orders.

The island-by-island discussions that follow include summaries of soil data maintained by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA). The data identify soil series and the amount of land area occupied by each, along with land areas for portions of the islands not classified as soil (for example, water, rock outcrops, and rough mountain land). Where soil series are present, the data characterize the soil by its textural classification based on the amounts of clay, silt, and sand that are present. In this system, a loam soil is a mixture of the three that is within specific percentage bounds. The data for soil series often provide additional breakouts on the amount of soil area at different slope intervals or whether certain soil areas have high amounts of stones or gravel. The high-level summaries of the NRCS soil survey data provided for the islands are based on the textural characteristics of the various soil series, which are then grouped together. When the information was available, the tables provide a breakout for soils with slopes of less than (and greater than) about 15 percent. This slope breakout was done because the NRCS data also identify soil that qualifies as prime farmland, and soils with slopes greater than 15 percent generally do not qualify as prime farmland.

It should be noted that the State of Hawai‘i incorporates a land resource evaluation system into its Land Use Commission statutes that rates agricultural productivity of land based, in part, on soil characteristics. The rating system, employed in the 1960s and 1970s by the Land Study Bureau of the University of Hawai‘i, considered soil characteristics such as texture (that is, proportions of sand, silt, and clay), structure, depth, drainage, parent material, and stoniness. These soil characteristics, along with location descriptors, including topography and climate, were used to establish a five-class productivity rating system (A, B, C, D, and E) for agricultural lands. Land rated with the highest agricultural productivity potential is assigned a classification of “A” and the lowest an “E.” The applicable State legal statute [Hawai‘i Revised Statute Chapter 13, Section 205 (HRS 13-205)] sets acceptable uses for agricultural lands, with a primary goal of protecting (for agricultural uses) lands with high agricultural productivity, particularly those with A and B ratings. This rating system is not addressed further in this section, but its land use implications are noted in Section 3.5.

3.1.1.2 Kaua‘i

3.1.1.2.1 Geology

Kaua‘i, the northernmost and geologically oldest of the main Hawaiian Islands, is roughly circular in shape and formed from one or possibly two shield volcanoes about 5 million years ago. The single shield volcano is the best-known interpretation of Kauaʻi's volcanic history, but there is some evidence suggesting there may have been two systems erupting. This alternate hypothesis is considered one that is yet to be resolved (Sherrod et al. 2007).

Figure 3-3 is a generalized geologic map of Kauaʻi. The large central caldera, is mapped by the Olokele Member of the Waimea Canyon Basalt in the figure. The Olokele Member consists primarily of thick lava flows that ponded within the caldera about 4 million years ago. The Nāpali Member consists of thin flows apparently formed from spill-over from the caldera. The Hāʻupu Member is believed to have originated in a small caldera on the southeastern flank of the volcano complex. Late in the period of the Olokele Member, a structural trough, termed the Makaweli graben, developed on the southern side of the caldera. Lava flows into this trough are assigned to the Makaweli Member, which was emplaced from about 4 to 3.5 million years ago. The Kōloa Volcanics were erupted long after the main stage of shield growth ended. They represent rejuvenated-stage lava flows that were emplaced mainly between 2.6 and 0.15 million years ago (Sherrod et al. 2007).

Kauaʻi is generally considered the most structurally complex of the Hawaiian Islands (Sherrod et al. 2007). This is largely due to the deep erosion and weathering that has occurred over time plus the large amount of rejuvenated-stage lavas that covered much of the island. These more recent lavas covered much of the eastern half of the island and included eruptions on the submarine east and southeastern flanks. These flows also filled canyons and diverted rivers and were subsequently carved into new river beds (UH Hilo 1998).

3.1.1.2.2 Soils

NRCS data for Kauaʻi identify more than 40 soil series. Table 3-1 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. As can be seen in the table, classified soil series represent about half of the island's area, with silty clays and silty clay loams representing the largest land areas. The table also shows that about 20 percent of the island qualifies as prime farmland. It should be noted, however, that many of the NRCS prime farmland classifications are identified with an "if irrigated" caveat, and a few are identified with "if protected from flooding" or "if drained" notes.

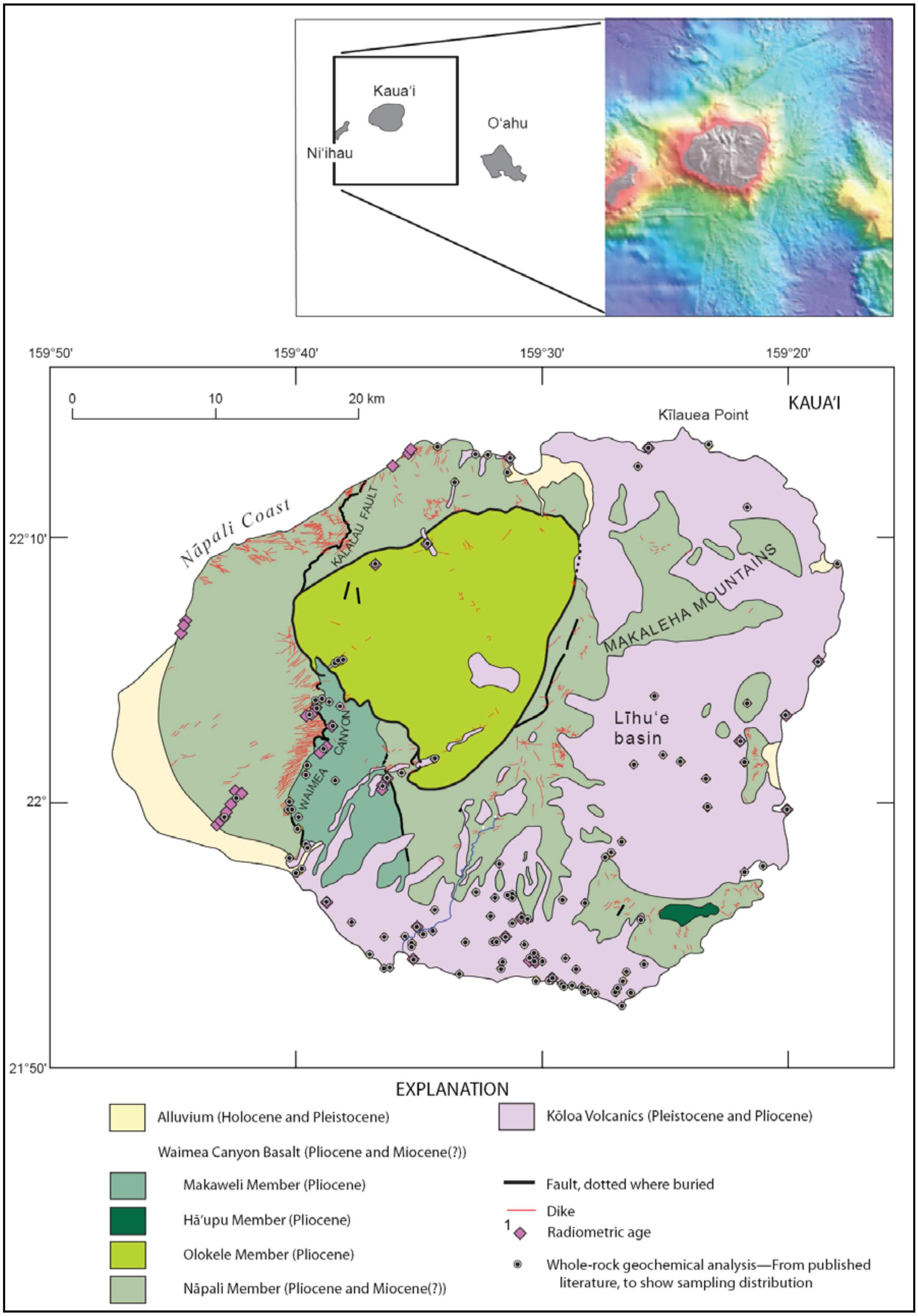


Figure 3-3. Generalized Geologic Map of Kaua'i (Source: Sherrod et al. 2007)

Table 3-1. High-Level Summary of the NRCS Soil Survey Data for Kaua‘i

Description	Slopes	Acres	Portion of Island	Prime Farmland Acres	Prime Farmland Portion of Island
Soils					
Clay and stony clay	< about 15%	6,317	1.8%	5,613	1.6%
	> about 15%	9,212	2.6%	0	
Silty clays – including silty clays that are gravelly, stony, or bouldery	< about 15%	46,037	13.2%	36,614	10.6%
	> about 15%	21,596	6.3%	891	0.3%
Loam and sandy loam	< about 15%	1,548	0.4%	1,548	0.4%
	> about 15%	3,299	0.9%	0	
Clay loams – including clay loams that are stony, gravelly, and stony sandy	< about 15%	6,886	2.1%	2,017	0.7%
	> about 15%	0		0	
Silt loam	< about 15%	505	0.1%	0	
	> about 15%	10,016	2.8%	0	
Silty clay loams – including silty clay loams that are peaty, gravelly, and stony	< about 15%	26,876	7.6%	25,788	7.3%
	> about 15%	39,387	11.0%	0	
Sand – including beaches and dunes	< about 15%	1,555	0.5%		
	> about 15%	0		0	
Loamy fine sand	< about 15%	4,098	1.1%	0	
	> about 15%	0		0	
Subtotal		177,333	49.9%	72,470	20.4%
Miscellaneous designations					
Badland (bedrock) and badland/soil complexes	NA	5,149	1.5%		
Borrow pit	NA	13	<0.1%		
Fill land	NA	1,460	0.4%		
Marsh	NA	605	0.2%		
Pits	NA	20	<0.1%		
Quarry	NA	31	<0.1%		
Alaka‘i mucky peat	NA	6,101	1.7%		
Riverwash	NA	641	0.2%		
Rock land and outcrop	NA	43,076	12.1%		
Rough broken land	NA	49,659	14.0%		
Rough mountainous land	NA	68,378	19.2%		
Rubble land	NA	987	0.3%		
Water (>40 acres)	NA	1,961	0.6%		
Subtotal		178,082	50.1%		
TOTALS		**355,415**	**100%**	**72,470**	**20.4%**

Source: NRCS 2013.
< = less than; > = greater than; NA = not applicable.

3.1.1.3 O‘ahu

3.1.1.3.1 Geology

O‘ahu was formed by two volcanoes: Wai‘anae on the west and Ko‘olau on the east. Wai‘anae is the older of the two and consists of shield-stage lavas, erupted between 3.9 and 3.5 million years ago, and a thick sequence of postshield-stage basalt, erupted from about 3.2 to 2.5 million years ago. Ko‘olau consists of shield-stage lavas, erupted between 2.5 and 1.7 million years ago, and younger rejuvenated lavas; no postshield lavas have been identified for this volcano. Both volcanoes experienced giant submarine landslides. Figure 3-4 is a geologic map of O‘ahu. The Wai‘anae caldera is centered near

Lualualei Valley, shown on the west side of the island. The caldera complex that developed for the Koʻolau volcano is referred to as the Kailua caldera and its location is shown in the figure near the southeastern corner of the island.

Waiʻanae Volcano

The oldest exposed lava flows on Oʻahu are those of the Lualualei Member of the Waiʻanae Volcanics, which formed from about 3.9 to 3.5 million years ago. A subsequent sequence, also of the shield-building stage, the Kamaileʻunu Member, involved eruptions lasting from 3.5 to 3.1 million years ago. The Pālehua and Kolekole Members form the postshield cap of the volcano. The postshield volcanism started with the Pālehua about 3.1 million years ago and continued with the Kolekole, which formed about 3 to 2.9 million years ago. A massive submarine slumping on the western side of the Waiʻanae Volcano or a related event may have been the separation between the two Members. The huge landsliding event, designated the Waiʻanae Slump (see the bathymetric (or underwater topography) map at the top of Figure 3-4), is one of the larger submarine landslides associated with the Hawaiian Islands, covering roughly 2,100 square miles. It initiated a major erosional episode that preceded the Kolekole time (Sherrod et al. 2007).

Koʻolau Volcano

The Koʻolau Range that extends along the northeastern side of Oʻahu is the western slope of the Koʻolau volcano. Shield-stage lavas erupted from this volcano from about 3 to 1.8 million years ago and are designated the Koʻolau Basalt shown in Figure 3-4. The Kailua Member of the Koʻolau Basalt provides the demarcation for the Kailua caldera. A northwest-trending rift zone on the eastern side of the range is characterized by a dike complex containing over 7,400 dikes (Sherrod et al. 2007). It is shown in Figure 3-4 as the line of scattered red markings all along the eastern-northeastern side of the island. Section 3.3 of this PEIS describes how these dikes (and similar ones on other islands) cause infiltrating rainwater to be caught in subsurface storage areas or compartments, well above the lens of fresh water that underlies the island. These groundwater storage areas often feed springs located at lower elevations.

During Koʻolau's building stage, a giant debris avalanche or landslide, designated the Nuʻuanu Slide (see the bathymetric map at the top of Figure 3-4), tore away a large portion of the volcano's eastern half. The resulting submarine landslide material extends more than 100 miles to the northeast and involves an estimated debris volume of up to 1,000 cubic miles (Sherrod et al. 2007). Nuʻuanu Pali, the northeast-facing cliffs that extend 25 miles along the crest of the volcano, as well as the steep slopes along the northeastern side of the Koʻolau Range, are exposed features due to the Nuʻuanu Slide and the subsequent erosion.

The final element of the Koʻolau geology described here is the rejuvenated-stage volcanism that involved lava flows and vent deposits scattered above the Koʻolau Basalt. These eruptions, which occurred from about 0.8 to 0.1 million years ago, and possibly as recently as about 40,000 years ago (Sherrod et al. 2007), are designated the Honolulu Volcanics because they erupted mainly in the Honolulu area. Many of the vents associated with this stage erupted through a coral reef along Oʻahu's southern side, tended to be explosive, and often produced tuff cones (UH Hilo 1998). Some of Hawaiʻi's best known vents, including Diamond Head, Punchbowl Crater, Salt Lake Crater, and Koko Head, formed during this stage (Sherrod et al. 2007).

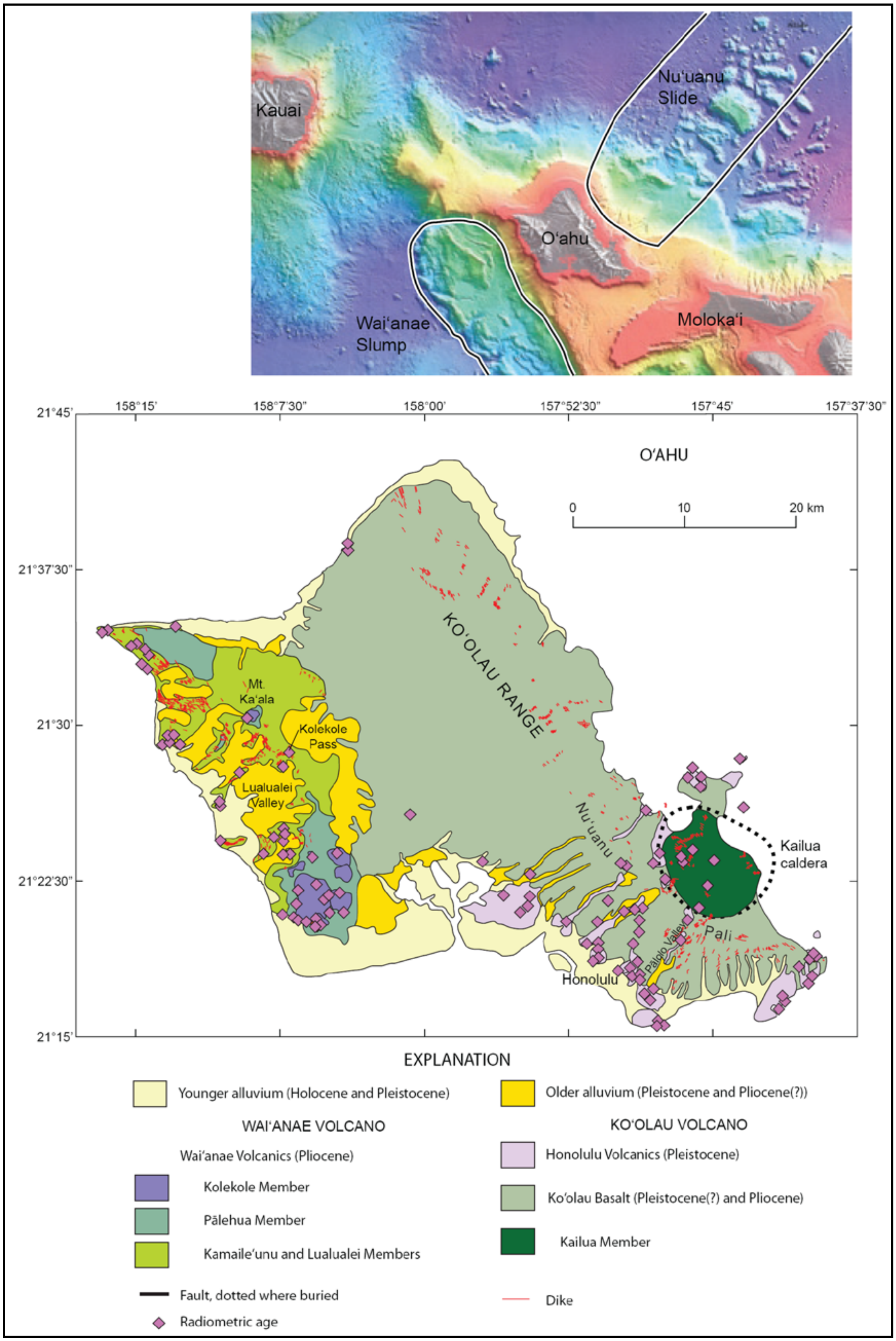


Figure 3-4. Generalized Geologic Map of Oʻahu (Source: Sherrod et al. 2007)

3.1.1.3.2 Soils

NRCS data for O‘ahu identify about 50 soil series. Table 3-2 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. As can be seen in the table, classified soil series represent more than half of the island’s area, with silty clays the most common soil type, followed by clay and silty clay loam. The table also shows that more than 25 percent of the island qualifies as prime farmland. It should be noted, however, that many of the NRCS prime farmland classifications are identified with an “if irrigated” caveat.

Table 3-2. High-Level Summary of the NRCS Soil Survey Data for O‘ahu

Description	Slopes	Acres	Portion of Island	Prime Farmland	
				Acres	Portion of Island
Soils					
Clay – including clays that are stony and very stony	< about 15%	20,556	5.6%	13,888	3.8%
	> about 15%	9,767	2.6%	0	
Silty clays – including silty clays that are stony or very stony	< about 15%	80,290	20.8%	60,803	15.8%
	> about 15%	67,446	17.8%	0	
Loam	< about 15%	567	0.1%	567	0.1%
	> about 15%	0		0	
Clay loams – including clay loams that are stony and very stony	< about 15%	10,801	2.9%	9,046	2.5%
	> about 15%	0		0	
Silt loams	< about 15%	1,914	0.6%	1,318	0.4%
	> about 15%	2,352	0.6%	0	
Silty clay loams	< about 15%	24,305	6.6%	15,647	4.3%
	> about 15%	5,596	1.5%	0	
Sand	< about 15%	5,443	1.5%	0	
	> about 15%	0		0	
Subtotal		229,036	59.7%	101,269	26.4%
Miscellaneous designations					
Beaches	NA	1,125	0.3%		
Coral outcrop	NA	10,921	2.8%		
Fill land	NA	13,770	3.6%		
Soil and badland (bedrock) complexes	NA	9,149	2.4%		
Marsh	NA	878	0.2%		
Quarry	NA	572	0.1%		
Alaka‘i mucky peat	NA	172	<0.1%		
Cinder land	NA	434	0.1%		
Rock and stony land and outcrops	NA	58,962	15.3%		
Rough mountainous land	NA	56,455	14.7%		
Water (>40 acres)	NA	2,386	0.6%		
Subtotal		154,824	40.3%		
TOTALS		**383,861**	**100%**	**101,269**	**26.4%**

Source: NRCS 2013.
< = less than; > = greater than; NA = not applicable.

3.1.1.4 Moloka‘i

3.1.1.4.1 Geology

Moloka‘i was formed by two volcanoes: West Moloka‘i and East Moloka‘i. West Moloka‘i is the older of the two; East Moloka‘i, the larger of the two. East Moloka‘i experienced a giant submarine landslide that resulted in the northern half of the volcano dropping away into the ocean. Figure 3-5 is a geologic map of Moloka‘i. A buried fault (dashed line) roughly separates flows from the West and East volcanoes. This fault has a displacement of at least 490 feet. This displacement was subsequently filled with flows from East Moloka‘i. West Moloka‘i has no exposed caldera, while the location of the East Moloka‘i caldera is shown in Figure 3-5.

West Moloka‘i

It is speculated that West Moloka‘i experienced a landslide to the east that dropped the summit and the eastern half of the volcano. If this occurred, it would have happened before East Moloka‘i had expanded to the west and up against the eastern flank of the older volcano (UH Hilo 1998) at the fault line described above. In the last 100 years, soil eroded from this portion of the island appears to have expanded the southern coastline and buried a portion of the fringing reef along the southern coast. This high rate of erosion is attributed to historic overgrazing (Sherrod et al. 2007).

East Moloka‘i

Lava from East Moloka‘i covers about two-thirds of the island. The volcano’s last eruptions were from vents along the northern side of the island that formed the Kalaupapa Peninsula (Sherrod et al. 2007).

The northern side of the East Moloka‘i volcano was removed by the Wailau landslide that resulted in blocks and debris falling away to the north and traveling as far as 100 miles (UH Hilo 1998). As can be seen in the bathymetric maps at the tops of Figures 3-4 and 3-5, debris from the Wailau landslide extends into the same area of debris created by the Nu‘uanu slide that occurred off the northeastern side of O‘ahu. The steep cliffs on the northern side of the island represent the slide’s headwall and expose about 4,900 feet of shield and postshield lava flows (UH Hilo 1998).

3.1.1.4.2 Soils

NRCS data for Moloka‘i identify about 30 soil series. Table 3-3 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. As can be seen in the table, classified soil series represent slightly less than half of the island’s area, with silty clays and silty clay loams the most common soil types. The table also shows that about 18 percent of the island qualifies as prime farmland, but all of these land classifications are identified with an “if irrigated” caveat. More than 20 percent of the island’s land is characterized as rough mountainous land.

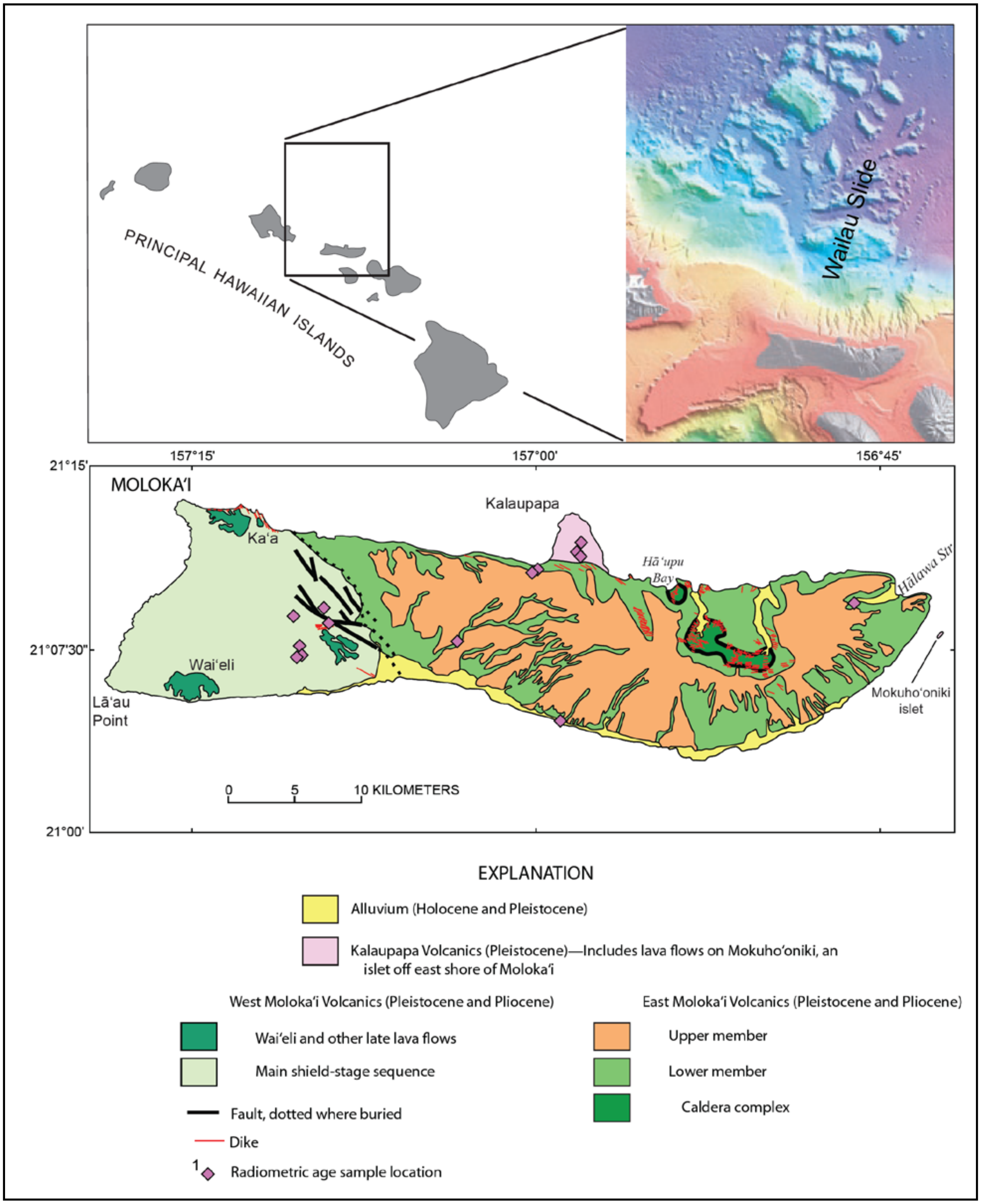


Figure 3-5. Generalized Geologic Map of Moloka'i (Source: Sherrod et al. 2007)

Table 3-3. High-Level Summary of the NRCS Soil Survey Data for Moloka‘i

				Prime Farmland	
Description	**Slopes**	**Acres**	**Portion of Island**	**Acres**	**Portion of Island**
Soils					
Clay – including clays that are stony	< about 15%	2,122	1.3%	491	0.3%
	> about 15%	162	0.1%	0	
Silty clays – including silty clays that are stony, gravelly, or peaty	< about 15%	25,560	15.1%	10,592	6.2%
	> about 15%	3,425	2.2%	0	
Sandy loam	< about 15%	215	0.2%	215	0.2%
	> about 15%	0		0	
Clay loam	< about 15%	1,441	0.8%	1,198	0.7%
	> about 15%	0		0	
Silt loam	< about 15%	8,283	4.9%	3,873	2.3%
	> about 15%	3,439	2.0%	0	
Silty clay loams – including silty clay loams that are very stony or with loamy sand	< about 15%	28,747	17.0%	14,212	8.4%
	> about 15%	5,567	3.3%	0	
Sand	< about 15%	1,139	0.7%	0	
	> about 15%	0		0	
Subtotal		80,100	48.0%	30,581	18.3%
Miscellaneous designations					
Beaches	NA	216	0.1%		
Marsh	NA	803	0.5%		
Rock land and outcrops	NA	15,689	9.4%		
Rough broken land	NA	9,129	5.5%		
Rough mountainous land	NA	33,763	20.2%		
Very stony land	NA	26,974	16.0%		
Water (>40 acres)	NA	248	0.1%		
Subtotal		86,822	52.0%		
TOTALS		**166,922**	**100%**	**30,581**	**18.3%**

Source: NRCS 2013.
< = less than; > = greater than; NA = not applicable.

3.1.1.5 Lānaʻi

3.1.1.5.1 Geology

Lānaʻi is a one-volcano island that was built up by shield-stage eruptions. A large deposit on the seafloor on the southern side of the island is attributed to a landslide, designated the Clark debris avalanche (see the bathymetric map at the top of Figure 3-6), that came from the outer slopes of Lānaʻi. It is thought to have occurred about 0.65 million years ago (Sherrod et al. 2007).

Coral cobbles and fine material found on the southeastern flank of the island at elevations up to 1,000 feet above sea level are thought by some to be deposits from a tsunami triggered by the Alika landslide on Mauna Loa’s western side (UH Hilo 1998). Other interpretations of these materials are deposit locations that represent storm beaches or uplifted shorelines (Sherrod et al. 2007).

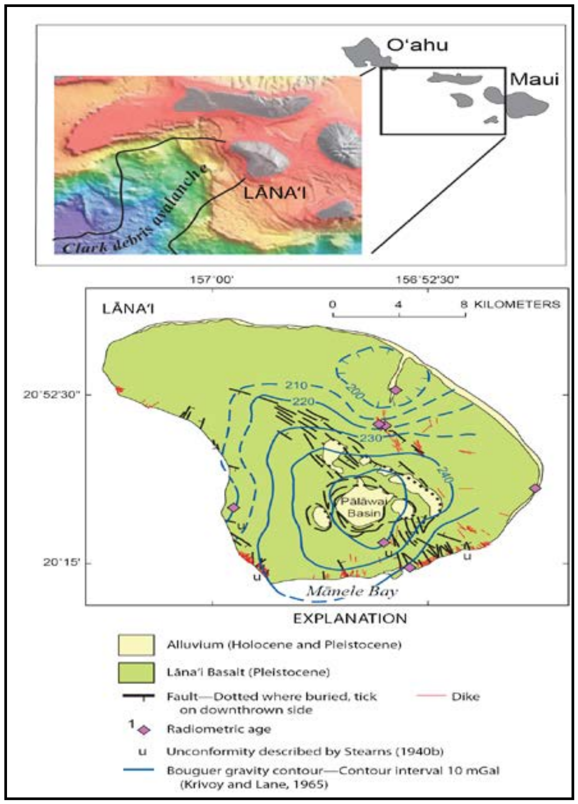


Figure 3-6. Generalized Geologic Map of Lāna‘i (Source: Sherrod et al. 2007)

3.1.1.5.2 Soils

NRCS data for Lāna‘i identify fewer than 20 soil series. Table 3-4 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. As can be seen in the table, classified soil series represent less than half of the island's area, with silty clays and silty clay loams the most common soil types. The table also shows that slightly more than 20 percent of the island qualifies as prime farmland, but all of these land classifications are identified with an "if irrigated" caveat. More than 50 percent of the island's land can be characterized as rock outcrops or very rocky land.

3.1.1.6 Maui

3.1.1.6.1 Geology

Maui is a two-volcano island with a broad, low plain between the two. West Maui, the older of the two volcanoes, is extinct, but experienced a rejuvenated stage. The younger East Maui volcano, or Haleakalā, is still active (or potentially still active). This volcano has erupted frequently in the last 10,000 years and as recently as about 1600 based on recent radiocarbon dating (Sherrod et al. 2007). Previously it was thought to have erupted as recently as about 1790. Figure 3-7 is a geologic map of Maui.

West Maui

The oldest exposed strata on West Maui volcano, the shield-stage lavas, are designated the Wailuku Basalt. The caldera-filling sequence and the dike complex shown in Figure 3-7are separately mapped flows within the Wailuku. The Honolua Volcanics are the postshield eruptions that overlie the Wailuku

Table 3-4. High-Level Summary of the NRCS Soil Survey Data for Lānaʻi

Description	Slopes	Acres	Portion of Island	Prime Farmland Acres	Prime Farmland Portion of Island
Soils					
Clay – including clays that are gravelly	< about 15%	3,550	3.9%	3,249	3.6%
	> about 15%	101	0.1%	0	
Silty clays – including silty clays that are stony or extremely stony	< about 15%	12,821	14.3%	5,506	6.1%
	> about 15%	534	0.6%	0	
Sandy loam	< about 15%	301	0.3%	301	0.3%
	> about 15%	0		0	
Clay loam	< about 15%	240	0.3%	240	0.3%
	> about 15%	0		0	
Silty clay loams – including a complex of silty clay loam and bedrock	< about 15%	20,168	22.2%	10,086	11.1%
	> about 15%	587	0.7%	0	
Sand and loamy sand	< about 15%	1,378	1.5%	0	
	> about 15%	0		0	
Subtotal		39,680	43.9%	19,382	21.5%
Miscellaneous designations					
Beaches	NA	40	<0.1%		
Coral outcrop	NA	434	0.5%		
Rock and very stony land and outcrops	NA	46,631	51.6%		
Rough broken land	NA	985	1.1%		
Rough mountainous land	NA	2,516	2.8%		
Water (>40 acres)	NA	2	<0.1%		
Subtotal		50,608	56.1%		
TOTALS		**90,288**	**100%**	**19,382**	**21.5%**

Source: NRCS 2013.
< = less than; > = greater than; NA = not applicable.

Basalt (Sherrod et al. 2007). The postshield stage is well represented by cones, domes, dikes, flows, and pyroclastic deposits (UH Hilo 1998). Although the dates for the Wailuku and Honolua overlap, there is no known evidence of interfingering, so it appears the shield stage ended fairly abruptly, at least in geologic terms (Sherrod et al. 2007).

Four cinder and spatter cones represent the rejuvenated stage of West Maui. Deposits from these features are designated the Lahaina Volcanics for the town where the most extensive of the flows is exposed (Sherrod et al. 2007). In Figure 3-7, the town of Lahaina is located on the southeastern coast of the West Maui portion, within the mapped segment of younger alluvium deposits just south of the largest area of Lahaina Volcanics.

Deep gulches have been eroded and radiate outward from the high caldera area of West Maui. Nearly 4,900 vertical feet of volcanic layers have been exposed by erosion in places on this portion of the island (UH Hilo 1998).

East Maui (Haleakalā)

The oldest exposed flows on the East Maui volcano are the Honomanū Basalt, which erupted 1.1 to 0.97 million years ago. As can be seen in Figure 3-7, the areas of exposed Honomanū Basalt are very limited, as it was almost completely buried by the subsequent postshield flows designated the Kula and Hāna Volcanics. The Kula Volcanics formed a thick mantle over most of the volcano's volume; at the summit, it is more than 3,200 feet thick. As noted previously, the last eruption was about 400 years ago. Previous

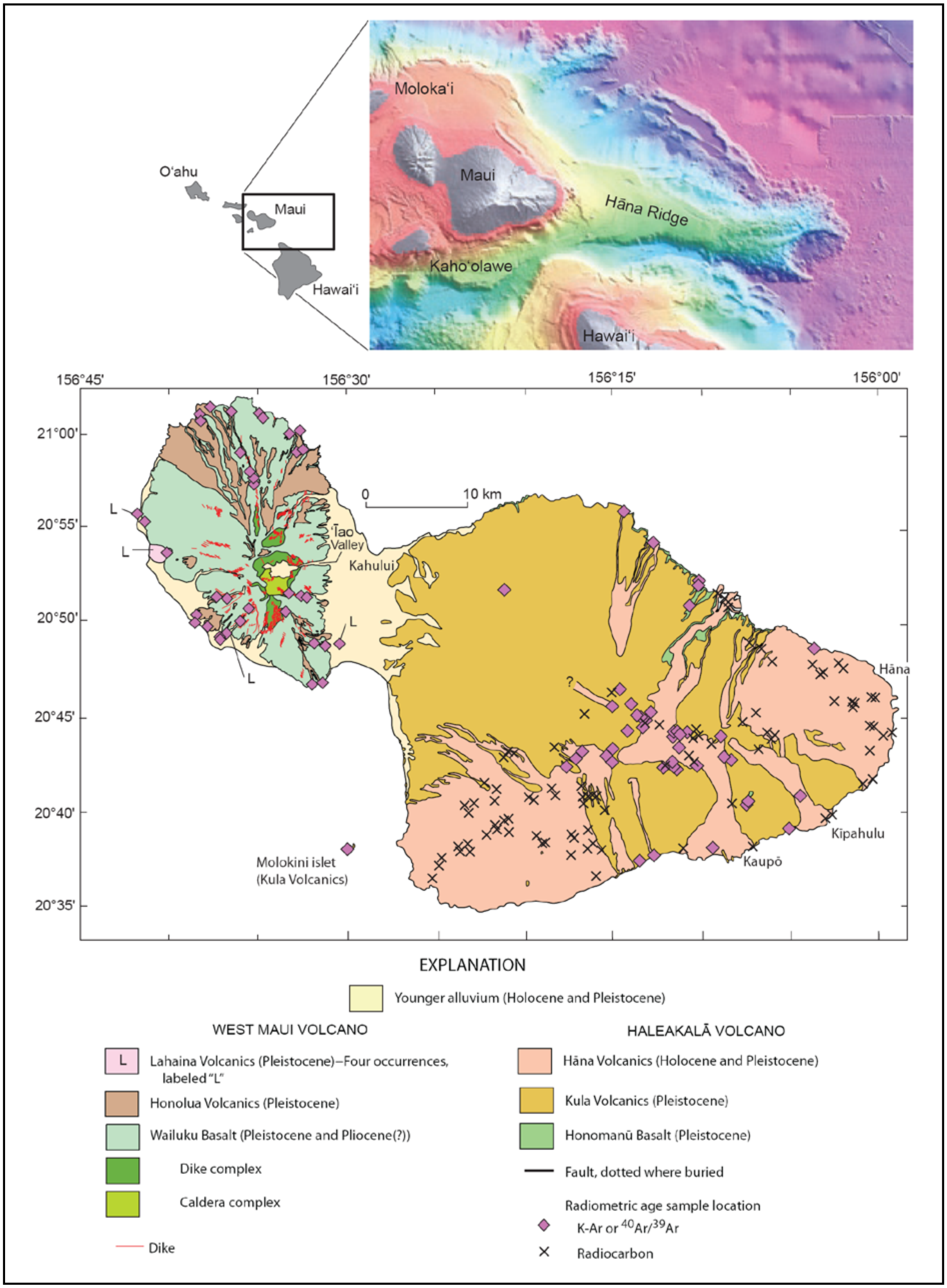


Figure 3-7. Generalized Geologic Map of Maui (Source: Sherrod et al. 2007)

interpretations of the Hāna were that it represented a rejuvenated-stage deposit. However, more recent data indicate only a small gap in ages between it and the Kula and similarity in the geochemistry, which indicates it, too, is part of the postshield stage. Evaluations of the postshield volcanics indicate that Haleakalā has continued to erupt every 200 to 500 years (Sherrod et al. 2007).

No specific caldera is identified for Haleakalā. A large summit depression, once believed to be a caldera, is now interpreted to be an erosional feature generated by landslides that merged two river canyons. The rift zones along which the Kula and Hāna Volcanics erupted extend along an east-to-southwest line through the summit area with a branch to the north-northwest.

Maui Nui

Descriptions of the Hawaiian Islands geology sometimes address Maui Nui, the ancient island believed to include what are now the islands of Maui, Kahoʻolawe, Lānaʻi, and Molokaʻi. At its maximum size, this island would have been roughly 50 percent larger than the present-day Hawaiʻi island. As Maui Nui subsided, the area evolved into the current island configuration. About 300,000 to 400,000 years ago, the area probably consisted of two islands: the Molokaʻi, and Lānaʻi group to the northwest, and the Maui and Kahoʻolawe group to the southeast. The current configuration probably came into being within the last 100,000 to 200,000 years (UH Hilo 1998).

3.1.1.6.2 Soils

NRCS data for Maui identify more than 50 soil series. Table 3-5 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. As can be seen in the table, classified soil series represent more than 60 percent of the island's area, with silty clay loams and silty clays the most common soil types. The table also shows that about 17 percent of the island qualifies as prime farmland, but many of these land classifications are identified with an "if irrigated" caveat. More than 20 percent of the island's land can be characterized as rough broken or mountainous land.

3.1.1.7 Hawaiʻi

3.1.1.7.1 Geology

Hawaiʻi island encompasses five major shield volcanoes and a sixth submerged off the northwestern shore. A seventh volcano, Lōʻihi is the newest in the chain, lying about 3,200 feet beneath the sea off the island's southeastern shore. Figure 3-8 is a geologic map of Hawaiʻi. Figure 3-9 is a bathymetric map of the island such as has been presented for the other islands.

Table 3-5. High-Level Summary of the NRCS Soil Survey Data for Maui

Description	Slopes	Acres	Portion of Island	Prime Farmland Acres	Prime Farmland Portion of Island
Soils					
Clay	< about 15%	9,615	2.1%	9,615	2.1%
	> about 15%	1,990	0.4%	0	
Silty clays – including silty clays that are peaty, gravelly, cobbly, or extremely stony	< about 15%	70,471	15.2%	31,627	6.8%
	> about 15%	2,733	0.6%	0	
Loam – including loam that is rocky, cobbly, and extremely stony	< about 15%	3,508	0.7%	404	<0.1%
	> about 15%	29,992	6.5%	0	
Sandy loam – including sandy loam that is cobbly	< about 15%	2,058	0.5%	2,058	0.5%
	> about 15%	0		0	
Clay loam	< about 15%	10,582	2.2%	3,978	0.8%
	> about 15%	0		0	
Silt loam – including silt loam that is stony, cobbly, or very stony	< about 15%	29,882	6.3%	5,286	1.2%
	> about 15%	13,504	2.9%	0	
Silty clay loams – including silty clay loam that is cobbly or stony	< about 15%	109,715	23.6%	27,034	5.9%
	> about 15%	713	0.2%	0	
Sand and loamy sand	< about 15%	5,545	1.2%	0	
	> about 15%	7,957	1.7%	0	
Subtotal		298,265	64.0%	80,002	17.3%
Miscellaneous designations					
Beaches	NA	464	0.1%		
Cinder or gravel pit, quarry	NA	154	<0.1%		
Extremely stony muck or peat	NA	5,756	1.2%		
Cinder land	NA	7,096	1.5%		
Lava flows	NA	9,820	2.1%		
Rock land or outcrops	NA	31,970	6.9%		
Rough broken or stony land	NA	57,296	12.3%		
Rough mountainous land	NA	54,222	11.6%		
Water (>40 acres)	NA	810	0.2%		
Subtotal		167,588	36.0%		
TOTALS		**465,853**	**100%**	**80,002**	**17.3%**

Source: NRCS 2013.
< = less than; > = greater than; NA = not applicable.

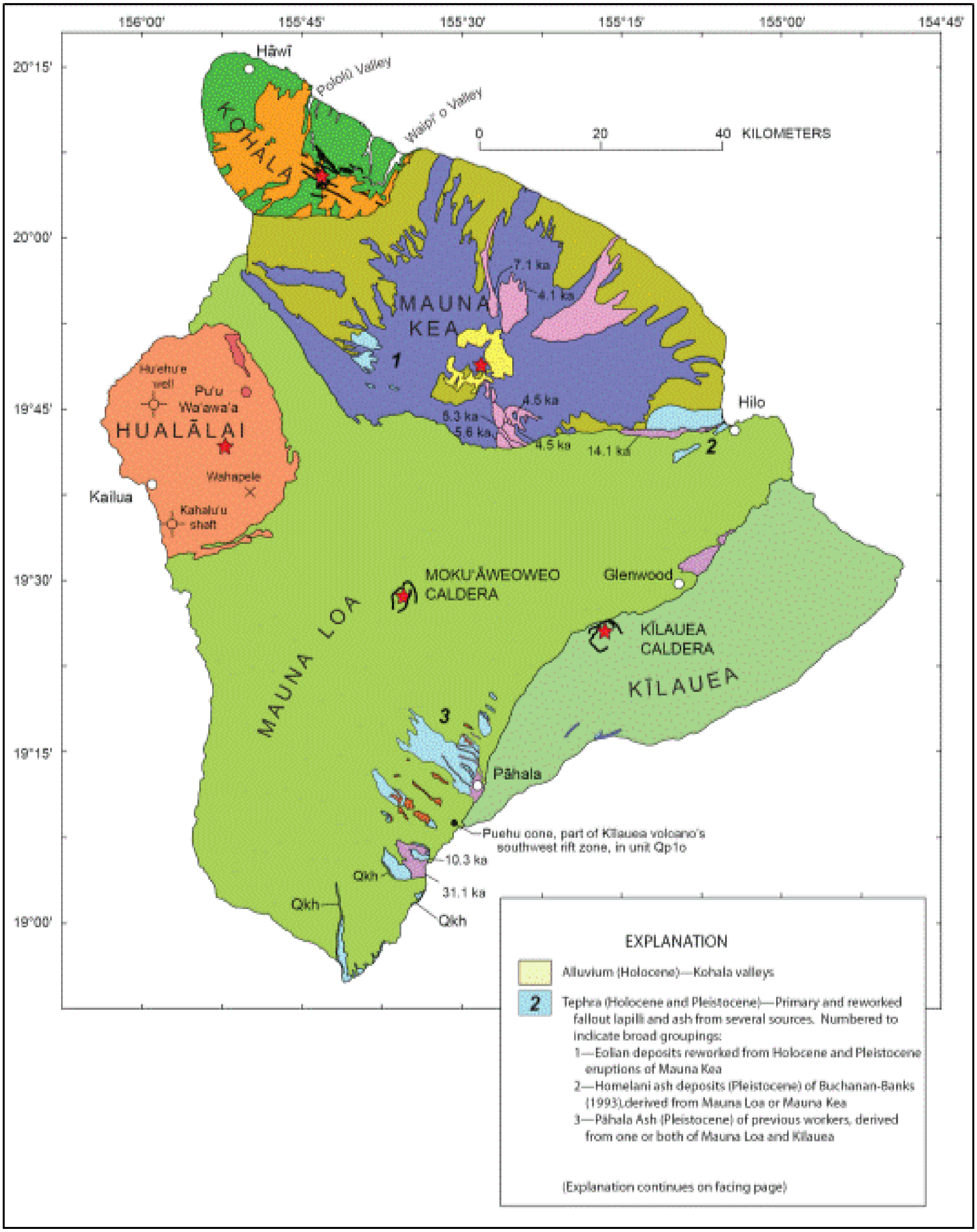
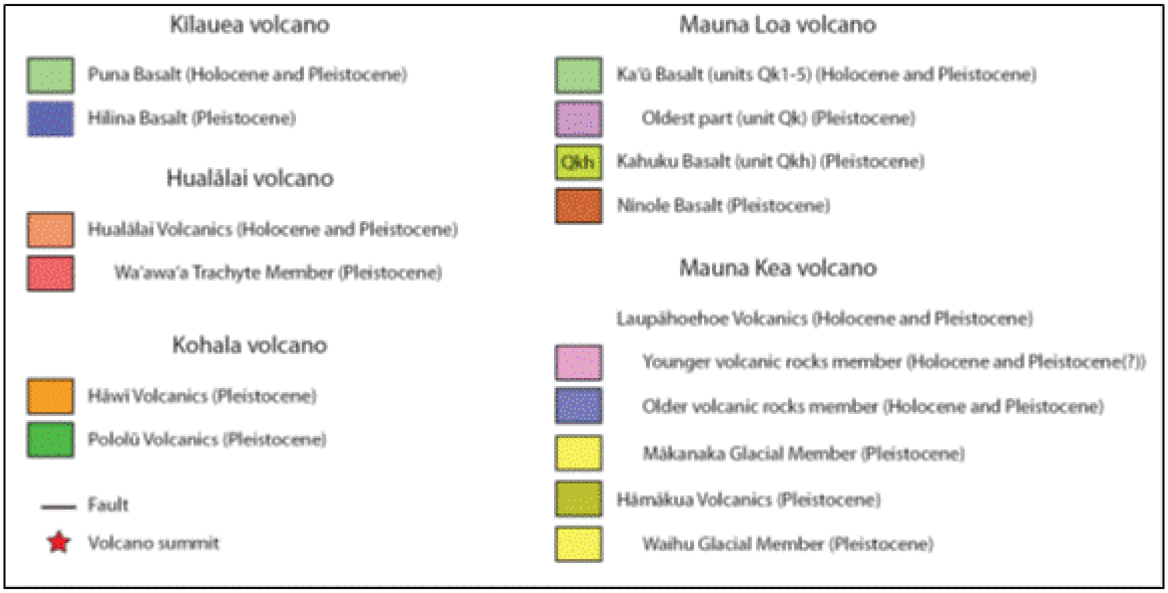


Figure 3-8. Generalized Geologic Map of Hawai'i island (Source: Sherrod et al. 2007)

Figure 3-8. Continued



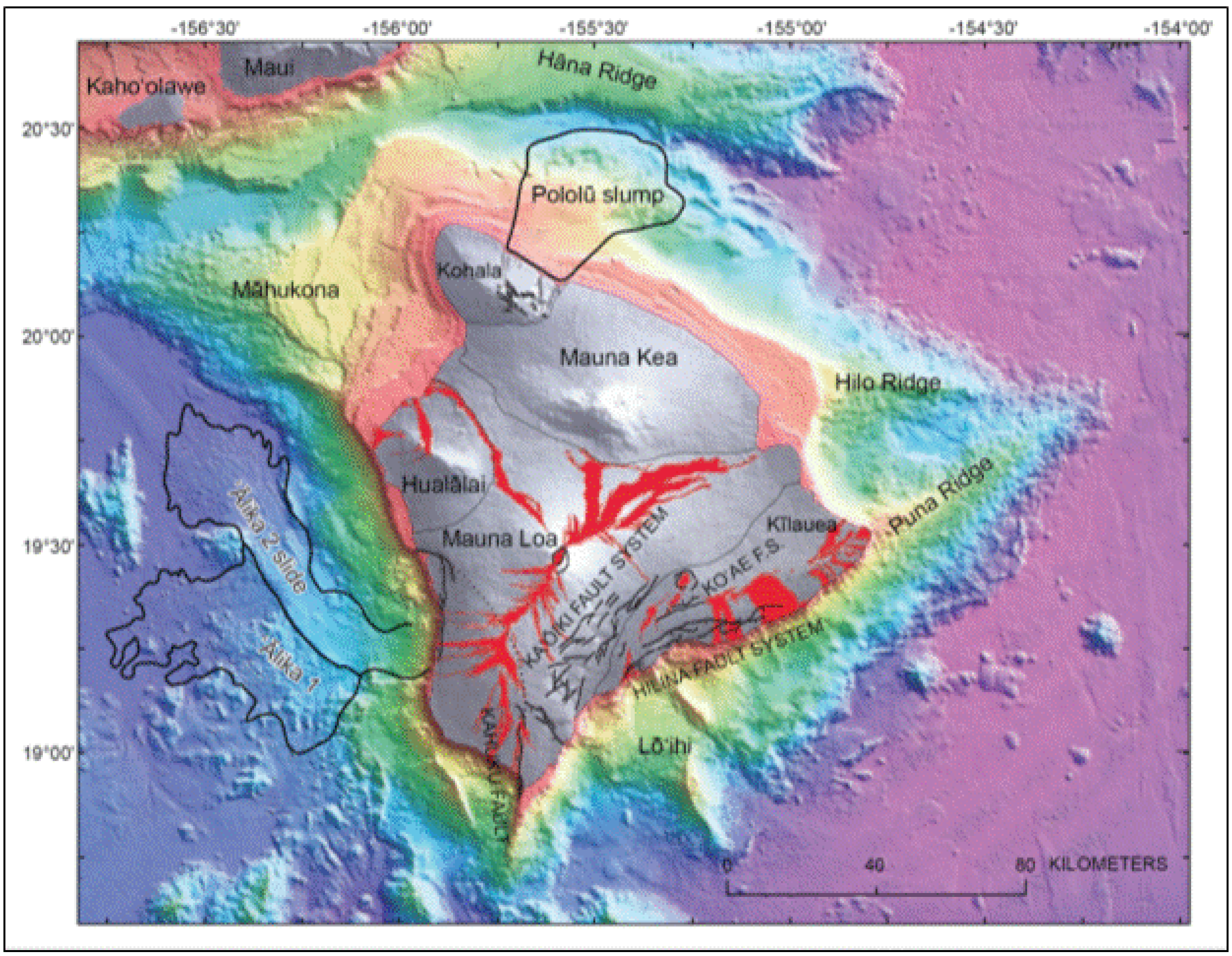


Figure 3-9. Bathymetric Map of Hawai'i island (Source: Sherrod et al. 2007)

The following discussion of the Hawai‘i volcanoes starts with the oldest and moves to the youngest.

Mahukona

This was the first volcano to form part of the island. It rose only about 820 feet above sea level and submerged off the northwestern shore (Figure 3-9) (UH Hilo 1998).

Kohala

This is the oldest of the island’s surface volcanoes and forms the protrusion that is the north-northwest extent of the island (Figure 3-8) (Sherrod et al. 2007). Late in the time of the Pololū Volcanics there was a large landslide or slump off the northeastern side of Kohala (see the Pololu slump in Figure 3-9). Large stream valleys were cut into the resulting indentation along the shoreline. The subsequent Hāwī flows draped the valley walls and flowed down into Pololū Valley (Sherrod et al. 2007). Most of the thick ash cover on Kohala is believed to have come from Mauna Kea eruptions (UH Hilo 1998).

Mauna Kea

This is a dormant volcano that forms much of the northern section of the island (Figure 3-8) and last erupted about 4,600 years ago. Mauna Kea forms the highest summit in the State and is the only volcano in the chain known to have been glaciated. Many of Mauna Kea’s eruptions were explosive, possibly triggered by interaction of lava with glacial water, and produced widespread ash deposits (UH Hilo 1998). Mauna Kea is more symmetrical than other volcanoes on the island and lacks well-defined rift zones.

The oldest exposed volcanic layers are designated the Hāmākua Volcanics. These materials are found on all flanks of the volcano, are of postshield stage origin (that is, no shield-stage lavas are exposed). Two glacial sequences are interbedded with the Hāmākua on the upper flanks of Mauna Kea and are designated the Pōhakuloa Glacial (the older) and the Waihū Glacia (the younger) Members. The latest stages of Mauna Kea volcanism (still of the postshield stage) are designated the Laupāhoehoe Volcanics. The younger member of the Laupāhoehoe formed from 7,100 to 4,600 years ago.

Hualālai

Hualālai is an active volcano on the central-west portion of the island (Figure 3-8). Its most recent eruption was about 200 years ago, before that was about 700 years ago, and it erupted three times from about 900 to 1,200 years ago (UH Hilo 1998). The volcano’s summit caldera is buried, but vents, including spatter and cinder cones, define the rift zones that extend northwest and southeast from the summit. This volcano is one of several Hawaiian volcanoes known to have phreatic explosions (Sherrod et al. 2007), which are explosive eruptions of steam and rock fragments resulting from magma very rapidly heating ground or surface water into steam.

Hualālai is completely covered by postshield lavas. The earlier, shield-stage lava flows have been identified offshore and in wells, some as shallow as about 250 feet below the surface. The shield-stage eruptions stopped about 130,000 years ago. The overlying postshield lavas, designated the Hualālai Volcanics, started about 114,000 years ago. The oldest, or lowest, member of the Hualālai Volcanics is the Wa‘awa’a Trachyte Member and it erupted from about 114,000 to 92,000 years ago (Sherrod et al. 2007).

Mauna Loa

Mauna Loa comprises the central and southern parts of the island (Figure 3-8). It is the world’s largest volcano with an above-ocean-floor edifice that ranges in volume from 16,000 to 19,000 cubic miles, which includes a load-induced subsidence of 5 to 6 miles in the Pacific Plate (Sherrod et al. 2007). This growth was accompanied by several landslides to the west, the latest (and most recent in the Hawaiian Islands) being the Alika slide that occurred about 110,000 years ago (UH Hilo 1998). The Kahuku and Kealakekua faults on Mauna Loa’s west flank likely had exposures of more than 4,900 to 6,600 feet during the volcano's history as a result of these landslides, although now they are hidden by subsequent flows (Sherrod et al. 2007). Mauna Loa is in the late shield stage, with a declining eruption rate: 36 eruptions in the 170 years since 1843 and 3 eruptions in the 60-plus years since 1950, with the last eruption in 1984. Eruptions have been primarily along two prominent rift zones with repeated fissure eruptions on the northern and northwestern flanks (UH Hilo 1998).

The oldest exposed rocks on Mauna Loa are the lava flows of the Nīnole Basalt, dated at 0.2 to 0.1 million years ago. Younger lava flows are divided into two formations: the older Kahuku Basalt and the younger, far more widespread, Kaʻū Basalt. These two basalts are generally separated by an intervening ash that has been dated at 30,000 to 13,000 years ago. The summit caldera, Mokuʻāweoweo, has younger, thin deposits of explosive debris on its northwest and southeast rims. These deposits are interpreted as being phreatic in origin and are dated at less than 1,000 years ago (Sherrod et al. 2007).

Kīlauea

Kīlauea forms the southeastern flank of the island (Figure 3-8) and is the youngest of Hawaiʻi's emergent volcanoes. It is also perhaps the most active volcano in the world, having erupted 60 times since 1840 and almost continually since 1983. Eruptions occur anywhere at the summit or along two rift zones. Kīlauea is currently in the explosive phase of its shield stage. It primarily discharges lava, but past lava flows are interbedded with ash deposits from infrequent explosive eruptions (UH Hilo 1998). The summit is mantled with a thick ash, or tephra, designated the Keanakākoʻi Ash Member, that accumulated during a series of explosive eruptions over the time from about 1500 to 1790. A system of faults along Kīlauea's southern flank have offsets in the range of 1,600 to 2,200 feet and are highly active. This fault system has been associated with large earthquakes; a magnitude 7.2 earthquake occurred on the southern flank in November 1975 (Sherrod et al. 2007).

Kīlauea's surface materials are divided into three major units (starting with the oldest): (1) the Hilina Basalt, (2) an overlying accumulation of basaltic ash, and (3) the capping Puna Basalt (Sherrod et al. 2007).

3.1.1.7.2 Soils

NRCS presents data for the island of Hawaiʻi in two groups: one group for Hawaiʻi Volcanoes National Park and one group for the rest of the island. In combination, the data identify more than 150 soil series. Table 3-6 provides a high-level summary of the NRCS soil survey data based on the textural characteristics of the various soil series. The NRCS data for most of the island did not contain the same level of detail as was available for the islands addressed above. For example, there was no information for the major portion of the island on which soil series qualified as prime farmland. Because of this, no attempt was made to sort soils by slopes as was done for the previous island soils. As can be seen in the table, classified soil series represent slightly less than 60 percent of the island's area, with silty clay loams and silt loams the most common soil types. The table also shows that 40 percent of the island qualifies as lava flows or lava flow-soil complexes.

Table 3-6. High-Level Summary of the NRCS Soil Survey Data for Hawai‘i island

Description	Volcanoes National Park		Rest of Island		Island Total	
	Acres	Portion	Acres	Portion	Acres	Portion
Soils						
Silty clays – including silty clays that are cobbly, stony, or ashy			15,201	0.7%	15,201	0.6%
Loam – including loam that is cobbly, stony, or ashy, or that contains organic material	5,914	1.6%	120,526	5.5%	126,440	4.9%
Ashy or Sandy loam – including sandy loam that is cobbly or stony	6,598	1.6%	242,068	10.7%	248,666	9.6%
Silt loam – including silt loam that is cobbly, or that contains organic material	26,207	7.0%	352,222	15.5%	378,429	14.7%
Silty clay loams – including silty clay loam that is cobbly or stony, or that has rock outcrops or contains organic material	1,355	0.3%	385,277	17.5%	386,632	15.0%
Ashy or loamy sand – including loamy sand that is cobbly or gravelly	2,582	0.7%	15,209	0.6%	17,791	0.7%
Organic soils (decomposed plant material) – including organic soil that is gravelly or cobbly	7,900	2.2%	309,758	14.2%	317,658	12.3%
Subtotal	**50,556**	**13.7%**	**1,440,261**	**65.2%**	**1,490,817**	**57.8%**
Miscellaneous Designations						
Soils not assigned to a series	1,132	0.3%	1,071	0.0%	2,203	0.1%
Beaches and dunes			520	0.0%	520	<0.1%
Dumps, landfills, and fill land			204	0.0%	204	<0.1%
Pits and quarry			54	0.0%	54	<0.1%
Water, sewage treatment			22	0.0%	22	<0.1%
Cinder land	2,498	0.7%	30,912	1.4%	33,410	1.3%
Lava flows	222,185	60.3%	356,342	16.1%	578,527	22.4%
Lava flow – soil complexes	90,671	24.6%	368,022	15.9%	458,693	17.8%
Rubble land and badlands	125	0.0%	11,763	0.5%	11,888	0.5%
Water (>40 acres), tide pools, and riverwash	888	0.2%	275	0.0%	1,163	<0.1%
Subtotal	317,499	86.3%	769,185	34.8%	1,086,684	42.2%
TOTALS	**368,055**	**100%**	**2,209,446**	**100%**	**2,577,501**	**100%**

Source: NRCS 2013.

3.1.2 GEOLOGIC HAZARDS

3.1.2.1 Earthquakes

3.1.2.1.1 Earthquake Occurrences and Magnitudes

The process that is building the Hawaiian Islands is also responsible for the State’s seismic activity. Unlike most areas where seismic activity is associated with movement along tectonic plate boundaries, Hawai‘i’s earthquakes primarily are the direct result of volcanic activity, occurring before or after eruptions, or as a result of magma moving underground without erupting (UH Hilo 1998). Another type of earthquake affecting the State involves flexing of the lithosphere under the weight of the islands rather than active volcanism (USGS 2011). Thousands of earthquakes occur each year in Hawai‘i , but most are only detectable by highly sensitive instruments. Throughout recorded time, the State’s seismic activity has been concentrated beneath Hawai‘i island and the surrounding ocean floor. The type of earthquake involving flexing of the lithosphere, however, could occur beneath the older Hawaiian Islands (USGS 2011).

Table 3-7 lists Hawaiʻi earthquakes with magnitudes 6.0 or greater occurring since 1868 based on recorded measurements or eye witness accounts. The size of an earthquake typically is expressed in terms of its magnitude, which is an instrument's measurement of the amount of energy released at the source of the earthquake. The magnitude is a measure of the size or amplitude of the seismic wave that is created and is based on a logarithmic scale such that an increase in one whole number represents a tenfold increase in the size of the seismic wave. Earthquake magnitudes of 3 or less are generally not felt; magnitudes greater than 6 can cause widespread damage.

Table 3-7. Destructive Earthquakes in Hawaiʻi since 1868

Year-Mon-Day	Magnitude	Maximum Intensity	Source Description
1868-03-28	7.0	IX	Southern Hawaiʻi Island
1868-04-02	7.9	XII	Southern Hawaiʻi Island
1918-11-02	6.2	VII	Ka'ōiki, between Mauna Loa and Kīlauea
1919-09-14	6.1	VII	Ka'u District, Mauna Loa south flank
1926-03-19	>6.0		Northwest of Hawaiʻi Island
1927-03-20	6.0	VII	Northeast of Hawaiʻi Island
1929-09-25	6.1	VII	Hualālai
1929-10-05	6.5	VIII	Hualālai
1938-01-22	6.9	VIII	North of Maui
1940-06-16	6.0	VII	North of Hawaiʻi Island
1941-09-25	6.0	VII	Ka'ōiki
1950-05-29	6.4	VIII	Kona
1951-04-22	6.3	VIII	Lithospheric
1951-08-21	6.9	VIII	Kona
1952-05-23	6.0	VII	Kona
1954-03-30	6.5	VIII	Kīlauea south flank
1955-08-14	6.0	VII	Lithospheric
1962-06-27	6.1	VII	Ka'ōiki
1973-04-26	6.3	VIII	Lithospheric, north of Hilo
1975-11-29	7.2	VIII	Kīlauea south flank
1983-11-16	6.6	VIII	Ka'ōiki
1989-06-25	6.1	VII	Kīlauea south flank
2006-10-15	6.1	VII	Northwest of Hawaiʻi Island, north of Kīholo Bay
2006-10-15	6.7	VIII	Northwest of Hawaiʻi Island, near Kīholo Bay

Sources: UH Hilo 1998; USGS 2006, USGS 2013a.
Intensity = Modified Mercalli Intensity Scale measure.

Another measuring approach for earthquakes is the Modified Mercalli Intensity Scale, which ranks on a scale from I to XII based on the shaking severity of the earthquake and its effects on people, human structures, and the natural environment. An intensity of I is "not felt except by a very few under especially favorable conditions" and a XII indicates "Damage total - lines of sight and level are distorted - objects thrown into the air" (USGS 2013b). Table 3-7 shows the intensity values for each of the magnitude 6.0 or greater earthquakes since 1868. Earthquake magnitudes of less than 3 correspond to a level I on the Intensity Scale. A level II earthquake generally is felt by only a few people, particularly on upper floors of buildings; a level III generally is felt by people indoors, but is often not recognized as an earthquake because the vibrations are similar to those a passing truck might cause. Although there might be superficial damage to some structures at intensity levels V and VI, it generally takes a level of VII before there is considerable damage in poorly constructed structures and a level of VIII before there is widespread damage in other buildings except those specially designed to withstand earthquakes (USGS

2013b). Modified Mercalli Intensity Scale levels of VII and greater are associated with earthquakes of magnitude 6.0 and greater.

As a better indication of where earthquakes take place, Figure 3-10 shows locations of earthquakes occurring since 1973. This figure shows more earthquakes than Table 3-7 lists for this timespan because it shows events down to a magnitude 5. As can be seen in the figure, very few of the depicted earthquakes occurred outside of the immediate area of Hawaiʻi island, and all of those occurring in outer areas were in the smallest category shown; that is, they were all of a magnitude from 5.0 to 6.0.

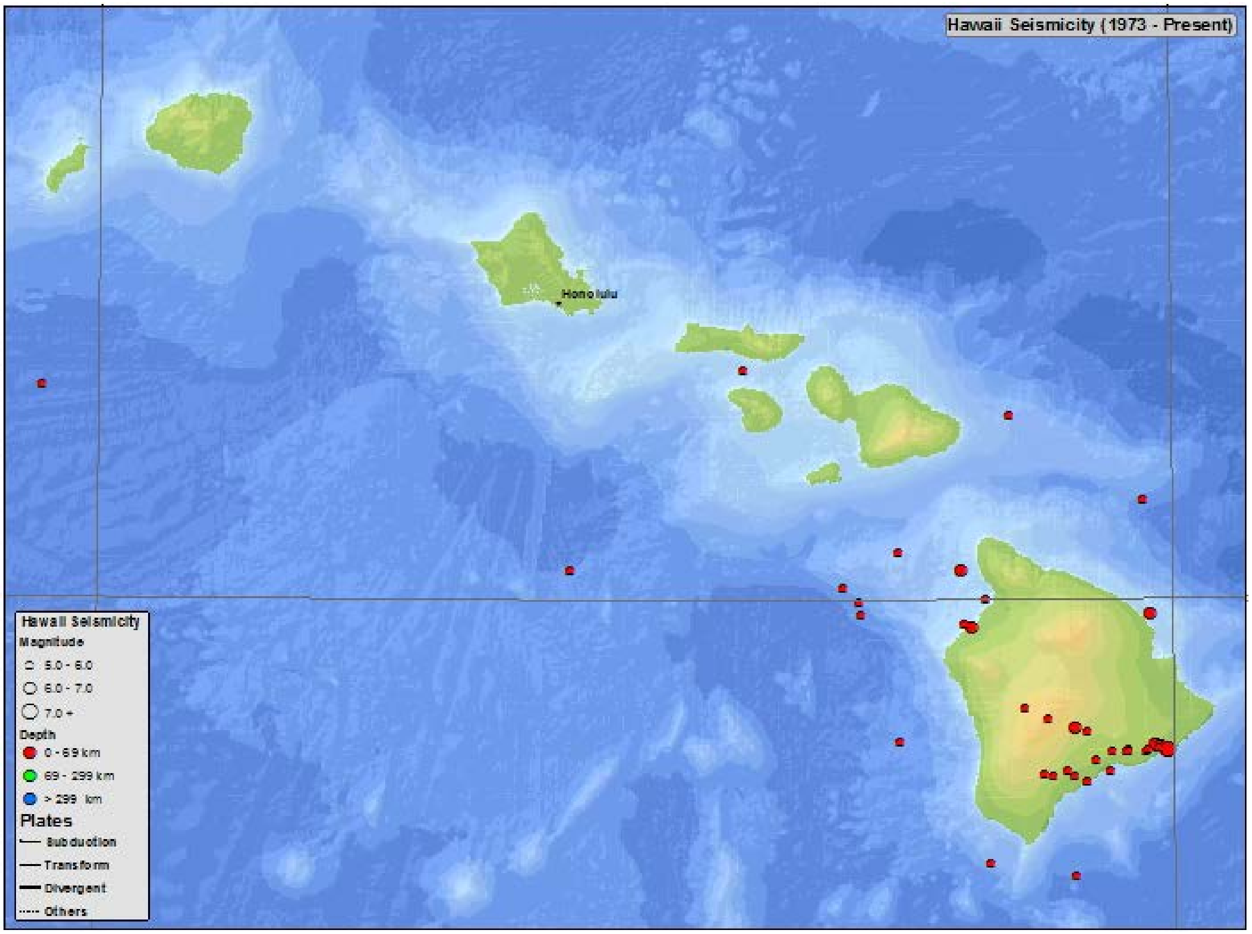


Figure 3-10. Hawaiian Earthquake Locations from 1973 to Present (Source: USGS 2013c)

3.1.2.1.2 Earthquake Hazards

The U.S. Geological Survey (USGS) has developed probabilistic seismic hazard maps for the entire United States that depict the magnitude of an earthquake with a specific probability of occurring. For example, a typical seismic hazard map generated by the USGS shows how the earthquake magnitude varies over a region for an earthquake with a 10 percent probability of occurring in 50 years. This is equivalent to a 100 percent probability in 500 years (or 1 percent in 5 years). Restated, it is the magnitude of an earthquake that would be expected to occur, on average, once every 500 years. Another earthquake frequency typically shown in another set of maps is one with a 2-percent probability of occurring in 50 years. This would be an earthquake that would be expected to occur, on average, once every 2,500 years. This latter earthquake would have less probability of occurring in any year and, accordingly, would be a larger earthquake. These seismic hazard maps show earthquake magnitude in terms of the peak ground motion they would generate and, specifically, the peak acceleration. The maps show the peak acceleration in terms of a percentage of acceleration due to gravity or “g.”

Figure 3-11 is a three-part figure presenting different seismic hazard map information. At the top of the figure is the official USGS seismic hazard map for the Hawaiian Islands that shows the peak acceleration for an earthquake with a 10-percent chance of occurring in 50 years. The middle figure presents the same information from a different source that generally provides a clearer distinction of where peak acceleration values change. For comparison purposes, the bottom of the figure provides a map of the conterminous United States that shows peak acceleration for an earthquake of the same probability of occurrence. Note that the scale in the bottom map is slightly different, in that it presents peak acceleration as a factor of “g,” whereas the top two present peak acceleration as a percentage of “g” (that is, a peak acceleration of 100 percent g on the top two maps is equivalent to a value of 1 g on the bottom).

As can be seen in Figure 3-11, the southeastern side of Hawai‘i island shows that an earthquake with a 10-percent chance of occurring in 50 years would produce a peak acceleration of up to about 120 percent g (or 1.2 g). This is equivalent to an earthquake with a magnitude of about 6.9 and a Modified Mercalli Intensity of IX for violent shaking with heavy damage (USGS 2013b). For this earthquake recurrence frequency, only a few areas along the very westernmost coast of the conterminous United States would reach similar peak acceleration values. Beyond the island of Hawai’i (and even the northwestern side of it), however, peak acceleration drops to about 30 percent g or less (see also USGS 2013d). At a peak acceleration of about 30 percent g, the equivalent magnitude is below 6.0 and the Modified Mercalli Intensity is about VII or less. As noted above, an intensity of VII would result in considerable damage in poorly built structures, but negligible damage in buildings of good design and construction.

From about midway on Maui and for the rest of the islands to the west, peak acceleration drops to about 20 percent of g and less. The respective magnitude and intensity would be about 5.5 and VI and less. At an intensity of VI, damage to structures would be expected to be superficial at most.

3.1.2.2 Volcanic Eruptions and Lava Flows

The Hawaiian Islands have six volcanoes classified as active: Kīlauea, Mauna Loa, Hualālai, and Mauna Kea on Hawai‘i island; Haleakalā on Maui; and the submarine volcano Lō‘ihi to the southwest of Hawai‘i island. The following points summarize eruption characteristics on these six (from youngest to oldest):

- Lō‘ihi is the newest volcano of the Hawaiian Ridge, and it has small and infrequent eruptions. Still about 3,200 feet below sea level, this volcano is not expected to surface for approximately 200,000 years (UH Hilo 1998).

- Kīlauea has been erupting almost continuously since 1983 (Sherrod et al. 2007).

- Mauna Loa last erupted in 1984 (Sherrod et al. 2007) and is expected to erupt frequently throughout the foreseeable future (UH Hilo 1998).

- Hualālai last erupted in 1801, and it is believed to be on an eruption cycle of about 250 years (UH Hilo 1998).

- Mauna Kea last erupted about 4,600 years ago (Sherrod et al. 2007) and, though active, is considered dormant.

- Haleakalā last erupted in about 1600, and it is believed to be on an eruption interval of every 200 to 500 years (Sherrod et al. 2007).

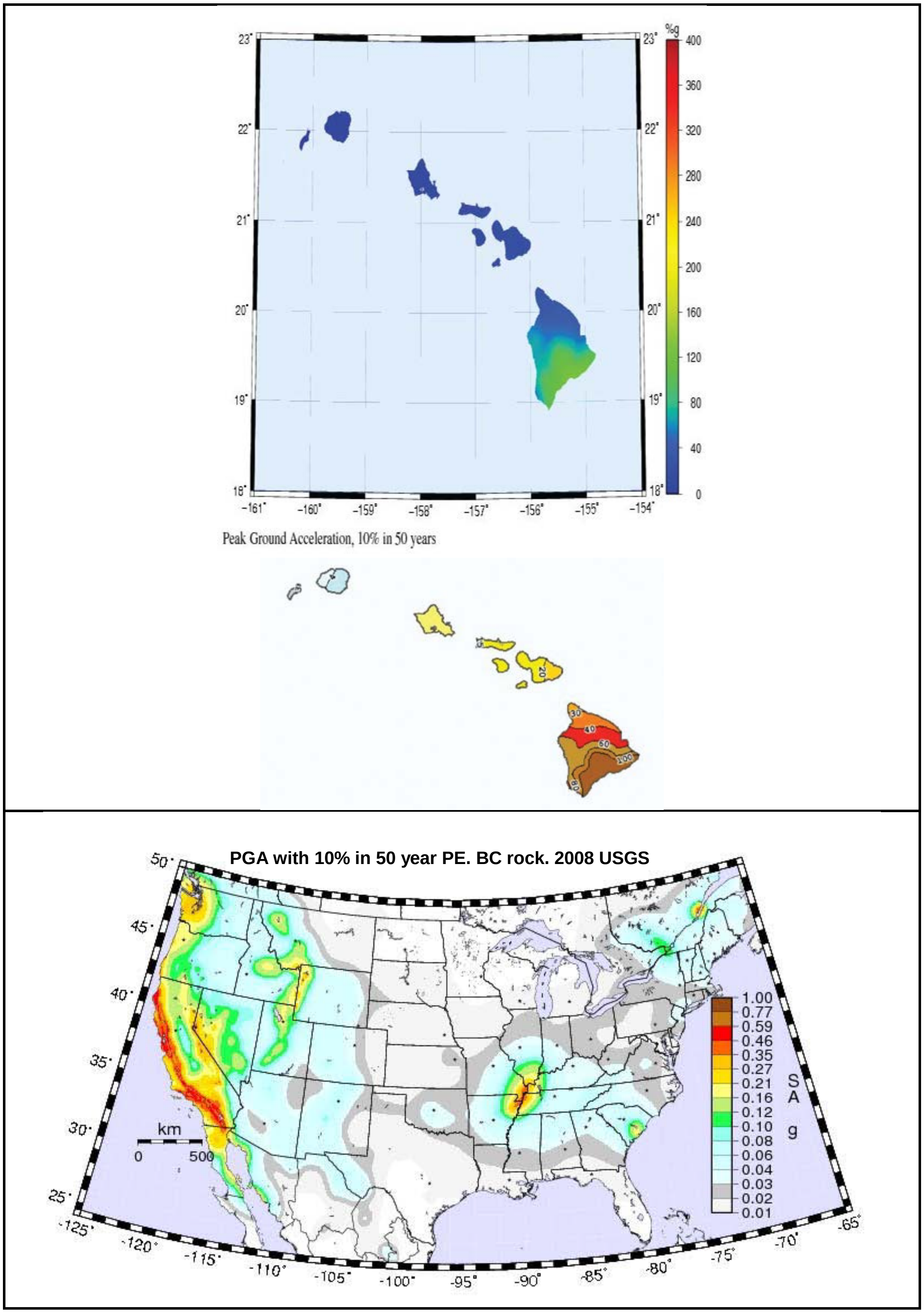
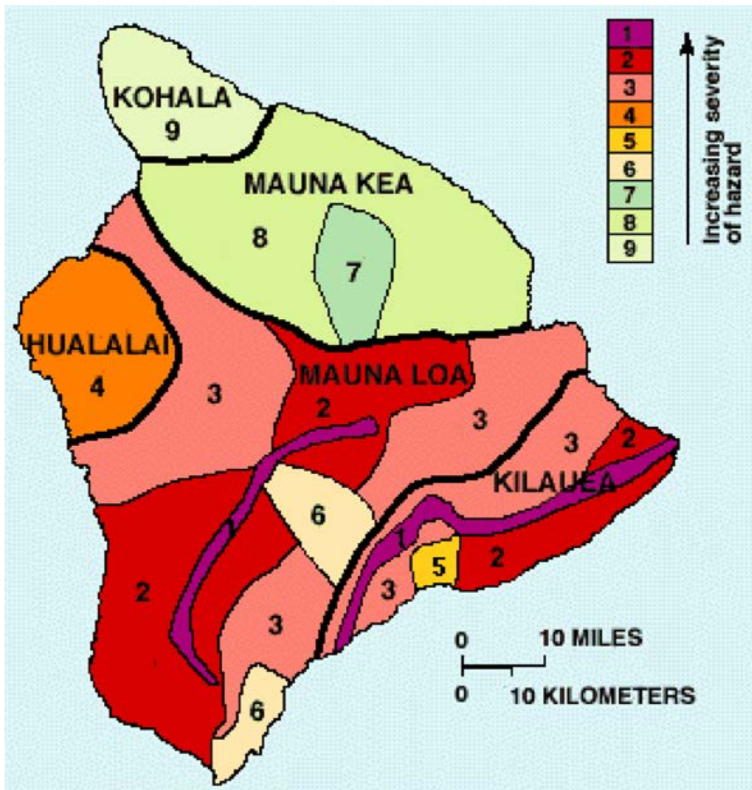


Figure 3-11. Seismic Hazard Maps for the Hawaiian Islands and the Conterminous United States for an Earthquake with a 10-percent Chance of Occurring in 50 Years (Sources: USGS 1998, USGS 2008, USGS 2011)

Kohala, the fifth volcano on Hawai‘i island, is considered extinct, but as noted in the geology discussion, some believe that the extensive rejuvenated stage that occurred on some of the older islands is an indication that some of the younger volcanoes could go through additional eruptions. Kohala was specifically identified as a case in point.

Since most Hawaiian volcano eruptions produce fluid lava flows that can travel for miles, these lava flows represent the primary volcanic hazard to island residents and property (UH Hilo 1998). Figure 3-12 is a hazard map the USGS developed to depict the relative risk presented by lava flows on Hawai‘i island.



Legend			
Zone	**Percentage of area covered by lava since 1800**	**Percentage of area covered by lava in last 750 years**	**Explanation**
1	Greater than 25	Greater than 65	Includes the summits and rift zones of Kīlauea and Mauna Loa where vents have been repeatedly active in historic time.
2	15 to 25	25 to 75	Areas adjacent to and downslope of active rift zones.
3	1 to 5	15 to 75	Areas gradationally less hazardous than Zone 2 because of greater distance from recently active vents and/or because the topography makes it less likely that flows will cover these areas.
4	About 5	Less than 15	Includes all of Hualālai, where the frequency of eruptions is lower than on Kīlauea and Mauna Loa. Flows typically cover large areas.
5	None	About 50	Areas currently protected from lava flows by the topography of the volcano.
6	None	Very little	Same as Zone 5.
7	None	None	20 percent of this area covered by lava in the last 10,000 years.
8	None	None	Only a few percent of this area covered in the past 10,000 years.
9	None	None	No eruption in this area for the past 60,000 years.

Figure 3-12. Lava Flow Hazard Map for the Island of Hawai‘i (Source: USGS 1997)

The information in the map is based on past coverage of lava flows, the location of vents, and the larger topographic features of the volcanoes that would affect distribution of the flows. The USGS generated this map for general planning purposes only and notes that the boundaries are approximate, with transitions from one zone to another being gradual and likely occurring over a distance of a mile or more (USGS 1997).

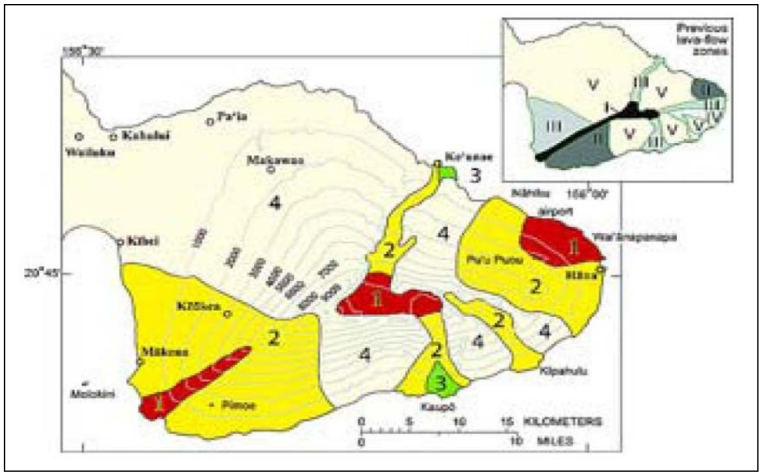


Figure 3-13. Lava Flow Hazard Map for Maui (Source: USGS 2012a)

A similar lava flow hazard map has also been developed for the eastern portion of Maui, where eruptions from Haleakalā are expected to occur at some time in the future. This map is shown in Figure 3-13, which includes, as an inset, an older version. No legend is available for the Maui map, but the USGS suggests that Zone 1 on the Maui map is roughly equivalent to the Zone 3 on the Hawaiʻi island map; the Maui Zone 2 is roughly equivalent to Hawaiʻi island Zone 4; and Maui Zone 3 is roughly equivalent to Hawaiʻi island Zone 6. The implication in these approximate equivalencies is that there are no locations on Maui with volcanic hazards comparable to those of Zones 1 and 2 on Hawaiʻi island (USGS 2012a).

3.1.2.3 Tsunami Hazards

Tsunami are caused by sea floor disturbances that displace water. They typically are caused by earthquakes, but they can also be the result of underwater slides or volcanic eruptions. The Hawaiian Islands are susceptible to tsunami generated along the "Ring of Fire" fault zone that borders the Pacific Ocean, and Pacific-wide tsunami are only moderately weakened as they travel across the ocean. For example, the massive earthquake that occurred in Chile in May 1960 generated a tsunami that not only impacted and caused severe damage to the bayfront of Hilo, it caused considerable damage to coastal areas in Japan. Over the open ocean, tsunami waves are basically imperceptible, but as the water gets shallower, the waves slow down and the tremendous energy they carry transforms their height. These wave heights can reach up to 30 feet, and when they hit shore, the "sloshing" action or runup can be even greater. As the tsunami waves encounter the varying depths and ocean floor topographies that are often around islands, their directions can change such that coasts not facing the source of the tsunami can also be impacted (UH Hilo 1998).

Since 1819 when the first tsunami was recorded in Hawaiʻi, there have been 87 observed tsunami, 15 of which resulted in significant damage. Figure 3-14 provides a graphical representation of the major tsunami runups that have been observed in the Hawaiian Islands from 1819 through 1994 from sources outside of Hawaiʻi. Major is defined as a runup of 3 feet or greater. As noted in the figure, the tsunami database the National Oceanic and Atmospheric Administration (NOAA) developed (NOAA 2013a) shows one additional event since 1994. In March of 2011, a magnitude 9 earthquake in Japan caused a tsunami that impacted the Hawaiian Islands with runups recorded in several locations, the largest almost 7 feet on Oʻahu. The database did not specify significant injuries or property losses for this event.

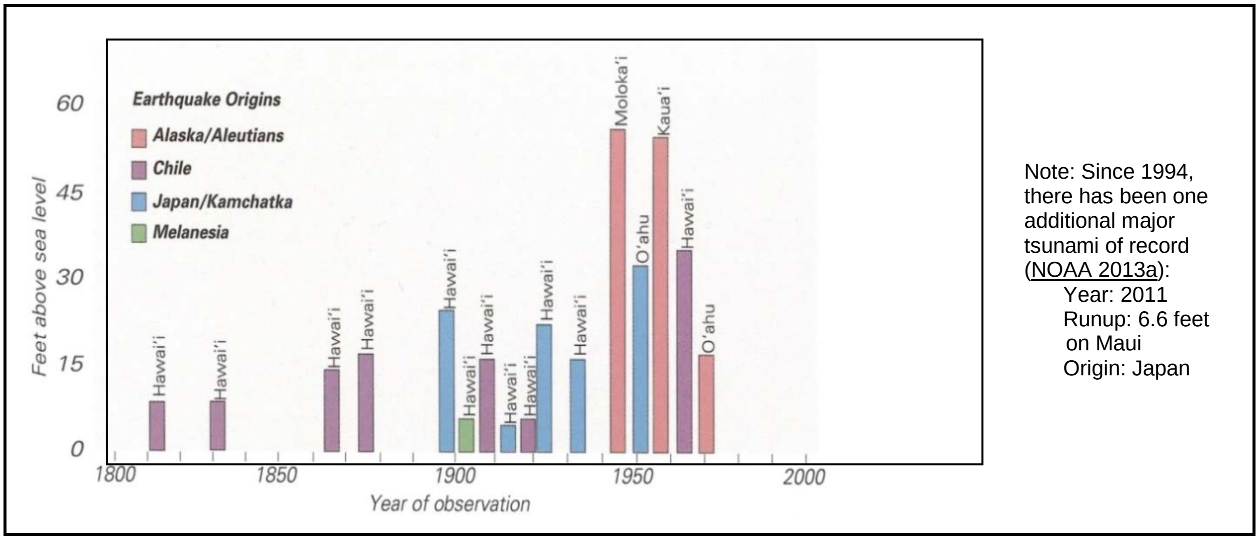


Figure 3-14. Observed Major Tsunami Runups in Hawai'i, 1819 to 1994, from Outside Sources (Source: UH Hilo 1998)

Of the tsunami depicted in Figure 3-14, two are worth specific note. The most destructive tsunami to hit Hawai'i was one that occurred in April 1946 as a result of an earthquake in the Aleutian Islands. Waves 55 feet high struck the northeastern coast of Hawai'i island. At Hilo, 173 people were killed and a similar number were injured, 488 buildings were demolished, and railroads were destroyed. During the same event, railroads on the north shore of O'ahu also were destroyed (USGS 1972). Figure 3-15 shows runups reported throughout the State from this tsunami and provides an indication of how extensive the effects were. As shown in the figure, runups were reported on all sides of all islands. The northern sides of the islands generally had the higher waves, as might be expected since the wave source was the Aleutian Islands to the north. The highest runup, as shown on the map, was 54 feet on the north shore of Moloka'i. However, there also were several instances where runups of about 30 feet occurred on the western and even southwestern sides of the islands (UH Hilo 1998). The other notable event shown in Figure 3-14 was the previously mentioned May 1960 tsunami resulting from the Chilean earthquake. This one hit Hilo very hard, killing 61 people (USGS 2011).

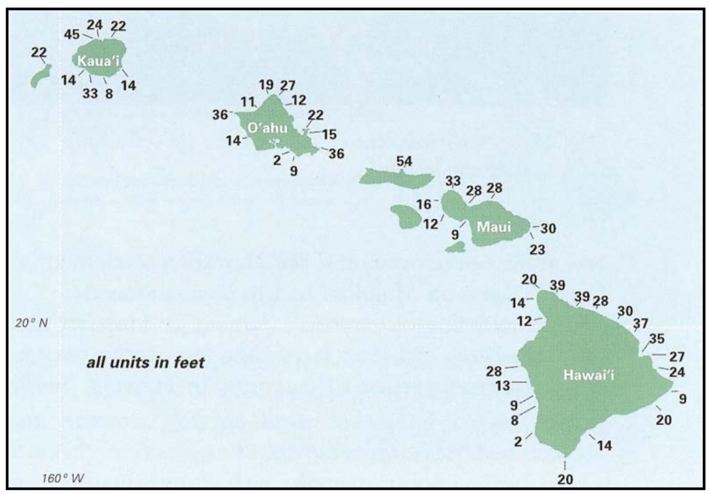


Figure 3-15. Wave Runups from 1946 Tsunami (Source: UH Hilo 1998)

Two additional significant tsunami are not included in Figure 3-14 because they were generated from local events. Specifically, they were the result of two of the earthquakes identified in Table 3-7. The great earthquake of 1868 generated a 45-foot tsunami wave on the southeastern coast of Hawai'i island that killed 46 people. The November 1975 earthquake on the southern flank of Kīlauea also generated a tsunami wave with a maximum height of 45 feet. Two people were killed by this wave. During the twentieth century, tsunami of all sources were responsible for taking 234 lives in Hawai'i (UH Hilo 1998).

NOAA operates the Pacific Tsunami Warning Center, a tsunami warning and evacuation system developed after World War II, out of O‘ahu. This operation supports Hawai‘i and 25 countries around the Pacific Rim in tracking potential tsunami based on earthquake events. When an earthquake occurs that could potentially trigger a tsunami, wave paths or directions are projected and wave speeds are calculated that allow tsunami warnings to be issued. Local civil defense agencies, police, and fire departments can then oversee evacuations. These type of tsunami warnings can be very effective for locations distant from the source. For example, the May 1960 tsunami that originated off Chile took about 14 hours to reach Hawai‘i (UH Hilo 1998). However, in the case of local events, the short time available to react makes warnings difficult if not impossible.

3.1.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

Effects on geology and soils from common construction actions would be limited primarily to: (1) the potential for disturbed soils in construction areas to be eroded as a result of being carried away by storm water runoff or wind, and (2) the potential for contaminants to be present that could be imparted to soils. This second issue would also include pollutants that could be transported with runoff to other soil areas. Contaminants in soils have the potential to be transported in normal runoff flows to receiving waters, be leached into groundwater, or pose a direct health risk to people living, working, or playing in or near the soil area.

As described in Hawai‘i Administrative Rules Title 11, Chapter 55, “Water Pollution Control” (HAR 11-55), any construction activity that would disturb one or more acres of land is required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of storm water before beginning construction. The common construction actions addressed here are assumed to involve land disturbance of one or more acres, which would be applicable to most of the utility-scale renewable energy projects analyzed in this PEIS.

In order to obtain this storm water NPDES permit, the action proponent must develop a construction site BMPs plan that (as specified in Appendix C of HAR 11-55) includes:

- A county-approved erosion and sediment control plan.
- A site-specific plan to minimize erosion of soil and discharge of other pollutants into State waters.
- Descriptions of measures that will minimize the discharge of pollutants via storm water after construction operations have been finished.

These would be considered the minimum requirements because, depending on the project location, the proponent may also be subject to county permitting requirements. In general, the construction activities associated with renewable energy projects would not be expected to involve unusual activities or sources of potential contamination, so common BMPs would be implemented and would be expected to provide appropriate protection against soil erosion or contamination. The primary concern with regard to pollutants for common construction actions would be spills or leaks of fuel and lubricants from vehicles and equipment, and the types of precautions normally implemented (such as response plans, cleanup equipment, and secondary containment) would keep the potential for soil contamination at a minimum.

Areas with highly erodible soils and high slopes would, of course, present sensitive locations for any soil disturbing activities and represent areas where erosion and contamination control measures could be more difficult to implement. Such obstacles would also increase project costs and make such areas less attractive.

Areas of high earthquake activity (primarily on the island of Hawai'i), areas with lava flow hazards (areas on the Islands of Hawaiʻi and Maui), and coastal areas with tsunami risks (all islands) represent locations with higher-than-average (though still small) risks of damage due to the islands' geological settings. Because these types of risks involve events with a low probability of occurrence in any short period of time, they would be unlikely to affect construction activities, but would pose a higher threat to long-term operations of a project. These risks are typically addressed by land use regulations (zoning) and building codes that limit construction in areas with unacceptably high risks and/or set design standards that reduce risks to widely acceptable levels.

3.1.4 COMMON BEST MANAGEMENT PRACTICES

Typical or common BMPs to reduce impacts to geology and soils are generally associated with construction but can often be extended into subsequent project phases. BMPs described in this section are grouped in categories of those intended to reduce soil erosion and those intended to reduce the potential for soil contamination. BMPs that would be considered during construction actions to control soil erosion include the following (from Appendix C of HAR 11-55, unless referenced otherwise):

- Construction management techniques:
  - Hold clearing and grubbing to the minimum necessary for grading and equipment operations.
  - Sequence construction actions to minimize the exposure time for any cleared surface area. For large projects, phase construction actions so that areas disturbed in one phase can be stabilized (that is, protecting disturbed soil from rainfall impacts and runoff) before another phase is initiated.
  - Have erosion and sediment control measures in place and functional before beginning earth moving operations and ensure their proper monitoring and maintenance throughout the construction period. This includes establishing a monitoring schedule that is consistent with the use of the control measures; for example monitor the control measures weekly during dry periods, within 24-hours of rainfall, and daily during prolonged rainfall. Maintain records of monitoring checks and repairs.
  - Consider constructing during summer when rainfall potential is lower (Tetra Tech 2011).
  - Assign a specific individual to be responsible for erosion and sediment controls at each project site.
- Vegetation controls:
  - Avoid disturbance of existing vegetation more than 20 days prior to land disturbance.
  - If disturbed areas are to remain unfinished for more than 30 days, apply temporary soil stabilization using appropriate vegetation.
  - Apply permanent soil stabilization, with perennial vegetation or pavement, as soon as practical after final grading. If perennial vegetation is used, provide irrigation and maintenance for 30 days or until the vegetation takes root.
  - Use fertilizers in areas of poor, nutrient deficient soils to promote faster growth and better erosion control, but use only if needed (Keller and Sherar 2003).

  - Develop local plant sources and nurseries for vegetative erosion control materials. Use local native species whenever possible, selecting species appropriate for the use, the site, and the bioregion (Keller and Sherar 2003).

- Structural and operational controls:

  - Divert storm water flows away from the construction area using appropriate control measures, as practical. Control measures may include ditches, berms, check structures, live grass barriers, or rock (Keller and Sherar 2003).

  - Design erosion control measures according to the size of the disturbed or drainage areas to detain runoff and trap sediment. Sediment control structures can include rock berms, sediment catchment basins, straw bales, brush fences, and silt fencing (Keller and Sherar 2003).

  - Reduce wind erosion by using common dust suppression techniques, such as regularly watering exposed soils and soil stockpiles and by stabilizing soil.

  - Maintain and reapply erosion control measures until vegetation is successfully established (Keller and Sherar 2003).

BMPs that would be considered during construction actions to minimize the potential for releasing contaminants to soil include the following (from EPA 2007):

- Design and implement waste management procedures and practices that address actions such as trash disposal, recycling, proper material handling, and cleanup measures. Provide toilet facilities that are regularly inspected and serviced and located away from storm drain inlets and waterways.

- Establish comprehensive procedures for the handling and management of building materials, particularly those that may be hazardous or toxic (such as paints, solvents, pesticides, fuels and oils, etc.) and store such materials indoors or under cover whenever possible or in areas with secondary containment. Designate staging areas for activities such as fueling vehicles/equipment, mixing paints, mixing mortar, and so on.

- Designate washout areas for concrete operations as well as for operations such as painting or stucco use and keep such areas at least 50 yards from storm drains and watercourses whenever possible.

- If equipment/vehicle fueling and maintenance actions must be performed on-site, create a clean and dry site, covered if possible, with a spill kit present and staff that know how to use it.

- Establish procedures and practices for equipment/vehicle washing that include use of off-site facilities; washing in designated, contained areas only; eliminating discharges to storm drain by using infiltration systems or routing to the sanitary sewer; and training staff in proper washing procedures.

- Develop a spill prevention and response plan that identifies ways to reduce the chance of spills, stop the source of spills, contain and clean up spills, dispose of spill residues, and train appropriate personnel.

Although the above measures are designated BMPs, it should be noted that the intent of the storm water NPDES permit described in Section 3.1.3 is for the proponent to develop plans that identify the control measures they intend to implement. Those plans and the control measures then become requirements under the permit, unless there are more stringent requirements in the permit's standard conditions.

3.2 Climate and Air Quality

3.2.1 REGIONAL CLIMATE

The climate of the Hawaiian Islands is characterized by mild temperatures throughout the year, moderate humidity, persistence of trade winds from the northeast, significant differences in rainfall within short distances, and infrequent severe storms (NWS 2007). The mountainous topography creates one of the most spatially diverse climates in the world and significantly influences every aspect of weather and climate. Rainfall, solar radiation, temperature, humidity, and wind often have large changes over short distances (University of Hawaiʻi Press 1998). Changes in climate are especially noticeable along mountain slopes, where the mountains obstruct, deflect, and accelerate the flow of air. When warm, moist air rises over windward coasts and slopes, clouds and rainfall are much greater than over open sea. Air descending over leeward areas causes those areas to be more sunny and dry. Air temperature decreases with increasing elevation gain by about 3 degrees Fahrenheit (°F) per thousand feet, so Hawaiʻi's mountains, which range from sea level to nearly 14,000 feet, contain a climatic range from tropical to sub-Arctic (NWS 2007).

Most of Hawaiʻi experiences only two noticeable seasons: "summer" (dry season) between May and September and "winter" (wet season) between October and April. Summer is the warm season with the sun almost directly overhead and winds reliably from the northeast. Winter has cooler temperatures, a lower sun, more variable winds, and extensive rains (University of Hawaiʻi Press 1998). Hawaiʻi does not have extremes of cold winters and hot summers and does not normally have associated storms such as hail storms or hurricanes. However, the tallest mountains can get winter season blizzards, ice, and snow. The highest temperature ever recorded in the State of Hawaiʻi was 100°F at Pahala (elevation 870 feet) on the island of Hawai'i on April 27, 1931, and the lowest temperature was 12°F on Mauna Kea (elevation 13,770 feet) also on the island of Hawaiʻi on May 17, 1979 (NWS 2007).

The Hawaiian Islands are located at the edge of the tropics and inside a belt of steady trade winds and accompanying downwelling of upper-level air. The length of the day and the monthly temperatures in Hawaiʻi are relatively uniform throughout the year due to its location. The uniform day lengths result in small seasonal variations in incoming solar radiation, and therefore, produce only small variations in seasonal temperature. The annual variation in mean monthly temperatures is only about 9°F for areas at sea level (University of Hawaiʻi Press 1998).

The ocean temperature varies about 6°F during the year, which also contributes to the small variation in seasonal air temperature. The ocean temperature ranges from a low of 73° or 74°F during the winter to a high of near 80°F during the summer. The warmest months in Hawaiʻi are August and September, and the coolest months are February and March, reflecting the seasonal lag in the ocean's temperature.

The ocean near Hawaiʻi averages between 25 and 30 inches of rainfall per year. The islands can receive as much as 15 times that amount of rain or as little as one-third of it, depending on the mountain rains that form when the moist trade winds move from the ocean to the mountain slopes of the islands. Over the lower islands, the average rainfall distribution closely resembles the topographic contours, with greater amounts over the upper slopes. On the higher mountains, the belt of maximum rainfall lies between 2,000 and 3,000 feet, and rainfall amounts decrease rapidly with further elevation. As a result, the highest slopes are relatively dry (NWS 2007). Another source of rainfall are the cumulus clouds that build up over the mountains and interiors on sunny afternoons due to *convection*. These rainfalls may be intense, but they are usually brief and localized.

Hawaiʻi's heaviest rains usually come from winter storms between October and April. While the effects of terrain are not as great on winter storm rainfall as they are on trade wind showers, large differences in rainfall still can occur over small distances. These differences in rainfall amount vary with each storm. The leeward and other dry areas receive precipitation mainly from winter storms, so summers are relatively dry. Climate change appears to be impacting the timing, intensity, and duration of rains across the islands.

Drought can occur when there are no winter storms or trade winds. In the absence of winter storms, the normally dry leeward areas are hardest hit. The absence of trade winds affects mostly the windward and upland regions, which receive a smaller percentage of their rain from winter storms (NWS 2007) than from trade winds.

Scientists at the University of Hawaiʻi at Manoa have observed a decrease in the frequency of northeast trade winds and an increase in eastern trade winds over the past four decades. Northeast trade winds occurred 291 days per year 37 years ago at the Honolulu International Airport and now occur only 210 days per year. A dramatic reduction in trade wind frequencies could affect Hawaiʻi's future overall climate and reduce the amount of precipitation on the islands (UH Manoa 2012).

Although the regional climate applies to all the islands, each island has localized characteristics.

3.2.1.1 Kauaʻi

Trade winds from the northeast affect the climate of the island of Kauaʻi. The range in normal temperature between February, the coolest month, and August, the warmest month, is less than 8°F. The daily range in temperature is less than 15°F. Trade wind showers are relatively common and most are light and of short duration. Normal annual rainfall is over 40 inches at Lihue Airport (100 feet above sea level on the eastern coast), with most rain falling during the seven-month wet season from October through April. Normal precipitation in January, the wettest month, is more than 6 inches. The frequency and intensity of showers increase in the western mountains, with Mt. Waiʻaleʻale receiving 486 inches of rain annually, which historically has been considered the highest recorded average in the world (NWS 2005a). However, recent studies indicate that eastern Maui receives more rainfall per year (Giambelluca 2013).

Hurricanes and other severe windstorms are rare. Although strong winds can occur in connection with storm systems, they seldom cause extensive damage. Relative humidity, moderate to high all year, is slightly higher during the wet season. However, even during periods of high temperature and humidity, the trade winds provide a system of natural ventilation that keeps the weather from seeming oppressive (NWS 2005a).

3.2.1.2 Oʻahu

The northeasterly trade winds are the prevailing wind, although the average frequency of the wind varies from 90 percent during the summer to only 50 percent in January. The temperature range is moderate due to the small seasonal variation in the energy received from the sun and the tempering effect of the surrounding ocean. Honolulu Airport has recorded temperatures as high as the mid-90s and as low as the lower 50s (°F) (NWS 2005b). Rainfall is heaviest in the mountains (over 100 inches per year) and lowest along the coast west of the Waiʻanae Mountains, where rainfall drops to about 20 inches per year. Rains during the wet season, October through April, can sometimes cause serious flash flooding. Hail seldom occurs, but small tornadoes or waterspouts are known to do damage.

3.2.1.3 Molokaʻi

As with the other Hawaiian Islands, topography has a large effect on the climate of Molokaʻi. West Molokaʻi is hilly with little rainfall while east Molokaʻi is mountainous with significantly greater rainfall (University of Hawaiʻi Press 1998). Southwestern portions of the island receive less than 15 inches of rain per year, and the eastern mountains can receive greater than 160 inches of rain per year. The central plains, which include the island's airport, receive less than 30 inches of rain per year (University of Hawaiʻi Press 1998). The weather on Molokaʻi shows little variation between the seasons. Average February high temperatures at Molokaʻi Airport (elevation 450 feet) are 77°F, while average September temperatures are 85°F. The highest and lowest recorded temperatures are 96° and 46 °F, respectively (WRCC 2012).

3.2.1.4 Lānaʻi

Lānaʻi falls in the rain shadow of Maui, which greatly affects its weather conditions. Lānaʻi is one of the driest of the Hawaiian Islands and rarely receives continuous showers because most of the rain associated with the trade winds falls on Maui to the east. The center of the island receives about 30 to 40 inches of rain per year while the rest of the island receives only about 10 to 20 inches of rain per year (University of Hawaiʻi Press 1998). Temperatures in Lānaʻi City (near the center of the island) are cooler than at sea level. The average high temperature in Lānaʻi City in January is 72°F, while the average low temperature is 60°F. By contrast, the average high and low temperatures in September are 79° and 65°F, respectively (WRCC 2006).

3.2.1.5 Maui

As with the other islands, the northeasterly trade winds affect the climate of the island of Maui. The normal temperature between February, the coolest month, and August, the warmest month, ranges less than 7.2°F. The lack of temperature differences is associated with the tempering effect of the Pacific Ocean and the small seasonal variation in the amount of energy received from the sun. At Kahului Airport (in a central valley near the northern coast), rainfall is relatively light, although the contrasts between the wet season, November through April, and the dry season, May through October, are quite pronounced. Approximately 50 percent of the normal annual rainfall occurs in the three months of December through February, and over 80 percent during the six months of the wet season (NWS 2005c). As with the other Hawaiian Islands, the amount of rainfall across the island varies greatly as the result of influences from the mountainous terrain. Whereas Kahului Airport receives less than 30 inches of rain per year due to its location in a broad valley, the northeastern coast can receive more than 100 inches, and the mountain peak of Puʻu Kukui can receive more than 360 inches of rain per year (University of Hawaiʻi Press 1998). Recent studies indicate that Big Bog on eastern Maui receives the highest average annual rainfall in the State (Giambelluca 2013).

The trade wind flow is most prevalent during the dry season (May through October). Wind is more variable during the wet season although the trade winds still occur more than 50 percent of the time during the wetter months. Hurricanes rarely affect the Kahului area, but tropical storms may pass close enough to produce heavy rain and strong winds (NWS 2005c).

3.2.1.6 Hawai‘i

Similar to the other islands, the island of Hawai’i lies within the belt of northeasterly trade winds generated by the semi-permanent Pacific high-pressure cell to the north and east. In Hilo (located near the midpoint of the eastern coast), July and August are the warmest months with average daily highs and lows of 83° and 68°F, respectively. January and February are the coolest months with highs and lows of 80° and 63°F. Greater variations can occur in areas with less rain and clouds, but temperatures in the mid-90s or low 50s (°F) are uncommon anywhere on the island near sea level (NWS 2005d). Mean annual rainfall on the windward slopes of the island, with the exception of the semi-sheltered Hāmākua area, increases from 100 inches along the coasts to a maximum of over 300 inches at elevations of 2,000 to 3,000 feet, and then drops to about 15 inches at the summits of the Mauna Kea and Mauna Loa volcanoes. The leeward areas are topographically sheltered from the trade winds and are drier. The driest area receives an annual rainfall of less the 10 inches (NWS 2005d).

The trade winds can occur throughout the year and greatly affect the climate. Severe weather seldom occurs except for periods of heavy rain. During the winter, cold front or subtropical storms may bring blizzards to the upper slopes of Mauna Loa and Mauna Kea, with snow extending down to 9,000 feet or below (NWS 2005d).

3.2.2 EXISTING AIR QUALITY

3.2.2.1 Ambient Air Quality Standards

The *Clean Air Act* (42 U.S.C. §§ 7401 *et seq*.) requires the U.S. Environmental Protection Agency (EPA) to set standards for pollutants considered harmful to public health and the environment. National primary ambient air quality standards define levels of air quality that EPA has determined necessary to provide an adequate margin of safety to protect public health, including the health of sensitive populations such as children and the elderly. National secondary ambient air quality standards define levels necessary to protect the public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. EPA has established primary standards for six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter [which includes particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) and less than or equal to 2.5 micrometers ($PM_{2.5}$)], and sulfur dioxide. The State of Hawai‘i also has established ambient air quality standards that apply throughout the State including an ambient standard for hydrogen sulfide. Table 3-8 presents applicable National Ambient Air Quality Standards (NAAQS) and Hawai‘i ambient air quality standards.

AMBIENT AIR

The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to an emission source.

The State of Hawai‘i Department of Health (HDOH) Clean Air Branch monitors ambient air in Hawai‘i to determine compliance with the NAAQS. The air monitoring system includes 14 air monitoring stations on 4 islands. The State reviews the number and locations of the stations annually and can relocate, add, or discontinue stations as needed. The monitoring stations on O‘ahu measure air quality impacts from commercial, industrial, and transportation activities; the station on Maui measures impacts from

Table 3-8. National and State of Hawai‘i Ambient Air Quality Standards

Pollutant	National Primary Standards[a]	National Secondary Standards[a]	Form (national standards)	State of Hawai‘i Standards[b]
Carbon monoxide				
8-hour average	9 ppm	None	Not to be exceeded more than once per year	4.4 ppm
1-hour average	35 ppm	None		9 ppm
Lead				
Rolling 3-month average	0.15 μg/m^3	Same as primary	Not to be exceeded	None specified
Calendar quarter average	None	None	None	1.5 μg/m^3
Nitrogen dioxide				
Annual arithmetic mean	0.053 ppm	Same as primary	Annual Mean	0.04 ppm
1-hour	0.10 ppm	None	98th percentile, averaged over 3 years	None specified
Ozone				
8-hour average (2008 standard)	0.075 ppm	Same as primary	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years	0.08
PM_{10}				
Annual (arithmetic mean)	None	None		50 μg/m^3
24-hour average	150 μg/m^3	Same as primary	Not to be exceeded more than once per year on average over 3 years	Same as national
$PM_{2.5}$				
Annual arithmetic mean	12.0 μg/m3	15.0 μg/m3	Annual mean, averaged over 3 years	None specified
24-hour average	35 μg/m^3	Same as primary	98th percentile, averaged over 3 years	None specified
Sulfur dioxide				
Annual average	None	None		0.03 ppm
24-hour average	None	None		0.14 ppm
3-hour average	None	0.5 ppm	Not to be exceeded more than once per year	0.5 ppm
1-hour average	0.075 ppm	None	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years	None specified
Hydrogen Sulfide				
1-hour average	None	None		0.025 ppm

a. Source: 40 CFR Part 50 (as of December 2012).
b. Source: HDOH 2010.
ppm = parts per million; μg/m^3 = micrograms per cubic meter.

agriculture activities; the station on Kaua‘i measures impacts from cruise ships; and the stations on Hawai‘i measure air quality impacts from volcanoes and geothermal energy production (HDOH 2012a).

The State of Hawai‘i has set an ambient air standard for hydrogen sulfide even though no such standard exists within the NAAQS. While hydrogen sulfide is a naturally occurring gas related to volcanic eruptions, HDOH is concerned about hydrogen sulfide emissions related to geothermal energy production. Consequently, an air monitoring station is located approximately 1 mile southwest of the geothermal energy facility on the island of Hawai’i (HDOH 2012a). The HDOH operates this ambient air quality monitoring station located downwind of the facility and reviews monthly data from three continuous hydrogen sulfide monitoring stations operated by the geothermal facility (HDOH 2013a).

The Kīlauea volcano on Hawai‘i island emits sulfur dioxide, which is considered a natural volcanic event. Therefore, EPA may exclude the NAAQS exceedances of sulfur dioxide and sulfate particles (measured as $PM_{2.5}$) from attainment determinations (HDOH 2012a).

3.2.2.2 Air Quality Control Regions and Attainment Status

The Hawaiian Islands are within the State of Hawai‘i Air Quality Control Region. As defined by 40 CFR 81.76, the region consists of the territorial area encompassed by the outermost boundaries of Hawai‘i including the territorial area of all municipalities geographically located within the outmost boundaries of the area.

Ambient air quality in an area is characterized by whether it complies with the primary and secondary NAAQS. All counties of Hawai‘i meet the NAAQS and are designated as attainment areas for all criteria air pollutants (40 CFR 81.312).

3.2.2.3 General Conformity

Promulgated under the *Clean Air Act* [Section 176(c)(4)], the General Conformity Rule requires Federal agencies to ensure their actions conform to applicable implementation plans for the achievement and maintenance of the NAAQS for criteria pollutants. To achieve conformity, a Federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern (for example, a state or a smaller air quality region). Federal agencies prepare written Conformity Determinations for Federal actions that are in or affect NAAQS nonattainment areas or maintenance areas when the total direct or indirect emissions of nonattainment pollutants (or their precursors in the case of ozone) exceed specified thresholds. Because all counties in Hawai‘i are in attainment, the general conformity requirements do not apply to projects proposed on any of the Hawaiian Islands.

3.2.3 EXISTING FACILITY EMISSIONS AND AIR PERMITS

3.2.3.1 Existing Air Quality and Emissions for Hawai‘i Counties

Emissions of criteria pollutants are recorded by Hawai‘i counties rather than by island (that is, Maui County reports for the islands of Moloka‘i, Lāna‘i, and Maui). Table 3-9 lists regional air pollutant emissions for the counties. The emissions are for the year 2008, the most recent year with available data.

In addition to the emissions shown in the table, the Kīlauea volcano on the island of Hawai’i emitted about 1,100 tons of sulfur dioxide from its summit and 550 tons of sulfur dioxide from its rift zone vents per day in April 2013 (USGS 2013e). Sulfur dioxide emissions from the volcano vary over time, but the

April 2013 emission rate would account for annual sulfur dioxide emissions of about 600,000 tons per year. Volcanic eruptions are considered natural events.

The sulfur dioxide emitted from the Kīlauea volcano can mix and react with oxygen, moisture in the air, dust, and sunlight to create a phenomenon called *vog*. Vog is volcanic smog, and its sulfuric acid and other toxic compounds can create health hazards for people with respiratory conditions. Vog can produce headaches, breathing difficulties, and irritation to the lungs and eyes. HDOH monitors vog, and emergency health advisories and evacuations can occur due to a high vog index.

Table 3-9. Air Emissions Reported for Counties within the State of Hawaiʻi for Calendar Year 2008

Pollutant	Hawaiʻi County Emissions (tpy)	City and County of Honolulu Emissions (tpy)	Kauaʻi County Emissions (tpy)	Maui County Emissions[a] (tpy)
Particulate matter less than 2.5 microns ($PM_{2.5}$)	1,600	4,800	1,000	2,600
Particulate matter less than 10 microns (PM_{10})	9,300	17,000	4,400	9,900
Carbon monoxide (CO)	31,000	136,000	19,000	40,000
Nitrogen oxides (NO_x)	6,500	33,000	3,900	10,000
Sulfur dioxides (SO_2)	6,100	21,000	360	5,300
Volatile organic compounds (VOC)	6,000	30,000	3,500	6,000

Source: EPA 2013a.
a. Includes Kalawao County emissions.
Tpy = tons per year.

Geothermal wells located at a geothermal power plant on Hawaiʻi island can possibly release hydrogen sulfide into the atmosphere. Island residents have much concern about potential hydrogen sulfide emissions, and the Puna Geothermal Venture has made available five-minute averages for hydrogen sulfide concentrations (http://www.ormat.com/case-studies/puna-geothermal-venture-Hawaiʻi). In addition, the State of Hawaiʻi has installed an air monitoring station near the Puna facility to measure hydrogen sulfide and sulfur dioxide concentrations. The highest 1-hour hydrogen sulfide concentration in 2011 (the most recent year with published data) was 0.004 ppm, which was well below the State attainment standard of 0.025 ppm (HDOH 2012a). Near-time concentration measurements from the State's Puna E monitoring station can be accessed via the HDOH website (http://emdweb.doh.hawaii.gov/air-quality/StationInfo.aspx?ST_ID=42). In addition to possible hydrogen sulfide emissions from Puna, the volcanic system on Hawaiʻi island naturally releases hydrogen sulfide.

3.2.3.2 Prevention of Significant Deterioration Class I Areas

Prevention of Significant Deterioration applies to new or major modifications at existing sources where the source is located in attainment or unclassifiable areas of the NAAQS. The Prevention of Significant Deterioration portion of the *Clean Air Act* is an important authority for protecting the resources of national parks and wilderness areas that are designated as Class 1 air quality areas. Class 1 areas include national wilderness areas and national memorial parks larger than 5,000 acres, and national parks larger than 6,000 acres. A Class I area is one in which very little increase in pollution is allowed due to the pristine nature of the area. The Prevention of Significant Deterioration Class I areas within the Hawaiian Islands are Haleakalā National Park on Maui and Hawaiʻi Volcanoes National Park on Hawaiʻi island. The remaining portions of the State of Hawaiʻi are classified as Class II. A Class II area is one in which more moderate increases in pollution are allowed.

3.2.3.3 Greenhouse Gases

The burning of fossil fuels such as coal, diesel, and gasoline emits carbon dioxide, which is a greenhouse gas. Greenhouse gases can trap heat in the atmosphere, similar to the glass walls of a greenhouse, and have been associated with global *climate change*. Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) that lasts for an extended period (decades or longer). The Intergovernmental Panel on Climate Change, in its Fourth Assessment Report, stated that warming of the earth's climate system is unequivocal, and that most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in concentrations of greenhouse gases from human activities (IPCC 2007). These gases are well mixed throughout the lower atmosphere, so emissions add to cumulative regional and global concentrations of carbon dioxide. The effects from an individual source, therefore, cannot be determined quantitatively.

Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, water vapor, and several hydrocarbons and chlorofluorocarbons. Each greenhouse gas has an estimated global warming potential, which is a function of its atmospheric lifetime and its ability to absorb and radiate infrared energy emitted from the earth's surface. The global warming potential for a greenhouse gas provides a relative basis for calculating its carbon dioxide equivalent. This is a measure for comparing emissions from various greenhouse gases to carbon dioxide based on their global warming potential. Carbon dioxide has a global warming potential of 1 and is, therefore, the standard by which all other greenhouse gases are measured.

The total greenhouse gas emissions for the State of Hawaiʻi for the year 2007 were 24.3 million metric tons of carbon dioxide equivalent. Carbon dioxide accounted for 91 percent of that total (ICF 2008). Table 3-10 shows the greenhouse gas emissions for the different islands for that period.

Table 3-10. Greenhouse Gas Emission Summary by Island, for Calendar Year 2007 (in MMTCO$_2$Eq)

Pollutant	Hawaiʻi	Kauaʻi	Lānaʻi	Maui	Molokaʻi	Oʻahu
Greenhouse gas	2.81	1.10	0.08	2.69	0.17	17.4

Source: ICF 2008.
MMTCO$_2$Eq = million metric tons of carbon dioxide equivalent.

3.2.3.4 Air Quality Permits

Air quality in the Hawaiʻi is subject to a variety of Federal and State regulations pertaining to the construction and operation of air emission sources. The EPA and HDOH regulate air quality on the various islands throughout the State.

The State of Hawaiʻi requires air pollution control permits prior to constructing, reconstructing, modifying, or operating a stationary air pollution source (HDOH 2011a). The State issues two types of air pollution control permits: *covered source* and *noncovered source*. A covered source is any major source, any source subject to a standard or other requirements under Section 111, "Standards of performance for new stationary sources," of the *Clean Air Act*, or any source subject to an emissions standard or other requirements for hazardous air pollutants under Section 112, "Hazardous air

MAJOR SOURCE
Hawaiʻi Air Rules 2011

"A source or a group of stationary sources located on one or more contiguous or adjacent properties that is under common control of the same person or persons and that emits or has the potential to emit:

- 10 tons or more per year of any single hazardous air pollutant or 25 tons or more per year of any combination of hazardous air pollutants.
- 100 tons or more per year of any other air pollutant."

pollutants," of the *Clean Air Act* (with specified exceptions). A covered source permit generally is synonymous with a Title V or operating permit as referred to in Federal regulations. A noncovered source is any stationary source constructed, modified, or relocated after March 20, 1972, that is not a covered source (Hawaii Air Rules 2011).

Section 165 of the *Clean Air Act* requires a major stationary source in an attainment area to obtain a Prevention of Significant Deterioration (PSD) permit before beginning construction. The EPA has two largely identical sets of regulations implementing the PSD program. Hawai‘i's State Implementation Plan lacks an approved PSD program, so the applicable requirements governing the issuance of PSD permits in Hawai‘i are the Federal PSD regulations at 40 CFR 52.21. Although EPA Region 9 delegated administration of the PSD program to Hawai‘i, PSD permits issued by HDOH are Federal permits.

Permit applicability requirements for noncovered and covered sources are specified in HAR 11-60.1-62 and HAR 11-60.1-82, respectively. An applicant for an air quality permit should contact the Engineering Section of the HDOH Clean Air Branch as soon as questions arise as to applicability of regulations and any application data requirements. Applicants are encouraged to consider seeking professional assistance, consisting of qualified engineering and consulting firms.

3.2.4 COMMON CONSTRUCTION AND OPERATION IMPACTS

Air quality impacts associated with construction would be short-term, intermittent, and limited to the duration of the construction project. Construction-related impacts to air quality would include emissions of fugitive dust (airborne particulate matter generated from a source other than a stack or chimney) and emissions from fossil-fueled construction equipment, temporary fuel transfer systems, and associated fuel storage tanks. Construction equipment, such as earth-moving equipment, cranes, and trucks, would be powered by diesel or gasoline engines and the burning of fossil fuels in these engines would result in the emission of criteria pollutants, small amounts of hazardous air pollutants, and greenhouse gas emissions.

Estimating exact emissions for any construction project depends on a number of variable factors, including the type of construction, the number and types of construction vehicles and equipment, the length of the construction period, the area encompassed by the construction, and the number of workers.

For any large construction project, criteria pollutants would be emitted from a variety of sources that could operate during construction. These sources could include:

- Grading and clearing of the land;
- Earth-moving equipment;
- Generators, bulldozers, cranes, and trucks; and
- Vehicles of commuting workers.

Clearing and grading the land would cause fugitive dust emissions. The amount of fugitive dust generated during construction would be affected by specific construction activities, silt content in the soil, soil moisture, wind speed, frequency of precipitation, vehicle traffic, and roadway characteristics. The EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) Section 13.2.3, "Heavy Construction Operations," estimates that 1.2 tons of total suspended particulates are emitted per acre per month of construction. Based on experiments on dust emission during construction, approximately 30 percent of that amount would be PM_{10} and that the remainder would be larger particles (EPA 1988). In addition, fugitive dust from off-road travel would be expected, but would be mitigated by BMPs.

Criteria pollutants and carbon dioxide would be emitted by the engines of construction equipment. For example, a generic construction project that would include two cranes, two short-haul trucks, one backhoe, and two front-end loaders would emit an estimated 0.38 ton of carbon monoxide, 0.84 ton of nitrogen oxides, 0.0011 ton of sulfur oxides, 0.041 ton of particulate matter, and 100 tons of carbon dioxide from the engines of the construction equipment during each month of construction. These estimates are based on generic construction equipment emission factors and assuming 21 work days per month. In addition, the vehicles of workers commuting to the work site would emit criteria pollutants. A workforce of an estimated 100 workers, with a 20-mile daily roundtrip would travel an estimated 42,000 miles per month. The estimated monthly emissions would be about 0.15 ton of carbon monoxide, 0.015 ton of nitrogen oxide, 0.00022 ton of sulfur oxides, 0.043 ton of particulate matter, and 23 tons of carbon dioxide. The actual amount of criteria pollutants emitted for a specific construction project would be dependent on the construction equipment and number of workers for that project.

3.2.5 COMMON BEST MANAGEMENT PRACTICES

Developers of clean energy facilities need to be aware of potential issues due to global climate change. For instance, coastal areas could be impacted by sea level rise due to rising global temperatures. Consequently, initial planning of the facilities should develop adaptive management strategies to protect clean energy facilities from the impacts of climate change. Initial planning should insure that major modifications to clean energy facilities and operations are not required due to sea level rise and other impacts of climate change.

General BMPs that can be used to minimize air emissions include:

- Identify applicable Federal, State, and county air quality management agencies and follow requirements and application procedures;
- Identify all emission sources associated with the proposed technology and/or use information from existing facilities with similar characteristics; and
- Consider dust abatement procedures that will minimize particulate matter emissions while reducing the use of extensive amounts of water.

Specific BMPs that can be used to reduce criteria pollutants from fuel-burning equipment include:

- Minimize idling time;
- Maintain all construction equipment in proper working condition according to the manufacturer’s specifications;
- Use late model/low emission engines; and
- Comply with EPA regulations for on-road and non-road engines (40 CFR Parts 86 and 89).

Specific BMPs that can be used to reduce fugitive dust and particulate matter emissions include:

- Limit vehicle speed to less than 25 miles per hour on non-paved roads,
- Water non-paved roads and disturbed land,
- Apply mulch to reduce wind erosion, and
- Install fences to reduce wind velocities to non-erosive levels.

3.3 Water Resources

This section describes Hawai‘i’s water resources in terms of surface water and groundwater. It also discusses the State’s floodplains, wetlands, and oceans. Each of the topical areas is addressed first in terms of a State overview then, as applicable, on an island-by-island basis.

3.3.1 SURFACE WATER

3.3.1.1 State Overview

The primary inland surface water features in Hawai‘i are the streams that drain the watersheds. There are very few natural lakes in Hawai‘i (CWRM 2008a). Most streams in Hawai‘i originate in the mountainous interiors, within the rainfall belts, and terminate at the coast (Oki 2003). Trade winds from the northeast dominate Hawai‘i’s weather pattern and carry moisture-rich air over the islands. As the air masses are lifted over or around the mountainous areas, they cool and create local rain and fog drip. Because of this predominant weather pattern, the windward sides of the islands (that is, the east to northeast sides) generally receive more rainfall than the leeward areas and contain most of the perennial streams (CWRM/NPS 1990). The islands of Ni‘ihau, Kaho‘olawe, and Lāna‘i are affected by both of these rainfall trends in that their maximum elevations are the lowest of any of the primary islands and they are located on the leeward side of larger islands. As a result, Ni‘ihau, Kaho‘olawe, and Lāna‘i are dry in comparison to the other islands and have no perennial streams (CWRM 2008a).

WATERSHED

An area that drains into a body of water, such as a river, lake, reservoir, estuary, sea, or ocean. It includes the rivers, streams, and lakes that convey the water, as well as the land surfaces from which water runs off.

The 1990 *Hawai‘i Stream Assessment: A Preliminary Appraisal of Hawai‘i’s Stream Resources* (CWRM/NPS 1990), which is still a key reference for Hawaiian stream information and cited often in this document, identifies 376 perennial streams within the State. By island, 61 of the perennial streams are on Kaua‘i, 57 are on O‘ahu, 36 are on Moloka‘i, 90 are on Maui, and 132 are on Hawai‘i. Approximately two-thirds of the *perennial* streams are continuous, with the others classified as *interrupted* streams (see text box definitions).

The U.S. Army Corps of Engineers (USACE) recently completed its 2011 *Hydroelectric Power Assessment – State of Hawai‘i* (http://energy.hawaii.gov/wp-content/uploads/2011/10/HydroelectricPowerAssess.pdf) to determine if there was Federal interest for the USACE to participate in further cost-share feasibility studies to identify, evaluate, and recommend solutions to address the potential hydroelectric power needs in Hawai‘i. While the USACE identified several candidate hydroelectric facilities, to date no further USACE study has been approved.

STREAM CLASSIFICATIONS

Perennial Stream: A stream that flows continuously throughout the year over at least a portion of its course. In Hawai‘i, perennial streams are ***continuous*** if they normally flow all the way to the sea, but often they are termed interrupted because they flow year-round in upper portions and intermittently at lower elevation under normal conditions. Interruptions may be natural or manmade.

Intermittent Stream: A stream, or part of a stream, that flows only at certain times of year, generally for several weeks or months in response to seasonal precipitation and subsequent groundwater discharge.

Ephemeral Stream: A stream with little or no groundwater influence that flows only a few hours or days in direct response to rainfall. These streams typically are manifest by dry gulches and in Hawai‘i are generally found on the leeward side of mountainous areas.

The topography of the islands typically results in drainage patterns that radiate out from the central high areas such that streams flow away from one another. Since distances to the streams' mouths (that is, the ocean) are relatively short, this leads to many small streams draining relatively small watersheds rather than having many streams combine over long flow paths as is common in continental drainages. This is particularly true on the geologically younger islands, such as the island of Hawai'i, where watersheds tend to be short with narrow channels and streams have few tributaries. On the older islands, such as Kauaʻi, watersheds have more eroded features, including deeper channels and more complex networks of tributary branches. The older islands also tend to have more developed estuaries at the river-ocean interface compared to the island of Hawai'i where streams sometimes end in a waterfall at the ocean (CWRM 2008a).

3.3.1.1.1 Stream Flow and Length Characteristics

Stream flow in Hawaiʻi is dominated by runoff and, as a result, flow rates are highly variable (CWRM/NPS 1990). It is estimated that about 30 percent of annual Statewide precipitation goes to runoff and stream flow. Within smaller areas and over shorter timeframes, this number can easily vary up or down by 20 percent or more depending on the nature of the specific drainage basin, the intensity of the precipitation, and the existing moisture content of the ground (Oki 2003). Even with the relatively small size of most watersheds, these runoff rates can produce large quantities of water given the high precipitation rates in some areas, particularly in the mountains. However, perennial streams and even intermittent streams or segments are augmented with a base flow from groundwater or through bog areas; that is, some water storage mechanism that acts to even out the variable, sporadic nature of precipitation. Section 3.3.2 discusses the occurrence of groundwater in Hawaiʻi and its contribution to surface water flows.

MEDIAN VERSUS AVERAGE FLOW RATES

Median flow rate is the rate that is equaled or exceeded 50 percent of the time. Average (that is, mean) flow rate is the total water volume passing a point in the stream over a period of time, typically a year, divided by the total time units (such as seconds) during that same period.

Because of the high contributions of runoff and the associated high variability in flow, it is typical for a Hawaiian stream to have an average flow rate that is notably higher than its median flow rate. In most continental drainage systems, the average and median flow rates would be expected to be close together. However, in Hawaiʻi, the very high flows for relatively short periods of time effectively push the average flow rate higher than the median; high enough that the average may only be exceeded 10 percent of the time (CWRM/NPS 1990).

The 1990 Hawaiʻi Stream Assessment (CWRM/NPS 1990) evaluated flow data from 110 streams with continuous gauging records. The evaluation grouped the streams in the following size categories based on their median or average flow rate:

- Large streams – Streams with median flow rates greater or equal to 50 cubic feet per second, or average flow rates greater or equal to 80 cubic feet per second.
- Medium streams – Streams with median flow rates between 10 and 50 cubic feet per second, or average flow rates between 20 and 80 cubic feet per second.
- Small streams – Streams with median flow rates less than or equal to 10 cubic feet per second, or average flow rates less than or equal to 20 cubic feet per second.

The evaluation indicated that a majority of the gauged streams fit into the category of small streams. Of the 110 streams, 11 were considered large, 36 medium, and 63 small. Table 3-11 lists the streams that were characterized as large. The list includes several on Hawaiʻi island that are suspected to meet the above definition of a large stream, but which do not have gauging stations. The table also includes two

Table 3-11. Large Streams in Hawaiʻi

Stream	Code[a]	Flow in cfs	
		Average	Median
Kauaʻi			
Wainiha River	2-1-14	138	79
Lumahai River	2-1-15	117	67
Hanalei River	2-1-19	212	130
Wailua Stream	2-2-08s	239	110
Hanapepe	2-3-07	85	32
Koula River	Tributary to Hanapepe	85	34
Waimea Stream	2-4-04s	253	63
Makaweli River	Tributary to Waimea	100	23
Maui			
Waiheʻe	6-2-07	82	NA
ʻIao	6-2-09	65	43
Hawaiʻi			
Wailoa/Waipio	8-1-44	75	51
Honoliʻi	8-2-56	125	38
Wailuku River	8-2-60	84	59
Others suspected to qualify as large, all on Hawaiʻi island			
Kaula	8-1-90	NA	NA
Kapehu	8-2-12	NA	NA
Pohakupuka	8-2-16	NA	NA
Kolekole	8-2-23	NA	NA
Umauma	8-2-30	NA	NA
Hakalau	8-2-32	NA	NA
Kawainiu	8-2-43	NA	NA
Maile	8-2-57	NA	NA

Sources: Information on the tributaries, the Koula and Makaweli rivers, come from USGS 2007. All other information comes from CWRM/NPS 1990.

a. The State's coding system includes a first digit that identifies the island, a second that identifies the hydrographic unit within the island, and a third that identifies the stream mouth where it enters the ocean (originally assigned in a clockwise order within the hydrographic unit). The "s" designation indicates this is a stream system in which tributaries drain separate valleys and merge close to the mouth.

cfs = cubic feet per second; NA = not available.

tributaries that were not identified in the 1990 evaluation but are included here because they appear to qualify on their own before joining the subsequent stream. As can be seen in the table, the islands of Kauaʻi and Hawaiʻi have the greatest number of large streams. This is consistent with the fact that the peaks of Kauaʻi receive some of the largest annual precipitation of any of the islands (UH Hilo 1998) and, because it is an older island, there are more networks of tributaries contributing to the large streams. With regard to Hawaiʻi, it has the highest peaks of the State and its large size supports a wide band of land with high precipitation and a high number of large streams in spite of not having significant networks of tributaries. The individual island discussions identify the number of streams characterized as medium and small, but it should be noted that this information is more likely an indication of where the gauging stations were located than how medium and small streams are distributed among the islands.

The 1990 Hawaiʻi Stream Assessment (CWRM/NPS 1990) describes an evaluation of stream lengths. The evaluation measured map lengths for all streams thought to have an average flow of at least 5 cubic feet per second. The evaluation concluded that there were only 28 streams in the State at least 10 miles long. The longest, at almost 60 miles each, are the Wailua River on Kauaʻi and the Kiikii (Kaukonahua Stream) on Oʻahu.

The Hawaiʻi Commission on Water Resource Management (CWRM) administers the State Water Code (HRS, Chapter 174C), which was created by the 1987 Hawaiʻi State Legislature. The Commission's general mission is to protect and enhance the water resources of the State of Hawaiʻi through wise and responsible management, including determining the allowable use of Hawaiʻi's water resources. Water resource management is so critical to Hawaiʻi that Article XI, Section 7 of the State Constitution states:

> "The legislature shall provide for a water resources agency which, as provided by law, shall set overall water conservation, quality and use policies; define beneficial and reasonable uses; protect ground and surface water resources, watersheds and natural stream environments; establish criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establish procedures for regulating all uses of Hawaiʻi's water resources."

3.3.1.1.2 Diversions and Dams

Diversions and dams are common surface water modifications. The major ditch systems of the islands are significant physical and historical features. Traditional Hawaiian civilization included elaborate hydraulic works to support taro irrigation, which requires large volumes of cool, running water. The primary sources of water used for this purpose were the perennial streams originating in the mountains and springs (UH Hilo 1998). Irrigation systems became much more extensive in the late 1800s when they were developed to support the sugar cane industry. Although commonly referred to as ditches, these irrigation systems included concrete-lined and unlined channels, tunnels, and flumes, often designed to move water from wet, windward areas to the drier leeward areas (CWRM 2008a).

Developers built the first great ditch, the Hāmākua, on Maui in 1878, and since then, over a dozen major systems have been developed on the four largest islands. These systems usually divert water from higher elevations, but some move water out of the watershed in which it originated. In some instances, water traveled through tunnels cut in the mountains to go from windward to leeward sides of the island (CWRM/NPS 1990). By 1920, the sugar industry likely used about 800 million gallons of surface water and about 400 million gallons of groundwater each day (CWRM 2008a).

Since the demise of the sugar industry toward the end of the twentieth century, most of the diversion systems are not maintained as they once were and are not as efficient. As a result of their planned drainage paths and because of leakage, these diversion systems continue to affect surface water and groundwater hydrology (CWRM 2008a).

Although there are few natural lakes in Hawaiʻi, numerous reservoirs have been constructed to serve the sugar and pineapple industries, for flood control, or as impoundments to feed drinking water treatment plants (CWRM 2008a). Many of these reservoirs also support recreational boating and fishing.

Roughly one-third of the streams on Oʻahu and Hawaiʻi and over one-half of Maui's streams support notable diversions. There is little diversion of streams on Molokaʻi, the eastern part of East Maui, or the north shore of Kaua‘i (CWRM/NPS 1990). Because Lānaʻi does not have perennial streams, there are no notable diversions. Some of the more significant diversion systems and dams are described further in the individual island discussions below.

3.3.1.1.3 Water Quality

The *Clean Water Act* (33 U.S.C. §§ 1251 *et seq*.) establishes a framework for regulating quality standards for surface waters and discharges into those waters. Under that framework, the states evaluate their surface waters, determine applicable beneficial uses, set water quality criteria to support those uses, and implement rules and regulations to achieve or maintain water quality criteria. In Hawai‘i, HDOH established HAR 11-54, “Water Quality Standards,” which sets beneficial uses for inland and marine waters of the State and establishes water quality criteria applicable to beneficial uses. Section 305(b) of the *Clean Water Act* requires states to develop and periodically update an inventory of the water quality of all water bodies in the state. These inventories, provided to EPA, and released to the public, indicate if the water quality supports the designated uses. Section 303(d) of the Act requires states to develop and periodically update an inventory of water bodies that do not meet water quality standards, which the states also provide to EPA and release to the public.

The State’s inland waters are assigned to a Class 1 or 2 category to identify their beneficial uses that are to be protected. These water uses are set in HAR Chapter 11-54 as follows:

- Class 1 – “It is the objective of Class 1 waters that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of these areas shall be protected. Waste discharge into these waters is prohibited.” Uses to be protected in this class include “protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other nondegrading uses.” Class 1.a waters are also to be protected for scientific and educational purposes and class 1.b waters are to be protected for domestic water supplies and food processing.

- Class 2 – “The objective of Class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters.”

The State’s marine waters are assigned to a Class AA or A category to identify the beneficial uses that are to be protected. These water uses are set in HAR Chapter 11-54 as follows:

- Class AA – “It is the objective of Class AA waters that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions. To the extent practicable, the wilderness character of these areas shall be protected.”

- Class A – “It is the objective of Class A waters that their use for recreational purposes and aesthetic enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters.”

Table 3-12 summarizes criteria set by the State in HAR Chapter 11-54 for Class 1 and 2 inland waters and Class AA and A marine waters.

Table 3-12. Inland and Marine Water Classification Criteria from HAR Chapter 11-54

Water Category	Water Quality Classification Criteria for Inland and Marine Waters	
	Inland Waters	
Fresh waters Flowing waters - **A** Standing waters - **B** Elevated and low wetlands - **C** Brackish or saline waters - **D**	Class 1.a • All **A**, **B**, **C**, or **D** within the natural reserves, preserves, sanctuaries, and refuges established by DLNR under HRS Chapter 195 or similar reserves for the protection of aquatic life established under HRS Chapter 195. • All **A**, **B**, **C**, or **D** in national and State parks. • All **A**, **B**, **C**, or **D** in State or Federal fish and wildlife refuges. • All **A**, **B**, **C**, or **D** that have been identified as a unique or critical habitat for threatened or endangered species by the USFWS. • All **A**, **B**, **C**, or **D** in Wai-manu National Estuarine Research Reserve (Hawaii). • All **D** in the Lumahai and Kīlauea estuaries (Kaua‘i). Class 1.b • All **A**, **B**, **C**, or **D** in protective subzones designated under Chapter 13-5 of the State Board of Land Natural Resources.	Class 2 • All **A**, **B**, **C**, or **D** in areas not otherwise classified.
	Marine Waters	
Embayments - **E** Open coastal waters - **F** Oceanic waters - **G**	Class AA • Specific **E** or **F** by island (see discussions of individual islands in this PEIS) • All **E** or **F** in preserves, reserves, sanctuaries, and refuges established by DLNR under HRS Chapter 195 or 190 or similar reserves for the protection of marine life established under HRS Chapter 190. • All **E** or **F** in State or Federal fish and wildlife refuges and marine sanctuaries. • All **E** which have been officially identified as a unique or critical habitat for threatened or endangered species by the USFWS • All **F** surrounding the islands not otherwise classified in this section.	Class A • Specific **E** by island • All **F** not otherwise specified. • All **G**.

DLNR = Department of Land and Natural Resources; HRS = Hawai‘i Revised Statutes; USFWS = U.S. Fish and Wildlife Service.

The most recent Section 303(d) and Section 305(b) reports the State developed are in the form of an integrated report (covering both *Clean Water Act* requirements) for the 2008 to 2010 timeframe (HDOH 2012b). Water quality conditions the State's report describes are addressed on an island-by-island basis later in this section. Table 3-13 summarizes the report findings for inland waters of the entire State. The table shows 177 specific inland waters (streams, estuaries, wetlands, lakes, and reservoirs) identified, and the results of assessments for 116 of those waters. There was insufficient characterization data on the other 61 waters to support a water quality assessment. Of the 116 assessed, 101 were identified as impaired for not meeting one or more applicable water quality standards and 15 were identified as meeting some but not all standards. The 101 impaired waters include 7 that do not require the development of Total Maximum Daily Loads (TMDLs), which are the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Once TMDLs have been determined, discharge requirements can be developed that will bring a water body back into compliance. If a TMDL is not required, it generally means that stage of the process is already complete. The most common water quality standard exceeded by inland waters was turbidity, the second most common was nitrate-plus-nitrite nitrogen.

Table 3-13. Summary of State of Hawai‘i Inland Waters Considered Impaired

Number of Impaired Inland Waters[a]	Reason(s) for Impairments					
	Enterococci	**Total N**	**NO_3+NO_2**	**Total P**	**Turbidity**	**Other Pollutants (number of waters)**
36[b]					X	Trash (2)
30[c]		X	X	X	X	Trash (8); suspended solids (3); dieldrin (3); chlordane (2); metals (1); lead (1)
11		X	X		X	Trash (1)
5		X	X	X		
3			X			
3			X		X	
3	X	X	X	X	X	Suspended solids (3)
3[d]						(No specific pollutants identified, but assigned to category 5.)
1		X		X		
1		X			X	Trash (1)
1			X	X		
1	X					
1		X				
1				X	X	
1						Trash (1)
TOTALS						
101[a]	4	52	56	41	85	Trash (13); suspended solids (6); dieldrin (3); chlordane (2); metals (1); lead (1)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 168 streams, 6 estuaries, 1 lake, 1 reservoir, and 1 wetlands area; of which, 116 were assessed with the following results: 94 impaired, 7 impaired but need no TMDL, and 15 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).
b. This group consists of 33 streams, two estuaries, and one lake.
c. This group consists of 26 streams, three estuaries, and one reservoir.
d. This group consists of one stream, one estuary, and one wetlands area.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; TMDL = Total Maximum Daily Load.

Table 3-14 summarizes HDOH (2012) findings for marine waters of the entire State, which identifies 522 specific marine waters and the results of assessments for 279 of those waters. There was insufficient characterization data on the other 243 waters to support a water quality assessment. Of the 279 assessed, 207 were identified as impaired for not meeting one or more applicable water quality standard and 72 were identified as meeting some but not all standards. Again, this latter designation indicates the characterization data available were in compliance with applicable standards, but there were insufficient data to evaluate against all applicable standards. The most common water quality standard exceeded by marine waters was turbidity; the second most common was total nitrogen. HDOH provides current water quality data on many discharge points under its regulation at http://emdweb.doh.hawaii.gov/CleanWaterBranch/WaterQualityData/default.aspx.

Table 3-14. Summary of State of Hawai‘i Marine Waters Considered Impaired

Number of Impaired Marine Waters[a]	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
58					X	Chlorophyll a (26); ammonia nitrogen (3); suspended solids (3); nutrients (2); trash (1)
25		X	X		X	Chlorophyll a (22); ammonia nitrogen (13)
16	X					
16		X	X	X	X	Nutrients (8); suspended solids (7); ammonia nitrogen (6); phosphate (5); chlorophyll a (3); trash (1); PCB (1); fish consumption advisory (1)
13		X			X	Chlorophyll a (5); fecal (2); phosphate (1)
11		X				Chlorophyll a (5); ammonia nitrogen (1)
10			X		X	Chlorophyll a (7); ammonia nitrogen (4)
8			X			Chlorophyll a (7); ammonia nitrogen (6)
7		X		X	X	Chlorophyll a (7)
6	X	X		X	X	Chlorophyll a (5)
6		X	X			Chlorophyll a (6); ammonia nitrogen (6)
5				X	X	Chlorophyll a (5)
5	X				X	
3						Chlorophyll a (2); ammonia nitrogen (2); trash (1)
3	X		X			Ammonia nitrogen (2); chlorophyll a (1)
2	X	X	X	X	X	Suspended solids (2); nutrients (2); pathogens (2); metals (2); lead (1); organochlorine pesticide (1)
2		X	X	X		Nutrients (1)
2				X		
2						Chlorophyll a (2)
1		X		X		Chlorophyll a (1)
1	X	X	X		X	Ammonia nitrogen (2)
1	X	X		X		Chlorophyll a (1)
1	X		X		X	
1	X			X	X	Chlorophyll a (1)
1	X		X		X	Chlorophyll a (1); ammonia nitrogen (1)
1		X	X			Chlorophyll a (1); ammonia nitrogen (1)
TOTALS						
207[a]	37	92	76	43	151	Chlorophyll a (108); ammonia nitrogen (47); nutrients (13); suspended solids (12); phosphate (6); trash (3); fecal (2); pathogens (2); metals (2); lead (1); PCB (1); organochlorine pesticide (1); fish consumption advisory (1)

Source: HDOH 2012b.

a. The source document identifies 522 marine waters; of which, 279 were assessed with the following results: 204 impaired, 3 impaired but need no TMDL, and 72 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but data are not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; PCB = polychlorinated biphenyl; TMDL = Total Maximum Daily Load.

3.3.1.1.4 Water Use

Table 3-15 summarizes water use in the State of Hawai‘i for the year 2005. It includes both surface water and groundwater (both fresh and saline) uses to provide a more complete picture. Three-quarters of the State’s water usage is for thermoelectric purposes. The thermoelectric designation is for water, all of which is saline, used in generating electricity. If water used in production of electricity is excluded, municipal water supplies represents by far the greatest water use in the State, and irrigation, at about 21 percent, is the next largest water user. With or without the thermoelectric category, groundwater is the primary source of the water used in Hawai‘i. The USGS compiles water use data every five years, but data are not yet available for 2010.

Table 3-15. 2005 Water Use (in million gallons per day) by Category and Source for the State of Hawai‘i

Water Use Category	State Totals				Percentage of State Water Use	
	Groundwater		Surface Water[a]	Totals[b]	With Thermoelectric	Without Thermoelectric
	Fresh	Saline				
Municipal	231.8	0	11.4	243.2	12.6%	50.4%
Domestic (self)[c]	0.5	0	0	0.5	<0.1%	0.1%
Industrial	52.9	0	0.4	52.9	2.8%	11.0%
Irrigation	25.5	0	74.2	99.7	5.2%	20.7%
Agriculture	55.1	0	1.3	56.4	2.9%	11.7%
Aquaculture	0	0	2.6	2.6	0.1%	0.5%
Mining	0	0	0.4	0.4	<0.1%	0.1%
Thermoelectric	0	1,445.0	0	1,445.0	75.0%	
Military	26.4	0	0	26.4	1.4%	5.5%
TOTALS[b] (% of State total)	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	100.0%	100.0%

Sources: CWRM 2008a for fresh groundwater values, USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.1.2 Kaua‘i

Sixty-one of the State’s 376 perennial streams are located on Kaua‘i. Figure 3-16 is a simple map of Kaua‘i showing approximate locations of some of the island’s more prominent perennial streams. The figure also shows how the State of Hawai‘i divided the island into five hydrologic regions that were used in the numeric designation of the island’s streams. The State assigned the number “2” to the island, itself, and assigned numbers to each stream mouth (where they drain to the ocean) within each of the hydrologic regions. These three numbers provide the basis for coding the streams. For example, the Hanalei River, which drains to the north shore of the island and is one of its largest streams (Table 3-11), is assigned a numeric designation of “2-1-19” because it is on Kaua‘i, in hydrologic region 1, and its mouth is numbered “19” on Figure 3-16.

Since publication of the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), which is the source for Figure 3-16, the State has divided Kaua‘i into a more refined, smaller set of hydrologic units, or watershed areas. The island now comprises 74 hydrologic units, each with an average size of about 7.6 square miles. The largest unit is about 86 square miles and the smallest is less than 0.3 square mile (CWRM 2008a). Boundaries of the five regions shown in the figure match well with boundaries of the 74 hydrologic units such that:

- Region 1 of the map contains 34 hydrologic units designated 2001 through 2034,
- Region 2 of the map contains 12 hydrologic units designated 2035 through 2046,
- Region 3 of the map contains 8 hydrologic units designated 2047 through 2054,
- Region 4 of the map contains 6 hydrologic units designated 2055 through 2060, and
- Region 5 of the map contains 14 hydrologic units designated 2061 through 2074.

3.3.1.2.1 Stream Flow and Length Characteristics

Most streams shown in Figure 3-16 originate in the mountainous area in the central part of the island. The exception is region 5, where the streams drain the portion of island to the west of Waimea Canyon. Section 3.3.1.1 above presents criteria used to rate Hawaiian streams as large, medium, or small. As shown in Table 3-11, of the 21 streams in the State that qualify or are believed to qualify as large, 8 are on Kaua‘i and, based on their identifying codes, they are found in each of the regions shown in the map except region 5. Region 1, with three large streams, has the most. Of the streams evaluated for flow characteristics in the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), 5 of the 36 medium-sized streams and 6 of the 63 small-sized streams are on Kaua‘i.

The CWRM/NPS (1990) evaluation of stream lengths concluded there are only 28 streams or stream systems in the State that were at least 10 miles long, and 10 of those are on Kaua‘i. This includes one of the longest rivers, the Wailua River (2-2-08), and the third longest, the Waimea River system (2-4-04s).

3.3.1.2.2 Diversions and Dams

The State of Hawai‘i has inventoried stream diversions by hydrologic unit and shows a total of 289 for Kaua‘i (CWRM 2008a), with the majority occurring in regions 1 and 2 in Figure 3-16. The elaborate irrigation diversion systems (see Section 3.3.1.1.2) are also well represented on Kaua‘i. These typically are systems that include concrete weirs in the main stream channels that divert flow to ditches. Within the region 1 area shown in Figure 3-16, the Hanalei River (2-1-19) and the Kalihiwai Stream (2-1-25) both had multiple diversions feeding ditch systems. There was even a tunnel that carried water from the Hanalei to the North Fork of the Wailua River in region 2. In region 2, the Anahola Stream (2-2-01), Wailua River system (2-02-08s), and Huleia (2-2-15) drainage all had multiple diversions, including two designated as aqueducts and one tunnel. In region 3, there was a ditch diversion and a pump station out of the Hanapepe River (2-3-07). Finally, in region 4 there were multiple diversions out of the Waimea River system (2-4-04s) (CWRM/NPS 1990).

The Hawai‘i DLNR is responsible for inspection and regulation of dams or reservoirs that are 25 feet or taller and that have a capacity of at least 50 acre-feet (about 17 million gallons) (DLNR 2013a). DLNR maintains a database of qualifying dams or reservoirs, and shows 55 dams on Kaua‘i. These dams are found primarily in regions 2 and 3 in Figure 3-16, with 20 and 22 dams, respectively. Region 1 has five qualifying dams and regions 4 and 5 each have four dams (DLNR 2013b).

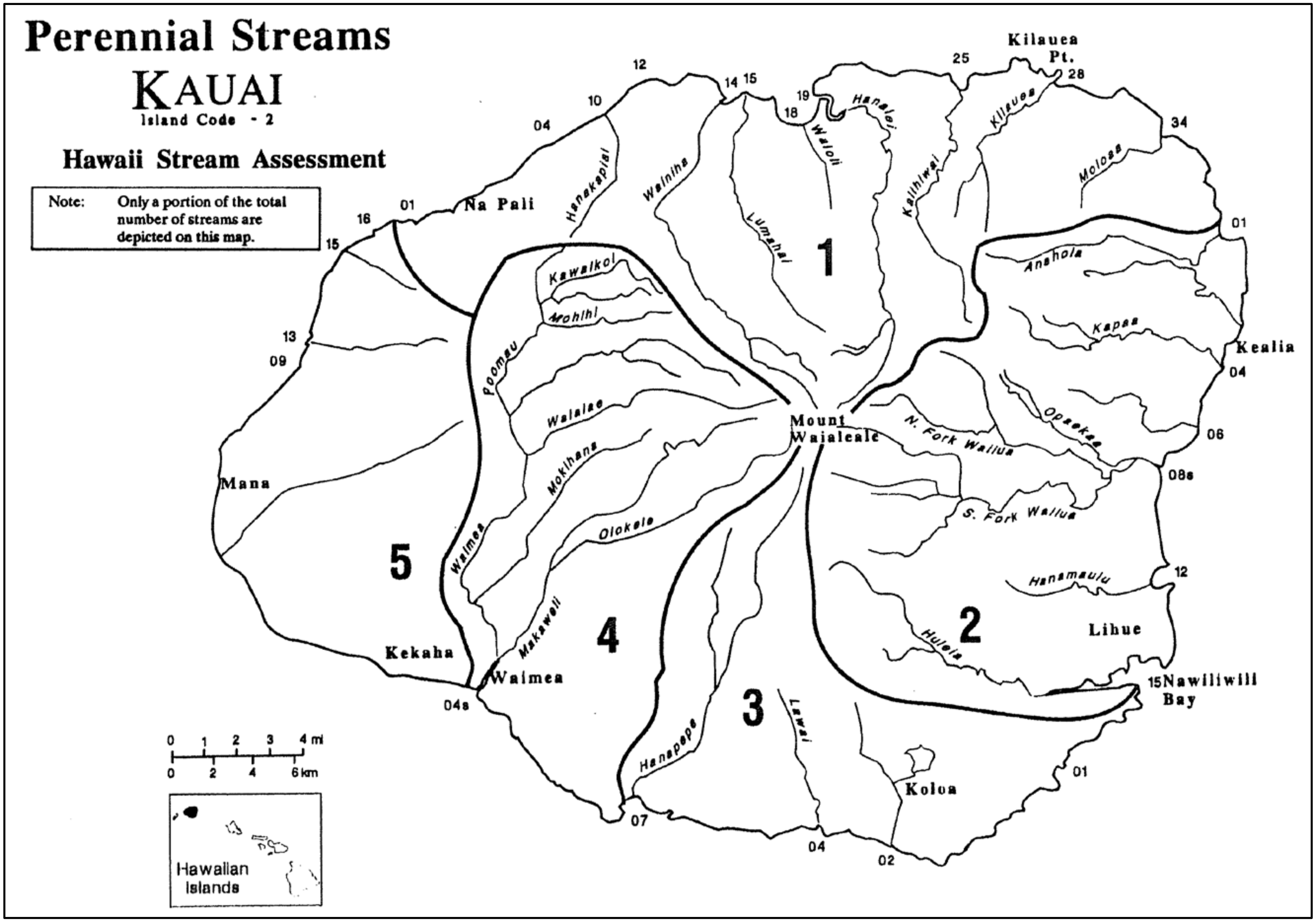


Figure 3-16. Map of Kaua'i Showing Some of the Island's More Prominent Perennial Streams (Source: CWRM/NPS 1990)

3.3.1.2.3 Water Quality

Figure 3-17 shows the inland and marine waters of Kauaʻi that are designated Class 1 and Class AA waters, respectively. These are the most protected waters in the State (see Section 3.3.1.1.3). Class 1 inland waters are those waters or segments of waters located within the dark-brown shaded areas. For marine waters, HAR 11-54 specifically identifies the following as Class AA waters:

- Embayments – Hanalei Bay (north, central side of the island, Figure 3-17); and
- Open Coastal Waters – (1) between Hikimoe Valley and Makahoe Point (the long band on the northwestern side of the island) and (2) between Makahuena Point and the westerly boundary of Hoai Bay (the short band on the south-central side of the island).

Table 3-16 summarizes information on impaired inland and marine waters on Kauaʻi from Hawaiʻi's Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. With regard to inland waters, the table shows that out of the 24 waters assessed, 21 were considered impaired. As with the Statewide summary (Table 3-13), the most common reason for impairment of inland waters was high turbidity levels.

In the case of marine waters, the table shows that of the 36 waters assessed, 26 were considered impaired. As identified in the Statewide summary (Table 3-14), the most common reason for impairment of marine waters was high turbidity levels, but in Kauaʻi the second most frequently encountered issue was unacceptable enterococci levels. Enterococci are indicator bacteria used to identify the possible presence of contamination such as might occur from a sewage leak.

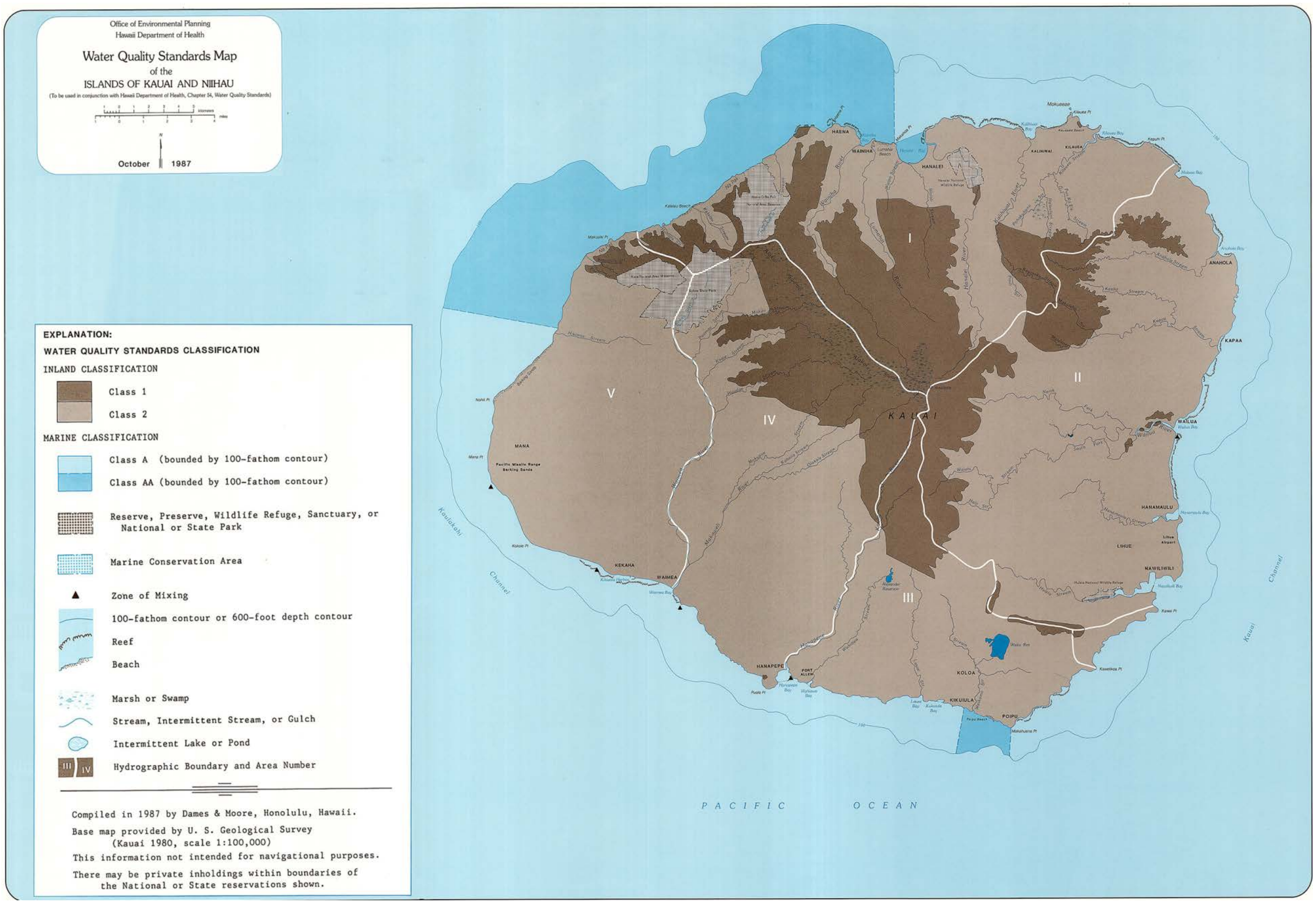


Figure 3-17. Water Quality Designations for the Island of Kaua'i (Source: Modified from HDOH 1987)

Table 3-16. Summary of Kaua‘i Inland and Marine Waters Considered Impaired

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
Kaua‘i Inland Waters[a]						
11[c]					X	
4		X	X		X	
3	X	X	X	X	X	Suspended solids (3)
1	X					
1			X			
1				X	X	
TOTALS						
21	4	7	8	4	19	Suspended solids (3)
Kaua‘i Marine Waters[b]						
10					X	Suspended solids (1)
7	X					
2	X				X	
2	X		X			Ammonia nitrogen (1)
2			X		X	Chlorophyll a (1); ammonia nitrogen (1)
1		X	X	X		Nutrients (1)
1		X	X	X	X	Nutrients (1)
1			X			Chlorophyll a (1); ammonia nitrogen (1)
TOTALS						
26	11	2	7	2	15	Chlorophyll a (2); ammonia nitrogen (3); nutrients (2); suspended solids (1)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 29 streams and 1 estuary; of which, 24 were assessed with the following results: 16 impaired, 5 impaired but need no TMDL, and 3 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

b. The source document identifies 81 marine waters; of which, 36 were assessed with the following results: 23 impaired, 3 impaired but need no TMDL, and 10 meet some, but not all standards.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; TMDL = Total Maximum Daily Load.

3.3.1.2.4 Water Use

Table 3-17 summarizes water use in the County of Kaua‘i for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. Surface water values are for Kaua‘i County, which includes the island of Ni‘ihau, but surface water use on Ni‘ihau, if any, would be very minor. As can be seen in the table, a majority of the water used on Kaua‘i is from groundwater, and the largest use category is municipal water supplies. The table also shows that the total amount of water used on Kaua‘i is less than 2 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, Kaua‘i’s percentage would increase to more than 4 percent of the State’s value.

Table 3-17. 2005 Water Use (in million gallons per day) by Category and Source on Kaua‘i and for the State of Hawai‘i

Water Use Category	Kaua‘i				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[a]	Totals[b]	Fresh	Saline	Surface[a]	Totals[b]	
Municipal	11.5	0	0.7	12.2	231.8	0	11.4	243.2	5.0%
Domestic (self)[c]	0	0	0	0	0.5	0	0	0.5	0%
Industrial	0	0	0	0	52.9	0	0	52.9	0%
Irrigation	0.1	0	8.7	8.7	25.5	0	74.2	99.7	8.8%
Agriculture	0	0	0	0	55.1	0	1.3	56.4	0%
Aquaculture	0	0	0	0	0	0	2.6	2.6	0%
Mining	0	0	0	0	0	0	0.4	0.4	0%
Thermoelectric	0	10.8	0	10.8	0	1,445.0	0	1,445.0	0.7%
Military	0	0	0	0	26.4	0	0	26.4	0%
TOTALS[b] (% of County or State total)	11.5 (36.3)	10.8 (34.0)	9.4 (29.7)	31.8	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	1.6%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.1.3 O‘ahu

Fifty-seven of the State’s 376 perennial streams are located on O‘ahu. Figure 3-18 is a simple map of O‘ahu showing approximate locations of some of the island’s more prominent perennial streams. The figure also shows how the State of Hawai‘i divided the island into six hydrologic regions that were used in the numeric designation of the island’s streams. The State assigned the number “3” to the island, itself, and assigned each stream mouth within each of the hydrologic regions a number. These three numbers provide the basis for coding the streams. For example, the Kahana Stream, which drains to the northeast of the island and is one of its largest streams, by flow, is assigned a numeric designation of “3-1-18” because it is on O‘ahu, in hydrologic region 1, and its mouth is numbered “18” on Figure 3-18.

Since publication of the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), which is the source for Figure 3-18, the State has divided O‘ahu into a more refined, smaller set of hydrologic units or watershed areas. The island now comprises 87 hydrologic units with an average size of about 6.8 square

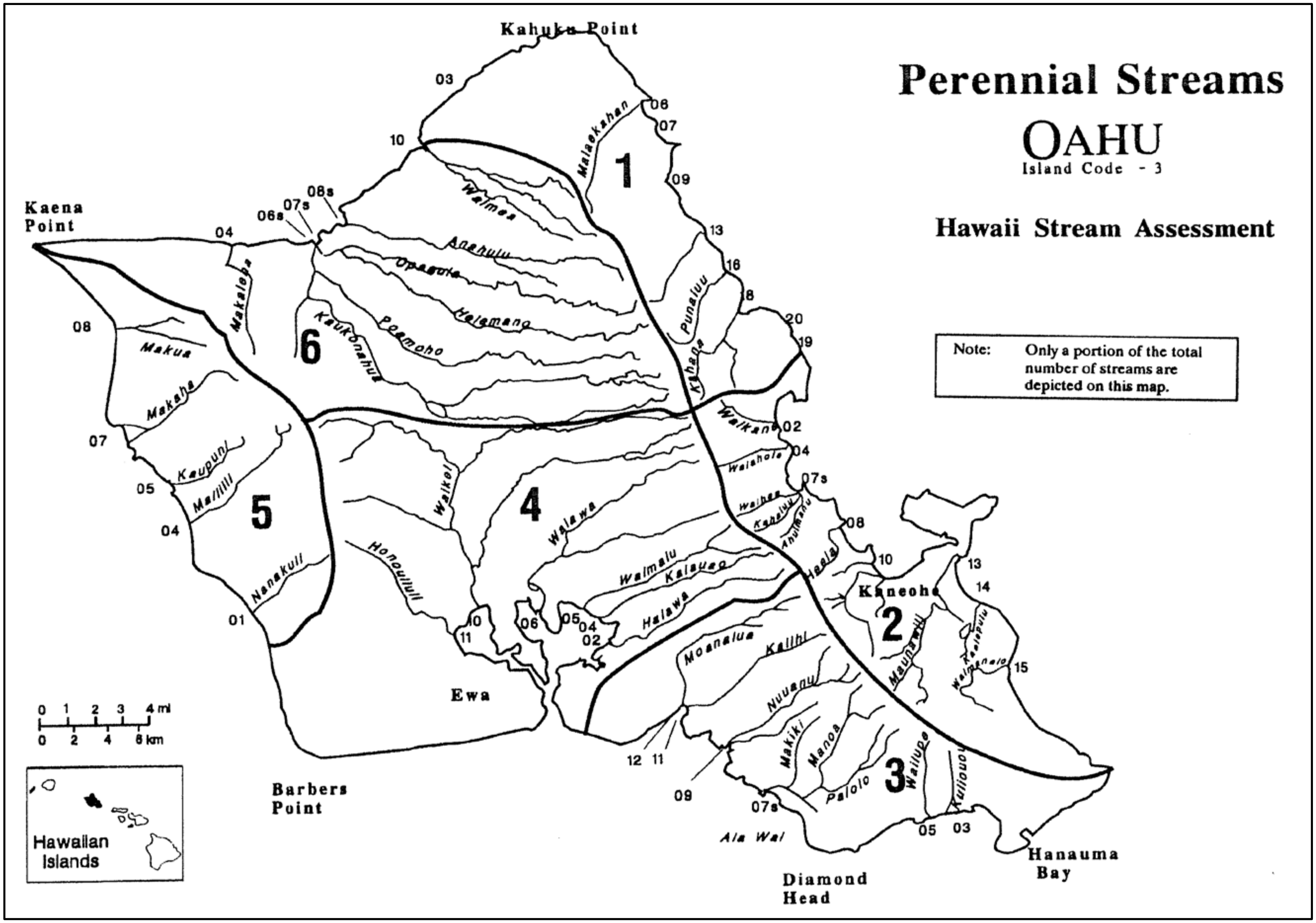


Figure 3-18. Map of O'ahu Showing Some of the Island's More Prominent Perennial Streams (Source: CWRM/NPS 1990)

miles each. The largest unit is about 59 square miles and the smallest is less than 0.3 square mile (CWRM 2008a). Boundaries of the six regions shown in the figure match well with boundaries of the 87 hydrologic such that:

- Region 1 of the map contains 19 hydrologic units designated 3001 through 3019,
- Region 2 of the map contains 18 hydrologic units designated 3020 through 3037,
- Region 3 of the map contains 18 hydrologic units designated 3038 through 3055,
- Region 4 of the map contains 12 hydrologic units designated 3056 through 3067,
- Region 5 of the map contains 9 hydrologic units designated 3068 through 3076, and
- Region 6 of the map contains 11 hydrologic units designated 3077 through 3087.

3.3.1.3.1 Stream Flow and Length Characteristics

Most streams shown in Figure 3-18 originate either in the Koʻolau Range that runs northwest-southeast along the eastern side of the island or the Waiʻanae Range that curves through the western side. Section 3.3.1.1 above presents criteria used to rate Hawaiian streams as large, medium, or small. As shown in Table 3-11, none of the 21 streams in the State that qualify or are believed to qualify as large are located on Oʻahu. Of the streams evaluated for flow characteristics in the 1990 Hawaiʻi Stream Assessment (CWRM/NPS 1990), 10 of the 36 medium-sized streams and 16 of the 63 small-sized streams are on Oʻahu.

The CWRM/NPS (1990) evaluation of stream lengths concluded there are only 28 streams in the State that were at least 10 miles long, and 5 of those are on Oʻahu. This includes the longest system in Hawaiʻi, the Kiikii River system (3-6-06s), which includes the Kaukonahua Stream.

3.3.1.3.2 Diversions and Dams

The State of Hawaiʻi has inventoried stream diversions by hydrologic unit and shows a total of 198 for Oʻahu (CWRM 2008a), with almost half occurring in region 2 (see Figure 3-18). The elaborate irrigation diversion systems (see Section 3.3.1.1.2) are also represented on Oʻahu, primarily by the Waiahole tunnel and ditch system. This system was constructed in the early 1900s to collect surface water and high groundwater from the windward side of the Koʻolau Range and deliver it to sugar cane fields on the leeward side of the range. Flow through this system was typically on the order of 25 to 30 million gallons per day (CWRM/NPS 1990).

The Hawaiʻi DLNR's database of dams and reservoirs (see Section 3.3.1.2.2) shows 16 dams on Oʻahu. These dams are found primarily in region 6 in Figure 3-18, which has nine dams. Region 4 has four dams, region 2 has two dams, and region 3 has one dam (DLNR 2013b).

3.3.1.3.3 Water Quality

Figure 3-19 shows the inland and marine waters of Oʻahu that are designated Class 1 and Class AA, respectively. These are the most protected waters in the State (see Section 3.3.1.1.3). Class 1 inland waters are those waters or segments of waters located within the dark-brown shaded areas. For marine waters, HAR 11-54 specifically identifies the following as Class AA waters:

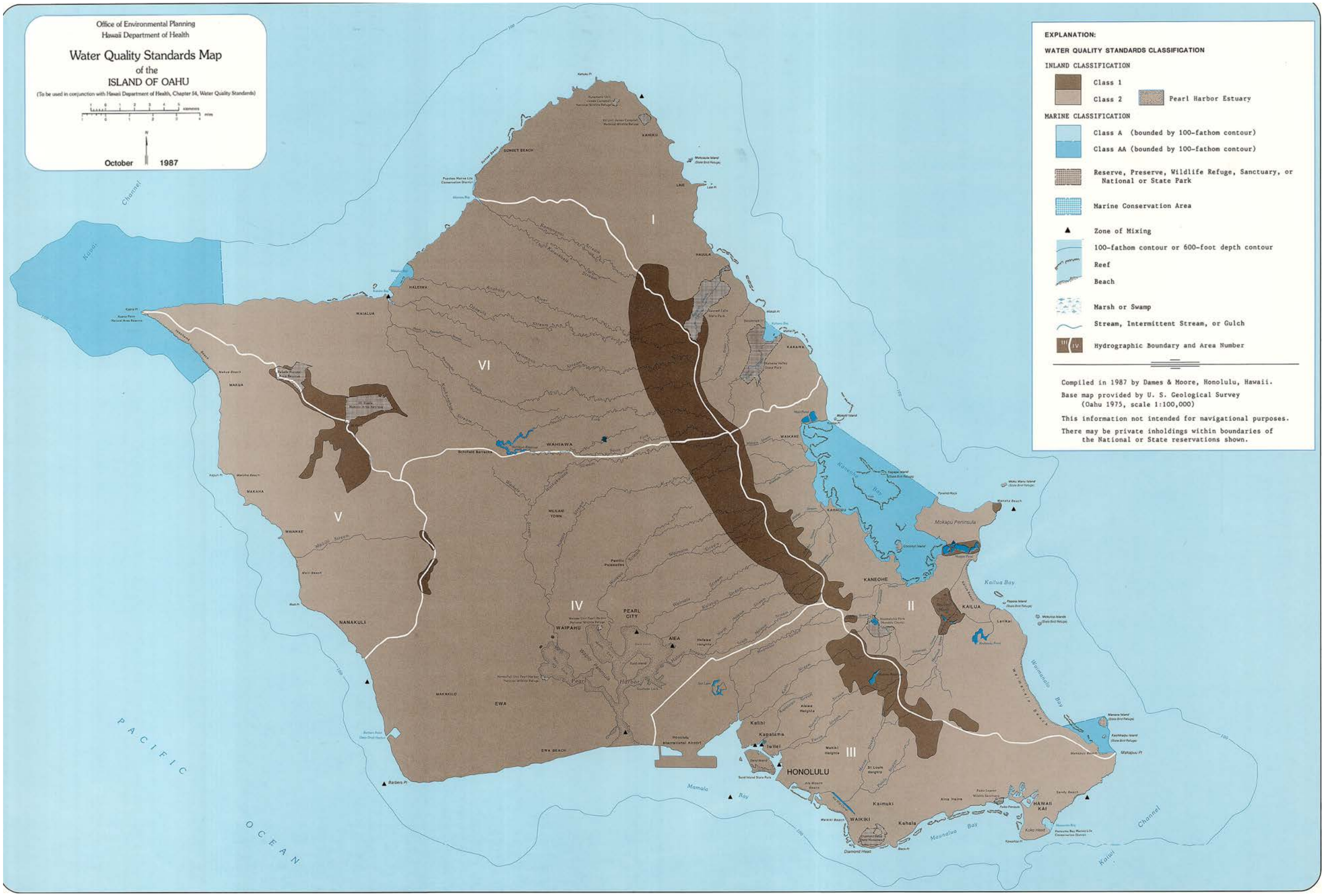


Figure 3-19. Water Quality Designations for the Island of O'ahu (Source: modified from HDOH 1987)

- Embayments – Kahana Bay in the southeast of region 1 (Figure 3-19), Kāne'ohe Bay in the northeast of region 2, Hanauma Bay in the southeast of region 3, and Waialua Bay in the north-central area of region 6.

- Open Coastal Waters – (1) Waimanalo Bay from the southerly boundary of Kaiona Beach Park to Makapu'u Point (the southeastern tip of region 2 in Figure 3-19), and (2) along Pua'ena Point, about 3.5 miles from Ka'ena Point toward Mākua and 3.5 miles from Ka'ena Point toward Mokulē'ia (along the northwestern tips of regions 5 and 6).

Table 3-18 summarizes information on impaired inland and marine waters on O'ahu from Hawai'i's Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. With regard to inland waters, the table shows that out of the 52 waters assessed, 51 were considered impaired. As the Statewide summary (Table 3-13), the most common reason for impairment of inland waters was high turbidity levels, but nitrogen constituents, both total and as nitrate-plus-nitrite, were close behind.

Table 3-18. Summary of O'ahu Inland and Marine Waters Considered Impaired

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
O'ahu Inland Waters[a]						
27[b]		X	X	X	X	Trash (7); suspended solids (3) dieldrin (3); chlordane (2); metals (1); lead (1)
7[c]					X	Trash (1)
7		X	X		X	Trash (1)
3[d]						(No specific pollutants identified, but assigned to category 5.)
2			X		X	
1		X		X		
1		X			X	Trash (1)
1			X			
1			X	X		
1						Trash (1)
TOTALS						
51	0	36	38	29	44	Trash (11); suspended solids (3); dieldrin (3); chlordane (2); metals (1); lead (1)
O'ahu Marine Waters[e]						
8		X	X		X	Chlorophyll a (6); ammonia nitrogen (5)
7		X		X	X	Chlorophyll a (7)
6					X	Chlorophyll a (4); ammonia nitrogen (2); suspended solids (1); trash (1)
6	X	X		X	X	Chlorophyll a (5)
5		X			X	Chlorophyll a (3); fecal (2)
5	X					
5			X			Chlorophyll a (4); ammonia nitrogen (5)
5		X	X	X	X	Suspended solids (5); nutrients (5); trash (1); PCB (1); fish consumption advisory (1)
4		X				Chlorophyll a (4)

Table 3-18. Summary of O‘ahu Inland and Marine Waters Considered Impaired (continued)

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
3						Chlorophyll a (2); ammonia nitrogen (2); trash (1)
2	X	X	X	X	X	Suspended solids (2); nutrients (2); pathogens (2); metals (2); lead (1); organochlorine pesticide (1)
2			X		X	Chlorophyll a (1); ammonia nitrogen (2)
2		X	X			Chlorophyll a (2); ammonia nitrogen (2)
1		X		X		Chlorophyll a (1)
1	X	X	X		X	Ammonia nitrogen (2)
1	X	X		X		Chlorophyll a (1)
1	X		X			Chlorophyll a (1); ammonia nitrogen (1)
1		X	X			Chlorophyll a (1); ammonia nitrogen (1)
TOTALS						
65	16	43	27	22	42	Chlorophyll a (42); ammonia nitrogen (22); suspended solids (8); nutrients (7); trash (3); fecal (2); pathogens (2); metals (2); lead (1); PCB (1); organochlorine pesticide (1); fish consumption advisory (1)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 50 streams, 4 estuaries, 1 wetland, 1 lake, and 1 reservoir; of which, 52 were assessed with the following results: 49 impaired, 2 impaired but needing no TMDL, and 1 meets some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

b. This group consists of 24 streams, two estuaries, and one reservoir.

c. This group consists of five streams, one estuary, and one lake.

d. This group consists of one stream, one estuary, and one wetlands area.

e. The source document identifies 176 marine waters; of which, 112 were assessed with the following results: 65 impaired and 47 meet some, but not all standards.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; PCB = polychlorinated biphenyl; TMDL = Total Maximum Daily Load.

In the case of marine waters, the table shows that out of the 112 waters assessed, 65 were considered impaired. As identified in the Statewide summary (Table 3-14), a common reason for impairment of marine waters was high turbidity levels, but in O‘ahu the most frequently encountered issue was unacceptable total nitrogen levels.

3.3.1.3.4 Water Use

Table 3-19 summarizes water use on O‘ahu for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. As can be seen in the table, a great majority of the water used on O‘ahu is from groundwater, and other than thermoelectric, the largest use category is municipal water supplies. The table also shows that the total amount of water used on O‘ahu is more than 83 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, O‘ahu’s percentage would decrease to about 48 percent of the State’s value.

Table 3-19. 2005 Water Use (in million gallons per day) by Category and Source on O‘ahu and for the State of Hawai‘i

Water Use Category	O‘ahu				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[b]	Totals[c]	Fresh	Saline	Surface[b]	Totals[c]	
Municipal	149.4	0	0	149.4	231.8	0	11.4	243.2	61.4%
Domestic (self)[c]	0.3	0	0	0.3	0.5	0	0	0.5	62.3%
Industrial	4.9	0	0	4.9	52.9	0	0	52.9	9.2%
Irrigation	6.7	0	34.7	41.4	25.5	0	74.2	99.7	41.5%
Agriculture	6.1	0	0	6.1	55.1	0	1.3	56.4	10.8%
Aquaculture	0	0	1.0	1.0	0	0	2.6	2.6	37.6%
Mining	0	0	0	0	0	0	0.4	0.4	0%
Thermoelectric	0	1,378.6	0	1,378.6	0	1,445.0	0	1,445.0	95.4%
Military	26.4	0	0	26.4	26.4	0	0	26.4	100%
TOTALS[b] (% of County or State total)	193.8 (11.1)	1,378.6 (86.6)	35.7 (2.2)	1,608.0	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	83.4%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.1.4 Moloka‘i

Thirty-six of the State’s 376 perennial streams are located on Moloka‘i. Figure 3-20 is a simple map of Moloka‘i showing approximate locations of some of the island’s more prominent perennial streams. The figure also shows how the State of Hawai‘i divided the island into four hydrologic regions that were used in the numeric designation of the island’s streams. The State assigned the number “4” to the island, itself, and assigned each stream mouth within each of the hydrologic regions a number. These three numbers provide the basis for coding the streams. For example, the Wailau Stream, which drains to the north shore of the island and is one of its larger streams, is assigned a numeric designation of “4-1-15” because it is on Moloka‘i, in hydrologic region 1, and its mouth is numbered “15” on Figure 3-20.

Since publication of the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), which is the source for Figure 3-20, the State has divided Moloka‘i into a more refined, smaller set of hydrologic units or watershed areas. The island now comprises 50 hydrologic units with an average size of about 5.3 square miles each. The largest unit is about 25 square miles and the smallest is less than 0.2 square mile (CWRM 2008a). Boundaries of the five regions shown in the figure match well with boundaries of the 50 hydrologic such that:

- Region 1 of the map contains 21 hydrologic units designated 4001 through 4021,
- Region 2 of the map contains 16 hydrologic units designated 4022 through 4037,
- Region 3 of the map contains nine hydrologic units designated 4038 through 4043 and 4048 through 4050, and
- Region 4 of the map contains four hydrologic units designated 4044 through 4047.

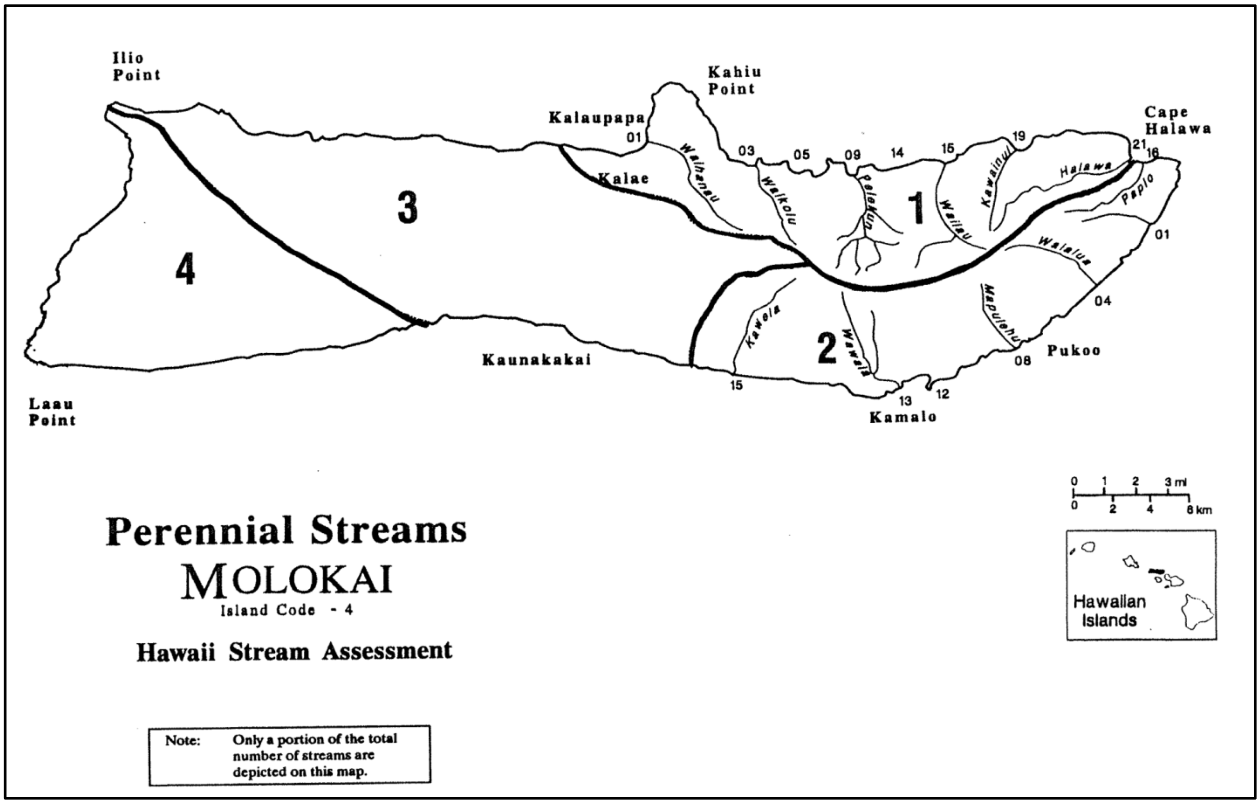


Figure 3-20. Map of Moloka'i Showing Some of the Island's More Prominent Perennial Streams (Source: CWRM/NPS 1990)

3.3.1.4.1 Stream Flow and Length Characteristics

Most streams shown in Figure 3-20 originate in the mountainous area on the eastern half of the island. There are also numerous gulches draining the hilly area on the southern half of region 4 in the figure. Section 3.3.1.1 above presents criteria used to rate Hawaiian streams as large, medium, or small. As shown in Table 3-11, none of the 21 streams in the State that qualify or are believed to qualify as large is located on Moloka'i. Of the streams evaluated for flow characteristics in the 1990 Hawai'i Stream Assessment (CWRM/NPS 1990), 5 of the 36 medium-sized streams and 4 of the 63 small-sized streams are on Moloka'i.

The CWRM/NPS (1990) evaluation of stream lengths described previously concluded there are only 28 streams in the State that are at least 10 miles long and none of those is on Moloka'i.

3.3.1.4.2 Diversions and Dams

The State of Hawai'i has inventoried stream diversions by hydrologic unit and shows a total of 47 for Moloka'i (CWRM 2008a), with all but one in regions 1 and 2 and the majority occurring in region 2 (see Figure 3-20). The most elaborate of the diversions systems is the Moloka'i Tunnel, which is about 5 miles long and was completed in 1968 (Moloka'i Dispatch 2007). This tunnel diverts water, at an average rate of 4 to 5 million gallons per day, from Waikolu Stream (4-1-03) and two tributaries in the Waikolu Valley to west-central Moloka'i (region 3 in Figure 3-20).

The Hawai'i DLNR's database of dams and reservoirs (see Section 3.3.1.2.2) shows just one dam on Moloka'i (a reservoir at Kualapu'u). This dam is located within region 3 in Figure 3-20 (DLNR 2013b).

3.3.1.4.3 Water Quality

Figure 3-21 shows the inland and marine waters of Molokaʻi that are designated Class 1 and Class AA waters, respectively. These are the most protected waters in the State (Section 3.3.1.1.3). Class 1 inland waters are those waters or segments of waters located within the dark-brown shaded areas. For marine waters, HAR 11-54 specifically identifies the following as Class AA waters:

- Embayments – No specific Molokaʻi embayments are named; and
- Open Coastal Waters – (1) from the westerly boundary of HaleʻoʻLono Harbor to Lamaloa Head Point (the long band starting on the southwestern side of the island and extending around the northern side, all the way to the eastern end of the island in Figure 3-21) and (2) from Cape Hālawa to the easterly boundary of Kaunakakai Harbor (the band starting at the eastern end and extending along the southeastern side of the island).

Table 3-20 summarizes information on impaired inland and marine waters on Molokaʻi from Hawaiʻi's Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. With regard to inland waters, the table shows that out of the three waters assessed, just one was considered impaired. High turbidity levels were the only parameter identified as the cause of the impairment.

In the case of marine waters, the table shows that three waters were assessed and all were considered impaired. Consistent with the Statewide summary (Table 3-14), the most common reason for impairment of marine waters was high turbidity levels, and for two of the Molokaʻi marine waters it was the only identified cause for impairment. The third marine water also indicated nitrogen and phosphate levels.

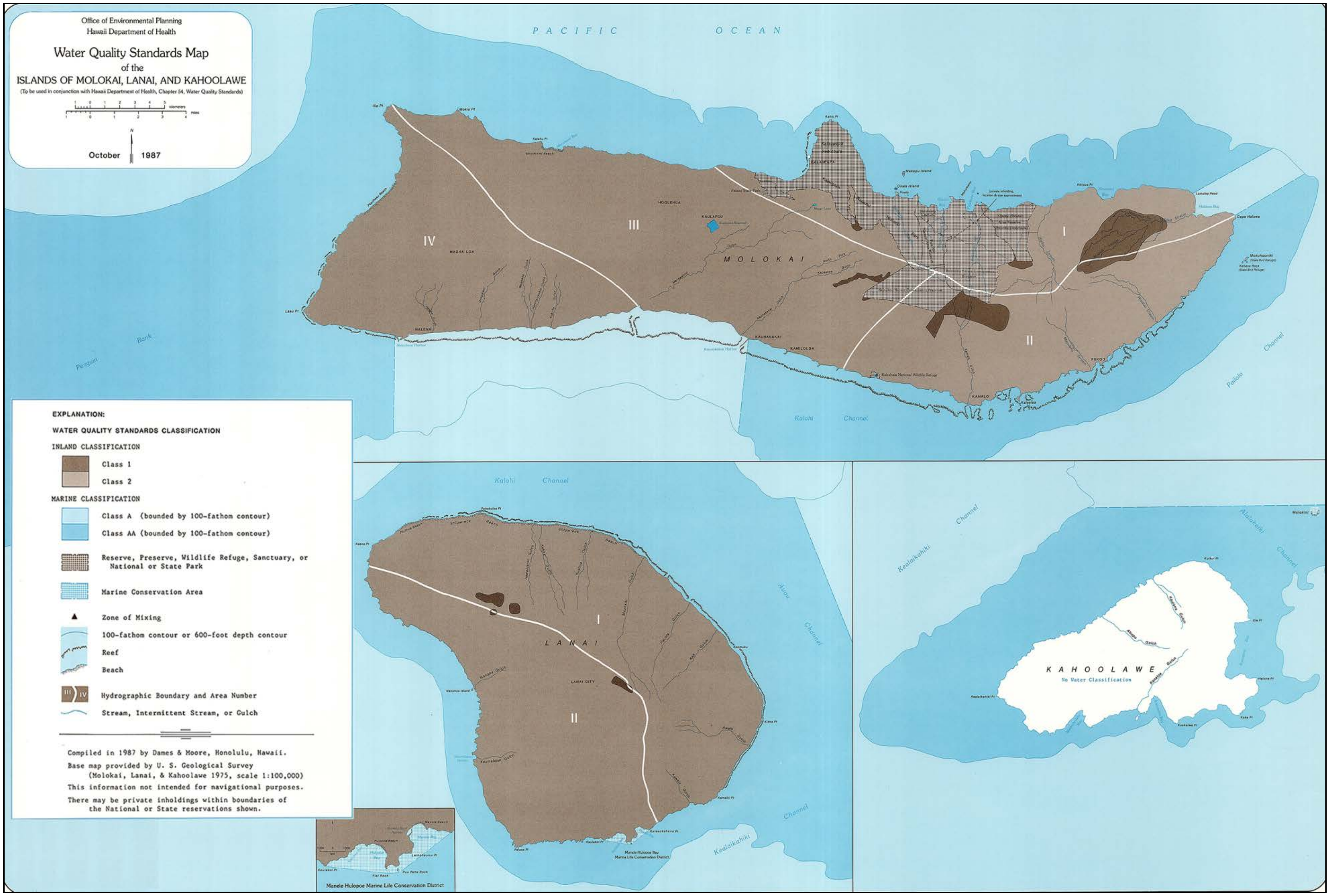


Figure 3-21. Water Quality Designations for the Islands of Moloka‘i and Lāna‘i (Source: modified from HDOH 1987)

Table 3-20. Summary of Moloka‘i Inland and Marine Waters Considered Impaired

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
Moloka‘i Inland Waters[a]						
1					X	
TOTALS						
1	0	0	0	0	1	
Moloka‘i Marine Waters[b]						
2					X	
1		X	X	X	X	Suspended solids (1); nutrients (1)
TOTALS						
3	0	1	1	1	3	Suspended solids (1); nutrients (1)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 6 streams; of which, 3 were assessed with the following results: 1 impaired and 2 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

b. The source document identifies 37 marine waters; of which, 3 were assessed with the following results: 3 impaired.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; TMDL = Total Maximum Daily Load.

3.3.1.4.4 Water Use

Table 3-21 summarizes water use on Moloka‘i for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. As can be seen in the table, municipal water supply and irrigation represent the primary water uses on Moloka‘i and it comes from groundwater. The table also shows that the total amount of water used on Moloka‘i is about 0.2 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, Moloka‘i’s percentage would increase to about 0.6 percent of the State’s value.

3.3.1.5 Lāna‘i

None of the State’s 376 perennial streams is located on Lāna‘i. However, the State of Hawai‘i divided Lāna‘i into a set of hydrologic units or watershed areas, based on drainages and the presence of intermittent or ephemeral streams. Lāna‘i comprises the 32 hydrologic units, as shown in Figure 3-22.

3.3.1.5.1 Stream Flow and Length Characteristics

Consistent with the layout of hydrologic areas in Figure 3-22, Lāna‘i has a large number of eroded gulches that radiate out from the higher interiors portions of the island and drain toward the ocean. Based on aerial views of the island, these gulches typically run 1 to 3 miles, but in places they can be up to 5 miles or more.

Table 3-21. 2005 Water Use (in million gallons per day) by Category and Source on Moloka‘i and for the State of Hawai‘i

Water Use Category	Moloka‘i				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[a]	Totals[b]	Fresh	Saline	Surface[a]	Totals[b]	
Municipal	1.9	0	N/A[c]	1.9	231.8	0	11.4	243.2	0.8%
Domestic (self)[c]	0	0	N/A[c]	0	0.5	0	0	0.5	0%
Industrial	0	0	N/A[c]	0	52.9	0	0	52.9	0%
Irrigation	0.9	0	N/A[c]	0.9	25.5	0	74.2	99.7	0.9%
Agriculture	0.1	0	N/A[c]	0.1	55.1	0	1.3	56.4	0.2%
Aquaculture	0	0	N/A[c]	0	0	0	2.6	2.6	0%
Mining	0	0	N/A[c]	0	0	0	0.4	0.4	0%
Thermoelectric	0	0	N/A[c]	0	0	1,445.0	0	1445.0	0%
Military	0	0	N/A[c]	0	26.4	0	0	26.4	0%
TOTALS[b] (% of County or State total)	2.8 (100)	0 (0)	N/A[c] (0)	2.8	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1927.2	0.2%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.

b. Values may not add up to totals because of independent rounding, here and in the referenced source.

c. N/A = Not Available. The reference provided surface water use only at the county level. As a result, any surface water use on Moloka‘i is included in the surface water use shown for Maui.

d. Self-supplied domestic water, as opposed to domestic water from a municipal source.

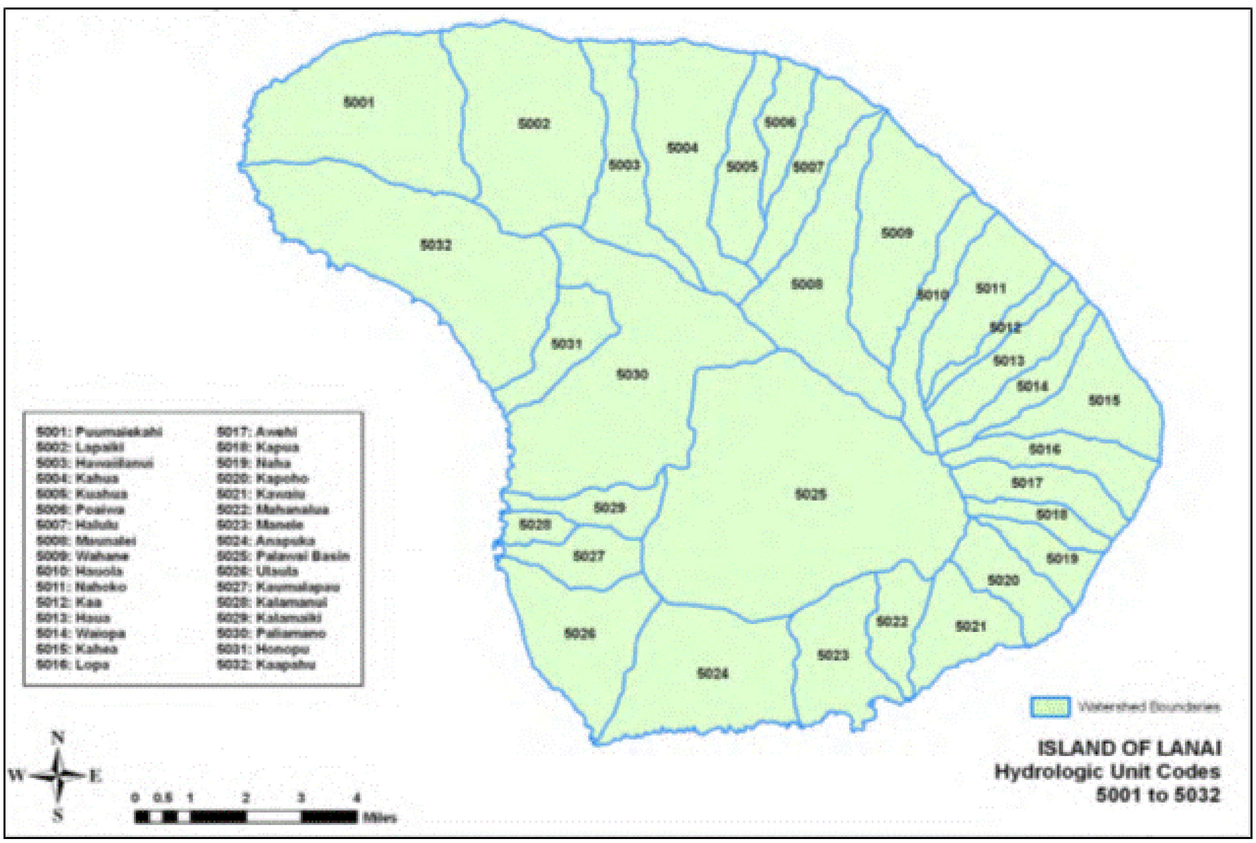


Figure 3-22. Map of Lānaʻi Showing Areas Designated as Hydrologic Units (Source: CWRM 2008a)

3.3.1.5.2 Diversions and Dams

The State’s inventory of stream diversions has no entries for the island of Lānaʻi (CWRM 2008a). The Hawaiʻi DLNR’s database of dams and reservoirs indicates there are no regulated dams on Lānaʻi (DLNR 2013b).

3.3.1.5.3 Water Quality

Figure 3-22 shows the marine waters of Lānaʻi that are designated Class AA waters. These are the most protected waters in the State (Section 3.3.1.1.3). HAR 11-54 specifically identifies the following as Lānaʻi’s Class AA waters:

- Embayments – No specific Lānaʻi embayments are named, and
- Open Coastal Waters – All open coastal waters surrounding the island.

Table 3-22 summarizes information on impaired marine waters on Lānaʻi from Hawaiʻi’s Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. The table shows that out of the eight waters that were assessed, all were considered impaired. As opposed to the Statewide summary (Table 3-14), which shows turbidity as the most common reason for impairment of marine waters, the most frequent cause of impairment in the Lānaʻi waters was total nitrogen. Turbidity, however, was an issue in about half of the assessed waters.

Table 3-22. Summary of Lānaʻi Marine Waters Considered Impaired

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
Lānaʻi Inland Waters – None identified						
Lānaʻi Marine Waters[a]						
4		X				Chlorophyll a (1)
2		X			X	Chlorophyll a (2)
2					X	Chlorophyll a (1); ammonia nitrogen (1)
TOTALS						
8	0	6	0	0	4	Chlorophyll a (4); ammonia nitrogen (1)

Source: HDOH 2012b.

a. The source document identifies 17 marine waters; of which, 8 were assessed with the following results: 8 impaired. In the case of waters identified but not assessed, data are insufficient to determine whether standards are met (or if the water is impaired).

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus.

3.3.1.5.4 Water Use

Table 3-23 summarizes water use on Lānaʻi for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. As can be seen in the table, municipal water supply and irrigation represent the only water uses on Lānaʻi and it comes from groundwater. The table also shows that the total amount of water used on Lānaʻi is about 0.1 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, Lānaʻi’s percentage would increase to about 0.4 percent of the State’s value.

Table 3-23. 2005 Water Use (in million gallons per day) by Category and Source on Lānaʻi and for the State of Hawaiʻi

Water Use Category	Lānaʻi				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[a]	Totals[b]	Fresh	Saline	Surface[a]	Totals[b]	
Municipal	1.1	0	0[c]	1.1	231.8	0	11.4	243.2	0.4%
Domestic (self)[c]	0	0	0[c]	0	0.5	0	0	0.5	0%
Industrial	0	0	0[c]	0	52.9	0	0	52.9	0%
Irrigation	0.7	0	0[c]	0.7	25.5	0	74.2	99.7	0.7%
Agriculture	0	0	0[c]	0	55.1	0	1.3	56.4	0%
Aquaculture	0	0	0[c]	0	0	0	2.6	2.6	0%
Mining	0	0	0[c]	0	0	0	0.4	0.4	0%
Thermoelectric	0	0	0[c]	0	0	1,445.0	0	1,445.0	0%
Military	0	0	0[c]	0	26.4	0	0	26.4	0%
TOTALS[c] (% of County or State total)	1.8 (100)	0 (0)	0[c] (0)	1.8	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	0.1%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawaiʻi data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. The reference provided surface water use only at the county level. As a result, any surface water use on Lānaʻi is included in the surface water use shown for Maui. However, because of the lack of surface water on Lānaʻi, it is assumed there was little, if any, use reported for the island.
d. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.1.6 Maui

Ninety of the State's 376 perennial streams are located on Maui. Figure 3-23 is a simple map of Maui showing approximate locations of some of the island's more prominent perennial streams. The figure also shows how the State of Hawaiʻi divided the island into five hydrologic regions that were used in the numeric designation of the island's streams. The State assigned the number "6" to the island, itself, and assigned each stream mouth within each of the hydrologic regions a number. These three numbers provide the basis for coding the streams. For example, the Waiheʻe River, which drains to the north-central portion of the island and is one of its largest streams, by flow, was assigned a numeric designation of "6-2-07" because it is on Maui, in hydrologic region 2, and its mouth is numbered "07" on Figure 3-23.

Since publication of the 1990 Hawaiʻi Stream Assessment (CWRM/NPS 1990), which is the source for Figure 3-23, the State has divided Maui into a more refined, smaller set of hydrologic units or watershed areas. The island now comprises 112 hydrologic units with an average size of about 6.6 square miles. The largest unit is about 56 square miles and the smallest is less than 0.2 square mile (CWRM 2008a). Boundaries of the five regions shown in the figure match well with boundaries of the 112 hydrologic such that:

- Region 1 of the map contains 13 hydrologic units designated 6003 through 6015;
- Region 2 of the map contains 11 hydrologic units designated 6001, 6002, and 6016 through 6024;
- Region 3 of the map contains 24 hydrologic units designated 6025 through 6043 and 6108 through 6112;
- Region 4 of the map contains 33 hydrologic units designated 6044 through 6076; and
- Region 5 of the map contains 31 hydrologic units designated 6077 through 6107.

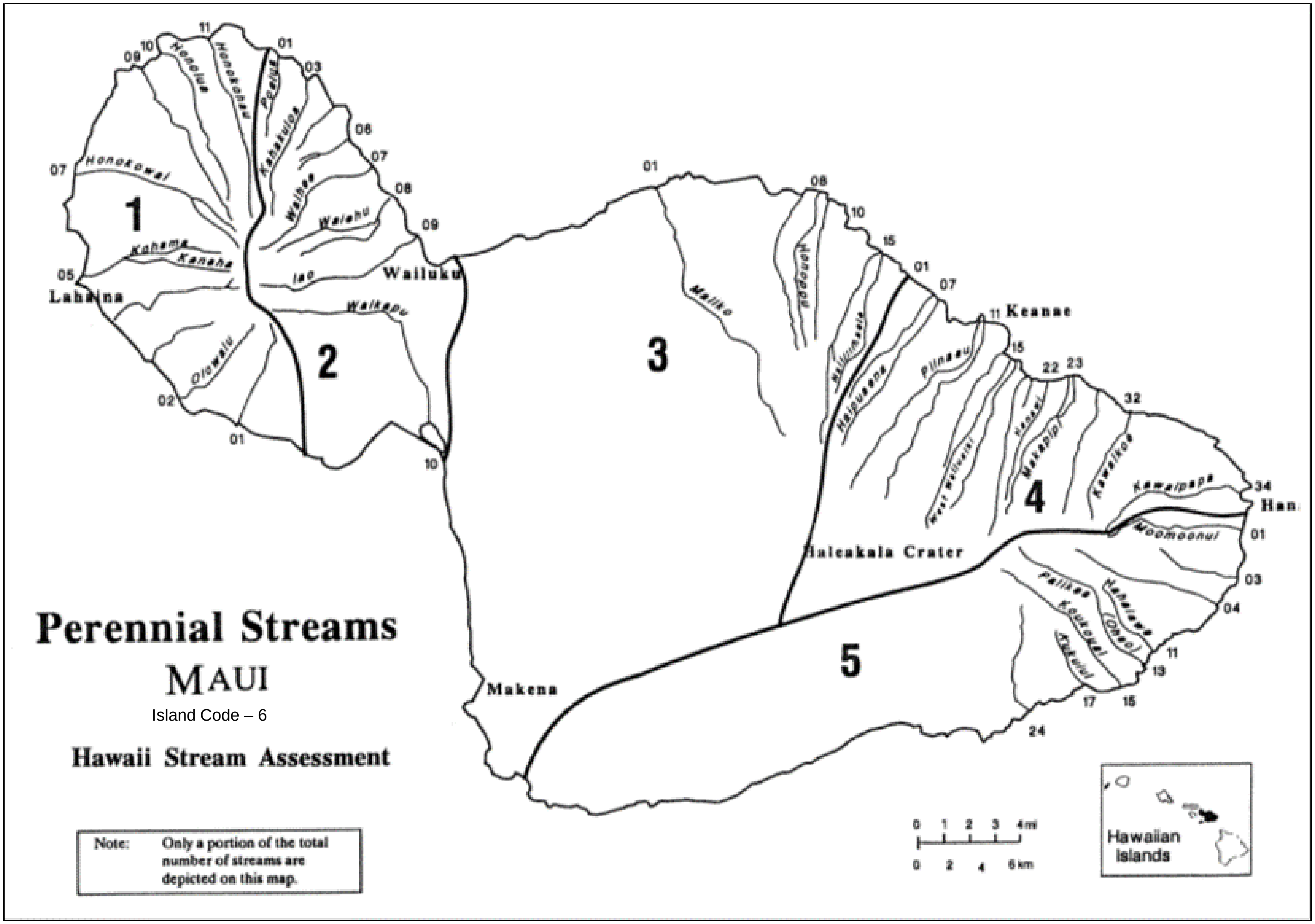


Figure 3-23. Map of Maui Showing Some of the Island's More Prominent Perennial Streams (Source: CWRM/NPS 1990)

3.3.1.6.1 Stream Flow and Length Characteristics

Most streams shown in Figure 3-23 originate either in the West Maui Mountains or in the area of the Haleakalā Crater. Section 3.3.1.1 above presents criteria used to rate Hawaiian streams as large, medium, or small. As shown in Table 3-11, 2 of the 21 streams in the State that qualify or are believed to qualify as large are located on Maui. Of the streams evaluated for flow characteristics in the 1990 Hawaiʻi Stream Assessment (CWRM/NPS 1990), 12 of the 36 medium-sized streams and 23 of the 63 small-sized streams are on Maui.

The CWRM/NPS (1990) evaluation of stream lengths described previously concluded there are only 28 streams in the State that are at least 10 miles long, and two of those are on Maui. These are the Kakipi (6-3-07) and the Piinau (6-4-11), (the latter is shown in Figure 3-23).

3.3.1.6.2 Diversions and Dams

The State of Hawaiʻi has inventoried stream diversions by hydrologic unit and shows a total of 489 for Maui (CWRM 2008a), with almost half occurring in region 3 (see Figure 3-23). Region 4 has the next largest number of diversions. The elaborate irrigation diversion systems (see Section 3.3.1.1.2) are well represented on Maui. Several east Maui streams are used to feed a system of ditches that move more than 160 million gallons per day. In region 1 in Figure 3-23, the Honokohau Stream (6-1-11) is the primary source for the Honokohau Tunnel, which carries more than 20 million gallons per day to several northwestern coast communities. In region 2, the Waiheʻe (6-2-07), Waiehu (6-2-08), ʻIao (6-2-09), and Waikapū (6-2-10) streams all include diversions to multiple ditches that, in combination, carry in excess of 80 million gallons per day (CWRM/NPS 1990).

The Hawaiʻi DLNR's database of dams and reservoirs (see Section 3.3.1.2.2) shows 53 dams on Maui. These dams are found primarily in region 3 in (Figure 3-23), which has 33 dams. Region 1 is next with 14 dams, region 2 has four dams, and region 4 has two dams (DLNR 2013b).

3.3.1.6.3 Water Quality

Figure 3-24 shows the inland and marine waters of Maui that are designated Class 1 and Class AA, respectively. These are the most protected waters in the State (Section 3.3.1.1.3). Class 1 inland waters are those waters or segments of waters located within the dark-brown shaded areas. For marine waters, HAR 11-54 specifically identifies the following as Class AA waters:

- Embayments – No specific Maui embayments are named; and
- Open Coastal Waters – (1) between Nākālele Point and Waiheʻe Point (the northern shore dark-blue band off region 2 in Figure 3-24), and (2) between Huelo Point and Puʻuōlaʻi (the long band along the eastern and southern shores.

Table 3-24 summarizes information on impaired inland and marine waters on Maui from Hawaiʻi's Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. The table shows that out of the 16 inland waters assessed, 11 are considered impaired. As identified in the Statewide summary (Table 3-13), the most common reason for impairment of inland waters was high turbidity levels.

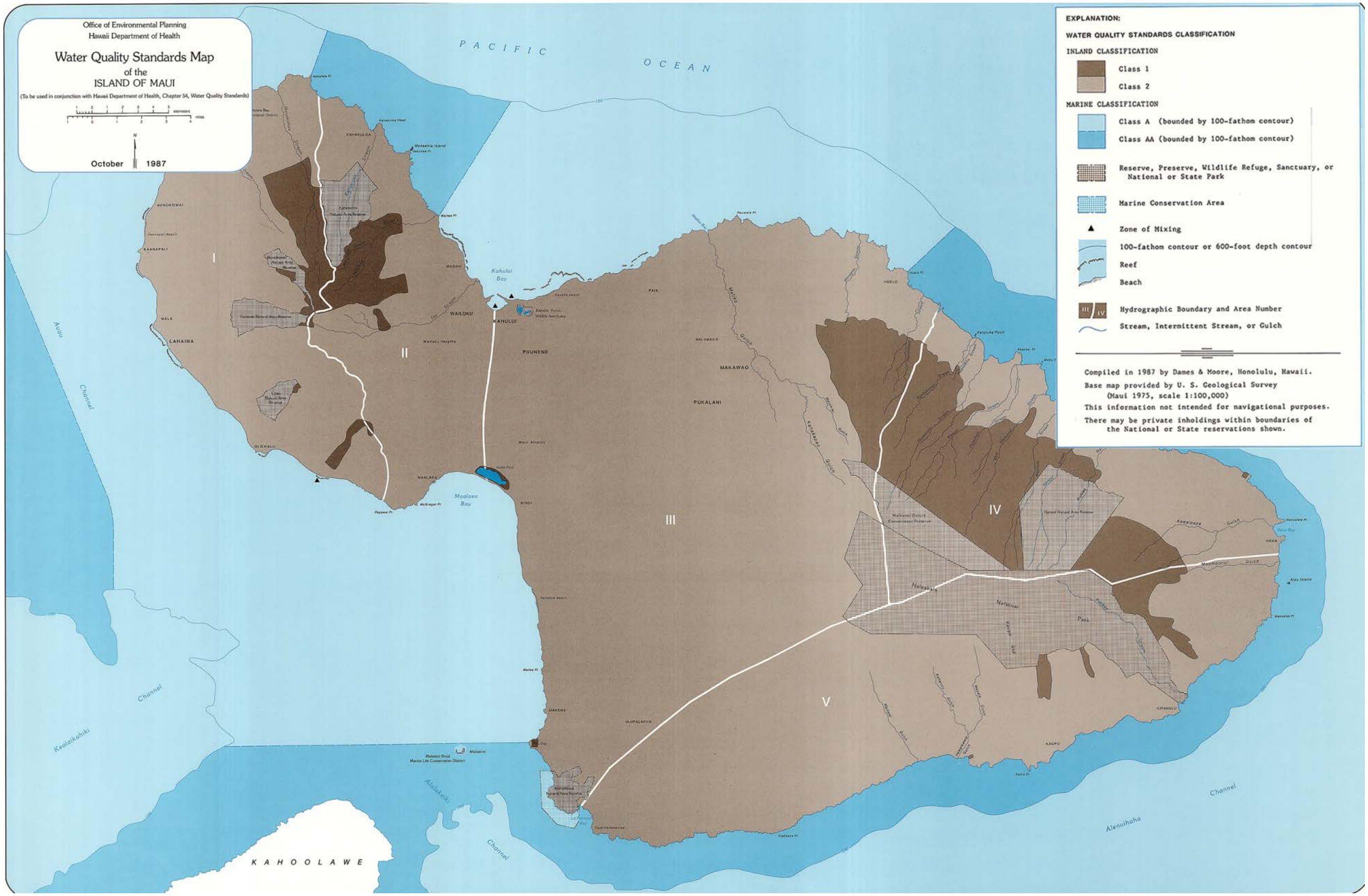


Figure 3-24. Water Quality Designations for the Island of Maui (Source: modified from HDOH 1987)

Table 3-24. Summary of Maui Inland and Marine Waters Considered Impaired

Number of Impaired Waters	Reason(s) for Impairments					
	Enterococci	**Total N**	**NO_3+NO_2**	**Total P**	**Turbidity**	**Other Pollutants (number of waters)**
Maui Inland Waters[a]						
8					X	Trash (1)
1		X	X	X	X	Trash (1)
1		X				
1		X	X	X		
TOTALS						
11	0	3	2	2	9	Trash (2)
Maui Marine Waters[b]						
30					X	Chlorophyll a (17); suspended solids (1); nutrients (1)
17		X	X		X	Chlorophyll a (16); ammonia nitrogen (8)
5			X		X	Chlorophyll a (4)
5				X	X	Chlorophyll a (5)
4		X	X			Chlorophyll a (4); ammonia nitrogen (4)
3		X	X	X	X	Chlorophyll a (1); ammonia nitrogen (1); suspended solids (1); nutrients (1)
2	X					
2			X			Chlorophyll a (2)
1	X		X		X	
1		X				Ammonia nitrogen (1)
1	X			X	X	Chlorophyll a (1)
1						Chlorophyll a (1)
TOTALS						
72	4	25	32	9	62	Chlorophyll a (51); ammonia nitrogen (14); suspended solids (2); nutrients (2)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 48 streams; of which, 16 were assessed with the following results: 11 impaired and 5 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

b. The source document identifies 122 marine waters; of which, 73 were assessed with the following results: 72 impaired and 1 meets some, but not all standards.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; PCB = polychlorinated biphenyl; TMDL = Total Maximum Daily Load.

In the case of marine waters, the table shows that of the 73 waters assessed, 72 of those were considered impaired. As identified in the Statewide summary (Table 3-14), the most common reason for impairment of marine waters was high turbidity levels, high nitrogen (both total and nitrate-plus-nitrite) were the next most common issues.

3.3.1.6.4 Water Use

Table 3-25 summarizes water use on Maui for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. As can be seen in the table, a great majority of the water used on Maui is from groundwater and the largest use category is thermoelectric, with agriculture uses the next largest. The table also shows that the total amount of water used on Maui is less than 9 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, Maui's percentage increases to about 24 percent of the State's value.

Table 3-25. 2005 Water Use (in million gallons per day) by Category and Source on Maui and for the State of Hawai‘i

Water Use Category	Maui				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[a]	Totals[b]	Fresh	Saline	Surface[a]	Totals[b]	
Municipal	30.2	0	10.7[c]	40.9	231.8	0	11.4	243.2	16.8%
Domestic (self)[d]	<0.1	0	0	<0.1	0.5	0	0	0.5	0.2%
Industrial	1.7	0	0	1.7	52.9	0	0	52.9	3.2%
Irrigation	9.6	0	14.4[c]	24.0	25.5	0	74.2	99.7	24.0%
Agriculture	48.1	0	0	48.1	55.1	0	1.3	56.4	85.3%
Aquaculture	0	0	0.2[c]	0.2	0	0	2.6	2.6	5.8%
Mining	0	0	0.4[c]	0.4	0	0	0.4	0.4	100.0%
Thermoelectric	0	54.7	0	54.7	0	1,445.0	0	1,445.0	3.8%
Military	0	0	0	0	26.4	0	0	26.4	0%
TOTALS[b] (% of County or State total)	89.6 (52.7)	54.7 (32.2)	25.6[c] (15.1)	170.0	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	8.8%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. The reference provided surface water data only at the county level. As a result, these values include surface water uses, if any, reported for Lāna‘i and Moloka‘i.
d. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.1.7 Hawai‘i

One hundred and thirty-two of the State’s 376 perennial streams are located on Hawai‘i island. Figure 3-25 is a simple map of Hawai‘i showing approximate locations of some of the island’s more prominent perennial streams. The figure also shows how the State of Hawai‘i divided the island into five hydrologic regions that were used in the numeric designation of the island’s streams. The State assigned the number “8” to the island, itself, and assigned each stream mouth within each of the hydrologic regions a number. These three numbers provide the basis for coding the streams. For example, the Honoli‘i Stream, which drains to the eastern side of the island, near Hilo, and is one of its largest streams, by flow, was assigned a numeric designation of “8-2-56” because it is on Hawai‘i, in hydrologic region 2, and its mouth is numbered “56” on Figure 3-25. As indicated in the figure, nearly all of Hawai‘i’s perennial streams are in regions 1 and 2; the only exceptions are one in region 4 and three in region 5 **(**CWRM/NPS 1990).

Since publication of the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), which is the source for Figure 3-25, the State has divided Hawai‘i into a more refined, smaller set of hydrologic units or watershed areas. The island now comprises 166 hydrologic units with an average size of about 24 square miles. The largest unit is about 389 square miles and the smallest is less than 0.2 square mile (CWRM 2008a). In region 1, which is the smallest region and which has been divided into the greatest number of units, the average unit size is 4.7 square miles, the largest unit is about 31 square miles, and it is the site of the smallest unit. Boundaries of the five regions shown in the figure match fairly well with boundaries of the 112 hydrologic such that:

- Region 1 of the map contains 82 hydrologic units designated 8001 through 8082;
- Region 2 of the map contains 58 hydrologic units designated 8083 through 8140;
- Region 3 of the map contains 9 hydrologic units designated 8141 through 8149;
- Region 4 of the map contains 6 hydrologic units designated 8150 through 8155; and
- Region 5 of the map contains 11 hydrologic units designated 8156 through 8166.

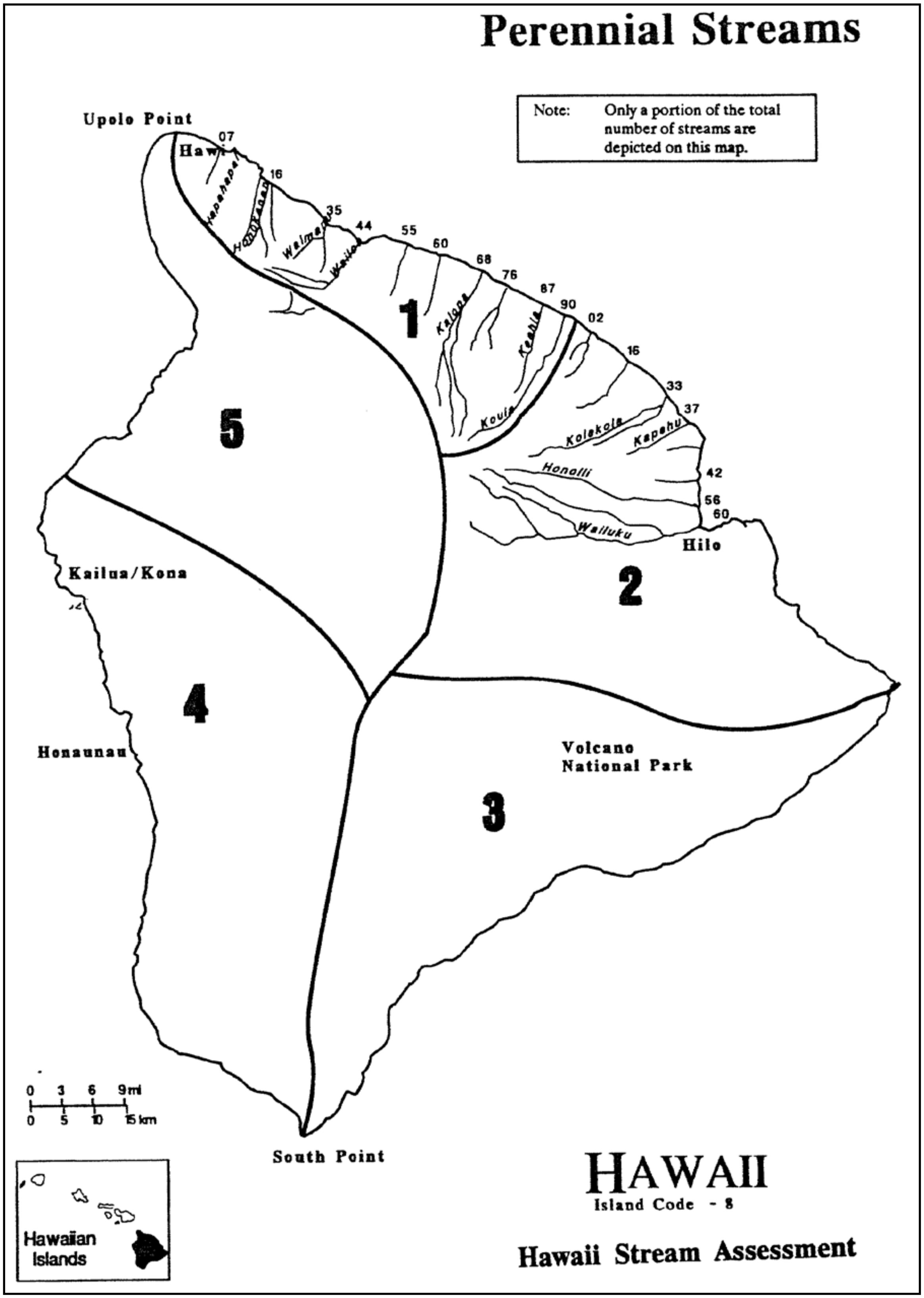


Figure 3-25. Map of Hawai'i Showing Some of the Island's More Prominent Perennial Streams (Source: CWRM/NPS 1990)

3.3.1.7.1 Stream Flow and Length Characteristics

Streams shown in Figure 3-25 originate on the windward sides of the Kohala Mountains and Mauna Kea. Section 3.3.1.1 above presents criteria used to rate Hawaiian streams as large, medium, or small. As shown in Table 3-11, 11 of the 21 streams in the State that qualify or are believed to qualify as large are located on Hawai‘i. Of the streams evaluated for flow characteristics in the 1990 Hawai‘i Stream Assessment (CWRM/NPS 1990), 4 of the 36 medium-sized streams and 14 of the 63 small-sized streams are on Hawai‘i.

The CWRM/NPS (1990) evaluation of stream lengths described previously concluded there are only 28 streams in the State that are at least 10 miles long, and 11 of those are on Hawai‘i. These include the Wailoa/Waipi‘o (8-1-44) and the Wailuku (8-2-60), which are both shown in Figure 3-25.

3.3.1.7.2 Diversions and Dams

The State of Hawai‘i has inventoried stream diversions by hydrologic unit and shows a total of 206 for Hawai‘i (CWRM 2008a), with three-quarters of those occurring in regions 1 and 2 (see Figure 3-25). The elaborate irrigation diversion systems (see Section 3.3.1.1.2) are well represented on Hawai‘i. The large ditch systems, many in the Kohola area, carried more than 70 million gallons of water per day for irrigation (CWRM/NPS 1990).

The Hawai‘i DLNR’s database of dams and reservoirs (see Section 3.3.1.2.2) shows 13 dams on Hawai‘i. These dams are found predominantly in region 1 in Figure 3-25, which has 12 dams. The only other dam is in region 3 (DLNR 2013b).

3.3.1.7.3 Water Quality

Figure 3-26 shows the inland and marine waters of Hawai‘i that are designated Class 1 and Class AA, respectively. These are the most protected waters in the State (Section 3.3.1.1.3). Class 1 inland waters are those waters or segments of waters located within the dark-brown shaded areas. For marine waters, HAR 11-54 specifically identifies the following as Class AA waters:

- Embayments – Puakō Bay, Waiulua Bay, Anaeho‘omalu Bay, Kīholo Bay, Kailua Harbor, Kealakekua Bay, and Hōnaunau Bay; and

- Open Coastal Waters – from Leleiwi Point to Waiulaula Point (the dark-blue band around the southern shore and most of the east and west shores of the island in Figure 3-26).

Table 3-26 summarizes information on impaired inland and marine waters on Hawai‘i from the State’s Section 303(d) and Section 305(b) integrated report for the 2008 to 2010 timeframe (HDOH 2012b). The table identifies the number of impaired waters and the constituent that caused the impairments. The table shows that out of the 21 inland waters assessed, 17 were considered impaired. As identified in the Statewide summary (Table 3-14), the most common reason for impairment of inland waters was high turbidity levels.

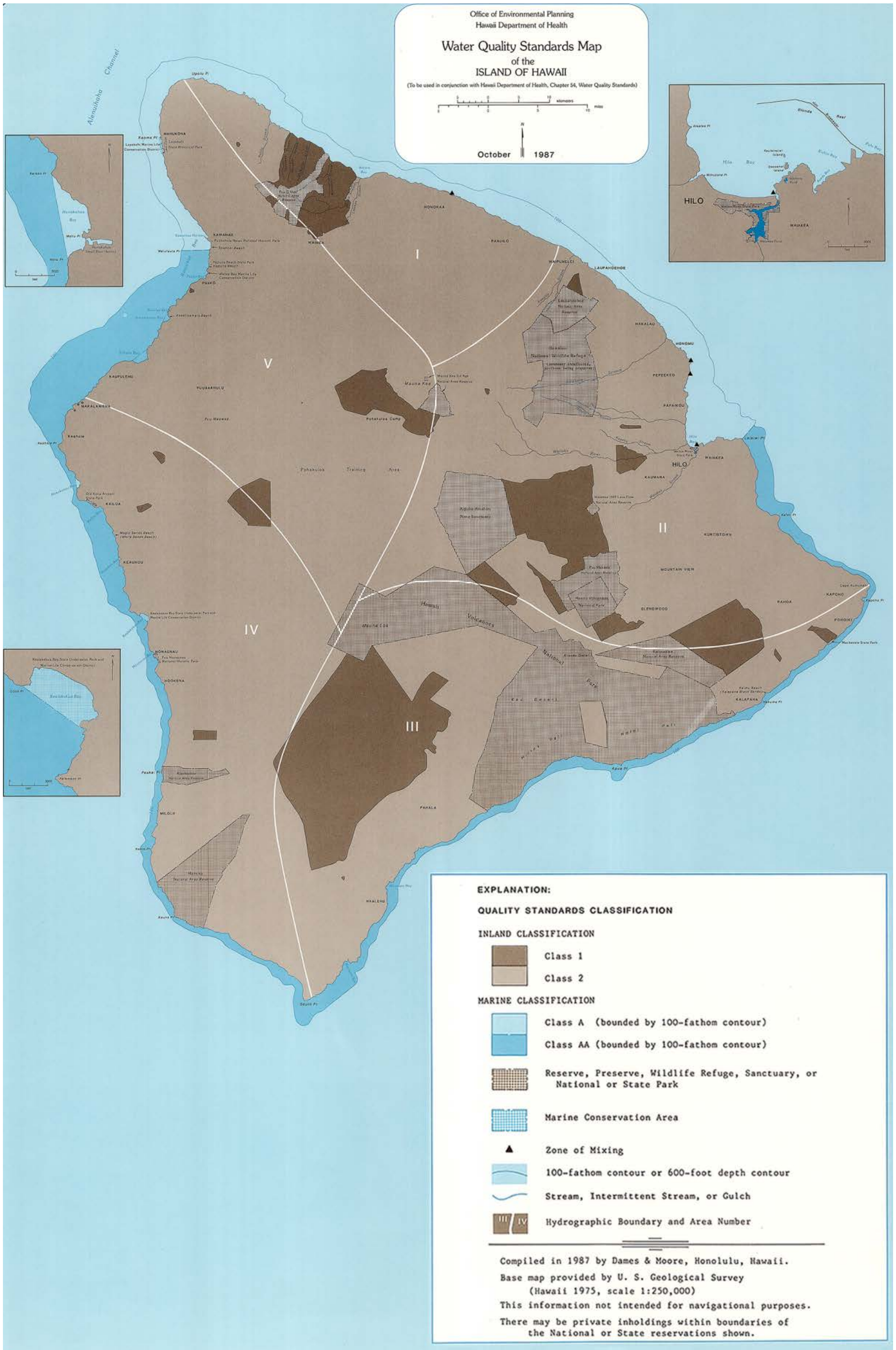


Figure 3-26. Water Quality Designations for the Island of Hawai‘i (Source: modified from HDOH 1987)

Table 3-26. Summary of Hawai'i island Inland and Marine Waters Considered Impaired

Number of Impaired Inland Waters	Reason(s) for Impairments					
	Enterococci	Total N	NO_3+NO_2	Total P	Turbidity	Other Pollutants (number of waters)
Hawai'i Inland Waters[a]						
9					X	
4		X	X	X		
2[c]		X	X	X	X	
1			X		X	
1			X			
TOTALS						
17	0	6	8	6	12	None
Hawai'i Marine Waters[b]						
8					X	Chlorophyll a (4); nutrients (1)
6		X	X	X	X	Chlorophyll a (2); ammonia nitrogen (5); phosphate (5)
6		X			X	Phosphate (1)
3	X				X	
2	X					
2				X		
2		X				
1		X	X	X		
1	X		X		X	Chlorophyll a (1); ammonia nitrogen (1)
1			X		X	Chlorophyll a (1); ammonia nitrogen (1)
1						Chlorophyll a (1)
TOTALS						
33	6	15	9	9	25	Chlorophyll a (9); ammonia nitrogen (7); phosphate (6); nutrients (1)

Source: HDOH 2012b.

a. Inland waters identified in the source document consist of 35 streams and 1 estuary; of which, 21 were assessed with the following results: 17 impaired and 4 meet some, but not all standards. The last category is for instances where there are data sufficient to show certain standards are met, but not sufficient to make a determination with regard to other standards. In the case of waters identified but not assessed, available data are insufficient to determine whether standards are met (or if the water is impaired).

b. The source document identifies 89 marine waters; of which, 47 were assessed with the following results: 33 impaired and 14 meet some, but not all standards.

Total N = total nitrogen; NO_3+NO_2 = nitrate + nitrite nitrogen; Total P = total phosphorus; TMDL = Total Maximum Daily Load.

In the case of marine waters, the table shows that out of the 47 waters assessed, 33 were considered impaired. As identified in the Statewide summary (Table 3-14), the most common reason for impairment of marine waters was high turbidity levels, high total nitrogen was the next most common issue.

3.3.1.7.4 Water Use

Table 3-27 summarizes water use on the island of Hawai'i for the year 2005. For comparison purposes, the table also shows Statewide water usage for the same period. As can be seen in the table, a majority of the water used on Hawai'i island is from groundwater, and the largest use categories are industrial and municipal water supplies. The table also shows that the total amount of water used on Hawai'i is less than 6 percent of the water used in the State. If the thermoelectric category were to be excluded from the totals, the island of Hawai'i's percentage would increase to about 23 percent of the State's value.

Table 3-27. 2005 Water Use (in million gallons per day) by Category and Source on Hawai‘i island and for the State of Hawai‘i

Water Use Category	Hawai‘i island				State				Island Percentage of State
	Groundwater				Groundwater				
	Fresh	Saline	Surface[a]	Totals[b]	Fresh	Saline	Surface[a]	Totals[b]	
Municipal	37.8	0	0	37.8	231.8	0	11.4	243.2	15.6%
Domestic (self)[c]	0.2	0	0	0.2	0.5	0	0	0.5	37.5%
Industrial	46.4	0	0	46.4	52.9	0	0	52.9	87.6%
Irrigation	7.5	0	16.5	24.0	25.5	0	74.2	99.7	24.1%
Agriculture	0.8	0	1.3	2.1	55.1	0	1.3	56.4	3.7%
Aquaculture	0	0	1.5	1.5	0	0	2.6	2.6	56.7%
Mining	0	0	0	0	0	0	0.4	0.4	0%
Thermoelectric	0	0.9	0	0.9	0	1,445.0	0	1,445.0	0.1%
Military	0	0	0	0	26.4	0	0	26.4	0%
TOTALS[b] (% of County or State total)	92.6 (82.1)	0.9 (0.8)	19.3 (17.1)	112.8	392.2 (20.3)	1,445.0 (75.0)	90.0 (4.7)	1,927.2	5.8%

Sources: CWRM 2008a for fresh groundwater values; USGS 2012b for surface water and all thermoelectric values.

a. The reference tracked both fresh and saline sources, but the Hawai‘i data identified use of only fresh surface water sources.
b. Values may not add up to totals because of independent rounding, here and in the referenced source.
c. Self-supplied domestic water, as opposed to domestic water from a municipal source.

3.3.2 GROUNDWATER

3.3.2.1 State Overview

3.3.2.1.1 Hydrogeology

In any groundwater system, the geology of the area dictates how groundwater moves and where it can move at rates and quantities that support an aquifer designation. In very general terms, rocks of the islands can be grouped into two hydrogeologic categories: the older volcanic rocks and the younger deposits (Oki et al. 1999). The volcanic materials are found throughout the islands. The younger deposits include alluvium derived from erosion of volcanic rock, coralline limestone, and cemented beach or dune sand. These materials are scattered about the islands, mostly in coastal areas, and, where present, generally overlay volcanic rock. The following text describes the two hydrogeologic materials to provide a basis for subsequent groundwater discussions.

> **AQUIFER**
>
> Water-bearing geologic formation(s) with sufficient saturated, permeable material to yield significant quantities of water to wells or springs.

The flanks of each volcano, which represent the largest area of the island, were formed by thousands of lava flow eruptions from the caldera or associated rift zones. These lava flows were either *pāhoehoe* or *‘a‘ā* lavas. The pahoehoe is the predominant type of flow and is characterized by its undulating surface and ropy appearance that is consistent with its thinner, more fluid flows. The ‘a‘ā flows have a coarse rubble (clinker) surface and a massive rock interior (Gingerich and Oki 2000). The clinker sections, voids between flows, shrinkage joints, fractures, lava tubes, and other such features in these materials provide porosity and, generally, permeability, so they are very good aquifers (UH Hilo 1998). The interior of the thicker flows, particularly the ‘a‘ā, can have very low permeability, so groundwater movement can be hindered by some layers. Also, deposits of pyroclastic rock, consisting of ash, cinder, spatter, and large blocks, can be present as occasional layers within the lava flows. Where present, compaction and weathering of these pyroclastic rock layers generally resulted in thin confining layers; that is, layers with low permeability that can confine overlying groundwater. The most productive aquifers in the islands are in thick sequences of numerous thin lava flows, and these are also the most widespread aquifers (Gingerich and Oki 2000).

One other volcanic formation is important to the distribution of groundwater. In the center area of the volcano and along rift zones, the molten lava intruded into fissures and hardened as sheets of basalt rock, or dikes, which are dense and generally of low permeability (UH Hilo 1998). These dikes can extend vertically and laterally for long distances (Gingerich and Oki 2000). Where present, they restrict and often trap groundwater flows within intervening permeable lava flows. At high elevations in the rift zones, these dikes can occur in great numbers and are called dike complexes. In such areas, percolating rainwater can be caught in the compartments formed by the dikes. In places where these compartments overflow or are cut into by erosion, the water can discharge as springs and feed streams or feed streams directly (UH Hilo 1998). Water spilling from the diked areas can also continue to move downward in the ground to deeper aquifers.

As noted previous, the younger consolidated sedimentary deposits are found mostly in the coastal areas. The limestone can be quite permeable in places, but generally yields *brackish* water (fresh- and saltwater mixes) because it has good hydraulic connection with the ocean and receives little recharge from percolating precipitation (Oki et al. 1999). In some areas, weathered volcanic rock and overlying sedimentary deposits have combined to form a low permeability material called caprock. Where caprock is present, it can confine water in adjacent volcanic rocks. Though it has low permeability, caprock can still be saturated, primarily with water from the ocean, and can result in brackish water overlying fresh water in the volcanic rock (Gingerich and Oki 2000).

Sedimentary deposits and some types of volcanic rocks, such as pyroclastic material, are typically productive aquifers in the conterminous United States, but are commonly confining units or aquifers with poor production in Hawai‘i (Gingerich and Oki 2000).

3.3.2.1.2 Recharge and Primary Aquifer Systems

Recharge

Rainfall (or snowfall in some high elevations) and *fog drip* are the natural sources of fresh water for the islands. Fog drip, which is cloud vapor that condenses on vegetation and drips to the ground, commonly occurs at elevations between 2,000 and 6,000 feet (Gingerich and Oki 2000). In very simple terms, water reaching the islands soaks into the ground, collects and moves as surface runoff, or is lost to evapotranspiration. The amount of water going to these three pathways can vary greatly depending on the location. Runoff can be very high in areas of steep slopes that receive a lot of rain and in areas where the surface has low permeability. Attempting to estimate the amount of water partitioned to the three pathways is further complicated by the fact that streams created by runoff can contribute to, or be fed by, groundwater at different locations along their course. Likewise, groundwater or surface water used for irrigation can be a significant source for groundwater at its point of use. With these factors in mind and noting that some areas can be much different than typical, recharge to groundwater typically is about 10 to 50 percent of the rainfall, fog drip, and irrigation water; runoff typically is 10 to 40 percent of rainfall; and evapotranspiration can exceed 50 percent of rainfall (Gingerich and Oki 2000).

EVAPOTRANSPIRATION

Loss of water to the atmosphere by a combination of transpiration of plants and direct evaporation.

Most groundwater is recharged at high elevations, so regional movement of fresh groundwater is from the interior toward the ocean, and water diffuses to the ocean or discharges at springs near sea level (Oki et al. 1999). The average total rainfall on the Hawaiian Islands is about 21 billion gallons per day (Gingerich and Oki 2000), so the average amount of water moving through this recharge-discharge cycle can be estimated at 10 to 50 percent of this value. That is, on a Statewide basis, a rough estimate of the amount of groundwater discharging to the ocean could be on the order of 2 to 10 billion gallons of water per day.

Primary Aquifer Systems

Basal groundwater and high-level groundwater are the terms often used to describe the two most significant types of groundwater in the Hawaiian Islands (UH Hilo 1998). Figure 3-26 simplistically depicts these groundwater types. The basal water is found in the large flank areas of the islands where the layered volcanic materials can form very productive aquifers. The high-level water is generally found in the central areas (or rift zones) where the presence of volcanic dikes influence where water is present and where it can move. The figure also shows how sediments, if present, might be positioned along the coastal areas.

The largest bodies of fresh groundwater on the islands are the basal waters that float on salt water within the aquifers. This type of groundwater is also referred to as a freshwater lens due to its lenticular shape (Oki et al. 1999). Because of the difference in density between fresh water and salt water, fresh groundwater can build up in elevations above the surrounding sea water and still be in pressure equilibrium at the base. A 41-foot column of fresh water weighs about the same as a 40-foot column of the salty seawater. So if fresh groundwater accumulates on top of the saline groundwater that moves in from the ocean, and there is minimal mixing, the fresh groundwater can build up to 41 feet and displace only a 40-foot depth of the saline groundwater. As a result of this relationship, if a person on an island drills for groundwater and encounters fresh water at an elevation of 1 foot above sea level, it can be assumed there is an underlying 41-foot thick lens of fresh water at that location. In literature, this is often referred to as the Ghyben-Herzberg principal, named after the two scientists who independently described the relationship (Oki et al. 1999). Correspondingly, if fresh water is first encountered at 10 feet above sea level, there should be a 410-foot lens of fresh water below. Of course mixing does occur to some extent at the base of the fresh groundwater and the thickness of the freshwater lens predicted by the Ghyben-Herzberg principal is actually closer to the thickness down to the mid-point of the mixing or transition zone as shown in Figure 3-27 (Oki et al. 1999). In the transition zone, water is brackish and ranges in chloride concentration from 250 milligrams per liter (the level commonly considered the maximum for fresh water) to about 19,500 milligrams per liter (the chloride concentration of seawater) (Gingerich and Oki 2000).

As would be expected, and as shown in Figure 3-27, the water table of basal aquifers slopes toward the level of the ocean and the thickness of the lens decreases accordingly. However, it can be imagined that if the sediments shown in the figure were the low permeability caprock material described previously, and if the caprock extended further up the shoreline, the freshwater lens would be at least partially confined and would build up to greater heights. This is what happens in some island areas and results in a very productive and thick aquifer. Since the caprock materials are generally more interconnected with the ocean than the groundwater on the other side, the water they contain is often quite brackish. Imagining the caprock extending further up the shoreline, one could visualize why drilling through those materials could encounter brackish groundwater first, then fresh water at greater depths. The presence of the caprock or other layers with low permeability can also result in artesian conditions, where water will come up in the well to a level higher than first encountered. As depicted in the figure, drilling wells too deep results in pumping saline or brackish water. Similarly, pumping wells too hard that are near the transition zone can pull brackish water toward the well.

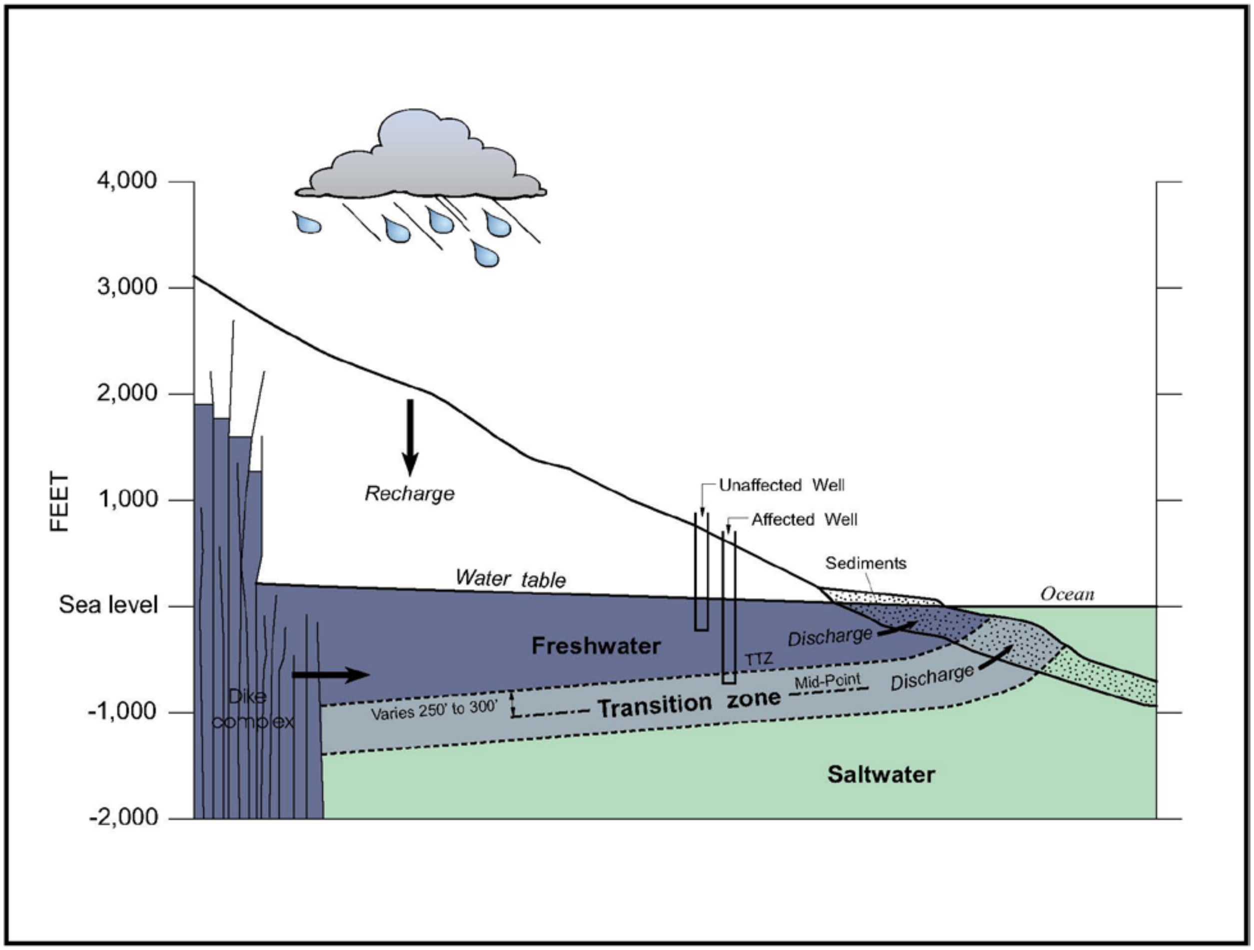


Figure 3-27. Stylized Depiction of Typical Hawai'i Aquifers (Source: CWRM 2013)

In the island areas with dike complexes, aquifers and the associated water tables occur at fairly high elevations; up to about 3,300 feet above sea level on Maui and Hawai'i, and about 1,600 feet above sea level on O'ahu. Because of the controlling influence of the dikes, these elevations do not translate into a corresponding depth of fresh water below sea level and, in general, the depth to which fresh water extends in these areas is not known (Oki et al. 1999). These high-level aquifers represent an important source of fresh water on some of the islands. Not only do they often feed surface waters, even keeping some streams flowing during periods of low runoff, in some cases shafts have been constructed into the dike complexes to intercept water for transport to other parts of the island. The island geologic maps presented in Section 3.1.1 of this PEIS generally identify those areas where significant numbers of dikes are located.

There are instances of high-level aquifers, such as in eastern Kaua'i, that might be considered almost a cross between the basal- and dike-influenced aquifers. They are vertically extensive, with water tables several hundreds or even thousands of feet above sea level, but instead of being associated with dike systems, they are in low-permeability volcanic rock. Because of the vertical hydraulic-head gradients present in these aquifers, the Ghyben-Herzberg principle is not valid for estimating the depth to underlying salt water (Oki et al. 1999).

Whereas it is believed that groundwater in dike zones is continuous all the way down to the water table of the surrounding flank areas, there are places on the island with *perched water tables*, which are places where downward percolating water is held up by a layer of material with low permeability, and the water accumulates above that layer. As described previously, there are several means by which layers of materials with low permeability form within the more permeable volcanic materials. Some perched water bodies are large enough to supply usable quantities of waters to wells and can be of local importance (Oki et al. 1999).

The distribution and characteristics of these aquifer systems vary by island. The following are a few generalities (in addition to those already discussed) that may help in understanding these variations (Oki et al. 1999):

- Islands receiving little precipitation and having permeable rock likely will have a very thin lens of fresh water. Islands with heavy recharge and less permeable rock will have a thicker lens.
- Water tables in permeable rocks are generally no more than several tens of feet above sea level. In rocks of low permeability, water table levels typically are greater than several tens of feet above sea level.
- Larger islands have very productive freshwater aquifers, but their hydrologic properties vary widely.
- In some places there is significant mixing between fresh water and salt water and, as a result, brackish water may exist immediately below the water table.
- Groundwater levels fluctuate based on the tide, season, and pumping.

3.3.2.1.3 Groundwater Quality

The source of Hawai‘i’s fresh water is precipitation of water evaporated from the surrounding ocean. As a result, the groundwater has sodium and chloride as its dominant ions. The salinity of groundwater tends to decrease with distance inland and increase with depth. As noted previously, wells pumped too hard or drilled too deep experience increased concentrations of sodium and chloride (Oki et al. 1999).

Manmade sources of groundwater contamination are typical of inhabited areas and include waste disposal (septic tanks and drainage fields), underground storage tanks, and pesticide and fertilizer applications in agricultural areas. Whether contaminants from these types of activities have reached groundwater is site specific. In some areas, groundwater used for municipal supplies is treated before being put into the distribution system. For example, carbon filters are sometimes used on O‘ahu and aeration has been used on Maui (Oki et al. 1999).

In the past, HDOH developed and made available groundwater contamination maps (http://health.hawaii.gov/sdwb/gwprotection/) that identify locations where contaminants have been detected in wells and springs throughout the State. Tables with the detected concentrations and, as applicable, drinking water standards are also made available with the maps. Contaminant concentrations are generally below Federal and State drinking water standards, but if standards are exceeded, HDOH takes appropriate measures to protect human health.

3.3.2.1.4 Groundwater Use and Availability

Section 3.3.1 discussed total water use (groundwater and surface water). As shown in Table 3-15, the total amount of fresh groundwater used in the State averaged just under 400 million gallons per day in 2005. Along with this was the use of more than 1,400 million gallons per day of saline groundwater. The saline or brackish water was used for cooling in thermoelectric plants.

Groundwater is considered a renewable resource because it is constantly being replenished by natural recharge. In very broad terms, the amount of groundwater that can be safely developed in Hawai‘i generally is considered the amount of recharge less whatever is needed to prevent seawater intrusion (by maintaining aquifer storage volumes) and to maintain stream flow. The amount of groundwater that can be safely developed is termed the *sustainable yield*, which is defined in State law as “the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the [Hawai‘i Commission on Water Resource Management]” (HRS 174C-3).

As a means to manage its groundwater resources, the Hawai‘i Commission on Water Resource Management (CWRM) has performed extensive data evaluation and groundwater modeling to develop estimates of recharge, groundwater and surface water interaction, and sustainable yield. These efforts and their results are described in the *Hawai‘i Water Plan – Water Resource Protection Plan* (CWRM 2008a). These concepts must be applied within each island and within portions of each island to be effective. For example, an attempt to manage an entire island through an island-wide sustainable yield might result in a concentration of water wells in a local populous or heavy water use area that could lead to upwelling and intrusion of underlying salt water. To avoid this situation and optimize island-wide pumpage, as well as to provide a consistent basis for managing groundwater resources, the State has established groundwater hydrologic units. Each island is divided into *aquifer sector areas* that are based, to the extent possible, on hydrographic, topographic, and historical boundaries. These sector areas are then divided into smaller sub-regions designated *aquifer system areas*. These subdivisions are each assigned a five-digit numerical code, with the first digit designating the island (as with the previously described surface water numbering system). The second and third digits designate the sector area, and the last two digits designate the systems area. The sections below discuss groundwater on an island-by-island basis, including the aquifer sector and system areas and the respective identifying codes,.

Table 3-28. Groundwater Sustainable Yield for the Entire State

Island	Sustainable Yield (in million gallons per day)
Kaua‘i	312
O‘ahu	407
Moloka‘i	79
Lāna‘i	6
Maui	427
Hawai‘i	2,410
TOTAL	**3,641**

Source: CWRM 2008a.

The estimated sustainable yield for the entire State is more than 3.6 billion gallons of water per day (Table 3-28). This is far more than the 400 million gallons per day of the groundwater used in 2005. However, this comparison provides no indication of whether there are groundwater availability issues in portions of the State. That issue is addressed in the sections below. The discussions below provide estimates of sustainable yields and water use down to the aquifer sector areas for each of the islands. Although this level of detail is considered adequate for this discussion, the source of this information, *Water Resource Protection Plan* (CRWM 2008a), includes the same information down to the aquifer system area. It may be noted in some instances that the 2005 groundwater use figures included in the preceding surface water discussions differ slightly from those presented in the groundwater use discussions of this section even though they come from the same reference. Such differences are attributed to differences in the pumping period being represented. Annual water use values in this section are based on 12-month moving averages as of July 2005.

3.3.2.3 Kauaʻi

3.3.2.3.1 Aquifer Systems

The basal aquifer system is the primary source of groundwater in Kauaʻi. On the eastern side of the island there is a large area of high-level groundwater. Wells that penetrate to below sea level in this area have shown the aquifer to be vertically extensive (not a perched water table) and it is not within any known rift system (not a known dike complex). An extensive caprock in western Kauaʻi impedes discharge of groundwater to the ocean and supports a thickening of the basal aquifer in this area (Gingerich and Oki 2000).

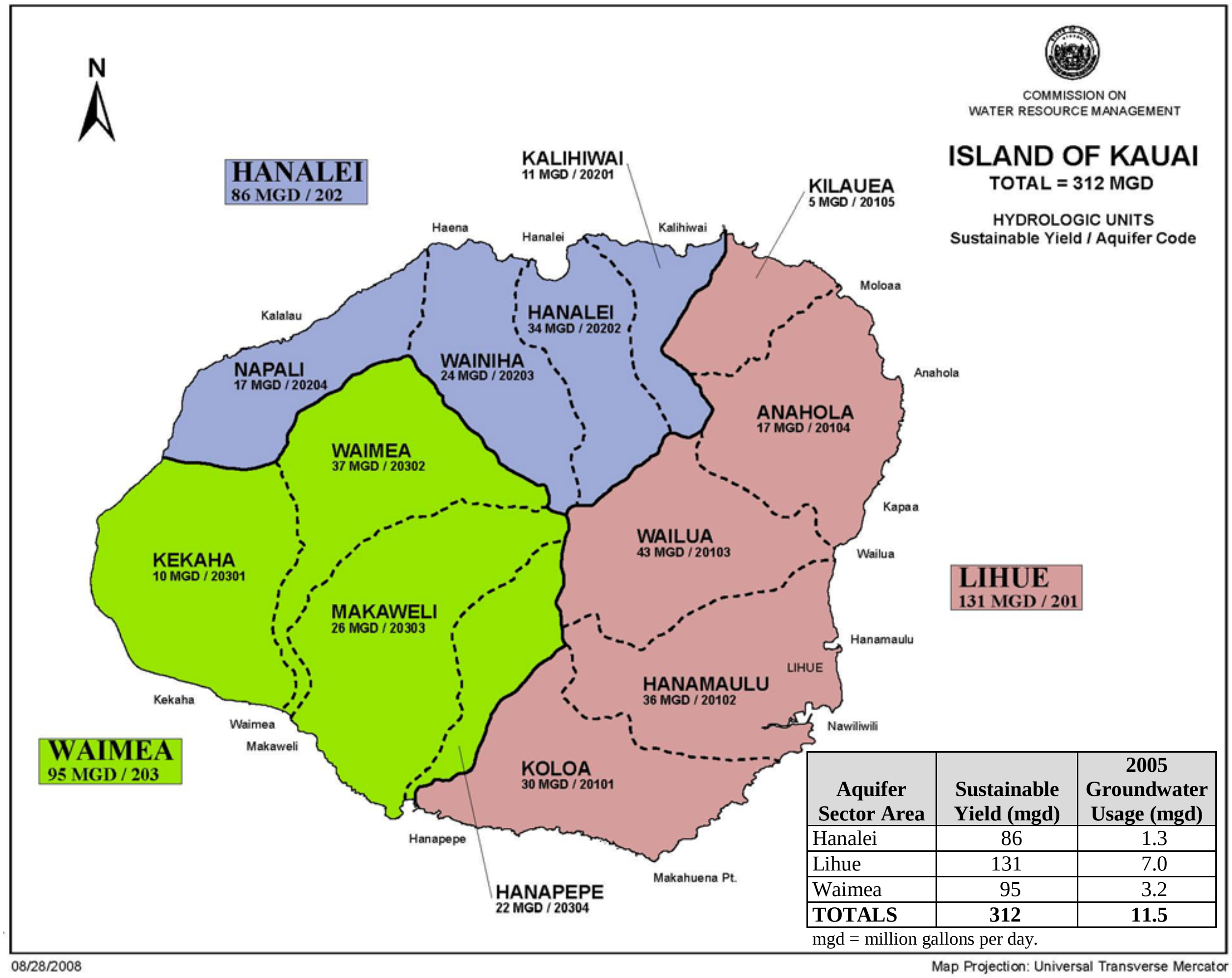
3.3.2.3.2 Groundwater Quality

Chemicals associated with agricultural activities have been detected occasionally in Kauaʻi groundwater samples collected from areas downgradient of those activities. The 2005 groundwater contamination map HDOH developed (HDOH 2006) identifies eight wells, all in southern Kauaʻi, where contaminants were detected in small concentrations (parts per billion or less). Eight different contaminants were detected, including several that were detected in multiple wells. Seven of the detected contaminants were materials commonly used in agricultural activities and one, atrazine, was reported in one sample at a concentration above its drinking water standard. The single non-agricultural contaminant, trichloroethylene, is a common industrial solvent and was detected in one well at a concentration below 1 part per billion; within drinking water standards.

3.3.2.3.3 Groundwater Use and Availability

Section 3.3.1.2 discusses Kauaʻi's total water use (groundwater and surface water) and presents use categories and quantities in Table 3-17. As was described in Section 3.3.2.1.4, the Hawaiʻi CWRM developed estimates of sustainable yield down to hydrologic areas (that is, the aquifer sector and system areas) to better manage the groundwater resources. Figure 3-28 shows Kauaʻi and the aquifer sector and system areas into which it was divided. The figure also shows the sustainable yield for each of the areas as well as for the island in total. A table of water use values, by aquifer sector area, has been inserted into the figure to support direct comparisons of sustainable yield and current water usage. It might be noted that Table 3-17 includes 10.8 million gallons per day of saline groundwater usage that is not shown in Figure 3-28. The State does not include saline groundwater as a resource to be managed against sustainable yield.

The water use data included in Figure 3-28 show that groundwater use in Kauaʻi is only a small portion (less than 4 percent) of the island's sustainable yield. The figure also shows that this is true for each of the aquifer sector areas. In 2008, there were 228 production wells on Kauaʻi, 130 of those with pumping capacities of greater than 25 gallons per minute. Most wells are located along the southern and eastern coasts (CWRM 2008a) and correspond to the areas of heaviest water usage. However, as indicated, no areas appear to be approaching availability issues. It should be noted that comparing water use and sustainable yield by aquifer sector is a simplification to support a high-level evaluation. It does not take into account local areas of high demand and it is generally not practicable for estimates of sustainable yield to consider all possible interactions between groundwater and surface water.



Aquifer Sector Area	Sustainable Yield (mgd)	2005 Groundwater Usage (mgd)
Hanalei	86	1.3
Lihue	131	7.0
Waimea	95	3.2
TOTALS	**312**	**11.5**

mgd = million gallons per day.

Figure 3-28. Kaua‘i Groundwater Hydrologic Areas, Sustainable Yields, and Water Usage [Sources: CWRM 2008a (water usage); CWRM 2008b (map)]

3.3.2.4 O‘ahu

3.3.2.4.1 Aquifer Systems

A freshwater lens (basal aquifer system) underlies most of O‘ahu. Around the periphery of the island, water levels in the basal aquifer system are relatively low. In the central part of the island, low permeability features create areas of high-level groundwater. High-level groundwater areas also are present in the rift zones near O‘ahu’s eastern and western sides (Gingerich and Oki 2000). O‘ahu has larger areas of overlying sedimentary deposits than any other island, including coralline limestone in coastal areas. These deposits have developed into caprock in many of the coastal areas, particularly the area southwest of Pearl Harbor where the large ‘Ewa Caprock is located. In the coastal areas where caprock overlies the highly permeable volcanic rocks, groundwater discharge to the ocean is impeded and the inland wedge of fresh groundwater is thicker than it would be without the caprock. The caprock of the coastal plain contains brackish water, used for cooling and industrial purposes, which overlies the fresh water in the volcanic rocks (Oki et al. 1999).

Dike systems on O‘ahu impound water at elevations up to about 1,600 feet above sea level and represent an important source of water. Much of the O‘ahu’s precipitation falls along the dike complexes in the

Ko‘olau Range running along the northeastern side of the island. Shafts constructed into the dike complexes are particularly important sources of water on the eastern side of O‘ahu (Gingerich and Oki 2000). The alluvial deposits of the southern part of O‘ahu contain small areas of perched water, but they are not significant sources of water (Oki et al. 1999).

Long-term groundwater monitoring records show declining water levels in some areas of O‘ahu. In the Honolulu area, 1880 water levels of about 43 feet above sea level declined to 20 to 25 feet above sea level during the early 1990s. Groundwater in the Pearl Harbor area declined by about 5 feet from 1910 to the early 1990s (Oki et al. 1999).

3.3.2.4.2 Groundwater Quality

Chemicals associated with agricultural activities have been detected in O‘ahu groundwater samples collected from areas downgradient of those activities. The 2005 groundwater contamination map HDOH developed (HDOH 2006) identifies 51 wells, predominantly in the central valley area between the two mountain ranges, where contaminants were detected in small concentrations (parts per billion or less). Sixteen different contaminants were detected, most in multiple wells between 1983 and 2005. Fourteen of the detected contaminants were materials commonly used in agricultural activities and two, 1,2-dibromo-3-chloropropane (DBCP) and 1,2,3-trichloropropane, were reported in several samples at a concentration above drinking water standards. The two non-agricultural contaminants were common industrial solvents and one, trichloroethylene, was detected in one sample at a concentration above the drinking water standard.

3.3.2.4.3 Groundwater Use and Availability

Section 3.3.1.3 discusses O‘ahu’s total water use (groundwater and surface water) and presents use categories and quantities in Table 3-19. Figure 3-29 shows O‘ahu and the aquifer sector and system areas into which it was divided to better manage the groundwater resources. The figure also shows the sustainable yield for each of the areas as well as for the island in total. Table 3-29 provides water use values, by aquifer sector area, to support direct comparisons of sustainable yield and current water usage. It might be noted that Table 3-19 shows almost 1,380 million gallons per day of saline groundwater usage not shown in Table 3-29. The State does not include saline groundwater as a resource to be managed against sustainable yield. The total 2005 groundwater usage shown here is slightly smaller than that shown in Table 3-19 for the same reason; that is, the Table 3-19 total includes a minor amount of saline groundwater use (CWRM 2008a).

Table 3-29. O‘ahu Groundwater Availability and Usage in Million Gallons per Day[a]

Aquifer Sector	Sustainable Yield	Existing Permit Allocations	2005 Groundwater Usage
Honolulu	50	53.2	44.1
Pearl Harbor	165	146.3	103.5
Central	23	20.4	9.2
Waianae	16	0	3.6
North	62	40.2	4.2
Windward	91	34.6	23.4
TOTALS	**407**	**294.7**	**187.9**

Source: CWRM 2008a.

Because of the high demand and competition for groundwater on O‘ahu (almost half of the State’s fresh groundwater usage occurs on O‘ahu), the Hawai‘i CWRM designated the entire island, except for the Wai‘anae Aquifer Sector Area as a *groundwater management area*. This authorizes the State to manage the island’s groundwater through a water use permitting process. Water use permits are discretionary approvals and there are seven criteria that must be met in order to obtain a water use permit. (Water permits for well construction and pump installation are required Statewide.) Table 3-29 includes the amount of groundwater allocations the State has issued under this permitting process.

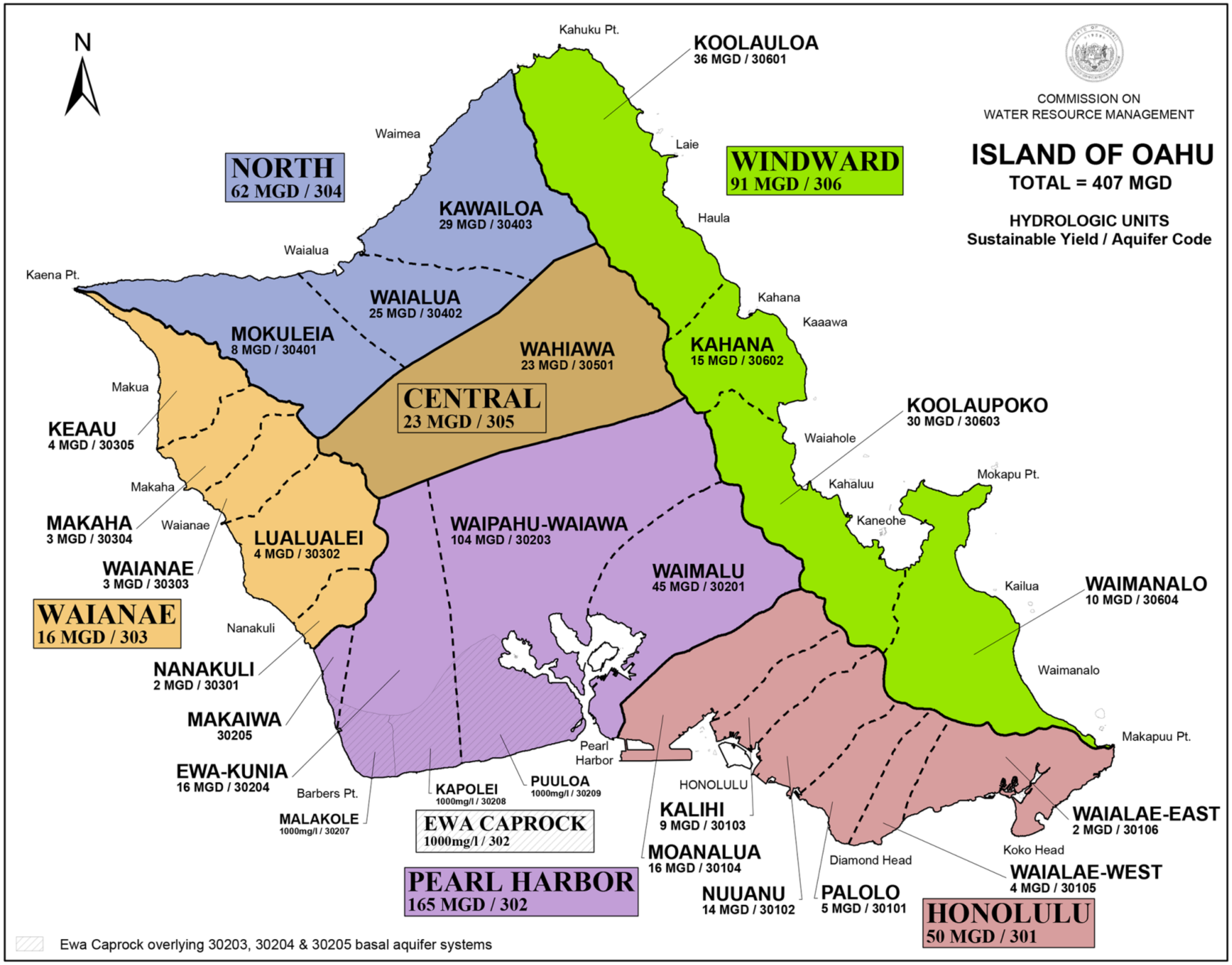


Figure 3-29. O‘ahu Groundwater Hydrologic Areas and Sustainable Yields (Source: CWRM 2008b)

The water use data included in Table 3-29 show that the total groundwater use in O‘ahu is 46 percent of the island’s sustainable yield. However, in the Honolulu sector, groundwater use is 88 percent of the area’s sustainable yield, and the permitted allocations are greater than the sustainable yield. This over-allocation situation resulted because declared uses at the time of designation exceeded the subsequent establishment of sustainable yield for some aquifer system areas. CWRM is monitoring the situation in over-allocated aquifers to determine whether adjustments to sustainable yields or water use permit allocations are warranted. Water use in the aquifer sector areas around the west, north, and east peripheries of the island (that is, Wai‘anae, North, and Windward) are notably smaller percentages of the sustainable yield of those areas. In 2008, there were 948 production wells on O‘ahu, 379 of those with pumping capacities greater than 25 gallons per minute. Well locations are heaviest in the Pearl Harbor and Honolulu areas, but are relatively well distributed throughout much of the island.

3.3.2.5 Moloka‘i

3.3.2.5.1 Aquifer Systems

Basal aquifer systems are prevalent throughout Moloka‘i and volcanic dikes are found in the rift zones of both East Moloka‘i and West Moloka‘i, the two volcanoes that formed the island. In the western third of the island, although the volcanic rock may be permeable, there is little potable water available because it receives little recharge (Oki et al. 1999). The northern part of Moloka‘i has areas of high-level groundwater associated with the northwest rift zone of the East Moloka‘i volcano (Gingerich and Oki 2000). The bulk of the island’s groundwater resources occur in the high-level and basal aquifers of East Moloka‘i.

3.3.2.5.2 Groundwater Quality

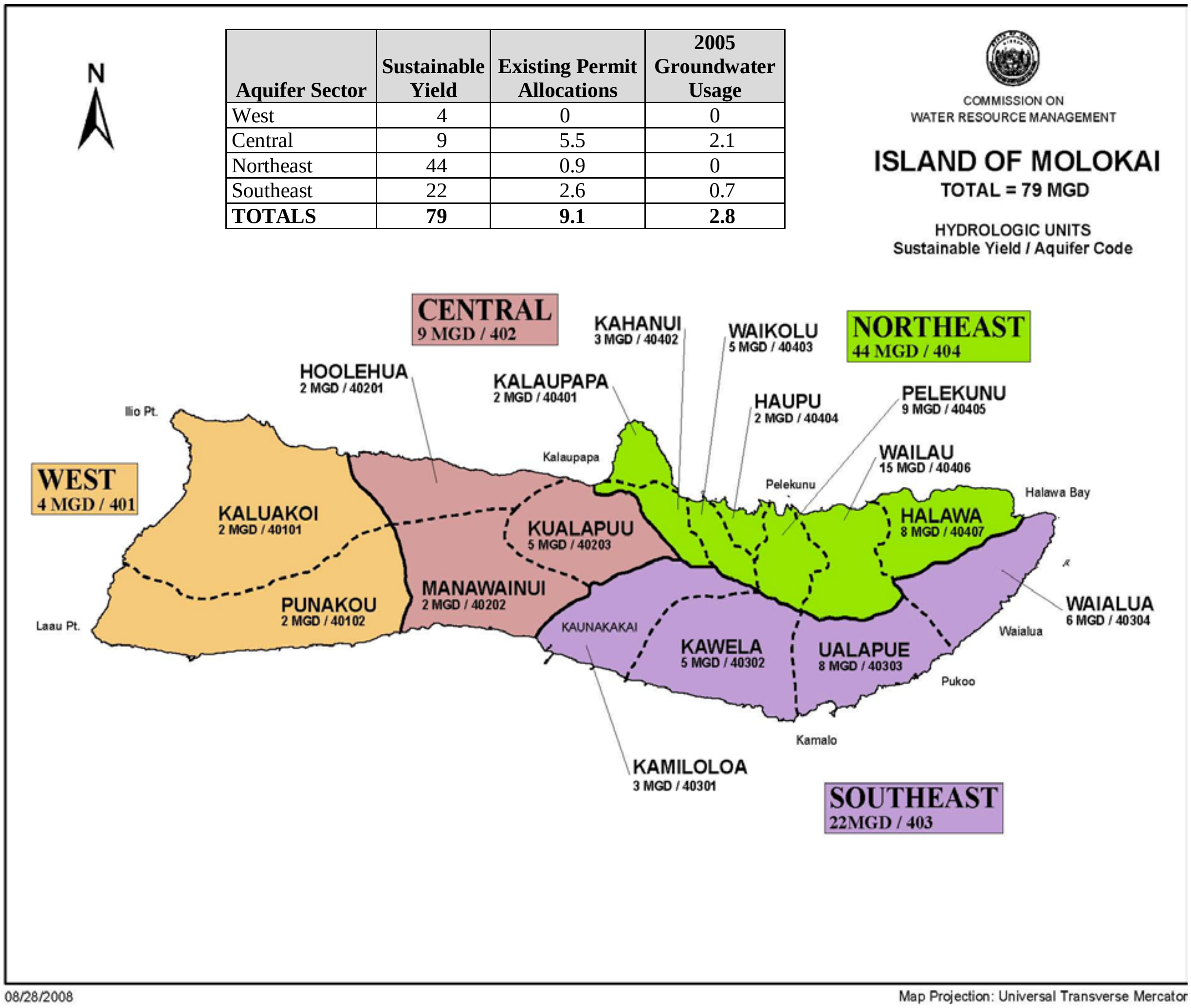
The 2005 groundwater contamination maps HDOH developed (HDOH 2006) identify no contamination issues for Moloka‘i.

3.3.2.5.3 Groundwater Use and Availability

Section 3.3.1.4 discusses Moloka‘i’s total water use (groundwater and surface water) and presents use categories and quantities in Table 3-21. Figure 3-30 shows Moloka‘i and the aquifer sector and system areas into which it was divided to better manage the groundwater resources. The figure also shows the sustainable yield for each of the areas as well as for the island in total. A table of water use values, by Aquifer Sector Area, has been inserted into the figure to support direct comparisons of sustainable yield and current water usage.

Because of the groundwater resource concerns on Moloka‘i (disputes and concerns regarding future planned uses), the CWRM designated the entire island as a groundwater management area. This authorizes the State to manage the island’s groundwater through a water use permitting process. The table inserted in Figure 3-30 includes the amount of groundwater allocations issued under this permitting process.

The water use data included in Figure 3-30 show that groundwater use in Moloka‘i is only a small portion (less than 4 percent) of the island’s sustainable yield. However, in the Central sector, groundwater use is 23 percent of the area’s sustainable yield and the permitted allocations are more than 60 percent of the sustainable yield. In 2008, there were 99 production wells on Moloka‘i, 34 of those with pumping capacities greater than 25 gallons per minute. Most wells are located along the island’s southern coast in the Central and Southeast sectors (CWRM 2008a), corresponding to the areas of highest groundwater usage.



Aquifer Sector	Sustainable Yield	Existing Permit Allocations	2005 Groundwater Usage
West	4	0	0
Central	9	5.5	2.1
Northeast	44	0.9	0
Southeast	22	2.6	0.7
TOTALS	**79**	**9.1**	**2.8**

Figure 3-30. Molokaʻi Groundwater Hydrologic Areas, Sustainable Yields, and Water Usage [Sources: CWRM 2008a (water usage); CWRM 2008b (map)]

3.3.2.6 Lānaʻi

3.3.2.6.1 Aquifer Systems

Basal aquifer systems are prevalent throughout Lānaʻi and volcanic dikes are present in the three rift zones that radiate from the volcano summit. The island is in the rain shadow of Maui and Molokaʻi, so it receives less rain and recharge than the larger islands (Oki et al. 1999). There is high-level groundwater in the island's interior within the rift zone and caldera complex (Gingerich and Oki 2000). This interior portion of the island is the only area with sufficient recharge to have sustainable yield.

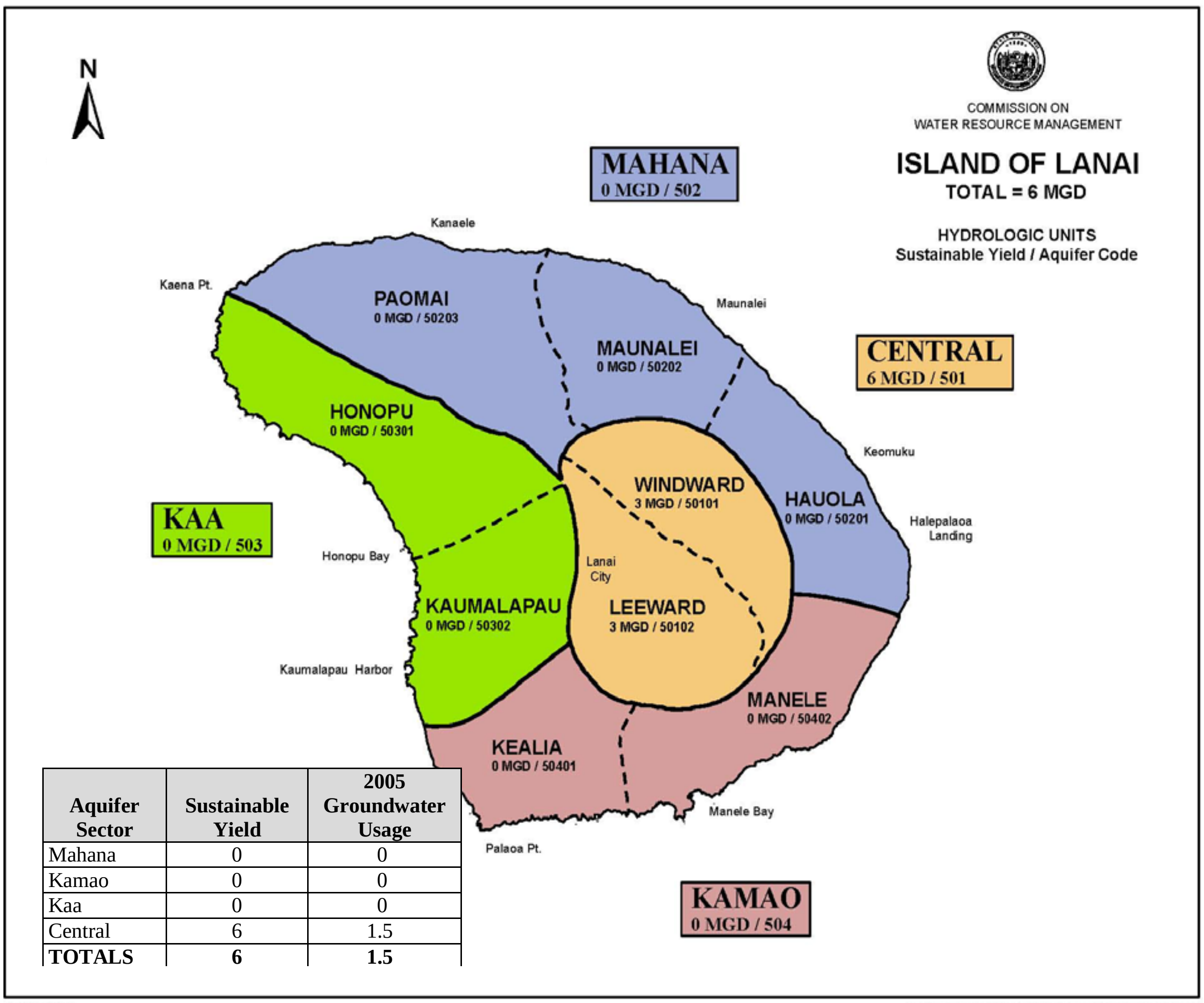
3.3.2.6.2 Groundwater Quality

The 2005 groundwater contamination maps HDOH developed (HDOH 2006) identify no contamination issues for Lānaʻi. As with other island areas with low recharge, some groundwater areas are affected by degradation of fresh water by salt water (Oki et al. 1999).

3.3.2.6.3 Groundwater Use and Availability

Section 3.3.1.5 discusses Lānaʻi's total water use (groundwater and surface water) and presents use categories and quantities in Table 3-23. Figure 3-31 shows Lānaʻi and the aquifer sector and aquifer system areas into which it was divided to better manage the groundwater resources. The figure also shows the sustainable yield for each of the areas as well as for the island in total. A table of water use values, by aquifer sector area, was inserted into the figure to support direct comparisons of sustainable yield and current water usage. It might be noted that Table 3-23 shows a slightly higher groundwater use than that in Figure 3-31. This is because the water use in Table 3-23 includes a small amount of saline groundwater, and the State does not include saline groundwater as a resource to be managed against sustainable yield (CWRM 2008a).

The water use data included in Figure 3-31 show that groundwater use in Lānaʻi is small, but because recharge is so small, it equates to 25 percent of the island's sustainable yield. In 2008, there were 16 production wells on Lānaʻi, 12 of those with pumping capacities of greater than 25 gallons per minute. The wells are primarily located within the island's Central sectors (CWRM 2008a).



Aquifer Sector	Sustainable Yield	2005 Groundwater Usage
Mahana	0	0
Kamao	0	0
Kaa	0	0
Central	6	1.5
TOTALS	**6**	**1.5**

Figure 3-31. Lānaʻi Groundwater Hydrologic Areas, Sustainable Yields, and Water Usage [Sources: CWRM 2008a (water usage); CWRM 2008b (map)]

3.3.2.7 Maui

3.3.2.7.1 Aquifer Systems

The central isthmus (the low area lying between the two volcanoes that formed the island) and most coastal areas of Maui have low-level groundwater with water tables less than 50 feet above sea level, which is consistent with a freshwater lens system (basal groundwater system). High-level groundwater is present in the interior of the West Maui Volcano along with dikes (dike groundwater system) that impound water as high as 3,300 feet above sea level (Oki et al. 1999). High-level groundwater also is present on the northern flanks of East Maui Volcano in areas of high rainfall. Areas along the northern rift zone of the east volcano have both high- and low-level groundwater, indicating a perched groundwater zone above the freshwater lens. Farther to the east, outside of the rift zone, there is an area of high-level groundwater where wells have penetrated to below sea level and shown the aquifer to be a vertically extensive freshwater lens system (Gingerich and Oki 2000).

Sediments, including coralline limestone, overlie the isthmus area of the island, but these rocks are not a significant source of potable water. These materials have helped form the caprock within Maui's central coast lines. Where present, the caprock impedes discharge of groundwater to the ocean and supports a thickening of the basal aquifer (Gingerich and Oki 2000).

3.3.2.7.2 Groundwater Quality

Chemicals associated with agricultural activities have been detected occasionally in Maui groundwater samples collected from areas downgradient of those activities. The 2005 groundwater contamination map HDOH developed (HDOH 2006) identifies 21 wells, predominantly in the northern, central, and northwestern coastal areas, where contaminants were detected in small concentrations (parts per billion or less). Eight different contaminants were detected, most in multiple wells between 1985 and 2005. All of the detected contaminants were materials commonly used in agricultural activities, and three, 1,2-dibromo-3-chloropropane (DBCP), ethylene dibromide, and 1,2,3-trichloropropane, were reported in several samples at a concentration above drinking water standards.

3.3.2.7.3 Groundwater Use and Availability

Section 3.3.1.6 discusses Maui's total water use (groundwater and surface water) and presents use categories and quantities in Table 3-25. Figure 3-32 shows Maui and the aquifer sector and aquifer system areas into which it was divided to better manage the groundwater resources. The figure also shows the sustainable yield for each of the areas as well as for the island in total. A table of water use values, by aquifer sector area, has been inserted into the figure to support direct comparisons of sustainable yield and current water usage. It might be noted that Table 3-25 shows almost 55 million gallons per day of saline groundwater usage not shown in the water usage table inside Figure 3-32. The State does not include saline groundwater as a resource to be managed against sustainable yield. The total 2005 groundwater usage shown in the figure is slightly smaller than that shown in Table 3-25 for the same reason; that is, the Table 3-25 total includes a minor amount of saline groundwater use (CWRM 2008a).

The water use data included in Figure 3-32 show that the total groundwater use in Maui is 18 percent of the island's sustainable yield. However, in the Central sector, the sector with the highest water demand, groundwater use is 174 percent of the sector's sustainable yield. Further, most of the sector's water use occurs in the Kahului Aquifer System Area, which has the lowest sustainable yield of any system area on the island. The sustainability of the aquifers can be attributed to large amounts of recharge from the irrigation of the area's sugar cane crops. The sector with the next heaviest water demand, Wailuku, uses about 64 percent of the sector's sustainable yield. The CWRM designated the ‘Iao groundwater system, within the Wailuku Sector, as a groundwater management area, which authorizes the State to manage the ‘Iao system through a water use permitting process. In 2008, there were 450 production wells on Maui, 191 of those with pumping capacities greater than 25 gallons per minute. The northern and western coastal areas and the isthmus area of the island are the areas where well distribution is most dense (that is, the highest number of wells per area of land) (CWRM 2008a).

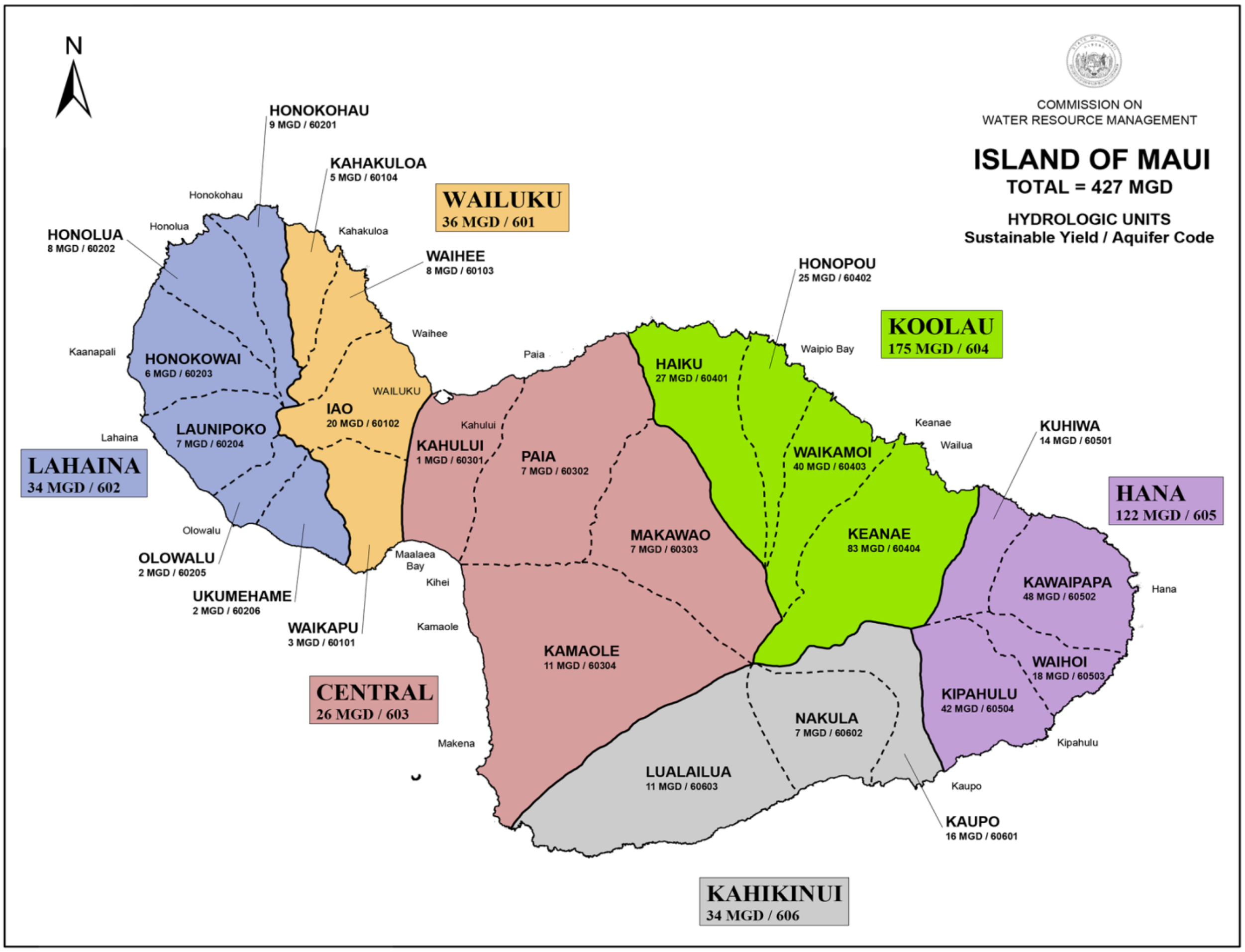


Figure 3-32. Maui Groundwater Hydrologic Areas, Sustainable Yields, and Water Usage [Sources: CWRM 2008a (water usage); CWRM 2008b (map)]

3.3.2.8 Hawai‘i

3.3.2.8.1 Aquifer Systems

Basal aquifer systems (or freshwater lens systems) are extensive throughout most of the island. In some of the western parts of Hawai‘i, however, a freshwater lens is very thin to non-existent, as brackish water overlies salt water because of tidal fluctuations, low recharge and lack of a coastal caprock. High-level groundwater is present in the rift zones of the Kīlauea and Kohala volcanoes (the volcanoes at the southeastern and northwestern extents of the island). The dike complexes impound water to great heights in these areas, as much as 3,300 feet above sea level (Oki et al. 1999). There is high-level groundwater along the western coast of the island, possibly associated with a buried rift zone of Hualālai Volcano. There also is high-level groundwater along the northern and eastern flanks of Mauna Kea near Hilo and on the southeastern flank of Mauna Loa (Gingerich and Oki 2000).

Deep drilling was performed in the Hilo area in the 1990s and 2000s as part of the Hawaiʻi Scientific Drilling Project to study the geochemical and geophysical processes within the mantle that form volcanoes, such as Hawaiʻi, in the middle of tectonic plates. The drilling extended primarily into rocks of the Mauna Kea volcano and found groundwater of the site to be much more complicated than previously envisioned. The second, deeper borehole of the project was drilled to a depth of almost 9,900 feet below sea level in 1999 and extended to about 11,500 feet below sea level in 2007 (Stopler et al. 2009). Different than the traditional view of a fresh water lens sitting atop salt-water that extends to the island's base, the project encountered several layers of rock saturated with freshwater that were below saline groundwater. Evidence of fresh, formation water was reported as deep as about 9,800 feet below sea level. The project also found layers where groundwater was more saline than sea water. Closer to the surface, the drilling encountered multiple artesian aquifers and the site has no sedimentary caprock that supports the artesian conditions on Oʻahu. More studies are required to determine how extensive any of these conditions might be, but one implication of the study is that there may be much more freshwater within Mauna Kea's geologic formations than previously estimated (Stopler et al. 2009).

3.3.2.8.2 Groundwater Quality

Chemicals associated with agricultural activities have been detected occasionally in Hawaiʻi groundwater samples collected from areas downgradient of those activities. The 2005 groundwater contamination map HDOH developed (HDOH 2006) identifies 32 wells or springs, predominantly along the northeastern coastal area, where contaminants were detected in small concentrations (parts per billion or less). Ten different contaminants were detected, most in multiple sample locations between 1984 and 2005. Nine of the detected contaminants were materials commonly used in agricultural activities, and all were reported at concentrations that met drinking water standards. The single non-agricultural contaminant, tetrachloroethylene, is a common industrial solvent that was detected in a single sample at a concentration that met the drinking water standard.

3.3.2.8.3 Groundwater Use and Availability

Section 3.3.1.7 discussed Hawaiʻi island's total water use (groundwater and surface water) and presented use categories and quantities in Table 3-27. Figure 3-33 shows the island of Hawai'i and the aquifer sector areas and aquifer system areas into which it was divided to better manage the groundwater resources. The figure also shows the sustainable yield for each of the areas as well as for the island in total. Table 3-30 provides water use values, by aquifer sector area, to support direct comparisons of sustainable yield and current water usage.

Table 3-30. Hawaiʻi Groundwater Availability and Usage in Million Gallons per Day

Aquifer Sector	Sustainable Yield	2005 Groundwater Usage
Kohala	140	1.4
E. Mauna Kea	388	2.0
N.E. Mauna Loa	744	56.3
Kīlauea	621	1.5
S.E. Mauna Loa	293	0.1
S.W. Mauna Loa	114	2.1
Hualālai	56	14.4
N.W. Mauna Loa	30	4.9
W. Mauna Kea	24	9.2
TOTALS	**2,410**	**91.9**

Source: CWRM 2008a.

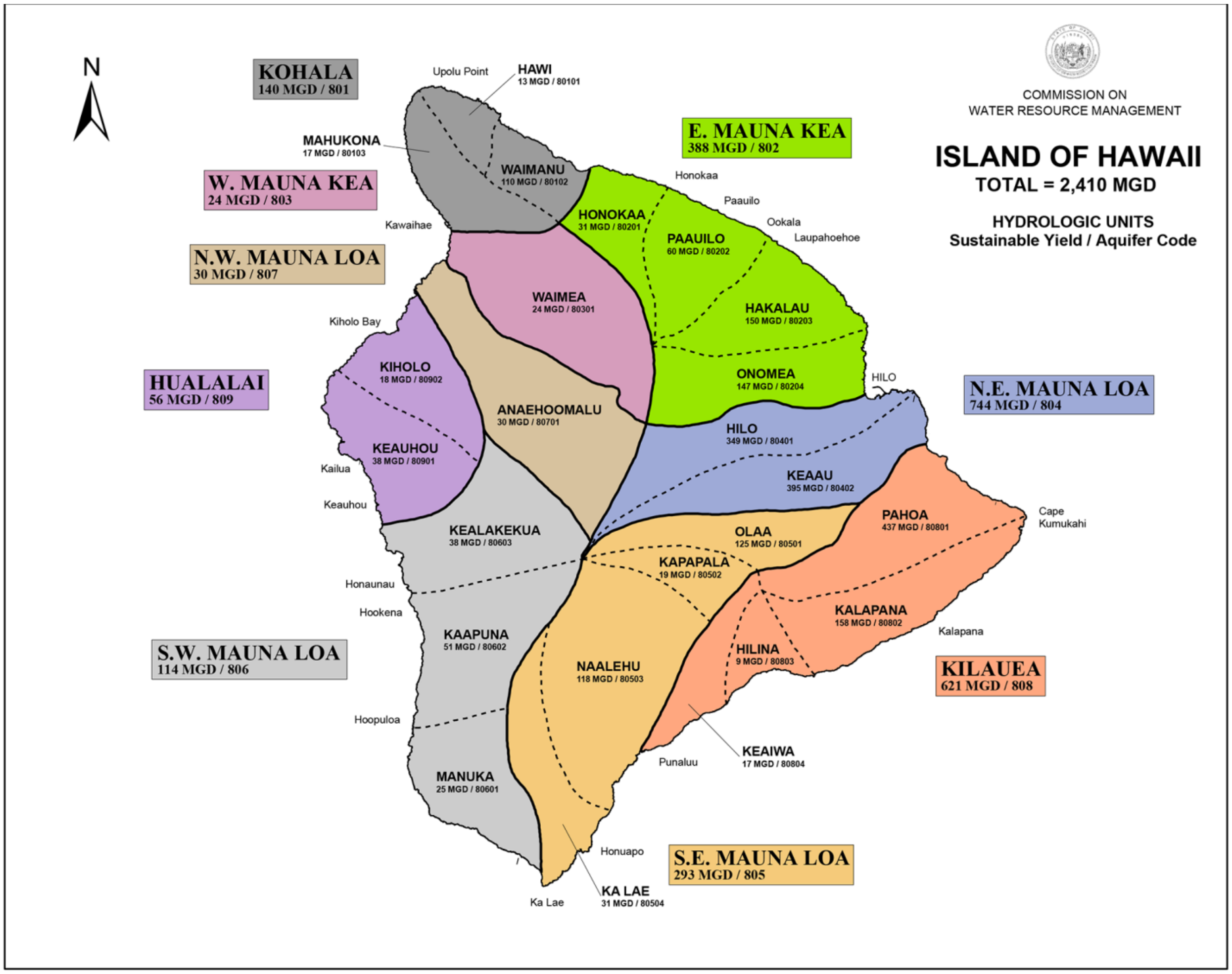


Figure 3-33. Island of Hawai'i Groundwater Hydrologic Areas and Sustainable Yields (Source: CWRM 2008b)

The water use data in Table 3-30 show that the total groundwater use in Hawai'i is a small portion, less than 4 percent, of the island's sustainable yield. The sector with the highest groundwater usage, N.E. Mauna Loa, uses less than 8 percent of its sustainable yield. The sector using most of its sustainable yield is W. Mauna Kea at 38 percent. In 2008, there were 400 production wells on Hawai'i, 204 of those with pumping capacities greater than 25 gallons per minute. The coastal areas of the northern half of the island are where well distribution is most dense (CWRM 2008a).

3.3.3 FLOODPLAINS AND WETLANDS

3.3.3.1 Floodplains

Floodplains are lowland and flat areas adjoining inland and coastal waters. These areas often are prone to flooding, and the amount of adjacent land inundated depends on the magnitude of the flooding event. The Federal Emergency Management Agency (FEMA)-administered National Flood Insurance Program (NFIP) has set the "100-year flood" as the national standard for purposes of requiring flood insurance and regulating new development and substantial improvements (FEMA 2013). A "100-year flood" is a flood with a 1 percent chance of occurring in any single year. A flood with a probability of occurring less often than this, for example a 500-year flood, would be a larger magnitude flood and would inundate more floodplain area than a 100-year flood. Conversely, a flood with a probability of occurring more often, for example a 10-year flood, would be of smaller magnitude and would inundate less area of the floodplain.

FEMA has developed Flood Insurance Rate Maps for most of the United States that show areas prone to inundation by “100-year floods.” This information for the State of Hawaiʻi is available via the State’s Flood Hazard Assessment Tool, (http://www.hidlnr.org/eng/nfip/NfipHome.aspx), which allows the user to navigate to any location on any of the islands and, where data are available, zoom into any area to view flood zones. The tool also allows the user to generate a Flood Hazard Assessment Report, like that shown in Figure 3-34.

The land area shown in Figure 3-34 is on the eastern coastline of Kauaʻi. The figure shows coastal areas (in red), inland stream areas, and inland reservoirs or low accumulation areas prone to flooding. Even in this relatively small portion of an island, a more zoomed in view is necessary to get any real detail on flood zone boundaries. It is not practical for this PEIS to show the level of detail in Figure 3-34 for all areas of each of the islands, let alone more detailed information. Accordingly, interested parties are directed to the State’s Flood Hazard Assessment Tool to obtain more information on the location and extent of floodplains in Hawaiʻi.

3.3.3.2 Wetlands

Wetlands are areas periodically or permanently inundated by surface water or groundwater and that support vegetation adapted for life in saturated soil. For a location to qualify as a wetland, it must have hydric soils, hydrology indicators, and wetland vegetative species (USACE 2013). Wetlands are valued for their contributions in reducing flooding impacts; filtering or absorbing nutrients, sediments, and even pollutants before they reach streams and marine areas; facilitating recharge to groundwater; providing wildlife habitat; enhancing scenic landscapes; and providing recreational opportunities (PCJV 2009).

The wetlands most common in Hawaiʻi are as follows (PCJV 2009):

- Riverine wetlands – These are the surface water systems found along the edges of rivers and streams.
- Palustrine wetlands – These include marshes and bogs and generally are found in depressions where rain and groundwater collect. Hawaiʻi’s rare montane bogs, which take millions of years to form, are in this group.
- Estuarine wetlands – These include swamps and mudflats that occur on coasts where streams empty to the ocean. These areas typically are influenced by tides, are brackish, and provide habitat for fish, shellfish, and waterbirds.
- Marine wetlands – These include intertidal shorelines, seagrass beds, and tidepools. They are saltwater systems that often provide habitat for many species harvested by humans for food.

The U.S. Fish and Wildlife Service (USFWS) maintains an electronic inventory of wetlands within the United States through a “Wetlands Mapper” tool (http://www.fws.gov/wetlands/Data/Mapper.html). Like the State’s Flood Hazard Assessment Tool, the USFWS online mapper tool allows the user to navigate to any location on any of the islands and zoom into any area to view potential wetlands areas. The tool also allows the user to generate digital maps of the areas of interest like that shown in Figure 3-35.

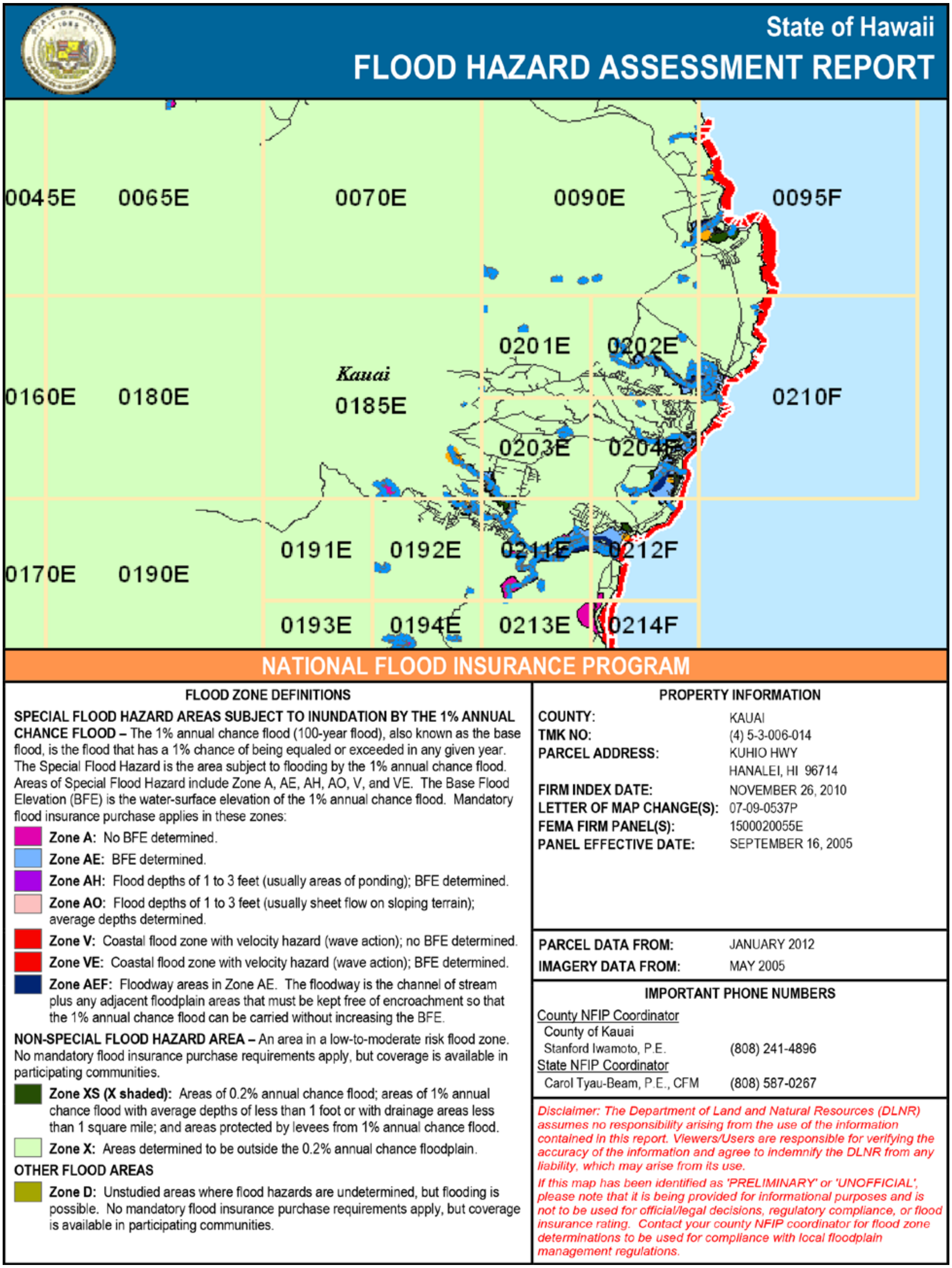


Figure 3-34. Example Report Generated from the State's Flood Hazard Assessment Tool

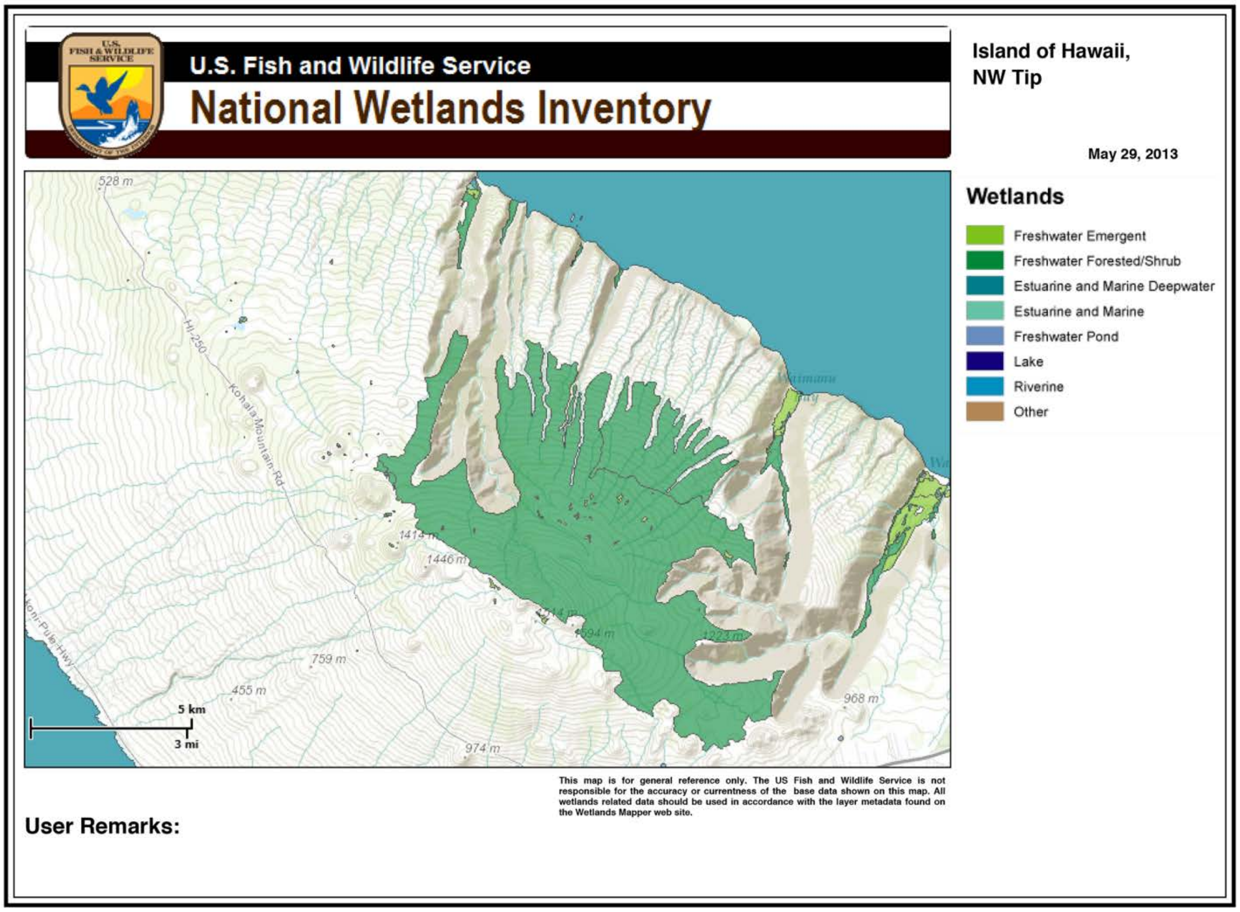


Figure 3-35. Example Wetland Map Generated from the USFWS's Wetlands Mapper

The land area shown in the example map in Figure 3-35 is on the northwestern tip of Hawai‘i island (the Kohala Volcano area). The figure shows a large area and several smaller areas of potential palustrine freshwater forested/shrub wetlands (green) and several small areas of potential palustrine emergent wetlands (light green). As with the online flood hazard tool, a more zoomed in view is necessary to get better detail on the wetlands areas. For example, in closer views, USFWS data include codes for the colored wetlands areas that provide additional detail on their characteristics. Again, it is not practical for this PEIS to show the level of detail in Figure 3-35 for all areas of each of the islands, and certainly not for more detailed information. Accordingly, interested parties are directed to the USFWS online Wetlands Mapper tool to obtain more information on the location and nature of potential wetlands in Hawai‘i.

The USFWS Wetlands Mapper tool is based on reconnaissance-level information, generally prepared from the analysis of high-altitude imagery and based on vegetation, visible hydrology, and geography (USFWS 2014). Highlighted areas identified through use of the online tool are best described as "potential" wetlands areas. Activities that could involve dredging, filling, or other land disturbance in these or other areas of potential wetlands should include field surveys to verify whether project areas meet the criteria to be wetlands.

Jurisdictional wetlands are those associated with a Water of the United States (e.g., a traditional navigable water or a relatively permanent tributary to one) and are regulated by the USACE under Section 404 of the *Clean Water Act*. Any action involving discharge of dredge or fill materials into a jurisdictional wetland requires a permit (commonly referred to as a Section 404 permit) from USACE to do so. Such a permit may be accompanied by a requirement to establish, or contribute to the establishment of, replacement wetlands at some other location.

The State of Hawaiʻi regulates wetlands under its surface water regulations (HAR 11-54) and the general policy of water quality anti-degradation. In its regulatory definitions, the State indicates "wetlands may be fresh, brackish, or saline and generally include swamps, marshes, bogs, and associated ponds and pools, mud flats, isolated seasonal ponds, littoral zones of standing water bodies, and alluvial floodplains." Any wetland action that requires a Section 404 permit from the USACE also requires certification from the State pursuant to Section 401 of the *Clean Water Act*. Individual certification applications are required if the project cannot be authorized under one of the State's conditional blanket Section 401 certifications. In either case, the certification dictates BMPs and monitoring and assessment plans to ensure project discharges comply with State water quality standards (ELI 2008). Wetlands are also known to attract and house protected species, warranting a biological review prior to project development of any renewable project to be sited in a wetland.

3.3.4 OCEAN

3.3.4.1 Surface Temperatures and Salinity

Surface water temperatures in the North Pacific have a strong north-to-south gradient, but in the area of the Hawaiian Islands, the isothermal lines depicting that gradient tend to veer from an east-west path to one that almost parallels the island chain. As a result, there is not as much difference in ocean surface temperatures between the islands as might be expected based just on the north-south distances involved. The annual cycle of surface water temperatures is relatively small. On Oʻahu, surface water is coldest from February to April and warmest from August to October, but the difference in average temperature between the two extremes is only about 6°F (3°C). During the cold period, the surface water temperature averages 75°F (24°C) and during the warm period, the average is 81°F (27°C) (UH Hilo 1998).

The salinity of the ocean's surface water is affected by the relationship of the region's evaporation and precipitation rate. In the large ocean band between latitudes 15 and 36 degrees north, which includes the Hawaiian Islands, evaporation exceeds precipitation so salinity is slightly higher than either to the south or north of the band. At about 26 degrees north, roughly midway in the band, ocean water salinity is at its highest, at about 35.2 parts per thousand. Whereas, at a latitude of 10 degrees north, the surface water's salinity reaches a minimum of 34.3 parts per thousand (UH Hilo 1998).

3.3.4.2 Vertical Profiles of Water Properties

The surface of the ocean is subject to wind and wave mixing so the water temperature stays fairly constant within a turbulent layer. During the stormy winter periods, this layer can be nearly 400 feet (120 meters) thick; in the calmer summer time, it can be less than 100 feet (30 meters) thick. Below the mixed layer, there is a zone called a *thermocline*, where the temperature decreases rapidly with depth. In the thermocline, temperature drops from about 77°F (25°C) in the turbulent layer to 41°F (5°C) at a depth of 2,300 feet (700 meters). The water temperature decreases at a much more gradual rate below the thermocline until it reaches the temperature at the ocean floor, which is at about 35°F (1.5°C). Figure 3-36 shows a typical, average ocean temperature profile for the area of Hawaiʻi. This profile is based on a NOAA weather buoy monitoring site located at latitude 23 degrees, 24 minutes north and longitude 162 degrees, 20 minutes west (PacIOOS 1996), which is about 280 miles northwest of Kauaʻi.

Figure 3-36 shows that the average vertical profile for salinity has some similarities with that of temperature, but also notable differences. Salinity concentrations are high in the turbulent surface layer due to the evaporation-precipitation relationship described above. The changes in concentration are then due primarily to sinking of lower-salinity water coming in from the north. The initial increase from the surface down to about the 500-foot (150-meter) depth is attributed to higher salinity surface water north of Hawai‘i; the lower salinity water is from farther to the northwest. Below the depth of influence from water from the north, salinity levels increase gradually with depth toward a concentration of 34.7 parts per thousand for the deep ocean (PacIOOS 1996).

Figure 3-36 also shows a vertical profile for nutrients as measured by concentrations of nitrite (NO_2) and nitrate (NO_3). Nutrients are depleted in the upper layer where there is enough sunlight for photosynthesis and the growth of phytoplankton to occur. The nutrient levels then increase with depth as the amount of light decreases and photosynthesis diminishes. At locations and times of vertical motions at these depths, nutrients brought up from below can result in increased biological activity in the near surface layers. Vertical distributions of phosphate and silicate concentrations are similar to those shown for NO_2 and NO_3 nutrients (UH Hilo 1998).

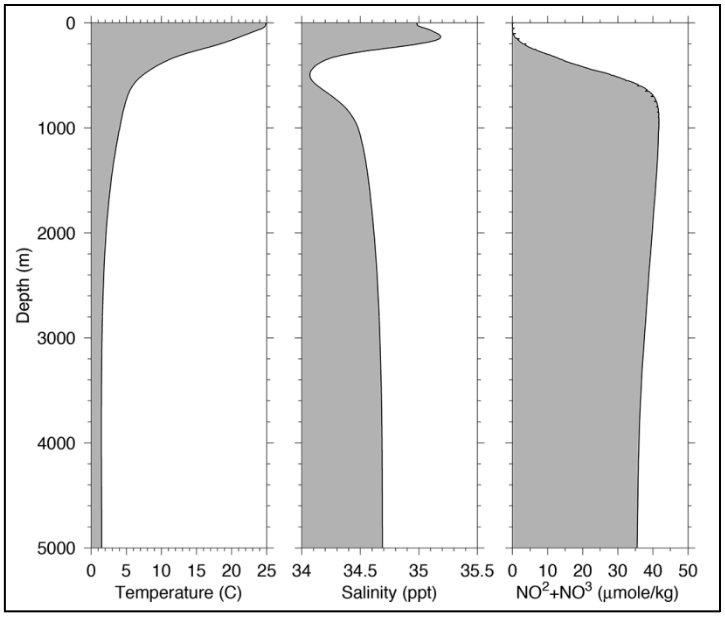


Figure 3-36. Vertical Profiles of Several Ocean Properties (Source: PacIOOS 1996)

3.3.4.3 Ocean Currents

The depth of the thermocline varies in different parts of the ocean and the variations in temperature are associated with changes in water density and water column pressures. These variations in pressure are responsible for ocean currents. The pressure-driven currents and the earth’s rotation combine to result in geostrophic (related to the force caused by the earth’s rotation) currents that form large, basin-scale, circulations called a *gyre*. In the northern hemisphere, these gyres have a clockwise circulation. The main Hawaiian Islands are in the southern portion of the North Pacific Gyre, which is centered at about 26 degrees north latitude. At the Islands’ location, ocean water circulation is roughly from east to west, with the current intensifying to the south of the islands. At the surface, however, these currents are greatly influenced by wind and result in much more complicated flow patterns (UH Hilo 1998).

The ocean currents around the islands are further complicated when the gyre currents and winds interact with the island masses. The gyre currents and winds move in between islands, forcing increased velocities in both and basically generating systems of eddies on the leeward sides of the islands. This is particularly true of Hawai‘i island, where eddies can cause significant changes in circulation over relatively short distances. This can include large differences in the depth of the thermoclines within different eddies. Satellite images of surface temperatures even show upwelling of cold water in this area (UH Hilo 1998).

In the early 2000s, the National Aeronautics and Space Administration (NASA) announced some unexpected findings with regard to ocean currents and Hawai‘i. NASA found evidence from a satellite using microwave radar to measure wind that Hawai‘i’s wake (the disturbance in the westerly flow of wind and water caused by their encounter with the islands) stretches nearly 5,000 miles across the ocean to Asia. It is believed a disturbance of such great length was able to develop because the winds and current at Hawaiʻi's location are so predominantly east to west. It is also speculated that the countercurrent generated within the wake may have provided the route by which Polynesians were able to reach the Hawaiian Islands thousands of years ago against the prevailing currents (NASA 2002).

3.3.4.4 Tides and Surface Waves

3.3.4.4.1 Tides

Tides are predictable because they are caused by the positions of the moon and, to a lesser extent, the sun. The gravitational attraction of the moon creates a bulge of water in the nearest ocean. At the same time on the opposite side of the earth, where the gravitational influence of the moon is at its lowest, another ocean bulge is formed. In this case the bulge is formed by the force of inertia that results from the earth's rotation (NOAA 2008). During the earth's daily rotation, a location on the ocean's surface passes through these two bulges of water, so there is a semidiurnal (or half-daily) component to the tides. Since the moon is not positioned directly over the equator (in that it is not in a constant position with regard to the earth's rotation), a single point on the ocean experiences one of the bulges as larger than the other as it rotates. This results in a diurnal (or daily) component to tides. Accordingly, most locations subjected to tides experience two high tides (one higher than the other) and two low tides each day. These tides are basically very long period waves that move through the ocean in response to the forces exerted by the moon and sun (NOAA 2008) coupled with those resulting from the earth's rotation.

Although tide levels are predictable, they are also quite complicated. For example, the two bulges on the opposite sides of the earth are aligned with the positions of the moon, and to a lesser extent the sun, but the moon and sun's positions change over time with respect to their angle from the equator. This causes the locations of the bulges' high areas to change over time in addition to the daily cycles. Also, it takes 24 hours and 50 minutes for the earth to rotate such that the same location is positioned beneath the moon. This is because the moon is orbiting in the same direction as the earth's rotation and progresses farther (50 minutes of Earth rotation time) when the earth has rotated to its starting point in 24 hours. As a result, the semidiurnal and diurnal periods of the tides do not quite match up with true daily cycles. Added to this are the cycles by which the sun affects the tides. When the moon and the sun are in alignment on the same side of the earth (that is, at the time of the new or full moon), the added gravitational pull of the sun results in extra-high high tides, referred to as spring tides, and very-low low tides. A week later, when the sun and moon are at right angles to each other in relation to the earth, the tidal bulges are lowest and are referred to as neap tides. So two sets of spring tides and two sets of neap tides occur during each lunar month. As the distance from the earth to the sun changes over the seasons, the sun's influence on the tides also changes.

The tidal currents resulting from tidal variations in sea level are relatively weak in the open ocean, but near inlets or narrow straits, their speeds can be significant, often stronger than the large-scale currents described above. The tidal currents off Oʻahu, Maui, and Hawaiʻi tend to align with shorelines, as shown in Figure 3-37. But there is significant variability in the tidal currents due to the variability of the tides themselves and the other currents affecting the islands. In Figure 3-37, current speeds are presented in metric units of centimeters per second. As a point of reference, 45 centimeters per second is equal to a velocity of 1 mile per hour.

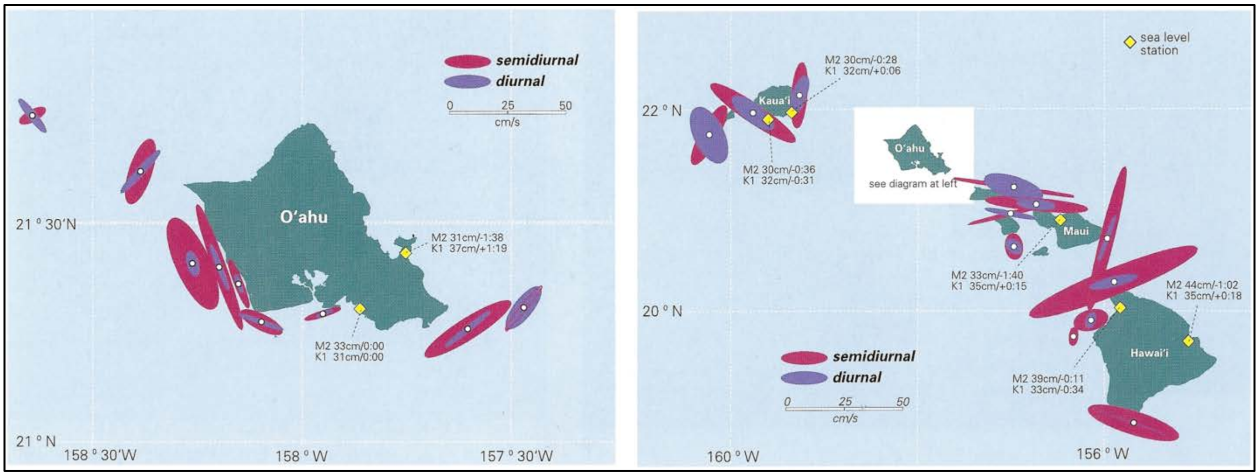


Figure 3-37. Tidal Current Directions and Velocity Ranges within the Hawaiian Islands (Source: UH Hilo 1998)

3.3.4.4.2 Waves

The open seas offshore of the Hawaiian Islands are moderately rough with wave heights of 3 to 14 feet depending on the season and the intensity of the trade winds. Moving between islands, the seas intensify, and on the leeward sides of the islands, the seas are generally calmer. Sea conditions outside of these norms can occur during winter when the winds can shift to the northwest or southwest.

The northeastern shores of the islands typically are exposed to moderate trade wind seas and the associated waves. The northwestern shores receive some of these waves, but their highest exposures are from the large swells generated in the northwest Pacific during winter. The famous North Shore of O‘ahu occasionally gets breaking waves with heights over 50 feet. The northern shores of the islands are calmer in summer.

Southern shores of the islands are shielded from the northwest swells and are usually calm in winter. In the summer, however, these shores are subject to swells from storms in the southern hemisphere. These waves generally have lost much of their energy by the time they reach the Hawaiian Islands and rarely approach anything like the heights seen on the northwestern shores (PacIOOS 1996).

3.3.5 COMMON CONSTRUCTION AND OPERATION IMPACTS

Common construction and operation impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

3.3.5.1 Surface Water

Effects on surface water from common construction actions would be limited primarily to the potential for storm water runoff from construction areas to carry sediments or other contaminants away from the site and to receiving waters. Sediments or other contaminants reaching a receiving water could cause that water to exceed applicable water quality standards, possibly posing a threat to the stream’s biota or its designated uses. In some locations, the displacement of contaminants or sediments could have adverse impacts on traditional and customary native Hawaiian practices, such as loi taro farming, loko ia (fishponds), and loko ia kalo (combination fish and taro farming), which are addressed in Section 3.6. As described in HAR 11-55, “Water Pollution,” any construction activity that would disturb one or more acres of land is required to obtain an NPDES permit for storm water discharges before beginning construction. The common construction actions addressed here are assumed to involve land disturbance of one or more acres, which would be applicable to most of the utility-scale renewable energy projects. To obtain this storm water NPDES permit, the action proponent must develop a construction site BMPs plan that includes (Appendix C of HAR 11-55):

- A county-approved erosion and sediment control plan,
- A site-specific plan to minimize erosion of soil and discharge of other pollutants into State waters, and
- Descriptions of measures that will minimize the discharge of pollutants via storm water after construction operations have been finished.

These would be considered the minimum requirements because, depending on the project location, the proponent may also be subject to county permitting requirements. Also, on Oʻahu, construction activities on or adjacent to State highway rights-of-way would have additional storm water permitting requirements because of the Hawaiʻi Department of Transportation's NPDES permit for the Oʻahu municipal separate storm sewer system (MS4).

In general, the construction activities associated with renewable energy projects would not be expected to involve unusual activities or sources of potential contamination, so common BMPs would be implemented and would be expected to provide appropriate protection for the area's storm water collection system and receiving waters. The primary concern with regard to pollutants for common construction actions would be spills or leaks of fuel and lubricants from vehicles and equipment, and the types of precautions normally implemented (such as response plans, cleanup equipment, and secondary containment) would keep the potential for storm water runoff contamination at a minimum.

Storm water runoff from the construction site would likely be decreased when there were large areas of loosened, disturbed soil present, but these would be only temporary changes. The long-term effects from construction would be expected to involve increases in the amount of impervious surfaces with associated increases in runoff. On a large scale this could result in impacts to surrounding streams, rivers, and ultimately the ocean. But the design of new facilities would be required to address and provide for appropriate storm water runoff collection and control systems. This could consist of measures such as connections to existing storm water collection systems; controlled and, as applicable, permitted discharges to existing surface drainage systems; or collection areas designed for groundwater recharge. In most cases, storm water runoff from a single, operating renewable energy project would be relatively minor, but storm water management would still need to be an element of its design.

3.3.5.2 Groundwater

Normal construction actions would not be expected to impact groundwater. If excavations required for construction of foundations were to encounter groundwater and if dewatering measures were required, the removed water would have to be discharged under a NPDES permit. The permit would require BMPs in dealing with the water, which could include treatment such as settling ponds or filtration systems in order to meet discharge standards. The excavation and construction actions would not be expected to involve any unusual sources of contamination, so BMPs should be well defined and there would be little potential for either surface water or groundwater contamination from any dewatering actions. As noted above for Oʻahu construction activities on or adjacent to State highway rights-of-way, there would be additional permitting requirements for discharges if they involved the storm sewer system because of the HDOT NPDES permit for the Oʻahu municipal separate storm sewer system (MS4).

Periods during construction when loosened soil conditions result in decreased storm water runoff, as described above, would also represent periods when there would be more storm water soaking into the ground and potentially providing additional recharge to groundwater. As noted previously, these would be temporary conditions with little potential to have any notable effect on groundwater.

Water needs during construction would be expected to come from groundwater resources, either via municipal water systems or private wells, but they would be minor, involving such uses as for dust suppression and in soil compaction.

3.3.5.3 Floodplains and Wetlands

The proponent of a renewable energy project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, were the project located in a floodplain or wetland area, certain requirements and potential effects can be described.

If the project were in a floodplain, construction activities would be temporary and unlikely to be impacted by flooding or to impact flood zone boundaries. It is assumed that facilities and equipment would be designed to incorporate appropriate flood protection measures. This could be no more than keeping critical items above flood levels. To meet Federal Emergency Management standards, flood protection measures could also involve having elevated platforms for sensitive equipment and breakaway walls for areas of the structure below the base flood elevation. It is reasonable to assume such actions would be taken because they protect the value of the facilities and equipment and would likely be required by building permits as well as insurers. If in a floodplain, facilities would take up space that would otherwise be available for flood water. Without features such as the breakaway walls below the base flood elevation, the action would therefore change the height and area of inundation for a given magnitude flood. Depending on the characteristics of the flood zone and the proximity of other facilities, flood level changes could adversely impact other facilities. County agencies responsible for issuing building permits would be considering these types of concerns and would be expected to deny building permits or require mitigation measures if potential effects to flood levels were anything but minor. If the representative project was part of a Federal action or if it was, in whole or in part, Federally funded, the applicable Federal agency would be required to adhere to requirements of Executive Order 11988, “Floodplain Management,” which requires Federal agencies to take actions to reduce the risk of flood damage; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains.

If wetlands were present in the construction area, there is a high probability they would be jurisdictional wetlands (for example, associated with a traditional navigable Water of the United States or a relatively permanent tributary to one) and regulated by the USACE under Section 404 of the *Clean Water Act*. Accordingly, if it could not be avoided, any action involving discharge of dredge or fill materials into the wetland would require a permit from the USACE to do so. Such a permit could be accompanied by a requirement to establish, or contribute to the establishment of, a replacement wetland at some other location. Any wetland action that requires a Section 404 permit from the USACE must also obtain certification from the State pursuant to Section 401 of the *Clean Water Act*. The certification dictates BMPs and monitoring and assessment plans to ensure project actions associated with the wetlands area comply with State water quality standards. If there was any question about the applicability of a Section 404 permit, discussion with the USACE would be the appropriate course of action.

In the unlikely event that either floodplains or wetlands were present in the project area, permitting requirements and anticipated building restrictions would minimize the potential for any serious environmental consequences.

3.3.6 COMMON BEST MANAGEMENT PRACTICES

BMPs associated with water resources are presented in two categories: general BMPs and BMPs specific to construction.

General BMPs

- Prioritize technologies that minimize water use.
- Promote the sustainable use of water resources through appropriate technology selection and implementation of conservation practices that protect and preserve the function, acreage, and quality of the existing natural water bodies (including streams, wetlands, ephemeral washes, and floodplains, as well as groundwater aquifers and recharge areas).
- Consider the use of rain, gray, and/or other recycled water for facility operations, including plant cooling, steam generation, irrigation, maintenance, and dust suppression.
- To the extent practicable, minimize the use of and impacts on surface and groundwater resources (including sole source aquifers) during construction and operations.
- Avoid groundwater resource project requirements that would result in over appropriation or over drafting of any groundwater basin.
- Identify source capacity, prior water rights, and adequacy of capacity to serve project requirements and dependent biological resources in the area.
- Avoid or minimize the use of land within an identified 100-year floodplain or identify engineering controls to mitigate potential impacts.
- Avoid locating facilities on steep slopes, in alluvial fans, and in other areas prone to landslides or flash floods, or within gullies or washes.
- Compare preliminary site grading, drainage, erosion, and sediment control plans with applicable county jurisdiction requirements
- Consult Federal, State, and county "water-wise" guidelines, as applicable, for project development in the arid areas.
- Coordinate with the USACE to discuss the reach and extent of waters of the United States on the proposed project site. As appropriate, present a reasonable range of on- and offsite alternatives and an analysis that evaluates alternatives to avoid impacts on waters in compliance with Section 404 of the *Clean Water Act.*

Construction BMPs

Best management practices that would be considered during construction actions to prevent storm water runoff from carrying sediments off the site are basically the same as those described in Section 3.1.4 for controlling soil erosion and include the following (from Appendix C of HAR 11-55):

- Construction management techniques:

- Hold clearing and grubbing to the minimum necessary for grading and equipment operations.

- Sequence construction actions to minimize the exposure time for any cleared surface area. For large projects, phase construction actions so that areas disturbed in one phase can be stabilized (that is, protecting disturbed soil from rainfall impacts and runoff) before another phase is initiated.

- Have erosion and sediment control measures in place and functional before beginning earth moving operations and ensure their proper monitoring and maintenance throughout the construction period. This includes establishing a monitoring schedule that is consistent with the use of the control measures; for example monitor the control measures weekly during dry periods, within 24-hours of rainfall, and daily during prolonged rainfall. Maintain records of monitoring checks and repairs.

- Maintain records of the duration and estimated volume of storm water discharges.

- Assign a specific individual to be responsible for erosion and sediment controls at each project site.

- Vegetation controls:

  – Avoid disturbance of existing vegetation more than 20 days prior to land disturbance.

  – If disturbed areas are to remain unfinished for more than 30 days, apply temporary soil stabilization using appropriate vegetation.

  – Apply permanent soil stabilization, with perennial vegetation or pavement, as soon as practical after final grading. If perennial vegetation is used, provide irrigation and maintenance for 30 days or until the vegetation takes root.

- Structural controls:

  – Divert storm water flows away from the construction area using appropriate control measures, as practical.

  – Design erosion control measures according to the size of the disturbed or drainage areas to detain runoff and trap sediment.

  – Discharge water in a manner that does not cause or contribute to a violation of water quality criteria established for the specific location.

Best management practices that would be considered during construction actions to minimize the potential for storm water runoff carrying contaminants off the site include the following (EPA 2007):

- Design and implement waste management procedures and practices that address actions such as trash disposal, recycling, proper material handling, and cleanup measures. Provide toilet facilities that are regularly inspected and serviced and located away from storm drain inlets and waterways.

- Establish comprehensive procedures for the handling and management of building materials, particularly those that may be hazardous or toxic (paints, solvents, pesticides, fuels and oils, etc.) and store such materials indoors or under cover whenever possible or in areas with secondary containment. Designate staging areas for activities such as fueling vehicles/equipment, mixing paints, mixing mortar, and so on.

- Designate washout areas for concrete operations as well as for operations such as painting or stucco use and keep such areas at least 50 yards from storm drains and watercourses whenever possible.
- If equipment/vehicle fueling and maintenance actions must be performed on-site, create a clean and dry site, covered if possible, with a spill kit present and staff that know how to use it.
- Establish procedures and practices for equipment/vehicle washing that include use of off-site facilities; washing in designated, contained areas only; eliminating discharges to storm drain by using infiltration systems or routing to the sanitary sewer; and training staff in proper washing procedures.
- Develop a spill prevention and response plan that identifies ways to reduce the chance of spills, stop the source of spills, contain and clean up spills, dispose of spill residues, and train appropriate personnel.

Although the above measures are designated BMPs, it should be noted that the intent of the storm water NPDES permit described in Section 3.3.5 is that the proponent develop plans that identify the control measures they will be implementing. Those plans and the control measures then become requirements under the permit, unless there are more stringent requirements in the permit’s standard conditions.

3.4 Biological Resources

Hawai‘i is an island chain located 20 degrees north of the equator, more than 2,000 miles from the nearest continent. Despite its small size (4.1 million acres) Hawai‘i is characterized by a wide variation in elevation, temperature, precipitation, and habitat and, therefore, biological communities.

3.4.1 TERRESTRIAL ECOSYSTEMS

The terrestrial ecosystems of Hawai‘i are the result of multiple factors including geography, geology, topography, climate, and humans. The geographic isolation from continental land masses and other oceanic archipelagos has had a major influence on the composition and development of the flora and fauna. Because the Hawaiian Islands are oceanic islands built by volcanic eruptions from the seafloor, the flora and fauna (i.e., prior to human habitation) had to arrive by long-distance dispersal. The biota lacks representation of many plant and animal species that populate continental land masses. Those species with the best dispersal capabilities, such as species capable of flight such as birds and bats and plants dispersed by wind, birds, or water (e.g., floating seeds), are well represented while those groups lacking the ability to cross ocean waters (amphibians and mammals) are rare or absent (Juvik 1998). Geographic isolation also allowed the speciation and development of biota unique to the Hawaiian Islands. This resulted in a native biota composed of a large number of endemic species (i.e., species that occur only in Hawai‘i) and smaller numbers of indigenous species (i.e., species that occur elsewhere but colonized Hawai‘i without human assistance). Local topography (shaped by geological processes) through elevation, slope, and aspect and climate (temperature, wind, and precipitation patterns) influence the distribution of biota within and among the islands.

Humans have affected the biota of Hawai‘i dating back to the arrival of the first Polynesian settlers approximately 1,500 years ago. Because Hawai‘i ecosystems developed in isolation from many of the large herbivores, predators, and biological competitors found on continental systems, many Hawaiian plant and animal species have been significantly affected by human-assisted introduction of nonnative animals and plants. Early settlers introduced largely domesticated species whose impacts were largely confined to lower elevation cultivated areas. As European human habitation increased, agriculture, forestry, and urbanization physically altered the landscape and the rate and establishment of newly introduced species and resulting impacts on both flora and fauna greatly increased. New plant and animal species were introduced both intentionally and accidentally. Intentional introductions have included plants and animals for food production, fiber, forestry, and landscaping. Other introductions were made as biological control responses to species previously introduced that had become invasive species. Other species arrived unintentionally in soil or as seeds through the importation of other products and plants.

3.4.1.1 Flora

The origins of the Hawaiian flora are derived from multiple sources but primarily by plants with origins in the Indo-Pacific, the Americas, and the South Pacific regions. However, the native Hawaiian flora developed largely in isolation from a relatively small number of indigenous species as evidenced by the high degree of endemism (85 to 95 percent). The present day flora contains a great number of introduced species (i.e., alien species), many of which have become established, some of which have become invasive. Other introduced species exist only in forestry and cultivated plantings and have not established self-sustaining populations.

The vegetation of Hawaiʻi is complex in part because of the large environmental variations over short distances. A case in point is on Kauaʻi where over a distance of 15 to 20 miles, average annual rainfall varies from about 20 inches (semiarid) along the leeward southern coast to 450 inches (over 37 feet) on the windward side of Mount Waiʻaleʻale (elevation 5,066 feet) in the center of the island. Through many efforts to develop vegetation classification systems for the Hawaiian vegetation, one system that has been commonly used is to classify plant communities into broader vegetation zones or habitats based on topography, moisture regimes, elevation, and substrate (Pratt and Gon 1998).

Understanding the roles of climate and topography is important in appreciating the types and distribution of the vegetation zones. Because of Hawaiʻi's geographic position between 18 to 22 degrees north latitude, the overall climate is subtropical with warm temperatures along the coasts and lower elevations featuring little daily or seasonal variations. The surrounding ocean moderates temperatures because it heats and cools much slower than land surfaces. However, because of mountainous terrain, Hawaiʻi has areas that frequently experience freezing temperatures.

A significant feature of the climate is Hawaiʻi's geographic position relative to the global atmospheric circulation pattern (Section 3.2.1). The prevailing winds are the descending northeasterly trade winds. When the winds intersect mountainous terrain of the islands, the moist air is forced to rise, cooling and saturating the air, resulting in heavier precipitation on the windward side (i.e., places with north and northeasterly exposures). In contrast, the leeward sides of the mountains are substantially drier because the mountains either block the moisture or the moisture is lost as precipitation before it reaches the leeward side (i.e., these areas are in a rain shadow). The rain shadow causes significant variation in rainfall over relatively short distances.

Another important aspect of the descending northeasterly trade winds is the creation of a mid-altitude (i.e., 5,000 to10,000 feet) temperature inversion. The trade winds warm as they descend creating a warm air layer above rising warm, moist surface air that forms clouds as the air rises and cools. The warm trade wind layer inhibits the rising surface air and prevents the formation of deep clouds that are more effective at producing precipitation. The consequence of this temperature inversion is that the upper slopes of Hawaiʻi's higher mountains such as those on Maui and Hawaiʻi often experience clear skies (i.e., above the cloud layer), low humidity, and low precipitation. Therefore, the subalpine and alpine vegetation zones are typically cool and dry.

Hawai‘i has five major ecological zones defined by elevation (Pratt and Gon 1998) (see Table 3-31). Although considered a subtropical climate, Hawai‘i does have vegetation zones that experience frost and freezing temperatures. Within these five ecological zones are vegetation zones that are more specifically defined by the amount of precipitation (classified as dry, mesic, or wet). Vegetation zones classified as “dry” typically receive less than 50 inches of annual rainfall and may have seasonal dry periods (e.g., summer months) with limited precipitation. Mesic (moist) zones receive about 50 to 100 inches of annual rainfall. Wet zones average more than 100 inches of rainfall per year.

Table 3-31. Ecological Zones of the Hawaiian Islands Based on Elevation Range

Ecological Zone	Elevation Range (feet)	Key Environmental Factor
Alpine	> 9,000	Frost common
Subalpine	6,000 - 9,000	Frost frequent
Montane	3,000 - 6,000	Frost infrequent
Lowland	0 - 3,000	Frost-free
Coastal	0 - 100	Sea spray

Source: Pratt and Gon 1998.

In addition to the ecological and vegetation zones, a third level of classification uses vegetation physiognomy or structure (e.g., grassland, shrubland, and forest). The classification and description of Hawai‘i vegetation zones presented in the following sections was adopted from multiple sources but largely follows the 10 broadly defined ecological systems from *An Ecoregion Assessment of Biodiversity Conservation for the Hawaiian High Islands* (TNC 2006). The primary difference among native vegetation zone classification schemes involves the amount of grouping versus partitioning of zones by elevation, precipitation amount (dry, mesic, or wet), or vegetation physiognomy (grassland, shrubland, and forest). For example, some authors may ignore elevation differences and simply combine the lowland wet and montane wet forest zones into a wet forest or rainforest. Others may separate a lowland dry community but include both dry shrublands and dry forests within the same classification. Still others may separate lowland dry shrubland from lowland dry forest.

3.4.1.1.1 Coastal Vegetation

The coastal zone is a relatively narrow strip of vegetation that encircles each island up to an elevation of about 100 feet. Vegetation in this zone is greatly influenced by the ocean, particularly sea spray, and in some areas there exist plant communities composed of salt-tolerant species. This zone is sometimes divided into two zones: strand and coastal. The strand zone is those areas affected by sea spray and occurs along the edge of the ocean while the coastal zone occurs just inland from the strand zone. This PEIS considers these as one vegetation zone. The substrates in this zone are highly variable and include sandy beaches, basaltic and coral boulders, basaltic cliffs, and coral substrates. Rainfall may vary between less than 30 inches to around 120 inches depending on whether the location is on the leeward or windward side of the island. Coastal forests may occur on some mesic windward shores. These forests were most often dominated by hala (*Pandanus tectorius*) but many of these coastal forests have been eliminated. Naupaka kahakai (*Scaevola sericea*) is an important native shrub throughout the coastal system. The diversity of species in this zone was related to the variety of substrates and variation in rainfall. Coastal plant communities have been severely altered by humans because most of the urbanization and tourist industry has developed along the coasts. Many of the plant species now observed along the coastal regions are introduced species especially near population centers and resorts (Sohmer and Gustafson 2000).

3.4.1.1.2 Lowland Dry Forest and Shrub

The lowland dry ecosystem occurs below ~3,000 feet and above the coastal vegetation zone on the leeward side of the islands. This vegetation zone has annual precipitation between 20 to 50 inches and is seasonally dry. This zone has a variety of natural plant communities including grasslands, shrublands, and forest. This zone was once one of the most diverse vegetation zones on the islands but has been extensively altered by human activity because of its proximity to the coast and because the moderate topography makes it suitable to human development. Remnants of native lowland dry forest and shrubland occur across the islands but most of this zone contains urban development, resorts, and land modified for agriculture and rangeland. The lowland dry forest and shrub zone, like many of the other vegetation zones, has been negatively impacted by feral ungulates. Some of the formerly dominant species include ʻohiʻa (*Metrosideros polymorpha*), lama (*Diospyros sandwicensis*), olopua (*Nestegis sandwicensis*), and wiliwili (*Erythrina sandwicensis*) trees, ʻaʻaliʻi shrubs (*Dodonaea spp.*), and pili grass (*Heteropogon contortus*) (Mitchell et al. 2005).

3.4.1.1.3 Lowland Mesic Forest and Shrub

Mesic forest and shrub vegetation occurs in lowland areas with about 50 to 75 inches of annual precipitation and can be found on both windward and leeward sides of the islands up to elevations of 4,000 feet. It typically occurs above the Lowland Dry Forest and Shrub zone. The lowland mesic forest and shrub zone is the most species-rich of the vegetation zones on the Hawaiian Islands. However, like the lowland dry forest and shrub zone, it is highly disturbed or entirely eliminated in many areas. The lowland mesic forest and shrub zone does not suffer extended dry periods like some of the lowland dry and coastal zone communities but receives less rainfall than the rainforests (wet forest). This vegetation typically consists of open-canopy forest with a mixture of trees and shrubs and contains many endemic plant species. The line of demarcation between the lowland dry forest and mesic forest is often difficult to define. Some authors define a lowland dry shrub and grassland zone and then combine the lowland dry and mesic forest into one vegetation zone. In the remaining lowland mesic communities, dominant plants include kāwelu (*Eragrostis variabilis*), pūkiawe (*Styphelia tameiameiae*), ʻaʻaliʻi (*Dodonaea viscosa*), and ulei (*Osteomeles anthyllidifolia*) shrubs, and koa (*Acacia koa*), ʻohiʻa, and lama (*Diospyros sandwicensis*) trees (Sohmer and Gustafson 2000; Mitchell et al. 2005).

3.4.1.1.4 Dry Cliff

The dry cliff vegetation zone occupies steep (greater than 65-percent) slopes in areas receiving less than 75 inches of annual rainfall or where the cliff has a dry substrate and is generally best developed on the leeward side of the islands. The dry cliff zone typically occurs below or adjacent to the lowland mesic or lowland dry forest and shrub vegetation zones. The communities within the dry cliff zone are usually composed of grasses and shrubs as the slopes are too steep to support forests. Some authors include dry cliffs as a community type with the lowland dry or mesic zones. Biological diversity is lower than many of the other vegetation zones and is relatively inaccessible to human activity. Several species have adapted to this environment including Hawaiian wormwood (*Artemisia australis*), ʻakoko (*Euphorbia celastroides*), and species of *Schiedea* and *Bidens*. *Tetramolopium filiforme*, an endangered aster, occurs on dry cliffs on Oʻahu.

3.4.1.1.5 Lowland Wet Forest

The lowland wet forest and montane wet forest zones together compose Hawaiʻi's rainforests. Some authors treat these two vegetation zones as one. Because of large elevation range over which rainforest occurs in Hawaiʻi (sea level to 6,000 feet), the lower and upper rainforest zones have been impacted differently by human activity. For the purposes of understanding potential impacts of renewable energy technologies, the wet forest or rainforest is described as two separate zones. The boundary between the lowland and montane wet forest is generally not agreed upon by ecologists but probably ranges from 1,500 to 3,000 feet. Defining the boundary is complicated by the human disturbance that has occurred in the lowlands. Lowland wet forest is a vegetation zone of the windward side of the higher islands and to the summits of lower islands. Annual precipitation is typically greater than 80 inches and is often 150 to 300 inches. Similar to other lowland ecosystems of Hawaiʻi, the lowland wet forest has been greatly modified by human activity for agriculture and urban development, particularly in windward valleys and gently sloping tablelands. However, where lowland wet forest still exist, biological diversity is high. Dominant plants include ʻohiʻa and koa trees, mamaki (*Pipturus albidus*) and uluhe (*Dicranopteris linearis*) shrubs, and hāpuʻu ferns are an important component of the native understory.

3.4.1.1.6 Montane Wet Forest

The montane wet forest occupies mountain slopes at elevations of about 3,000 to 6,000 feet either on the windward side of higher mountains and the summit regions of lower mountains. Annual precipitation exceeds 80 inches and is often much higher without a dry period. For example, the summit region of Mount Waiʻaleʻale on Kauaʻi receives about 450 inches (over 37 feet) of rainfall. Many areas of the montane wet forest are frequently enveloped in clouds or mist for long periods of time. Montane wet forest still covers large areas on some islands and has been less modified by human activities than lower elevation ecosystems. The upper elevation, steep topography, and climate have made the montane wet forest less accessible and conducive to human activity and habitation. This vegetation zone still faces impacts by both introduced plants and animals (for example, nonnative feral ungulates). This zone also includes bogs that form in generally small, poorly drained areas and has open vegetation composed primarily of grasses, sedges, and stunted woody plants. Important native plants include the ferns hāpuʻu (*Cibotium* spp.) and ʻamaʻu (*Sadleria* spp.), sedges (*Carex* spp.), *Oreobolus furcatus* (found in many bogs), and the ʻohiʻa tree.

3.4.1.1.7 Wet Cliff

The wet cliff vegetation zone occupies steep slopes (greater than 65-degree angle) in wet forest zones (both lowland and montane wet forest) located typically on windward sides of the islands where annual rainfall exceeds 80 inches. Some authors include this vegetation zone as a community type within the wet forest zones. Biological diversity is lower than the surrounding wet forest because the steep slopes and shallow soils prevent establishment of forests and many shrubs. Communities in the wet cliff vegetation zone include grasslands and shrublands. Dwarf shrubs such as ʻohiʻa (*Metrosideros polymorpha*), ʻōhelo ʻai (*Vaccinium reticulatum*), and the endemic species of the genus *Brighamia* (Sohmer and Gustafson 2000). Wet cliffs have been less impacted by human activity because of lack of access and steep topography and contain a variety of endemic species.

3.4.1.1.8 Montane Mesic Forest

The montane mesic forest zone typically occurs above the montane wet forest zone where annual rainfall is between 50 and 75 inches but is best developed on the leeward side of the islands. It also occurs on the windward side near the temperature inversion layer that creates drier conditions at higher elevations and occurs below the montane dry forest and subalpine zones. Montane mesic forest has a restricted distribution based on elevation and precipitation. ʻŌhia, koa, olopua (*Nestegis sandwicensis*), and aʻe (*Sapindus saponaria*) are dominant trees, and the understory is composed of diverse trees, shrubs, sedges, and ferns. The montane mesic forest also has been impacted through browsing, grazing, and soil disturbance by feral ungulates.

3.4.1.1.9 Montane Dry Forest

Montane dry forest is the primary vegetation zone of the leeward montane zone (3,000 to 6,000 feet) and annual precipitation is usually greater than 50 inches. This zone is restricted to the islands of Hawai‘i and east Maui. Dominant plants include ‘ohi‘a, ‘a‘ali‘i (*Dodonaea viscosa*), lovegrass (*Eragrostis atropioides*) and pili grass (*Panicum tenuifolium*). Feral ungulates also have impacted the montane dry forest zone.

3.4.1.1.10 Subalpine Woodland and Shrubland

Subalpine vegetation occurs between 6,000 to 9,000 feet and is restricted to Maui and Hawai‘i and occupies the near-summit regions of the highest mountains just below the alpine zone. This vegetation zone includes forest, shrubland, and grass communities. The subalpine is characterized by frequent frost, large diurnal variation in temperatures, clear skies, and relatively low annual precipitation (20 to 50 inches). High elevation zones in Hawai‘i are dry because the temperature inversion layer created by the northeasterly trade winds between 5,000 to 8,000 feet inhibits development of clouds at higher elevations. Biological diversity is not high but specialized plants and invertebrates exist here. Forests are dry and open woodlands of mamane-naio (*Sophora chyrsophylla* and *Myoporum sandwicense*) and occur on older lavas (Sohmer and Gustafson 2000). On younger, less weathered substrates on Hawai‘i island, open forests of low-statured ‘ohi‘a are common. Subalpine grasslands are dominated by the endemic bunchgrass *Deschampsia nubigena*. A variety of shrub species occur in the subalpine zone. Pukiawe (Styphelia tameiameiae) and ‘ōhelo ‘ai (*Vaccinium reticulatum*) are often dominate with ‘a‘ali‘i (*Dodonaea viscose*) and naenae (*Daubautia ciliolata*) being important components. A distinct dry shrubland of primarily ‘āweoweo (*Chenopodium O‘ahuense*) occurs in the saddle between Mauna Loa and Mauna Kea. Scattered silverswords occur on cinder cone substrates. Feral ungulates have had impacts on the vegetation of the subalpine zone.

3.4.1.1.11 Alpine Desert

The alpine vegetation zone occurs above 9,000 feet and is restricted to the islands of Maui and Hawai‘i and occupies summits of the highest mountains; Mauna Loa and Mauna Kea on Hawai‘i and Haleakalā on Maui. The alpine zone is characterized by frequent frost and freezing temperatures, large diurnal temperature variation, clear skies, and very low annual precipitation (less than 20 inches). Snow occurs in this vegetation zone. Communities in this vegetation zone are limited and consist of alpine lake, aeolian desert, and a sparse shrubland. Common shrub species include pūkiawe (*Styphelia tameiameiae*) and ‘ōhelo ‘ai (*Vaccinium reticulatum*). Also occurring in the alpine zone is the unique endemic ‘āhinahina or silversword (*Argyroxiphium sandwicense*). Very high elevation sites have very few plants and support a few mosses and lichens and some grasses (*Trisetum glomeratum* and *Agrostis sandwicensis*). Alpine zones have been impacted by feral and domestic ungulates.

3.4.1.1.12 Alien and Anthropogenic Areas

Many of the vegetation zones have been severely altered by clearing of vegetation for agriculture crops, pasture, firewood, urbanization, resort development, and by the introduction of nonnative plants and animals (Cuddihy and Stone 1990; Warshauer 1998; Pratt and Gon 1998). This impact has been most significant along coastal areas and lower elevation zones with less severe topography that is most suitable for human habitation and agricultural production (TNC 2006). Most of the vegetation along the coastal zone is nonnative species (Sohmer and Gustafson 2000). The least impacted vegetation zones are those at higher elevations and in regions with steep topography. However, even these more remote locations have been impacted either by introductions of nonnative plants or animals such as goats, sheep, pigs, and deer that have established self-sustaining populations (Cuddihy and Stone 1990).

3.4.1.2 Existing Vegetation by Island

Vegetation patterns across the islands follow a common theme. Most of the native vegetation at lower elevations from the coastline onto the flanks of the more mountainous terrain on each island has been greatly modified by vegetation clearing, introduction of nonnative species, and human development (i.e., urban, industrial, commercial, residential, and resorts). Within these areas, many of the native plant species have been replaced by introduced species. Most of the remaining native vegetation on each island is confined to upper elevations, mountainous terrain that is less accessible and amenable to human development. However, there are areas where native lowland vegetation communities still exist.

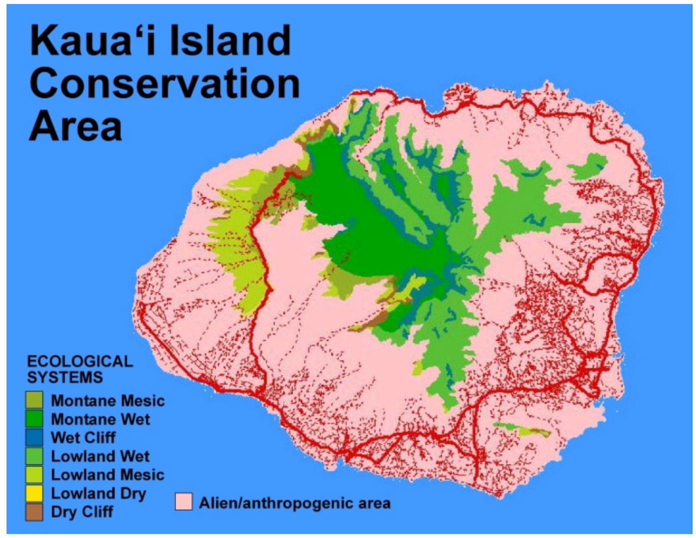


Figure 3-38. Location of Native Plant Communities on Kauaʻi

3.4.1.2.1 Kauaʻi

Most of the lowland dry and mesic forest and shrubland vegetation on Kauaʻi has been altered by human activity. This area was developed for agriculture such as sugarcane, resorts, and human habitation. Approximately 38 percent of the island is dominated by native vegetation (Mitchell et al. 2005). Most of the remaining native ecosystems occur in the central highlands and consists of montane mesic and wet forest, bogs, and cliff ecosystems (Figure 3-38) (TNC 2006). On the west side of island, an area of native lowland mesic and wet forest remains. The highest elevation on Kauaʻi is 5,243 feet and no subalpine or alpine ecosystems exist on the island. Annual precipitation in the central highlands is about 450-plus inches.

3.4.1.2.2 Oʻahu

Oʻahu comprises two volcanoes with a central plateau between them. Oʻahu is the most populous island of the State. The lowland dry and mesic forest and shrublands have almost all been altered by human activity. The remaining native ecosystems are associated with the upper elevations of the Koʻolau and Waiʻanae mountain ranges on the northeast and southwest sides, respectively, of the island (Figure 3-39) (TNC 2006). These are characterized by steep topography and poor access. Maximum elevation in the Koʻolau range is 3,105 feet and 4,003 feet in the Waiʻanae Mountains. Therefore, Oʻahu does not have any subalpine or alpine ecosystems. Lowland wet ecosystem is covers an extensive

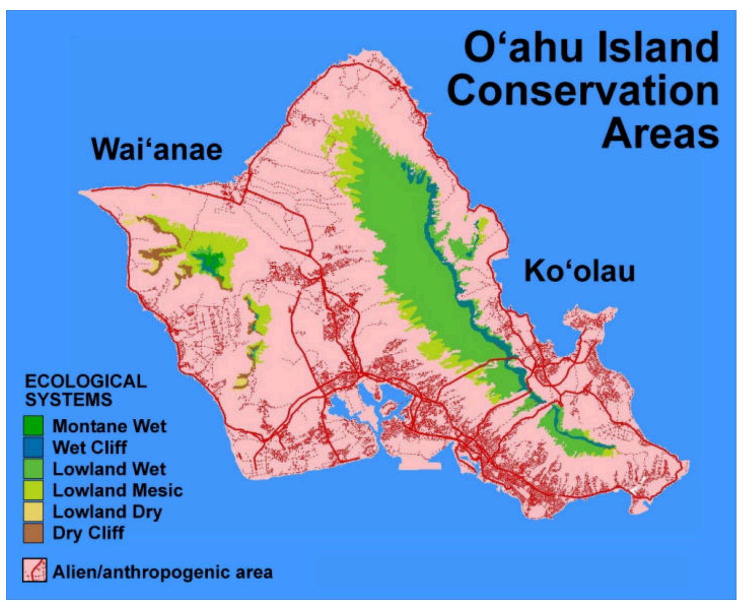


Figure 3-39. Location of Native Plant Communities on Oʻahu

area of the Koʻolau Mountains while the Waiʻanae Mountains are sufficiently high to have a small area of montane wet ecosystem. Small areas of lowland mesic ecosystems remain along lower elevations of both mountain ranges. An extensive wet cliff ecosystem remains on the steep windward (northeast) side of the Koʻolau range. Areas of the dry cliff ecosystem still exist along the steep southwest slopes of the Waiʻanae range.

3.4.1.2.3 Molokaʻi

The maximum elevation on Molokaʻi is 4,970 feet on the east end of the island, too low for subalpine and alpine ecosystems. Like the other islands, the lowland dry and mesic forest and shrubland ecosystems have been largely altered by human activity, particularly in the less mountainous western part of the island. The mountains of eastern Molokaʻi are cut into deep valleys by perennial streams, and due largely to their inaccessibility contain much of the remaining native vegetation on the island (Figure 3-40). Some areas of lowland mesic forest remain on the south slopes of the east Molokaʻi volcano with larger areas of lowland wet and montane wet forest at higher elevations (TNC 2006). Areas of the wet cliff ecosystem still remain on the steep north (windward side) slopes of the volcano. The coastal strand along Molokaʻi's northwest coast contains of the State's last intact dune systems.

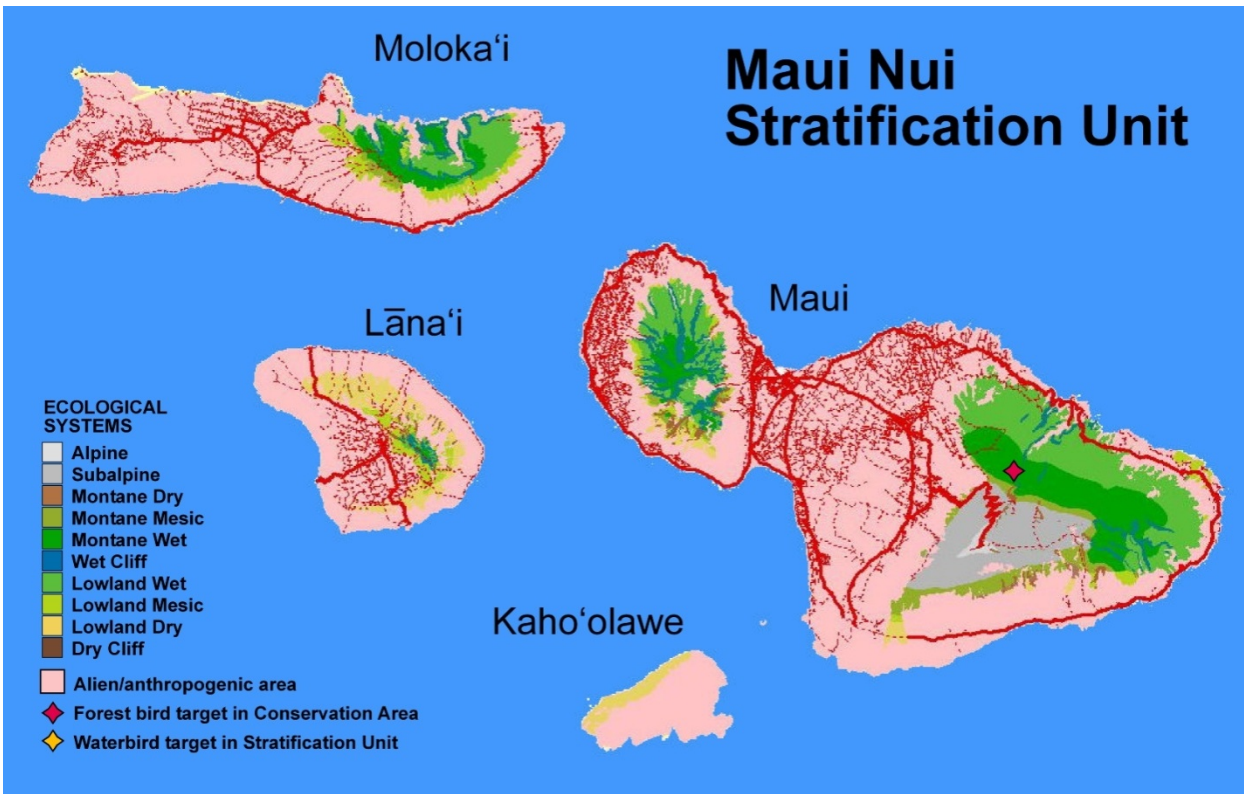


Figure 3-40. Location of Native Plant Communities on Molokaʻi, Maui, and Lānaʻi (Source: TNC 2006)

3.4.1.2.4 Maui

The island of Maui comprises two volcanic mountains connected by an isthamus. The West Maui Mountains is the oldest volcano with an elevation of 5,788 feet at Puʻu Kukui. Haleakalā or East Maui Volcano is larger and taller at an elevation of 10,023 feet. Approximately 30 percent of the island is dominated by native vegetation with the largest area occurring in East Maui (Mitchell et al. 2005). Native vegetation remains primarily on peaks and slopes of the two mountains. The lowland dry forest and shrub, lowland mesic forest, and montane dry and mesic forest have been replaced by anthropogenic vegetation although areas of native lowland vegetation exist in both East and West Maui. Areas of montane wet forest still remain in both East and West Maui. At 10,023 feet, Haleakalā supports a subalpine zone comprising forests, woodlands, and shrublands. A small alpine zone is present at the peak of the mountain. Some of these higher elevation zones have been impacted by feral ungulates such as goats, pigs, sheep, and deer.

3.4.1.2.5 Lānaʻi

Lānaʻi is the smallest of the six main Hawaiian Islands being evaluated in this PEIS. The highest point on the island, Lānaʻihale, is 3,370 feet near the center of the island. The upland area surrounding Lānaʻihale contains most of the remaining native vegetation, primarily mesic montane forest (Figure 3-41). Small areas of wet montane forest occur on the windward side of Lānaʻihale. However, vegetation is dominated by coastal and lowland dry communities as much of the island is lower elevation with low annual precipitation. The last major remnant of olopua and lama dryland forest that once covered large portions of Maui, Molokaʻi, and Lānaʻi occurs on Lānaʻi (Mitchell et al. 2005). The vegetation on Lānaʻi has been greatly modified in the past by agriculture (i.e., pineapples) and grazing by cattle, goats and axis deer.

3.4.1.2.6 Hawaiʻi

The island of Hawaiʻi is the largest and tallest of the islands and is composed of five volcanoes, three that are still active. The two tallest mountains are Mauna Kea at 13,796 feet and Mauna Loa at 13,677 feet. Because of the large elevation gradient and spatial variation in annual rainfall from windward and leeward aspects, as well as the presence of active volcanoes, Hawaiʻi has a great diversity of vegetation. Hawaiʻi has relatively large alpine and subalpine zones surrounding the summits and slopes of Mauna Kea and Mauna Loa. Like the other islands, the lowland dry forest and shrub and lowland mesic forests on Hawaiʻi have been mostly altered by urban and resort development, agriculture, and ranching. However, sugarcane is no longer produced on the island. Hawaiʻi still retains significant areas of native ecosystems (approximately 60 percent), primarily in the center of the island around Mauna Kea and Mauna Loa (Pratt and Gon 1998; TNC 2006) (Figure 3-41). Remaining native ecosystems include wet forests, montane dry and mesic forest, subalpine, and alpine vegetation zones.

3.4.1.3 Fauna

The extreme isolation of the Hawaiian Archipelago—it is 2,000 miles to the nearest continental land mass—greatly influenced the development and composition of the terrestrial fauna. Those taxa adapted to long distance migration (e.g., birds) are well represented while those who are not, such as land mammals are not. Birds, invertebrates (i.e., spiders and insects), and mollusks (e.g., land snails) are well-represented groups.

3.4.1.3.1 Terrestrial Mammals

Only one terrestrial mammal species, the ʻōpeʻapeʻa or Hawaiian hoary bat (*Lasiurus cinereus semotus*) is native to Hawaiʻi and is an endemic subspecies of the hoary bat found throughout North and South America. The Hawaiian hoary bat is Federally listed as endangered (see Section 3.4.3). It is known from the islands of Hawaiʻi, Maui, Oʻahu, Kauaʻi, and Molokaʻi. Little is known of population numbers but the species is regularly observed on Hawaiʻi, Kauaʻi, and Maui, but ongoing research is improving the information on this poorly understood species (USFWS 1998a; Bonaccorso 2010). The Hawaiian hoary bat is solitary and forages in open areas, near edges of native forests and over open water.

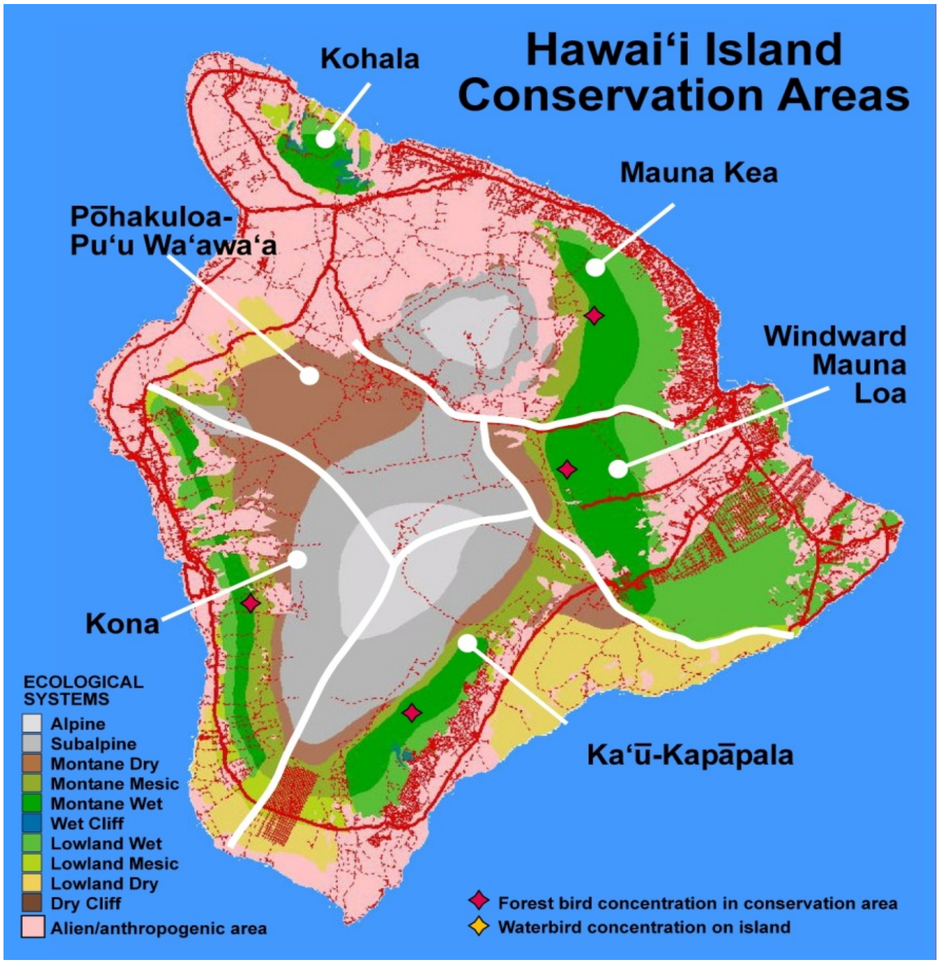


Figure 3-41. Location of Native Plant Communities on Hawai‘i (Source: TNC 2006)

Other terrestrial mammals have been introduced to the Hawaiian Islands with often deleterious effects on other native animal and plants species. Several ungulate species that were introduced for food or sport (hunting) and have now established self-sustaining populations and include feral pigs (*Sus scrofa*), feral goats (*Capra hircus*), feral sheep (*Ovis aries*), mouflon sheep (*Ovis musimom*), mule deer (*Odocoileus hemionus columbianus*), and axis deer (*Axis axis*). Introduced rodent species include the Norway rat (*Rattus rattus*), Polynesian rat (*Rattus exulans*), and the house mouse (*Mus musculus*). The small Asian mongoose (*Herpestes javanicus*) was introduced to control rats in the sugarcane fields and now has established populations on most of the islands.

3.4.1.3.2 Birds

Birds (*avifauna*) are a major component of the vertebrate fauna on the Hawaiian Islands. Because of their flight capability, birds were able to successfully colonize and adapt to the variety of unique habitats on the islands. The original avifauna contained a high proportion of endemic species, including many flightless species (Conant 1998). As a result of human development and habitation on the islands, approximately 50 percent of original Hawaiian avifauna is now extinct and many species are currently listed as threatened or endangered species (see Section 3.4.3). A wide variety of bird species numbering approximately 170 have been introduced to the islands (Conant 1998). Many of the common bird species observed in the lowlands and coastal regions are introduced species. In addition to resident species, Hawai‘i also hosts a variety of migratory species during part of the year.

The avifauna of Hawai‘i is commonly divided into three groups: marine or sea birds, water birds, and land birds. A fourth group is not as well defined but is referred to as open country birds. This latter group contains several introduced game birds but also several native species that are listed as endangered. Each of these groups is briefly described in the following sections. It is beyond the scope of this PEIS to describe any of the groups or species in detail. The focus of the discussion is on habitats, specific locations, and life-history characteristics that are important to evaluating potential impacts from reasonable future renewable energy projects.

Seabirds

Marine or seabirds are a collection of many different families of birds that share the trait of making their living at sea (Table 3-32). However, seabirds return to land to nest and rear young before returning to their ocean habitat. Many seabird species are colonial nesters where individuals gather in concentrated areas to nest. The land-based nesting habitat of seabirds is an important resource. Seabirds often use islets (near-shore rock islands), cliffs, beaches, volcanic crater walls, rock piles or crevices, burrows, under vegetation, and shrubs as nesting areas. Many species of petrels and shearwaters use burrows for nesting while other species are adaptable and may nest on bare ground, under shrubs, or in crevices. Information about islets surrounding the Hawaiian Islands, including information on seabirds, can be found at http://www.Hawai‘ioirc.org/OIRC-ISLETS.htm and in Harrison (1990) and Mitchell et al. (2005). Although islets are important seabird nesting areas, seabirds nest in parts of the mainland islands, including volcanic crater walls, steep mountainous terrain, and sea cliffs.

Table 3-32. Species of Seabirds that Occur in the Main Hawaiian Islands

Common Name	Scientific Name
Laysan Albatross	*Phoebastria immutabilis*
Black-footed Albatross	*Phoebastria nigripes*
Wedge-tailed Shearwater	*Puffinus pacificus*
Christmas Shearwater	*Puffinus nativitatis*
Newell’s Shearwater	*Puffinus auricularis newelli*
Bulwer’s Petrel	*Bulweria bulwerii*
Bonin Petrel	*Pterodroma hypoleuca*
Hawaiian Petrel	*Pterodroma sandwichensis*
Band-rumped Storm Petrel	*Oceanodroma castro*
Sooty Shearwater	*Puffinus griseus*
Red-tailed Tropicbird	*Phaethon rubricauda*
White-tailed Tropicbird	*Phaethon lepturus dorotheae*
Great Frigatebird	*Fregata minor*
Masked Booby	*Sula dactylatra*
Brown Booby	*Sula leucogaster*
Red-footed Booby	*Sula sula*
Sooty Tern	*Sterna fuscata*
Gray-backed Tern	*Sterna lunata*
White Tern	*Gygis alba*
Black Noddy	*Anous minutus*
Brown Noddy	*Anous stolidus pileatus*
Blue-gray Noddy	*Procelsterna cerulean*

Source: Harrison 1990.

Waterbirds

Waterbirds include species that primarily use a variety of wetland habitats including freshwater marshes and ponds, coastal estuaries and ponds, artificial water reservoirs, irrigation ditches, streams, and swamplands. The Hawaiian Islands historically supported a diverse array of waterbirds in both wetland and forest habitats (USFWS 2011a). However, many of species have become extinct during the past 2,000 years of human presence on the islands. The six endemic species of waterbirds that persist today are the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Laysan duck (*A. laysanensis*), Hawaiian coot or ‘alae ke‘oke‘o (*Fulica alai*), Hawaiian common moorhen or ‘alae ‘ula (*Gallinula chloropus sandvicensis*), Hawaiian stilt or ae‘o (*Himantopus mexicanus knudseni*), and the Hawaiian goose or nēnē (*Branta sandvicensis*) (USFWS 2011a). All six species are listed as endangered (see Section 3.4.3). The Layson duck historically occurred in the main Hawaiian Islands about 1,500 years ago but now exists only on Laysan Island and Midway Atoll (USFWS 2009a). All but the nēnē require wetlands for survival.

A wide variety of waterbirds inhabit the Hawaiian Islands as seasonal migrants. These species include species of ducks, geese, and shorebirds (plovers and sandpipers). Because of their affinity for fresh and coastal water, wetland, and shoreline habitats, all of these habitats are important to waterbird populations. Section 3.3.3 of this PEIS describes water resources and wetlands.

Forest Birds

The forest birds are the group of bird species that have had the greatest adaptive radiation on the islands and contain the most unique and endemic species of the Hawaiian avifauna. The isolation of the Hawaiian Islands has contributed to the endemism of the forest birds but is also a factor in their extreme vulnerability to outside forces (Scott et al. 1986). The native forest regions of the islands typically receive 50 to over 500 inches of precipitation each year and range in elevation from sea level to about 6,000 feet. Many of the remaining forest birds are now found in upper elevation forests (higher than 4,000 feet) that have been less affected than lower elevation vegetation zones. This group of birds has been severely impacted by human development and many of these native species are now extinct or listed as endangered species from loss of habitat, predation by introduced species, and mortality from introduced diseases and pathogens (USFWS 2006a; Scott et al. 1986). Over two-thirds of the remaining forest birds in Hawai‘i are Federally listed as threatened or endangered (see Section 3.4.3). Many of these species are now managed under recovery plans prepared under the *Endangered Species Act* (ESA). Remaining areas of native forest and nonnative forests are important resources for this group of bird species.

Open Country Birds

What consists of open country is not well defined. The vegetation of Hawai‘i has been greatly altered, particularly along the coast and areas of lowland dry and mesic shrubland and forests. These areas are now a mosaic of agricultural fields, grazing lands, urban development, resorts, and remnants of native species mixed with introduced species. Open country also occurs in lava fields and at higher elevations on Maui and Hawai‘i in the subalpine zone because of the dry climate. A variety of gamebirds introduced to Hawai‘i have established populations including chukar (*Alectoris chukar*), three species of francolin (*Francolinus* spp.), wild turkey, (*Meleagris gallopavo*), California quail (*Callipepla californica*), and ring-necked pheasant (*Phasianus colchicus*). Other introduced species of the open country include the Western meadowlark (*Sturnalla neglecta*), skylark (*Alauda arvensis*), and barn owl (*Tyto alba*). Three native bird species that typically occupy more open country include the Hawaiian State bird, the nēnē or Hawaiian goose (*Branta sandvicensis*), the ‘io or Hawaiian hawk (*Buteo solitarius*), and the pueo or short-eared owl (*Asio flammeus sandwichensis*). All three species are listed as endangered (see Section 3.4.3).

3.4.1.3.3 Freshwater Aquatic Species

Freshwater streams are described in Section 3.3.1. Because of the small size and steep topography of the islands, most streams are relatively small with a steep profile. Waterfalls are common. Stream flow tracks precipitation patterns. The isolation of the Hawaiian Islands has resulted in a sparse freshwater fauna but most are endemic species. Hawaiian streams have only five native species of fish (4 endemic, 1 indigenous), two species of crustacean (both endemic), and three species of mollusk (all endemic) (Table 3-33). The aquatic species have a mainly diadromous life cycle in that hatched larvae move to the ocean and then return to the freshwater as juveniles. Therefore, maintaining the stream to ocean connection is important for these species.

Table 3-33. Native Freshwater Aquatic Species Found in Hawaiʻi Streams and Estuaries

Common Name	Scientific Name	Origin	Habitat
Fish			
ʻoʻopu hiʻu kole	*Lentipes concolor*	Endemic	Upper stream reaches
ʻoʻopu nōpili	*Sicyopterus stimpsoni*	Endemic	Middle stream reaches, fast flowing water
ʻoʻopu nākea	*Awaous guamensis*	Indigenous	Lower to middle stream reaches
ʻoʻopu naniha	*Stenogobius Hawaiiensis*	Endemic	Estuaries and lower stream reaches
ʻoʻopu ʻakupa	*Eleotris sandwicensis*	Endemic	Estuaries and lower stream reaches
Crustaceans			
ʻōpaekalaʻole	*Atyoida bisulcata*	Endemic	Upper stream reaches, fast flowing water
ʻōpae ʻoehaʻa	*Macrobrachium grandimanus*	Endemic	Estuaries and lower stream reaches
Mollusks			
hīhīwai	*Neritina granosa*	Endemic	Lower and middle stream reaches
hapawai	*Neritina vespertina*	Endemic	Estuaries and lower stream reaches
pipiwai	*Theodoxus cariosus*	Endemic	Brackish water, estuaries and pools

Source: Nishimoto 2014.

3.4.2 MARINE ECOSYSTEMS

Important factors shaping the marine ecosystems surrounding the Hawaiian Islands include the volcanic origins of the islands, geographic isolation, subtropical climate, and geographic exposure to storm waves. The islands that compose the Hawaiian Archipelago formed as isolated volcanic seamounts as the Pacific Plate moved northwest over the Hawaiian hotspot (Section 3.5.1). As a result, many of the submarine slopes of the main Hawaiian Islands are relatively steep. Shallow ocean floor environments surrounding the islands are relatively limited because of the steep slopes. The exception is the ocean area surrounding Maui County including the islands of Maui, Molokaʻi, Lānaʻi, and the uninhabited island of Kahoʻolawe. Ocean depth is important because of the influence on light penetration, photosynthesis, and secondary productivity. The shallower depths to about 600 feet called the epipelagic or euphotic zone (the sunlit zone) has sufficient light for the production of phytoplankton and zooplankton. The euphotic zone contains much of the ocean's marine life and is one of the most ecologically important ocean zones. The amount of ocean floor within the euphotic zone is generally limited to 1 to 4 miles offshore on the islands of Kauaʻi, Oʻahu, and Hawaiʻi. However, the amount of ocean floor within this highly productive zone is much more extensive surrounding the Maui County islands. Note that some authors consider the euphotic zone to be shallower (less than100 meters, or 300 feet) with 100- to 200-meter depth representing a *twilight zone* or disphotic zone where light penetration is insufficient for much plant production and overall marine productivity is more limited.

Similar to terrestrial ecosystems, the geographic isolation of the Hawaiian Islands is an important factor in the development of the marine ecosystems surrounding the islands. The large distance from continents and other major island and reef systems has limited the colonization of the Hawaiʻi marine ecosystems by many species. Because the islands developed in sequence from the northwest to southeast (i.e., Kauaʻi to Hawaiʻi for the inhabited islands), older islands served as colonizing sources of marine life for the younger islands. As a result, the Hawaiian marine ecosystems have high percentage of endemic species (i.e., found in nowhere else) of any tropical archipelago in the Pacific Ocean and possibly the world.

The Hawaiian Islands range in latitude from 19 to 28 degrees north and straddle the Tropic of Cancer (23.5 degrees). The Tropic of Cancer is the imaginary dividing line between tropical and temperate climates. The exposure to cooler winter seawater and destructive waves has created a mostly subtropical marine environment. The mid-ocean location of Hawai‘i exposes the islands to periodic storm waves from both the Arctic and Antarctic regions that cause damage to marine habitats such as beaches and reefs (Friedlander et al. 2008). Tropical cyclones also cause storm surges and waves that disturb coastal and marine environments. Earthquakes and possible tsunami are other natural disturbances that may impact submarine and coastal habitats.

Water motion in the ocean occurs over a wide range of time and spatial scales. Other than tides that are caused by the gravity of the moon and sun, all other water motion (with the exception of tsunami) are caused by interactions with the atmosphere through horizontal force of the wind, heating and cooling by the air, and by radiation, precipitation, and evaporation (Flament et al. 1998). Patterns of water motion and variation in those patterns at different time scales (annual, seasonal, and daily) create horizontal and vertical changes in ocean water characteristics such as temperature, salinity, and nutrient distribution, factors important in shaping marine ecosystems. The annual variation in surface ocean temperature is relatively small varying from 75ºF in winter/spring to 81ºF in summer/fall near O‘ahu. Important to marine life are the vertical profiles in temperature and nutrients. Water temperature at the surface is warm (about 77ºF) and the depth of warm water (100 to 400 feet) varies by season and depends on surface mixing from winds. Below this mixed layer of ocean water is a sharp thermocline where water temperature declines rapidly to around 41ºF at a depth of 2,300 feet. Vertical distribution nutrients in the ocean water are opposite of the temperature profiles. The near surface warm waters are typically low in nutrients but increase rapidly through the thermocline and are relatively uniform in distribution at depth (Flament et al. 1998). This pattern limits the productivity of phytoplankton and thence other marine life in the shallower, warm, sun lit zones around the islands. At depth, lack of sunlight limits production in spite an abundance of nutrients.

Large-scale ocean currents in the vicinity of Hawaiian Islands generally flow from east to west. The interaction of both the ocean currents and the surface winds with the physical structure of islands creates local or regional variations in ocean currents and depth of the surface mixing layer. For example, the mixed layer of the channels between islands is deeper because of stronger surface winds. On the leeward side of the islands, winds are calmer, mixing is shallower, and surface waters are warmer from lack of mixing. Coupled with the effects of the earth rotation, varying patterns of winds, currents, and water temperatures can cause localized eddies or circulation of water columns that allows upwelling of colder, nutrient rich water. Diurnal tides cause a rise and fall in ocean level along the coast. Tide levels vary throughout the islands but important to tidepool, *anchialine pond*, and estuary ecosystems along the coast.

3.4.2.1 Marine Habitats

The Hawaiian Islands have a wide variety of marine habitats. The following habitat descriptions start with marine habitats on or near the coastal zone and proceeds to the deep ocean environment. The information is adapted from that presented by Maragos (1998).

3.4.2.1.1 Marine Pools (tidepools and anchialine ponds)

Marine pools are found along the rocky coasts of the Hawaiian Islands and may occur up to several hundred meters inland. Anchialine ponds are inshore landlocked ponds that have a subterranean connection to the ocean. Anchialine pools are extremely common worldwide especially along neo-tropical coastlines where the geology and aquifer system are relatively young, and there is minimal soil development. Such conditions occur notably where the bedrock is limestone or recently formed volcanic lava such as in Hawai‘i. The ponds form in depressions in lava rock. Water levels in anchialine ponds often fluctuate with tidal changes due to the coastal location and the connection with the ocean. The range in water level fluctuations are decreased (damped) and delayed compared to the range and time observed for the adjacent tide depending on the distance from the coast and the hydraulic conductivity of the volcanic lava rock. Water in anchialine ponds typically has marine salinities except in surface layers where the water may be more brackish depending on the influx of freshwater. Ecological studies of anchialine ponds frequently identify regionally rare and sometimes endemic species living in them. Ponds typically contain marine algae, grasses and rushes if sediments accumulate, shrimp, and a variety of other crustaceans and mollusks.

Tidepools are open and subject to flooding during changing tides. At high tide, tidepools are flooded and continuous with and indistinguishable from the ocean. At low tide, pools are left in depressions in the volcanic rock. Tidepools are an extreme environment including full submersion by the ocean and subject to wave action and currents during high tides,plus exposure to wind, sun, and predators during low tide, as wells as changes in water temperature and salinity. However, tidepools are habitats with a high diversity of species.

3.4.2.1.2 Beaches (sandy and rocky)

Beaches occur along shorelines and may either be sandy or rocky. Sandy beaches in Hawaiʻi occur in a variety of colors depending on the parent material from which the sand was derived. Pink sands are derived from iron-rich cinder cones, green sand from olivine crystals eroded from lava, black sand from tephra particles formed when molten lava flows into the ocean, and white sand primarily from the breakdown of coralline algae and coral. Sandy beaches are subject to wave action and depend on seasonal cycles of erosion, accretion, and alongshore drift of offshore sand reservoirs. Sandy beaches generally are more common on older islands and in locations that favor formation of sand particles or the accumulation of sand. Sandy beaches may serve as resting and nesting habitat for seabirds, clams, crabs, sea turtles, and the Hawaiian monk seal.

Rocky beaches occur on the shorelines of all the Hawaiian Islands where sand is absent owing to constant wave action, currents, steep submarine slopes and lack of offshore sand reservoirs. Most rocky beaches are formed from basalts but may be consolidated limestone formed of cemented beach rock or raised coral reefs. Rocky beaches provide habitat for a variety of algaes, limpets, snails, rock crabs, gastropods and urchins. In many areas, the beach area consists of rocky cliffs rising directly from the shoreline.

3.4.2.1.3 Estuaries

Estuaries are formed where fresh and marine water meets along the coastlines. This can occur under several different conditions including at large embayments (naturally protecting inlets) such as Pearl Harbor, where freshwater streams enter the ocean, and where coastal groundwater discharges abundantly offshore. Freshwater is less dense than seawater and floats on the surface until it is mixed by waves and currents. Freshwater brings an abundance of nutrients that stimulates productivity in estuaries which typically have sediment covered bottoms. Estuaries can have abundant herbaceous growth and a wide variety of animal species including crustaceans, mollusks, fish, shorebirds, and waterbirds. Estuaries serve as important nursery areas for native freshwater, estuarine, and marine species by providing habitat, nutrients, and protection.

3.4.2.1.4 Fishponds and Harbors

Fishponds and harbors are human created marine ecosystems. Fishponds were part of the intensive aquaculture practiced by early Hawaiians. Four hundred forty nine ponds have been recorded with the majority on Oʻahu and Molokaʻi (Kirch 1998). The fishponds were typically constructed with stone walls on shallow reef flats, in embayments, and over submarine springs. Some larger ponds enclosed more than 500 acres. Tidal flows through gates replenished nutrients while fish remained trapped within the pond.

Mullet, anchovies, shrimp, clams, oysters, seabirds, shorebirds, and waterbirds inhabit or feed in the ponds.

Harbors are constructed inlets generally built in areas sheltered from heavy waves. Because of the importance of marine transportation (both commercial and recreational) in Hawaiʻi, harbors are an important human resource but also can be a source of coastal degradation from erosion, sewage contamination, and oil and litter pollution.

3.4.2.1.5 Mangroves

Mangroves were introduced in Hawaiʻi in the early 1900s to south Molokaʻi and Kāneʻohe Bay on Oʻahu. Mangroves have since spread to muddy reef flats and estuarine waters around most of the major islands and to some rocky coastal waters of Hawaiʻi island. Mangrove seeds float in seawater but sink and root in brackish water. Tidal flows and mangrove leaf fall maintain mangrove productivity. Roots and lower trunks are submerged at high tide. Mangroves provide habitat for Samoan crab, oysters, clams, and other crabs that attach to mangrove roots as well as shelter for juvenile fishes. The native black-crowned night heron, cattle egret, and endangered Hawaiian silt nest and feed among mangroves. However, mangroves are considered invasive and displace native species such as marine algae and seagrasses.

3.4.2.1.6 Seagrasses

Seagrasses are found close to shore below the tidal zone. Hawaiʻi has a single endemic species of seagass (*Halophila Hawaiiana*). Widgeon-grass (*Ruppia maritima*) is commonly found with seagrass. Seagrass ecosystems are common off the inner reef flats of south Molokaʻi and Kauaʻi. It is found in a few other locations but is not common. Seagrasses root in sands and muds and are totally submerged. They usually survive best where wave action is not severe. Seagrasses commonly grow in fishponds. Some of the common animal species in this ecosystem include sea cucumbers, gastropods, clams, crabs, shrimps, mullets, and rudderfish. The green sea turtle grazes on seagrasses.

3.4.2.1.7 Shallow Benthic Communities

Shallow benthic communities are found to depths of 160 feet or more within the euphotic (sunlit) zone of the ocean. This community occurs on a variety of substrates including basalts, consolidated limestone (reef carbonates, beach rock), and sediments (sands, gravels, and pebbles). The composition and distribution of the shallow benthic community is determined by the amount of light penetration, temperature, wave action, and substrate (hard or soft). The composition of the community can be diverse ranging from primarily fleshy algae (brown, red, and green) to coralline algae or coral communities. Shallow benthic communities on sand include cone shells, tritons, pen shells, and garden eels. Animals in this community include parrotfishes, wrasses, damselfishes, surgeonfishes, reef fishes, sea urchins, and sea cucumbers.

3.4.2.1.8 Fringing Reefs

Fringing reefs are reefs that grow, terrace-like, offshore to outer slopes of about 165 feet. Fringing reefs are poorly developed on islands where shorelines are rapidly subsiding or are exposed to heavy waves. The State's longest continuous fringing reef (30 miles long) is off the south shore of Molokaʻi. The reefs are composed of calcium carbonate skeletons and sediments produced by corals and coralline algae. On the inner reef flats, sand deposits and seaweeds are common. Living corals and coralline algae dominate on the reefs outer edge. Underneath the outer layer of living reef organisms are the remains of previous reef organisms that are compacted and cemented into a hard limestone, wave-resistant structure. The other biota that lives in the fringing reef is similar to those that live in the shallow benthic communities. The threatened green sea turtle forages in reef areas and the endangered hawksbill turtle feeds where sponges are common. Wave action is a primary force that shapes and alters reefs around the islands (Friedlander et al. 2008). For example, reefs on the windward side versus leeward side of the islands can differ primarily because of wave stress.

3.4.2.1.9 Barrier Reefs and Lagoons

Barrier reefs lie further offshore than fringing reefs and may develop through a combination of island subsidence, erosion, and rising sea levels. Between barrier reefs and the shore are deep lagoons where waters are relatively calm because the reef acts as a natural breakwater. Hawai‘i has two barrier reefs: Kāne‘ohe Bay on the northeast coast of O‘ahu and the Mānā reef off the northwest coast of Kaua‘i. Barrier reefs occur to a depth of approximately 165 feet. The lagoons and ocean are connected by cuts through the reef. The barrier reef is composed of consolidated carbonate rock and lagoons have a floor covered with gravel to mud sediments.

The Kāne‘ohe Bay barrier reef developed on a shallow offshore platform of land during a period of rising sea levels. Pinnacle and patch reefs occur within the lagoons. The Mānā barrier reef off the northwest coast of Kaua‘i is submerged about 50 feet below the sea level and the lagoon floor is about 100 feet deep. Other biota in the barrier reefs and lagoon ecosystem are similar to those that live in the shallow benthic communities and fringe reefs including the threatened green sea turtle and endangered hawksbill turtle.

3.4.2.1.10 Atolls

Atolls generally form as volcanic islands, subside, and erode over time leaving behind a coral reef that may have started as a fringing reef, transitioned to a barrier reef and eventually forming an atoll. An atoll typically consists of a raised coral reef, possibly some land area, and a protected lagoon area. The lagoon area may be nearly or only partially encircled by a raised or shallowly submerged coral reef. The lagoon floor is typically covered with sands or mud. Atolls may have some vegetated areas. Wave-driven currents frequently wash over atoll reefs. Below the ocean surface, the upper parts of atolls are composed of reef carbonates, often to great depths (3,300 feet). Below the carbonate, volcanic basalts form the foundation. Sandy beaches are common on the lagoon side of an atoll while rock beaches are common on the ocean side of an atoll.

No atolls exist within the main Hawaiian Islands. Six true atolls exist in the Northwestern Hawaiian Islands northwest of Kaua‘i. This region is outside of the main Hawaiian Islands being considered in this PEIS and therefore atolls will not be evaluated as a potentially affected marine ecosystem.

3.4.2.1.11 Offshore Deep Reefs (twilight zone)

Offshore deep reefs are found at approximate depths of 165 to 660 feet, encircling all of the Hawaiian Islands. Although light penetrates to these depths, it is insufficient for much photosynthesis. This zone is often referred to as the twilight zone because of the low light levels. Substrates are often rocky on outcrops and steep slopes but also include areas of sediment deposits. Other biota includes species adapted to deep water such as some species of algae, deep-dwelling fish, corals and other invertebrates. Black corals are concentrated below normal scuba-diving depths. Endangered monk seal and sea turtles forage in these habitats.

3.4.2.1.12 Offshore Islands

Distributed around the main islands are small islets or sea stacks. Small islets are typically more common around larger or older islands because they generally are connected to the mainland island but form through the processes of erosion and subsidence. Limestone islets are typically lithified dunes or relict reefs. Islets are normally separated from the main island by strong currents that effectively isolate them from easy access. Islets are typically characterized by seacliffs, rocky beaches, some sand beach area, rocky submarine slopes, and are usually covered with live coral and coralline algae. The biota of islets is comparable to those of benthic communities, fringing reefs, and barrier reefs. Islets are important seabird rookeries and used as resting sites for the Hawaiian monk seal and sea turtles.

3.4.2.1.13 Neritic Water

The Neritic water zone consists of open ocean water to depths of 660 feet associated with the coasts surrounding all of the Hawaiian Islands. There are no substrates in this ecosystem as the habitat consists solely of open water. Neritic water includes both the euphotic or sunlit area and the twilight zone where light for photosynthesis is limited. The biota includes phytoplankton, floating seaweeds, zooplankton, fish, marine mammals, marine turtles, and seabirds. The endangered hawksbill turtle, Hawaiian monk seal, humpback whale, and threatened green turtle all use the neritic waters around the Hawaiian Islands.

3.4.2.1.14 Pelagic Oceanic and Deep Ocean Floor

The pelagic oceanic zone includes open waters beyond the neritic zone (greater than 660 feet below sea level contour) and the deep ocean floor. The pelagic oceanic is often divided into zones based on amount of sunlight penetration, water pressure, and temperature. The epipelagic zone extends to the same depth as the neritic zone which is about the limit of visible light penetration. Below the epipelagic is the mesopelagic zone (600 to 3300 feet) and is considered the twilight zone as visible light rapidly diminishes. However, the mesopelagic zone contains a wide variety of marine species. Because of the steep submarine slopes of many of the islands, the pelagic oceanic zone is common around the islands but to a lesser extent between the islands of Maui County. In the ʻAlenuihāhā Channel between the islands of Hawaiʻi and Maui, the pelagic zone reaches depths exceeding 6,000, and 10,000 feet in the Kauaʻi Channel between Kauaʻi and Oʻahu.

3.4.2.2 Marine Mammals

The oceanic waters surrounding the main Hawaiian Islands are inhabited by a variety of marine mammals (Table 3-34). Marine mammals are protected by the Marine Mammals Protection Act and others may receive additional protection if listed under the ESA (see Section 3.4.3). Many species of marine mammals are migratory and may occupy areas around the islands only during part of the year.

The National Marine Fisheries Service (NMFS) prepares marine mammal stock assessment reports by species/stock (http://www.nmfs.noaa.gov/pr/sars/species.htm). Stock refers to a particular regional area occupied by a species. The stock assessment reports provide information distribution, abundance, and mortality.

Marine mammals are typically divided into two groups: cetaceans (whales and dolphins) and pinnipeds (seals and sea lions). The humpback whale (*Megaptera novaeangliae*) is the most well-known whale species found in Hawaiian waters. Sightings of other whale species may be rare because some primarily live in deeper ocean waters. The humpback whale is listed as an endangered species and is discussed in Section 3.4.3.1.3. Other common cetaceans in Hawaiian waters include the pilot whale, false killer whale (*Pseudorca crassidens*), bottlenose dolphin, and spinner dolphin. The main Hawaiian Islands insular false killer whale distinct population segment was recently listed as endangered (77 FR 70915, November 28, 2012) (see Section 3.4.3.1.3). The Hawaiian monk seal (*Monachus schauinslandi*) is the most common pinniped in the islands but is considered critically endangered. It is most common in the Northwestern Hawaiian Islands but does occur in the main Hawaiian Islands. Information about individual marine mammal species and their distribution around the Hawaiian Islands can be found in Mitchell et al. (2005).

Table 3-34. Hawaiian Marine Mammals

Common Name	Scientific Name
Minke whale	*Balaenoptera acutorostrata*
Sei whale	*Balaenoptera borealis*
Bryde’s whale	*Balaenoptera edeni*
Blue Whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Northern right whale	*Eubaleana japonica*
Pygmy killer whale	*Feresa attenuata*
Short-finned pilot whale	*Globicephala macrorhynchus*
Risso’s dolphin	*Grampus griseus*
Longman’s beaked whale	*Indopacetus pacificus*
Pygmy sperm whale	*Kogia breviceps*
Dwarf sperm whale	*Kogia sima*
Fraser’s dolphin	*Lagenodelphis hosei*
Humpback whale	*Megaptera novaeangliae*
Blainesville’s beaked whale	*Mesoplodon densirostris*
Killer whale	*Orcinus orca*
Melon-headed whale	*Peponocephala electra*
Sperm whale	*Physeter macrocephalus*
False killer whale	*Pseudorca crassidens*
Spotted dolphin	*Stenella attenuata*
Striped dolphin	*Stenella coeruleoalba*
Spinner dolphin	*Stenella longirostris*
Rough-toothed dolphin	*Steno bredanensis*
Pacific bottlenose dolphin	*Tursiops truncatus*
Cuvier’s beaked whale	*Ziphius cavirostris*
Hawaiian monk seal	*Monachus schauinslandi*

3.4.2.3 Marine Reptiles

Marine reptiles native to Hawai‘i include five species of sea turtles. All species are listed as threatened or endangered and are discussed in Section 3.4.3.1.3. Three of the species are considered incidental to the Hawaiian Islands.

3.4.2.4 Marine Fisheries

The marine fisheries of the Hawaiian Islands are classified into four types: bottomfish fisheries, crustacean fisheries, precious coral fisheries, and coral reef fisheries (WPRFMC 2009a). The deep-slope bottomfish fishery primarily occurs at depths of 180 to 900 feet and includes species of snappers, jacks, and a single species of grouper. The bottomfish fishery is about equally divided between State and Federal waters. Important bottomfish areas of the main Hawaiian Islands include Middle Bank (northwest of Kaua‘i), Penguin Bank (west of Moloka‘i), and the 600-foot deep bottomfish habitat in the Maui-Lāna‘i-Moloka‘i island complex. The crustacean fishery is centered on two species of spiny lobster (*Panulirus marginatus* and *P. penicillatus*) and species of slipper lobster in the Family Scyllaridae. The crustacean fishery around the main Hawaiian Islands is not large (WPRFMC 2009a). The fishery for precious corals involves primarily black (*Antipathes* spp.), pink (*Corallium*), gold (*Gerardia* spp. and *Narella* spp.), and bamboo (*Lepidisis olapa*) corals from six coral beds: Makapuʻu Point, Oʻahu; the Auʻau Channel bed, Maui; 180-Fathom Bank, Brooks Bank, Kaʻena Point, and Keahole Point. Precious corals may be divided into deep- and shallow-water species. Deep-water precious corals are generally found between 1000 and 5000 feet and include pink, gold, and bamboo corals. Shallow-water species occur between 100 and 300 feet and consist primarily of three species of black coral. Only black coral is harvested from the Auʻau Channel bed located near Maui. Pink, gold, and bamboo coral are harvested from the other five coral beds except no gold coral is harvested from the Makapuʻu coral bed WPRFMC 2009a). Coral reef fish species are the most diverse of the four fisheries (WPRFMC 2009a). Akule (coastal pelagic scads), soldierfish (*Myripristis* spp.), parrotfish (*Scarid* spp.), surgeonfishes (including *Acanthurus dussumieri*, *A. trostegus* and *Naso* spp.) and goatfishes (including *Mulloidichthys* spp.) are some of the top species by weight and value. The coral reef fishery is important to both commercial, recreational, and subsistence fishermen.

3.4.2.5 Marine Birds

Marine birds (sea birds) are discussed under terrestrial birds (Section 3.4.1.3.2). Although marine birds spend considerable time in neritic and pelagic ocean habitat, they depend on land-based nesting colonies for reproduction and therefore their life-cycle is dependent on terrestrial habitats and impacts to those habitats. For a review of Hawaiian seabirds natural history and ecology, see Harrison (1990).

3.4.3 PROTECTED SPECIES AND HABITATS

Many terrestrial and marine species and their habitats in Hawaiʻi are protected under Federal and State laws and regulations. These statutes include the Federal *Endangered Species Act* (ESA), *Migratory Bird Treaty Act, Marine Mammal Protection Act*, *Magnuson-Stevens Fishery Conservation and Management Act*, and State of Hawaiʻi's ESA. These laws have provisions that typically prohibit the take (including habitat), harm, and harassment of any species protected by the respective statute.

The Federal ESA is the primary statute that provides protective status to those species that are either likely to become an endangered species within the foreseeable future (threatened) or is in danger of extinction in the near future (endangered). NMFS and USFWS share responsibility for implementing ESA. Generally, the USFWS regulates activities that may impact threatened and endangered terrestrial and freshwater species, while the NMFS regulates activities that may impact marine and anadromous species. Federal agencies must consult with NMFS and USFWS, under Section 7(a)(2) of the ESA on Federal activities, including Federally funded activities, that might affect a listed species. These interagency consultations, or Section 7 consultations, are designed to assist Federal agencies in fulfilling their duty to ensure Federal actions do not jeopardize the continued existence of a species or destroy or adversely modify critical habitat. Section 7 consultations may conclude with the issuance of Incidental Take Statements, under which the Federal agency is authorized to incidentally take certain members of a listed species but only under certain conditions.

FEDERAL ENDANGERED SPECIES ACT TERMINOLOGY

Endangered Species: Any species in danger of extinction throughout all or a significant portion of its range.

Threatened Species: Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Proposed Species: Any species of fish, wildlife or plant proposed in the Federal Register to be listed under Section 4 of the *Endangered Species Act*.

Critical Habitat: Areas deemed necessary to a species' conservation and officially designated under the *Endangered Species* Act; provided that the species is legally protected.

Listed Species: Any species of fish, wildlife, or plant determined to be endangered or threatened under Section 4 of the *Endangered Species Act*.

Take: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.

The State of Hawaiʻi ESA statute links the species listed under the Federal ESA to protection under State law. The State coordinates its efforts with the USFWS for incidental take permits and habitat conservation plans. As part of its continuing partnership with the USFWS, the DLNR, Division of Forestry and Wildlife prepared a *Comprehensive Wildlife Conservation Strategy* (Mitchell et al. 2005), the goal of which is to guide conservation efforts across the State to ensure protection of Hawaiʻi's wide range of native wildlife and the diverse habitats that support them. In the conservation strategy, the State developed both Statewide (terrestrial) conservation needs and marine conservation needs including identifying species of greatest conservation need that includes but is not limited to those species listed as threatened and endangered. Other reports the State has prepared that address prioritized areas for forest management and conservation include *Hawaiʻi Statewide Assessment of Forest Conditions and Trends: An Assessment of the State of Our 'Aina* and *Rain Follows the Forest Initiative*. The Statewide assessment, better known as the State of Hawaiʻi's Forest Action Plan, was required by the USDA Forest Service in order to access funding through its programs. The initiative was developed by the Governor of Hawaiʻi in November 2011 and focuses on watershed protection across the State through a number of natural resource management actions such as fencing, invasive plant and animal removal, and reforestation of degraded lands. Both documents are available online at http://dlnr.hawaii.gov/forestry/info/fap/ and http://dlnr.hawaii.gov/rain/, respectively.

USFWS also implements the *Migratory Bird Treaty Act* (16 U.S.C. §§ 703–712) and the *Bald and Golden Eagle Protection Act* (16 U.S.C. §§ 668–668c). The unauthorized take of species protected under these statutes is prohibited. As such, the project proponent may need to discuss with USFWS necessary mitigation, minimization, or avoidance measures that would limit the risk of the project proponent violating the statutes. The project proponent may also need to obtain a permit under the applicable statute.

The *Marine Mammal Protection Act* (MMPA) was implemented to provide protection for populations of marine mammals. The Act prohibits take of marine mammals except through special authorization under an incidental take permit or other special permits for such activities as scientific research, population management, and public education. The provisions of MMPA are implemented by NMFS.

The *Magnuson-Stevens Fishery Conservation and Management Act* (MSA) provides for the overall management and protection of the fishery resources in Federal waters of the United States and is administered by NMFS. The MSA as amended by the *1996 Sustainable Fisheries Act* required that *essential fish habitat* be identified and described for all Federally managed species. Essential fish habitat (EFH) is defined as those waters and substrate necessary to fish for spawning, breeding or growth to maturity. The EFH provisions allow the regional fisheries councils to provide comments and make recommendations to Federal and State agencies that propose actions which may affect habitat, including EFH, of a managed fishery species. The Western Pacific Fishery Management Council has authority for the State of Hawaiʻi and the commonwealths, territories, and possessions of the United States in the Pacific Ocean. Whenever Federal agencies authorize, fund, or carry out actions that may adversely impact Federal waters, they must consult with NMFS regarding the impact of their activities on EFH. NMFS must provide the consulting Federal agency with EFH conservation recommendations for any action that would adversely affect EFH. However, conservation recommendations concerning EFH are advisory, but a Federal agency must provide a written explanation if the agency chooses not to adopt the recommendations.

The different groups of species and habitat protected by these laws are discussed in the following sections.

3.4.3.1 Threatened and Endangered Species

Because of the isolation of Hawaiʻi from other continental land masses and islands, the flora and fauna of the islands developed a high degree of endemism as species adapted to local environmental conditions. These same factors, small land area and unique species, also made the flora and fauna of the islands highly susceptible to outside influences such as human settlement and introduced species, diseases, and pathogens. A large number of native Hawaiʻi plant and animal species are now extinct. Human impacts, including the alteration of native plant communities and introduction of nonnative plants and animals, has occurred for many years starting first with early Polynesian settlers and then accelerating since Western contact about 200 years ago (Scott et al. 1986).

As shown in Table 3-35, the State of Hawaiʻi has 524 species and subspecies (taxa) of plants and animals listed as threatened and endangered, the highest number in the United States. The list of threatened and endangered species in Hawaiʻi is not provided in the PEIS because the list of officially recognized threatened and endangered species is subject to change, as the USFWS and NMFS currently have active proposed threatened and endangered listings and status reviews in progress. The actual number of listed taxa also may vary based on accepted taxonomy of subspecies or species. Some species included on the list may actually be extirpated in the wild. The USFWS recently completed several listing determinations. On September 18, 2012, the USFWS published a final rule in the Federal Register designating 20 Hawaiian plant species and 3 damselflies as endangered (77 FR 57648, September 18, 2012). In addition, this final rule designated 42,804 acres of critical habitat for 25 species and revised critical habitat for 99 species. On November 28, 2012, NMFS designated the main Hawaiian Islands insular false killer whale (*Pseudorca crassidens*) distinct

Table 3-35. State of Hawaiʻi Threatened and Endangered Species

	Quantity	Percent
Terrestrial	516	98
Animals	98	19
Plants	418	81
Marine	8	2
Animals	8	2
Plants	0	0
TOTAL	**524**	

Note: Numbers are based on best available information and subject to change from proposed listings and taxonomic revisions.

population segment (DPS) as an endangered species. On May 28, 2013, the USFWS published a final rule in the Federal Register designating 37 plants and 3 species of tree snail on Maui, Molokaʻi, and Lānaʻi as endangered (78 FR 32014). In addition, the final rule delisted one plant species based on taxonomic error, reaffirmed the endangered status of two previously listed plant species, and discussed the taxonomic revision of several previously listed species. On October 29, 2013, the USFWS published a final rule in the Federal Register designating 13 plant species, 1 picture-wing fly, and 1 anchialine pool shrimp on the island of Hawaiʻi as endangered (78 FR 64638). In addition, the final rule also formally recognizes and corrects the scientific name of a plant species (*Mezoneuron kavaiense*) previously listed as endangered in 1986. To obtain official lists of threatened and endangered species or information on the status of proposed listing actions, contact the USFWS, Pacific Islands Fish and Wildlife Office, and the Pacific Islands Regional Office of NMFS.

3.4.3.1.1 Terrestrial Threatened and Endangered Species

The majority of species (98 percent) listed as threatened and endangered in Hawaiʻi are terrestrial animal and plant species. This reflects the disproportionate impact on land resources of the Hawaiian Islands compared with the marine ecosystems. Of the 516 terrestrial species listed, 14 are listed as threatened and 502 are classified as endangered. The USFWS has designated critical habitat for 24 terrestrial animal species and 323 plants. Critical habitat is area considered important for the conservation and recovery of the species and may not be currently occupied by the species.

Plants

The majority of listed terrestrial species (81 percent) are plants. Native Hawaiian plants have been impacted by land clearing for agriculture, pasture, and urbanization, and resort development. These impacts have been particularly severe in coastal and lowland regions where both climate and topography is most suitable for human activity. Hawaiian plants also have been impacted by the introduction of nonnative ungulates such as pigs, goats, deer, and sheep (Cuddihy and Stone 1990; NPS 2011). Foraging, trampling of plants, and digging by ungulates directly damages plants, causes soil erosion, and destroys native habitat.

Threatened and endangered plant species occur on all the main Hawaiian Islands and vegetation zones. Most of these species are now managed under a series of recovery plans prepared under the ESA (Table 3-36). The habitat requirements, distribution, and potential threats are discussed in the recovery plans. Recently listed species do not have recovery plans yet. Critical habitat has been designated for 323 of these plant species.

Animals

Thirty bird species are listed as threatened (1) or endangered (29). Listed bird species occur on all the main Hawaiian Islands. Forest birds comprise a large proportion of the threatened and endangered bird species. Many of these species are now confined to the remaining higher elevation native ecosystems. However, some species have adapted to areas with largely nonnative vegetation. Threatened and endangered forest birds are managed in accordance with several recovery plans and outlines (USFWS 2006a, 2009b, 2010). The Forest Bird Recovery Plan addresses 21 taxa of forest birds. The recovery plan provides detailed information on life history characteristics, current range and distribution, and recovery areas for individual species. The endangered Hawaiian crow (*Corvus Hawaiʻiensis*) is managed under a separate recovery plan (USFWS 2009b). The Hawaiian crow is endemic to the island of Hawaiʻi and no individuals are known to exist in the wild ; however, two populations remain in captivity at the Keauhou and Maui Bird Conservation Centers on Hawaiʻi and Maui islands, respectively. The Kauaʻi Recovery Outline addresses multiple species including forest birds (USFWS 2010).

Table 3-36. List of Recovery Plans and Outlines Prepared for Endangered Plant Species in the Hawaiian Islands

Recovery Plan Title	Year	Citation
Recovery Plan for *Gouania hillebrandii* (Rhamnaceae)	1990	USFWS (1990)
Recovery Plan for *Haplostachys haplostachya* and *Stenogyne angustifolia*	1993	USFWS (1993)
Recovery Plan for *Lipochaeta venosa* and *Isodendrion hosakae*	1994	USFWS (1994a)
Recovery Plan for the Wahiawa Plant Cluster: *Cyanea undulate*, *Dubautia pauciflorula*, *Hesperomannia lvdgatei*, *Labordia lvdgatei*, and *Viola helenae*	1994	USFWS (1994b)
Recovery Plan for the Kauaʻi Plant Cluster	1995	USFWS (1995a)
Lānaʻi Plant Cluster Recovery Plan	1995	USFWS (1995b)
Recovery Plan for the Big Island II Plant Cluster Recovery Plan	1996	USFWS (1996a)
Recovery Plan for the Molokaʻi Plant Cluster	1996	USFWS (1996b)
Recovery Plan for the Maui Plant Cluster	1997	USFWS (1997)
Big Island II: Addendum to the Recovery Plan for the Big Island Plant Cluster	1998	USFWS (1998b)
Kauaʻi II: Addendum to the Recovery Plan for the Kauaʻi Plant Custer	1998	USFWS (1998c)
Molokaʻi II: Addendum to the Recovery Plan for the Molokaʻi Plant Cluster	1998	USFWS (1998d)
Recovery Plan for the Oʻahu Plants	1998	USFWS (1998e)
Recovery Plan for Multi-Island Plants	1999	USFWS (1999)
Addendum to the Recovery Plan for the Multi-Island Plants	2002	USFWS (2002)
Recovery Outline for the Kauaʻi Ecosystem	2010	USFWS (2010)
Draft Recovery Plan for *Phyllostegia hispida*: Addendum to the Molokaʻi Plant Cluster Recovery Plan	2011	USFWS (2011b)

Source: USFWS 2012.
Note: Recovery outlines are preliminary recovery documents to guide recovery efforts until recovery plans are prepared.

All six endemic species of Hawaiian waterbirds that persist today are listed as endangered (USFWS 2011a). Five of these six species, the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian coot or ʻalae keʻokeʻo (*Fulica alai*), Hawaiian common moorhen or ʻalae ʻula (*Gallinula chloropus sandvicensis*), Hawaiian stilt or aeʻo (*Himantopus mexicanus knudseni*), and the Hawaiian goose or nēnē (*Branta sandvicensis*), occur on the main Hawaiian Islands. The sixth species, the Laysan duck (*A. laysanensis*), exists only on Laysan Island and Midway Atoll. Management and recovery goals for these five species are found in two recovery plans (USFWS 2011a; USFWS 2004). Four of the species—excepting the Hawaiian goose—require wetlands.

One bird-of-prey, the Hawaiian hawk or ʻio (*Buteo solitarius*) is listed as endangered and exists only on the island of Hawaiʻi (USFSW 1984; 73 FR 45680, August 6, 2008). The Hawaiian hawk had been considered for down listing to threatened in 1993, but that proposal was withdrawn in 2008 with a proposal to remove the *io* from the threatened and endangered species list owing to recovery (73 FR 45680, August 6, 2008; 74 FR 27004, June 5, 2009). However, no final rule on the proposal has been published.

Two of Hawaiʻi's seabirds are listed as threatened or endangered. The dark-rumped or Hawaiian petrel (*Pterodroma phaeopygia sandwichensis*) is considered endangered and the Newell's shearwater (*Puffinus auricularis newelli*) is listed as threatened (USFWS 1983). The Newell's shearwater nests primarily on the island of Kauaʻi although small colonies may occur on other islands (USFWS 2011c). The largest nesting colony of Hawaiian petrels occurs on Maui at Haleakla within the National Park. Other colonies of the Hawaiian petrel have been located on Kauaʻi, Hawaiʻi, and Lānaʻi (USFWS 2011d). Introduced predators and ungulates have significantly impacted nesting colonies of both species. Artificial lighting also causes disorientation in flying seabirds causing birds to fly in circles, leading to exhaustion and death (fallout). Recovery efforts have focused on reducing predation, destruction of colonies (e.g., by feral pigs), and artificial lighting.

The one native species of terrestrial mammal in Hawai‘i, the Hawaiian hoary bat (*Lasiurus cinereus semotus*), is listed as endangered. The Hawaiian hoary bat is a solitary species that roosts in trees (USFWS 1998a). It is known from all the main islands except Lāna‘i with largest populations thought to exist on Hawai‘i, Kaua‘i, and Maui. The hoary bat ranges across a wide range of habitats and elevations. Research is currently being performed to better understand the distribution, population status, and ecology of this species (USFWS 2011e).

Sixty-eight species or subspecies of Hawaiian invertebrates are listed as threatened or endangered (Table 3-37). Many of these species are managed under recovery plans (USFWS 1992, 2005, 2006b, 2006d, 2011a, 2011b, and 2012). These species include a large group of endangered O‘ahu tree snails (*Achatinella* spp.) that exist in dry to wet montane (higher than1200 feet elevation) forests and shrublands. The most serious threats are predation by the introduced carnivorous snail, *Euglandina rosea*, and rats and loss of native vegetation (USFWS 1992). Hawai‘i’s tree snails are well known for their colorful and variable shells.

Another large group of endangered invertebrates are the picture-wing flies of the genus *Drosophilia*. Each species of Hawaiian picture-wing fly is found only a single island and depends on a single or few related species of a native host plant (USFWS 2006c). Species occur on the islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i. Critical habitat has been designated for each species.

Table 3-37. Recovery Plans and Outlines Prepared for Endangered Animal Species in the Hawaiian Islands

Recovery Plan Title	Year	Citation
Hawaiian Dark-Rumped Petrel and Newell’s Manx Shearwater	1983	USFWS (1983)
Hawaiian Hawk Recovery Plan	1984	USFWS (1984)
Recovery Plan for the O‘ahu Tree Snails of the Genus *Achatinella*	1992	USFWS (1992)
Recovery Plan for the Hawaiian Hoary Bat	1998	USFWS (1998a)
Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose (*Branta sandvicensis*)	2004	USFWS (2004)
Recovery Plan for the Blackburn’s Sphinx Moth (*Manduca blackburni*)	2005	USFWS (2005)
Recovery plan for the Newcomb’s snail (*Erinna newcombi*)	2006	USFWS (2006b)
Recovery Outline for 12 Picture-wing Flies	2006	USFWS (2006c)
Recovery Plan for the Kaua‘i Cave Arthropods: the Kaua‘i Cave Wolf Spider (*Adelocosa anops*) and the Kaua‘i Cave Amphipod (*Spelaeorchestia koloana*)	2006	USFWS (2006d)
Revised Recovery Plan for Hawaiian Forest Birds	2006	USFWS (2006a)
Revised Recovery Plan for the alala (*Corvus Hawai‘iensis*)	2009	USFWS (2009b)
Recovery Outline for the Kaua‘i Ecosystem	2010	USFWS (2010)
Recovery Outline for Two Damselflies	2011	USFWS (2011f)
Recovery Plan for Hawaiian Waterbirds	2011	USFWS (2011a)

Source: USFWS 2012.

Note: Recovery outlines are preliminary recovery documents to guide recovery efforts until recovery plans are prepared.

Proposed Listing Actions

The USFWS and NMFS both have open listing actions in the main Hawaiian Islands that would designate additional species as threatened or endangered and designate critical habitat. On January 24, 2012, USFWS published a 90-day petition finding and initiation of a status review to determine if listing of the ‘i‘iwi (*Vestiaria coccinea*) as threatened or endangered is warranted (77 FR 3423). The ‘i‘iwi is an endemic bird in the Hawaiian honeycreepers subfamily and occurs on Hawaiʻi, Maui, Molokaʻi, Oʻahu, and Kauaʻi, primarily in montane-wet, closed canopied forest.

On April 5, 2013 NMFS published a proposed rule for public comment that would designate two of six DPSs of the scalloped hammerhead shark as endangered, two DPS as threatened, and not list two as either threatened or endangered (78 FR 20718). The Central Pacific DPS that occurs around the Hawaiian Islands was one of the two DPS determined not to warrant listing. On December 7, 2012, NMFS published a proposed rule for public comment on the findings of a status review under the ESA of 82 reef-building coral species (77 FR 73220). Listing of six species of coral in the main Hawaiian Islands under the ESA was determined to be warranted. These species (*Acropora paniculata*, *Montispora dilatata*, *M. flabellata*, *M. turgescens*, *M. patula*, and *M. verrilli*) are now considered candidates for listing as threatened under the ESA.

3.4.3.1.2 Marine Threatened and Endangered Species

Compared with terrestrial species, Hawaiʻi has many fewer (8 versus 516) threatened and endangered marine species. These eight species include three endangered marine mammals, two endangered sea turtles, and three threatened sea turtles. NMFS has primary responsibility for threatened and endangered marine and anadromous species under the ESA. However, NMFS shares responsibility with the USFWS, especially for those species that depend on terrestrial habitats for part of their life cycle. Section 6 of the ESA provides for the development of cooperative agreements between either the USFWS or NMFS and individual states that establish and maintain a program of conservation for threatened and endangered species. Through the cooperative agreements, states can receive funding to assist in the recovery of listed species. On August 29, 2006, NMFS and the State of Hawaiʻi DLNR entered an agreement for the management of two marine mammals and two sea turtles (Hawaiian monk seal, humpback whale, hawksbill sea turtle, and green sea turtle).

The three endangered marine mammals include the humpback whale or kohola (*Megaptera novaeangliae*), Hawaiian monk seal or ʻilio-holo-i-kauaua (*Monachus schauinslandi*), and main Hawaiian Islands insular false killer whale (*Pseudorca crassidens*) distinct population segment. Of the five species of sea turtles, the leatherback (*Dermochelys coriacea*), the loggerhead (*Caretta caretta*), and olive-ridley (*Lepidochelys olivacea*) are considered incidental (rare or uncommon) in Hawaiʻi (NMFS and USFWS 1998a, 1998b, 1998c, respectively). None of these three species nest in the Hawaiian Islands. Both the hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) sea turtles nest in the Hawaiian Islands. Although sea turtles spend much of their lives at sea foraging and migrating long distances, some species forage in nearshore habitats and beach nesting habitat is a critical component of their life cycle. Loss of beach nesting habitat, destruction of nests by predators or harvesting by humans, and collection of adults all pose risks to sea turtle populations.

Humpback Whale

The humpback whale is a large (45 to 50 feet, 55,000 to 100,000 pounds) baleen whale that is distributed worldwide but was heavily exploited by commercial whalers and was listed as endangered when the ESA was passed in 1973 (NMFS 1991; Wilson and Ruff 1999). Baleen whales feed largely on small schooling fish and krill (crustaceans) filtered from of the large volume of water with which they fill their mouths. Populations of humpback whale exhibit fidelity between wintering areas and northern latitude summer feeding waters. The humpback whales that winter among the Hawaiian Islands are considered part of the Central North Pacific stock that migrates to summer feeding waters near northern British Columbia/ Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Allen and Angliss 2013). Humpback whale abundance peaks in the February-to-March timeframe, but are common from December through May and seen as early as September and as late as June (Darling 2001). Humpback whales usually spend much of their time in shallower water (less than 600 feet). Reproduction and calving typically occurs in the wintering areas, and cows with newborn calves often occupy shallow, inshore waters presumably to separate themselves from mating activity and harassment by males, more turbulent offshore conditions, and predators (Darling 2001).

The highest densities of humpback whales reportedly occur in the four-island region of Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe, on Penguin Bank west of Molokaʻi, around Niʻihau Island, and the leeward coast of Hawaiʻi (NMFS 1991). Lower densities occur around Oʻahu and Kauaʻi. Potential threats to humpback whales include collisions with boats and ships, entanglement in fishing gear, and acoustic disturbance. The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawaiʻi. The sanctuary lies within the shallow (less than 600 feet), warm waters surrounding the main Hawaiian Islands (Figure 3-42 in Section 3.4.4.1.2). Additional information on the Hawaiian Islands Humpback Whale National Marine Sanctuary and restrictions on activities within the sanctuary are provided in Section 3.4.5.1.2.

Hawaiian Monk Seal

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands, with subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. They also occur throughout the main Hawaiian Islands (Carretta et al. 2013). The current best minimum estimate of Hawaiian monk seals' abundance in the main Hawaiian Islands is 153 in 2010 (Carretta et al. 2013) or approximately 12 percent of the population. Current threats are human disturbance, intentional killing by humans, and entanglement in nearshore fishing gear and other marine debris. However, monk seal abundance is increasing on the main Hawaiian Islands. Monk seals spend nearly two-thirds of their time in the marine environment and are primarily benthic (ocean-floor) foragers. The main terrestrial habitat requirements include: haul-out areas for pupping, nursing, molting, and resting. These are primarily sandy beaches, but virtually all substrates are used at various islands (NMFS 2007). Monk seals tend to frequent remote areas with limited access and less human presence. The number of monk seal sightings tend to decrease from the northwest (Niʻihau/Kauaʻi) to the southeast (Hawaiʻi).

In 1988, NMFS designated critical habitat for the Hawaiian monk seal around the Northwestern Hawaiian Islands to a depth of 120 fathoms (53 FR 18988, May 26, 1988). On June 2, 2011, NMFS published a proposed rule to revised critical habitat for the monk seal by extending it out to the 500-meter (1,640-foot) depth in the Northwestern Hawaiian Islands and designating six new areas in the main Hawaiian Islands (76 FR 32026, June 2, 2011). Specific areas proposed for the main Hawaiian Islands include terrestrial and marine habitat from 5 meters inland from the shoreline extending seaward to the 500-meter (1,640-foot) depth contour around: Kaula Island, Niʻihau, Kauaʻi, Oʻahu, Maui Nui (including Kahoʻolawe, Lānaʻi, Maui, and Molokaʻi), and Hawaiʻi except those areas that have been identified in the Federal Register notice as not included in the designation. Excluded areas are largely related to military operations and have national security benefits. A final rule on the new proposed critical monk seal habitat has not been published.

Insular False Killer Whale

False killer whales are the second largest member of the dolphin family (Delphinidae) (3.3- to 6-meters long; maximum weight, 1,360 kilograms) and live in tropical and warm-temperate waters around the world (Wilson and Ruff 1999). On November 28, 2012, NMFS published a final rule listing the main Hawaiian Islands distinct population segment of the insular false killer whale as endangered (77 FR 70915, November 28, 2012). No critical habitat was designated. The insular false killer whale was listed following review of additional scientific information that the population of false killer whales inhabiting the waters surrounding the main Hawaiian Islands met the criteria as a separate stock or distinct population segment from those inhabiting the waters around the Northwestern Hawaiian Islands (77 FR 70915; Carretta et al. 2013). Genetic, photographic, and telemetry data suggests that the main Hawaiian

Island Insular and Northwestern Hawaiian Island distinct population segments may overlap in the region around the island of Kauaʻi. The best estimate of minimum abundance (distinct identified individuals) in the insular population is 129 (Carretta et al. 2013). Threats to the insular false killer whale include reduction in food availability (fish biomass) from commercial and recreational fisheries and incidental take in fisheries operations (77 FR 70915).

Hawksbill Turtle

Hawksbill turtle populations have greatly declined. In the central Pacific, nesting is widely distributed but in low numbers. The hawksbill turtle nests on the main island beaches of Hawaiʻi, primarily along the east coast of the island of Hawaiʻi (NMFS and USFWS 1998d). Two of these sites (Halape and ʻĀpua Point) are in the Hawaiʻi Volcanoes National Park. Other beaches on Hawaiʻi with recorded hawksbill nesting include Kamehame, Punaluʻu, Horseshoe, Nīnole, Kawa, and Pohue (NMFS and USFWS 1998d). Nesting is also known to occur on the east end of Molokaʻi. Peak nesting occurs from late July to early September but may occur anywhere from late May to early December. No critical habitat in the Hawaiian Islands has been designated for the hawksbill turtle.

Green Turtle

The green turtle is the most common sea turtle found in the Hawaiian Islands. Green turtles live in nearshore coastal habitats throughout Hawaiʻi with a high degree of fidelity to specific feeding locations (NMFS and USFWS 1998e). Green turtles are primarily herbivores, feeding largely on sea grasses and algae. Because green turtles live in shallower (less than 100 feet), nearshore habitats, they are vulnerable to habitat deterioration, entanglement in fishing line and other marine debris, boat strikes, and illegal harvesting. Although nesting occurs throughout the Hawaiian Archipelago, over 90 percent of nesting occurs at French Frigate Shoals in the Northwest Hawaiian Islands with minor nesting on Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, and Maui (NMFS and USFWS 1998e; Maison et al. 2010). Green turtles exhibit a high degree of fidelity to the beaches on which they were born. Therefore, excessive harvesting of turtles or eggs at a nesting site will not be replenished by recruitment from other nesting sites or necessarily by individuals that use foraging habitats nearby. No critical habitat in the Hawaiian Islands has been designated for the green turtle.

3.4.3.2 Migratory Birds Protection

In addition to those bird species protected under the ESA, those bird species listed as migratory species under the *Migratory Bird Treaty Act* are protected against take (including eggs, nests, and feathers), harm, and harassment. Many of the endangered bird species are residents. However, Hawaiʻi also seasonally supports a variety of migratory species that either are migratory transients between summer and winter habitats, winter migratory residents, or temporary residents for nesting (e.g., marine birds).

3.4.3.3 Marine Mammals Protection

All marine mammals (Section 3.4.2.2) are protected under the *Marine Mammal Protection Act*. Those species listed as threatened and endangered receive additional protection under the ESA. The *Marine Mammals Protection Act* provides for certain authorized take of marine mammals provided that the taking (lethal, injurious, or harassment) is minimal and have a negligible impact on marine mammals. Marine mammals occur in all waters surrounding the main Hawaiian Islands.

3.4.3.4 Essential Fish Habitat

The *Magnuson-Stevens Fishery Conservation and Management Act* as amended by the *1996 Sustainable Fisheries Act* required that EFH be identified and described for all Federally managed species. EFH has been designated for the four fisheries (see Section 3.4.2.4) in Hawaiʻi. EFH designations for managed species of bottomfish and seamount groundfish, crustaceans, and precious corals fisheries were approved on February 3, 1999 (64 FR 19067). EFH designations for the species of the Coral Reef Ecosystem fishery were approved on June 14, 2002 (69 FR 8336). The EFH designations were made for the broader Western Pacific Regional Fishery which includes the main Hawaiian Islands.

The description of EFH for all four fisheries can be found in the *Fishery Ecosystem Plan for the Hawai‘i Archipelago* (WPRFMC 2009a). The Western Pacific Regional Fishery Management Council designated EFH for adult and juvenile bottomfish as the water column and all bottom habitat extending from the shoreline to a depth of 1,200 feet encompassing the steep drop-offs and high-relief habitats that are important for bottomfish throughout the Western Pacific Region (WPRFMC 2009a). For the Crustacean fishery, the Council designated EFH for spiny lobster larvae as the water column from the shoreline to the outer limit of the United States exclusive economic zone (EEZ) (i.e., 200 miles) down to a depth of 150 meters throughout the Western Pacific Region. The EFH for juvenile and adult spiny lobster is designated as the bottom habitat from the shoreline to a depth of 100 meters throughout the Western Pacific Region. The EFH for deepwater shrimp eggs and larvae is designated as the water column and associated outer reef slopes between 550 and 700 meters (1,800 and 2,300 feet), and the EFH for juveniles and adults is designated as the outer reef slopes at depths between 300 to 700 meters (990 and 2,300 feet). For the precious coral fishery, the Council designated the six known beds of precious corals as EFH (see Section 3.4.2.4). In addition, the Council designated three black coral beds between Miloli‘i and South Point on Hawai‘i, Au‘au Channel between Maui and Lāna‘i, and the southern border of Kaua‘i as EFH. Because of the diversity of fish species managed under the Coral Reef fisheries, designation of EFH was more complex. The EFH for both currently harvested and potentially harvested coral reef fish can be summarized as the water column and all benthic (bottom) substrate to a depth of 300 feet from the shoreline to the outer limit of the EEZ (WPRFMC 2009a). Collectively, the EFH designated for the four fisheries comprises most of the marine waters and ocean floor habitat surrounding the Hawaiian Islands.

3.4.4 PROTECTED LAND AND MARINE AREAS

Various land and marine areas within and surrounding the Hawaiian Islands are administratively protected, primarily for natural, cultural, and historic resources (Loope and Juvik 1998). These areas are managed by Federal agencies, State of Hawai‘i, and nongovernment organizations for the resources contained within their boundaries. While some State controlled land areas restrict development for other reasons (e.g., Department of Hawaiian Home Lands land assets designated for homesteading), the focus of protected land and marine areas discussed in this section are those that have high conservation value for biological resources. Some protected areas that have primary value for protecting cultural or historic resources (e.g., National Historical Parks, Trails, and Sites) are not discussed here but included in Section 3.6. However, it is recognized that some protected historical or cultural sites also provide a measure of protection for biological resources. Because of land ownership and management goals for these protected areas, renewable energy development within their boundaries could be restricted and in some cases prohibited.

Information on protected areas was obtained from Federal and State agency websites as noted in the respective sections. As available, information on geographic location is provided for illustrative purposes to provide geographical context. It is recognized that management goals and area boundaries for protected areas may change with time. Some areas are too small to illustrate in detail. The reader is encouraged to always reference the responsible Federal or State management agencies website or contact the agency for more detailed information for any protected area of interest.

3.4.4.1 Federally Protected Areas

Three Federal agencies manage protected land or marine areas in Hawai‘i. The U.S. National Park Service manages two National Parks and several National Historical Parks. NOAA manages the Hawaiian Islands Humpback Whale National Marine Sanctuary in cooperation with the State of Hawai‘i DLNR. The USFWS manages nine wildlife refuges on the main Hawaiian Islands.

3.4.4.1.1 National Parks

The National Park Service manages the Haleakalā National Park on Maui and Hawai‘i Volcanoes National Park on Hawai‘i. Both parks protect important Hawaiian biological resources in addition to other resources (e.g., water, geology, cultural). The National Park Service also manages several National Historical Parks in the islands (see Section 3.6)

Haleakalā National Park

Haleakalā National Park, established in 1916, is located on the east side of Maui and extends from the ocean near Hana to the 10,023-foot summit of Mount Haleakalā. The park encompasses 30,183 acres of which 24,719 acres are designated as Wilderness Area. Because of the elevation range the park contains most of the native vegetation zones from alpine to lowland dry forest. However, lowland vegetation zones are represented by small remnant patches because of previous disturbances. A primary mission of the Haleakalā National Park is to manage and protect the remaining native Hawaiian plants and animals that live within the park boundaries. The nesting colony of the Hawaiian petrel or uau located near the top of Mount Haleakalā is the largest known for this seabird. The Hawaiian goose or nēnē also nests at Haleakalā (http://www.nps.gov/hale/index.htm).

Hawai‘i Volcanoes National Park

Hawai‘i Volcanoes National Park, established in 1916, is located on the southern part of the island of Hawai’i. Hawai‘i Volcanoes National Park protects approximately 333,000 acres of public land which includes some of the most unique geologic, biologic, and cultural landscapes in the world. Extending from sea level to the summit of Mauna Loa at 13,677 feet, the park encompasses the summits and rift zones of two of the world’s most active shield volcanoes—Kīlauea, representing the newest land in the Hawaiian Islands chain, and Mauna Loa, the largest mountain in the world. Because of its extensive elevation range, Hawai‘i Volcanoes National Park contains all of the major vegetation zones and has populations of many endangered species including the ‘āhinahina (Mauna Loa silversword), honu ea (hawksbill turtle), nēnē (Hawaiian goose), uau (Hawaiian petrel), io (Hawaiian hawk) and ‘ōpe‘ape‘a (Hawaiian hoary bat).

In addition to its geological and biological significance, the park also plays a unique role in the history of human development on the Hawaiian Islands and remains an important home to living cultures in Hawai‘i. Just as the volcanic and biological features of the land have shaped the landscape of Hawai‘i Volcanoes National Park, so too have the people who have been a part of its history. Over five centuries before the establishment of the park, Native Hawaiians lived, worked, and worshiped on this sacred ground. Later, in the 19th and early 20th centuries, adventurers, scientists, philanthropists, and other individuals also left their mark on the landscape. Today, ancient petroglyphs, stone walls, and footpaths persist between massive lava flows, and historic housing districts, ranch buildings, and historical roads dot the developed corridors of the park, together revealing the diverse history and cultures that have been, and continue to play, an integral role in this landscape (http://www.nps.gov/havo/index.htm).

Kalaupapa National Historical Park

Kalaupapa National Historical Park, established in 1980, is located on the northern coast of the island of Moloka‘i. The park is extremely isolated and is accessible only by small aircraft, by mule or foot down the 2,000-foot sea cliffs, and by boat with special use permit. Managed through cooperative agreements between the NPS and the State of Hawaiʻi, the park boundary protects 10,725 acres of land and water and includes numerous significant cultural and natural features associated with the Hansen's disease settlement, Native Hawaiian culture, and sensitive ecosystems. The park includes hundreds of historic buildings, several cemeteries, and thousands of archaeological resources situated in a picturesque, cultural landscape that reflects the evolution of the settlement. Viewsheds to and from the park to the surrounding landforms and ocean are virtually unaltered from the historic period, creating an intact setting and feeling of isolation. Because of its high integrity and national cultural significance, the buildings and landscape at Kalaupapa have been designated a National Historic Landmark district. However, the main cultural resources for the park are the Hansen's disease patients that continue to reside in the settlement today.

The natural resources of the park are similarly significant, with an abundance of geological, terrestrial, aquatic, and marine resources. Typically expanded over an entire island, the natural resources at Kalaupapa National Historical Park are additionally unique since they are concentrated within one location. Geological resources within the park include north shore cliffs that are some of the highest sea cliffs in the world, and are a designated National Natural Landmark. The intervening valleys, volcanic crater and crater lake, lava tubes, caves, and offshore islets are home to a number of terrestrial and aquatic resources, spanning numerous habitats from ohiʻa rain forest to a coastal spray area to freshwater streams. The terrestrial fauna and flora identified in the park comprise nearly 30 Federally listed threatened and endangered species of plants and animals. The park preserves some of the last remaining examples of indigenous plant and animal communities found nowhere else in the world, including the Hawaiian monk seal, loulu palm, montane wet forest, and coral reef communities. Important natural resources are listed as part of the Puu Alii Natural Area Reserve, Forest Reserve, Hawaiʻi State Seabird Sanctuary, and National Natural Landmark (http://www.nps.gov/kala/index.htm).

3.4.4.1.2 National Marine Sanctuaries

National marine sanctuaries were established under the *National Marine Sanctuaries Act* to protect areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities. The management of national marine sanctuaries is the responsibility of the Office of National Marine Sanctuaries under the NOAA.

Hawaiian Islands Humpback Whale National Marine Sanctuary

The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawaiʻi (see Section 3.4.3.1.3). The Hawaiian Islands Humpback Whale National Marine Sanctuary ranges from north to south through six of the eight main Hawaiian Islands (Figure 3-42). The primary purpose is to protect the endangered humpback whale and its habitat. Other marine species also benefit from this protected area. The sanctuary lies within the shallow warm waters surrounding the islands. Regulations restrict activities within the sanctuary including approach distances to whales by both boats and aircraft. Management includes efforts to reduce entanglement in marine debris (e.g., fishing gear), vessel-whale collisions, acoustic disturbance, and protect water quality. Because approximately 65 percent of the sanctuary waters fall under the jurisdiction of the State of Hawaiʻi, the sanctuary is managed in full partnership with State agencies to ensure the coordinated management of sanctuary resources and habitats (http://Hawaiʻihumpbackwhale.noaa.gov/welcome.html).

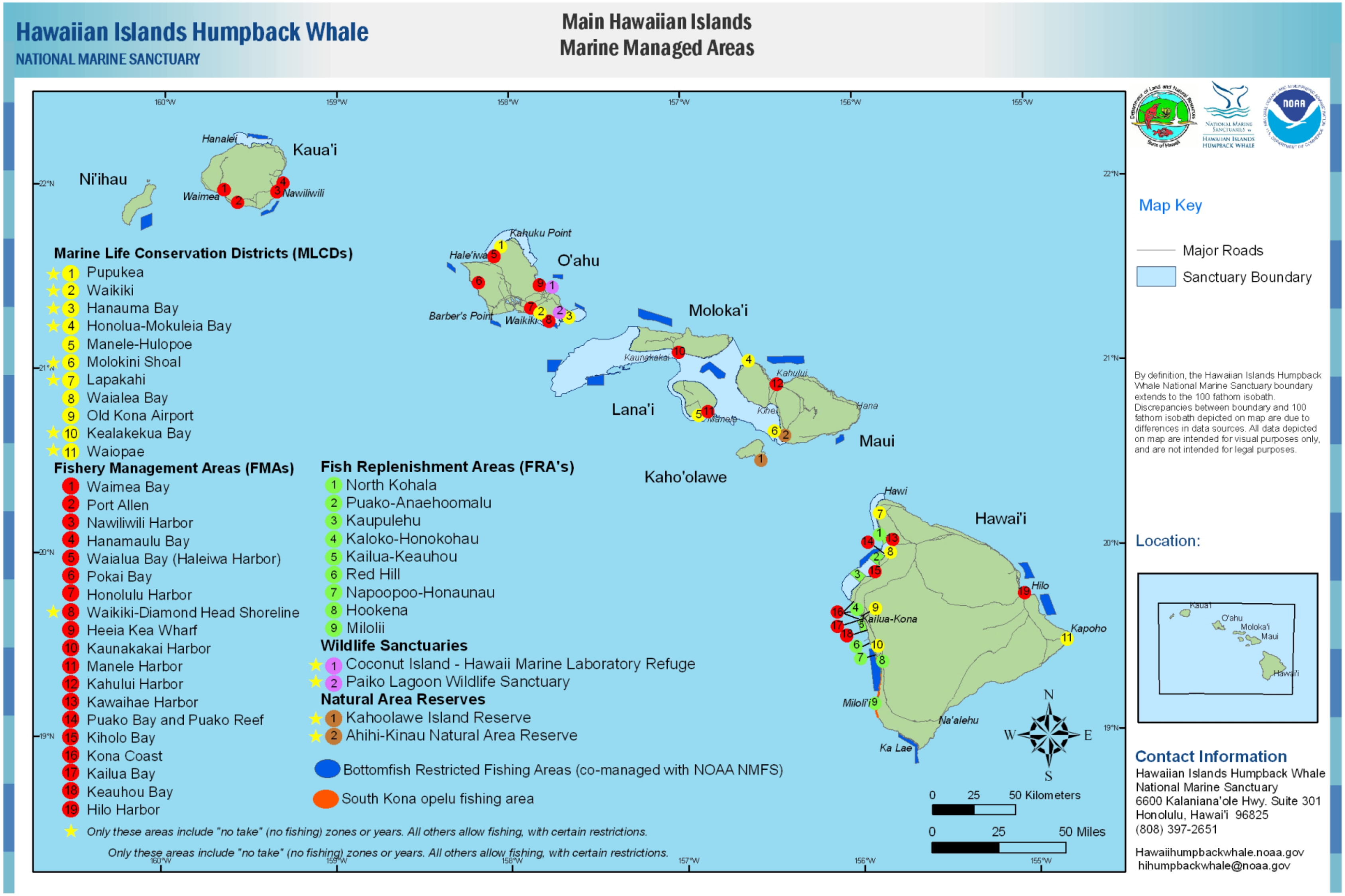


Figure 3-42. Location of the Hawaiian Islands Humpback Whale National Marine Sanctuary and Other Marine Managed Areas (Source: http://hawaiihumpbackwhale.noaa.gov/documents/maps.html)

3.4.4.1.3 National Wildlife Refuges

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. The administration and management of the National Wildlife Refuge System is the responsibility of the USFWS. Information on the National Wildlife Refuges is from the USFWS Website of Pacific Island Refuges (http://www.fws.gov/pacificislandsrefuges/).

Hakalau Forest National Wildlife Refuge

Hakalau Forest National Wildlife Refuge was established in 1985 to protect and manage endangered Hawaiian forest birds and their rainforest habitat. Located on the windward slope of Mauna Kea, Island of Hawaiʻi, the 32,733-acre Hakalau Forest Unit supports a diversity of native birds and plants equaled by only one or two other areas in the State of Hawaiʻi.

Eight of the 14 native bird species occurring at Hakalau are endangered. Thirteen migratory bird species and 20 introduced species, including eight game birds, as well as the endangered ʻōpeʻapeʻa (Hawaiian hoary bat) also frequent the refuge. Twenty-nine rare plant species are known from the refuge and adjacent lands. Twelve are currently listed as endangered. Two endangered lobelias have fewer than five plants known to exist in the wild.

In 1997, the USFWS purchased approximately 5,300 acres of land to create the Kona Forest Unit of Hakalau Forest National Wildlife Refugre. The Kona Forest Unit includes lands within the Hookena and Kalahiki land divisions on the western slopes of Mauna Loa, at elevations between 2,000 and 6,000 feet. Kona Forest Unit is located approximately 23 miles south of Kailua-Kona. The primary purpose for establishing the Kona Forest Unit is to protect, conserve, and manage this native forest for threatened or endangered species. Of particular concern was the ʻalala (*Corvus Hawaiʻiensis*), whose wild population is known only from the west side of Hawaiʻi island. The Kona Forest Unit also offers protected areas for other endangered species, including the Hawaiʻi ʻakepa (*Loxops coccineus*), Hawaiʻi creeper (*Oreomystis mana*), ʻakiapōlaʻu (*Hemignathus munroi*), io (Hawaiian hawk), and ʻōpeʻapeʻa (Hawaiian hoary bat), as well as, several endangered plants and an insect (http://www.fws.gov/hakalauforest/).

Hanalei National Wildlife Refuge

Hanalei National Wildlife Refuge is located in the Hanalei Valley on the north shore of Kauaʻi. The refuge was established under the ESA to conserve five endangered water birds that rely on the Hanalei Valley for nesting and feeding habitat: the koloa maoli (Hawaiian duck), theʻalae keʻokeʻo (Hawaiian coot), the ʻalae ʻula (Hawaiian moorhen), the aeʻo (Hawaiian stilt), and the nēnē (Hawaiian goose). Forty-five other species of birds (18 of which are introduced species) also use the refuge.

The refuge is a relatively flat river valley ranging from 20 to 40 feet above sea level and surrounded by steep, wooded hillsides, up to 1,000 feet high. The water from the Hanalei River is diverted into an east and west supply ditch. It then flows northwest and irrigates approximately 75 acres of wildlife and impoundments, 180 acres of taro patches, and 90 acres of wet pasture before returning to the river. Hanalei National Wildlife Refugre is closed to the public to minimize disturbance and protect endangered waterbirds (http://www.fws.gov/hanalei/).

Huleia National Wildlife Refuge

Located on the southeast side of Kauaʻi, Huleia National Wildlife Refuge lies adjacent to the Menehune Fish Pond, a registered site on the National Register of Historic Places. The Huleia Refuge is approximately 241 acres and was purchased from the Grove Farm Corporation in 1973 to provide open, productive wetlands for five endangered Hawaiian waterbirds that rely on the Huleia River Valley for nesting and feeding habitat. The refuge is located in a relatively flat valley along the Huleia River bordered by a steep wooded hillside. This land was used for wetland agriculture including taro and rice, but is managed today as a refuge for wildlife.

Thirty-one species of birds, including endangered aeʻo (Hawaiian stilt), ʻalae keʻokeʻo (Hawaiian coot), ʻalae ʻula (Hawaiian moorhen), nēnē (Hawaiian goose), and koloa maoli (Hawaiian duck) can be found here. Twenty-six other species of birds (18 of which are introduced species) also use the refuge. In order to protect the endangered species that live in Huleia National Wildlife Refuge, it is closed to the public but can be viewed at an overlook maintained by the State of Hawaiʻi at the historic Menehune Fish Pond (http://www.fws.gov/huleia/).

James Campbell National Wildlife Refuge

James Campbell National Wildlife Refuge is located near the northernmost point on the North Shore of Oʻahu. It was established in 1976 to provide habitat for Hawaiʻi's four endangered waterbirds*:* aeʻo (Hawaiian stilt), ʻalae keʻokeʻo (Hawaiian coot), ʻalae ʻula (Hawaiian moorhen), and koloa maoli (Hawaiian duck). As part of the Oʻahu National Wildlife Refugre Complex, the refuge consists of both natural and artificially maintained wetlands. Two wetland units are included within the James Campbell Refuge, the Kiʻi Unit (126 acres) and the Punamano Unit (134 acres). The wildlife refuge was expanded to 1,100 acres in 2005.

The refuge provides protection for endangered Hawaiian waterbirds, migratory shorebirds, and waterfowl, as well as native plants that rely on coastal wetlands and surrounding lands. Protection of two miles of the dune and strand vegetation along the coast conserves resting habitat for the endangered Hawaiian monk seal and nesting habitat for threatened green turtles and seabirds. The refuge provides a strategic landfall for migratory birds coming from Alaska, Siberia, and Asia (http://www.fws.gov/jamescampbell/).

Kakahaia National Wildlife Refuge

Kakahaia National Wildlife Refuge on the island of Molokaʻi is part of the Maui National Wildlife Refuge Complex. It was established in 1976 to permanently protect wetland habitat for endangered waterbirds, primarily Hawaiian stilt and Hawaiian coot, and to provide habitat for wintering migratory wetland birds.

The refuge contains a 15-acre coastal freshwater marsh. This spring-fed pond lies on a narrow plain just above sea level at the foot of volcanic hills. An additional 5.5-acre managed impoundment was constructed in 1983 to provide shallow-water habitat for wading birds. Kamehameha V Highway bisects the southern part of the refuge, allowing access to the coastal portion managed as a park by the County of Maui (http://www.fws.gov/kakahaia/).

Kealia Pond National Wildlife Refuge

Established in 1992, Kealia Pond National Wildlife Refuge encompasses approximately 700 acres and is one of the few natural wetlands remaining in the Hawaiian Islands. Located along the south-central coast of the island of Maui, between the towns of Kihei and Māʻalaea, it is a natural basin for a 56-square-mile watershed from the West Maui Mountains.

The seasonal conditions that occur at Kealia Pond National Wildlife Refuge provide habitat for endangered wetland birds, along with a diversity of migratory birds from as far away as Alaska and Canada, and occasionally from Asia (http://www.fws.gov/kealiapond/).

Kīlauea Point National Wildlife Refuge

Kīlauea Point National Wildlife Refuge was established in 1985 to preserve seabird nesting colonies on the steep seaside cliffs. The refuge is located on the northernmost point of Kauaʻi along the island's north coast (Figure 3-43). The refuge was expanded in 1988 to include Crater Hill and Mokolea Point. The refuge is home to some of the largest populations of nesting seabirds in the main Hawaiian Islands. It also contains native Hawaiian coastal plants and Hawai'i's State bird, the nēnē or endangered Hawaiian goose (http://www.fws.gov/kilaueapoint/).

O'ahu Forest National Wildlife Refuge

O'ahu Forest National Wildlife Refuge is home to at least four species of endangered pupu kani oe (O'ahu tree snails); 15 endangered plant species; and many native birds, including the O'ahu 'elepaio, 'i'iwi, pueo, and native honeycreepers. The refuge is located on the upper slopes of the northern Ko'olau Mountains and contains some of the last remaining native intact forests on O'ahu. The primary purpose of the refuge is to protect native biodiversity threatened by nonnative plants and animals (http://www.fws.gov/oahuforest/).

Figure 3-43. Kīlauea National Wildlife Refuge, Kīlauea Point and Bay (Source: USFWS)

Pearl Harbor National Wildlife Refuge

Pearl Harbor National Wildlife Refuge was established in 1972 as mitigation for construction of the Honolulu International Airport Reef Runway. The Honouliuli and Waiawa Units are managed under a cooperative agreement with the U.S. Navy. The Kalaeloa Unit was established during military base closure proceedings in 2001.

Pearl Harbor National Wildlife Refuge, in close proximity to historic visitor attractions such as the *USS Arizona* and the *USS Missouri*, serves to protect some of the last remaining wetland areas on O'ahu. The refuge protects endangered wildlife and sensitive habitats along O'ahu's coastal area (http://www.fws.gov/pearlharbor/).

3.4.4.2 State-Protected Areas

The State of Hawai'i manages a variety of protected areas, each with different management goals and objectives (Loope and Juvik 1998). Information is provided in the following sections those areas most important to fish, wildlife, and plant conservation.

3.4.4.2.1 State Forest Reserves

Forest Reserves are multi-use land areas that encompass and incorporate a variety of public uses and benefits. Each forest reserve within the system has different management and use goals depending on the nature of the resources found within the reserve. Management goals include protecting forested watersheds to produce fresh water supplies, maintaining biological integrity of native ecosystems, providing public recreational opportunities, and producing a sustainable supply of forest products. The Hawai'i Forest Reserve System was created in 1903 and now includes approximately 642,000 acres. The forest reserves are managed by the Division of Forestry and Wildlife within the Hawai'i DLNR. Management plans have been prepared for some but not all forest reserves. Management plans and more detailed information on individual forest reserves are available on the Hawai'i Forest Reserve System Website (http://hawaii.gov/dlnr/dofaw/forestry/FRS). The island of Hawai'i has the most acreage of forest reserves with 443,000 acres. Kaua'i has the second most acreage with 86,000 acres. Of the six main islands, only Lāna'i has no forest reserve as the island is mostly privately owned.

3.4.4.2.2 Marine Life Conservation Districts

The variety of marine life and habitats that exist in the nearshore waters of the Hawaiian Islands is one of the important natural resources of the State. Approximately 400 species of inshore and reef fishes inhabit coastal waters of Hawaiʻi. Marine Life Conservation Districts were designed to conserve and replenish marine resources. Fishing and other consumptive uses are limited or may be prohibited in Marine Life Conservation Districts (Table 3-38). They provide fish and other aquatic life with a protected area in which to grow and reproduce, and are home to a great variety of species. Fishes in most Marine Life Conservation Districts are fairly tame and often show little fear of humans. Marine Life Conservation Districts are most popular as sites for snorkeling, diving and underwater photography.

Table 3-38. Marine Life Conservation Districts

Island/Marine Life Conservation District Name	Size (acres)
Oʻahu	
Hanauma Bay	101
Pupukea	(a)
Waikīkī	76
Maui County	
Honolua-Mokuleʻia Bay	45
Manele-Hulopoʻe	309
Molokini Shoal	77
Hawaiʻi	
Kealakekua Bay	315
Lapakahi	146
Old Kona Airport	217
Waialea Bay	35
Waiopae Tidepools	(a)

a. No acreage available.

The locations of the 11 Marine Life Conservation Districts are illustrated (in yellow) in Figure 3-42 (Section 3.4.4.1.2). Compared with many land-based conservation areas, Marine Life Conservation Districts are relatively small, the largest being Kealakekua Bay at 315 acres with many being less than 100 acres. The DLNR Division of Aquatic Resources provides detailed descriptions of each Marine Life Conservation District including location, history, marine resources, safety considerations, facilities, and regulations (http://hawaii.gov/dlnr/dar/mlcd.html).

3.4.4.2.3 Natural Area Reserves

The State of Hawaiʻi's Natural Area Reserve System was established to preserve in perpetuity specific land and water areas that support natural flora and fauna communities, as relatively unmodified as possible, as well as geological sites, of Hawaiʻi. The system presently consists of 20 reserves on five islands, encompassing 123,431 acres of the State's most unique ecosystems (Lānaʻi is 98 percent privately owned and there are no natural area reserves on the island). The diverse areas found in the Natural Area Reserve System range from marine and coastal environments to lava flows, tropical rainforests, and even an alpine desert. Within these areas one can find rare endemic plants and animals, many of which are endangered. The reserves also protect some of the major watershed areas which provide sources of fresh water. The DLNR Division of Forestry and Wildlife administers the Natural Area Reserves System. The following sections briefly discuss the natural area reserves on the five islands.

Kauaʻi

Hono O Nā Pali Natural Area Reserve

Hono O Nā Pali Natural Area Reserve occupies 3,579 acres northwest side of the island of Kauaʻi and contains lowland mesic forest and shrub, lowland wet forest, and montane wet forest. The Reserve includes perennial streams, rare plants, endemic stream fauna, and forest bird and seabird habitat. The Reserve stretches from sea level along the Nā Pali coast to the highest point at Pihea (4,284 feet) (http://hawaii.gov/dlnr/dofaw/nars/reserves/Kauaʻi/honoonapali).

Kuʻia Natural Area Reserve

Kuʻia Natural Area Reserve occupies 1,636 acres on the west side of Kauaʻi. Elevation ranges from 2,000 to 3,900 feet, encompassing lowland dry shrubland and lowland mesic, montane mesic, and montane wet forest. Many rare plant taxa are found within the Reserve's mesic and wet forests. The Kuʻia Reserve protects important rare native communities and associated rare species (http://hawaii.gov/dlnr/dofaw/nars/reserves/Kauaʻi/kuia).

Oʻahu

Kaʻena Point Natural Area Reserve

Kaʻena Point, the westernmost point on Oʻahu, is the site of one of the last intact dune ecosystems in the main Hawaiian Islands. The Reserve protects native coastal Hawaiian plants and animals that have been largely displaced on most coastal areas. During the winter breeding season, humpback whales will frequent the waters surrounding Kaʻena Point (http://hawaii.gov/dlnr/dofaw/nars/reserves/Oʻahu/kaenapoint).

Pahole Natural Area Reserve

The 685 acre Pahole Reserve was established in 1981 on the north end of the Waiʻanae Range on the west side of Oʻahu. It protects rare Hawaiian plants, animals, and ecosystems of the lowland mesic zone. The mesic gulches are home to more species of native trees than the lush Hawaiian rainforests (http://hawaii.gov/dlnr/dofaw/nars/reserves/Oʻahu/pahole).

Mount Kaʻala Natural Area Reserve

Mount Kaʻala, the highest peak on the island of Oʻahu, rises to 4,025 feet in the Waiʻanae Range on the west side of Oʻahu. Established in 1981, the Mount Kaʻala Reserve comprises 1,100 acres of rugged mountain terrain. Most of the reserve's area consists of steep-sided gulches and ridges that form the eastern flank of Mount Kaʻala. It protects rare Hawaiian plants, animals, and ecosystems, most found only in Hawaiʻi. The Reserve contains all the lowland and montane ecosystems including lowland dry forests that once covered the drier portions of Oʻahu, but are now nearly gone (http://hawaii.gov/dlnr/dofaw/nars/reserves/Oʻahu/mountkaala).

Molokaʻi

Puu Alii Natural Area Reserve

Puu Alii Reserve is located in the mountains of northern Molokaʻi and includes 1,330 acres. It is a wet summit plateau inhabited by wet forests, mixed fern and shrub montane cliff communities, and wet shrublands, and Hawaiian intermittent stream communities. Puu Alii reserve is an important part of the Molokaʻi watershed and contains forest bird habitat. The Puu Alii Reserve is located within the Kalaupapa National Historic Park (http://dlnr.hawaii.gov/ecosystems/nars/reserves/Molokaʻi/puu-alii/).

Olokui Natural Area Reserve

Olokui Reserve encompasses 1,620 acres of an isolated, cloud-shrouded mountain plateau with slopes extending down to sea cliffs. The reserve is located in the eastern half of Molokaʻi along the north coast and is one of the few areas left undisturbed by feral ungulates. It contains wet and dry ecosystems and coastal dry grasslands. Lowland and montane wet and mesic forests are also represented. Surveys of this area have confirmed the presence of rare snails (http://hawaii.gov/dlnr/dofaw/nars/reserves/Molokaʻi/olokui).

Maui

ʻAhihi-Kinaʻu Natural Area Reserve

The ʻAhihi-Kinaʻu Natural Area Reserve is located on the southwest corner of the island of Maui and was the first designated Natural Area Reserve in 1973. The 1,238 acres contain marine ecosystems (807 submerged acres), rare and fragile anchialine ponds, and lava fields from the last eruption of Haleakalā 200 to 500 years ago, native plant communities that include naio, wiliwili and native cotton exist in kipuka, or pockets, but are severely imperiled by the encroachment of weeds and feral ungulates such as goats. A coral reef survey done by the Division of Aquatic Resources in 2007 indicated that the reef community within the NAR boundary waters was the only reef from their test sites that was not declining overall. Preserving the integrity of the anchialine pools is a major management focus. All access to them is closed. Main threats to these wetlands include nonnative invasive species such as fish or prawns, algal mat formations, and human disturbance (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/ahihikinau).

Hanawi Natural Area Reserve

The Hanawi Natural Area Reserve encompasses 7,500 acres on the wet slopes on the north flank of Mount Haleakalā. This Reserve extends into subalpine zones of East Maui and includes rare subalpine grassland, as well as montane and lowland mesic and wet grasslands and forests. The reserve protects rare plants and contains habitat for the State's largest concentration of rare and endangered Hawaiian birds (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/hanawi).

Kanaio Natural Area Reserve

Kanaio Natural Area Reserve is 876 acres and located in rough lava terrain on the southeast slope of Mount Haleakalā. The reserve protects a remnant of the native dryland forest that once covered the leeward slope of Mount Haleakalā. Kanaio protects a rich assemblage of native dryland trees and shrubs There are large stands of halapepe (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/kanaio).

Nakula Natural Area Reserve

The Nakula Natural Area Reserve encompasses 1,420 acres. This reserve contains a rare leeward koa-ohia forest and alpine shrublands on the south slope of Haleakalā. The reserve is potential reintroduction site for endangered birds (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/nakula).

West Maui Natural Area Reserve

The West Maui Natural Area Reserve comprises four separate units for a total of 6,702 acres. The reserve encompasses lowland and montane native communities ranging from dry grasslands to wet ʻohiʻa forests. The reserve also includes bogs, montane lakes, forest bird habitat, and rare and endangered plants. The areas are extremely important watershed sites which contain the headwaters of perennial streams. This reserve is made up of four noncontiguous sections: Honokōwai, Kahakuloa, Panaʻewa, and Lihau. All sections of the reserve contain rare plants.

The Honokōwai section (750 acres) is on the wet upper northern slopes of the West Maui Mountains. The native communities include two kinds of rare bogs, as well as wet forests, shrublands, and a montane lake. The Kahakuloa section (3,275 acres) lies on wet, windward slopes of the West Maui Mountains. The plateau of Eke Crater is still undisturbed by feral ungulates. This section includes the upper reaches of two perennial streams, and includes a rare montane bog surrounded by ʻohiʻa wet forests. Panaʻewa (1,717 acres) includes a rare montane bog, as well as representative ʻohiʻa forests and shrublands. The

Lihau section is the driest of the four sections of the West Maui Natural Area Reserve. Lihau is a steep-sloped volcanic remnant that extends from dry leeward lowlands to a wet summit with cliffs on all sides (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/west-maui).

Hawai‘i Island

Kahaualea Natural Area Reserve

Kahaualea Natural Area Reserve (22,520 acres) can be found on the gentle slopes of Kīlauea; site of much recent volcanic activity. Kahaualea includes representatives of pioneer vegetation on lava flows, lowland rainforest and mesic forest. The largest population of *Adenophorus periens*, an endangered fern, is found in Kahaualea (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/kahaualea).

Kipahoehoe Natural Area Reserve

Kipahoehoe Natural Area Reserve (5,583 acres) is a narrow piece of land running down the southwest slopes of Mauna Loa in the district of South Kona. It includes a rare lowland grassland, as well as mesic and wet forests of ‘ohi‘a and koa. Recent volcanic flows run through the Reserve, leaving a variety of different aged communities (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/kipahoehoe).

Laupahoehoe Natural Area Reserve

Laupahoehoe Natural Area Reserve is located on the windward slopes of Mauna Kea and stretches from just above 1,600 feet to about 4,600 feet in elevation. Hakalau National Wildlife Refuge is adjacent to Laupahoehoe Reserve, and also protects habitat for several endangered forest birds known to occur in Laupahoehoe Reserve. Five native natural communities can be observed in the Reserve, including a tall-stature koa-‘ohi‘a forest in both montane and lowland zones, ‘ohi‘a/hapu‘u (*Cibotium* spp.) forest, *Carex alligata* wet grassland, and nonnative dominated patches (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/laupahoehoe).

Manuka Natural Area Reserve

Manuka is the largest reserve (25,550 acres) in the State’s system. Extending from sea level to 5,000 feet in elevation, this reserve features a broad range of habitats. These include subalpine shrublands and forests, mesic montane kipuka forests, wet montane forests, lowland mesic and dry forests, and lava anchialine pools. Recent lava flows add a variety of pioneer vegetation types, as well as uncharacterized and unsurveyed lava tubes. Concentrations of the Hawaiian hoary bat occur in the area. (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/manuka)

Mauna Kea Ice Age Natural Area Reserve

Located in the upper, southern flank of Mauna Kea, the 3,894 acre Mauna Kea Ice Age Natural Area Reserve contains a rare alpine aeolian desert dominated by invertebrates and the only alpine lake in Hawai‘i. Rare native invertebrates and evidence of Pleistocene glaciation can be found. The area also contains important cultural resources as it was once a Hawaiian adze quarry site. (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/maunakeaiceage)

Puu Makaala Natural Area Reserve

The wet koa and ‘ohi‘a forest of the Puu Makaala Natural Area Reserve (18,730 acres) on the northeast flank of Mauna Loa are important habitat for some of Hawai‘i’s rarest birds, as well as several rare plants. Montane wet grassland occurs in the poorly drained portions of the Reserve. (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/puumakaala)

Pu‘u O Umi Natural Area Reserve

The Pu‘u O Umi Natural Area Reserve (10,142 acres) includes the wet summit lands of the Kohala Mountains in the northern part of the island, with two rare kinds of montane bogs surrounded by *‘ohi‘a* forests, shrublands, and grasslands. The Reserve extends downslope to the Kohala sea cliffs and coastal dry grassland. Rare plants are known from bogs and forests. The steep cliffs of Waipio and Waimanu valleys form part of the Reserve boundary. Numerous streams run through the area. The Reserve is an important watershed for the region. The Reserve contains habitats for several rare plants and animals such as the endangered *koloa* (Hawaiian duck). (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/puuoumi)

Waiakea 1942 Lava Flow Natural Area Reserve

A recent lava flow being recolonized by young ‘ohi‘a forest dominates this Reserve. Other successional communities in a montane wet ‘ohi‘a forest ecosystem are also represented. This Reserve (640 acre) is located on the sloping northeast flank of Mauna Kea (http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/waiakea).

3.4.4.2.4 State Wildlife Sanctuaries

State wildlife sanctuaries or management areas include an array of areas set aside or recognized as important areas to protect individual or groups of rare or endangered animals and plants (Loope and Juvik 1998). Although most are managed by the Division of Forestry and Wildlife or Division of Aquatic Resources, several exist on military lands or waters (Table 3-39). Two wildlife sanctuaries are discussed and illustrated in the following paragraphs.

Figure 3-44. Kanaha Pond State Wildlife Sanctuary

Kanaha Pond State Wildlife Sanctuary is a 143-acre wetland located on the north coast of Maui near Kahului (Figure 3-44). It is a waterfowl sanctuary, home to three endangered Hawaiian bird species, the Hawaiian coot (‘alae ke‘oke‘o) (*Fulica alai*), the Hawaiian duck (koloa) (*Anas wyvilliana*), and the Hawaiian (or black-winged) stilt (ae‘o) (*Himantopus mexicanus knudseni*). Kanaha Pond was designated a State sanctuary in 1951.

Thirty-eight islets offshore from the Hawaiian Islands have been integrated into a State Seabird Sanctuary for nesting seabirds (Table 3-39). O‘ahu has 17 islets along its windward coast, 13 of which are designated Hawai‘i State Seabird Sanctuaries (DLNR 2006) (Figure 3-45). Approximately 150,000 to 200,000 breeding individuals nest in dense colonies on 11 of these offshore islets and a few on-shore sites. Efforts have been made to restore and improve seabird nesting colonies on these islands through removal of nonnative predators (e.g., rats) that prey on eggs and hatched young and nonnative vegetation that over grow nesting sites. The re

Figure 3-45. Moku Manu (Bird Island) Islet off the Windward Coast of O‘ahu (Source: Starr and Starr 2006)

The Puu Waawaa Forest Bird Sanctuary was established by the State Board of Land and Natural Resources in 1984 to protect habitat for endangered forest birds, especially the Hawaiian crow (*Corvus Hawai‘iensis*) (Griffin 2003). It is located on the leeward side or northern flank of the Hualālai volcano on the island of Hawai‘i. It was officially designated a State wildlife sanctuary in 2002 managed by the Hawai‘i Division of Forestry and Wildlife. In 2007 its designation was officially changed to a forest reserve (see Section 3.4.4.2.1).

3.4.4.3 Nongovernment Organization Lands and Public-Private Partnerships

In addition to Federal and State administratively protected land areas, a variety of other nongovernment organizations are involved in the management and conservation of biological and other natural resources (e.g., water) of the Hawaiian Islands. These include national conservation organizations such as The Nature Conservancy, corporations with large land holdings, land trusts, and organizations with vested interest in natural resources such as water management companies or irrigation districts. Government agencies also may form public-private partnerships with nongovernment organizations to develop management plans for particular land units or watersheds.

The Nature Conservancy is actively involved in the management and conservation of biological resources throughout the Hawaiian Islands and manages nature preserves throughout the islands (http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/Hawai‘i/index.htm). Mitchell et al. (2005) provides a general list by island of some of the nongovernmental organizations and public-private partnerships that manage land for the purposes of conserving and protecting biological resources. The Farm Service Agency (FSA) in the U.S. Department of Agriculture administers the Conservation Reserve Program (CRP) whose purpose is to assist private landowners in conserving soil, water, and wildlife resources on farms and ranches. CRP participants enter into 10 to 15 year contracts for converting lands to conservation purposes. In 2006, the FSA prepared a programmatic environmental assessment to evaluate potential impacts of implementing the Hawai‘i Conservation Reserve Enhancement Program (CREP) Agreement between the U.S. Department of Agriculture and the State of Hawai‘i. The CREP Agreement is designed to enroll 30,000 acres of cropland and marginal pastureland in 15-year CRP agreements on Hawai‘i, Moloka‘i, Maui, O‘ahu, Maui, and Kaua‘i with the primary goal of reducing soil erosion and improving water quality. These agreements would limit the potential land uses on these private lands for the term of the contract.

Table 3-39. Wildlife Sanctuaries and Wildlife Management Areas

State/Sanctuary or Management Area	Size (acres)	Primary Biological Resource
Kauaʻi		
Kawaiʻele Wildlife Sanctuary	37	Waterbirds, migratory shorebirds, seabirds, migratory waterfowl
Alakaʻi Wilderness Preserve	9,939	Forest birds, short-eared owl, Hawaiian duck, terrestrial invertebrates, rare plants
Oʻahu		
Kawai Nui and Hāmākua Marsh Complex	850	Waterbirds, migratory shorebirds, Hawaiian stream gobies, freshwater shrimp
Nuupia Pond Wildlife Management Area, U.S. Marine Corps Base Hawaiʻi	482	Waterbirds, migratory shorebirds, seabirds, particularly wedge-tailed shearwater
Paiko Lagoon	40	Migratory shorebirds
Pouhala Marsh Wildlife Sanctuary	70	Waterbirds, particularly Hawaiian stilt
Ulupau Wildlife Management Area, U.S. Marine Corps Base Hawaiʻi	23	Seabirds, particularly red-footed booby
Nearshore waters surrounding Kāneʻohe Marine Corps Base, U.S. Marine Corps Base Hawaiʻi	(a)	Marine invertebrates, coral reef fishes, and sea turtles
Coconut Island Wildlife Sanctuaries	(a)	Marine species
Molokaʻi		
North and West Shore Coastal Strand	(a)	Seabirds, Hawaiian monk seal, and sea turtles
Ilio Point, State Land	(a)	Seabirds
Maui		
Kanaha Wildlife Sanctuary	235	Seabirds, waterbirds, migratory birds, terrestrial invertebrates
Hawaiʻi		
Kīpuka Āinahou Nēnē Sanctuary	11,157	Hawaiian goose, forest birds, terrestrial invertebrates, rare plants, and public hunting
Puu Waawaa Wildlife Sanctuary	3,806	Hawaiian hoary bat, forest birds, Hawaiian hawk, short-eared owl, Hawaiian goose, recovery habitat for Hawaiian crow, terrestrial invertebrates, including rare moths and insects, rare plants.
State Seabird Sanctuary		
Kauaʻi (3 islets)	(a)	The species vary by island but collectively the State Seabird Sanctuary serves to protect the many species of seabirds that forage in the ocean waters surrounding the Hawaiian Islands and use the islets for breeding and nesting. For island specific information refer to Mitchell et al. 2005 or Harrison 1990. The islets also serve as habitat for a variety of migratory shorebirds.
Oʻahu (13 islets)	(a)	
Molokaʻi (7 islets)	(a)	
Lānaʻi (4 islets)	(a)	
Maui (8 islets)	(a)	
Hawaiʻi (3 islets)	(a)	

(a) = acreage unavailable.

Conservation practices and agreements (i.e., contracts, management plans, and easements) on private and nongovernment organizations lands may create areas of important biological resources or establish areas where development of renewable energy projects may be restricted. In 2010, 13 land trusts were operating in Hawaiʻi, protecting approximately 20,000 acres (Land Trust Alliance 2010). In 2011, four land trusts, the Kauaʻi Public Land Trust, Oʻahu Land Trust, Maui Coastal Land Trust, and the Hawaiʻi island Land Trust merged to form the Hawaiian Islands Land Trust and oversees approximately 15,000 acres of conservation lands (http://www.unpo.org/article/12098).

3.4.4.4 Distribution of Protected Land and Marine Areas

Protected land and marine areas occur throughout the islands and in the surrounding ocean and serve to protect, conserve, or sustainably use biological resources. Protected land and marine areas for each island include a variety of different designations and uses and include national and State parks and monuments, national wildlife refuges, wildlife sanctuaries, marine sanctuaries, forest reserves, natural area reserves, nature preserves, essential fish habitat, and designated critical habitat for threatened and endangered species. An overview is of these areas is provided for each island in the following sections.

Important biological resources are not limited to protected land and marine areas as many species are highly mobile (e.g., birds, the hoary bat, marine mammals and reptiles) and use any suitable habitat available. Not all areas that contain high quality habitat or have important populations of plants and animals are within land or marine areas that have some level of protective status. However, protected area may be important to the long-term conservation of some species. Protected areas also have restricted uses that would limit or even prohibit their potential use for renewable energy development.

3.4.4.4.1 Kaua‘i

Approximately 38 percent of the island is dominated by native vegetation (Mitchell et al. 2005). Most of the remaining native ecosystems occur in the central highlands and consists of montane mesic and wet forest, bogs, and cliff ecosystems (Figure 3-46) (TNC 2006). Much of the central highlands and western part of Kaua‘i contains most of the administratively protected land including parks, natural area reserves, forest reserves, and wildlife refuges. There are also several lower elevation forest reserves and wildlife refuges in the east and northern part of the island.

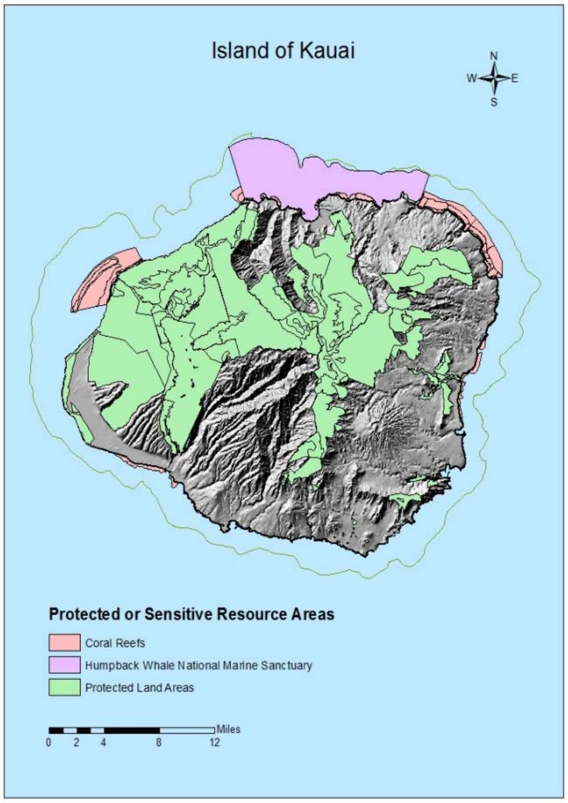


Figure 3-46. Protected or Sensitive Resource Areas on Kaua‘i

Kaua‘i contains a wide variety of threatened and endangered species including one terrestrial mammal, many species of birds, invertebrates, and several species of marine mammals and reptiles. Approximately 55,000 acres of critical habitat have been designated on Kaua‘i. Much of the designated critical habitat overlaps with many of the administratively protected land areas.

The ocean sea slope surrounding Kaua‘i is relatively steep with the 600 foot contour depth typically only two to five miles offshore. Kaua‘i has one of the two barrier coral reefs in the islands on its west coast. Fringing coral reefs also occur offshore. Part of the Hawaiian Islands Humpback Whale National Marine Sanctuary occurs along the Kaua‘i’s north coast.

The ocean waters surrounding Kaua‘i have been designated essential fish habitat for the bottomfish, crustacean, and coral reef fisheries. The south sea slope of Kaua‘i is classified as essential fish habitat for the precious coral fishery.

3.4.4.4.2 O‘ahu

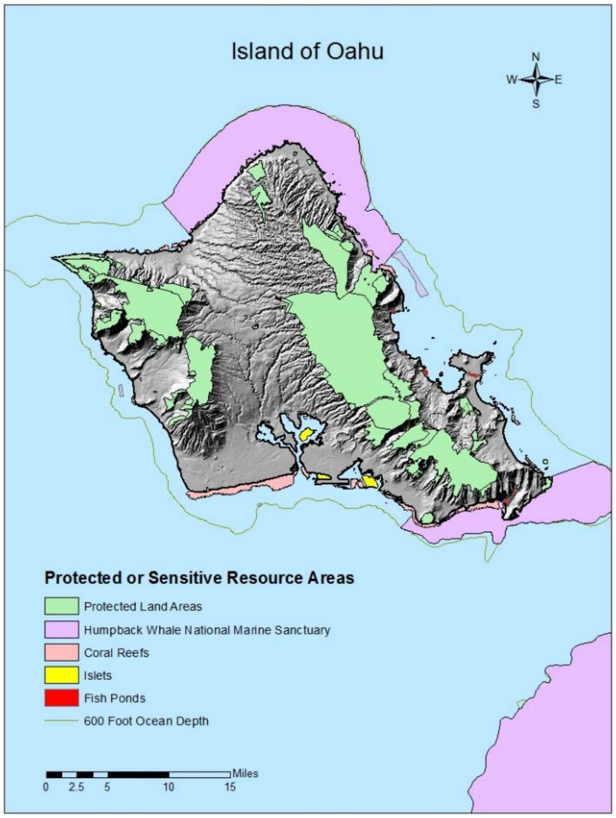


Figure 3-47. Protected or Sensitive Resource Areas on O‘ahu

O‘ahu is the most populous island of the State. The remaining native ecosystems are associated with the upper elevations of the Ko‘olau and Wai‘anae mountain ranges on the northeast and southwest sides, respectively, of the island (TNC 2006). These are characterized by steep topography and poor access. These areas contain most of the protected land areas on O‘ahu (Figure 3-47).

O‘ahu contains a wide variety of threatened and endangered species including one terrestrial mammal, many species of birds, invertebrates, and several species of marine mammals and reptiles. More than 55,000 acres of critical habitat have been designated for plants on O‘ahu. An additional 66,000 acres has been designated for the O‘ahu elepaio (*Chasiempis sandwichensis ibidis*) that overlaps with acreage designated for plant species. Much of the designated critical habitat overlaps with many of the administratively protected land areas.

Portions of the Hawaiian Islands Humpback Whale National Marine Sanctuary border the southeastern and north sides of the island. In addition to the humpback whale, other threatened and endangered species that occur in offshore waters or use beach areas on O‘ahu include the Hawaiian monk seal, insular false killer whale, green turtle, and hawksbill turtle. The island of O‘ahu has several large estuaries and bays and a barrier reef complex off of the northeast coast near Kāne‘ohe Bay. The island also has fringing reefs in many areas along the coast.

3.4.4.4.3 Moloka‘i

Like the other islands, the lowland dry and mesic forest and shrubland ecosystems have been largely altered by human activity. Most of the remaining native vegetation is on the mountainous east volcanic area with deep valleys that makes access difficult. Some areas of lowland mesic forest

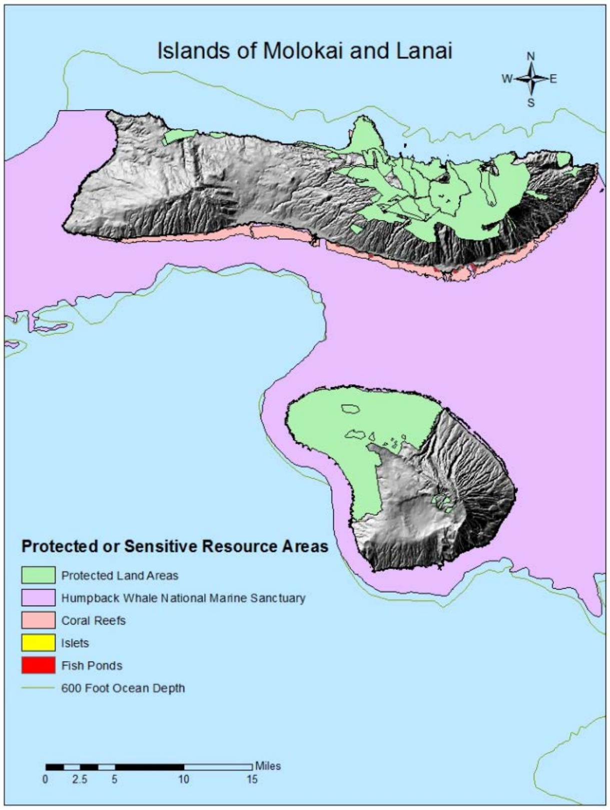


Figure 3-48. Protected or Sensitive Resource Areas on Moloka‘i and Lāna‘i

remain on the south slopes of the east Molokaʻi volcano with larger areas of lowland wet and montane wet forest at higher elevations (TNC 2006). Areas of the wet cliff ecosystem still remain on the steep north (windward side) slopes of the volcano.

Protected land areas occur primarily in the mountainous eastern portion of the island (Figure 3-48). These areas range from sea level to the highest mountain peak and include critical habitat, parks, natural area reserves, forest reserves, and wildlife refuges. Molokaʻi supports a variety of threatened and endangered species including forest birds, the Hawaiian hoary bat, the Hawaiian goose, and several waterbirds such as the Hawaiian silt and Hawaiian coot. Approximately 25,000 acres of critical habitat has been designated for a variety of plant species and about 3,100 acres has been designated for the Blackburn's sphinx moth which partially overlaps the plant critical habitat. The coastal strand along the island's northwest coast contains one of the State's last intact dune systems and is important to nesting seabirds and marine animals.

The southern coast of Molokaʻi has the longest fringing reef within the State, approximately 30 miles. The ocean waters surrounding Molokaʻi and the neighboring islands of Lānaʻi and Maui are the shallowest among the islands. These waters comprise the largest portion of the Hawaiian Islands Humpback Whale National Marine Sanctuary. Several fish ponds occur along the southern coast. The ocean waters surrounding Molokaʻi have been designated essential fish habitat for the bottomfish, crustacean, and coral reef fisheries.

3.4.4.4.4 Lānaʻi

Very little native ecosystem is left on the island. A small area of montane mesic forest and lowland dry and mesic forest remains on Mount Lānaʻihale. Historically, much of Lānaʻi was covered with coastal, lowland dry forest and shrub, and lowland mesic ecosystems. Much of the vegetation was altered when Lānaʻi was a major producer of pineapples. Lānaʻi is largely privately owned and no State or Federally protected land occurs on the island. However, the State leases approximately 30,000 acres for use as the Lānaʻi Cooperative Game Management Area (Figure 3-49). Like the other islands, Lānaʻi contains multiple threatened and endangered species. The Hawaiian Islands Humpback Whale National Marine Sanctuary surrounds the island.

3.4.4.4.5 Maui

The island of Maui comprises two volcanic mountains. Native vegetation remains primarily on peaks and slopes of the two mountains. The lowland dry forest and shrub, lowland mesic forest, and montane dry and mesic forest have been replaced by anthropogenic vegetation. Areas of montane wet forest still remain in both East and West Maui.

Protected land areas on Maui occur primarily in east and west mountain areas but span the range of habitats from the coast to the alpine zone (Figure 3-49). Approximately, 200,000 acres or 43 percent of Maui is under some form of conservation management (e.g., a management plan exists) or protected. Maui also contains multiple areas of designated critical habitat for threatened and endangered species.

The ocean waters surrounding Maui have been designated essential fish habitat for the bottomfish, crustacean, coral reef, and precious coral fisheries. The ocean area west of Maui, between Maui, Molokaʻi and Lānaʻi, is part of the Hawaiian Islands Humpback Whale National Marine Sanctuary.

3.4.4.4.6 Hawaiʻi

The island of Hawaiʻi is the largest and tallest of the islands and comprises five shield volcanoes. The two tallest mountains are Mauna Kea at 13,796 feet and Mauna Loa at 13,677 feet. Hawaiʻi has relatively large alpine and subalpine zones. Like the other islands, the lowland dry forest and shrub and lowland mesic forests on Hawaiʻi have been mostly altered by human activity. However, Hawaiʻi still retains significant areas of native ecosystems, primarily in the center of island around Mauna Kea and Mauna Loa (Pratt and Gon 1998; TNC 2006) (Figure 3-50). Remaining native ecosystems include wet forests, montane dry and mesic forest, subalpine, and alpine vegetation zones.

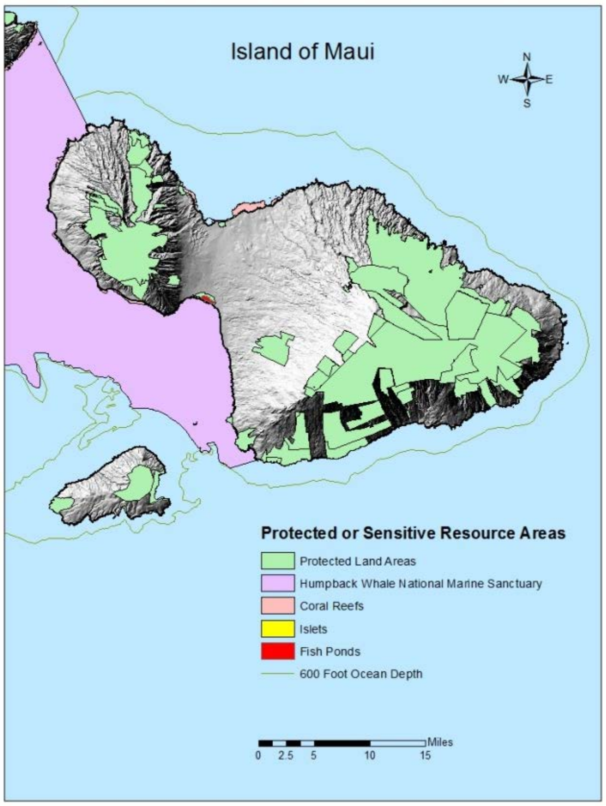


Figure 3-49. Protected or Sensitive Resource Areas on Maui

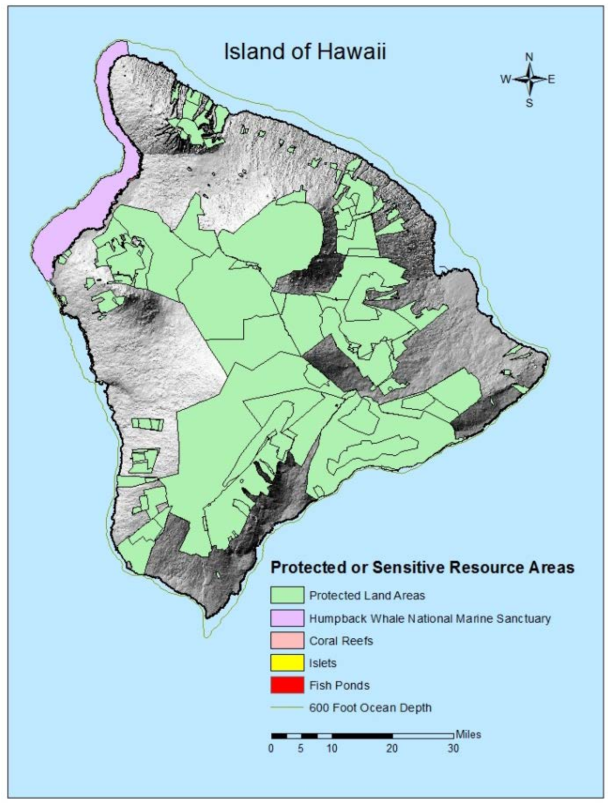


Figure 3-50. Protected or Sensitive Resource Areas on Hawaiʻi

Protected land areas on Hawaiʻi range from the ocean to the peaks of Mauna Loa and Mauna Kea. Most of the protected land area occurs in uplands areas. Approximately 38 percent of the island is under State or Federal Management. The National Park Service manages a relatively larger area (406,000 acres) on Hawaiʻi. Most of this land is in Hawaiʻi Volcanoes National Park. Like its neighboring islands, Hawaiʻi has designated critical habitat for threatened and endangered habitats.

Essential fish habitat has been designated around the island and the waters off of the northwest coast out to the 600 foot depth have been designated as part of the Hawaiian Islands Humpback Whale National Marine Sanctuary.

3.4.5 COMMON CONSTRUCTION AND OPERATION IMPACTS

This section contains a discussion of common impacts that could occur to terrestrial and marine ecosystems from the development of renewable energy technologies. The impacts discussed in this section are those impacts that are not unique to a particular energy technology. Impacts discussed in Chapters 4 through 8 are those impacts to terrestrial and marine ecosystems that are more specific to the implementation of a particular technology. This approach to discussing impacts is done to avoid repeated discussion of common impacts for each technology but does not assume that either common impacts or impacts unique to a particular technology are any less or more important. Section 3.4.6 discusses BMPs that could be implemented to reduce, minimize, or avoid potential impacts.

3.4.5.1 Terrestrial Ecosystems

Land disturbance is a common impact associated with most land-based renewable energy technologies including clearing or modification of vegetation, soil disturbance, and loss of wildlife habitat. These impacts are not limited to the footprint of the facilities but could include access roads, utility corridors, and a buffer zone around the facility. Development of some energy technologies have an exploratory or data collection phase that could require construction of access roads, drilling, and field studies that also could disturb land and wildlife. The potential amount of land and habitat that could be disturbed varies among energy technologies. Development of distributed renewable energy projects may often involve smaller land disturbances than utility-scale projects because they are usually smaller and are often developed in close proximity to existing commercial or industrial facilities where the land may already be disturbed or the vegetation has been previously modified. The potential impact of land disturbance on vegetation communities, wildlife habitat, and individual wildlife species will depend on specific development locations and the size of the land disturbance. Threatened and endangered species, both plants and animals, could be killed or disturbed by land disturbances. Locations that have been previously disturbed or contain less valuable wildlife habitat would be preferred sites and would minimize potential impacts.

Where vegetation is cleared and bare soil is exposed the potential exists for the establishment of invasive and weedy species. These species can establish either through wind and water dispersal or by human transport on equipment (i.e., tires) or vehicles. Access roads and transmission line corridors could provide potential corridors for nonnative species to become established in new areas that could then in turn provide a source of invasive species into nearby undisturbed areas. Revegetation or landscaping with native or non-invasive species soon after completion of facility construction would minimize potential impacts.

Human activity (both physical presence of workers and associated noise) during construction of renewable energy facilities could cause wildlife species to temporarily avoid a construction area. This impact could be minimized by locating energy facilities away from high wildlife use areas and important habitats (e.g., wetlands, nesting sites, and roost trees) and scheduling construction during times of minimum wildlife use. Disturbance of important habitats even though they may be small in size such as a roost tree or nesting site (e.g., sea bird colony or beach) can have disproportionately large impacts on a species.

Sea bird species including the threatened Newell’s shearwater, endangered Hawaiian petrel, and the candidate band-rumped storm-petrel are nocturnal flyers and become disoriented by bright outdoor night lighting. The birds eventually become exhausted and fall to the ground (i.e., fallout). Sea turtles also are susceptible to artificial light visible from the beach and disorient turtles away from the ocean. Most renewable energy facilities would require some type of lighting whether it is for worker visibility or safety (e.g., lighting of tall structures). HRS 205A-30.5 prohibits the direct illumination of the shoreline and ocean waters by artificial light or lighting. Lighting regulations also have been established in some counties (e.g., Hawai‘i) to minimize potential impacts of light on wildlife as well as “dark night skies.” Following lighting guidelines and lighting regulations should minimize potential impacts.

3.4.5.2 Marine Ecosystems

Disturbance of the ocean floor or benthic environment would be a common impact associated with development of most renewable energy technologies in marine ecosystems. Disturbance impacts could occur from laying pipelines (e.g., water intake and discharge pipes), power cables, anchors for floating platforms, and placement of marine kinetic energy devices on the ocean floor. Suspension of sediments in the water and could impact surrounding marine organisms through sediment deposition which can block sunlight and decrease photosynthesis. Of particular concern is sediment deposition on coral reefs. Impacts also could include displacement or mortality of bottom organisms. However, avoidance of high value ocean habitats such as coral reefs, marine pools, estuaries, and sea grass habitat would minimize potential impacts. These construction impacts would be temporary until benthic organism’s recolonized disturbed areas, but sediment deposition on coral reefs could have longer lasting impacts. Placement of structures in the ocean, either on the ocean floor or as floating platforms, creates surfaces that are often colonized by marine organisms in a process called biofouling. These structures often serve as artificial reefs and fish aggregation devices as fish and marine mammals are attracted to the increase in marine productivity and the potential shelter of the structure. Although the artificial reef effect may generally have a positive effect on local marine productivity surrounding the structures, structures with moving parts, such as marine kinetic energy devices, may pose a hazard to some marine animals.

Installation of energy devices in the ocean may have localized negative effects from human disturbance and underwater noise during construction. Some marine mammals are attracted to activity (e.g., whales are curious) in the ocean which may increase the probably of collisions with construction boats and ships. These impacts could be mitigated through having marine mammal monitors during construction. Many marine species have well developed sound communication and may be sensitive to acute construction noise. However, those effects would be temporary and limited to the construction period. During operation, any ocean energy device with rotating or oscillating parts would create sound waves that could cause marine mammals, reptiles, and fish to avoid an area surrounding the project. Sufficiently loud sounds can cause auditory injures but it is not known whether hydrokinetic energy devices produce sounds capable of causing auditory injury. Hydrokinetic energy devices with moving parts also could cause physical injury to marine mammals and fish or cause species to avoid the area creating loss of habitat.

Offshore renewal energy projects would need a power transmission cable to transfer energy produced to the islands. Installation of power cables across the coastline and onshore power stations could disturb a variety coastal marine habitats such as marine pools (tidal and anchialine), beaches, estuaries, fishponds, and reefs. Potential impacts (i.e., disturbance and mortality) to wildlife species and threatened and endangered species could occur in the vicinity of the construction. During construction, disturbance from cable installation and human activity could impact nesting sea turtles and sea birds. Monk seals also use remote beaches as resting places and could be disturbed. Sea turtles also can become disoriented by artificial light along beaches. Locating power cable crossings and associated transformer stations away from remote, undeveloped coastlines that would be more favored by marine and terrestrial wildlife species and minimizing lighting could reduce potential impacts (see HRS 205A-30.5, http://www.Kaua‘i-seabirdhcp.info/minimization/lights/index.html).

Another potential impact from undersea power cables is related to electromagnetic fields (EMF) on marine organisms along the cable. Although potential impacts to and responses of marine organisms to EMFs are not fully understood, many marine species such as sharks, marine mammals, sea turtles, and some bony fishes have well developed electrosensory systems that may be involved in orientation, homing, and navigation or life functions such as detection of prey and predators (Normandeau et al. 2011). The potential strength of the EMF surrounding the cable is a function of the voltage, cable shielding, and whether the cable is buried or laid along the ocean floor. However, the EMF attenuates relatively quickly with distance from the cable (15 and 30 feet for AC and DC cables, respectively) along and above the seafloor, and the potential impacts to those species most sensitive to EMFs is likely to be relatively small (Normandeau et al. 2011).

3.4.6 COMMON BEST MANAGEMENT PRACTICES

The following sections discuss BMPs that could be implemented to minimize and avoid potential impacts to terrestrial and marine ecosystems from the construction and operation of renewable energy technologies.

3.4.6.1 Terrestrial Ecosystems

- Review Federal and State databases and technical reports for regulatory requirements for protection of special status animal and plant species and habitats. Being aware of the applicable regulations and potential biological resources issues and concerns will help avoid unwanted surprises during the planning and implementation phases of the project. This also improves the potential for productive and informative coordination with Federal and State environmental agencies.

- Coordinate with the USFWS (i.e., begin early consultation processes) and State environmental and fish and wildlife agencies early in the planning phase of the project for identification of potential issues, and ensure ongoing communication in the course of project development. USFWS can also inform the developer whether the NMFS also should be consulted for a particular project. Both agencies share jurisdictional responsibility for some threatened and endangered species such as sea turtles. This BMP is one of the best ways to avoid or minimize potential environmental issues early in the project planning. Note that it best to coordinate with agencies prior to performing any exploratory field investigations as those studies also could have potential impacts.

- Become aware of possible pre- and post-construction environmental monitoring BMPs and mitigation measures through agency and public interactions. Depending on the particular issues associated with a project, there may be monitoring requirements for a particular species or group of species. For example, the adults and larvae of the endangered Blackburn’s sphinx moth feed on specific host plants and the developing pupae occupy the soil in the vicinity of the host plants for a year or longer. If a project could disturb the host plants, surveys to map their location and identify evidence of larval feeding may be recommended. Identifying these types of recommendations or requirements early will allow integration into the project.

- Locate project facilities and ancillary components so that environmentally sensitive areas (e.g., riparian habitats, streams, wetlands, critical wildlife habitats, and migration corridors, and other protected areas) are avoided. Potential impacts discussed in this PEIS are often dependent on location. Location of a project within a landscape will often determine the real potential for impacts to terrestrial ecosystems. For example, species that fly comprise a large proportion of the Hawaiian fauna and airspace is a valuable resource to these species that is difficult to identify and describe. Coordination with Federal and State wildlife agencies is a good way to identify project development locations from a landscape perspective that would minimize potential impacts.

- Develop biological survey protocols and plans in consultation with regulatory agencies to ensure that specific regional and other requirements are met. For example, acoustic monitoring devices are recommended for surveys for the presence of the Hawaiian bat. However, survey requirements (e.g., a onetime survey or a continuous survey over a longer time period) may vary depending on the specific project and type of action that would occur. Different plant and animal species may require different survey techniques and sampling designs.

- Consider potential impacts on indigenous and special status plant species while addressing controls for nonnative/invasive species and noxious weeds.

- Consider using a weed risk assessment tool such as the Hawai‘i Pacific Weed Risk Assessment (https://sites.google.com/site/weedriskassessment/home) to evaluate any introduced species proposed for biomass fuel production. Some species with characteristics such as rapid growth, high productivity, and adaptable to a wide range of environmental conditions (e.g., precipitation, temperature, and soils) that make them good biomass fuel candidates, also are characteristics that could make them invasive species. Introduced species that are used for biomass fuels production should be evaluated prior to use and monitored during use to detect potential spread beyond the production fields.

- Consider reclamation and conservation initiatives for disturbed lands after construction. Use native species or non-invasive species to restore bare soil. Establishing a plant cover not only restores potential wildlife habitat but also helps prevent establishment of weedy or invasive species.

- Consider developing habitat restoration and management plans and compensatory mitigation and monitoring plans.

- If lighting is required on renewable energy facilities for either worker or public safety, the lighting design should follow recommended guidelines such as those listed at http://www.Kaua‘i-seabirdhcp.info/minimization/lights/index.html, in applicable county regulations, or provided by Federal or State agencies. Generally lights should be positioned low to the ground, be motion-triggered, and be shielded or full cut-off. Effective light shields should be completely opaque, sufficiently large, and positioned so that the bulb is only visible from below bulb-height. Nighttime lighting during construction should be avoided if at all possible, particularly from mid-September through mid-December when sea birds are most susceptible to fallout.

- Use screens on freshwater diversion channels for small-scale hydroelectric power plants to prevent entrainment of freshwater fish species through the power generation system (i.e., forebay reservoir, penstock pipe, and turbine. Establish minimum stream flows for the diverted stream segment to ensure adequate flow for fish passage.

- Collect preconstruction data on bird and bat flight paths and activity in the vicinity of a wind energy project site. The flight paths of many seabirds from mountain nesting sites to the ocean are not well understood.

3.4.6.2 Marine Ecosystems

- Review Federal and State databases and technical reports for regulatory requirements for protection of special status animal and habitats. Being aware of the applicable regulations and potential biological resources issues and concerns will help avoid unwanted surprises during the planning and implementation phases of the project. This also improves the potential for productive and informative coordination with Federal and State environmental agencies.

- Coordinate with the NMFS (i.e., begin early consultation processes) and State environmental and fish and wildlife agencies early in the planning phase of the project for identification of potential issues, and ensure ongoing communication in the course of project development. NMFS can also inform the developer whether the USFWS also should be consulted for a particular project. This BMP is one of the best ways to avoid or minimize potential environmental issues early in the project planning. Note that it best to coordinate with agencies prior to performing any exploratory field investigations as those studies also could have potential impacts.

- Become aware of possible pre- and post-construction environmental monitoring BMPs and mitigation measures through agency and public interactions. Depending on the particular issues associated with a project, there may be monitoring requirements for a particular species or group of species. Identifying these requirements early will allow integration into the project.

- Locate project facilities and ancillary components so that environmentally sensitive areas (e.g., estuaries, coral reefs, critical habitats, and migration corridors, and other protected areas) are avoided. Potential impacts discussed in this PEIS are often dependent on location. Location of a project within the marine environment will often determine the real potential for impacts. Coordination with Federal and State fish and wildlife agencies is a good way to identify project development locations that would minimize potential impacts.

- Develop biological survey protocols and plans in consultation with regulatory agencies to ensure that specific regional and other requirements are met.

- Use observers during construction to avoid potential collisions of boats and ships with marine mammals. Performing construction during times when marine mammals are least likely to be present also would minimize potential collisions.

- If lighting is required on offshore renewable energy facilities for either worker or public safety, they should follow recommended guidelines such as those listed at http://www.Kaua‘i-seabirdhcp.info/minimization/lights/index.html, in applicable county regulations, or provided by Federal or State agencies. Pursuant to HRS 205A-30.5, artificial light or lighting shall not directly illuminate the shoreline and ocean waters. Generally, lights should be positioned low to the surface, be motion-triggered, and be shielded or full cut-off. Effective light shields should be completely opaque, sufficiently large, and positioned so that the bulb is only visible from below bulb-height. Flashing safety lighting should follow guidelines to reduce the potential for attracting sea birds. Construction and operational lighting should be limited or not used along beach areas when installing power cables from offshore energy projects, particularly from May through December when sea turtles nest on beaches.

- EMF exposure can be reduced, if necessary, by shielding and sheathing undersea cables, as well as by burying the cables in the ocean floor. Concrete or other material placed over an undersea cable may also provide shielding, but would cause seafloor and habitat disturbance and changes. Many marine species have electro and magnetic senses and use those senses to navigate. BOEM’s report *Effects of EMFs from Undersea Power Cables on Elasmobranches and other Marine Species* (BOEM 2011) addresses this topic, concluding that more research needs to be done to better understand these interactions.

- Use horizontal direction drilling technology to cross the coastline to lay pipelines and power cabling to avoid impacts to both terrestrial and marine habitats and organisms. However, caution needs to be used in application of HDD technology along the shore because some marine habitats such as landlocked anchialine pools are dependent on an underground connection to the ocean tide. Drilling could potentially disturb this underground ocean connection and HDD efforts should be located to avoid anchialine pools that may contain threatened and endangered species.

3.5 Land and Submerged Land Use

Sections 3.5.1and 3.5.2 present information on land ownership and land use for each of the six major islands, respectively. The sections begin with an overview from the State perspective. Section 3.5.3 presents information on submerged land uses by category rather than by each island.

3.5.1 LAND OWNERSHIP

Hawaiʻi public trust or "ceded" lands were transferred to the United States by the Republic of Hawaiʻi under the 1898 annexation of Hawaiʻi as a territory of the United States, following the end of the Hawaiian monarchy. The *Admissions Act of 1959*, which granted Hawaiʻi Statehood, established the State as trustee of the ceded lands and defined five purposes for their use, including the betterment of conditions for native Hawaiians. The 1963 *Ceded Lands Act* allowed the transfer of title to the State of Hawaiʻi for all ceded lands (less those parts retained by the Federal Government for national parks, military bases, and other public purposes) (aloha4all.org). In 1978, voters approved constitutional amendments to create the Office of Hawaiʻi Affairs and fund it with a share of the money derived from the use of ceded lands.

Ceded lands in Hawaiʻi comprise approximately 1.8 million acres of property throughout the State, or about 43 percent of the State's total land area. Figure 3-51 shows approximate areas of ceded lands (light green).

Because the exact amount of ceded lands was unknown, the 2000 State Legislature adopted Act 125 to facilitate the establishment of a comprehensive information system for inventorying and maintaining information about the ceded lands. In 2011, the Legislature amended Act 125 to require the State auditor to initiate and coordinate all efforts to establish a public land trust information system. Unfortunately for numerous reasons, development of the information system was overcome by events

The following sections provide land ownership information for each island for State, Federal, and private lands, including land ownership maps depicting the largest owners in terms of land acreage. DBEDT maintains listings of each landowner on each island on the following website: http://files.hawaii.gov/dbedt/op/gis/data/large_landowners_tables.xls.

Figure 3-51. Approximate Areas of Ceded Lands (light green)

3.5.1.1 Kaua‘i

Kaua‘i, with an area of about 562 square miles (approximately 359,680 acres), is the fourth largest of the six main Hawaiian Islands. Figure 3-52 shows the largest landowners on the island of Kaua‘i (Hawai‘i 2013a).

Land ownership on Kaua‘i is distributed as follows (Hawai‘i 2013a):

State Government:	167,257 acres
Federal Government:	3,074 acres
Private:	135,067 acres

Kaua‘i is home to the U.S. Navy’s Barking Sands Pacific Missile Range. The Range includes the majority of Federal lands on the island. The base itself is about 2,400 acres and includes a 6,000-foot runway. Support facilities at Port Allen, Makaha Ridge, and Kokee State Park make up the rest of Federal acreage on Kaua‘i.

3.5.1.2 O‘ahu

O‘ahu, with an area of about 597 square miles (approximately 382,080 acres), is the third largest of the six main Hawaiian Islands. Figure 3-53 shows the largest landowners on the island of O‘ahu (Hawai‘i 2013a).

Land ownership on O‘ahu is distributed as follows (Hawai‘i 2013a):

State Government:	156,661 acres
Federal Government:	61,050 acres
Private:	63,544 acres

O‘ahu encompasses the City and County of Honolulu. The County of Honolulu hosts a number of U.S. military facilities: Hickam Air Force Base, the Army’s Fort Shafter, the Army’s Schofield Barracks/Wheeler Army Air Field, the Coast Guard facilities at Barbers Point (Kapolei) and in Honolulu, and Pearl Harbor Naval Shipyard and Naval Station.

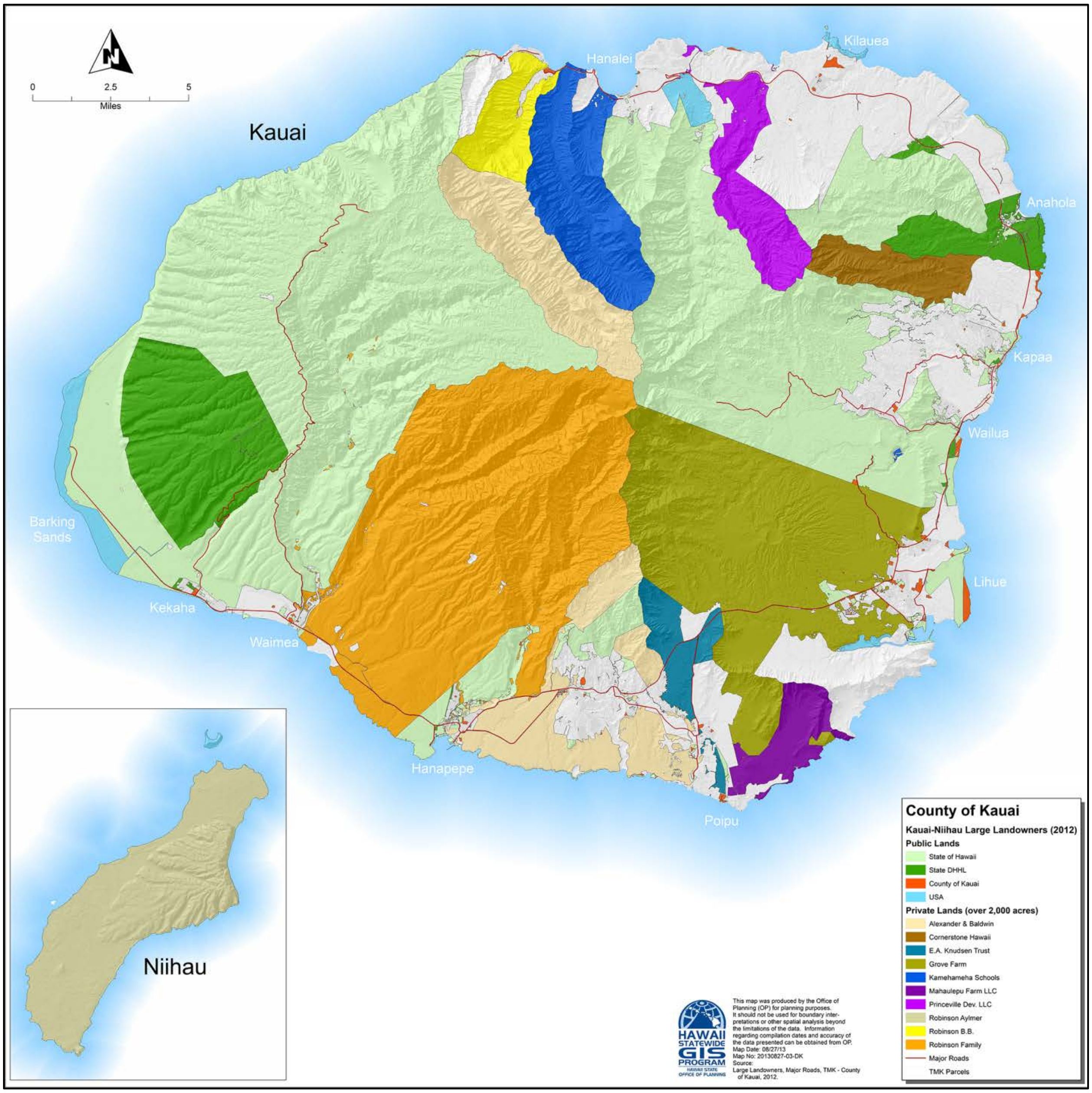


Figure 3-52. Land Ownership on Kaua‘i (Source: Hawai‘i 2013a)

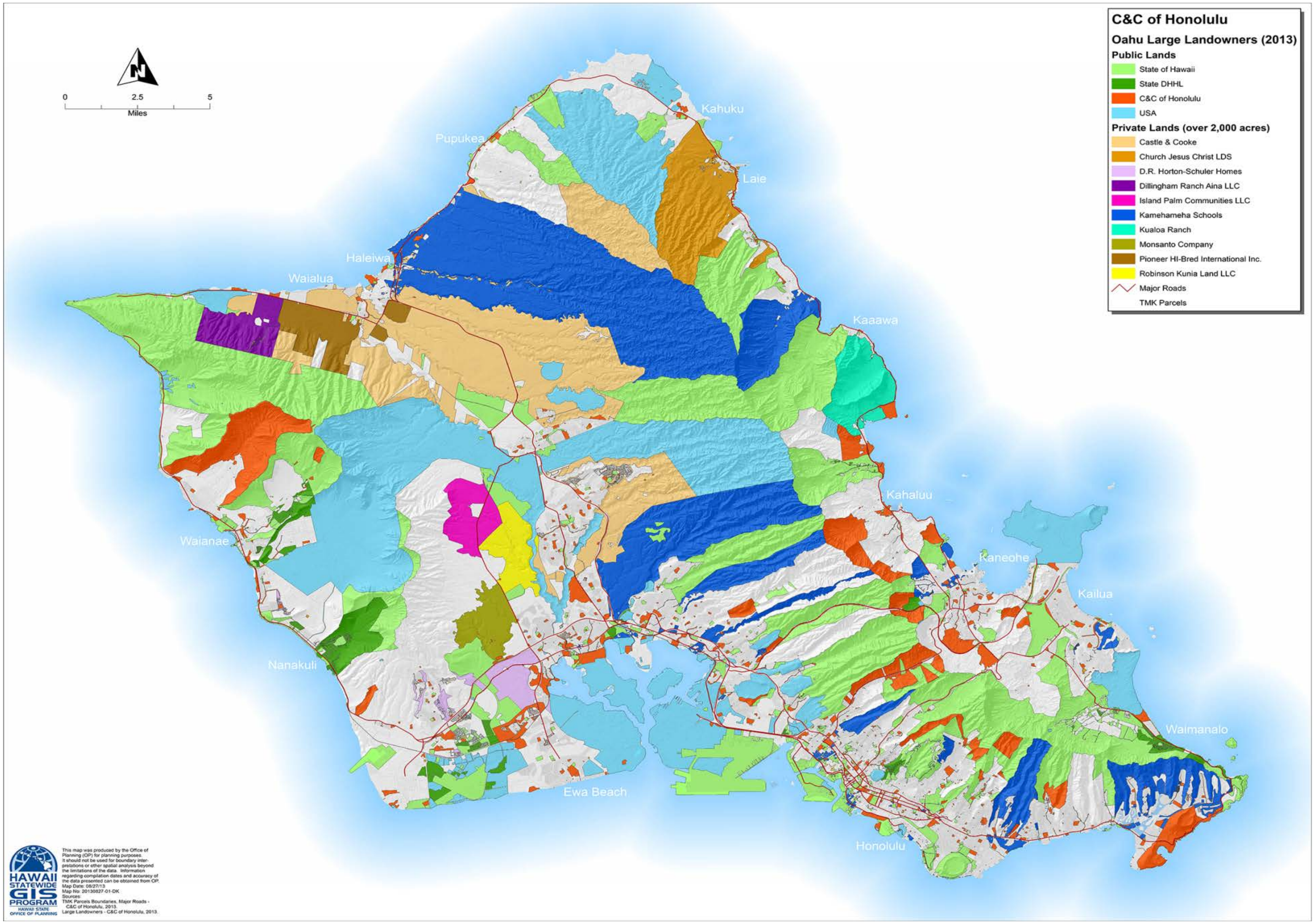


Figure 3-53. Land Ownership on O'ahu (Source: Hawai'i 2013a)

3.5.1.3 Moloka‘i

Moloka‘i, with an area of about 260 square miles (approximately 166,400 acres), is the fifth largest of the six main Hawaiian Islands. Figure 3-54 shows the largest landowners on the island of Moloka‘i (Hawai‘i 2013a).

Land ownership on Moloka‘i is distributed as follows (Hawai‘i 2013a):

State Government:	54,995 acres
Federal Government:	258 acres
Private:	101,935 acres

Moloka‘i Properties Limited owns the Moloka‘i Ranch and is the largest private landowner (over 60,000 acres) on the island. There is a small square of land, approximately 23 acres, (Figure 3-54) on the Kalaupapa Peninsula owned by the NPS. Though the NPS only owns a small portion of land within the Kalaupapa National Historical Park, the rest of the park is managed by the NPS through cooperative agreements with the State of Hawai‘i (see Section 3.4.4.1.1).

3.5.1.4 Lāna‘i

Lāna‘i, with an area of about 140 square miles (approximately 89,600 acres), is the sixth largest of the six main Hawaiian Islands. Figure 3-55 shows the largest landowners on the island of Lāna‘i (Hawai‘i 2013a).

Land ownership on Lāna‘i is distributed as follows (Hawai‘i 2013a):

State Government:	265 acres
Federal Government:	5 acres
Private:	89,188 acres

Until recently, the principal island landowner, of more than 89,000 acres, was Castle & Cooke. Castle & Cooke, Inc. is a Los Angeles-based company that, at one time, was in the agriculture business. Through various mergers over time, the company became present-day Dole Food Company, the world’s largest producer of fruits and vegetables (Dole 2012). In 1996, Castle & Cooke divested from Dole, and today most of the company’s business is in real estate; specifically, residential, commercial, and retail development.

In 2012, Mr. Larry Ellison, Chief Executive Officer of the Oracle Corporation, bought the landholdings of the island from Castle & Cooke, which amounted to about 98 percent of the island’s land. The acquisition also included various commercial and residential properties and utilities (New York Times 2012).

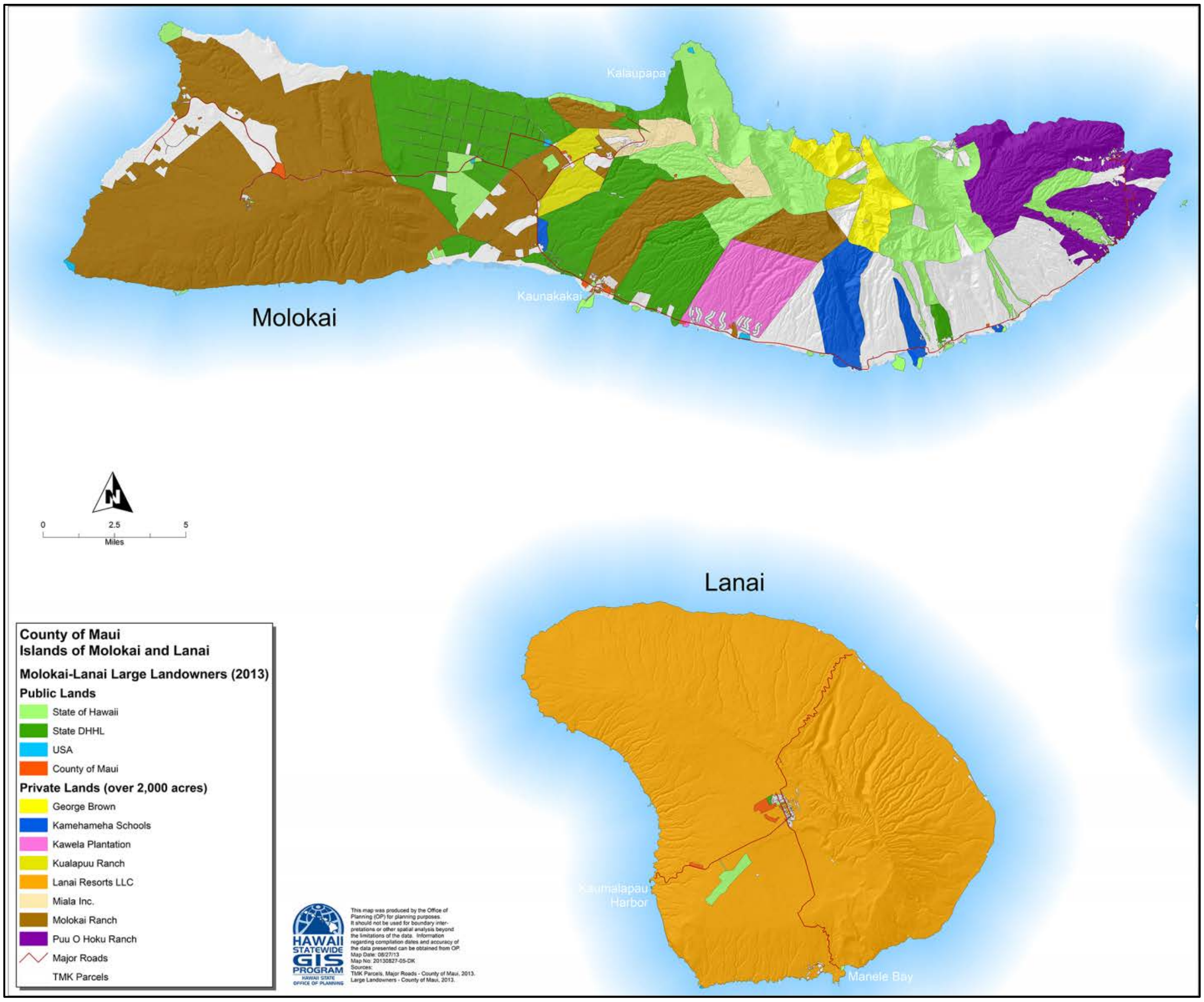


Figure 3-54. Land Ownership on the Islands of Moloka‘i and Lāna‘i (Source: Hawai‘i 2013a)

3.5.1.5 Maui

Maui, with an area of about 727 square miles (approximately 465,280 acres), is the second largest of the six main Hawaiian Islands. Figure 3-55 shows the largest landowners on the island of Maui (Hawai‘i 2013a).

Land ownership on Maui is distributed as follows (Hawai‘i 2013a):

State Government:	149,138 acres
Federal Government:	33,659 acres
Private:	197,697 acres

Alexander & Baldwin owns the most private land on the island (over 92,000 acres). Alexander & Baldwin has been in the agriculture business and a real estate company for 142 years.

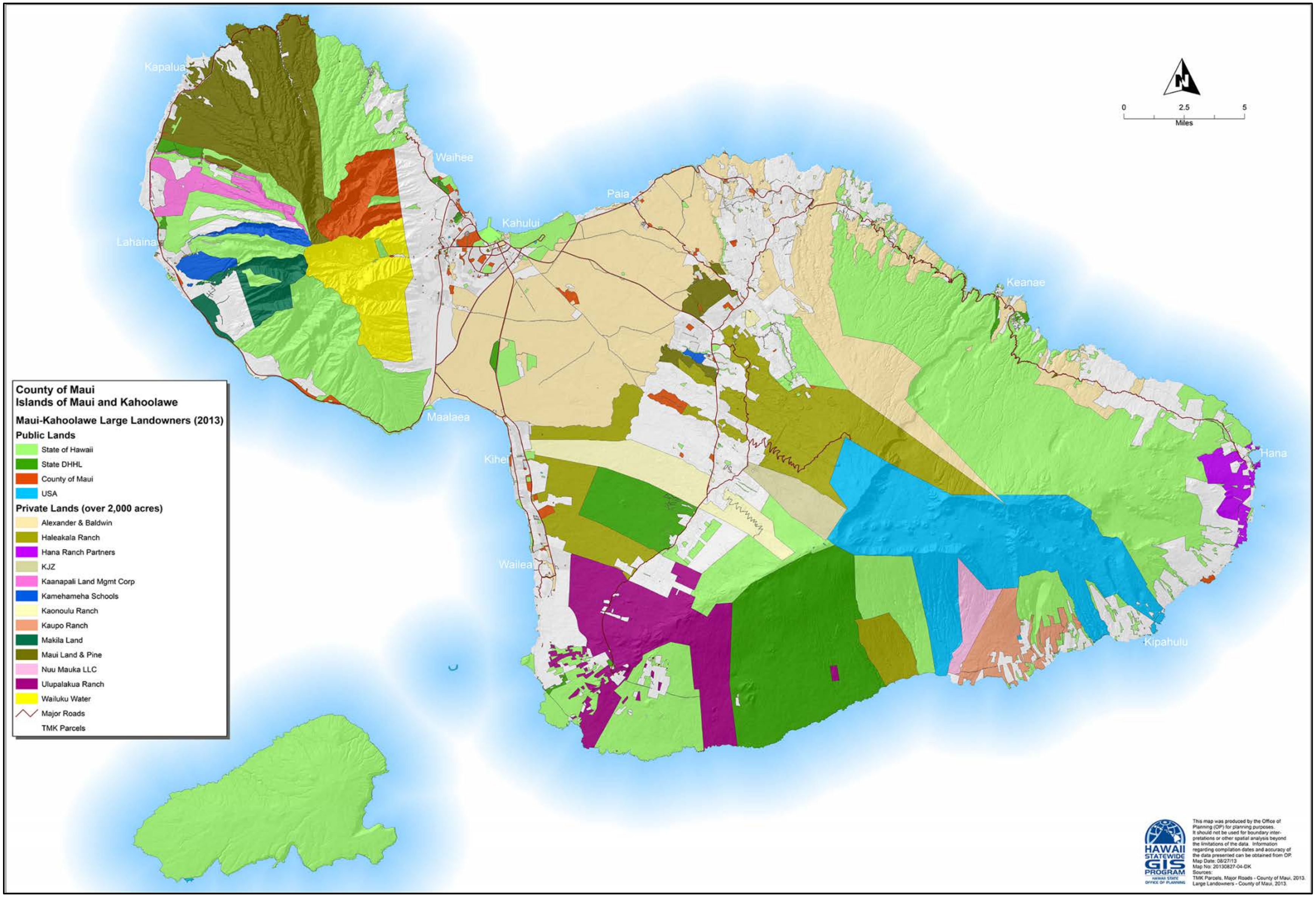


Figure 3-55. Land Ownership on Maui (Source: Hawai'i 2013a)

3.5.1.6 Hawai‘i

Hawai‘i, also called the Big Island, has an area of about 4,028 square miles (approximately 2,577,920 acres) and is the largest of the six main Hawaiian Islands. Figure 3-56 shows the largest landowners on Hawai‘i island (Hawai‘i 2013a).

Land ownership on Hawai‘i is distributed as follows (Hawai‘i 2013a):

State Government:	1,391,522 acres
Federal Government:	432,205 acres
Private:	388,891 acres

State, county, and Federal government entities owns the majority of the island.

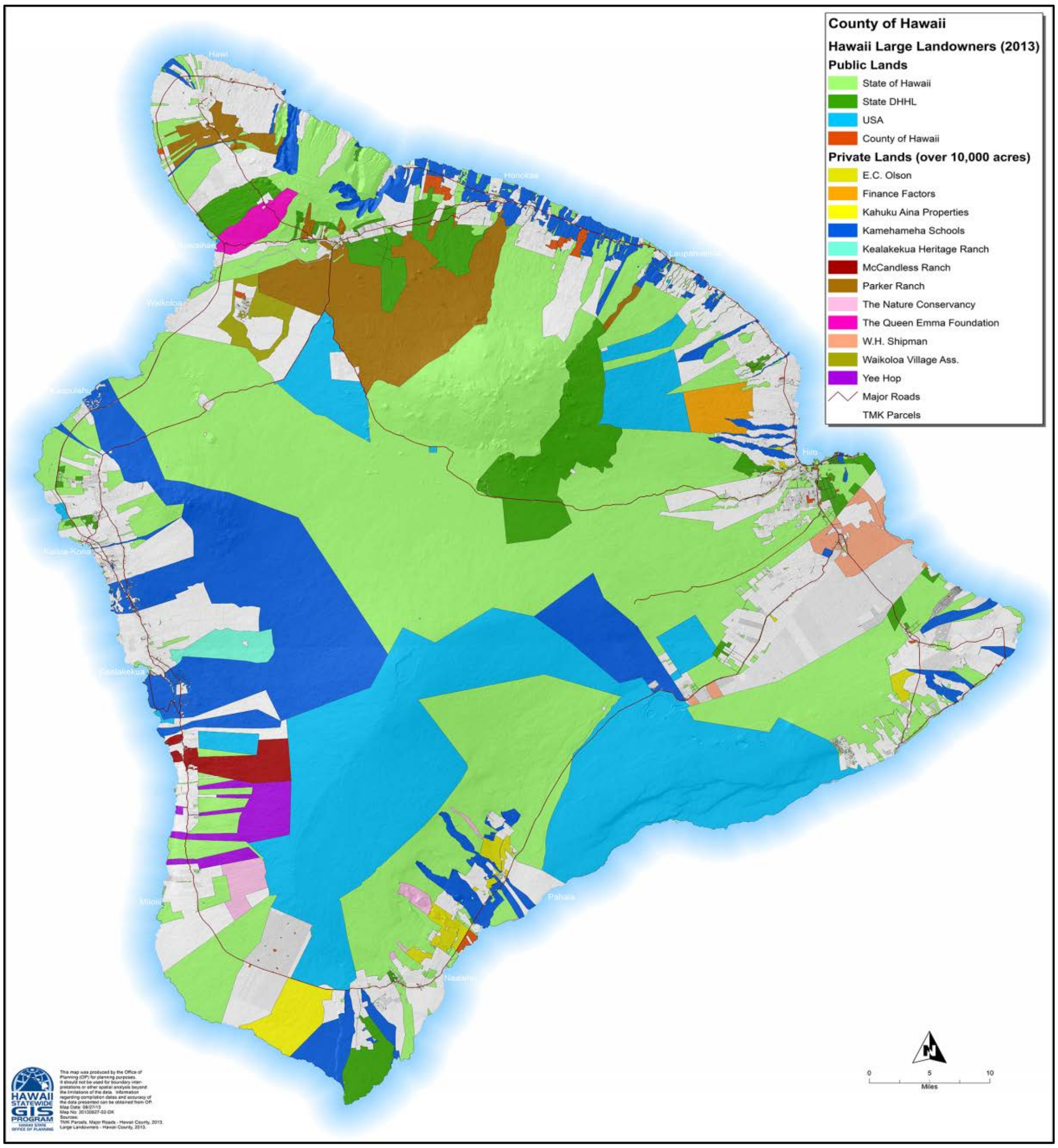


Figure 3-56. Land Ownership on Hawai‘i (Source: Hawai‘i 2013a)

3.5.2 LAND USE

The Hawaiʻi State Legislature adopted the State Land Use Law (HRS 205) in 1961. The Land Use Law establishes an overview framework on land use management whereby all lands in the State of Hawaiʻi are classified into one of four districts:

- Urban District – Urban Districts generally include lands characterized by "city-like" concentrations of people, structures, and services. Urban Districts also include vacant areas for future development. Jurisdiction of these districts lies primarily with the respective county through ordinances or rules.

- Rural District – Rural Districts are composed of small farms intermixed with low-density residential lots with a minimum lot size of one-half acre. Jurisdiction over Rural Districts is shared by the State Land Use Commission and county governments. Permitted uses include those relating to or compatible with agricultural use and low-density residential lots. Variances can be obtained through the special use permitting process.

- Agricultural District – Agricultural Districts include lands for cultivation of crops, aquaculture, raising livestock, wind energy facilities, timber cultivation, agriculture-support activities (e.g., mills and employee quarters), and land with significant potential for agricultural use. Golf courses and golf-related activities may also be included in these districts, provided the land is not in the highest productivity categories for agriculture. As a means of protecting them from development, HRS 205-4.5 restricts use of agricultural lands with productivity ratings of A or B, based on a five-class rating system from A at the highest productivity to E at the lowest (Section 3.1.1.1). Permitted uses include specific renewable energy actions, often with stipulations or limits. For example, wind energy facilities are permitted within Class A or B areas provided they "are compatible with agricultural uses and cause minimal adverse impact on agricultural land."

- Conservation District – Conservation lands are composed primarily of lands in existing forest and water reserve zones and include areas necessary for protecting watersheds and water sources, scenic and historic areas, parks, wilderness, open space, recreation areas, habitats of endemic plants, fish and wildlife, and all submerged lands seaward of the shoreline. Conservation Districts also include lands subject to flooding and soil erosion.

Each island also has county zoning ordinances, overlay zones, and other land use planning tools that can be applied within the four Statewide land use designations. Regarding the potential development of renewable energy facilities on any of the islands, the *Guide to Renewable Energy Facility Permits in the State of Hawaiʻi Version 1, January 2013* (HSEO 2013) provides information on Federal and State Permitting, as well as ordinances and regulations for each county. The Guide also includes a checklist of approvals for energy development.

The following sections describe land use and island characteristics for the six main Hawaiian Islands.

3.5.2.1 Kauaʻi

Kauaʻi has four distinct regions, each with its own unique characteristics. The windward coast, which catches the prevailing trade winds, consists of the North Shore and East Side, while the drier, leeward coast encompasses the South Shore and West Side. One main road nearly encircles the island, except for a 15-mile stretch of sheer cliffs called the Na Pali Coast. The center of the island, Mount Waiʻaleʻale, is completely inaccessible by car. One of the main land features on Kauaʻi is the Waimea Canyon and State Park. Pineapple and sugar plantations once dominated the agriculture industry; however, because these crops could be produced cheaper in other countries, the plantations began closing and/or consolidating in the mid-1960s. (Kaua‘i Plantation Railroad 2013).

Kaua‘i’s land use planning is focused on maintaining the island’s rural character. There are five planning districts on the island: Kawaihau, Koloa, Lihue, West, and North Shore. Figure 3-57 shows the four Statewide land use designations.

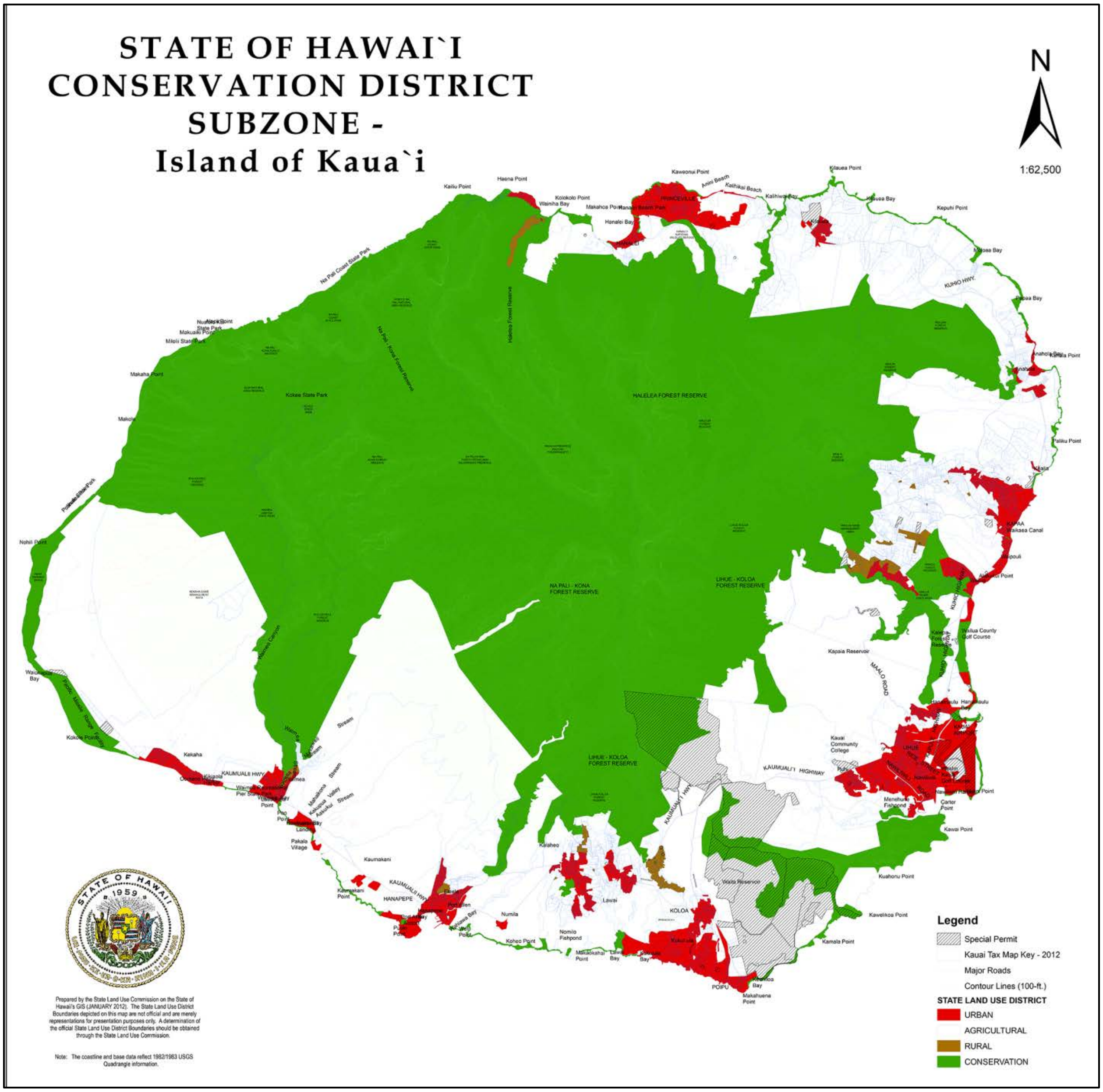


Figure 3-57. Statewide Land Use Designations on Kaua‘i (LUC 2012)

The *Kaua‘i General Plan* (County of Kaua‘i 2000a) includes detailed land use information for each district, including the following maps:

- Land Use Maps – Depict policies for long-range land uses with the following designations: Urban Center, Resort, Residential Community, Transportation, Military, Agriculture, Resources, Major Parks, Town Center, and Public Facilities.

- General Plan Heritage Resources Maps – Depict important natural, historic, and scenic resources.

The General Plan also establishes a vision for maintaining the island's physical environment and character. In brief, the physical environment on Kauaʻi includes:

- Small towns and communities that have a distinct character and are compact rather than sprawling;

- Wide expanses of open lands—natural areas and lands in active cultivation—that provide separation between towns and communities;

- The relatively small scale and low heights of buildings; and

- The relatively small scale of Kauaʻi's roads, the presence of natural vegetation along the roads, and the absence of medial concrete barriers.

Chapter 6 of the General Plan outlines the planning vision for enhancing towns and communities in Kauaʻi.

3.5.2.2 Oʻahu

Oʻahu hosts the City and County of Honolulu. Figure 3-58 provides a map showing the four Statewide land use designations. The island is divided into eight regions, or development plan areas: the Primary Urban Center (Honolulu), East Honolulu, Central Oʻahu, ʻEwa, Koʻolaupoko, Koʻolauloa, North Shore, and Waiʻanae. The City and County of Honolulu Department of Planning and Permitting is currently updating its *General Plan: Objectives and Policies* (City and County of Honolulu 2002) to cover physical development plans through 2035 (City and County of Honolulu 2013a). The discussion of land uses and land characteristics in the remainder of this section is presented in the order of the planning areas noted above.

3.5.2.2.1 Primary Urban Center

The Primary Urban Center includes the city of Honolulu, the largest city and State Capital, and main deepwater marine port for the State of Hawaiʻi. The Primary Urban Center extends from Kahala to Pearl City, and crosses the valleys and coastline plains that characterize the island's southern coastline.

Downtown Honolulu is the financial, commercial, and government center of Hawaiʻi. The Arts District is a 12-block area bounded by Bethel and Smith streets and Nimitz Highway and Beretania Street. Kakako is a light-industrial district between Downtown and Waikīkī. The Ala Moana District, between Kakako and Waikīkī, is a major shopping area. Waikīkī is the tourist district of Honolulu, located between the Ala Wai Canal and the Pacific Ocean next to Diamond Head. Residential districts include Manoa and Makiki, located in adjacent valleys just inland of Downtown and Waikīkī; Nuʻuanu and Pauoa, located inland from Diamond Head; and Pālolo Valley, which parallels Manoa and is the most populated area on Oʻahu. Plans are to continue to enhance lifestyle choices for residents, provide business and economic development opportunities, and attract visitors (City and County of Honolulu 2012a; City and County of Honolulu 2012b).

The United States military has a large presence in the greater Honolulu area. The Air Force's Hickam Field shares runways with Honolulu International Airport and has merged operations with the Navy's Pearl Harbor to become part of the Joint Base Pearl Harbor-Hickam. The Honolulu area also hosts the Army's Fort Shafter, the Coast Guard Station Hawai'i, and the Pearl Harbor Naval Shipyard.

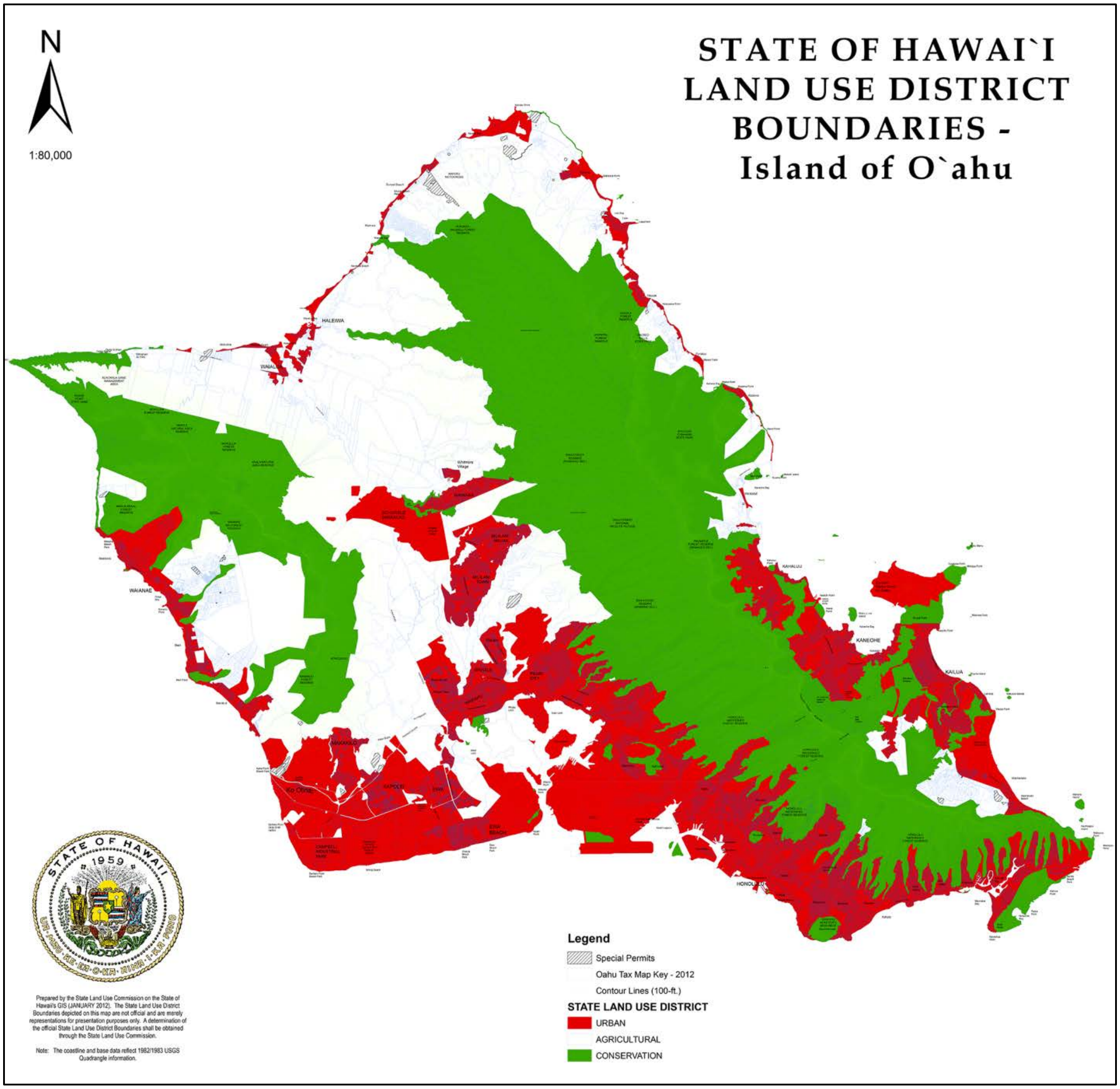


Figure 3-58. Statewide Land Use Designations on O'ahu (LUC 2012)

3.5.2.2.2 East Honolulu

East Honolulu is directly east of the center of Honolulu, from Wai'alae and extending east to Makapu'u Point, the easternmost point on the island of O'ahu. Plans for East Honolulu supports containment of urban development and protection of agricultural areas. The City and County of Honolulu plans to preserve significant scenic views and natural areas (City and County of Honolulu 2012a; City and County of Honolulu 2012b).

3.5.2.2.3 Central O‘ahu

Central O‘ahu plays a key role in implementing the land use and directed growth policies of the *General Plan Objectives and Policies* (City and County of Honolulu 2002). The towns of Waipahu and Wahiawa serve as gateways to ‘Ewa and the North Shore. Historically, these towns were headquarters for the sugar and pineapple plantations and support centers for the military. Beginning in 1968, Central O‘ahu began to play a role as a major area for housing development. Residential areas have been created in Mililani, above Waipahu and the H-1 Freeway in Village Park, Gentry Waipio, Waikele, and Royal Kunia. Central O‘ahu has become one of O‘ahu’s principal residential development areas (City and County of Honolulu 2002).

The 1,000-foot-high Leilehua Plateau is a prime agricultural region planted with fruits and vegetables, such as pineapple, coffee, and papaya, extending from the North Shore to the southern reaches of O‘ahu. The General Plan calls for maintaining the viability of agriculture, specifically in Central O‘ahu. The Wahiawa fields on the Leilehua Plateau contain the bulk of O‘ahu’s remaining pineapple fields, about 11,500 acres.

Most of the Waipio Peninsula lands were mostly used for sugar cultivation in the past. The General Plan supports continued use of these lands for diversified agriculture and aquaculture activities. A portion of the northernmost part of the Waipio Peninsula is used for active sports fields in conjunction with a soccer complex.

Wahiawa is a small, 100-year-old town about 30-miles from Waikīkī. The town hosts the 27-acre Wahiawa Botanical Gardens. Nearby, is the Army’s Schofield Barracks and Wheeler Army Air Field (about 18,000 acres in total). The base is separated from the town by Lake Wilson (also known as Wahiawa Reservoir). The base is considered to be the gateway to Kolekole, the lowest point in the Wai‘anae mountain range. The base has designated residential, commercial, and recreation areas. The major military bases of Schofield Barracks/Wheeler Army Airfield as well as the Pearl Harbor Naval Base are not expected to expand beyond their existing boundaries (City and County of Honolulu 2002).

3.5.2.2.4 ‘Ewa

‘Ewa is on the leeward side of O‘ahu, about 20 miles from downtown Honolulu. ‘Ewa once focused on sugar cane production, but is now a suburban growth center. Residential areas include ‘Ewa Beach on the south, Kalaeloa on the southwest, and Kapolei on the west. The ‘Ewa area is sometimes referred to as O‘ahu’s Second City, with its town center located in Kapolei. Plans envision protecting prime agricultural lands and natural, cultural, and historic resources. The County supports an urban type center in Kapolei (City and County of Honolulu 2012a; City and County of Honolulu 2012b).

As does Central O‘ahu, ‘Ewa plays a key role in the county’s growth implementation policies. Campbell Industrial Park opened in the early 1960s, bringing industry and jobs to the leeward coast, which previously had been predominantly a sugar economy with a plantation lifestyle. In the 1970s, residential growth began in ‘Ewa with the development of Makakilo and ‘Ewa Beach. In 1977, the Honolulu City Council designated ‘Ewa as the location for a Secondary Urban Center on O‘ahu, centered in the Kapolei area, the Secondary Urban Center is now the focus of major economic activity, a housing development, and government services. The Kapolei area is a secondary employment center for industrial and resort areas, higher education, and office and retail activities.

Even though the area has developed into a second urban center, diversified agriculture on prime agricultural lands exists along Kunia Road and surrounding the West Lock Naval Magazine.

3.5.2.2.5 Koʻolaupoko

Koʻolaupoko extends from Makapuʻu Point in the southeast to Kaʻoʻio Point in the north. Included within the district are the largest windward towns of the island, Kāneʻohe, Kailua, and Wiamanalo, and four rural valleys.

Kāneʻohe is the largest of several communities along Kāneʻohe Bay and one of the two largest residential communities on the windward side of Oʻahu (the other is Kailua, which is discussed below). The commercial center of the town is spread mostly along the Kamehameha V Highway. There is very little agriculture in the area; the only commercial crop of any consequence is bananas. The town features the Hoʻomaluhia Botanical Garden.

The Marine Corps Base Hawaiʻi lies between Kāneʻohe and Kailua. The base occupies all of the Mokapu Peninsula, about 3,000 acres and includes on-base housing, shopping, and recreational facilities.

Waimanalo is close to Waimanalo Beach, but the Bellows Air Force Base separates the town from its namesake beach. An important airfield in World War II, the base now serves as military training and recreation areas for active and retired military and civilian employees of the U.S. Department of Defense. The Marine Corps Base at Kāneʻohe Bay uses approximately 1,049 acres of the base as its Marine Corps Training Area Bellows. The town of Waimanalo has a small commercial center along the Kalanianaʻole Highway.

Waimanalo has large agricultural areas in the valley that extend back toward the Koʻolau Mountains from the center of town. Numerous plant nurseries operate in this area.

The Kualoa Valley is one of four valleys in the district. The Kualoa Ranch owns 4,000 acres within the valley. No longer a working ranch, the Kualoa Ranch now supports tourist activities such as hiking and horseback riding and has been the backdrop for a number of major movies. The other three valleys, Waiahole, Waikane, and Hakipuʻu are more rural, with a few small farms.

3.5.2.2.6 Koʻolauloa

Koʻolauloa extends from Kalaeokaoio in Kuala to Waimea Bay, and inland is bounded mostly by the ridgeline of the Koʻolau Mountains. The district is rural in character and has natural, scenic, and cultural areas. The town of Laie is of particular historical importance. Laie was a puʻuhonua (a city or place of refuge), a sanctuary for fugitives. While a fugitive was in the puʻuhonua, it was unlawful for the fugitive's pursuers to harm the fugitive. The Church of the Latter-day Saints (Mormon) bought the sugar plantation named Laie in 1865. Both schools and church buildings were constructed in the ensuing years.

Laie is one of the best known Mormon communities and is the site of the Lai Hawaiʻi Temple, the fifth oldest operating Mormon temple in the world. Brigham Young University-Hawaiʻi is located in Laie. The Polynesian Cultural Center, the State's largest living museum, also is in Laie. To the south of town is Pounders Beach, named for the pounding shorebreak; Hukilau Beach is located at the north end of town, at the mouth of Kahawainui Stream.

3.5.2.2.7 North Shore

The North Shore refers to the north-facing coastal area of Oʻahu between Kaʻena Point and Kahuka Point. The largest settlement is Haleiwa. This area is best known for its massive waves, attracting surfers from around the world. Plans are to support diversified agriculture and commercial activity in the district, and particularly in the towns of Haleiwa and Waialua, while retaining their historic character (City and County of Honolulu 2012a; City and County of Honolulu 2012b).

Additional plans are to seek preservation of the region's rural character by preserving agricultural land and open space, and maintaining a land use pattern that reflects the use of the ahupuaʻa as a tool for physical and natural resource planning. The area in question is known as Waiʻanae and is among Lualualei Valley, fringing the west side of Oʻahu between Kaʻena Point, the Waiʻanae Range, and Kamaileʻunu Ridge. The Waiʻanae Range is the eroded remains of an ancient volcano that comprises the western half of Oʻahu.

3.5.2.3 Molokaʻi

Molokaʻi is part of Maui County. The County is in the process of updating the Molokaʻi 2001 Community Plan (County of Maui 2013a). Figure 3-59 is the map showing the four Statewide land use designations for Molokaʻi.

Based on its physical characteristics, the island is divided into three main sections, West Molokaʻi, East Molokaʻi, and Central Molokaʻi. The west end makes up about 30 percent of the total land area and is relatively dry with gentle slopes. The eastern half of the island makes up about 50 percent of the land area and is mostly mountains and gulches that are covered in rainforests and mixed mesic forests (see Section 3.4.4 of this PEIS). The remaining 20 percent of the land mass makes up Central Molokaʻi, which is relatively level and has soil suitable for cultivation. Monsanto Company leases about 1,850 acres of land on Molokaʻi for cultivation. On Molokaʻi, Monsanto mostly grows genetically modified corn seed crops, which are sold to commercial farmers on the mainland (Molokai News 2013).

The southern coast is lined almost entirely with coral reef, except where it was removed for the Kaunakakai Harbor. The northern coastline is mostly sheer sea cliffs 2,000 to 3,000 feet in height, making it inaccessible, except for the abutting peninsula of Kalaupapa. The Kalaupapa Peninsula hosts the Kalaupapa National Historic Park which is only accessible by foot, mule, or small plane.

Kaunakakai, located about midway along the southern coast, is the island's primary population and commercial center. There are also the small plantation communities of Mauna Loa and Kualapuʻu, as well as the less compact rural Hawaiian homestead settlements, Hoʻolehua and Kalmaula.

The southeastern coast contains a settlement pattern along Kamehameha V Highway, which becomes more rural and scattered as it extends from Kaunakakai to Hālawa Valley. The peninsula of Kalaupapa and some of the surrounding area on the northern coast constitute the County of Kalawao [this county was not included as part of the planning area in the 2001 Molokaʻi Community Plan (Molokai 2001)].

Kalawao County has two small unincorporated towns, Kalaupapa and Kalawao. Kalaupapa is the site of a former settlement for patients with Hansen's Disease (leprosy) first established in Kalawao to the east in 1866. Later the colony was moved to Kalaupapa, which was the site of a fishing village. At its peak, about 1,200 men, women, and children were in exile in Kalaupapa. King Kamehameha V enacted the isolation law, which remained in effect until 1969, when it was finally repealed. The colony is now part of Kalaupapa National Historical Park. There are three communities on Molokaʻi as part of Maui County, Kaunakakai (once one of the summer homes of King Kamehameha V); Kualapuʻu, a former pineapple cannery village; and Mauna Loa, mostly supported by the Molokaʻi Ranch.

Molokaʻi Properties Limited (MPL) is the island's largest landowner at over 60,000 acres. MPL owns and operates the Molokaʻi Ranch, which is located primarily on the west end of the island, with three tracts of

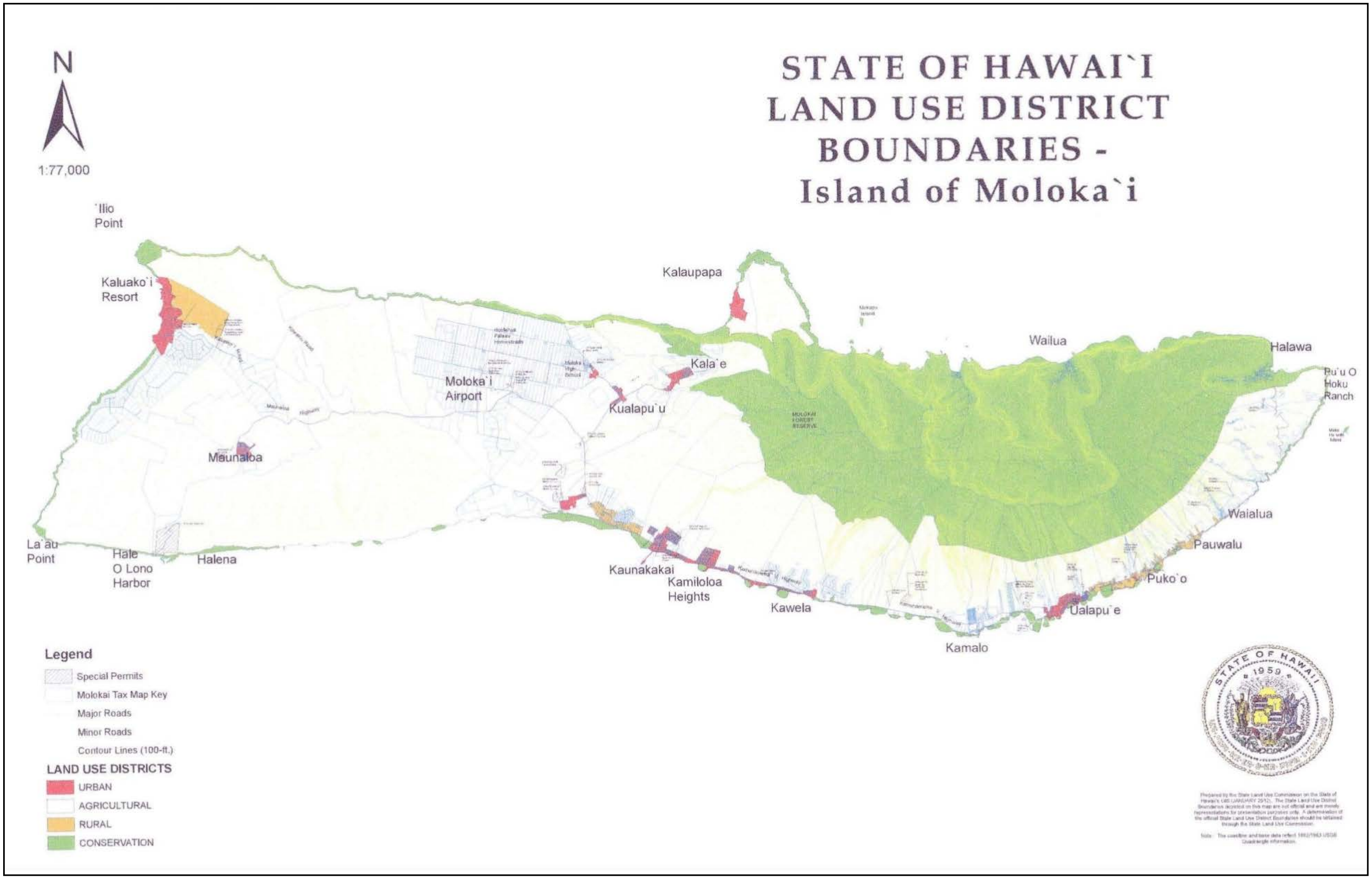


Figure 3-59. Statewide Land Use Designations on Moloka‘i (LUC 2012)

land in Central Moloka‘i. The boundary of the western property extends eastward from the western coast; from llio Point to Mo‘omomi in the north, and from La‘au Point to the Pala‘au Homesteads to the south.

The main population center in West Moloka‘i is the small town of Mauna Loa, headquarters of MPL. Along the shores south of Mauna Loa is Hale‘o‘Lono and Kolo Wharf. Mauna Loa Highway connects the west end of the island to the Moloka‘i Airport, Kaunakakai, and the rest of the island.

As previously noted, MPL owns three tracts of land in Central Moloka‘i. From west to east, the first tract encompasses Naiwa, Pala‘au State Park, the area surrounding Kualapu‘u town and Reservoir, and continues south to the Pala‘au Homesteads. The second tract includes land immediately surrounding Kaunakakai and a large area including the Moloka‘i Forest Reserve. The third tract is the Kamakou Preserve which consists of 2,774 acres of native rainforest ecosystem with a conservation easement managed by The Nature Conservancy. MPL also owns a 34-acre parcel south of the Kamakou Preserve at Kawela. This parcel is significant for its cultural history and archaeological sites (MPL 2005).

In 2003, MPL and Ke ‘Aupuni Lokahi (KAL) (a Moloka‘i enterprise community) began discussions to create a community-based master land use plan for Moloka‘i Ranch. KAL was formed in 1998 to develop a 10-year strategic plan to stimulate the island’s economy. The planning process was formally launched in August 2003 as a KAL project under Project # 47: Community-Based Compatible Development. In February 2004, the *MPL Community-Based Master Land Use Plan for Moloka‘i Ranch* was included as part of the Project and in November 2005, MPL published the Final Plan.

The plan includes development of La‘au Point, a 658-acre luxury residential development, and the permanent conservation of more than 50,000 acres of the Moloka‘i Ranch. The proposed La‘au Point development received heavy opposition; the project was terminated because the plan did not receive support (theMolokainews.com 2011). In 2012, the Moloka‘i Ranch resumed cattle operations and started swine operations (Molokai Ranch 2013).

3.5.2.4 Lāna‘i

Lāna‘i is part of Maui County, and its land use planning functions are supported by the Maui Department of Planning. Figure 3-60 is the map showing the four Statewide land use designations.

Since the 1850s, all, or nearly all, of the island has been owned by various single owners. Land uses have been shaped by successive visions of Lāna‘i as Mormon refuge, a sugar plantation, a pineapple plantation, and a resort island. Today, Lāna‘i includes approximately 89,000 acres of land, of which only about 626 acres are classified as urban (County of Maui 2012a).

In 1922, James Dole purchased the island of Lāna‘i and developed a vast pineapple plantation. It became the largest pineapple plantation in the world with over 20,000 acres devoted exclusively to growing pineapples. The Hawaiian Pineapple Company that Dole created later became the Dole Food Company. Starting in the 1960s the Hawaiian pineapple industry went into decline. The decline is mainly attributed to the fact that production costs of foreign-based pineapple canneries were approximately one-tenth the cost of producing pineapples in Hawai‘i. Consequently, large commercial pineapple operations on Lāna‘i ended in October 1992.

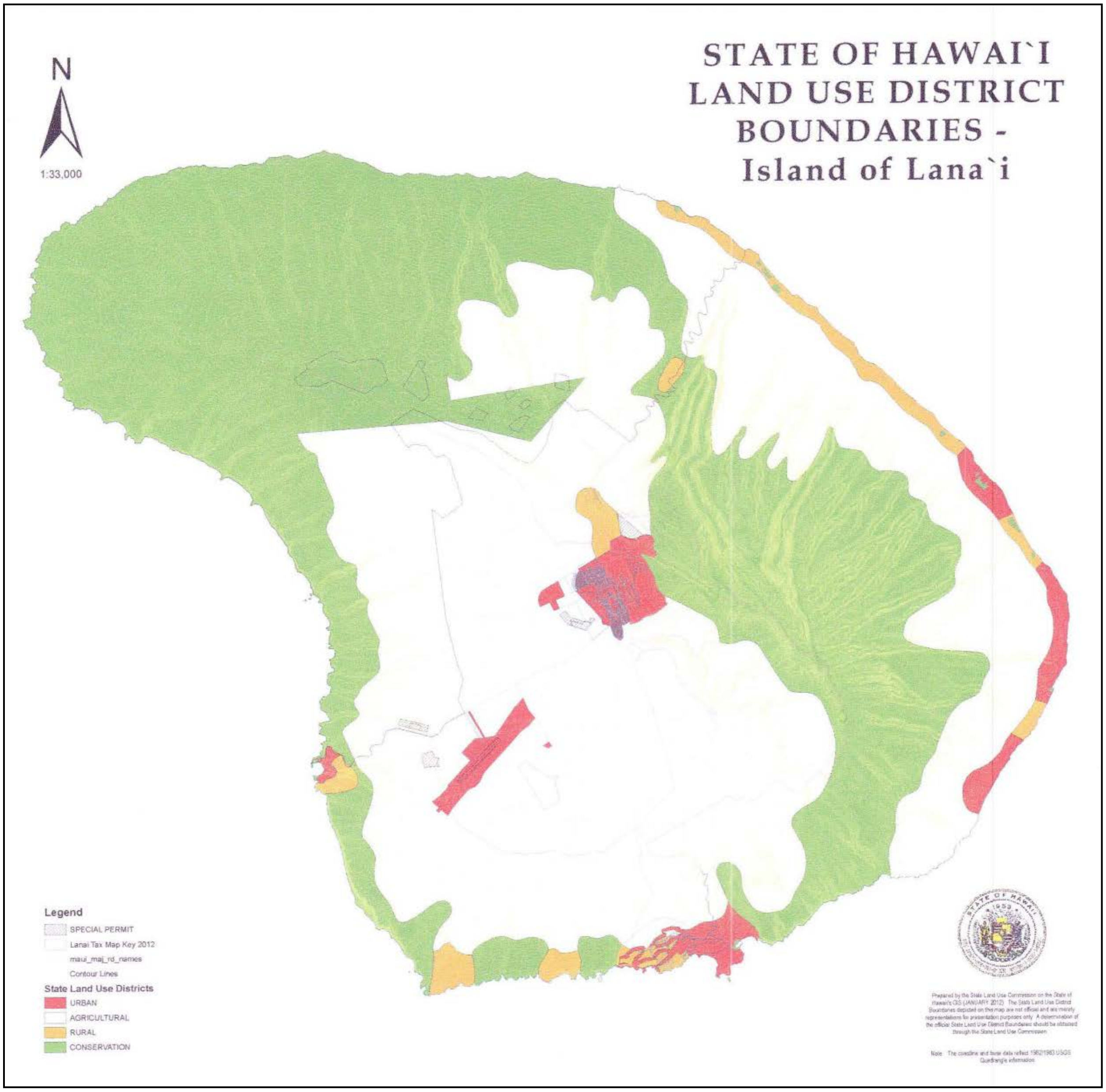


Figure 3-60. Statewide Land Use Designations on Lānaʻi (LUC 2012)

The once vast pineapple lands of Lānaʻi have now been converted to other uses, or remain fallow. The movement toward a resort economy for the island has resulted in two resorts. The first is on Manele Bay; the second is the upland lodge at Koele. The historic Hotel Lānaʻi is in Lānaʻi City.

The Palawai Basin has long been the central agricultural resource of the island. Still considered rural, the Miki Basin currently has more urban development than Palawai, with the island's power plant and a solar farm. The airport is located farther west, between Miki Basin and Kaumalapau Harbor.

Other areas with minimal or no current urban development include (County of Maui 2012a):

- The beaches of the northeastern and eastern coasts, including Shipwreck Beach. Now abandoned, Club Lāna‘i was an oceanfront property near the remote Lopa Beach with a wharf once used by day-trippers from Maui;
- Maunalei ahupua‘a, with the island's only perennial stream, was the site of a short-lived sugar plantation. Land in this valley was leased in recent years for taro cultivation. It remains a site of possible agricultural development.

In 2012, Lāna‘i issued its *Land Use Forecast* as part of the *Maui Island Plan: General Plan 2030*. The forecast determined that lands currently available for development would be capable of meeting future growth in the tourist industry through the year 2030 (County of Maui 2012a).

3.5.2.5 Maui

Figure 3-61 shows the four Statewide land use designations for Maui, as well as the smaller unoccupied island of Kaho‘olawe. Kaho‘olawe is about 7 miles southwest of Maui. During World War II and up to 1990, the United States military used Kaho‘olawe for live-fire training and bombing. The U.S. Navy ended live-fire exercises in 1990. In 1993, the Hawai‘i Legislature established the Kaho‘olawe Island Reserve, consisting of the entire island and its surrounding ocean waters in a 2-mile radius from the shore. By State law (Act 340 under HRS Chapter 64, 1993), Kaho‘olawe and its waters can only be used for Native Hawaiian cultural, spiritual, and subsistence purposes: fishing, environmental restoration, historic preservation, and education. All commercial uses are prohibited. The island is listed on the *National Register of Historic Places* (Napier 2006).

Maui has three primary urban centers: Central Maui, West Maui, and South Maui. Encompassing the towns of Wailuku and Kahului, the area known as Central Maui has the majority of the island's urban development. The County government civic center, the island's primary airport and sole deep-water harbor, the University of Hawai‘i Maui College, the island's primary business district, and vast acres of sugarcane fields make up the Central Maui area. Kahului also supports the island's primary industrial zones, large retail centers, and shopping malls.

West Maui has a string of coastal communities and mountainous areas. The stretch of coast between Lahaina and Napili is dominated by the resort industry due, in part, to its ocean access points that provide numerous recreational opportunities. The northeastern portion, stretching from Waihe‘e to Honolua Bay, offers vast open spaces and cliffs, ocean views, valleys, and streams.

The coastline that stretches from Mā‘alaea to Makena is known as South Maui. Development along this area has generally occurred in a linear pattern between the shoreline and Pi‘ilani Highway, forming a continuous urban corridor that attracts a large tourism industry (County of Maui 2012b).

As is typical of rural land use patterns, South Maui consists of small towns, low-density residential development, open space, and an agricultural landscape. In recent decades, the character of the landscape stretching from Haiku to ‘Ulupalakua and beyond has experienced a marked increase in lower-density residential sprawl. The implementation of a combination of rural planning tools and techniques can help influence the form of future development and mitigate its impact on the rural landscape.

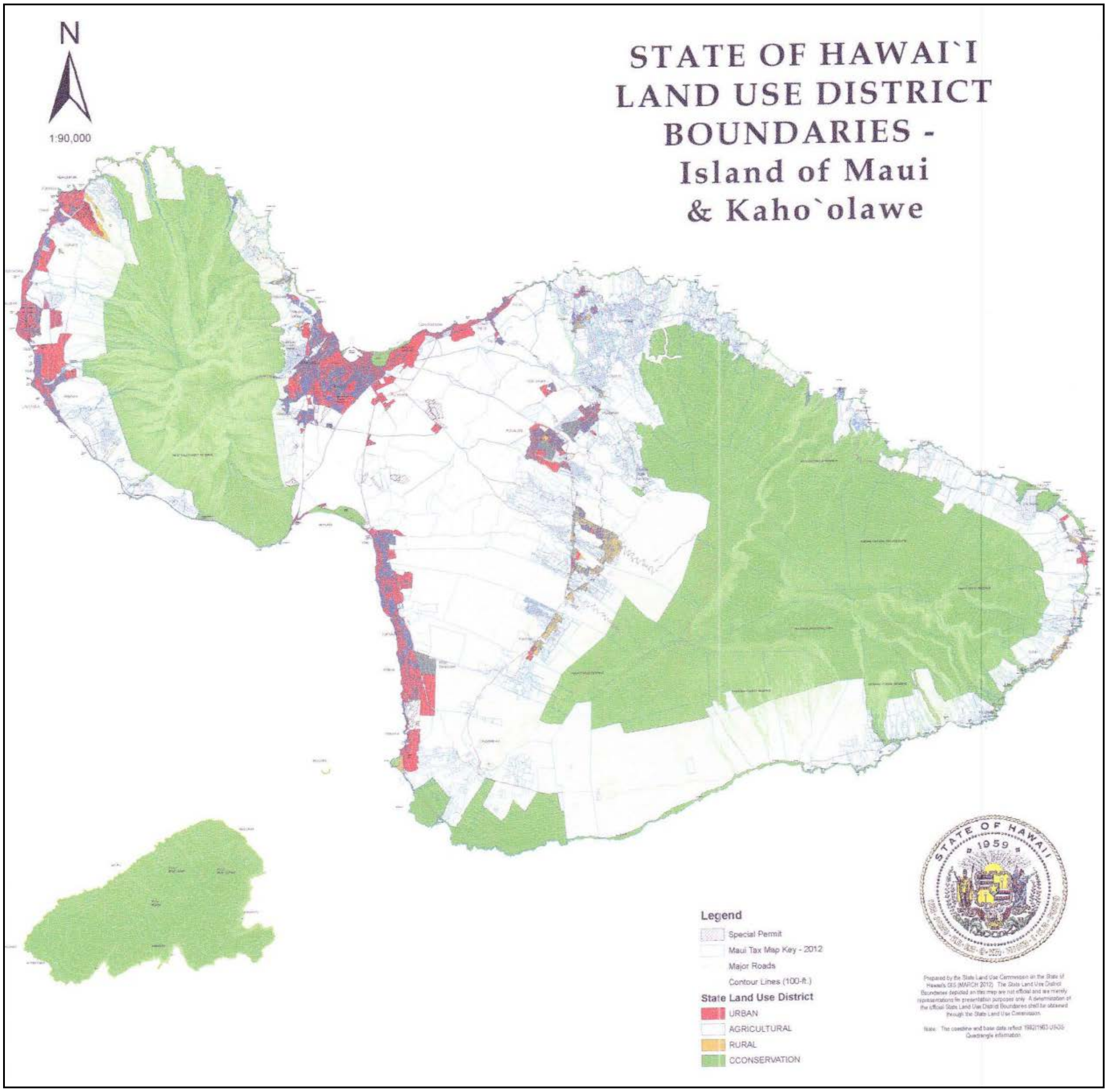


Figure 3-61. Statewide Land Use Designations on Maui (LUC 2012)

The east two-thirds of the island are knows as Upcountry Maui and East Maui. The Upcountry includes the small towns of Makawao, Hali‘imaile, Pukalani, and Kula, all of which are characterized by agriculture, ranching, and open space. Makawao has a long history of cattle ranching. East Maui represents a geographic area that comprises many small communities, natural areas, waterfalls, rugged coastline, and small-scale diversified agriculture. East Maui remains remote and generally accessible by the Hāna Highway.

The land use discussion in the *Maui Island Plan: General Plan 2030* focuses on agricultural, rural, and urban land. The State and County have enacted zoning laws to protect agricultural resources and promote agricultural activities. Agricultural land management is enhanced through a directed growth strategy that identifies areas appropriate for development, utilizing tools for agricultural protection such as zoning, transfer and purchase of development rights, and conservation subdivision design (County of Maui 2012c).

Chapter 8 of the *Maui Island Plan: General Plan 2030* focuses on directed growth plans. The chapter provides 20 directed growth maps.

3.5.2.6 Hawai‘i

Hawai‘i County covers the island of Hawai‘i, also referred to as the Big Island. Figure 3-62 shows the four Statewide land use designations for Hawai‘i. Hawai‘i’s diversity includes tropical forests, mountains, active volcanoes, beaches, deeply eroded valleys, and expanses of grazing land (County of Hawai‘i 2005).

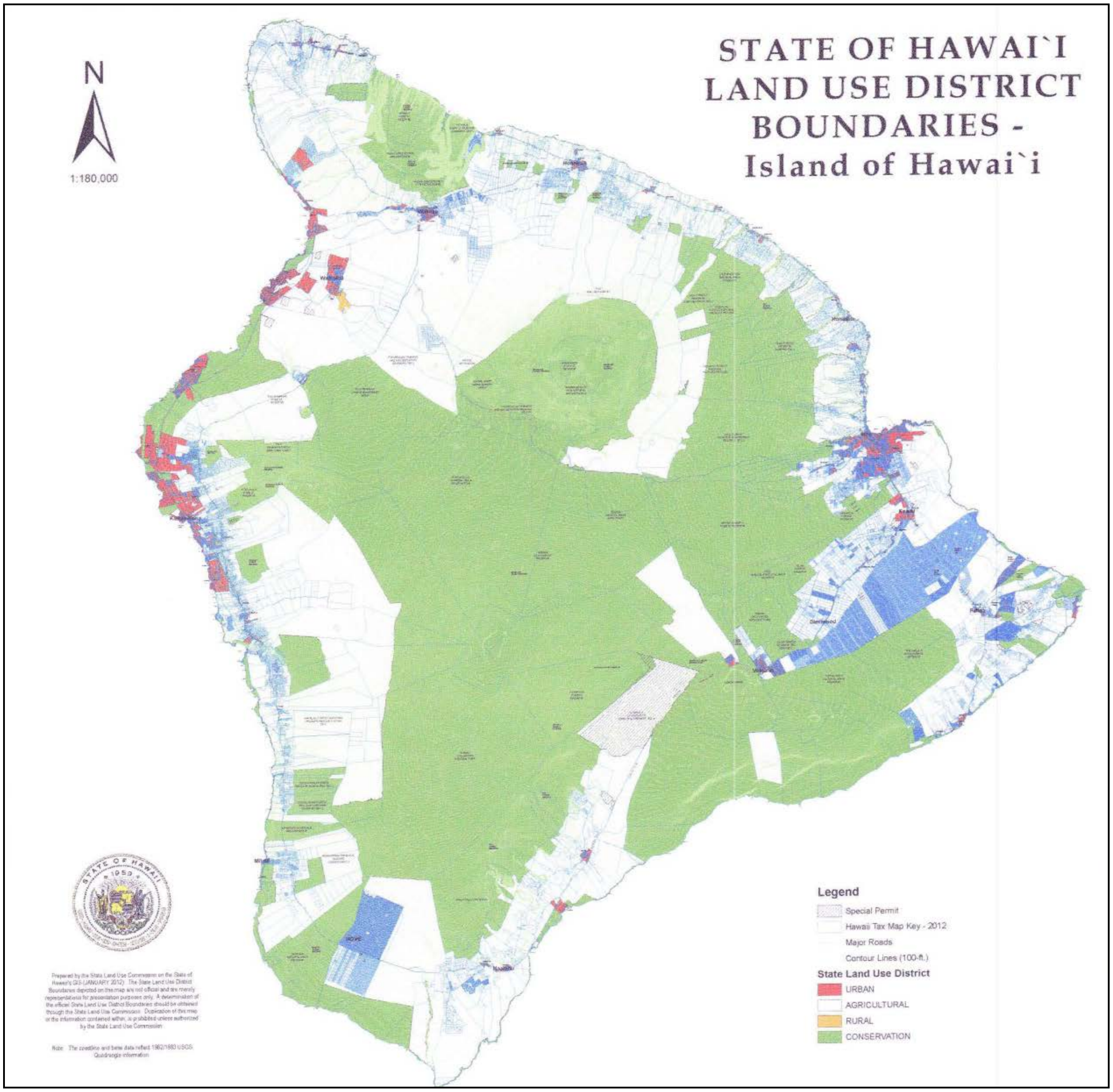


Figure 3-62. Statewide Land Use Designations on Hawai‘i (LUC 2012)

The following information is taken from the *County of Hawai‘i General Plan* released February 2005 and as amended (County of Hawai‘i 2005), unless otherwise noted. The plan covers the nine Hawai‘i County-wide development districts: Puna, South Hilo, North Hilo, Hāmākua, North Kohala, South Kohala, North Kona, South Kona, and Kau.

Almost 50 percent of the total land area in Hawai‘i is situated within the Agricultural District, including those with a high capacity or potential for agricultural use as well as those with low potential for productive activity. In addition to the agricultural land uses related to growing crops, agricultural land uses includes those related to packing, processing, and manufacturing the products. Although the latter uses have industrial characteristics, they are, nevertheless, agricultural in nature. With the demise of the sugar industry, thousands of acres of land have been removed from productive agricultural use and have either been converted to non-agricultural uses or lie fallow.

The State of Hawai‘i has set aside lands for agricultural activities to encourage continuation or initiation of agricultural operations. The State’s Agricultural Parks Program makes land available to small farmers at reasonable cost and with long-term tenure. There are four agricultural parks on the island, one each in the districts of Puna, South Hilo, Hāmākua, and North Kona.

Commercial activity in the county is characterized by the existence of the large urban centers in Hilo and around Kailua-Kona, several smaller centers and many rural neighborhood shopping centers are located in Honoka‘a, Kea‘au, Waimea, Kealakekua, and Na‘alehu.

Trends reflect commercial development outside of Hilo’s older commercial core and a more decentralized pattern. The decentralization is reflective of the growing markets outside of the immediate environs of downtown Hilo and the general trend toward multi-centered urban areas. Similarly, commercial development within Kailua-Kona is extending north of its traditional commercial areas.

A portion of the county’s industrial activity, as noted above, is related to agriculture. These agricultural activities include processing coffee, macadamia nuts, meat products, tropical fruits, vegetables, and timber. There are endeavors in alternative energy and aquaculture activities at Keahole in the North Kona District and a geothermal-related development in the Puna District. Service-oriented industries, such as wholesaling, government facilities, printing, and bakeries are located close to population centers. The majority of such facilities are located within the South Hilo District.

Residential housing in Hawai‘i County traditionally has been single-family residential. In 1981, the State Legislature recognized the increasing cost of housing and the limitations of land for housing. Thus, the Ohana Dwelling provisions of Act 229, and the subsequent amendment to the Zoning Code allows the construction of a second dwelling on lots where one dwelling was already permitted.

The resort areas typically are designed with large proportions of multiple family residential units sold as occasional visitor units. This land use pattern has manifested itself in the North Kona and South Kohala resort areas.

Hawai‘i County’s primary resort centers are located along the coastal areas of Hilo in East Hawai‘i and North Kohala in West Hawai‘i. The North Kona and South Kohala districts are seeing the majority of proposed new resort development. Additional smaller-scale resorts may be developed in the mountains.

Open space on Hawai‘i island consists of lands zoned as “open” by the County of Hawai‘i as well as those the State Land Use Conservation District designates. The open zoning district permits golf courses, with a use permit, some recreational facilities, and various public and special areas (e.g., as restricted watershed areas and forest reserves). Potential natural hazard areas also are designated as open space. There currently is no County zoning district that calls for land to be preserved in a largely natural State.

State and Federal Government entities own the majority of the land on Hawaiʻi island. Public lands include County, State, and Federal parks and beaches. The following is a breakdown of these public parks by district:

- Puna – Hawaiʻi Volcanoes National Park and nine other County and State parks and beaches.
- South and North Hilo – 18 State and County parks and beaches, including the Liliuokalani Gardens and the Panaʻewa Zoo.
- Hāmākua – Kalopa State Park, Waipio Beach, and the Waipio Valley Lookout.
- North and South Kohala –16 State and County parks and beaches, including the Kaloko-Honokohau and the Puuhonua O Hōnaunau National Historic Parks.
- North and South Kona –30 State and County parks and beaches, including access to five bays: Anaehoʻomalu, Heeia, Keauhou, Kīholo, and Kapua.
- Kau – 10 State and County parks and beaches, including part of Hawaiʻi Volcanoes National Park.
- Other National Park Service units on the island include: the Puʻukoholā Heiau National Historic Park, and the Ala Kahakai National Historic Trail.

3.5.3 SUBMERGED LAND USE

This section discusses submerged land uses or ocean uses. The section starts with a discussion of general ocean bathymetry, or underwater topography. The sections that follow focus on submerged land uses including aquaculture, commercial fisheries, recreation and tourism, dump sites and munitions, dredged channels, undersea cables, and protected natural areas.

Submerged lands in Hawaiʻi include all lands lying between the upper reaches of the waves on the shore and the seaward extent of the State's jurisdictional limits (Figure 3-63).

The Office of Conservation and Coastal Lands (OCCL) of the Hawaiʻi DLNR and the Land Division manages the publicly and privately zoned Conservation Districts of Hawaiʻi, as well as the beaches and submerged lands of the State. The Land Division issues leases, easements, and rights-of-way for the use of submerged State lands. The OCCL serves several functions for the State, including the leasing of submerged lands, coastal zone permitting, and beach restoration. The OCCL reviews and administers Conservation District Applications necessary for leasing submerged lands (MCA/TNC 2005). Section 3.7 of this PEIS provides an overview and background information on Coastal Zone Management.

3.5.3.1 Bathymetry

Bathymetry is the study of the underwater depths of water bodies. It is the underwater equivalent to topography. Bathymetric charts are typically produced to support safety of surface or sub-subsurface navigation and to show the relief or terrain and depths. Figure 3-64 is a synthesis of a chart for the islands.

The University of Hawai‘i (School of Ocean and Earth Technology), USGS, and other scientific organizations have collaborated on numerous bathymetry studies related the Hawaiian Islands. Sources for more detailed island information can be found at http://www.soest.hawaii.edu/hmrg/multibeam/.

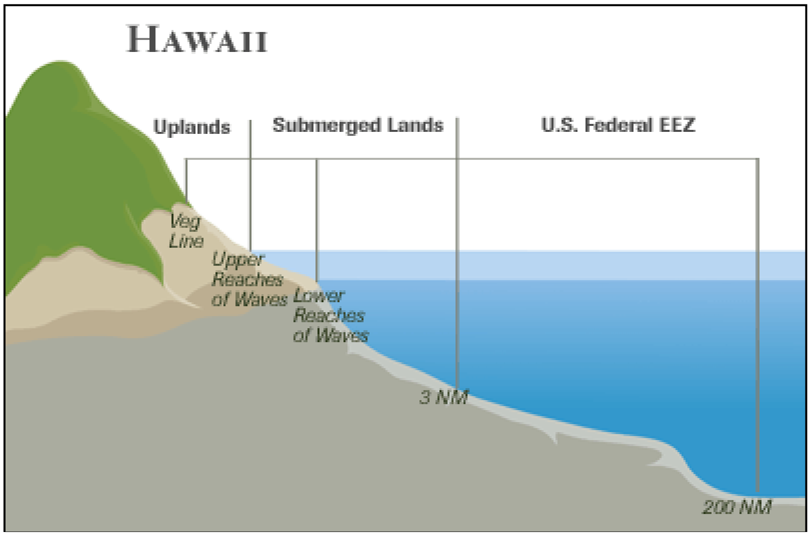


Figure 3-63. Submerged Land Designations in the State of Hawai‘i

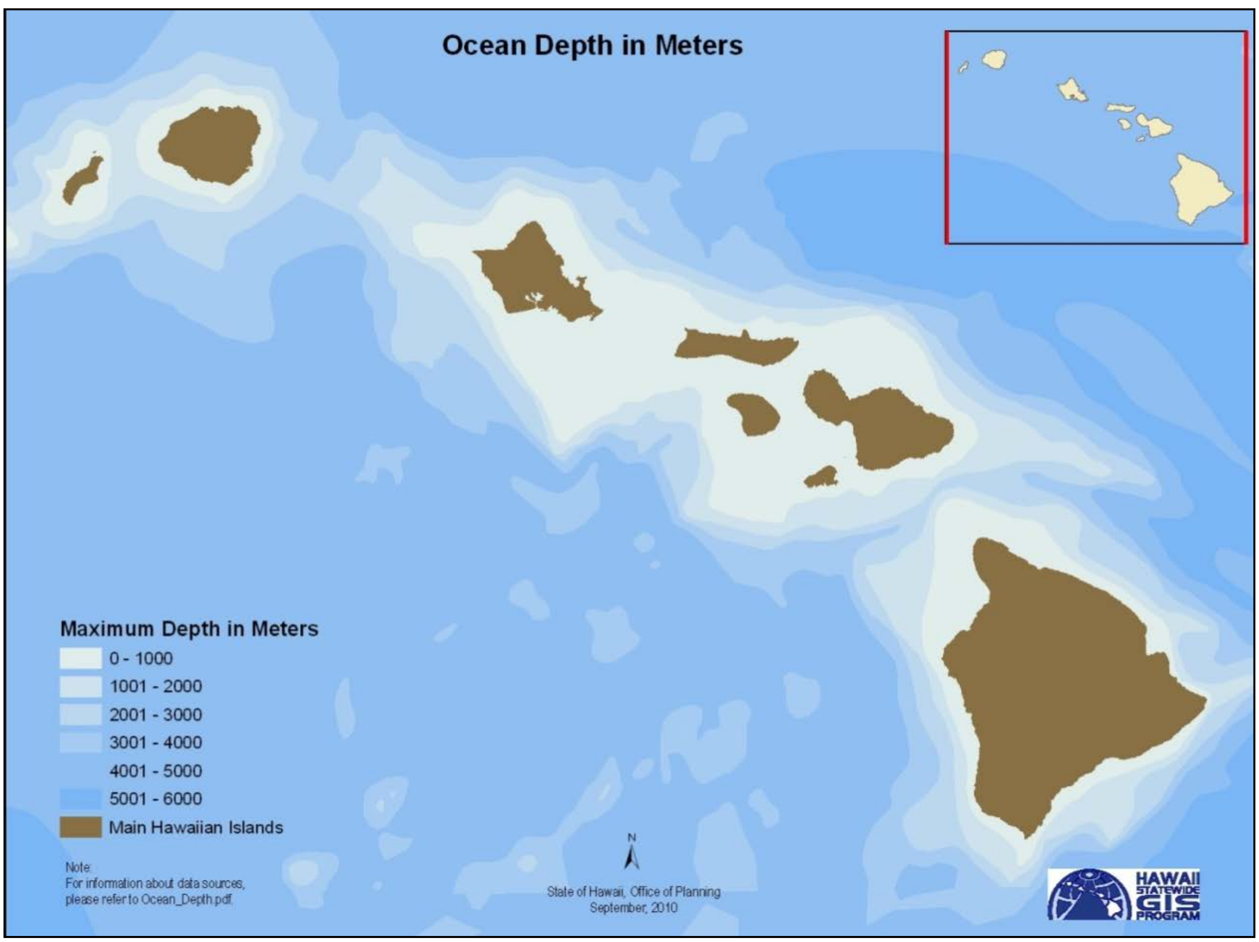


Figure 3-64. A General Bathymetry Depth Chart for the Main Hawaiian Islands

3.5.3.2 Aquaculture and Fisheries

Aquaculture is the controlled cultivation and harvest of aquatic plants and animals. Hawai‘i’s aquaculture industry consists of a Commercial Production Sector, which includes farming of a wide variety of species, and a Research Technology Transfer Sector, which provides technical assistance to the established and emerging aquaculture ventures in Hawai‘i.

Aquaculture operations produce both warm- and coldwater fish and shellfish, grown in fresh, brackish, and saltwater environments (HDOA 2013a). In 2011, Hawai‘i’s total aquaculture sales were about $40 million. Algae sales accounted for about 63 percent of the total. Other products including ornamentals, finfish, shellfish, seed stock, broodstock, and fingerlings accounted for the remaining 37 percent (HDOA 2013a).

In 2010, the State had about 75 aquaculture operations; the latest information available by county (2008) indicated that the operations are located in Hawai‘i and Honolulu, Kaua‘i, and Maui counties (NASS 2011).

Open ocean fish farming, or offshore mariculture, is an emerging approach to raising fish in open ocean waters utilizing submersible cages or net pens. The locations chosen for open ocean aquaculture are in deeper and less sheltered waters, far from shore and sensitive ecosystems. Strong ocean currents sweep away feed residues and waste (HDOA 2013b).

The Hawai‘i Archipelago is 1,500 miles long with more than 740 miles of coastline. The Hawai‘i *Ocean Leasing Law* allows farm operations in the State’s warm, subtropical marine waters, within 3 miles of shore. Mariculture operations located in the offshore waters of Kona have successfully raised and harvested Hawaiian Kampachi sustainably.

Hawai‘i’s commercial marine fisheries are located in two geographical areas:

- The inhabited main Hawaiian Islands, with their surrounding reefs and offshore banks; the islands of Hawai‘i to Kaua‘i; and

- The mid-north Pacific Ocean, ranging from latitude 40 degrees north to the Equator, and from longitude, 145 degrees to 175 degrees east.

Commercial fishers are required to obtain commercial marine licenses and submit fishing reports to the Hawai‘i Division of Aquatic Resources. The Commercial Marine Landings Summary Trend Report (DAR 2010) provides information on commercial fishing trends, pounds landed by species groups, fishing methods, and landings per port per island.

Information on commercial fishing, bottom fishing, and the location of artificial reefs can be found at https://dlnr.ehawaii.gov/cmls-fr/html/fishing_charts.html. The site also defines fishing restrictions. Impacts to commercial fishing from the renewable energy technologies and activities would be part of any project- or site-specific NEPA or HEPA review.

3.5.3.3 Recreation and Tourism

Hawai‘i hosted more than 9.5 million visitors during the 2011/12 timeframe. More than 80 percent of Hawai‘i’s visitors engage in recreation activities in the State’s coastal and marine areas, many of whom participate in scuba diving or snorkeling. Other popular marine recreation activities include ocean kayaking, parasailing, swimming, outrigger canoeing, and surfing. The Hawai‘i Division of Aquatic

Resources estimates that about 1,000 ocean recreation businesses operate on the major Hawaiian Islands (HTA 2012).

Coral reef areas are a focal point for much of this recreation use in terms of snorkeling and scuba diving, but these areas also are a natural resource that has social, cultural, environmental, and economic importance to the people of Hawaiʻi. Studies have shown that most coral is below snorkeling depth. Scuba diving is not as common as snorkeling and is usually at sites with more resilient habitat (HIMB / SOEST 2014). Section 3.9 of this PEIS presents information on resorts and outdoor land- and water-based recreation activities in Hawaiʻi. Interested parties may visit the Hawaiʻi DLNR website that provides listings by island of State and County recreational sites, opportunities, and use restrictions, including a comprehensive list of beaches (http://state.hi.us/dlnr/activities/).

3.5.3.4 Former Dump Sites and Munitions

Sea disposal of excess, obsolete, unserviceable, and captured enemy munitions was an internationally accepted practice until prohibited by Congress with the *Marine Protection, Research, and Sanctuaries Act of 1972*. Prior to the 1970s, destruction alternatives generally were limited to burning, burial on land, or disposal at sea.

The U.S. Armed Forces established specific procedures for munitions disposal beginning in 1917. These procedures, which defined depths and locations of disposal sites, became more stringent over time in an effort to reduce the possibility of recovery and accidental contact by the public. In 1944, the War Department required that chemical warfare material be disposed of in water at least 300 feet deep and 10 miles from shore (Carton 2009). By December 1945, the Department increased the disposal depth requirement to 6,000 feet for chemical warfare material and 3,000 feet for explosives and ammunition. The Department also required that disposal locations be published in a notice to mariners and on nautical charts (DoD 2008). Hawaiʻi has four known locations of munitions dumps; all in the vicinity of Oʻahu. Figure 3-65 shows the approximate locations around Oʻahu.

DoD (2008) provides tables for each of the known disposal sites and includes the type and quantity of the disposed munitions.

- Pacific Oʻahu HI-01 is approximately 10 miles from shore and at a depth greater than 1,500 feet. HI-O1 contains bombs and projectiles with mustard gas, bombs with cyanogen chloride, and bombs with cyanide (DoD 2008).
- Oʻahu HI-2 is approximately 10 miles from shore and at a depth greater than 1,500 feet. HI-2 has projectiles, shells, bombs, and stokes mortars containing mustard gas.
- Oʻahu HI-5 is more than 5 miles from shore and at a depth greater than 500 feet. The munitions include mustard gas in bombs and stokes mortars.
- Oʻahu HI-06 (Oʻahu Ordnance Reef) is about 1 mile from shore with a depth of 25 feet. The munitions include various calibers of cartridges, projectiles, naval gun ammunition, a mine, depth charge, a fragmentation bomb, and ammunitions boxes.

The Interisland Cable Ocean Floor Survey Reports (DBEDT and SOEST 2010) describe submerged munitions locations. Several similar reports are available from the HSEO Website at http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications. Military munitions inventory information for Hawaiʻi can be found at http://www.denix.osd.mil/mmrp/MRSI/mmrp-results.cfm.

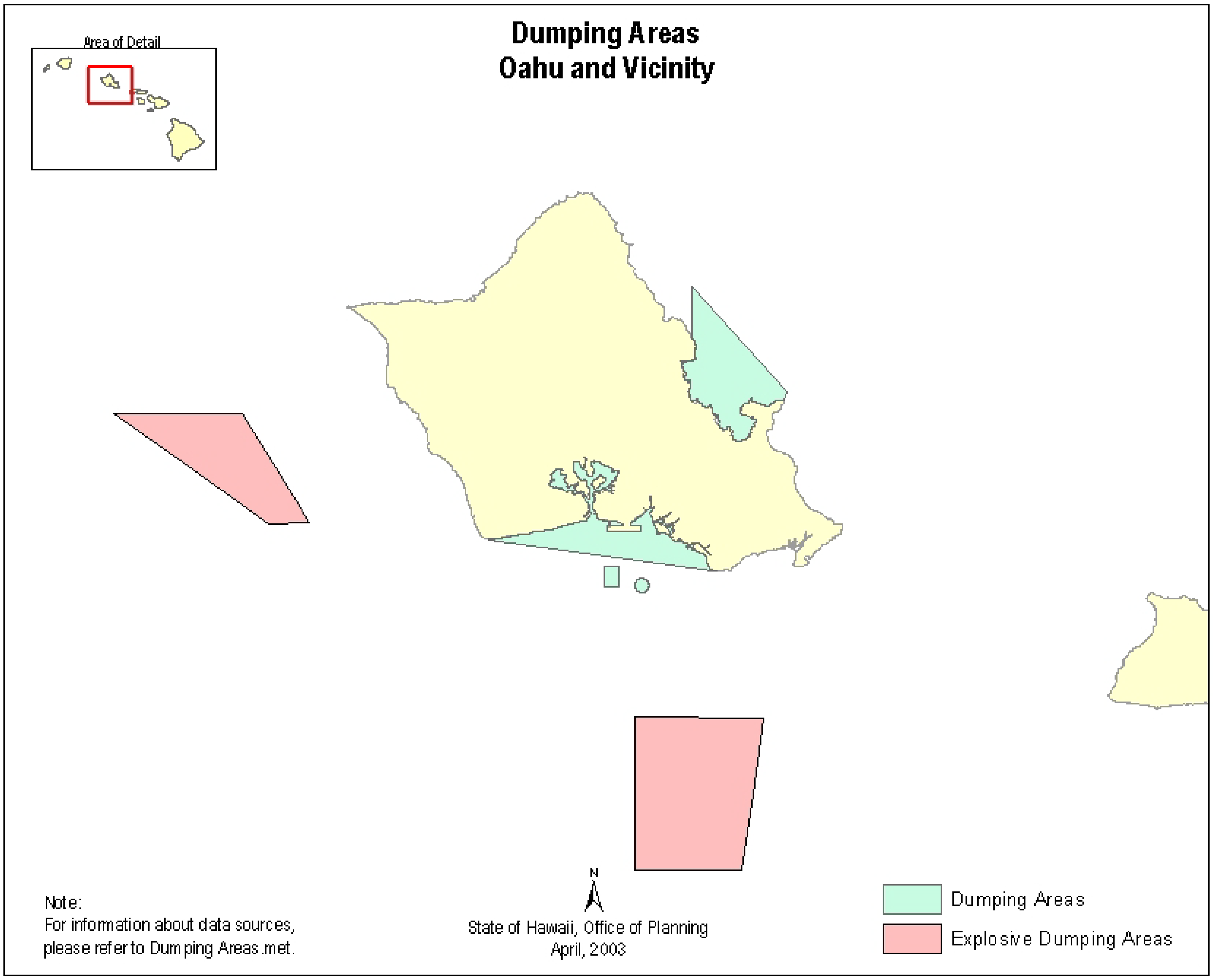


Figure 3-65. Known Munitions Dump Areas in the State of Hawai'i

3.5.3.5 Dredged Channels

Dredging is an excavation activity or operation usually carried out at least partly underwater, in shallow seas, with the purpose of gathering bottom sediments and disposing them at a different location. This technique is often used to keep waterways navigable.

Removed sediment can be disposed of through a combination of onsite, upland disposal and offshore, open-ocean disposal, or used as beach nourishment. The volume of material removed varies based on the scope of the project and the characteristics of the sediment being removed. The EPA Region 9 (which includes the State of Hawai'i) has designated five sites for ocean disposal of dredged material. Each site is managed according to a site management and monitoring plan. The offshore disposal areas around the Hawaiian Islands are (Carton 2009):

- South O'ahu, off Honolulu
- Hilo, off Hawai'i
- Kahului, off Maui
- Nawiliwill, off Kaua'i
- Port Allen, Kaua'i

The USACE shares a number of responsibilities with EPA regarding the ocean disposal of dredged material. The principle authority and responsibility for designating ocean sites for the disposal of dredged materials is vested with the EPA Regional Administrators (Hawaii Region 9). Accordingly, ocean dumping cannot occur unless a permit is issued by the USACE under the *Marine Protection Research and Sanctuaries Act*, using EPA environmental criteria and subject to EPA concurrence (see http://water.epa.gov/lawsregs/guidance/cwa/dredgdis).

Numerous channel and harbor dredging projects have occurred within the islands over the decades. One of the more recent efforts is the Hawai‘i Kai Marina and Entrance Channel Maintenance Dredging, which issued an environmental assessment in January 2011. Other notable dredging projects include the Pearl Harbor Naval Base and projects on Mokauea Island, Lahaina, and South O‘ahu.

3.5.3.6 Undersea Cables

There are seven major transpacific submarine cable landings in Hawai‘i, distributed at five cable-landing stations as follows (Submarine Cable Networks 2013):

- Two telecommunications cable landing stations in Kawaihae on Hawai‘i island: the Spencer Beach Cable Landing Station for the Honotua cable system and the Samuel M. Spencer Beach Cable Landing Site for the Southern Cross cable system

- Three telecommunications cable landing stations on O‘ahu: the Kahe Point Cable Landing Station for the Southern Cross; the Makaha Cable Landing Station for the Japan-U.S. Cable Network; the Keawaula Cable Landing Station for TPC-5 Cable Network, Telstra Endeavour (Australia-Hawai‘i Fiber Optic Cable System), Asia-America Gateway, and American Samoa Hawai‘i Cable.

Maps of the landing areas can be found at http://submarinenetworks.com/stations/north-america/usa-Hawaii. Figure 3-66 shows existing telecommunications cables in red. The map also shows distances and depths.

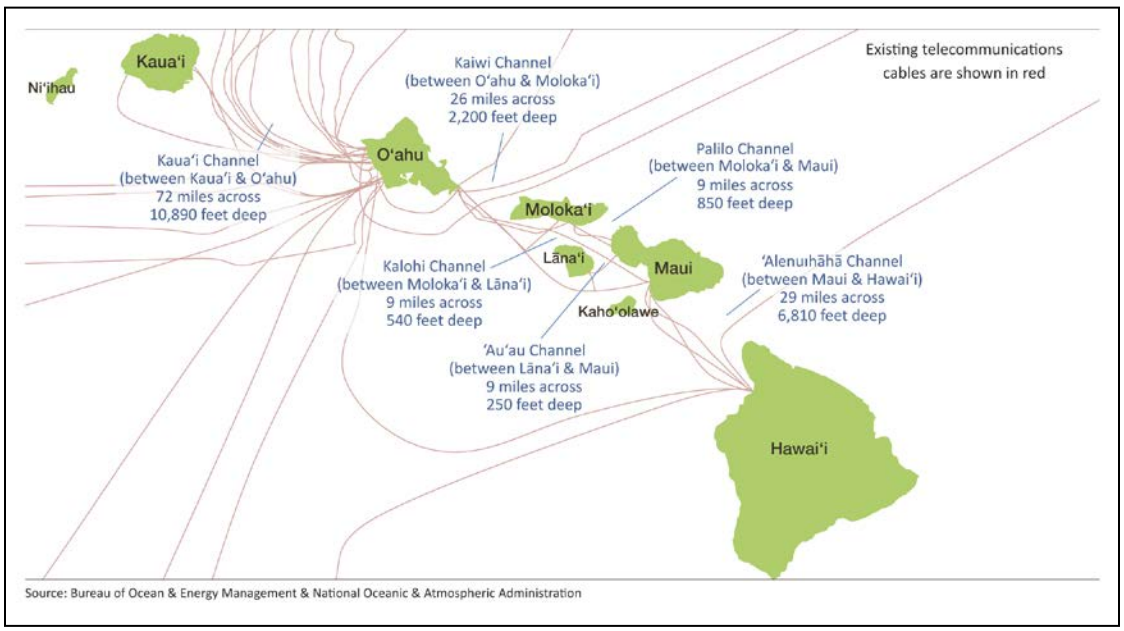


Figure 3-66. Telecommunications Cables in Hawai‘i

3.5.3.7 Protected Natural Areas

Marine Managed Areas are specific geographic areas designated by statute or administrative rule for the purpose of managing a variety of marine, estuarine, or *anchialine* resources and their uses. Anchialine resources are land-locked pools of water of varying salinity adjacent to the ocean (also known as tidal pools). These pools have indirect underground connections to the ocean and show tidal fluctuation water levels. Marine Protected Areas are a subset of Marine Managed Areas, and focus on protection, enhancement, and conservation of habitat and ecosystems (Hawaiʻi 2013b). Some Marine Protected Areas have very few fishing restrictions and allow sustainable fishing, while others restrict all fishing and are "no take" areas (NOAA 2013b). In Hawaiʻi, forms of Marine Protected Areas, such as Marine Life Conservation Districts, have been in use since 1967 (Hawaiʻi 2013c). Protected areas can cover multiple purposes in addition to the direct marine environment, such as reef preservation and shoreline erosion.

Marine Life Conservation Districts are designed to conserve and replenish marine resources. Marine Life Conservation Districts allow only limited fishing and other consumptive uses, or prohibit such uses entirely. They provide fish and other aquatic life with a protected area in which to grow and reproduce. Table 3-40 provides a summary of some of the key Marine Protected Areas in Hawaiʻi.

There are more than 50 areas within the Hawaiian Islands that are designated Marine Managed Areas, Marine Life Conservation Districts, or Marine Protected Areas (Figure 3-67). A complete list is available at http://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/. A mapping tool that provides visual representations of Marine Protected Area boundaries is available at http://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/mpaviewer/. The areas established are consistent with Executive Order 13158, "Marine Protected Areas."

Table 3-40. Size, Age, and Level of Protection for Key Marine Protected Areas in Hawaiʻi (in order by acreage)

Island	Protected Area	Acreage	Year Established	Protection Level
Hawaiʻi	Kealakekua	316	1969	Moderate
Lānaʻi	Manele	309	1976	Moderate
Hawaiʻi	Old Kona Airport	217	1992	High
Maui	Molokini	210	1977	High
Oʻahu	Pupukea	178	1983	Low
Hawaiʻi	Lapakahi	146	1979	High
Oʻahu	Hanauma Bay	101	1967	High
Hawaiʻi	Waiopae	84	2000	High
Oʻahu	Waikīkī	77	1988	High
Oʻahu	MokuʻoʻLoe	74	1967	High
Oʻahu	Honolulu	44	1978	High
Hawaiʻi	Waialea Bay	35	1985	Low

Source: NOAA 2007.

Two additional unique areas warrant discussion. The first is the Hawaiian Islands Humpback Whale National Marine Sanctuary. Congress created the Sanctuary in 1992 to protect humpback whales. The sanctuary consists of five separate areas abutting six of the main islands and covers relatively shallow offshore areas. The second is the Papahanaumokuakea Marine National Monument. This area is situated in the northwestern portion of the Hawaiian Islands, located northwest of the island of Kauaʻi and the other main Hawaiian Islands. A vast, remote, and largely uninhabited marine region, the Monument encompasses an area of approximately 140,000 square miles (Hawaiʻi 2013a). Because of its location, it would be unlikely that any of the potential activities or technologies would have any direct impact on this Marine National Monument.

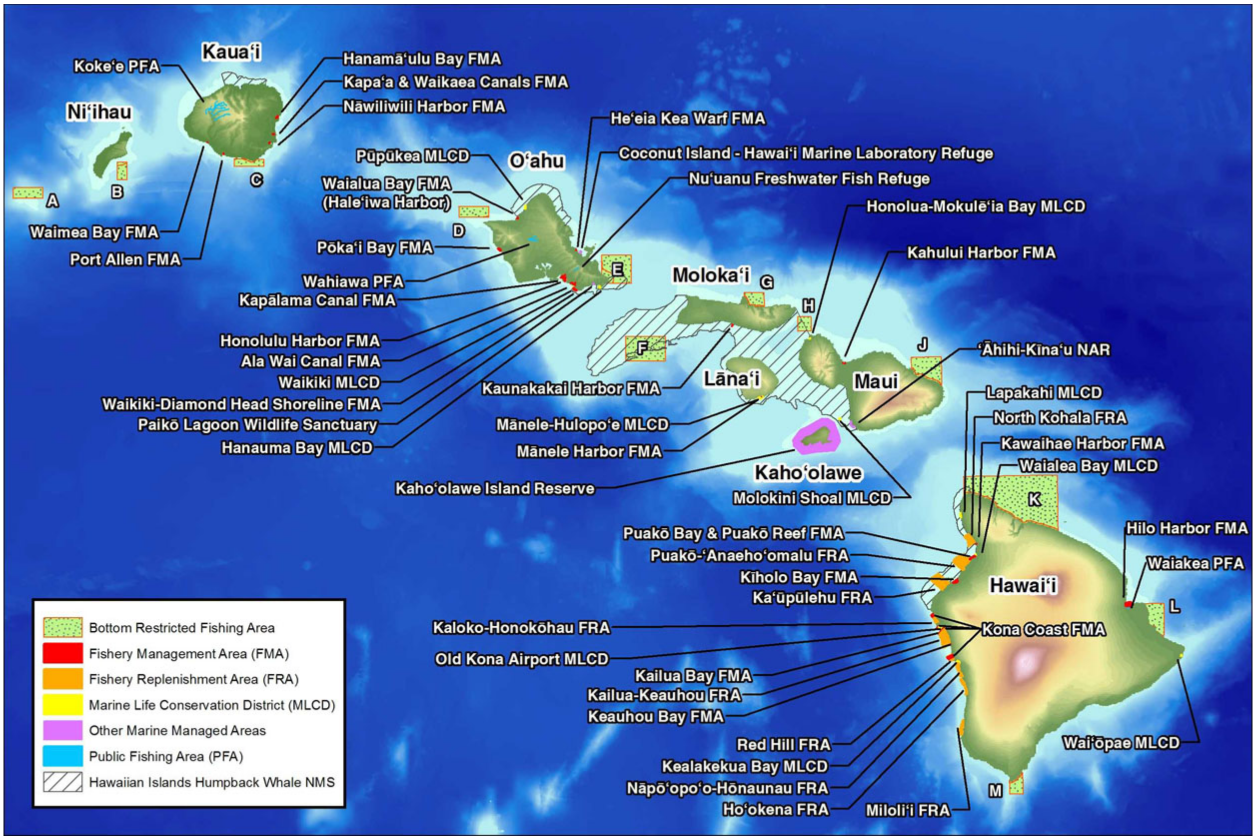


Figure 3-67. Restricted Areas Within the Hawaiian Islands

3.5.4 COMMON CONSTRUCTION AND OPERATION IMPACTS

3.5.4.1 Land Use

Typical impacts to land use from construction include ground disturbance (clearing, grading, and leveling of the construction site) and the temporary use of land required for construction laydown yards and storage and preparation areas. Construction and operation of access roads and utility corridors could also impact land use. Longer-term impacts from project operation could result in changes to land use and land ownership patterns, and could have potential compatibility issues with existing zoning and other local regulations if sited near coastal zones or other sensitive land use features.

3.5.4.2 Submerged Land Use

Construction of submerged projects in the marine environment would typically involve the installation of structures in the ocean including electrical and telecommunications cables; intake and discharge water pipelines; floating platforms with cable-tethered anchors; and submerged energy devices on the ocean floor. During construction, all of these structures could potentially cause temporary disruption of the marine environment including uses for commercial, recreational, and military purposes (both surface and subsurface).These impacts would be temporary and would be localized to the vicinity of the project.

Placement of projects in the marine environment could also have longer-term impacts. Submerged structures become potential obstacles to marine life and can influence the location and operation of future submerged and surface facilities. Any future actions would require investigation before locations were chosen to avoid conflicts with the existing structures.

3.5.5 COMMON BEST MANAGEMENT PRACTICES

3.5.5.1 Land Use

The following are BMPs related to land use construction and operation regardless of location:

- Maximize the use of previously disturbed lands;
- Avoid land requiring deforestation/descrubbing and/or significant slope leveling or grading;
- Avoid siting projects on prime or unique farmland;
- Avoid impacts on special use lands such as National Park Service lands, Wilderness Areas, National Wildlife Refuge System Lands, Wildlife Management Areas, National and Scenic Trails, traditional cultural properties and other culturally sensitive sites, critical habitat for special status species, and military operations areas and other regulated military lands;
- Consult with county agencies regarding potential impacts of developing within, adjacent to, or close to State or county special use areas such as parks;
- Use technologies and facility layouts and designs that would minimize land disturbance at a site;
- Avoid or minimize the use of lands that could adversely affect high-use land and ocean recreational areas used for surfing, paddling, fishing, hiking, and camping;
- Ensure lands considered are appropriately zoned for project development (e.g., industrial or energy development uses);
- Avoid land identified as incompatible for renewable energy development by county governments; and
- Consult with the FAA and/or appropriate DoD organization if project is close to airports or military lands.

In addition to the first BMP (maximize the use of previously disturbed lands), future renewable energy projects should also consider the use of degraded lands. EPA has implemented *RE-Powering America's Land*, an initiative to encourage renewable energy development on current and formerly contaminated lands, landfills, and mine sites when the development is aligned with the community's vision for the site. This initiative identifies the renewable energy potential of these degraded lands and provides other useful resources for anyone (e.g., communities, developers, industry, State and county governments) interested in reusing these sites for renewable energy development. More information on this initiative can be found at http://www.epa.gov/oswercpa/.

3.5.5.2 Submerged Land Use

The following are BMPs related to submerged land use for construction and operation:

- If required, obtain the necessary rights-of-way or easements and approvals for construction near and around existing subsurface utilities;
- Consider the location of protected and sensitive ocean habitats;

- Address ancillary onshore facilities in terms of local zoning and coastal zone management guidelines;
- Identify local fishing grounds and the areas of munitions dumps;
- Avoid or take necessary precautions when siting a project in the vicinity of submerged electrical and telecommunications cables and shore tie-ins; and
- Use bathymetric analyses to help determine the shortest distance to the desired depth; to avoid interfering with sensitive habitats, including coral reefs; to recognize the locations of existing undersea cables, dumps, and other structures; and to avoid or minimize impacts to fishing and recreation areas.

3.6 Cultural and Historic Resources

Hawaiian cultural and historic resources are rooted in an ancient and intricate culture first established by seafaring Polynesians branching out from the Marquesas Islands and central Polynesia hundreds of miles to the south of Hawaiʻi between 500 B.C. and A.D. 300. Native Hawaiians flourished on the islands 1,500 years before Western contact. They developed a complex society with a hierarchy of chiefs, an elaborate religion that gave the chiefs ultimate authority, and a system of irrigated agricultural fields and constructed fishponds that supported the dense population (Langlas 1998). Hawaiian cultural and natural resource management practices form the basis for why these valued resources are so important today, particularly to Native Hawaiians. As development continues to expand in Hawaiʻi, resolve to protect the remaining cultural and historic resources has strengthened. Developers must keep in mind all the renewable energy resources—sun, wind, land, volcanic materials, ocean, and streams—have major cultural significance to Native Hawaiian practitioners and their use must be treated with respect.

In addition to Native Hawaiian culture, Hawaiʻi has many generations of people with other ethnic backgrounds (e.g., Polynesian and Japanese) whose culture includes representative historic resources. Other significant historic resources that played a major role in the history of the United States include the pre-World War II military establishment and the preserved remains of resources following the attack on Pearl Harbor in 1941. A large majority of Hawaiʻi's existing built environment was constructed after 1947, which is significant as symbols of education and empowerment. These symbols are evident post-World War II and include the shift from the turn of the century plantations and agrarian activities to more participation in business and politics (DLNR 2012).

During scoping meetings in September 2012 on Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi, members of the public, including Native Hawaiians, provided unique cultural perspectives through oral and written comments and site-specific reports. These materials helped frame portions of the traditional cultural beliefs and practices discussions below. Residents of Molokaʻi and Lānaʻi, for example, provided ethnographic references, videos, and archaeological reports addressing cultural locations and perspectives on those islands.

The affected environment for cultural and historic resources is presented in four areas: (1) regulatory setting, (2) traditional cultural beliefs and practices, (3) archaeological sites, and (4) historic buildings and sites. As applicable, discussions of resources in Hawaiʻi start with a State overview then move to the individual islands.

3.6.1 REGULATORY SETTING

This section summarizes major, applicable Federal and State laws, regulations, and guidance that relate to the protection and preservation of cultural and historic resources and practices in Hawai‘i.

3.6.1.1 Federal Requirements

The major Federal requirements for addressing, evaluating, and developing mitigation measures for the protection of cultural and historic resources are identified below.

3.6.1.1.1 National Environmental Policy Act

The *National Environmental Policy Act* (NEPA) is a Federal law that requires all Federal agencies to consider the potential environmental impacts of their proposed actions. To implement NEPA, all Federal agencies follow procedures issued by CEQ. CEQ's implementing regulations for NEPA require that EISs, including PEISs, discuss the environmental consequences to historic and cultural resources [40 CFR 1502.16(g)].

3.6.1.1.2 National Historic Preservation Act: the Section 106 Process and the National Register of Historic Places

Federal agencies must also comply with the *National Historic Preservation Act* (16 U.S.C. § 470; NHPA). Congress passed the NHPA in 1966 to develop a Federal historic preservation program in response to widespread public concern about the loss of historic properties due to the implementation of Federal programs such as the urban renewal program, the Interstate highway program, and the USACE Civil Works program. A key provision of the NHPA is Section 106, which requires Federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Properties (ACHP) a reasonable opportunity to comment. This has evolved into a consultative process involving diverse stakeholders as well as the Federal agency. Agencies must consider effects on historic properties, defined in the NHPA as districts, sites, buildings, structures, and objects included in, or eligible for inclusion in, the *National Register of Historic Places* (National Register or NRHP), which is maintained by the Secretary of the Interior (ACHP 2014).

The ACHP has promulgated implementing regulations for Section 106, which can be found at 36 CFR Part 800. Federal agencies take into account the effects of any project carried out by them or that receives Federal financial assistance, permits, or approvals by following the steps set forth in these regulations for identifying, evaluating, and resolving potential adverse effects to historic properties within the area of potential effects for the undertaking. As part of this process, Federal agencies consult with the relevant State Historic Preservation Officer (SHPO), a State official tasked with advising and assisting Federal agencies in carrying out their Section 106 responsibilities [16 U.S.C. § 470a(b)(3); 36 CFR 800.2(c)(1)(i)]. The SHPO for Hawai‘i is the DLNR Historic Preservation Division (see http://dlnr.hawaii.gov/shpd/). Other possible consulting parties in the Section 106 process include Native Hawaiian Organizations (NHOs); representatives of county governments; applicants for Federal assistance or for a Federal permit, license or other approval; and individuals and organizations with a demonstrated interest in the undertaking [36 CFR 800.2(c)]. Federal agencies must also engage with the public during the process [36 CFR 800.2(d)].

The Section 106 process is concerned with potential adverse effects to historic properties, which are a subset of the historic and cultural resources that an EIS must discuss (see discussion above). Historic properties are "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior" and include “artifacts, records, and remains that are related to and located within such properties” and “properties of traditional religious and cultural importance to an Indian tribe or [NHO] and that meet the National Register criteria” [36 CFR 800.16(l)(1)]. The National Register is a list composed of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, engineering, and culture [16 U.S.C. § 470a(a)(1)(A)].

To be considered eligible for the National Register, properties must meet the criteria for evaluation found at 36 CFR 60.4. Properties that may meet these criteria include, but are not limited to, pre-contact and historic era archaeological sites and features, ethnographic resources (including traditional cultural properties), historic sites, structures of various kinds and ages, and, within the National Park System, cultural landscapes. Traditional cultural properties are “eligible for inclusion in the National Register because of [their] association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community” (NPS 1998). Paraphrased, the criteria for evaluation include association with significant historical events; association with significant people in the culture’s past; embodiment of distinctive characteristics of a type, period, or method of construction; embodiment of the work of a master, or one that possesses high artistic value; and potential to yield information important to the culture’s history. Generally, properties that achieved significance within the past 50 years are excluded unless they are of exceptional importance. Like NEPA for historic and cultural resources, the Section 106 process does not require the preservation of historic properties, only that effects to these properties are taken into account.

CEQ regulations encourage integration of the NEPA process with other planning and environmental reviews, such as Section 106 of NHPA [40 CFR 1502.25(a)]. ACHP also encourages integration of NEPA and NHPA in its regulations (36 CFR 800.8). In fact, in 2013, CEQ and ACHP jointly issued a handbook that provides important and practical guidance on integration (CEQ andACHP 2013). Federal agencies may choose to coordinate their NEPA and NHPA reviews, or they may choose a substitution framework, in which NEPA process and documentation are used to comply with Section 106.

Section 106 and the Section 106 regulations specifically include NHOs. See, for example, Section 101(d)(6)(b) (16 U.S.C. § 470a(d)(6)(b); Section 101(d)(6)(c)(i)-(iii) (16 U.S.C. § 470a(d)(6)(c)(i)-(iii); 36 CFR 800.2(c)(2), 36 CFR 800.3(f)(2), 36 CFR 800.4, 36 CFR 800.5, 36 CFR 800.6, and 36 CFR 800.8. For the purposes of Section 106, NHOs are “any organization which serves and represents the interests of Native Hawaiians; has as a primary and stated purpose the provision of services to Native Hawaiians; and has demonstrated expertise in aspects of historic preservation that are significant to Native Hawaiians” [36 CFR 800.16(s)(1)]. A Native Hawaiian is “any individual who is a descendant of the aboriginal people who, prior to 1778, occupied and exercised sovereignty in the area that now constitutes the State of Hawai‘i” [36 CFR 800.16(s)(2)].

Additionally, ACHP’s Policy Statement on the ACHP’s interaction with NHOs contains the commitments and principles that ACHP will implement when interacting with NHOs on matters relating to NHPA (ACHP 2008). The ACHP has also released a handbook on consultation with NHOs during the Section 106 process (ACHP 2011).

3.6.1.1.3 Archaeological Resources Protection Act

The *Archaeological Resources Protection Act* (ARPA) of 1979, as amended (Public Law 96-95; 16 U.S.C. §§ 470aa-470mm) focuses “on the regulation of legitimate archeological investigation on public lands and the enforcement of penalties against those who loot or vandalize archeological resources” (NPS 2014a). ARPA applies only to archaeological sites on Federal and tribal lands. The Act specifically:

- Establishes professional standards for excavations;

- Governs the excavation or removal of archaeological resources on Federal and tribal lands;
- Describes prohibited actions, including trafficking, that affect archaeological resources, in addition to their unpermitted excavation and removal;
- Protects the confidentiality of archaeological resource locations on Federal and native lands
- Requires Federal land managers to "…establish a program to increase public awareness of the significance of the archaeological resources located on public and Indian lands and the need to protect such resources."
- Requires the major land managing departments of the Federal government to schedule and conduct archaeological surveys of the lands under their control to enable better protection of archaeological resources.
- Establishes both civil and criminal penalties for the destruction or alteration of archeological resources.

3.6.1.1.4 Archaeological and Historic Preservation Act

The *Archaeological and Historic Preservation Act* (AHPA) of 1974 (Title 16 U.S.C. §469) addresses impacts to archaeological and historic resources resulting from Federal activities that would significantly alter the landscape. The law focuses on activities such as the creation of dams and the impacts resulting from flooding, worker housing, and creation of access roads; however, its requirements are applicable to any Federal action. AHPA aims to protect the recovery of data and the salvage of scientific, historic, and archaeological resources that may otherwise be irreparably damaged by applicable Federal actions.

3.6.1.1.5 Antiquities Act

The *Antiquities Act of 1906* (16 U.S.C. § 431) makes it illegal to excavate or remove certain archaeological resources from Federal land without permission. The law establishes a permitting process for conducting archaeological fieldwork on Federal lands. It also allows the President of the United States to establish historical monuments and landmarks with the aim of protecting these sites from excavation or destruction of the antiquities they hold.

3.6.1.1.6 American Indian Religious Freedom Act

Federal agencies are also required to consider the effects of their actions on sites, areas, and other resources that are of religious significance to Native Americans, including Native Hawaiians. This requirement is established under the *American Indian Religious Freedom Act* (AIRFA) of 1978 (Public Law 95-341, 92 Stat. 469). AIRFA protects the rights of Native Hawaiians to have access to their sacred places, to worship through ceremonial and traditional rights, and to use and possess all objects considered sacred. It requires consultation with NHOs if an agency action will affect a sacred site on Federal lands.

3.6.1.1.7 Native American Graves Protection and Repatriation Act

The *Native American Graves Protection and Repatriation Act* (NAGPRA) of 1990 (Public Law 101-601) requires Federal agencies to consult with the appropriate Native American tribes, including NHOs like the Office of Hawaiian Affairs (OHA), prior to the excavation of human remains and funerary objects on Federal and tribal lands. The law also extends to cultural items such as sacred objects and objects of cultural patrimony. It requires the repatriation of human remains found on Federal and tribal lands and in museums receiving Federal funds, and establishes a program of Federal grants to assist in the repatriation process. NAGPRA is considered one of the strongest pieces of Federal legislation pertaining to native peoples' remains and artifacts.

3.6.1.1.8 Abandoned Shipwreck Act

To discourage treasure hunters and others from damaging and looting abandoned shipwrecks, the *Abandoned Shipwreck Act of 1987* (Title 43 U.S.C. § 2101) was passed. The law specifies that any wreck embedded within a state's submerged lands is the property of that state and subject to its laws and jurisdictions provided the shipwreck is determined to be abandoned. "The U.S. Government continues to hold title to shipwrecks to sunken U.S. warships ... no matter where the vessels are located" (NPS 2014b).

3.6.1.2 State Requirements

The State of Hawai'i recognizes that potential areas identified for renewable energy development projects are living cultural resources to the Native Hawaiian community and that there is an obligation to preserve and protect historic property and associated constitutionally guaranteed rights to use of the land and waters of the State. *Historic property* means any building, structure, object, district, area, or site, including heiau (temple) and underwater site over fifty years old. The State Historic Preservation Division (SHPD) under the DLNR is responsible for administering programs of the NHPA and other State mandates related to historic property and preservation (DLNR 2012). More specifically, the SHPD is responsible for programs related to archaeology, history and culture, and architecture. The SHPD is the official keeper of the Hawai'i Register of Historic Places (HRHP). The list formally recognizes districts, sites, structures, buildings and objects and their significance in Hawai'i's history, architecture, archaeology, engineering and culture. Hawai'i Administrative Rules and Revised Statutes identify the legal requirements for historic preservation in the State.

3.6.1.2.1 Hawai'i Administrative Rules (HAR)

Administrative rules pertaining to historic preservation consist of the following:

Chapter 197:	Hawai'i Historic Places Review Board
Chapter 198:	Hawai'i and National Register of Historic Places Programs
Chapter 275:	Rules Governing Procedures for Historic Preservation Review for Governmental Projects Covered Under Sections 6E-7 and 6E-8, HRS
Chapter 276:	Rules Governing Standards for Archaeological Inventory Surveys and Reports
Chapter 277:	Rules Governing Requirements for Archaeological Site Preservation and Development
Chapter 278:	Rules Governing Standards for Archaeological Data Recovery Studies and Reports
Chapter 279:	Rules Governing Standards for Archaeological Monitoring Studies and Reports
Chapter 280:	Rules Governing General Procedures for Inadvertent Discoveries of Historic Properties during a Project Covered by the Historic Preservation Review Process
Chapter 281:	Rules Governing Professional Qualifications
Chapter 282:	Rules Governing Permits for Archaeological Work
Chapter 283:	Rules Governing Standards for Osteological Analysis of Human Skeletal Remains
Chapter 284:	Rules Governing Procedures for Historic Preservation Review to Comment on Chapter 6E-42, HRS, Projects
Chapter 300:	Rules of Practice and Procedure Relating to Burial Sites and Human Remains

3.6.1.2.2 Hawai‘i Revised Statutes (HRS)

The main HRS associated with cultural and historic resource protection is referred to as Chapter 6E (as administered through HAR Title 13), the Historic Preservation Program, which provides for “the research, protection, restoration, rehabilitation, and interpretation of buildings, structures, objects, districts, areas, and sites, including underwater sites and burial sites, significant to the history, architecture, or culture of the State, its communities, or the nation.” Chapter 6E consists of four main parts; historic preservation program, monuments and memorials, Pacific war memorial system, and a miscellaneous category. Protection and preservation of cultural and historic resources on Federal and State lands is covered by applicable administrative rules and statues. However HRS 6E-10, “Privately Owned Historic Property,” also mandates the review and protection of historic property on or eligible for the HRHP that is on private property prior to construction, alteration, disposition or improvement of any nature.

3.6.1.2.3 Act 50: Hawai‘i Session Laws of 2000

The Hawai‘i State Constitution, other State laws, and the courts of the State require government agencies to protect and preserve cultural beliefs, practices, and resources of Native Hawaiians and other ethnic groups. To assist decisionmakers in the protection of cultural resources, HRS Chapter 343, and HAR 11-200 require project proponents to assess proposed actions for their potential impacts to cultural properties, practices, and beliefs. This process was clarified by the Hawai‘i State Legislature in Act 50, Hawai‘i Session Laws 2000. Act 50 recognizes the importance of protecting Hawaiian cultural resources and specifically requires that EISs include the disclosure of the effects of a proposed action on the cultural practices of the community, and in particular the Hawaiian community, through preparation of cultural impact assessments (CIA). Specifically, the Environmental Council suggested that CIAs should include information relating to practices and beliefs of a particular cultural or ethnic group or groups. Such information may be obtained through public scoping, community meetings, ethnographic interviews, and oral histories.

3.6.1.2.4 Act 85: Hawai‘i State Legislature (2013)

In August 2012, in response to a project proponent’s attempt to conduct archaeological review in phases of the project as it was developed, the Hawai‘i Supreme Court interpreted (and ruled) in Kaleikini v. Yoshioka, that compliance with the State’s historic preservation law requires that an archaeological survey must be completed for the entire project rather than in phases. In response to this ruling, the State Legislature passed Act 85 in 2013 to allow DLNR to approve a phased review of a project where: (1) the proposed project consists of large corridors or large land areas, (2) access to properties is restricted, or (3) circumstances dictate that construction be done in stages.

Act 85 requires a programmatic agreement between DLNR and the project applicant that identifies each phase and the estimated timelines for each phase. Persons dissatisfied with DLNR’s decision may appeal to the Hawai‘i Historic Places Review Board, and then to the Governor should they be dissatisfied with the Review Board’s decision. Public notice must also be provided by DLNR.

3.6.1.2.5 Hawai‘i Supreme Court Decision

The Hawai‘i Supreme Court in its decision in *Ka Paakai O Ka ‘Āina v. Land Use Commission*, 94. Hawai‘i 31, 7 P.3d 1068 (2000) (Ka Paakai) provides government agencies an analytical framework to ensure the protection and preservation of traditional and customary Native Hawaiian rights by preserving valued cultural, historical, and natural resources while reasonably accommodating competing private development interests.

The State and its agencies have an affirmative obligation to preserve and protect the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible. The Court has described the analytical framework to fulfill this obligation by identifying the scope of valued cultural, historical, or natural resources in proposed project areas, including the extent to which traditional and customary Native Hawaiian rights are exercised in the area; to ascertain the extent to which those resources—including traditional and customary Native Hawaiian rights—will be affected or impaired by a proposed project; and to propose feasible action, if any, that should be taken to reasonably protect Native Hawaiian rights if they are found to exist.

3.6.1.2.6 Hawaiʻi State Historic Preservation Plan

The purpose of the Hawaiʻi State Historic Preservation Plan is to guide efforts to preserve and protect the valuable historic properties and cultural sites located in the State of Hawaiʻi. The plan establishes goals and objectives that the community has determined to be important for historic preservation. The statewide plan is required by NHPA [Section 101 (b)(3)(c)] for every state that participates in Federal historic preservation programs and receives funds from the Federal Historic Preservation Fund. The plan informs the State and county planning processes and is incorporated into their planning documents so that the preservation of cultural and historic resources becomes a part of the fabric of planning and doing business in the State of Hawaiʻi. The plan also informs members of the community, including developers and contractors, as well as individuals, on the direction and implementation steps planned for historic preservation in five-year increments (DLNR 2012).

3.6.1.3 Native Hawaiian Consultation

Both Federal and State law require consultation with NHOs in certain situations. The U.S. Department of the Interior (DOI), through the Office of Native Hawaiian Relations, maintains an NHO notification list for purposes of identifying NHOs for project consultations, their jurisdictional locations within the Hawaiian Islands, and their scope of interest (DOI 2013). There are 72 NHOs on the list, 30 represent interests associated with all of the islands, 30 on Oʻahu, 4 on Molokaʻi, one on Lānaʻi, 10 on Maui, and 9 on the Big Island. There are no specific NHOs identified solely for the island of Kauaʻi. Except for the 30 NHOs that have interests associated with all of the islands, a few of the NHOs identified for each of the islands have interests on more than one island.

With respect to Hawaiian burials, it is vital to note that ohana members (lineal and/or cultural descendants) play major roles with the disposition of burial sites and human remains, and they must be engaged in consultation along with the SHPD and appropriate Burial Councils. Failure to undertake measures to avoid or mitigate impacts commonly results in protracted litigation and other kinds of problems.

Native Hawaiians have a saying: "ʻAʻole pau ka ʻike i ka halau hoʻokahi" (Not all knowledge is learned in one school.) One source's opinion may not be the only salient consideration; broader consultation with kamaʻaina and cultural practitioners can yield more results when establishing significance criteria for resources. "Nana ʻike Kumu" (Look to the source) is another Hawaiian saying that confirms that input from Hawaiian kupuna (elders) is always regarded highly, so their wisdom and knowledge should be sought during the consultation process.

3.6.2 TRADITIONAL CULTURAL BELIEFS AND PRACTICES

The importance of traditional cultural properties is evident in the strong cultural attachment Native Hawaiians maintain with their natural, physical, and spiritual surroundings. The values and beliefs associated with these places have been passed on through the generations and continue to root Native

Hawaiians to their land and family. Native Hawaiians regard the environment as an integral component of their cultural heritage. The quality and abundance of natural resources within a Native Hawaiian community can be attributed to the persistence of ohana (family) values and practices in the conduct of subsistence activities still practiced by some individuals on the islands, especially Molokaʻi. Davianna Pomaikai McGregor describes the significance of these values and their foundation in resource management:

> “An inherent aspect of these ohana values is the practice of conservation to ensure availability of natural resources for present and future generations. These rules of behavior are tied to cultural beliefs and values regarding respect of the aina, the virtue of sharing and not taking too much, and holistic perspective of organisms and ecosystems that emphasizes balance and coexistence. The Hawaiian outlook that shapes these customs and practices is lokahi or maintaining spiritual, cultural and natural balance with the elemental life forces of nature” (McGregor et al. 1996).

These values along with ancestral knowledge about the land and its resources are currently reinforced through continued subsistence practices. Today’s practitioners stay alert to the condition of the landscape and its resources. They pay attention to both seasonal and life cycle changes in these resources and rely on these observations to preserve the natural and cultural landscape of their area. Unlike Western practice, the land is not a commodity to Hawaiians. Instead, it is the foundation of their identity, both spiritually and culturally, as evidenced by how closely linked their values are to the land and its resources (DBEDT 2012a). “They proudly trace their lineage to the lands in their region as being originally settled by their ancestors. The land is a part of their ohana and they care for it as they do the other living members of their families” (McGregor et al. 1996).

The holistic view of the environment by Native Hawaiians relies on the interdependence of the natural resources including land, air, fresh water, ocean, plants, and animals. Native Hawaiians regard the natural elements in a balanced and harmonious manner with changes to one element effecting change in the others. Ancestral knowledge of the land was recorded and passed down through place names, legends, and chants associated with a particular district. Native Hawaiians recognize a vast polytheist hierarchy similar to the ancient Greeks. Within this hierarchy, the most famous is Pele, the volcano goddess. When one speaks of Pele in contemporary Hawaiʻi, her name is oftentimes spoken with reverence. Pele’s home is in and around the active volcano, Kīlauea in Hawaiʻi Volcanoes National Park on the Big Island (ʻIolana 2013). The myth coincides with modern geological theories of shifting tectonic plates in the earth’s crust, erupting lava, and geothermal venting. Native Hawaiian stewardship and use of cultural and natural resources are centered on the practices of malama aina (respect and conservation) and lokahi (harmony and balance). These practices were important principles for Native Hawaiians that ensured the sustainability of their resources. These principles were tied to the virtue of taking only what was needed and complemented the holistic perspective of organisms and ecosystems that allowed Native Hawaiians to live in balance with their environment (DBEDT 2012a).

Many historic and present-day Native Hawaiian cultural practices are important components of Hawaiian cultural resource evaluations since those practices represent deep, spiritual connections to the environment and the specific locations on and around the Hawaiian islands where they take place. Some specific examples include agricultural practices, gathering, fishing and hunting, canoe paddling, trail access, burial practices, and worshipping.

3.6.3 CULTURAL LANDSCAPES

In considering programmatic impacts to cultural and natural resources from potential renewable energy projects and associated facilities, it became apparent that a broader approach should be considered because some renewable energy technologies and potential siting of future projects, especially on the utility-scale, can be geographically large. Thus, for larger-scale projects, cultural resource evaluations may need to focus on cultural landscapes rather than project-specific footprints and individual cultural resource sites. However, some of the smaller-scale technologies, such as distributed solar power, can still benefit from a more site-specific cultural resource survey and evaluation approach.

A cultural landscape consists of physical elements of a geographic area, including both cultural and natural resources and the wildlife, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values through time. The NPS definition of cultural landscapes includes four types; designed landscapes, vernacular landscapes, historic sites, and ethnographic landscapes. These landscape types are not mutually exclusive. Designed landscapes can be historic gardens, planned residential communities, or parks; vernacular landscapes can be farms or ranches; historic sites include battlefields or places where significant historical events occurred; and ethnographic landscapes can contain a variety of natural and cultural resources that associated people define as important (NPS 1998). Each type of landscape must have historic significance (eligible for the NRHP) and historic integrity (ability to convey its historic significance). Cultural landscapes are listed on or eligible for listing on the NRHP as sites or districts, but can also be included as traditional cultural properties. Cultural landscapes consist of the following 13 landscape characteristics:

- Buildings/structures
- Archaeological features
- Circulation patterns
- Constructed water features
- Cluster arrangement
- Cultural traditions
- Land use
- Natural systems and features
- Small-scale features
- Spatial organization
- Topography
- Vegetation
- Views/vistas

Native Hawaiian culture does not have a clear dividing line of where the cultural landscape ends and nature begins. There are several important components of the Hawaiian cultural landscape that warrant understanding such that interrelated Native Hawaiian perspectives can be addressed.

The ‘aina, wai (water), kai (ocean), and lewa (sky) were the foundation of life and the source of the spiritual relationship between people and their environment. Hawaiian moolelo, or traditions express the attachment felt between the Native Hawaiian people and the earth around them. In Hawaiian culture, natural and cultural resources are one and the same. Native traditions describe the formation (literally the birth) of the Hawaiian Islands and the presence of life on, and around them, in the context of genealogical accounts. All forms of the natural environment—from the skies and mountain peaks, to the watered valleys and plains, to the shore line and ocean depths—were the embodiments of Hawaiian gods and deities (Maly 2001).

Wahi pana (celebrated places) compose a large portion of the cultural landscape. They include all sites considered sacred by the Native Hawaiian people. These may take the form of heiau (religious temples), shrines, burial caves, graves, etc., that were built for religious or cultural purposes. Additionally, physical and geographic features associated with Hawaiian deities compose wahi pana and may include the sites of significant natural, cultural, spiritual, or historic phenomenon or events. Ed Kanahele offers a description of the large range of places that can be described as wahi pana in Ancient Sites of O‘ahu by Van James (1991):

> “The gods and their disciples’ specified places that were sacred. The inventory of sacred places in Hawai‘i includes the dwelling places of the gods, the dwelling places of venerable disciples, temples, shrines, as well as selected observations points, cliffs, mounds, mountains, weather phenomena, forests, and volcanoes.”

Domains of aumakua, or ancestral deities, add another component to the cultural landscape. Access to a family’s aumakua provided a way for Native Hawaiians to renew their ties to their ancestors. Within the domain of the aumakua, Native Hawaiians could experience hoailona, or natural signs and phenomena that would facilitate this reconnection. Thus, these areas are also a critical component to the Hawaiian cultural landscape. Finally, trails and roads are part of the cultural landscape because they provide access to cultural and natural resources that are used in all activity. By providing access to them, these trails and roads gain added importance as well (McGregor et al. 1996).

Each natural environment also contributes to the cultural landscape of the area. Streams and springs provide freshwater sources that are vital as habitats for native species and marine life, for taro and agricultural cultivation, and for domestic use. The importance of freshwater in the Native Hawaiian culture also elevates the importance of streams and springs. The shoreline, coral reefs, and ocean, both nearshore and offshore, provide another important element of the cultural landscape. By providing a place to gather food and medicine as well as an important setting for cultural and spiritual customs, the shoreline garners added importance. The forest and mountain areas are also part of the cultural landscape. Again, the area provides a place in which many Native Hawaiians gathered plants used for medicine, food, ceremonial adornment, and ritual offerings. It also provided a setting for Native Hawaiians to hunt pigs and other animals. Additionally, many spiritual customs were performed in the forest.

A vast array of components can be included in the Native Hawaiian cultural landscape: areas of cultivation, circulation networks, buildings, structures, facilities, irrigation systems, roads, tunnels, archaeological and historical sites, viewing points and visual corridors, and cultural resource and use areas. Particularly prominent examples of Hawaiian agriculturally based cultural landscapes include the broad valley floors whose wetlands were transformed and expanded into intricate systems of pond fields, ditches, and fishponds. In areas such as Hanalei on Kaua‘i, Ke-‘anae on Maui and Waipio on Hawai‘i, farmers still cultivate taro in these irrigated fields. Only by talking to community members and cultural practitioners are the important elements of these landscapes illuminated (DBEDT 2012a).

3.6.4 ARCHAEOLOGICAL SITES

Archaeological studies in Hawai‘i began early in the twentieth century with the pioneering work of William T. Brigham and John F. G. Stokes. Islandwide surveys of heiau and other aboveground sites continued throughout the pre-World War II period, but the excavation of subsurface sites did not begin until 1950, with Kenneth P. Emory’s work at Kuliouou Rockshelter (O‘ahu). Since then, archaeologists from the Bishop Museum, University of Hawai‘i, and other institutions (as well as private consultants performing extensive contract archaeology) have conducted excavations at several hundred archaeological sites. This work, together with thousands of radiocarbon dates from the sites, has yielded a rich record for constructing a detailed chronology of precontact history (Kirch 1998).

Hawaiian archaeology includes a wide range of site types, most consisting of dry-laid stone structures utilizing the natural geology (lava rock). The largest sites are typically the stone foundations of major luakini heiau (war temples), many covering more than 100,000 square feet. Smaller heiau are found throughout the Islands in a variety of platformed, walled, and terraced structures; many functioning as agricultural temples. Habitation sites typically were dispersed over the landscape rather than clustered, although some village-like aggregations apparently did exist. Precontact Hawaiian habitations consisted of groups of functionally separated structures, which are represented archaeologically by C- and L-shaped walls, rectangular enclosures, platforms, terraces, and other forms. In some areas, the ancient Hawaiians lived in rock shelters and lava tubes. Caves, lava tubes, and large sand dunes, served as burial places, and caves were also used as refuges.

Hawaiian subsistence was based on intensive forms of agriculture and aquaculture, and these have left their marks on the archaeological landscape as well. In windward and some leeward valleys with permanent streams, the islanders constructed terraces on alluvial plains and hillslope for the irrigated cultivation of taro. Stone-faced terrace complexes and stone-lined water ditches are major agricultural features in these regions.

Native Hawaiians practiced intensive aquaculture in large, loko kuapa (stone-walled fishponds) constructed on shallow reef flats. Altogether, approximately 449 ponds have been recorded, the majority of them on O‘ahu and Moloka‘i, where the coastal geomorphology was highly conducive to pond construction. Some of the larger ponds incorporated more than 500 acres and are estimated to have yielded as much as 365 pounds per acre annually, primarily of mullet and milkfish (Kirch 1998).

The State Inventory of Historic Places (SIHP) lists approximately 54,000 archaeological sites that are eligible for or identified in the HRHP and/or NRHP. Approximately 2 percent of those sites are actually listed on one or both of the Registers. A subset of the archaeological sites includes approximately 800 heiau. The State of Hawai‘i is unique in this perspective in that it is rich in archaeological sites that were not destroyed by early development, and therefore can still be identified, documented, or preserved (DLNR 2012). Nevertheless, the SIHP reflects only those archaeological sites that have been identified through surveys or other identification studies and should be considered a preliminary step in the literature review process for any site-specific projects being considered. A large percentage of Hawaiian lands have not been surveyed for archaeological resources and as a result, an unknown number of sites have yet to be identified and documented. For example, at Hawai‘i Volcanoes National Park on the Big Island, only 13 percent of the park has been surveyed for cultural resources and within that 13 percent, 300 archaeological sites and 14,000 prehistoric and pre-contact features have been identified. Therefore, the SIHP is not complete and should not be used without considering whether an area being researched has been surveyed and to what standard.

The sections below identify, by island, the numbers of archaeological sites on the SIHP that are eligible for, or identified on the HRHP and/or NRHP. In addition, general types of sites that appear on the HRHP and/or the NRHP are also identified along with some noteworthy examples to give the reader a better perspective of the archaeological resources present on each island.

3.6.4.1 Kaua‘i

The SIHP identifies approximately 2,100 archaeological sites on Kaua‘i; 135 are heiau.

Sites of particular note include the heiau complex at Wailua and Ke-ahu-a-Laka Halau Hula (dance platform) at Haena (Kirch 1998). Kāneiolouma Complex is a cultural site containing the remnants of an ancient Hawaiian village at Po‘ipū, Kōloa, Kaua‘i. The 13-acre complex contains numerous habitation, cultivation, sporting or assembly, and religious structures dating to at least the mid-1400s. It is considered sacred to the Hawaiian culture as well as an important cultural landmark for the residents of Kaua‘i .

Well-known burial sites on Kaua‘i include burial caves and the Anahola Dune Burials. The Alekoko (Menehune) Fishpond is another significant archaeological site located next to the Huleia Stream. A lava rock wall between the pond and the stream is 900 feet long and 5 feet high; archaeologists estimate the fishpond to be approximately 1,000 years old (To-hawaii.com 2013a).

3.6.4.2 O‘ahu

The SIHP identifies approximately 7,200 archaeological sites on O‘ahu; 145 are heiau. On O‘ahu, preserved and accessible heiau sites include Ulupō, Puuomahuka, Kane‘aki, and Keaiwa. Several fishponds (such as He‘eia) are still visible around the margins of Kāne‘ohe Bay. Two unique sites on O‘ahu are the chiefly birthing stones at Kukaniloko and the fortification notches at Nu‘uanu Pali, scene of the battle in 1795 between Kamehameha and Kalanikupule, high chief of O‘ahu (Kirch 1998). Kaniakapupu is an ancient historic site in Nu‘uanu on O‘ahu. King Kamehameha III built his summer palace there and the ruins of it are still visible today. An ancient heiau used to be located there as well (To-hawaii.com 2013b).

3.6.4.3 Moloka‘i

There are approximately 2,500 archaeological sites on Moloka‘i; 41 are heiau. Moloka‘i is particularly noteworthy for the numerous stone-walled fishponds that line its southern coastline; a few are still used. Several large heiau sites are located in the Kamalo-Mapulehu area, and Hālawa Valley on the eastern end of the island is a virtually continuous archaeological complex of irrigated terraces and habitation sites (Kirch 1998). Iliiliopae Heiau is an ancient Hawaiian temple site. Built in the 13th century to serve as a temple for sorcerers, the heiau is one of the largest and oldest religious sites in all of Hawai‘i. It also may have served as a temple for human sacrifice (To-hawaii.com 2013c). There are also two National Historic Landmarks (NHL) on Moloka‘i, Hokukano-Ualapue Complex and Kalaupapa Leprosy Settlement. The Kalaupapa NHL is located within Kalaupapa National Historical Park, which extends northward on a peninsula from the north-central part of the island. Archaeological resources within Kalaupapa National Historical Park show a vast variety of site types, extensive time range of habitation and land use, and exceptional preservation within a cultural landscape. Under NHPA Section 106 regulations, NHLs receive special consideration to resolve any adverse effects.

3.6.4.4 Lāna‘i

Approximately 1,900 archaeological sites are identified in the SIHP on Lāna‘i; 41 are heiau. Sites include Pu‘upehe Platform and the Kealiakapu Complex-Kaunolu Village. Halulu Heiau is one of the most impressive archaeological sites on Lāna‘i. The heiau once served as a place of refuge, built by King Kamehameha to challenge those who broke the law (Kirch 1998). Kahekili’s Leap is a rock ledge on Lāna‘i’s south shore. It was here where King Kamehameha’s warriors proved their bravery by leaping 80 feet into the ocean below (To-hawaii.com 2013d).

3.6.4.5 Maui

The SIHP identifies approximately 7,200 archaeological sites on Maui; 222 are heiau. Some of the sites include 18 archaeological districts and complexes, and numerous heiau and petroglyph sites. Preserved heiau sites on Maui include Pihana and Haleki‘i Piilanihale, and Wai‘anapanapa. A well-documented habitation complex is located in the Keoneoio Archaeological District near La Perouse Bay. The upland region of Kula was once a densely settled agricultural area, and remains of ancient Hawaiian dryland fields can still be seen (Kirch 1998). Recorded rock art sites include the Honokōwai, alae, and Papakea Petroglyphs.

3.6.4.6 Hawai‘i Island

Approximately 29,000 archaeological sites are identified in the SIHP on Hawai‘i; 275 are heiau. Sites consist of archaeological sites including complexes, districts, burial sites, and caves. Hawai‘i island contains a greater number of well-preserved sites, especially in the Kohala, Kona, and Kau districts, than any other island. Among the many temple sites are Mo‘okini and Pu‘ukoholā in Kohala, and Ahuena, Keeku, Hikiau, Hale O Keawe, and alealea in Kona. Large petroglyph complexes are found at Puako, Kalahuipuaa, anaehoomalu, and Puu Loa. A significant and unique archaeological site is the footprints of Keoua Kiiahuula’s army, preserved in volcanic ash in the Kaii Desert from an explosion on Kīlauea in 1790, within the present-day Hawai‘i Volcanoes National Park (Kirch 1998). Mo‘okini Luakini Heiau in North Kohala is one of the oldest and most significant in all of Hawai‘i. The heiau still bears the large, flat stone where actual human sacrifices were made. The heiau was designated as Hawai‘i’s first registered NHL in 1963. The stone structure is much smaller than it used to be in ancient times, but its remains still measure 250 feet by 125 feet, with 6-foot high walls (To-hawaii.com 2013e).

3.6.5 HISTORIC BUILDINGS AND SITES

This section focuses on cultural resources other than archaeological (pre-contact) sites, which generally consist of historic districts, buildings, objects, or structures, but that can also be part of a cultural landscape. Most of these resources in Hawai‘i are from the time period after Western contact with Native Hawaiians in the late 1700s. The Federal regulations define a historic district as: “a geographically definable area, urban or rural, possessing a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united by past events or aesthetically by plan or physical development” [36 CFR 60.3(d)]. Buildings are structures intended to shelter some sort of human activity such as a church, house, or barn [36 CFR 60.3(a)]. Objects are “material thing[s] of functional, aesthetic, cultural, historical or scientific value that may be, by nature or design, movable yet related to a specific setting or environment” [36 CFR 60.3(j)]. Structures differ from buildings, in that they are functional constructions meant to be used for purposes other than sheltering human activity and are “often . . . engineering project[s] large in scale” (e.g., aircraft, ships, and bridges) [36 CFR 60.3(p)].

The SIHP identifies approximately 850 buildings and districts Statewide that are eligible for or identified in the HRHP and/or NRHP. Although a district may be listed as one site, it can have numerous contributing resources (e.g., buildings). There are many more resources consisting of “objects” or “structures” also in the SIHP. Many structures in Hawai‘i may not have been evaluated yet for eligibility, or may have been determined to be eligible, but not yet officially listed. Sites that have not yet been formally listed or have not been determined eligible are treated as if they were eligible/listed, as required by State law, until eligibility can be determined. These are only the known resources, but many more likely exist and need to be considered during any site-specific evaluation. The population in the State grew relatively slowly until the 1960s, at which time construction increased dramatically. Those buildings are reaching the age of 50 years (historic property standard) and therefore significantly more buildings or districts are likely to be added. Since 2003, approximately 1,200 new properties per year have been added to the SIHP (DLNR 2012).

Prior to the nineteenth century Hawaiian architecture was based on thatch construction. Western contact altered Hawai‘i’s built environment. By the beginning of the twentieth century, thatched structures disappeared and were replaced by forms derived from Europe, North America, and Asia, which were based on wood and masonry construction. From the late 1800s onward, more sophisticated architecture emerged with many areas utilizing plantation-based building techniques. The post-World War II period eventually opened Hawai‘i to the world with a more international style of design (Hibbard 1998). Many of these structures survive today and retain prominent standing as historic resources in the State.

The sections below identify, by island, the numbers of historic buildings and sites on the SIHP that are eligible for, or identified on the HRHP and/or NRHP. In addition, general types of historic resources that appear on the HRHP and/or the NRHP are also identified along with some highlighted examples to give the reader a better perspective of some of the historic resources present on each island.

3.6.5.1 Kauaʻi

The SIHP identifies 77 historic buildings or districts on Kauaʻi. Some of the resources include 40 buildings, three bridges and others such as a lighthouse and locomotives. A prominent historic site on Kauaʻi is the Cook Landing Site. Captain James Cook happened accidently upon the Hawaiian Islands in 1778 while in search of a Northwest Passage between England and Orient. Cook's two ships first landed at Waimea on Kauaʻi (Langlas 1998). The Cook Landing Site was registered as a National Historic Landmark in 1935.

3.6.5.2 Oʻahu

The SIHP identifies 143 historic buildings or districts on Oʻahu. Some of the resources include eight historic districts, 185 residences, 20 military sites, 10 Hawaiian royalty sites and several churches and missions. Numerous residences appear on the SIHP, primarily because the county offers tax incentives for residences on the HRHP and does not for other property types at this time.

Of particular note on Oʻahu are the numerous historic military sites. During the 1930s and 1940s, Oʻahu was a major hub for the U.S. Pacific Naval Fleet, which figured prominently during World War II. Some of the well-known and preserved historic military installations and objects associated with the Japanese attack on Pearl Harbor and the ensuing war include Pearl Harbor Naval Base, Hickam Air Force Base, Kāneʻohe Naval Air Station, the *U.S.S. Missouri* battleship, the *U.S.S. Bowfin* submarine, and numerous artillery battery sites.

Much of the Hawaiian royalty occupied palaces and other residences on Oʻahu. These historic royalty sites include ʻIolani Palace, the Royal Flower Garden of Queen Liliʻuokalani, and Kamehameha III Summer Palace.

3.6.5.3 Molokaʻi

The SIHP identifies seven historic buildings or districts on Molokaʻi. Although Molokaʻi's historic resources consist of only a few buildings and sites such as the public library, Kaluaaha Church, and the Molokaʻi Light Station, the island is well known for the Kalaupapa settlement for patients with Hansen's Disease (leprosy), which is an NHL with over 200 contributing historic buildings. The Kalaupapa NHL is located within Kalaupapa National Historical Park, which extends northward on a peninsula from the north-central part of the island. The NHL designation for Kalaupapa includes historic buildings, structures, objects, archeological resources, and the vernacular cultural landscape. Under NHPA Section 106 regulations, NHLs receive special consideration to resolve any adverse effects.

3.6.5.4 Lānaʻi

Although the SIHP lists eight historic buildings or structures on Lānaʻi, none is listed on the HRHP or NRHP; however, all eight are categorized as eligible for listing on the State Register or National Register.

Lānaʻi City has been designated a potential historic district, and in April 2009 the National Trust for Historic Preservation included Lānaʻi City on its list of the 11 most endangered historic places in the United States. The National Trust considers Lānaʻi City to be "the last remaining intact plantation town in

Hawai‘i.” The island rose to prominence with the arrival of James Drummond Dole, whose pineapple empire once stretched over 20,000 acres and employed thousands of workers. In the 1920s, Dole, who owned the entire island, created a thriving company town, complete with hundreds of plantation-style homes, a laundromat, jail, courthouse and police station, all centered on a tree-lined park named in his honor (NTHP 2009).

3.6.5.5 Maui

The SIHP identifies 125 historic buildings or districts on Maui. Some of the resources include 18 historic districts and complexes, 10 residences, seven schools, nine churches and temples, and 10 commercial properties. Three of the several historic districts present on Maui include, Wailuku Civic Center, Lahaina, and Kipahulu.

The Wailuku Civic Center Historic District includes Circuit Courthouse, County Office Building, Police Station, Wailuku Library, and District Courthouse. A source of civic pride for the community, the entire district represents tangible links to the events that have shaped the island community. The district dates back into pre-contact times, to an era when Wailuku was the center of power for Maui (MHS 2010).

The Lahaina Historic District was declared a National Historic Landmark in 1962 and is located on the west side of the island. Long the residence of Maui kings and chiefs, Lahaina preserves the atmosphere of a mid-19th century Hawaiian seaport, when it was a favorite port of call for American whalers. It was also the center of missionary activities (NPS 2008)

Kipahulu is a remote farming district on Maui located about 10 miles from Hana. Kipahulu is an isolated coastal valley characterized by acres of lush vegetation in their native and undisturbed states. Once heavily populated, Kipahulu was farmed by native Polynesians about 1,200 years ago. Farm sites and terraces abound in the area. A former sugar town, Kipahulu was turned into a ranch-style village when the mill closed in 1923. During the 1900s, Kipahulu served as a port for an inter-island steamship company. Other highlights of the town include the nearby burial place of the American aviator Charles Lindbergh (To-hawaii.com 2013f).

3.6.5.6 Hawai‘i Island

The SIHP identifies 497 historic buildings or districts on the Big Island. Some of the resources that are specifically listed on the HRHP and/or NRHP include 75 buildings including schools, six roads, various bridges, and Kīlauea Volcano-related sites. Some of the historic roads on the Big Island consist of Mauna Loa Road, Crater Rim Drive, and Hilina Pali Drive all associated with and in close proximity to the Big Island’s volcanic activity. Two notable trails include Ala Loa Foot Trail and Kīholo-Puako Trail.

3.6.6 COMMON CONSTRUCTION AND OPERATION IMPACTS

Potential adverse impacts could occur to cultural, historical, and related natural resources during construction and operational phases of a relatively small, distributed to utility-scale renewable energy project if effective conservation and BMPs are not implemented. In many locations on the Hawaiian Islands it can reasonably be expected that there will be significant surface and subsurface archaeological and historic features present, as well as ongoing traditional and customary Native Hawaiian practices like taro farming, fishing, fisheries cultivation and limu (seaweed) gathering. Quite often these features are likely connected to each other through past and possible current practices and should be evaluated not only as discrete features but as integral parts of a larger cultural landscape. Given the potential scale of some renewable energy projects and the rural nature of the areas for which they may be sited, it is anticipated that direct and indirect impacts would occur to cultural and historic resources.

Significant cultural resources, including historic properties listed or eligible for listing in the HRHP and/or NRHP, could be affected by a renewable energy power project. The potential for impacts on cultural resources, including the ancillary facilities, such as access roads and transmission lines, is directly related to the amount of land disturbance and the location of the project. Indirect effects, such as impacts on the cultural landscape resulting from the erosion of disturbed land surfaces and from increased human access to possible site locations, should also be considered. Viewsheds of renewable energy developments from historic properties may have an effect to the overall integrity, setting, feeling, and association to the historic properties.

During construction, direct impacts to archaeological and historic properties, including burial sites and protected traditional and customary activities, could result from the clearing, grading, and excavation of a project area and from construction of facility components and associated infrastructure if archaeological sites, historic structures, or traditional cultural properties are located within the footprint of the project. The amount of land area for siting of the project could destroy or permanently alter the cultural landscape and resources present in the area. If the project were constructed on previously disturbed land in support of an existing facility, impacts to cultural resources might be minimized; however, this is not always the case and archaeological surveying of previously disturbed land is necessary at times depending on the situation.

Degradation and/or destruction of archaeological and historic properties could result from the alteration of topography, alteration of hydrologic patterns, removal of soils, erosion of soils, run-off into and sedimentation of adjacent areas, and contaminant spills if sites are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively affect cultural resources downstream of the project by potentially eroding materials and portions of the downstream archaeological sites, erosion can also destabilize historic structures.

Increases of human access and subsequent disturbance of cultural resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access exposes archaeological sites and historic structures and features to a greater probability of impacts. The collection of artifacts by workers or amateur collectors accessing areas that may have been previously inaccessible would be another possible impact. Increased access might also increase the potential for vandalism. Also, access by Native Hawaiians to traditional and customary cultural and natural resources for gathering rights, including religious practices, during construction can be limited or disallowed when areas are closed for safety reasons.

Visual impacts could occur from construction activities where significant cultural resources for which visual integrity is important to a site’s significance such as sacred locations (e.g., heiau and burial sites) and landscapes, historic structures, trails, prominent vistas, and other related sites. Large areas of exposed surfaces; the increase of dust and debris; and the presence of construction machinery, equipment, vehicles, and personnel could contribute to an adverse visual impact on specific cultural resources and landscapes.

Noise degradation of culturally sensitive locations and landscapes is possible from construction activities. Noise effects on the pristine nature and sacredness of a place should also be taken into consideration.

Construction within or in close proximity to historical buildings, structures or districts can impact the nature and contextual meaning of the resources present, and may have an impact on Native Hawaiian’s and the visiting public’s awareness and experiences associated with historic properties.

Although operational impacts to cultural and historic resources of a renewable energy project arguably may be less likely to occur than construction impacts, some adverse effects are still possible. Worker and public presence during operational activities of a project increases the likelihood of unauthorized access to culturally sensitive areas and the possibility of vandalism and collection of artifacts. Operations can have a visual and noise effect on sensitive cultural and historic resources, landscapes, vistas, and ceremonial aspects in the vicinity of a project. Operating facilities may have an adverse impact on a historical building, structure, or district by being incompatible with the historic context of a structure or area.

Cultural and historic resources listed or are eligible for listing on the HRHP and NRHP, as well as burial sites, fisheries, ocean ecosystems sustaining limu and sea life (and other sites pending eligibility), are considered sensitive locations or receptors for potential adverse impacts. The SIHP maintained by the Hawaiʻi SHPD provides a listing of these resources. However, consulting the SIHP by itself is not adequate to determine whether such resources are present. If proposed projects have not been adequately evaluated or not evaluated at all, then unknown but significant cultural and historic resources may be present. Any such resources will need to be identified and evaluated for their eligibility to the HRHP and the NRHP. It is infrequent that burial sites are listed because identification of burial sites is more unpredictable; thus, archaeological inventory survey work prior to construction is often recommended. Moreover, when survey studies fail to identify burial sites, discoveries of burials during construction triggers another set of regulatory requirements. In addition, artifacts, locations, landscapes, practices, visual corridors, and natural resources considered significant by Native Hawaiians must be addressed for consideration of sensitive locations and receptors.

3.6.7 COMMON BEST MANAGEMENT PRACTICES

Construction and operation BMPs must be implemented to ensure potential impacts to cultural and historic resources from a renewable energy project are addressed. Avoidance of impacts is the primary objective; however, when avoidance is not possible or practicable, then BMPs and/or mitigation would be applied. This also includes identifying and then avoiding or mitigating any potential for restraints to access and adverse impacts on traditional and customary Native Hawaiian practices, including but not limited to subsistence gathering, loi kalo (taro farming), loko ia (fishponds), and loko ia kalo (combined fish and taro farming) located outside of the project footprint or relating to traditional cultural landscapes or properties.

The NHPA Section 106 process would be conducted on individual, site-specific projects where a Federal agency is deciding whether to carry out the project or where the project might receive Federal financial assistance, permits, or approvals. In consultation with the SHPD, a detailed cultural and historic resource literature review, followed by an archaeological inventory survey, if necessary, might be conducted. Depending on the outcome of the reviews and surveys, additional surveys or other field identification studies may be required for other types of resources, such as ethnographic resources (including traditional cultural properties), historic structures, and cultural landscapes. A management plan or memorandum of agreement may also be required to address potential adverse effects to historic properties. Consultation with the NPS is desirable when NHLs are within a study area, or within the direct or indirect impact areas of a proposed project.

HRS Chapter 6E governs the State’s historic preservation process, as administered through HAR Title 13. Approaches to historic and cultural resources should be developed in consultation with the SHPD, NHOs, OHA, Island Burial Councils, lineal and cultural descendants, and other Native Hawaiians that can provide site-specific, traditional, religious, burial, and other culturally important information on any proposed project area. The opinions of kupuna, or elders, are traditionally given greater appreciation and weight pursuant to Native Hawaiian custom. Similarly, Native Hawaiian practitioners who carry on the traditional and customary practices and knowledge provide invaluable insights. In accordance with State law, if an historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for modification, the project proponent must complete and submit an Historic Preservation Review Form in compliance with HRS Chapter 6E such that the modifications may be reviewed prior to project implementation. Consultation with the SHPD and Native Hawaiians should occur early in the process and often enough to allow the maximum time possible to adequately address cultural issues.

For either the Federal or State processes, other options beyond literature reviews, surveys, and consultations include excavation, collection, and site monitoring activities. Although data recovery of cultural resources is an option for addressing adverse effects, it does not eliminate the potential impacts. Monitoring and surveillance of a site to protect resources *in situ*, cultural education and training, and funding of historic preservation efforts have proven to be effective in mitigating adverse impacts. Mitigation for the demolition or modification of historic buildings, structures, and other resources may require architectural and historic documentation using processes such as the Historic American Engineering Record program (see http://www.nps.gov/history/hdp/).

There are several construction and operations practices that can be employed, where applicable, to minimize adverse effects from a renewable energy project. BMPs include the following:

- Identify all NHOs with cultural and religious ties to the land and resources in the proposed project vicinity and begin an early dialogue of information sharing.
- Use Native Hawaiian monitors during pre-construction archaeological survey and inventory studies to ensure a culturally sensitive approach and to provide a native perspective to the studies.
- Avoid culturally significant natural resources such as fresh water springs, fishponds, and near shore resources whenever possible.
- Maximize the use of previously disturbed land, existing access roads, utilities, and other infrastructure.
- Conduct viewshed consultations and analyses and minimize siting of renewable energy facilities where viewshed incompatibilities could occur to historic properties and cultural landscapes.
- Develop monitoring plans for use during construction with provisions for addressing burial treatment in consultation with NHOs, OHA, SHPD, and potential lineal and cultural descendants, if applicable.
- Ensure compliance of inadvertent discovery of artifacts, shipwrecks, and historic sites, including burial remains during construction, with applicable laws including the *Abandoned Shipwreck Act*, NHPA, NAGPRA and State Burial Laws, as applicable.
- Halt work immediately as a result of inadvertent cultural discoveries until consultation and compliance in accordance with applicable requirements occu and mitigation measures are developed.
- Use archaeological and Native Hawaiian monitors during construction to monitor ground- and seafloor-disturbing activities, and to provide additional culturally sensitive perspectives and assurances to communities if resources are encountered.

- Avoid culturally important landscapes (e.g., pohaku quarries, coral reefs, and fishponds), wildlife (animals and fisheries), and plant (e.g., limu) species and their habitats.

- Conduct cultural worker training, orientations, and educational programs.

3.7 Coastal Zone Management

Coastal zone management (CZM) has a long history in Hawai‘i, predating the formal passage of the national *Coastal Zone Management Act of 1972* (16 U.S.C. §§ 1451–1464; CZMA) (Hawai‘i 1990 and Hawai‘i 2011). The coastal zone is an extremely important resource to the State of Hawai‘i because it is the primary location of human residences, business, tourism, and industry and the resources on which they depend. The formal development of the Hawai‘i Coastal Zone Management Program (CZMP) is rooted in the passage of the *Land Use Law* (HRS Chapter 205) in 1961and passage of the *State Shoreline Setback Law* (Act 136, SLH 1970) in 1970 (Hawai‘i 1990 and Hawai‘i 2011). The Shoreline Setback Law prohibited development of any structure within the shoreline area without a variance and eventually led to the development of a comprehensive coastal zone policy. As defined in HRS Chapter 205A and consistent with 15 CFR 923.31, which specify areas surrounded by water on all sides such as the Hawaiian Island chain must be included in their entirety as the coastal zone, Hawai‘i’s coastal zone management area includes all lands of the State and the area extending seaward from the shoreline to the limit of the State’s police power and management authority, including the United States territorial sea.

The CZMA is a Federal law whose goal, among other things, is to advance a national policy to preserve, protect, develop, and where possible restore or enhance the resources of the Nation’s coastal zone [16 U.S.C. § 1452 (1)]. Under the CZMA, the coastal zone means coastal waters and adjacent shorelands [16 U.S.C. § 1453 (1)]. The CZMA creates a framework for planning and approving coastal projects that turns on a complex network of relationships between the Federal, State, and local governments. While the full details of these relationships and the framework are not useful for the purpose of this PEIS, the key point is that Hawai’i, as a coastal State, has to develop and adopt a management program that guides the public and private uses of lands and waters in the coastal zone [16 U.S.C. § 1453(12), § 1454, § 1455(d)]. The management program must be approved by the U.S. Secretary of Commerce [16 U.S.C. § 1455(d)]. Federal activities, including Federally permitted activities, that impact a coastal State’s coastal zone must be consistent to the maximum extent practicable with the enforceable policies of the State management program [16 U.S.C. § 1456(c)].

In compliance with the CZMA, Hawai‘i prepared the Statewide CZMP that conforms to the national CZMA, which culminated in the enactment of the 1977 *Hawai‘i Coastal Zone Management Act* (HRS Chapter 205A) and was subsequently approved by the U.S. Department of Commerce in 1978 (Hawai‘i 1990 and Hawai‘i 2011). For more information about the CZMP and how Hawai‘i generally regulates the coastal zone under the CZMP, see Hawai‘i 1990 and Hawai‘i 2011; http://files.hawaii.gov/dbedt/op/czm/program/doc/czm_program_description_2011.pdf and http://files.hawaii.gov/dbedt/op/czm/program/doc/1990_czm_program_doc.pdf, (respectively).

3.7.1 ENERGY FACILITY SITING

The 1976 amendments to the CZMA required that the planning process for siting of energy facilities and identifying their impact be included in State coastal zone management programs [16 U.S.C. § 1455(d)(2)(h)]. HRS 226-18 presents objectives and policies for energy facility systems in Hawai‘i.

The CZMP collaborates with DBEDT and other State agencies in energy planning and conservation. Most energy facility siting decisions trigger various State and county planning and zoning regulations and compliance with other resource protection regulations.

3.7.2 FEDERAL CONSISTENCY REVIEW

Hawai‘i’s CZMP administers the Federal consistency review program (http://planning.hawaii.gov/czm/Federal-consistency/). Federal consistency requirements apply to Federal agency activities (including Federal development projects), Federal license or permit activities, and Federal financial assistance activities [16 U.S.C. § 1456(c)(1)-(3)]. Typically, Federal agencies make consistency determinations for their activities but Hawai‘i’s concurrence would be required before the agencies could engage in the activities (15 CFR 930.41, 930.54, 930.90-930.101).

The Federal consistency review process starts with a review of the proposed activity and determination of the type of review required. The Hawai‘i CZMP encourages early pre-application consultation. Public notices of CZM Federal consistency reviews are published in *The Environmental Notice,* which is distributed by direct mail and posted on the Hawai‘i Office of Environmental Quality Control Website (http://www.state.hi.us/health/oeqc/notice/index.html).

For more details on the Federal consistency review process and how developers or applicants for permits or funding can secure a Federal consistency determination and State concurrence, refer to 15 CFR Part 930 and http://planning.hawaii.gov/czm/Federal-consistency/.

The Federal consistency review process starts with a review of the proposed activity and determination of the type of review required. The Hawai‘i CZMP encourages early pre-application consultation.

3.7.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

Two major elements of the CZMP could be potentially impacted by development of renewable energy technologies: special management areas and shorefront access. Construction projects along the coastline such as power cable or pipeline crossings from offshore projects could disturb designated special management areas that have been designated by counties throughout the islands to avoid loss of coastal resources and ensure access to beaches, recreation areas, and natural reserves. Construction of energy facilities or ancillary components such as power cables and pipelines along the shoreline could limit access to shorefront areas depending on the particular location. Locating power cable crossings and any facilities in areas previously developed or outside designated special management areas would minimize potential impacts.

3.7.4 COMMON BEST MANAGEMENT PRACTICES

Best management practices that would prevent, minimize, or mitigate potential impacts to coastal zone management include the following:

- Developers should coordinate with CZMP office early in the project planning phase to identify potential coastal areas that should be avoided. Locating energy facilities or facility components outside of special management areas and avoiding undeveloped coastal areas that have high resource valuable would reduce potential impacts.

- Use horizontal directional drilling technology when technically feasible to install any power cabling or pipelines that cross the shoreline underground to avoid any aboveground impacts.

3.8 Scenic and Visual Resources

The Hawaiian Islands are world famous for their beautiful, scenic resources. These resources are diverse and include developed and undeveloped sections of shoreline, tropical rainforests, rugged valleys, cliffs, jagged peaks, active and inactive volcanoes, vast open spaces, historic towns and villages surrounded by productive agricultural land, and panoramic ocean views. On clear days, one can look across the ocean and see neighboring islands. Many of these scenic resources are accessed via Hawai‘i’s State and county roadways and State, county, and national parks.

Scenic resources are defined as the visual quality or character of an area, consisting of both the landscape features and the social environment from which they are viewed. The landscape features that define an area of high visual quality may be natural (e.g., mountain views) or manmade (e.g., a city’s skyline). *Visual resources* more specifically include places of cultural importance, such as traditional cultural properties, and areas and structures of historical importance (see Section 3.6 of this PEIS for a discussion on cultural and historic resources).

The physical character of an area is defined in terms of four primary components: water, landform, vegetation, and cultural modifications. Visual components also may be described as being distinct (unique or special), average (common or not unique), or minimal (a liability). Elements of the visual field can be characterized in terms of the degree to which they are visible to surrounding viewers, i.e., foreground, middle ground, and background. Scenic resources often include:

- Areas of high scenic quality (i.e., scenic hiking trails, designated scenic byways or locations);
- Recreation areas characterized by high numbers of users with sensitivity to visual quality (i.e., parks, preserves, and land- water- and commercial- based recreation areas);
- Important historic, cultural, and archaeological locations;
- Dark night skies that promote tourism and scientific research at astronomical observatories; and
- The natural beauty of the Hawaiian Islands, which include tropical rainforests, waterfalls, beaches, ocean views, sea cliffs, canyons and gorges, valleys, active and dormant volcanoes, and mountains.

Hawai‘i’s beauty enriches the quality of life for residents and serves as a primary visitor attraction. However, the growth of the visitor industry, and subsequent urbanization to support it, has dramatically impacted the State’s scenic resources. Over the past two decades, new development has blocked views of the ocean shoreline, changed the viewshed along State and county roadways, and produced urban conditions on agricultural land that once separated distinct communities (Hart 2006).

3.8.1 MANAGEMENT OF SCENIC AND VISUAL RESOURCES

Scenic resources, like other valuable natural resources, require a management strategy to protect the resource from unnecessary depletion. Lands rich in scenic resources are often the same lands that are in high demand for recreational, resort, and residential uses (Hart 2006).

Current Federal, State, and county laws and programs have established the regulatory authority and responsibility to protect scenic resources from development. In addition to the Federal CZMA, the Hawai‘i *Coastal Zone Management Act* (HRS Chapter 205A) incorporated the existing county special management areas as geographical areas subject to Federal and State coastal zone management policies and objectives. One objective of the CZMA is to “protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.” Within the special management areas, this translates into the requirement that all development be scrutinized for impact on scenic and open space resources (Hart 2006). See Section 3.7 of this PEIS for a discussion of coastal zone management.

County zoning permits also take into account a proposed project's visual impacts to the community and may require mitigation measures as a condition to a zoning permit. The Hawai'i Environmental Impact Statement Rules (HAR, Chapter 200) require all that environmental impact statements describe the potential impacts of a proposed project to resources with aesthetic significance and consider mitigation measures to avoid, minimize, rectify, or reduce impacts to these resources. This often requires accurate models or visual simulations in the impact statement, showing the project site before and after construction from key viewpoints (e.g., nearby residences, towns, and vantage points). Project proponents must also provide accurate day and night visuals of the project to local community leaders (neighborhood boards) to adequately inform the community of what can be expected. In Hawai'i, visual impacts can also be cultural impacts where line-of-sight is key to a particular area's cultural significance. HAR Chapter 200 requires extensive outreach with the community surrounding the project to identify and effectively mitigate all potential visual impacts. Visual impacts can also be caused by light pollution. For example, the night sky over the Big Island, where Mauna Kea Observatories is located, is protected by a strong lighting ordinance to preserve the dark night sky.

The State maintains a Hawai'i Scenic Byways Program. Currently there are four designated scenic byways: three on the island of Hawai'i, the fourth on the island of Kaua'i. Information regarding the Scenic Byways Program can be found at http://hawaiiscenicbyways.org.

Six of the eight main islands have a general land use plan and associated implementation tools such as zoning ordinances and development standards. Some of the counties' plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State's land use designations. For example, the *Maui County General Plan 2030* includes an inventory of scenic resources (Hart 2006).

Counties can participate in funding the acquisition of public lands through a Public Access, Open Space, and Natural Resources Preservation Fund. A commission in each county oversees the Fund. By ordinance, a percentage of the county's revenues go to the Fund. In some cases, State and Federal agencies, such as NOAA (via its Coastal and Estuarine Lands Conservation Program), DLNR (via its Legacy Lands Fund), and USFWS provide dollar-for-dollar matching funds (Hecht 2012). To qualify for a property acquisition using the Fund, a proposed site must meet at least one of nine criteria, including "conserving land for open space and scenic values." Additional information can be obtained from each county's website (www.Kaua'i.gov, www.co.maui.hi.us, www.honolulu.gov, and www.Hawaiicounty.gov).

Hawai'i has more than 50 State parks spread among five islands, and eight National parks, historical parks, landmarks, historical trails, and historic sites on five islands. In 1970, the Hawai'i State Legislature expressed the need to protect and preserve unique natural assets for the enjoyment of future generations (DLNR 2009a). To accomplish these purposes, the legislature established the Statewide Natural Area Reserves System to preserve in perpetuity specific land and water areas that support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites of Hawai'i. The system presently consists of 20 reserves on five islands. The reserves range from marine and coastal environments to lava flows, tropical rainforests, and alpine desert (DLNR 2014).

3.8.2 SCENIC RESOURCES BY ISLAND

The following sections provide representative scenic resources by island and region for each island. This PEIS does not attempt to present all of the vast scenic resources of the islands; only to provide a perspective of the scenic beauty that can be found and protected during future development. Collectively, these sections demonstrate the range of scenic resources in Hawai'i and the State's diversity and character. Information in the following section overlaps with other sections of this PEIS, particularly

Sections 3.4.4, 3.6, and 3.9. The following sections were prepared with material available at http://gohawaii.com/regions.

3.8.2.1 Kaua‘i

Kaua‘i has five regions with much diversity in terms of scenic resources and island character (Table 3-41). The Napali Coast has soaring sea cliffs more than 3,000 feet above the ocean, while Waimea Canyon is often called the “Grand Canyon of the Pacific.” This island has approximately 50 miles of beaches from Poipu Beach to Hanalei Bay (on the North Shore). Historical small towns include Hanapepe (on the West Side) and Koloa (on the South Shore). Scenic diversity includes valleys, mountain spires, cliffs, tropical rainforests, rivers, and waterfalls. The Koloa Heritage Trail on the South Shore covers 19 miles through an area mixed with pre-contact and post-contact cultural sites. Some parts of Kaua‘i are accessible only by sea or air.

Table 3-41. Kaua‘i Scenic Resources

Region	Feature	Attributes	Location
	Na Pali Coast Natural beauty (sea cliffs, ocean views, mountains)	Iconic, mountainous shoreline 17 miles long Offers panoramic views of the ocean Lumahai Beach is where portions of the movie *South Pacific* were filmed	North of Lihue
	Nounou Mountain (Sleeping Giant) Recreation area (hiking trail)	The Sleeping Giant looks like a human figure lying on his back There is a scenic hiking trail to the top of the Sleeping Giant	On Kaua‘i’s East Side between Wailua and Kapa‘a
	Alekoko, Menehune Fishpond Important historic, cultural location	Built nearly 1,000 years ago, the pond has been on the NRHP since 1973 The fishpond is located near the Huleia National Wildlife Refuge	Lihue

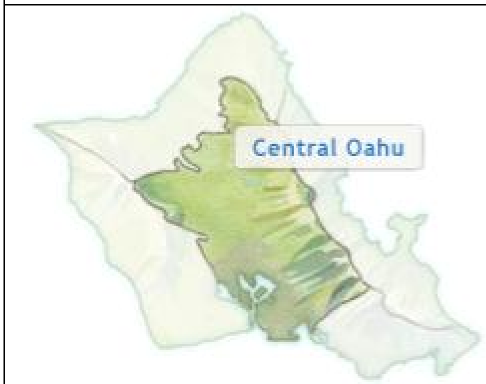
Region	Feature	Attributes	Location
	Spouting Horn Natural beauty (ocean views) Important cultural location	Scenic blowhole of Hawaiian legend The Poipu surf channels into a natural lava tube and releases a huge spout of water during large swells	On Kaua‘i’s South Shore near Poipu
	Waimea Canyon Natural beauty (canyon, gorges)	Scenic canyon nicknamed the Grand Canyon of the Pacific Stretches 14-miles long, one mile wide and more than 3,600 feet deep Provides panoramic views of crested buttes, rugged crags and deep valley gorges	On the southwest side of Kaua‘i in Waimea

3.8.2.2 O‘ahu

O‘ahu hosts the City and County of Honolulu, the State capital. O‘ahu has five regions (Table 3-42). Honolulu and vicinity is an urban and resort center and comprises most of the State’s population. Diamond Head offers tremendous scenic panoramas within an urban setting. In contrast, the Nu‘uanu Pali Lookout offers dramatic mountain views. The North Shore is famous for world-class surfing, with its endless horizon and waves cresting 30 feet or more in the winter months. Pearl Harbor is a National Historic Landmark with five memorials to recognize its role in the beginning of World War II. The *O‘ahu General Plan: Proposed 2013 Edition (Parts 1 and 2*), establishes a planning goal to preserve and enhance the natural landmarks and scenic views of O‘ahu (City and County of Honolulu 2012a; City and County of Honolulu 2012b).

Table 3-42. O‘ahu Scenic Resources

Region	Feature	Attributes	Location
	Lē‘ahi (Diamond Head) Area of high scenic quality (National Landmark)	Iconic State monument with panoramic views of Honolulu, Waikīkī, and O‘ahu’s South Shore 760-foot tuff crater Named a National Landmark in 1968	East of Waikīkī
	Nu‘uanu Pali Lookout Natural beauty (cliffs, mountains, valleys, ocean views) Important historical, cultural location	Historic landmark and scenic spot with panoramic views of the sheer Ko‘olau cliffs and the Windward Coast 1,000 feet above O‘ahu’s coastline amid mountain peaks	Pali Highway between Honolulu and Kailua
	Haleiwa Important cultural location Natural beauty (ocean views)	Historic surf town that is the cultural hub of the North Shore The town is on Waimea Bay, home of the Banzai Pipeline and Sunset Beach	North Shore about 1 hour from Waikīkī
	Ka‘ena Point Recreation (scenic hiking trail) Natural beauty (ocean views) Important cultural location	State park with trails to scenic vista points Dramatic lava shoreline Scenic views of the Waianae coast to the south, Mokulē‘ia to the north, and the	Western tip of O‘ahu

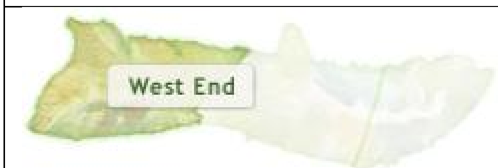
Region	Feature	Attributes	Location
		Pacific The site is deemed sacred	
	Pearl Harbor Important historic site (National Landmark)	Five historic sites honoring events occurring at this National Historic Landmark at the beginning of World War II	Center of the South Shore

3.8.2.3 Moloka‘i

Moloka‘i has three regions (Table 3-43), with no manmade structures taller than a single story or traffic lights. Moloka‘i is home to the highest sea cliffs in the world (up to 4,000 feet) along the northeastern coast and Hawai‘i's longest continuous fringing reef (28 miles) on the southern coast. The tallest mountain on Moloka‘i is Kamakou (4,961 feet). The Nature Conservancy has a preserve on the mountain's slopes with a 3-mile boardwalk through tropical rainforest. With a high percentage of its population of Native Hawaiian ancestry, Moloka‘i's town of Kaunakakai is strong in traditional culture, as is the sacred Hālawa Valley.

Table 3-43. Moloka‘i Scenic Resources

Region	Feature	Attributes	Location
	Hālawa Valley Natural beauty (valley, waterfalls) North Shore Sea Cliffs Natural beauty (sea cliffs, ocean views)	The valley is about a half-mile wide and three to four miles long and offers vistas of towering waterfalls Moa‘ula Falls has a 250-foot drop	Moloka‘i East End

Region	Feature	Attributes	Location
	Kaunakakai Important historic and cultural location North Shore Sea Cliffs Natural beauty (sea cliffs, ocean views)	Central Molokaʻi is a town that is virtually unchanged since the early 1900s Has the State's longest pier, which extends well past the reef The last Royal coconut grove is in town	Southeast of Molokaʻi Airport
	Kalaupapa National Park Important historic site	Preserves the setting and memories of isolation settlements established in 1866 to control Hansen's Disease (leprosy)	Northern tip of Molokaʻi
	Mauna Loa Important historic location	This small plantation village is set in the hills above the coast and is the only town in the West End. The town is near Papohaku Beach which is one of the largest white sand beaches in Hawaiʻi, 3-miles long and 100-yards wide	West of Molokaʻi Airport

3.8.2.4 Lānaʻi

Lānaʻi has three regions (Table 3-44). The island has just 30 miles of paved roads and about 400 miles of dirt roads. Many of the scenic sights require access by four-wheel drive vehicles. The Munro Trail offers stunning views from atop the pine-lined trail. Spinner dolphins and humpback whales can be watched at Hulopoe Bay in South Lānaʻi. Other features of interest include the lunar-like landscape of the Garden of the Gods (in North Lānaʻi) and Sweetheart Rock (in South Lānaʻi).

Table 3-44. Lānaʻi Scenic Resources

Region	Feature	Attributes	Location
	Kaumalapau Harbor Natural beauty (ocean views)	Located on the southwestern coast, Kaumalapau is the main commercial seaport for Lānaʻi The unobstructed views from the harbor are great for sunsets Whales are sometime spotted during the winter months, and also spinner dolphins	Kaumalapau Highway southwest to the sea
	Munro Trail Recreation (scenic hiking trail) Natural beauty (tropical rainforest, canyon, gorges, ocean views)	Trail with scenic views; driving and biking The trail offers spectacular views, and at the 1,600 foot elevation there is a tropical rainforest A lookout provides canyon views of Maunalei gulch, as well as the islands of Maui, Molokaʻi, Kahoʻolawe, the Big Island, and Oʻahu far in the distance	Begins north of Lānaʻi City and ends in the Palawai Basin

Region	Feature	Attributes	Location
	Kaiolohia (Shipwreck Beach) Important historic site Natural beauty (ocean views)	Shipwreck Beach is 8-miles long and has had a number of shipwrecks along its shallow and rocky shore over the years In fact, the hull of a 1940s oil tanker is stilled beached on Kaiolohia Bay's coral reef The beach offers excellent views of Moloka'i and Maui	North of Lāna'i City

3.8.2.5 Maui

The Island of Maui has five regions (Table 3-44). Hana has a small-town atmosphere with protected beaches, a rugged shoreline, and towering waterfalls. To the west of Hana in Upcountry Maui is the Haleakalā National Park, home to Haleakalā, the world's largest dormant volcano. Wailea, in South Maui, is a surfing and resort center.

Table 3-44. Maui Scenic Resources

Region	Feature	Attributes	Location
	Lahaina Important historic, cultural location	Lahaina is a historic town. Once the capital of the Hawaiian Kingdom in the early 19th century Lahaina was also a historic whaling village during the mid-1800s Lahaina is on the NRHP Also a center for whale watching	West Side of Maui about 45 minutes from Kahului Airport

Region	Feature	Attributes	Location
	Molokini Recreation area (preserve)	Small crescent - shaped island about 160-feet above the ocean It is a State Marine Life and Bird Conservation District Good spot for whale watching	Off Maui’s southwestern coast
	‘Iao Valley State Park Important historic and cultural area Recreation (park)	Historic State park, home to iconic 1,200 foot ‘Iao Needle, which is a green-mantled rock outcropping ‘Iao Valley also has sacred significance	Just West of Wailuku
	Haleakalā National Park Area of high scenic quality Natural beauty (mountains) Recreation (park)	A scenic national park known as the “House of the Sun” The park is the home to Maui’s highest mountain, which rises more than 10,000 feet above sea level The park has a wide diversity of environments, including desert The Haleakalā visitor center, at the 9,740 foot point, is a popular location to watch sunrises	Upcountry Maui to the southeastern coast

Region	Feature	Attributes	Location
	Hana Area of high scenic quality (scenic byway)	Small town connected to central Maui by legendary scenic highway from Kahului (52 miles) The Hānā highway has 360 curves and 59 bridges. The highway travels through tropical rainforests, waterfalls, plunging pools, and seascapes	Maui’s eastern coast line

3.8.2.6 Hawai‘i

Hawai‘i, the Big Island, has seven regions (Table 3-45). Because of its size, it hosts a vast range of environments: it is home to the world’s most active volcano (Kīlauea), the tallest sea mountain in the world (Mauna Kea), at more than 31,000 feet, the most massive mountain in the world (Mauna Loa), and the largest park in the State (Hawai‘i Volcanoes National Park). All but two of the world’s climate zones can be found on Hawai‘i; from a rainforest (Hāmākua Coast) to volcanic deserts, from snow-capped mountains to black sand beaches.

Table 3-45. Hawai‘i island Scenic Resources

Region	Feature	Attributes	Location
	Wailuku River State Park Natural beauty (waterfalls) Recreation (park)	Wailuku (Rainbow Falls), has an 80-foot drop and is known for the rainbows that are formed in the surrounding mist Further upland are the Boiling Pots, terraced pools with bubbling water, as if boiling, connected by a series of cascading water flows.	West of downtown Hilo

Region	Feature	Attributes	Location
	The Hāmākua Heritage Corridor Area of high scenic quality (scenic byway) Natural beauty (ocean views, waterfalls, valleys)	The corridor, a Hawai‘i Scenic Byway, begins in Hilo and ends at the Waipio Valley Lookout In between the start and finish are ocean views, old plantation towns, and views of Mauna Kea, and an overlook for Umauma Falls.	Starts at Hilo, ends at the Waipio Valley
	Pololu Valley Lookout Natural beauty (sea cliffs, ocean views, valley)	The lookout offers panoramic views of the northeastern coastline, sea cliffs, and the Pololu Valley	North Kohala at the end of Highway 270
	Pu‘ukoholā Heiau National Historic Site Important cultural location	The Park is the home of the largest restored heiau (temple) in Hawai‘i and is considered to be a historic sacred site The site is also a location to watch humpback whales during the winter months	On the Kohala Coast, south of Kawaihae Harbor
	Keauhou Bay and State Park Recreation area (preserve, park)	The Bay is a Marine Life Conservation District with coral and large numbers of tropical fish species Spinner Dolphins can sometimes be seen	South of Kailua-Kona

Region	Feature	Attributes	Location
		The park marks the location where Captain James Cook first landed in Hawai‘i and was also killed there a year later	
	Kalapana Important historic location	In 1990, lava from the Kīlauea Volcano engulfed the town of Kalapana In 2009, Federal, State, and county leaders officially opened the Kalapana viewing area to provide for the safe viewing of the lava flows Kalapana is a historic fishing village	At the end of Highway 130 in Puna
	Hawai‘i Volcanoes National Park Recreation area (park, hiking trails, lava viewing)	The park has two active volcanoes, Kīlauea and Mauna Loa The park has trails into very diverse environments Visitors can travel to the rim of the caldera	Southwest of Hilo

3.8.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

Typical impacts to visual resources from construction activities include ground disturbance; the presence of workers, vehicles, and equipment; and the generation of dust and vehicle exhaust. Lighting during nighttime construction activities could impact dark night skies. These impacts would be short term and intermittent and would depend on the project. Construction projects may require clearing, grading, and leveling of the construction site and extra workspaces, such as construction laydown yards and storage/preparation areas. Once construction is complete, the reclamation of disturbed areas would remove these visual impacts.

Common operational-related impacts to visual resources would depend on how the permanent or long-term structures associated with the specific technologies matched the nature and character of the surrounding environment. Similarly, the operational-related impacts to dark skies would also depend on the final design of the permanent lighting for the facilities or structures.

3.8.4 COMMON BEST MANAGEMENT PRACTICES

Best management practices to minimize impacts to visual resources include:

- Consider potential impacts on visual resources in the project planning and siting phase, for example, when siting structures, consider landscape characteristics, lighting and glare from facility components, minimizing structure profiles, views from key observation points and nearby recreation lands, and integration of project components with natural land contours and colors.

- Consider potential visual impacts on the nature and character of nearby culturally sensitive and historic structures.

- Consider visual effects of project location and components on nearby units of the National Park System and other areas under NPS management, including effects of light pollution.

- Consider visual effects of project components on local infrastructure facilities such as schools, hospitals, and housing developments in urban and rural communities.

- Consider the importance of dark night skies in the short term during construction and in the long term. Use low lumen lighting, on demand lighting, and well-directed lighting. Use the minimum amount of light necessary; select lamps using long-wavelength light [greater than 560 nm (in vacuum)]; and select the most energy efficient lamps and fixtures.

- Limit the hours of construction at night, limit total lumen output of artificial lighting, and direct lighting downward and shield fixtures to reduce impacts from construction lighting.

- Provide accurate day and night visual simulations of the proposed project to local community and regulatory stakeholders (e.g. neighborhood boards) to adequately inform the community of what can be expected.

3.9 Recreation Resources

Hawai‘i’s unique environment and mild climate provide an ideal backdrop for a myriad of outdoor recreation activities supported by National Parks and Historic Sites, National Wildlife Refuges, State Forest Reserves, State Parks, State Harbors and Boating Facilities, and County Parks and Recreation departments. In addition to public lands, each island has commercial resort/hotel facilities and vendors that support outdoor recreation activities.

Many different Federal, State, and county governmental agencies and commercial, private, and non-profit entities provide recreation opportunities in Hawai‘i. The more directly involved Federal agencies include the NPS, the USFWS, NOAA’s Office of Ocean and Coastal Resource Management, and the DoD, which administers the Morale, Welfare, and Recreation Facilities program. The DoD program provides a wide variety of recreational opportunities for active duty and retired military personnel and their dependents. At the State level, the most directly involved agency is DLNR and its divisions of Forestry and Wildlife and State Parks. The Division of Forestry and Wildlife administers the “Na Ala Hele” program, the Statewide trails and access program established by Act 236, SLH 1998. All four counties in Hawai‘i have

Parks and Recreation departments, which are responsible for providing community recreation programs. Private agencies and organizations that provide organized sporting and camping opportunities to children and adults include the Boy and Girl Scouts of America and the Young Men's and Women's Christian Associations.

Hawai‘i's recreational environment is often divided into mauka (inland or land-based) and makai (seaward or water-based). Land-based recreation activities, often in forest and park settings, include land and nature-based activities such as hiking, camping, picnicking, and hunting. Water-based recreation activities, along the shorelines and in the ocean, include surfing, swimming, snorkeling, scuba diving, fishing, and boating.

Various factors influence outdoor recreation in Hawai‘i. The *State Comprehensive Outdoor Recreation Plan* (SCORP), a 5-year planning document for Statewide outdoor recreation, provides detailed descriptions of the influencing factors, which include (DLNR 2009b):

- Population growth
- Aging population
- Military
- Visitors
- Public health
- Tourism
- Ecotourism
- Sports tourism

Appendix A of the *State Comprehensive Outdoor Recreation Plan* provides detailed matrixes of all recreation areas on each island and the recreational activities that are pursed at each area. Appendix A also provides detailed maps showing recreation areas on each island by the recreation planning district defined to in the Plan to concentrate survey and planning efforts.

State-managed public areas used for recreation include 23,000 acres of inland surface waters, 3 million acres of State ocean waters, and 410,000 acres of coral reef around the main Hawaiian Islands. In addition, there are 2 million acres of conservation land and 1.2 million acres of State-owned lands (Hawai‘i 2013a). In total, the islands have 55 State parks, 8 national parks and historic areas, 10 national wildlife refuges, 20 State small boat harbors and 25 boat ramps or landings, and hundreds of county parks and recreation areas (DLNR 2009b). The national park lands total about 379,000 acres. Also, The Nature Conservancy operates 11 nature preserves on six islands, eight of which are jointly administered with the U.S. Forest Service (DLNR 2009b).

From 2011 to 2012, the Outdoor Industry Association estimated that outdoor recreation in Hawai‘i represented $6.5 billion in consumer spending, 65,000 direct jobs, $2.1 billion in wages and salaries, and $478 billion in State and county revenue (OIA 2013). These estimates are based on the resident population and visitors. In 2012, the number of visitors to O‘ahu was 4.6 million; Maui, 2.3 million visitors; Hawai‘i, 1.4 million visitors; Kaua‘i, 1.1 million visitors; Lāna‘i, 78,000; and Moloka‘i, 57,000 visitors (Hawaii Tourism Authority 2013).

3.9.1 RESORT-BASED OUTDOOR RECREATION

Resorts commonly include a range of amenities including restaurants, pools, spas, access to golf, tennis, and other activities such as horseback riding. Most resorts in Hawai‘i are considered *seacoast resorts*, which typically offer beach access, ocean-oriented recreational activities such as whale and dolphin watching tours, and other water-based outdoor activities (see Section 3.9.3). Table 3-46 shows a distribution of seaside resort areas within the Hawaiian Islands.

Table 3-46. Distribution of Resorts in Hawai‘i

Island	Resorts	Locations
Kaua‘i	21	• North Shore (Princeville) • East Side (Coconut Grove) • Lihue (Kalapaki) • South Shore (Poipu) • West Side (Waimea)
O‘ahu	30	• Waikīkī • East Honolulu • North Shore • Leeward Coast
Maui	31	• West Maui • Kapalua • Kaanapali • Kihei • Wailea
Moloka‘i	7	Bed and breakfast, smaller hotel, cottage-type establishments
Lāna‘i	2	• Manele Bay • Central Lāna‘i (uplands area)
Hawai‘i	14	• Kohala Coast • Kailua Village at Kailua-Kona • Keauhou

3.9.2 LAND-BASED OUTDOOR RECREATION

Land-based resident and visitor outdoor recreation surveys conducted for the SCORP included a wide range of activities including those related to nature and sports. The surveys also included interpretive activities and activities that require use of manmade facilities. Table 3-47 lists the land-based activities.

Based on the SCORP 2008 surveys, the most popular (that is, more than 50 percent of the respondents stated they participated in at least once a year) land-based recreation activities Statewide are as follows:

- Picnicking/BBQ (86 percent)
- Visiting a scenic lookout (83 percent)
- Hiking (80 percent)
- Visiting a historic site (77 percent)
- Camping (69 percent)
- Visiting a botanical garden (65 percent)
- Visiting a nature center (65 percent)
- Bicycling on a roadway or path (60 percent)

Table 3-47. Land-Based Activities in Hawai‘i

Nature-Based Activities	
Nature-based land activities are recreation activities in undeveloped land settings. Limited developed facilities such as comfort stations or campsites may be used in conjunction with these activities. The purpose of a typical nature-based land activity is to experience natural surroundings. These activities include:	
• Camping • Hiking • Horseback riding	• Hunting (Mammals and Birds) • Mountain (Off-Road) • Off-Road or all-terrain vehicles
Sports Activities	
Sports activities involve some form of competition and require a built setting. Sports activities include:	
• Baseball/Softball • Soccer • Football • Basketball	• Tennis • Handball • Volleyball • Archery, rifle, or pistol shooting
Interpretive Facilities	
Interpretive activities generally involve viewing and learning about nature. Interpretive activities may also include cultural resources. Interpretive activities may not require a large degree of physical activity, although it often is a complementary component. Interpretive facilities include:	
• Nature parks • Botanical gardens • Scenic lookouts	• Historic/Cultural sites • Trailhead kiosks and interpretative trails
Activities in Developed Facilities	
Developed land setting activities include outdoor recreational activities that use some form of manmade development (such as roads or sidewalks), or involve a high level of social interaction. These activities include:	
• Bicycling • Picnicking/BBQ • Playground use	• Skateboarding/Rollerskating • Visiting a dog park • Walking/jogging on paths

Source: DLNR 2009b.

3.9.3 WATER-BASED OUTDOOR RECREATION

Beach parks and ocean-based activities are a major factor in the quality of life for residents and attracting visitors to Hawai‘i. Based on SCORP surveys of both residents and visitors, the top two activities are visiting a beach and swimming. Other popular water-based recreation activities include snorkeling, pool swimming, bodysurfing, surfing/bodyboarding, and stand-up paddling. In addition, respondents indicated they also participate in sunbathing, scuba diving, boat rides, and whale watching (Table 3-48) (DLNR 2009b).

Table 3-48. Water-Based Activities in Hawai‘i

Water-Based Activities	
Water-based activities are popular recreational activities in Hawai‘i. Abundant water resources Statewide offer a wide variety of recreation opportunities from motorized boating in the open ocean to bodysurfing the shorebreak, to sunbathing on the beach. Water-based facilities accommodate the following water-based activities.	
• Boating (motorized) • Boating (Sailing/non-motorized) • Fishing (deep sea) • Fishing (shore) • Kayaking • Paddling, Outrigger Canoe • Personal Watercraft (jet-ski)	• Scuba diving • Snorkeling • Surfing/Bodyboarding/Bodysurfing • Swimming (Ocean) • Swimming (Pool) • Visiting a beach • Windsurfing/Kitesurfing

Source: DLNR 2009b.

Based on SCORP 2008 surveys, the most popular (that is, more than 50 percent of the respondents stated they participated in at least once a year) water-based recreation activities Statewide include the following:

- Visiting a Beach (90 percent)
- Ocean Swimming (86 percent)
- Snorkeling (68 percent)
- Pool swimming (66 percent)
- Bodysurfing (57 percent)
- Surfing/bodyboarding (51 percent)

3.9.4 COMMON CONSTRUCTION AND OPERATION IMPACTS

Short-term impacts to recreation resources are caused by visual and noise impacts from construction activities. Impacts could result from ground disturbance; the presence of workers, vehicles, and equipment; and the generation of noise, dust, and vehicle exhaust during construction of new facilities if located near existing recreation areas. In addition, access restrictions to recreation areas may occur if construction is located near the recreation areas.

3.9.5 COMMON BEST MANAGEMENT PRACTICES

Best management practices to minimize impacts to recreation resources include:

- Consider potential impacts on visual resources in the project planning and siting phase, for example, when siting structures, consider landscape characteristics, lighting and glare from facility components, minimizing structure profiles, views from key observation points and nearby recreation lands, and integration of project components with natural land contours and colors.

- Consider visual effects of project location and components on nearby units of the National Park System and other areas under NPS management

- Consider the importance of dark night skies to recreation areas, for example areas popular for camping and stargazing. Use low lumen lighting, on demand lighting, and well-directed lighting. Use the minimum amount of light necessary; select lamps using long-wavelength light [greater than 560 nm (in vacuum)]; and select the most energy efficient lamps and fixtures.

- Identify and consult with key local recreational clubs (canoe clubs, fishing/diving clubs, hiking clubs) to get an accurate sense of the outdoor activities occurring within and near the proposed project area.

- Implement BMPs to limit impacts to visual resources (Section 3.8.4) and noise impacts (3.12.6)

3.10 Land and Marine Transportation

The Hawaiʻi transportation network differs from other states in that it relies entirely on marine and air (see Section 3.11) transport for imports and exports both at the State (overseas) and interisland levels. While land transportation planning is guided by a long range Statewide land transportation plan; implementation of land transportation projects is on an island-by-island basis (HDOT 2011a).

3.10.1 LAND TRANSPORTATION

The Hawaiʻi land transportation system consists of roads, freeways, bike paths, and multi-modal transportation including cars, trucks, mass transit (buses), bicycles, and mopeds. The Highways Division within the Hawaiʻi Department of Transportation (HDOT) is primarily responsible for the maintenance, development, and support of land transportation facilities within the State (HDOT 2013a). However, the Highways Division of HDOT partners with the counties and municipalities in planning, managing, and maintaining the land transportation system.

3.10.1.1 Highway and Road Systems

There are approximately 4,200 miles of paved streets and highways in the State of Hawaiʻi (Table 3-49). Oʻahu, the most populous island, has nearly 40 percent of the paved road and highway system including the only freeway system in the State. The Oʻahu freeway system comprises three roads primarily in the southern part of the island. Highway 1 extends from Diamond Head through the Honolulu metropolitan area, around Pearl Harbor to the Barbers Point region. Highway 2 extends north from Pearl Harbor to the Wahiawa region in the central valley between the Koʻolau and Waiʻanae Mountains. Highway 3 connects the Honolulu area near Pearl Harbor with the Kāneʻohe Bay area on the east side of the Koʻolau Mountains.

Table 3-49. Length of Streets and Highways in Hawaiʻi by Island

Island	Total Mileage	Paved		Unpaved
		Freeway	Other	
Kauaʻi	439	(a)	417	22
Oʻahu	1,663	89	1,566	8
Maui	636	(a)	579	57
Lānaʻi	48	(a)	34	14
Molokaʻi	136	(a)	124	12
Hawaiʻi	1,495	(a)	1,435	59
STATE TOTALS	**4,417**	**89**	**4,155**	**172**

Source: DBEDT 2013a.

a. Oʻahu is the only island in Hawaiʻi with freeways.

Hawaiʻi island has 35 percent of the paved roads and highways in the State. The HDOT Highways Division manages approximately half of the paved freeways, highways, and roadways in the State (HDOT 2011a). Counties and municipalities manage the remaining public roadways. In 2012, Hawaiʻi had 1,310,286 registered vehicles (DBEDT 2013a). Approximately two-thirds of those registered vehicles were on the island of Oʻahu. The Honolulu metropolitan region has the highest motor vehicle density within the State.

3.10.1.2 Public Transit

Each county has a public transit system, which are operated by the respective county governments. Each county has developed transit plans (HDOT 2011a). Mass transit is more developed in the City and County of Honolulu because of the large urban and tourist population base. In 2011, the City and County of Honolulu bus system operated 515 buses with an estimated 76.3 million passengers (DBEDT 2013a). The City and County of Honolulu is currently developing plans for a 20-mile elevated rail line that will connect West Oʻahu with downtown Honolulu and the Ala Moana Center. Transit systems in the other counties were developed for and have adapted to the particular needs of each island (HDOT 2011a).

3.10.1.3 Non-Motorized Transportation

HDOT has recognized the importance of bicycles as a means to move people. The first Hawai‘i bike plan was developed in 1977, updated in 1994, and again in 2003. The plan serves as roadmap for improving existing conditions for biking and encouraging new users (HDOT 2003). A separate Honolulu Bicycle Master Plan was prepared in 1999 (City and County of Honolulu 1999). The goal of both plans is to establish bicycling as a safe and convenient mode of transportation for residents and visitors throughout the State. The State of Hawai‘i requires that bicycles with a wheel diameter of 20 inches or greater be registered. In 2001 the Statewide registration of bicycles and mopeds was 32,110 (HDOT 2003). In 2011, one decade later, bicycle and moped registration increased by over 300,000, for a total of 359,378. Bicycle facilities are developed on an island-by-island basis.

3.10.2 MARINE TRANSPORTATION

The geography of the Hawaiian Islands dictates that marine transportation is a critical part of the economy of the State. The majority of imported and exported goods is transported through the marine transportation system (DBEDT 2013a). The primary components of the marine transportation system are the harbors, docks or piers, near-shore shipping lanes, and navigation aids. Navigation aids are largely the responsibility of the U.S. Coast Guard. The Coast Guard develops, establishes, operates, and maintains Aids to Navigation systems to assist mariners in determining position and a safe course, warning of dangers and obstructions, and promoting safe and economic movement of commercial vessel traffic (USCG 2013).

The following sections discuss marine transportation in terms of use and users.

3.10.2.1 Harbor Systems

The Statewide commercial harbors system consists of ten commercial harbors located at Honolulu, Kalaeloa Barbers Point, Hilo, Kawaihae, Kahului, Hana, Kaunakakai, Kaumalapau, Nāwiliwili, and Port Allen on the six major islands (Table 3-50). These harbors are used for cargo and bulk shipping, passenger cruises, commercial fishing, and excursions. Some harbors also handle military shipping. The military has a large maritime presence in Hawai‘i and is discussed separately below. The harbor system is operated under the Harbors Division of HDOT. One of the main objectives of the harbor system is to provide adequate maritime facilities to accommodate the needs of the commercial shipping industry and the public.

Table 3-50. Size of Hawai‘i’s Commercial Harbor Facilities

Harbor Name	Island	Number of Piers	Total Berth Length (feet)	2010 Vessel Arrivals[a]
Honolulu	O‘ahu	53	31,087	3,408
Kalaeloa Barbers Point	O‘ahu	6	3,255	899
Nāwiliwili	Kaua‘i	3	1,860	579
Port Allen	Kaua‘i	1	1,200	25
Kahului	Maui	3	3,052	987
Hana	Maui	1	337	(b)
Kaunanakai	Moloka‘i	1	689	211
Kaumalapau	Lāna‘i	1	400	(b)
Hilo	Hawai‘i	3	2,605	737
Kawaihae	Hawai‘i	2	1,562	644

Sources: HDOT 2013b; DBEDT 2012b.

a. Excluding domestic fishing vessels.

b. No data available.

The major activities of the Harbors Division are to maintain, repair, and operate the ten commercial harbors that comprise the Statewide harbors system; plan, design, and construct harbor facilities; provide program planning and administrative support; manage vessel traffic into, within, and out of harbor facilities; provide for and manage the efficient utilization of harbor facilities and lands; and maintain offices and facilities for the conduct of maritime business with the public (HDOT 2013c).

The Harbors Division interacts with other public and private sectors that are essential to the effective operation of the marine transportation system. The Federal Government agencies include the following:

- USACE, which administers and participates in the planning, construction, and maintenance of harbor navigational improvements;
- Federal Maritime Commission, which regulates ports and marine terminal operators and receives and reviews tariff filings;
- USCG, which oversees maritime security at the commercial harbors and is also involved in the enforcement of safety and oil pollution regulations within harbor complexes of the State;
- U.S. Treasury Department, which inspects foreign goods to ensure a proper assessment of duty.
- U.S. Department of Agriculture, which also inspects goods to safeguard the State against the introduction of biological pests and invasive species;
- U.S. Customs and Border Protection, which monitors the flow of foreign people and goods through State ports; and
- EPA, which is involved with water quality standards.

State agencies are involved in the management of coastal zone areas, land and water use, economic development, and implementation of environmental regulations and safety regulations. The counties are involved in matters involving zoning. The private sector provides a variety of services, including shipping services, stevedoring, warehousing, tug services, maintenance, ship chandlery and repair, and distribution.

3.10.2.1.1 O‘ahu

Figure 3-68. Aerial View of Honolulu Harbor

The island of O‘ahu has two commercial harbors, Honolulu Harbor and Kalaeloa Barbers Point Harbor. Pearl Harbor is used for military operations and discussed separately below. The Honolulu Harbor is the largest and most active harbor in the State. It is located on the south shore of O‘ahu, adjacent to downtown Honolulu and east of Honolulu International Airport (Figure 3-68). The majority of marine transported goods to Hawai‘i flows through this harbor. It also is the primary distribution point for interisland marine transportation. Honolulu Harbor handles all types of marine shipping including cargo, bulk goods, cruise ships, commercial fishing vessels, water taxis, bunkering (i.e., supplying ships with fuel), and petroleum products.

Kalaeloa Barbers Point Harbor is located along the southwestern shore of Oʻahu, approximately 20 miles west of Honolulu. Barbers Point Harbor is the second busiest port in Hawaiʻi and contains specialized cargo handling facilities not available at Honolulu Harbor, such as a coal bulk unloading system and a pneumatic cement pump system. It handles liquid-bulk (e.g., petroleum products) and dry-bulk (e.g., coal, cement, and scrap metal) cargos and has space for ship maintenance and repair facilities. Approximately a mile-and-a-half off of Barbers Point are berths (moorings anchored in 100 feet of water) where large oil tankers (up to 1 million barrel capacity) are docked to unload. The crude oil is pumped to the mooring where the crude oil is transferred to underwater pipes that deliver it to shore.

3.10.2.1.2 Kauaʻi

The primary port on Kauaʻi is Nāwiliwili Harbor. It is located on the southeastern coast near the county seat of Lihue about 96 nautical miles from Honolulu Harbor. Facilities include piers for handling both overseas and interisland containerized and general cargo. A second commercial harbor, Port Allen, is located on Kauaʻi's leeward south coast. Port Allen Harbor has facilities for liquid-bulk cargo. Military and excursion/charter vessels also use this harbor.

3.10.2.1.3 Maui

The island of Maui has two commercial harbors. Kahului Harbor is located on the north shore of Maui, within Kahului Bay and is approximately 89 nautical miles southeast of Honolulu Harbor. The harbor provides a full range of maritime services and facilities. It is a regular stop for passenger cruise ships. Maui's second commercial harbor is located at Hana Harbor on the east side of the island. Administrative authority for Hana Harbor was transferred in 2010 from the Hawaiʻi DLNR to the Department of Transportation, Division of Harbors. Hana Harbor currently is being improved to provide better commercial service to the Hana region that currently is accessible only by the narrow and winding 50-mile Hāna Highway.

3.10.2.1.4 Molokaʻi

The island of Molokaʻi has one commercial port facility located on the south (leeward) central shore at Kaunanakai Harbor. The port is 52 nautical miles from the Honolulu Harbor. It has facilities for interisland barge cargo operations, a passenger ferry terminal, and liquid-bulk cargo.

3.10.2.1.5 Lānaʻi

Kaumalapau Harbor is located on the southern shore of Lānaʻi, approximately 1 mile from Lānaʻi City. It has facilities for interisland barge cargo operations and liquid-bulk cargo.

3.10.2.1.6 Hawaiʻi

The island of Hawaiʻi has two commercial harbors, Hilo Harbor and Kawaihae Harbor. Hilo Harbor provides a range of maritime facilities and services and is the major distribution center for the island. Hilo Harbor is located on the northeastern coast of Hawaiʻi, 194 nautical miles from Honolulu Harbor. The harbor is at Kuhio Bay, which is a small extension of the larger Hilo Bay. Hilo Harbor handles overseas containers, cruise ships, interisland liquid- and dry-bulk cargo, and dry cargo.

Kawaihae Harbor is located on the northwestern coast of Hawai‘i, approximately 132 nautical miles from Honolulu Harbor. The Kawaihae Harbor handles barges, overseas containers, interisland cargo, and dry- and liquid-bulk cargos and serves west Hawai‘i island.

3.10.2.2 Cargo and Bulk Shipping

Honolulu Harbor is the primary cargo shipping port for the State. Much of the maritime cargo for the other islands passes through Honolulu Harbor and is then distributed by interisland marine transport (Figure 3-69). In 2012, the latest year for which statistics are available for Honolulu Harbor, 976 overseas vessels passed through the harbor carrying nearly 6.8 million short tons of cargo (DBEDT 2013a). The harbor had 2,705 interisland vessel arrivals carrying 3.2 million short tons of cargo during the same period (DBEDT 2013a). Kalaeloa Barbers Point Harbor is the primary bulk shipping port. In 2011, approximately 9.8 million short tons passed through Kalaeloa Barbers Point Harbor; most of which was petroleum and petroleum products. Most of the cargo and bulk shipping is done with large open or closed barges, container cargo ships, and liquid-bulk barges or ships.

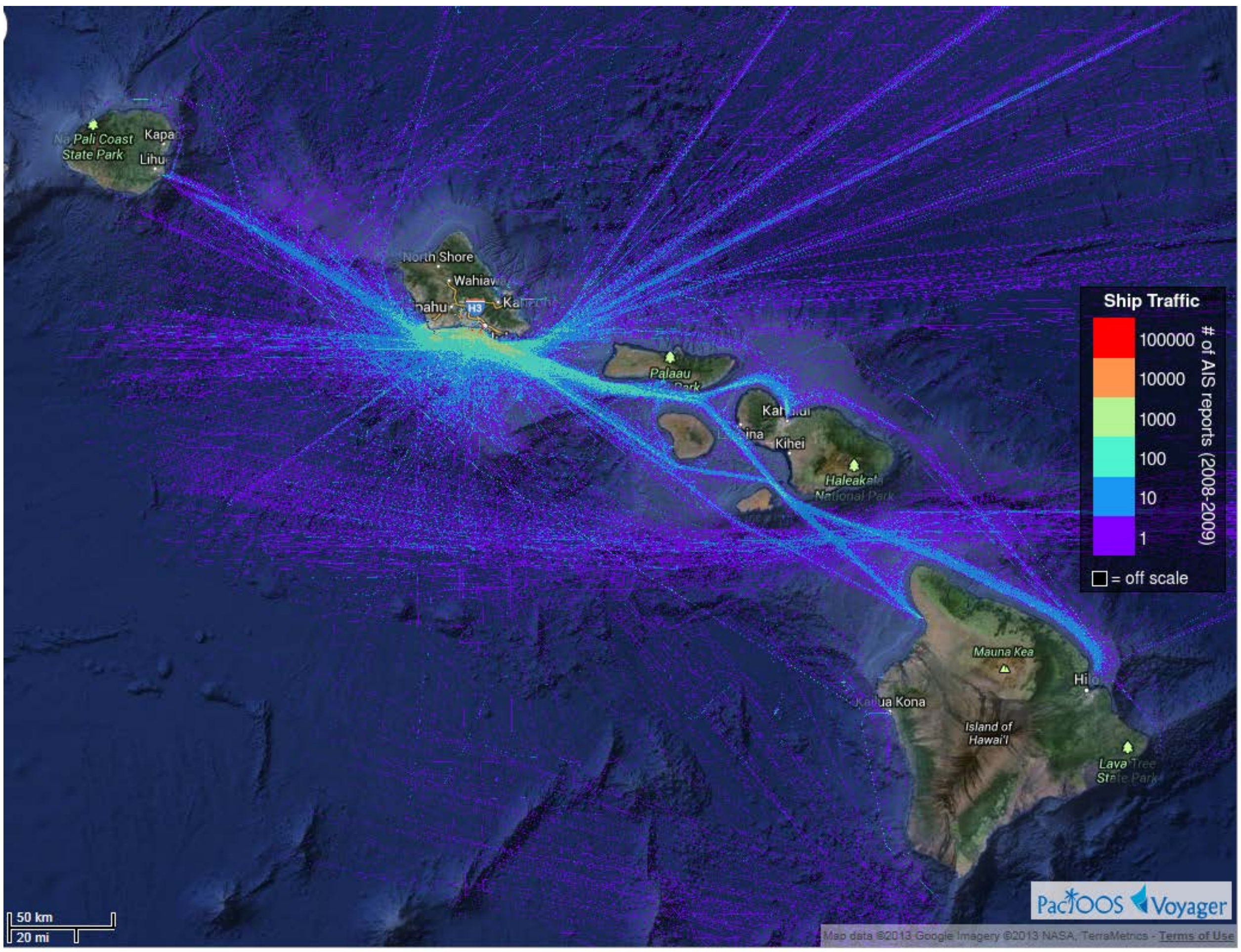


Figure 3-69. Primary Marine Transportation Routes (2008-2009 data)

As shown in Table 3-51, petroleum and petroleum products account for over one third of all marine transported cargo (35 percent in 2011). Of the 10.4 million short tons of petroleum transported in 2011, 79 percent was handled at the Kalaeloa Barbers Point Harbor on the southwestern shore of O‘ahu.

Manufactured equipment, machinery, and products account for about 55 percent of marine transported products, while food and farm products account for 7 percent) based on 2011 statistics (DBEDT 2013a).

Table 3-51. Amount of Cargo Handled at Six of the Ten Commercial Harbors in Hawaiʻi, 2011

Commodity	Weight (in 1,000 short tons)	Percent of Total
Petroleum and Petroleum Products	10,367	35
Primary Manufactured Goods	821	3
Food and Farm Products	2007	7
Manufactured Equipment, Machinery and Products	16,261	55
TOTAL	29,456	

Source: DBEDT 2013a.
Note: The six harbors include Honolulu, Barbers Point, Nāwiliwili, Kahului, Hilo, and Kawaihae.

3.10.2.3 Passenger and Tourism Excursions

Tourism is a primary industry of Hawaiʻi's economy. Passenger cruise lines, smaller excursion vessels, and recreational boating are important components of the marine transportation system. In 2011, over 420,000 cruise ship passengers arrived in Honolulu Harbor and 778,000 cruise ship passengers departed from the harbor. These numbers include both out-of-state and home-ported cruise ships. The larger harbor ports on Kauaʻi, Maui, and Hawaiʻi can also handle large cruise ships. There were over 14,000 registered vessels in the State in 2011. In addition to the larger harbors, Hawaiʻi has many small-craft facilities throughout the islands (DOBOR 2013). The DLNR Division of Boating and Outdoor Recreation manages many of these facilities although some are Federal, county, or private. Small-craft facilities include small boat harbors, launch ramps, anchorages, and piers.

3.10.2.4 Recreational and Commercial Fishing Vessels

Fishing is an important recreational and commercial industry in Hawaiʻi. Fishing vessels ranging from the smaller-sized sport fishing and charter boats to the large longline commercial vessels comprise a significant part of the marine transportation system. The smaller fishing boats typically operate within 25 miles of the islands with trips lasting one day (WPRFMC 2009b). The larger longline commercial fishing vessels are mostly steel-hulled ships that largely target tuna (e.g., bigeye and yellowfin) and billfish (e.g., marlins and swordfish). The larger longline vessels typically operate from 500 to 700 nautical miles from the islands but some larger tuna vessels travel out to 1,000 nautical miles (WPRFMC 2009b). Based on the amount of commercial sea landings, 86 percent of the commercial fish catch in Hawaiʻi passed through Oʻahu in 2011. The majority of that catch, approximately 27.2 million pounds, passed through Honolulu Harbor (DBEDT 2012b). Hawaiʻi island had the second highest commercial sea landings, with approximately 2.7 million pounds.

3.10.2.5 Military and Homeland Security Operations

Pearl Harbor, located 7 miles west of downtown Honolulu, is naval headquarters for the U.S. Pacific Fleet Command. The Navy maintains submarine, surface, and air defense capabilities in Hawaiʻi. Naval operations and training missions are an integral part of the marine transportation system, as the Navy uses waters in and around the islands. The Command for the Submarine Force, U.S. Pacific Fleet is based at Pearl Harbor and several submarine squadrons use Pearl Harbor as their homeport and are supported by the Pearl Harbor Naval Submarine Support Command. The U.S. Pacific Fleet, Naval Surface Force is based in San Diego, California. However, Pearl Harbor is the homeport for naval surface ships in the Pacific Fleet with two support commands, Commander for the Destroyer Squadron 31 and Commander Naval Surface Group Middle Pacific.

The U.S. military conducts training exercises (including gunnery and flare activities) throughout the year in specific areas (USCG 2013). Marine open water exercises are conducted in sea-space that coincides with Warning Areas (Section 3.11.2). To facilitate the safe operation of military operations and training in the marine regions around the Hawaiian Islands, the military notifies the respective U.S. Coast Guard Sector Office (and Federal Aviation Administration) to issue a Broadcast Notice to Mariners or NOTMAR (as well as Flight Information Publications or Notice to Airmen or NOTAM). In addition, a visual and radar search of the area is conducted. During these exercises, small craft which may not be readily visible are advised to remain clear of these areas during these exercises. Individuals are requested to direct their inquiries concerning the times of the exercises to the U.S. Coast Guard Sector, and Federal Aviation Administration offices covering these areas. Other types of restricted areas may be established in marine areas to ensure the safety of the general public and any commercial marine activity such as shipping and fishing (USCG 2013). A Safety Zone is a water area, shore area, or both to which access is limited to authorized persons, vehicles, or vessels for safety or environmental purposes. It may be stationary and described by fixed limits or it may be described as a zone around a vessel in motion. A security zone is an area of land, water, or land and water which is so designated by the Captain of the Port or District Commander (U.S. Coast Guard) for such time as is necessary to prevent damage or injury to any vessel or waterfront facility, to safeguard ports, harbors, territories, or waters of the United States. Information on active Safety or Security Zones may be obtained from the U.S. Coast Guard.

In addition to the general Safety and Security Zones, special marine restricted areas have been designated. The Special Operating Areas Four was established in 1995 as a permanent “Hot Area” named KAPU south of O‘ahu bounded by the coordinates: 20-46N/158-16W, 20-42 N/158-04W, 20-13N/158-36W, and 20-04N/158-11W (USCG 2013). Activities include intermittent naval gunnery exercises and airborne ordnance drops.

Intermittent missile firing operations are conducted by the Pacific Missile Range Facility (PMRF), Barking Sands, located on the southwest coast of Kaua‘i. PMRF conducts intermittent missile firing operations in the Warning Area 188 (W-188) operating area west of Kaua‘i. Approximate coordinates of the safety zone are provided in U.S. Coast Guard (2013). The safety zone is activated during launch operations at PMRF and is closed to all vessels except those specially authorized.

The Keahi Point Danger Zone is located in ocean waters southwest of Pearl Harbor as described by the coordinates 21-18-21N/157-59-14W, 21-18-11N/158-00-17W, 21-17-11N/158-00-06W, and 21-17-22N/157-59-03W. The Keahi Point Danger Zone is closed at all times to surface craft, swimmers, and divers, with the exception of authorized personnel. The Coast Guard provides notice of hazardous operations through published weekly Local Notice to Mariners.

The Ulupau Crater Weapons Training Range Danger Zone encompasses a sector extending seaward for 3.8 nautical miles between radial lines bearing 001 and 129 degrees true, from the Marine Corps Base on Mokapu Peninsula along the northeast coast of O‘ahu from coordinate point 21-27-12N/157-43-54W (74 FR 58846, November 16, 2009).

Many marine surface operations by the U.S. military and Homeland Security also require airspace control because the operation involves aerial fire and joint aviation operations. Airspace management and control is discussed in Section 3.11.2. However, airspace and marine navigation are often managed jointly because of links between surface and air operations.

3.10.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

3.10.3.1 Land Transportation

Construction and operation of most renewable energy projects would have minimal impacts on land transportation systems. Traffic could temporarily increase in the vicinity of project sites during construction. Local traffic may be disrupted from temporary road restrictions or closures if installation of utility services for energy projects requires road crossings.

3.10.3.2 Marine Transportation

Development of renewable energy projects in the marine environment would normally involve the installation of structures in the ocean including power cables, water pipes, floating platforms with cable tethered anchors, or submerged energy devices on the ocean floor. During construction, all of these types of energy projects could have the potential in cause temporary disruption of marine transportation including commercial, recreational, and military (both surface and sub-surface). These impacts would be temporary and be localized to the vicinity of the project location.

Placement of energy projects in the marine environment could have longer term impacts to marine transportation. Energy facility structures placed in the ocean become potential obstacles to all types of marine transportation depending on the location of the project. Ocean-based energy facilities would require coordination with the U.S. Coast Guard and possible marking through their Aids to Navigation program. Underwater structures, particularly anchor cabling for floating platforms, would be a hazard to submarine navigation. Locating ocean-based energy facilities away from highly used routes between islands would reduce potential impacts on commercial marine transportation.

3.10.4 COMMON BEST MANAGEMENT PRACTICES

- Coordinate early with State and county transportation agencies and local emergency response organizations if construction of a renewable energy project is expected to require road crossings or impact local transportation.

- Coordinate with the U.S. Coast Guard and HDOT early in the planning phase for any ocean-based energy project to evaluate potential project locations, issues with marine transportation, and any specific requirements such as safety marking. The Department of Defense should also be included in these early planning discussions because their organizations of have extensive surface and submarine transportation operations in the vicinity of the islands.

3.11 Airspace Management

Air transportation is an important component of the Hawai‘i transportation system, connecting the State with the world and the islands with each other; air is the primary mode of transportation for people traveling to and among the Hawaiian Islands. Tourism contributes significantly to air transportation in Hawai‘i. In addition to commercial transport of tourists to the islands, local tour operations including helicopters and airplanes use Hawai‘i airspace. Because of its location in the central Pacific Ocean, the islands are also a strategic military defense base for the United States and contain air defense operations for several branches of the U.S. military.

3.11.1 AIRPORT SYSTEMS

The HDOT Airport Division manages the public airport system in Hawai‘i. In addition, the U.S. Department of Defense operates airfields and training areas on the islands as part of its national defense mission. Refer to the *Hawai‘i Airports and Flying Safety Guide* (HDOT 2013d) for a description of airports and the air transportation system in Hawai‘i. All Hawai‘i airports and air transportation systems, including military operations, operate in accordance with rules and regulations established by the Federal Aviation Administration (FAA) (FAA 2012). FAA regulations address both the management and control of airspace and obstructions to airspace navigation.

3.11.1.1 Airspace

The FAA has developed a system of airspace designations to control and manage use of airspace. Airspace is a finite resource that is defined both vertically and horizontally and is classified into four types: controlled, uncontrolled, special use, and other airspace (FAA 2012). *Controlled airspace* is defined as airspace where air traffic control service is provided to both instrument and visual flights in accordance with the airspace classification. Controlled airspace in the United States is designated as Class A, B, C, D, or E. Class A airspace is above 18,000 feet above mean sea level, overlying land and the sea out to 12 nautical miles. For the purposes of this PEIS, Class A airspace is not a concern. Classes B through E are classified in descending order based on the amount of air traffic and air traffic control service. Class B airspace is the airspace from the ground surface to 10,000 feet mean sea level, surrounding the busiest airports. Class B airspace also contains two additional air layers defined at 2,900 and 5,500 feet above ground level and is designed to contain all published instrument procedures. Class C airspace generally is the airspace from the ground surface to 4,000 feet above ground level, surrounding airports that have an operational control tower, serviced by a radar control approach, and have a certain number of instrument flight rule operations. Class C airspace typically has a 5-nautical-mile radius at the surface and a 10-nautical-mile radius from 1,200 to 4,000 above ground level. Class D airspace generally is from the ground surface to 2,500 feet above ground level, surrounding airports with an operational control tower. Class D requires two-way communication with the air traffic control tower prior to entering the airspace. No separation services for visual flight rule aircraft are provided. Class E airspace is any controlled airspace not classified as A through D and includes a variety of different types such as transition airspace, surface area extensions, and Federal airways (FAA 2012).

Uncontrolled airspace is classified as Class G where no air traffic control services are provided. The primary purpose of *special use airspace* is to establish and designate airspace in the interest of national defense and security where activities must be confined or limits may be imposed on aircraft operating in the area. *Special use airspace* categories include Prohibited Areas, Restricted Areas, Warning Areas, Military Operation Areas, Alert Areas, Controlled Firing Areas, and National Security Areas (FAA 2012). Section 3.11.1.2 of this PEIS discusses special use airspace by island. *Other airspace* is airspace that does not fit into the other categories and includes categories such as En Route Domestic Airspace Areas and Offshore/Control Airspace Areas (in international airspace) (FAA 2012). Neither category is applicable to energy technologies being evaluated in this PEIS.

The FAA established regulations regarding obstructions to navigable airspace based on airport zoning (FAA 2012; HAR Chapter 19-12). Airport zoning is designed to prevent hazards to air traffic by establishing imaginary three-dimensional surfaces for both airports and heliports through which no obstruction may penetrate. Construction of structures of more than 200 feet above ground level or in a particular location relative to an airport as defined in 14 CFR Part 77.9 require an FAA obstruction analysis. Developers of any project that may affect airspace should file a Form 7460-1 (Notice of Proposed Construction or Alteration) with the FAA Office of Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) to request an evaluation and determination of potential hazard to navigable airspace (https://oeaaa.faa.gov/oeaaa/external/portal.jsp). OE/AAA coordinates the FAA review of potential hazards to air navigation and issues a determination.

3.11.1.2 Airports

There are 16 public airports in Hawaiʻi; 15 operated by the HDOT Airports Division, and 1 privately operated airport in Princeville, Kauaʻi. Honolulu International Airport is the only airport in the State that operates in Class B airspace and handled 263,340 operations in Calendar Year 2011 (arrivals and departures) (Table 3-52). Kalaeloa Airport in west Oʻahu, formerly the Naval Air Station Barbers Point, is the second busiest airport but mostly serves general aviation and military aircraft. Kahului Airport on Maui operates in Class C airspace while all other airports on the islands operate in Class D, E, or G airspace. Large air carriers primarily use Honolulu International while the other islands are served by a larger proportion of air taxi aircraft (60 seats or less) (Table 3-52).

Table 3-52. Airspace Classification of Hawaiʻi Airports and Number of Flight Operations in 2012

Island/Airport	Airspace Class[a]	Total Operations[b]	Air Carrier	Air Taxi[c]	General Aviation	Military
Kauaʻi						
Lihue	D/E	118,431	28,522	62,482	23,746	3,681
Port Allen Airport	G	(d)	(d)	(d)	(d)	(d)
Princeville Airport (Private)	G	(d)	(d)	(d)	(d)	(d)
Oʻahu						
Honolulu International	B	278,145	155,904	63,550	44,519	14,172
Dillingham Airfield	G	(d)	(d)	(d)	(d)	(d)
Kalaeloa Airport	D/E	121,114	(d)	54	98,175	22,885
Molokaʻi						
Molokaʻi Airport	D/G	34,672	(d)	26,475	6,352	1,845
Kalaupapa Airport	G	(d)	(d)	(d)	(d)	(d)
Lānaʻi						
Lānaʻi Airport	E	(d)	(d)	(d)	(d)	(d)
Maui						
Kahului Airport	C	130,010	43,374	65,872	18,418	2,346
Hana Airport	G	(d)	(d)	(d)	(d)	(d)
Kapalua Airport	E/G	(d)	(d)	(d)	(d)	(d)
Hawaiʻi						
Kona International	D/G	116,654	22,789	24,799	55,727	13,339
Hilo International	D/E	79,064	14,919	40,794	14,710	8,641
Waimea-Kohala Airport (Kamuela)	E/G	(d)	(d)	(d)	(d)	(d)
Upolu Airport	G	(d)	(d)	(d)	(d)	(d)

Source: DBEDT 2013a, Table 18.29.
Note: Statistics available for select airports and are for Calendar Year 2012.
a. Some airports have multiple airspace classifications based on time of available air traffic control services.
b. An operation is either an arrival or departure.
c. Air taxi is an aircraft with 60 seats or less.
d. No data available.

3.11.1.3 Commercial Air Passenger and Cargo

In 2011, 11.8 million overseas passengers arrived and departed through Honolulu International Airport, nearly 70 percent of the State's total overseas passenger arrivals and departures. Kahului Airport in Maui handled 18 percent of the State's total of overseas passenger arrivals and departures. On the other main islands, interisland passengers outnumbered overseas passengers. In 2011, ninety-four percent of overseas air cargo flew through Honolulu International Airport (DBEDT 2012b).

3.11.1.4 Air Tour Operators

Air tours, helicopter and airplanes, are a large industry in Hawai'i due to tourism. To support this industry and promote air safety, the FAA Honolulu Flight Standards District Office has published the *Hawai'i Air Tour Common Procedures Manual* (FAA 2008). All commercial air tour operators authorized to conduct operations below 1,500 feet above ground level within the State of Hawai'i must comply with the requirements and limitations set forth in this manual. The manual contains island-specific instructions, procedures, and requirements.

3.11.2 MILITARY AIR BASES AND OPERATIONS

The State of Hawai'i is a strategic location for the U.S. Departments of Defense and Homeland Security. Aviation operations are an important component of military and homeland security operations and training missions throughout the State and in the Pacific region. The military operates several air bases and training areas throughout the Hawaiian Islands. Airspace classification and special use airspace in Hawai'i associated with military and homeland security activities are described in two environmental impact statements (Navy 2008; Army 2004). The following types of special use airspace exist in the main Hawaiian Islands and are discussed by island in this PEIS: Alert Area, Restricted Area, Warning Area, and National Security Area. An Alert Area is an area that contains a high volume of pilot training or other unusual type of aerial activity. No special clearances are required. A Restricted Area contains activities that create hazards to aircraft such as artillery firing or aerial gunnery. Restricted Areas usually have specific hours of operation and require permission to enter the airspace. Warning Areas in the State of Hawai'i are located in off-shore waters. These open water areas may periodically be reserved for military use to protect the general public from safety hazards. The public is notified of activation of a Warning Area through notices from the USCG and FAA (i.e. NOTMAR, NOTAM and Flight Information Publication). A National Security Area is airspace where additional security is needed. Pilots are requested to voluntarily avoid flying through these areas. Airspace designations and locations are illustrated at http://aeronav.faa.gov/index.asp?xml=aeronav/applications/VFR/chartlist_sect (select Hawaiian islands). Special use airspace and marine surface areas are often linked because operations could affect both airspace and marine surface space. Activation of special use airspace also may require activation of a marine special use area. Marine navigation areas with respect to military and homeland security operations were discussed in Section 3.10.2.5.

3.11.2.1 Kaua'i Military Airspace

The Department of the Navy operates the Pacific Missile Range Facility (PMRF) on the southwestern coast of Kaua'i. The facility serves as a missile testing and training range and has a 6,000-foot airfield. Airspace surrounding the airfield is Class D with a 2,500-foot ceiling. The Class D airspace is surrounded to the north, south, and east by Class E airspace with a floor 700 feet above the ground surface. A Restricted Area R-3101 air space (surface to unlimited) lies immediately above the PMRF main base and extends offshore to the west approximately 5 nautical miles (Navy 2008). Two airspace Warning Areas, W-186 and W-188, lie approximately 5 nautical miles off of and outward from Kaua'i's southwestern, western, and northern coasts into international waters.

3.11.2.2 O‘ahu Military Airspace

The island of O‘ahu contains the largest military presence in the State. The Naval Station Pearl Harbor is located on the southern shore of the island and is home to Naval Command for the U.S. Pacific Fleet. The U.S. Navy and U.S. Air Force share the Joint Base Pearl Harbor-Hickam (JBPHH) air base at Pearl Harbor. Aircraft that use JBPHH include fixed wing, rotary, and airships. JBPHH and adjacent Honolulu International Airport constitute a single large airport complex and share airspace. Class B airspace lies above JBPHH, surrounded by several layers of floor altitudes (Navy 2008). Below the Class B layers are Class E airspace with a floor 700 feet above the ground surface. Special use airspace includes the Pali Air Traffic Control Assigned Airspace, which is in effect above the entire O‘ahu area from 25,000 feet up to unlimited. National Security Area airspace has been assigned above portions of the Naval Station Pearl Harbor, where pilots are requested not to fly below 5,000 feet.

The U.S. Army operates combat training centers on O‘ahu including Wheeler Army Airfield located in central O‘ahu adjacent to the Schofield Barracks between the Ko‘olau and Wai‘anae Mountains. Helicopter support to Army training exercises and helicopter training comprises much of the air traffic at Wheeler Army Airfield and over the Army training areas in the central and northern part of the island (Army Garrison 2010a). Wheeler Army Airfield also is home to the Air Force 6010th Aerospace Defense Group, the Hawai‘i Army National Guard Aviation Support Facility, and the 25th Infantry Division (Light) Aviation Brigade (Navy 2008). The airspace above Wheeler Army Airfield includes Class D airspace from the ground surface to 3,300 feet and Class E airspace with a floor 700 feet above the surface (Navy 2008; Army 2004). Intermittent Restricted Area airspace (3109 A, B, C and 3110 A, B, C) is located immediately to the northwest of the Wheeler Army Airfield Class D airspace. These Restricted Areas are associated with several military training areas and are activated as needed. To the north of Wheeler Airfield over the East Range training areas is an Alert Area (A-311) airspace associated with an area of pilot training activity (Army 2004).

Dillingham Airfield is on the northwestern coast of O‘ahu and is a general aviation joint-use facility located on Dillingham Military Reservation. Dillingham has a State-operated air traffic advisory facility, several hangars, and a tie-down area for recreation aircraft, but no other facilities. Air traffic is limited to daytime operation, visual operating rules by small single-engine and light twin-engine aircraft, sailplanes, ultra-light aircraft, and helicopters. Airspace above Dillingham is classified as Class G (uncontrolled) from the ground surface to 1,200 feet and Class E (controlled) above 1,200 feet (Army 2004).

The U.S. Coast Guard Air Station Barbers Point is on the southwestern coast of O‘ahu, at Kalaeloa Airport, which formerly was the active airfield portion of Naval Air Station Barbers Point. Kalaeloa Airport is a general aviation facility that uses 750 acres of the former Navy facility. The State operates the three runways at the airport, the control tower, and support facilities. Aircraft Support Operations are associated with U.S. Coast Guard Air Station Barbers Point. The airspace above Kalaeloa Airport includes Class D, surface Class E, and Class E airspace with a 700-foot floor above the ground surface (Navy 2008). Class B airspace from Honolulu International Airport also is located within and above Kalaeloa Airport airspace.

The U.S. Marine Corps operates the Marine Corps Base Hawai‘i on the northeastern coast of O‘ahu on the Mokapu Peninsula bounded by Kāne‘ohe Bay, the Pacific Ocean, and Kailua Bay. The Marine Aviation Group 24 and Marine Aviation Logistics Squadron 24 are based at the Kāne‘ohe Bay Marine Corps Airfield (Navy 2012). Airspace above the Marine Corps Base Hawai‘i includes both Class D (4.3-nautical-mile radius up to 2,500 feet) and E (Navy 2008 and Navy 2012).

3.11.2.3 Maui, Moloka‘i, and Lāna‘i Military Airspace

There is no special use airspace on Maui or Lāna‘i associated with any military activity. The Pali Air Traffic Control Assigned Airspace that is in effect above the entire O‘ahu area from 25,000 feet up to unlimited overlaps the western part of the island of Moloka‘i.

3.11.2.4 Hawai‘i Military Airspace

The Pohakuloa Training Area in the center of Hawai‘i island is a sub-installation of the Schofield Barracks on O‘ahu. Its primary mission is to provide training of full-scale, live fire exercises for the 25th Infantry Division (Light), U.S. Army Garrison, Hawai‘i. Bradshaw Army Airfield serves the Pohakuloa Training Area and is used for deploying, redeploying, and resupplying military units. Army personnel deploy to Pohakuloa from JBPHH or Wheeler Army Airfield using C-17 or C-130 aircraft. The area is used extensively for helicopter training with an average of 900 aircraft movements per month, 99 percent involving helicopters (Navy 2008). The U.S. Air Force and Navy train tactical aviation aircraft bombing and strafing, and the U.S. Navy uses the area for air-to-surface missile training and for high altitude, laser-guided, inert bombing of targets in the southern part of the Pohakuloa Training Area (Army Garrison 2010b).

Airspace above the Pohakuloa Training Area includes uncontrolled Class G airspace, which extends from the ground surface to a 1,200-foot ceiling, and controlled Class E airspace above 1,200 feet. Bradshaw Army Airfield is surrounded by Class D airspace, extending from the ground surface to a ceiling of 8,700 feet (Army 2004). However, the same airspace has the special use airspace classification of Restricted Area (Army 2004; Army Garrison 2010b; Navy 2008) that is intermittently activated. This restricted airspace, R-3103, extends from the ground surface up to 30,000 feet above mean sea level. Flight corridors are established for this airspace to control aircraft without interfering with ground-firing weapons systems and to prevent over-flight of active firing points. This airspace is under the control of the Range Office at Pohakuloa when activated and released back to the Honolulu Control Facility when deactivated. There is also one Air Traffic Control Assigned Airspace area (Pele) extending west and southwest of Pohakuloa that provides additional controlled airspace between R-3103 and Warning Area W-194, which is approximately 25 nautical miles from the coast. The Pele assigned airspace lies between 16,000 and 29,000 feet above mean sea level.

3.11.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

There are no common impacts to airspace management from construction and operation of renewable energy projects. The most obvious impact would be potential aviation obstruction from tall structures. Those and other potential impacts to airspace management are discussed in Chapters 4 through 8 under the appropriate energy technology.

3.11.4 COMMON BEST MANAGEMENT PRACTICES

The developer should coordinate with the FAA early in the planning phase if the energy project includes tall structures, reflective surfaces, or is located near an airfield. These discussions may include other State (e.g., Department of Transportation) and Federal (e.g., Department of Defense) agencies as appropriate to identify potential impacts and issues early in project planning.

3.12 Noise and Vibration

This section describes techniques used to analyze noise and vibration, and characterizes the affected environment for potential locations of future projects in the State of Hawai‘i.

3.12.1 NOISE

Noise is defined as unwanted sound and is a common environmental concern to the general public. Sound is defined as a varying pressure wave travelling through a media (such as air or water). People experience sound as a result of the pressure variations through such mediums. Sensitive receptors to noise include nearby residences, religious institutions, day care centers, libraries, schools, hospitals, nursing home facilities, and recreational areas. In the marine environment, sensitive noise receptors include species that depend on sound to navigate, feed, and socialize. A number of factors affect how noise is perceived by the listener. These include the noise's frequency and loudness; the type and number of sources; distance away from the source; duration; and the time of day.

Two important characteristics of noise are frequency (perceived as pitch) and amplitude (perceived as loudness). The frequency of sound is the number of pressure variations per second (also referred to as cycles per second), and is measured in Hertz. Humans hear frequencies ranging from approximately 20 Hertz to 20,000 Hertz, and are most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hertz) and less sensitive to sounds in the low and high frequencies. The higher the frequency, the more high-pitched a sound would be perceived. For example, sounds from drums have lower frequencies and sounds from whistles have higher frequencies. A loud sound has larger pressure variation and a weak sound has smaller pressure variation. Loudness of sound is measured in terms of decibels (dB), which uses a logarithmic scale.

Since people are less sensitive to low and high frequencies, the decibel scale is adjusted (A-weighted, or dBA) to reflect the normal hearing sensitivity range for humans. In general, people do not typically notice changes in a community noise level of less than 3.0 dBA; changes from 3.0 to 5.0 dBA may be noticed by extremely sensitive individuals; an increase greater than 5.0 dBA is readily noticeable; and most people perceive a 10.0 dBA increase in sound level to be a doubling of sound volume (FHWA 1980). Noise levels in dBA from typical sources are provided in Figure 3-70. The noise level for a quiet residential neighborhood is 40.0 dBA, while the noise level from heavy surf at 3 feet is 107 dBA (NPS 2010).

Sources for noise are grouped into two types: point and line noise sources. Point noise sources have fixed locations, such as stationary equipment used for normal operations. Line noise sources, such as roadways or railways, include a large number of point sources such as motor vehicles. In general, highway traffic noise levels depend on traffic volumes, speeds, number of trucks, as well as other factors such as terrain and vegetation.

Ambient noise, also known as background noise, is a combination of unwanted sounds from various sources heard simultaneously. Because the decibel scale is logarithmic and not linear, the combined noise level of two sounds occurring at the same time cannot just be added together. For example, a garbage truck with a noise level of 100 dBA combined with a lawn mower with a noise level of 95 dBA results in a noise level of 101.2 dBA, not 195 dBA.

Noise levels decrease, or attenuate, with distance from the source of noise. The decrease in noise level is inversely proportional to the square distance from the noise source. Noise levels from point sources typically attenuate at a rate of 6 dBA each time the distance from the noise source is doubled at acoustically "hard" sites (locations that do not provide excess ground-effect attenuation) and 7.5 dBA at acoustically "soft" sites (locations that absorb noise through ground-effect attenuation, such as normal earth and most ground with vegetation) (FHWA 1980). Noise levels from line sources attenuate at a rate of 3 to 4.5 dBA each time the distance from the source is doubled. Noise levels may be further reduced by natural factors such as temperature and climate and are reduced by barriers, both manmade (e.g., sound walls) and natural (e.g., forested areas, hills, etc.) (FTA 2006).

As an example of this relationship, if point source emitted noise on the order of 50 dBA at 50 feet from a specific location, you would expect that the noise measured at 100 feet from that same noise source to be reduced by 6 dBA, or to 44 dBA. This would continue to reduce as the distance increased (i.e., 38 dBA at 200 feet).

Noises that occur over a longer duration are more likely to be an annoyance or cause direct physical damage or environmental stress. The noise metric that considers both duration and noise level is the equivalent noise level (Leq). Leq is the average A-weighted noise level measured over a given time interval (1-minute, 15- minute, or 1-hour periods). Leq is also expressed in dBA.

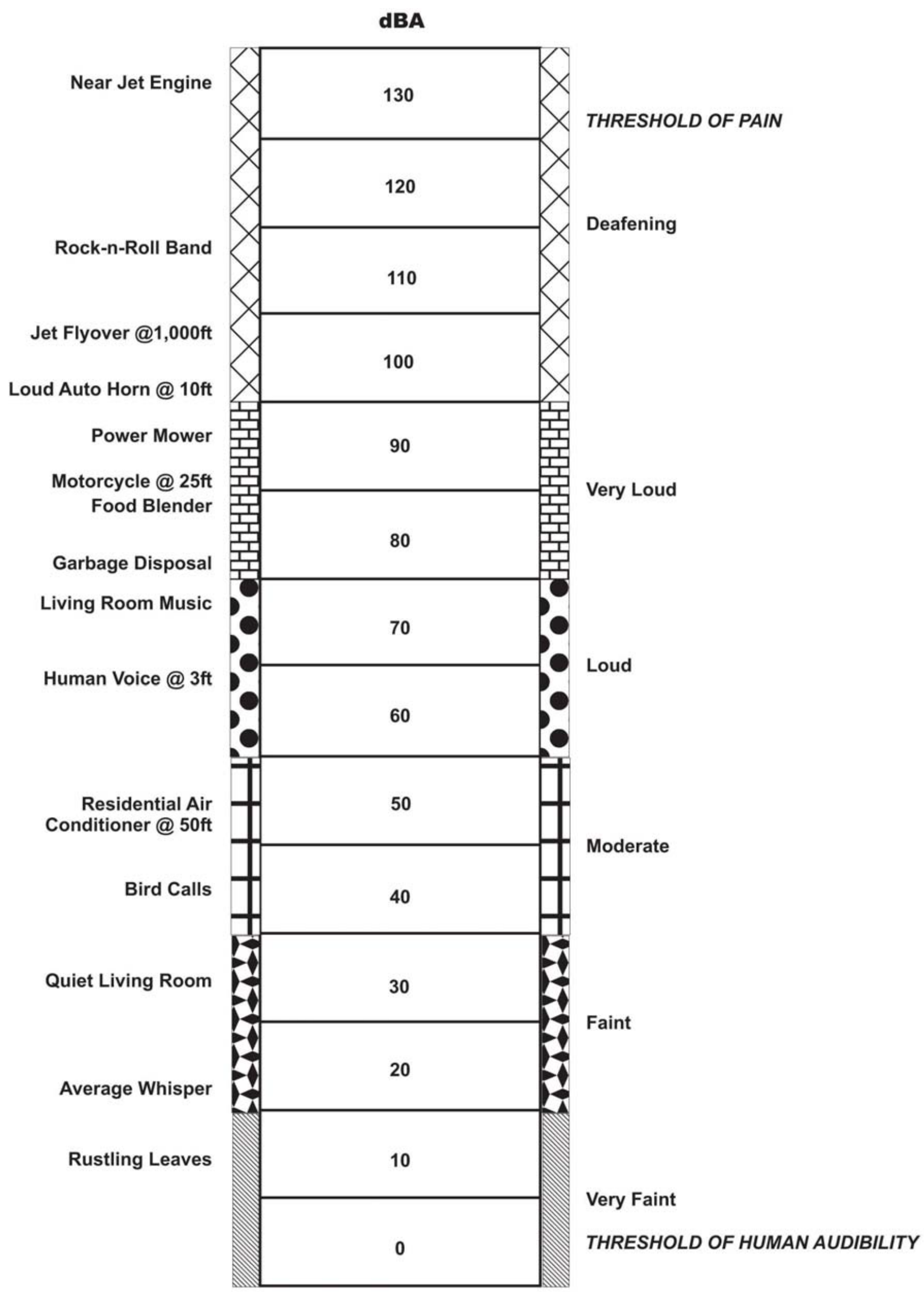


Figure 3-70. A-Weighted Noise Levels (Cowan 1993)

The time of day in which noise occurs is also important since noise that occurs at night tends to disturb people more than noise that occurs during the day. People perceive noise occurring in the evening (7 p.m. to 10 p.m.) as if the noise were 5 dBA higher than if it occurred during the day (7 a.m. to 7 p.m.), and at nighttime (10 p.m. to 7 a.m.) the same noise is perceived as 10 dBA higher. Two commonly used noise metrics are the Day-Night average level (Ldn) and the Community Noise Equivalent Level (CNEL), which weight hourly Leqs over a 24-hour period. Ldn adds 10 dB to nighttime noise levels, and Community Noise Equivalent Level is identical to the Ldn except 5 dBA is added for noise occurring during the evening.

Sound intensity in water is not directly comparable to the same sound intensity in air, and sound travels about five times faster underwater than it does in air. Current knowledge of marine species hearing frequencies and sound detection is limited. The amount of pressure and the duration of the exposure determine whether marine species might be harassed, injured or killed by an underwater noise. Due to the sensitivity of marine speices to sound intensity, the root-mean-square (rms) pressure is the most widely used metric to characterize noise levels underwater (BOEM 2012). The rms is the square root of the average of the square of the pressures of a sound signal over a given duration. Underwater noise levels are typically expressed in the notation "dB re 1 μPa-m," which is the pressure level that would be measured at a reference distance of 1 meter from a source.

3.12.2 VIBRATION

Vibration is defined as the oscillations or rapid linear motion of parts of a fluid or elastic solid whose equilibrium has been disturbed. The pressure waves that generate sound are created by vibrations (such as sound created by vibrating vocal cords), and pressure waves can also induce vibration (such as an ear drum vibrating in response to sound). Traffic, construction machinery and ground breaking activities such as drilling or excavation are common causes of vibration. Sources of vibration can be transient (a single isolated event), or continuous, frequent, or intermittent. Ground-borne vibration is transmitted from a source into the ground, and then transmitted through the ground to nearby buildings. Subsurface geological conditions affect vibration levels, and vibration levels decrease with increasing distance. Similar to noise, the sensitive receptors for vibration include nearby residences, religious institutions, day care centers, libraries, schools, hospitals, nursing home facilities, and recreational areas. Other sensitive receptors could also include scientific laboratories that use sensitive equipment. In the marine environment, sensitive vibration receptors include species that depend on sound to navigate, feed, and socialize. Vibration is measured in terms of the peak particle velocity in inches per second.

3.12.3 REGULATORY FRAMEWORK

The regulatory framework for noise and vibration includes Federal guidance and State regulatory standards that range from levels that cause annoyance up through levels that are hazardous.

In 1974, the EPA provided information suggesting that continuous and long-term noise levels in excess of Ldn 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals (EPA 1974). Similarly, the U.S. Department of Housing and Urban Development (HUD) established 65 dBA as a threshold for unacceptable noise levels for residential areas (HUD 1985). HUD's guidelines categorize noise level impacts on residential properties as acceptable, normally unacceptable, and unacceptable, as shown in Table 3-53. The HUD noise levels shown in Table 3-53 serve as guidance, not requirements.

Table 3-53. Guidelines for Evaluating Noise Level Impacts on Residential Properties

Acceptability for Residential Use	Guideline Levels (Ldn)
Acceptable	< 65 dB
Normally Unacceptable	> 65 dBA to < 75 dBA
Unacceptable	> 75 dBA

Source: HUD 1985.
dB = decibel; dBA = A-weighted decibel; Ldn = day-night average level.

The HDOH Indoor and Radiological Health Branch enforces, monitors, and issues permits and variances related to public noise issues. The regulations are found in HRS 342F, "Noise Pollution," and HAR 11-46, "Community Noise Control." HDOH issues noise permits when excessive noise levels are anticipated and issues variances when noise levels may exceed the maximum permissible amounts. Noise abatement measures may also be conditions of certain county zoning permits.

Maximum daytime permissible noise levels for stationary sources are based on the primary land use zoning classification and are shown in Table 3-54. Land use zoning classifications are shown on General Plans (see Section 3.5, Land and Submerged Land Use). The HDOH Community Noise Control rule does not address moving sources, such as vehicular, rail, and air traffic noise, but does regulate agricultural, construction, and industrial activities that may not be stationary. A permit or variance would be required for construction activities that exceed the maximum permissible sound levels for more than 10 percent of the time within any twenty minute period. Additionally, permits do not allow any construction activities which emit noise in excess of the maximum permissible noise levels during the following hours:

- Before 7 a.m. and after 6 p.m. of the same day, Monday through Friday
- Before 9 a.m. and after 6 p.m. on Saturdays
- Any time on Sundays or holidays

Table 3-54. Maximum Daytime Permissible Noise Levels in dBA

Zoning Class	Zoning Classification	Daytime (7 a.m. – 10 p.m.)	Nighttime (10 p.m. – 7 a.m.)
Class A	All areas equivalent to lands zoned residential, conservation, preservation, public space, open space, or similar type	55	45
Class B	All areas equivalent to lands zoned for multi-family dwellings, apartment, business, commercial, hotel, resort, or similar type	60	50
Class C	All areas equivalent to lands zoned agriculture, country, industrial, or similar type	70	70

Source: HAR, Title 11, Chapter 46.
dBA = A-weighted sound level in decibels.

The Federal Highway Administration (FHWA) uses the Leq 1-hour descriptor to estimate the degree of nuisance or annoyance arising from changes in traffic noise. The FHWA established noise abatement criteria that provide a benchmark to assess the level at which noise becomes a source of annoyance for various land uses. HDOT adopted FHWA goals (see Table 3-55), and according to the HDOT guidelines, a noise impact occurs when the predicted traffic noise levels approach FHWA goals by 1 dBA or exceed existing noise levels by at least 15 dBA (HDOT 2011b).

Table 3-55. HDOT Traffic Noise Abatement Criteria

TABLE 1 TO PART 772—NOISE ABATEMENT CRITERIA

[Hourly A–Weighted Sound Level_decibels (dB(A)) [1]]

Activity category	Activity Leq(h)	Criteria [2] L10(h)	Evaluation location	Activity description
A	57	60	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B [3]	67	70	Exterior	Residential.
C [3]	67	70	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	55	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E [3]	72	75	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A–D or F.
F				Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G				Undeveloped lands that are not permitted.

[1] Either Leq(h) or L10(h) (but not both) may be used on a project.
[2] The Leq(h) and L10(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.
[3] Includes undeveloped lands permitted for this activity category.

Source: HDOT 2011b.
Leq(h) = equivalent sound level over one hour.

The Federal Aviation Administration (FAA) issues guidelines for land uses around airports based on yearly Ldn noise contour maps due to aircraft operations. HDOT Airports Division adopted noise restrictions similar to but stricter than the FAA's. In most cases, HDOT maximum noise limits are 5 dB lower than the FAA restrictions (see Table 3-56). The HDOT also limits Ldn noise levels for noise sensitive receptors to Ldn 60 without noise level reduction measures.

Under provisions of the Federal *Occupational Safety and Health Act of 1970,* a hearing conservation program must be implemented when employees are exposed to 85 dB or more in an 8-hour day and engineering or administrative noise controls are required when exposure exceeds 90 dB. The State of Hawai'i, under an agreement with the Occupational Safety and Health Administration (OSHA), operates an occupational safety and health program in accordance with the Federal Act. The Occupational Safety and Health Division of the Hawai'i Department of Labor and Industrial Relations is responsible for both enforcement and consultation programs under provisions of HAR Title 12 Chapter 200.1, Occupational Noise Exposure. OSHA permissible noise exposures in the workplace are shown in Table 3-57.

Table 3-56. HDOT Recommendations for Airport Land Use Compatibility (Source: HDOT)

LAND USE	YEARLY DAY-NIGHT AVERAGE SOUND LEVEL (DNL) IN DECIBELS BELOW 65	65-70	70-75	75-80	80-85	OVER 85
RESIDENTIAL						
Residential, other than mobile homes and transient lodgings	Y	N[1]	N[1]	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N[1]	N[1]	N[1]	N	N
PUBLIC USE						
Schools, hospitals, nursing homes	Y	25	30	N	N	N
Churches, auditoriums, and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y[2]	Y[3]	Y[4]	N[4]
Parking	Y	Y	Y[2]	Y[3]	Y[4]	N
COMMERCIAL USE						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail -- building materials, hardware, and farm equipment	Y	Y	Y[2]	Y[3]	Y[4]	N
Retail trade, general	Y	Y	25	30	N	N
Utilities	Y	Y	Y[2]	Y[3]	Y[4]	N
Communication	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION						
Manufacturing, general	Y	Y	Y[2]	Y[3]	Y[4]	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y[6]	Y[7]	Y[8]	Y[8]	Y[8]
Livestock farming and breeding	Y	Y[6]	Y[7]	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL						
Outdoor sports arenas and spectator sports	Y	Y	Y[5]	N[5]	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts, and camps	Y	Y	Y	N	N	N
Golf courses, riding stables, and water recreation	Y	Y	25	30	N	N

The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable under Federal, state, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute Federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Key To Table A-2

Y (Yes) Land use and related structures compatible without restrictions.

N (No) Land use and related structures are not compatible and should be prohibited.

NLR Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

25, 30, 35 Land use and related structures generally compatible; measures to achieve a NLR of 25, 30, or 35 dB must be incorporated into design and construction of structure.

Notes for Table A-2

1. Where the community determines that residential or school uses must be allowed, measures to achieve outdoor-to-indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as five, ten, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.
2. Measures to achieve NLR of 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
3. Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
4. Measures to achieve NLR of 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
5. Land use compatible provided special sound reinforcement systems are installed.
6. Residential buildings require a NLR of 25 dB.
7. Residential buildings require a NLR of 30 dB.
8. Residential buildings not permitted.

Source: 14 CFR Part 150 Airport Noise Compatibility Planning, Appendix A, Table 1.

Table 3-57. Permissible Noise Exposures in the Workplace

Duration Per Day (hours)	Noise Level (dBA)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: Title 29 CFR 1910.95.
dBA = A-weighted decibel.

Kaua‘i, Honolulu, Hawai‘i, and Maui counties have established local noise control programs. Kaua‘i County Code Chapter 22, Article 14, outlines unlawful use of noise reproduction devices and excessive noise in public areas. Chapter 41, Article 5 of the Honolulu County Code prohibits conducting noisy activities from workshop, factory, trade, manufacture, industry or business within 500 feet of a hospital. Maui County Code, Title 9, Chapter 9.36 addresses amplification systems in vehicles, which cannot be heard outside of fifty feet from the vehicle. The noise ordinance in Hawai‘i County Code, Chapter 14, Article 3, is almost identical to Kaua‘i’s. Maui County includes Maui, Lāna‘i, and Moloka‘i, except for Kalawao County. Kalawao County is a county and a National Park; HDOH administers Kalawao County and Kalaupapa National Park is subject to National Park Service regulations (NPS 2010).

Currently there are no Federal, State, or county standards for underwater noise and vibration. NOAA is developing acoustic guidelines for assessing the effects of anthropogenic sound on marine mammal species (NOAA 2013c). Recent discussions have also highlighted the need for additional study on the emission of electromagnetic waves from undersea power cables, and potential impacts on nearby marine life. The acoustic guidelines will provide past criteria as well as updated assessment procedures for authorizations, permits, consultations, and exemptions under various environmental statutes (such as the *Marine Mammal Protection Act*, the ESA, and the *National Marine Sanctuaries Act*).

Guidelines have been published for land-based vibration. Table 3-58 presents guidelines for human perception and annoyance, and Table 3-59 presents guidelines for potential building damage.

Table 3-58. Guidelines for Potential Vibration Annoyance

	Maximum Peak Particle Velocity (inches per second)	
Human Response	Transient Sources	Continuous/Frequent/ Intermittent Sources
Barely Perceptible	0.04	0.01
Distinctly Perceptible	0.25	0.04
Strongly Perceptible	0.9	0.10
Severe	2.0	0.4

Table 3-59. Thresholds for Potential Vibration Damage

Structure and Condition	Maximum Peak Particle Velocity (inches per second)	
	Transient Sources	Continuous/Frequent/ Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.4
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Source: Jones & Stokes 2004.

3.12.4 REGION OF INFLUENCE

The ROI for the noise and vibration affected environment is based on the potential magnitudes of noise and vibration generated for the particular project being evaluated and baseline noise and vibration levels, which would affect how far away the noise might be heard or vibration might be felt. The ROI for this programmatic analysis is identified by addressing existing night and day ambient (background) noise and vibration sources and estimated levels in general for the State of Hawai‘i.

Baseline Noise and Vibration Levels

Estimated baseline project-related noise and vibration levels would be site-specific. Maximum daytime permissible noise levels for potential future clean energy projects in the State of Hawai‘i are based on the primary land use zoning classification at the proposed project location (see Tables 3-54, 3-55, 3-56, and Section 3.5). Existing land use zoning classifications and sensitive noise and vibration receptors vary by location. General locations for noise abatement areas recommended by the HDOT are shown for the islands of Kaua‘i (Figure 3-71), Oah‘u (Figure 3-72), Maui (Figure 3-73), and Hawai‘i (Figure 3-74) (HDOT 2013d).

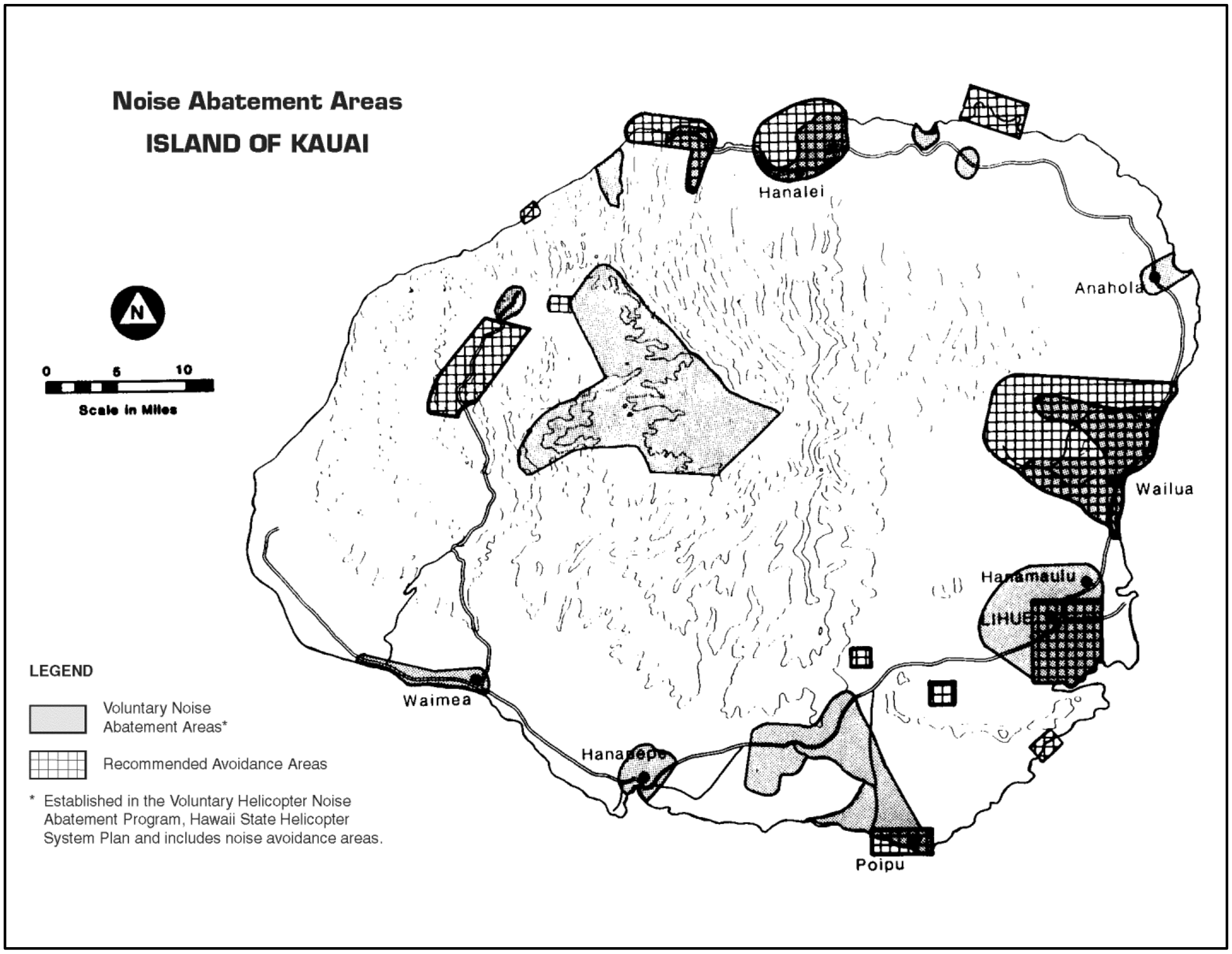


Figure 3-71. Noise Abatement Areas on the Island of Kaua‘i

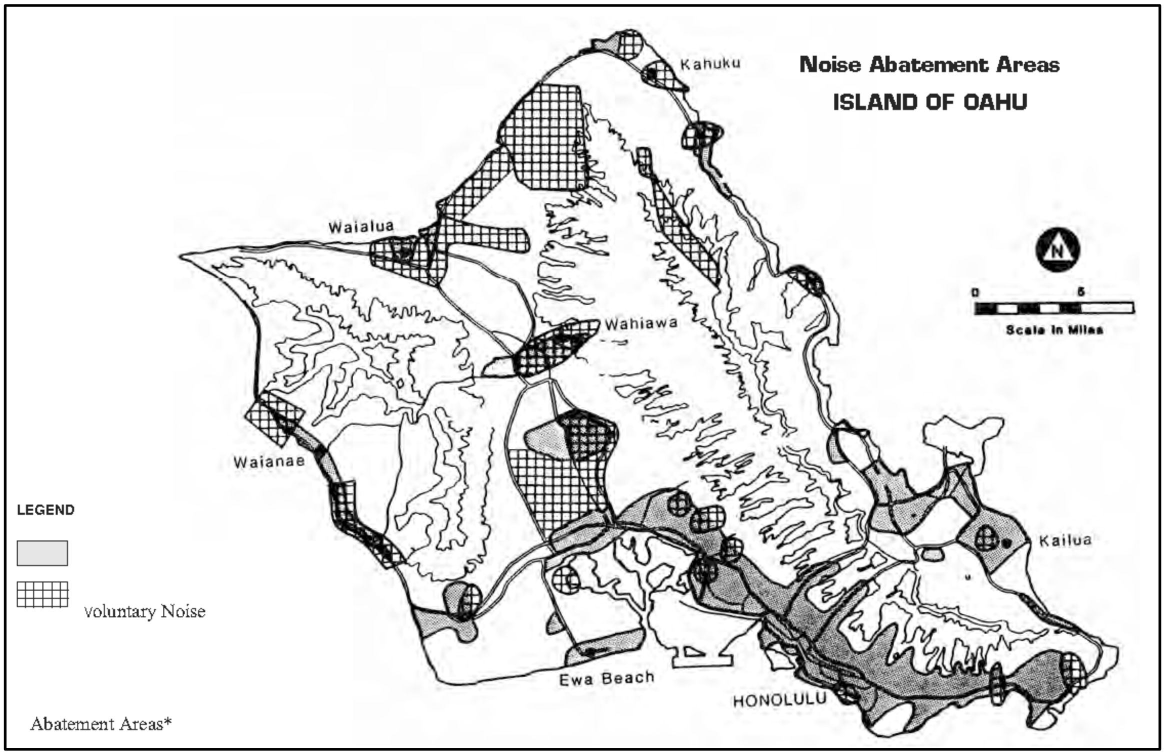


Figure 3-72. Noise Abatement Areas on the Island of Oʻahu

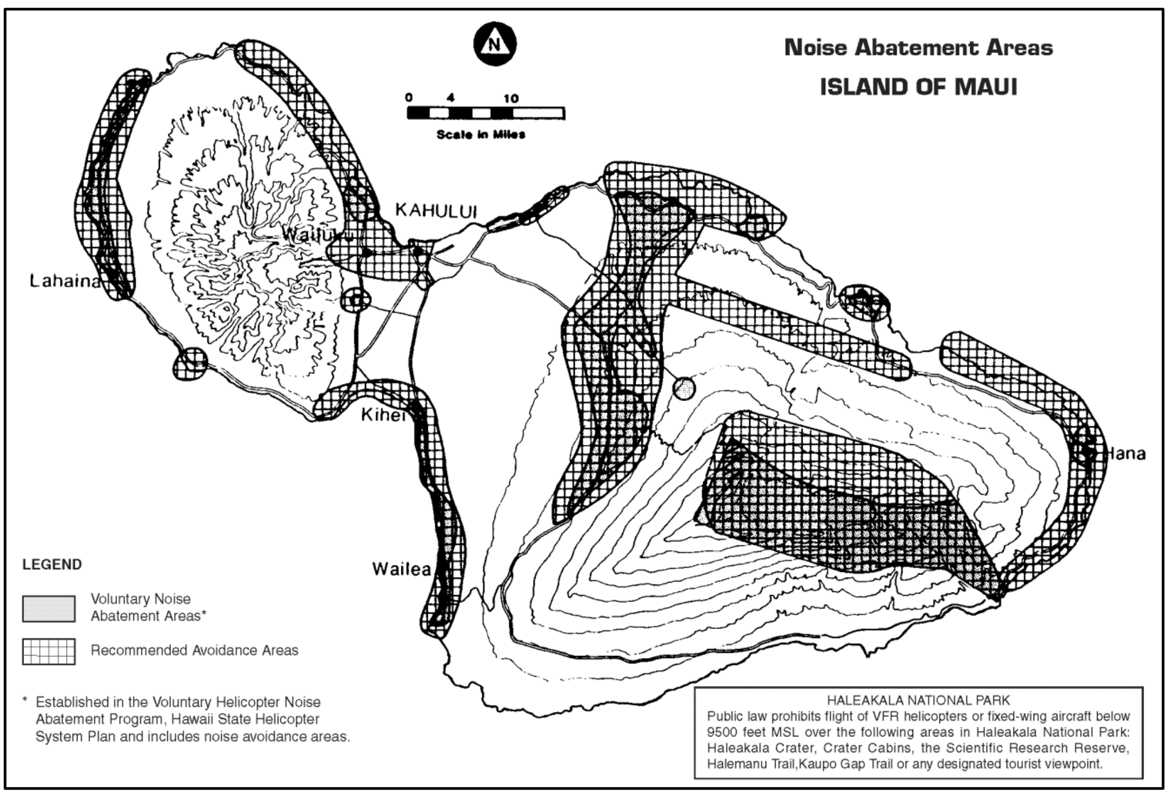


Figure 3-73. Noise Abatement Areas on the Island of Maui

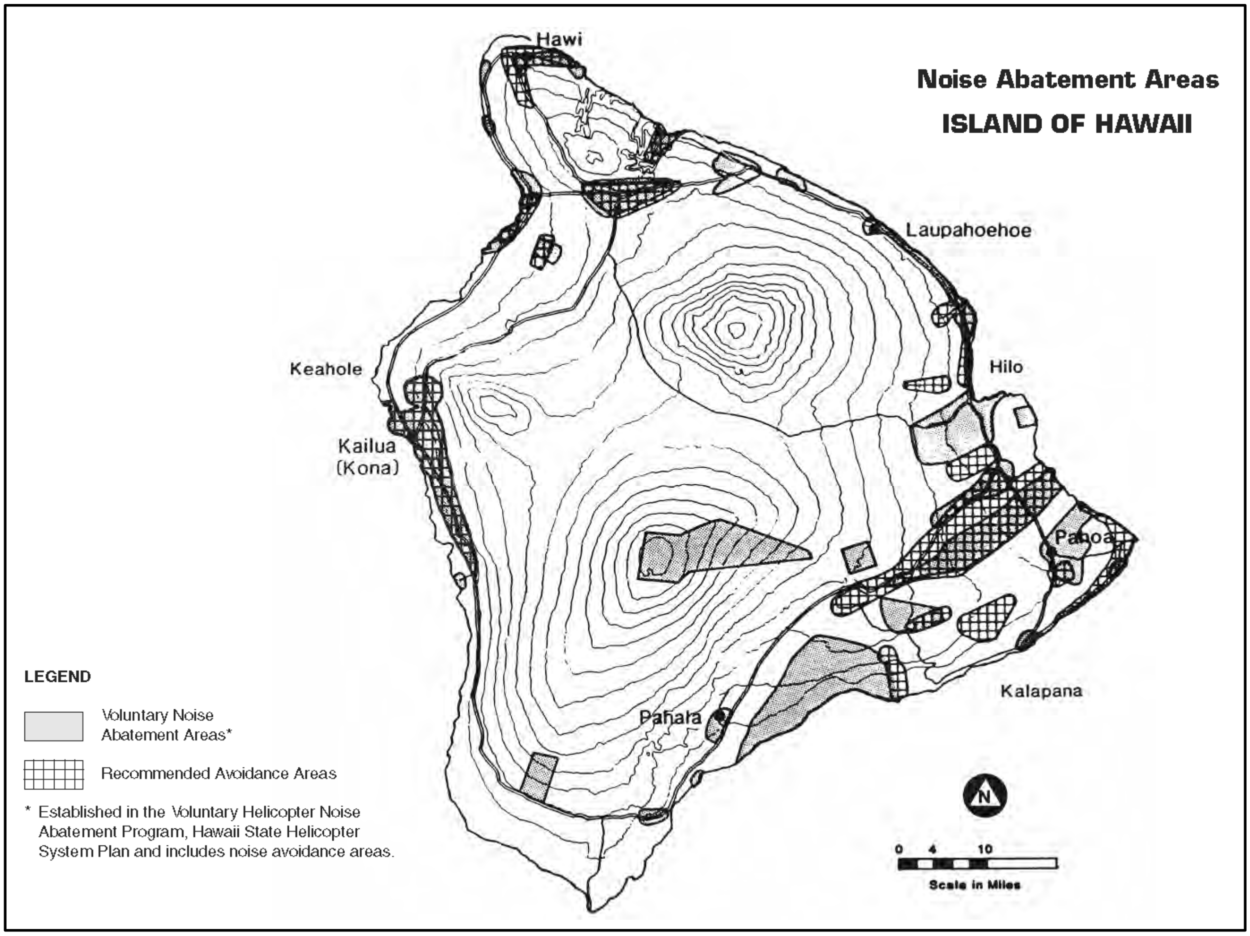


Figure 3-74. Noise Abatement Areas on the Island of Hawai‘i

3.12.5 COMMON CONSTRUCTION AND OPERATION IMPACTS

Construction activities inherently produce sound levels or sound characteristics that result in short-term noise and vibration impacts. Noise and vibration levels from common construction activities (which exclude pile-driving) are not anticipated to exceed regulatory levels, and a construction noise permit would be obtained if regulatory noise limits are temporarily exceeded. If common BMPs are applied (see Section 3.12.6), noise and vibration impacts from typical construction would be short-term and minor.

Sounds generated by operation of proposed facilities may be perceived as noise depending on land use surrounding the facilities, whether or not those noise levels exceed regulatory levels. If regulatory noise levels would be exceeded an operational noise permit would be required. When areas adjoining proposed facilities contain sensitive noise and vibration receptors, potential noise and vibration impacts are more likely to be a matter of concern. Potential noise and vibration impacts from operation would depend on operational noise and vibration levels, the proposed site location, and the proposed project.

3.12.6 COMMON BEST MANAGEMENT PRACTICES

Common BMPs for noise and vibration refer to actions that will be taken to avoid or reduce the effects of or levels of noise and vibration on a receptor. Common noise and vibration BMPs include:

- Avoid sensitive noise and vibration receptors. Typical sensitive receptors for noise and vibration include nearby residences, religious institutions, day care centers, libraries, schools, hospitals, nursing home facilities, recreational areas, and scientific laboratories that use sensitive equipment.

- Reduce adverse noise effects at the point of generation thereby diminishing the effects of the noise and vibration at the point of reception. Alternative construction or operational methods, equipment maintenance, selection of alternative equipment, physical barriers, siting of activities, setbacks, and established hours of construction or operation, are among the techniques that can successfully reduce adverse noise effects (State of New York 2001).

- Noise permits would be required if noise levels exceed regulatory limits. A noise permit variance would be necessary when permitted noise limits would be exceeded. Noise avoidance and mitigation measures may be imposed directly as conditions of permit issuance.

- Conduct site-specific and project-specific noise and vibration evaluations for proposed construction and operational-related activities.

3.13 Utilities and Infrastructure

Utilities and infrastructure are an important part of the daily life throughout Hawai‘i. Considered in this section are the existing electric utilities and electrical transmission and distribution services. The public sewer systems are discussed in section 3.14 and public safety (e.g. police, fire, and medical) services are discussed in section 3.17). The affected environment is described overall for the State of Hawai‘i. The depth of discussion is based upon the overall importance of each area for impacts development. Additional information is provided for each island of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i where important differences maybe noted.

3.13.1 ELECTRIC UTILITIES AND DISTRIBUTION

Electric power for the six Hawaiian Islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i is supplied by Hawaiian Electric Company (HECO), Hawai‘i Electric Light Company (HELCO), Maui Electric Company (MECO), and Kaua‘i Island Utility Cooperative (KIUC). HELCO and MECO are subsidiaries of HECO and those three companies supply power to about 95 percent of the population of Hawai‘i. MECO serves Maui, Lāna‘i, and Moloka‘i; and HELCO serves the island of Hawai‘i (Big Island). See Table 3-60 for the electricity demand and supply of Hawai‘i utilities.

Table 3-60. Electricity Demand and Supply for Hawaiian Utilities

2012 Demand (rounded)	HECO (O‘ahu)	MECO			HELCO (Hawai‘i Island)	HECO Companies	KIUC	State Total
		Maui	Lāna‘i	Moloka‘i			(Kaua‘i)	
System Peak (net MW)	1,141	199	4	5	189	N/A	65	N/A
Net firm utility and IPP capacity (MW)	1,783	262	10	12	292	2,359	125	2,456
Annual Utility Sales of Electricity (GWh)	6,976	1,090	24	30	1,085	9,206	433	9,639

Source: HECO 2013a.
GWh = gigawatt-hour; IPP = independent power producers; MW = megawatt; N/A = not applicable.

On-island transmission of electricity includes connections from the power generation source, transmission over a short or long distance, and connection to the power user. This system is often referred as the island electrical grid or simply “power grid” or “grid” (Figure 3-75). The power grid is how the majority of people and companies get their electricity. The generating station shown on the left in the figure may be current fossil fuel-fired power plants, auxiliary generators to help regulate power throughout the power grid, or any of the various renewable power generation sources (e.g., sun, wind, biomass, hydropower, geothermal).

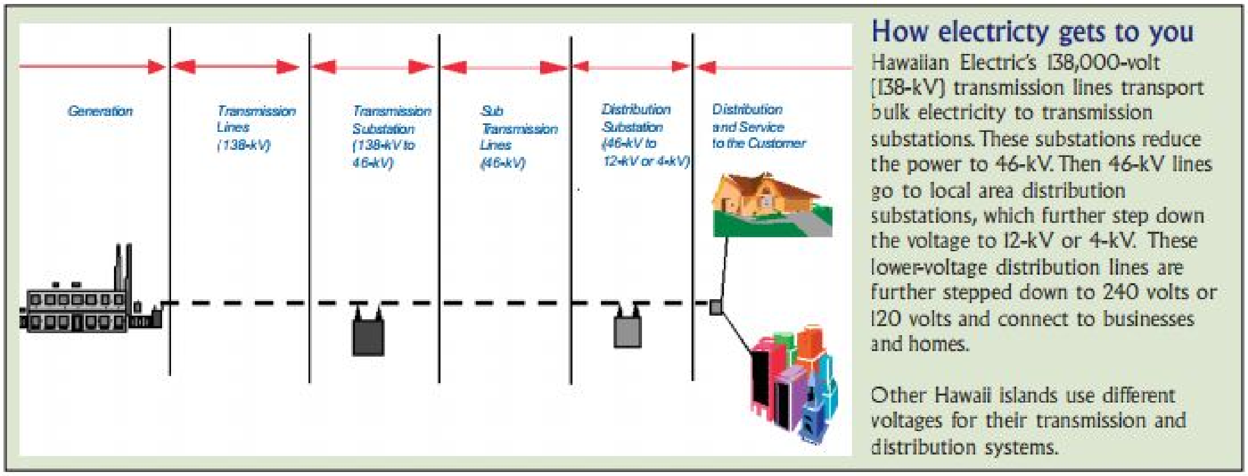


Figure 3-75. Electricity Transmitted from the Power Plant to the Consumer (HECO 2014a)

The power source connection may include meters, switch gear, circuit breakers, inverters, transformers, and connection to transmission lines. The transmission line may be above ground or buried to distribute the power to customers. At the power user, connections would also include switchgear, circuit breakers, inverters, transformers, meters and connection to customer facilities. Some customers with renewable power generation capability may be both users and/or suppliers of power to the grid. Each island has a stand-alone power-generating system, rather than a system of interconnected transmission lines between the islands. These self-contained power grids must be more reliable and self-reliant than comparable utilities in continental United States to maintain customer service.

Table 3-61 summarizes some of the key characteristics of the Hawai‘i power grids. For transmitting power long distances, “transmission lines” are typically used at voltages of 138 kilovolts. From 138 kilovolts to 34.5 kilovolts is considered to be subtransmission. Substations are facilities where the power electronics and transformers are located to change between voltage levels. Below 34.5 kilovolts is called “distribution,” and voltages are reduced in steps through a series of transformers all the way down to 220/110 volts in a neighborhood.

Table 3-61. Hawaiʻi Transmission and Distribution Lines

	Hawaiʻi[a, b]	Maui[b, a]	Molokaʻi[b, a]	Lānaʻi[b,a]	Oʻahua	Kauaʻi[c, b]
Provider	HELCO	MECO	MECO	MECO	HECO	KIUC
Residential Customers	69,700	54,500	2,600	1,400	264,200	28,200
Commercial Customers	12,400	9,000	500	200	33,100	4,700
Transmission Lines (miles)	623	240	N/A	N/A	746	161
Transmission Lines (voltage)	69 kV/ 34.5 kV	69 kV/ 23 kV	N/A	N/A	138 kV/ 46 kV	69 kV
Distribution Lines (miles)	3,141	1,475	No data	No data	2,249	1,226
Distribution Lines (voltage)	No data	No data	34.5 kV	12 kV	12 kV/ 4 kV	12 kV

a. Source: HECO 2013a.
b. Source: DBEDT 2013b.
c. Source: KIUC 2007.
HECO = Hawaiian Electric Company; HELCO = Hawaiʻi Electric Light Company; kV = kilovolt; MECO = Maui Electric Company; N/A = not applicable.

The electric utilities are undergoing major changes driven by the need to meet the 2030 goals of the State of Hawaiʻi to be a less fossil fuel dependent and more renewable energy based State. These changes are contributing to the decline in electricity consumption (Figure 3-76). Hawaiʻi electrical energy consumption has decreased by 7 percent (770 gigawatt-hours) since the peak in 2004. Energy conservation and other programs being planned and implemented under the Hawaiʻi Clean Energy Initiative may continue this downward trend. To be less oil dependent, utilities will be (HECO 2013a):

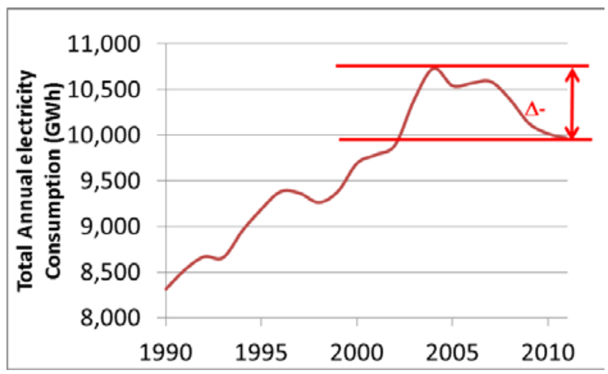


Figure 3-76. Electricity Use Decrease since 2004 Peak

- Accelerating the deactivation decommissioning of older, oil-fired steam generators.
- Procuring or developing low-cost, fast track utility-scale renewable energy sources,
- Converting existing generating units to cost effective renewable and low carbon fuels, including biomass, biofuels, and liquefied natural gas.

While assuring a stable electric power grid and minimizing disruption to service quality and reliability, the electric power grids on all islands are being modified to accommodate new renewable power generation and to compensate for the variations in power output from those sources (e.g. wind power varies with the wind flow; solar varies with the day/night cycle, clouds, and shading). These modifications include:

- Initiation of local connections of renewable sources to the power grid (e.g., residential or commercial customers);
- Construction of new transmission lines from new power sources to the existing power grid (e.g., connection of a solar power plant via transmission line) or replacement of older transmission lines and structures that are reaching the end of their service life; and
- Implementation of smart grid technologies (e.g., energy storage and load control/shifting).

Currently, the power grid on each of the six islands is connected to most of the residents and businesses on that island. For those already connected to the utility's electric grid, adding local residential or commercial renewable energy sources may be possible through the Net Energy Metering (NEM) program. NEM is available to customers of HECO, HELCO, MECO, and KIUC, while the programs differ slightly by island. In the HECO, HELCO, and MECO service territories, the maximum system size is 100 kilowatts, and as the program has grown rapidly in recent years, aggregate system caps were replaced by a screening process at the distribution circuit level. Under recently announced policy changes in September 2013, HECO may require additional studies and circuit upgrades to interconnect NEM customers when the total capacity of PV installed on the circuit exceeds 100 percent of the circuit's daytime minimum load. In January 2014, HECO announced that customers with PV inverters that met new technical standards for voltage trip settings may be allowed to interconnect on high saturation circuits (PUC 2014). Subsequently, in February 2014, HECO announced updates to 100 percent of the circuit's daytime minimum load threshold policy to allow more PV projects to proceed without an interconnection requirements study, as indicated in Table 3-62.

Table 3-62. Updated Daytime Minimum Load Thresholds

Aggregate PV Nameplate (kW) vs. Daytime Min Load on Circuit	Single Phase System, 10 kW or smaller	Single Phase System, from 10 kW to 100 kW	Three-Phase System, from 10 kW to 100 kW
Greater than 120% of DML	IRS may be required, possible upgrades	IRS may be required, possible upgrades	IRS may be required, possible upgrades
100 – 120% of DML	No IRS, possible upgrades	IRS may be required, possible upgrades	IRS may be required, possible upgrades
75 – 99% of DML	No IRS, possible upgrades	No IRS, possible upgrades	No IRS, possible upgrades
Up to 74% of DML	No IRS, no upgrades	No IRS, possible upgrades	No IRS, possible upgrades

Source: HECO 2014b.
DML = daytime minimum load; IRS = interconnection requirements study; kW = kilowatt.

In the KIUC service territory, the NEM Pilot Program has set the maximum system size at 50 kilowatts, and the aggregate capacity is capped at 1 percent of Kaua‘i's system peak demand (PUC 2014). It is worth noting that interconnection policies are rapidly evolving and subject to change as more variable renewable energy comes online.

The feed-in-tariff (FIT) program had been another avenue for adding residential and commercial renewable energy sources. However, on August 27, 2013, the PUC issued Order No. 31424 to re-examine the FIT program. As part of this re- examination, HECO and the Independent Observer Accion Group submitted a Joint Plan to the PUC for the continued administration of the current active projects in the FIT program. No additional projects are being added to the queue at this time.

Larger utility-scale power sources such as solar farms, wind farms, large biomass generators, hydropower facilities, or geothermal plants are being added to the power grids across the islands. Current information on new generation may be found at the Hawaiian Electric Website (see HECO 2013b). Each of these projects is required to comply with the Public Utilities Commission requirements, especially those for Transmission Line Approval and Power Purchase Agreements. Those requirements include interfacing with the appropriate utility (i.e., HECO, MECO, HELCO, or KIUC). During early development of a project, interface with the utilities helps the developer find feasible solutions to interconnections with the grid and allows the utilities to join planning for the additional power generation capabilities.

3.13.2 COMMON CONSTRUCTION AND OPERATION IMPACTS

On all islands, transmission line modifications may be needed to connect the generating facility to the power grid (see Section 8.1 in Chapter 8 for impacts related to on-island transmission lines). The utility connection to the power grid would be required to comply with the Public Utilities Commission requirements for Transmission Line Approval and Power Purchase Agreements. Those requirements include interfacing with the appropriate island utility.

The representative projects presented throughout Chapters 4, 5, 6, 7, and 8 highlight renewable energy changes that are described at HECO and KIUC websites. The IRP Report outlines extensive changes to adapt the utility system to meet the IRP goals and to match the various non-utility renewable energy initiatives (HECO 2013a). This PEIS outlines a few of the changes that would be necessary to handle intermittent power sources such as photovoltaic and wind power. The PEIS also identifies some changes to modify the existing utility generators and transmissions systems. Further changes to the utilities are noted in the sections on smart grids and energy storage, Sections 2.3.5.3 and 2.3.5.4, respectively. As more renewable sources come on line to meet IRP goals, the utilities will need to continue to adapt. the projects presented in this PEIS are examples of actions to meet the IRP goal of 4,300 gigawatt-hours per year for 2030.

3.13.3 COMMON BEST MANAGEMENT PRACTICES

BMPs applicable to utilities and infrastructure are as follows:

- Engineer, construct, and install projects so as to make them compatible with the continued operation and maintenance of co-located infrastructure (e.g., aboveground, below ground, and submerged electric, telecommunications, water, and wastewater infrastructure), and affected transportation systems.
- Consult with existing utility infrastructure operators prior to beginning any preconstruction activities and throughout any project’s design process.
- Develop and adhere to protection measures and specifications for existing and planned utility infrastructure and upgrades.

3.14 Hazardous Materials and Waste Management

3.14.1 HAZARDOUS MATERIALS

Hazardous materials include any item or agent (biological, chemical, physical) that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors (IHMM 2014). According to the EPA, hazardous waste is a hazardous material that can be characterized by ignitability, corrosiveness, reactivity, and toxicity. Those solid wastes that exhibit one or more of these characteristics are classified as hazardous wastes [pursuant to RCRA (40 CFR 262.11)], including discarded military munitions. Exposure to such waste may cause or contribute to an increase in mortality rates or cause serious, irreversible, or incapacitating illness (EPA 2012). Issues associated with hazardous materials and waste typically center around under- and aboveground storage tanks; and the storage, transport, and use of pesticides, fuels, petroleum, oils, paints, and lubricants. When such resources are improperly treated, stored, transported, disposed of, or managed, the resources can threaten the health and well-being of wildlife species, botanical habitats, air, soil, water resources, and humans. This section discusses how hazardous materials are managed in Hawai‘i and includes an identification of significant quantities hazardous material in each island that may require further site assessment and remediation planning.

3.14.1.1 Regulatory Setting

Different hazardous materials (including hazardous substances and hazardous wastes) are regulated in a variety of ways. Hazardous materials are defined and regulated in the United States primarily by laws and regulations administered by the EPA, OSHA, USDOT, the U.S. Nuclear Regulatory Commission, and state governments. Each agency incorporates hazardous substance safeguards according to its unique Congressional mandate.

- EPA regulations focus on the protection of human health and the environment (see Section 3.17).
- OSHA regulations primarily protect employee and workplace health and safety (see Section 3.17).
- USDOT regulations promote the safe transportation of hazardous substances used in commerce.
- The Nuclear Regulatory Commission regulations govern the safe transportation and disposal of radioactive and hazardous materials.

At the State level, the HDOH Solid and Hazardous Waste Branch regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes. This agency also administers EPA permits, procedures, and regulations for the State. Proper identification of hazardous materials is required for compliance with applicable regulations to ensure human and environmental health and safety and to support the design and implementation of mitigation measures (see Section 3.17). Where hazardous materials have already been identified, cleanup efforts are often underway by a wide range of State and Federal agencies and stakeholders. However, hazardous materials may be encountered during future site development, which would require handling and disposal safely and in compliance with county, State, and Federal regulations.

This section describes the regulatory setting for hazardous waste materials that commonly impact site development activities, including *Resource Conservation and Recovery Act* (RCRA), *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA), and those related to under-and aboveground storage tanks, pesticides, asbestos, lead based paint (LBP), polychlorinated biphenyls (PCBs), and arsenic.

3.14.1.1.1 Resource Conservation and Recovery Act

RCRA is a Federal law that provides, in broad terms, the general guidelines for the Federal waste management program. RCRA’s primary goals are to protect human health and the environment from the potential hazards of waste disposal, to conserve energy and natural resources, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner. RCRA regulates the management of solid waste (e.g., garbage), hazardous waste, and underground storage tanks holding petroleum products or certain chemicals. It includes a Congressional mandate directing EPA to develop a comprehensive set of regulations to implement the law. The hazardous waste program, under RCRA Subtitle C, establishes a system for controlling hazardous waste from cradle to grave; that is, from the time it is generated, during transport and treatment, to ultimate disposal. In any given state, EPA or the state hazardous waste regulatory agency enforces hazardous waste laws. EPA encourages states to assume primary responsibility for implementing a hazardous waste program through state adoption, authorization, and implementation of the regulations.

On November 13, 2001, the Federal Government authorized HDOH to administer the Hawaiʻi Hazardous Waste Program. As part of the delegation process, HDOH adopted amendments to the State's hazardous waste rules (found in the HAR), some of which are more stringent than Federal Government regulations including procedures required by the State for Federally approved variances and exclusions by the EPA, and those concerning permits. For example, the State must separately approve any exclusion, variance, or alternative treatment method approved by the EPA under 40 CFR 268.5, 268.6, 268.42(b), and 268.44; the State limits hazardous waste permits to five years (the Federal limit is 10 years) and landfill permits to three years (the Federal limit is five years). The State did not adopt 40 CFR 261.4(b)(5) and therefore does not exclude drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil, natural gas, or geothermal energy from regulation as a hazardous material. In addition, Hawaiʻi requires permits from HDOH for used oil transporters, marketers, and recyclers as well as an annual report of transporters, processors, re-refiners, and marketers in addition to the biennial RCRA reports. The State also requires additional information from foreign importers of hazardous waste, which is broader than Federal hazardous waste requirements (66 FR 55119, November 1, 2001).

3.14.1.1.2 Comprehensive Environmental Response Compensation and Liability Act

CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* in 1986, authorized the EPA to create a list of polluted locations requiring a long-term response to clean up hazardous material contaminations. These locations are known as Superfund sites and are placed on the National Priorities List (NPL). The NPL guides EPA in "determining which sites warrant further investigation" for environmental remediation. There are presently three Superfund sites on the NPL in Hawaiʻi. One additional site has been cleaned up and removed from the NPL. No sites are currently proposed for addition. All of these sites are on the island of Oʻahu (Figure 3-72).

3.14.1.1.3 Occupational Safety and Health Administration

The OSHA requirements are designed to protect workers and prevent workplace accidents, injuries, or illnesses (see Section 3.17). One such requirement is the Hazard Communication Regulation (29 CFR 1910.1200), which defines a hazardous chemical as one that poses a physical or health hazard and requires that workers are trained and notified of specific hazards associated with hazardous workplace substances. The definition of a hazardous chemical also includes:

- Carcinogens, toxins, toxic agents, irritants, corrosives, and sensitizers;
- Agents that act on the hematopoietic system (bodily system of organs and tissues);
- Agents that damage the lungs, skin, eyes, or mucous membranes;
- Chemicals that are combustible, explosive, flammable, unstable (reactive), or water reactive;
- Oxidizers;
- Pyrophorics (materials that can spontaneously ignite);

- Chemicals that in the course of normal handling, use, or storage may produce or release dusts, gases, fumes, vapors, mists, or smoke that may have any of the previously mentioned characteristics; and

- Workplace exposure to approximately 400 substances[1], including dusts, mixtures, and common materials such as paints, fuels, and solvents, currently regulated by OSHA.

3.14.1.1.4 U.S. Department of Transportation Regulations

USDOT Hazardous Materials Regulation 49 CFR Part 171 defines a hazardous material as a substance capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The USDOT definition includes hazardous substances, hazardous wastes, and marine pollutants. The hazardous materials are classified into different classes including explosives, gases, flammable liquid, flammable solids, oxidizing substances/organic peroxides, poisonous (toxic) and infectious substances, radioactive material, corrosives, and miscellaneous dangerous goods. USDOT regulations require the implementation of various protective and preventative measures designed to promote the safe transport of hazardous materials in commerce.

3.14.1.1.5 Right-to-Know Compliance

In 1993, the State of Hawai‘i enacted the Hawai‘i *Emergency Planning and Community Right-to-Know Act* (HRS 128E) which is modeled after the Federal *Emergency Planning and Community Right-to-Know Act*. Hawai‘i Administrative Rules (HAR 11-453) for implementing the Community Right-to-Know regulations became effective in November 2010 and established requirements for State, county, and industry regarding emergency planning and reporting on hazardous and toxic chemicals. The Community Right-to-Know provisions help increase the public’s awareness of the potential chemical hazards present in the community in order to improve chemical safety and protect human health and the environment. Under this regulation, facilities (both large and small) are required to plan for possible emergencies and report chemical information to the Hawai‘i State Emergency Response Commission, county emergency planning committees, and the local fire department. HRS 128E has four major provisions, including Emergency Response Planning, Emergency Release Reporting, Hazardous Chemical Storage and Tier II Reporting, and Toxic Release Inventory Reporting. A facility may be subject to more than one of these provisions depending on the types of chemicals stored, the quantities of stored chemicals, and the facility’s activities. Additional information on each provision can be found at http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/right-to-know-(hepcra)-compliance.

3.14.1.1.6 Under- and Aboveground Storage Tanks

Title 40 CFR Parts 280, promulgated under RCRA, and 281 contain Federal regulations concerning underground storage tanks, including information regarding general operating requirements, release detection, out of service tank systems and closure, purpose, general requirements and scope, and general provisions. The Hawai‘i State underground storage tank regulations require owners and operators to take specific steps to respond to confirmed releases from such tanks. These requirements are specified in HAR Title 11 for underground storage tanks (HAR Title 11 Chapter 281-7) and HRS 342-L. A map and list of known leaking underground storage tanks can be found online using the HDOH Environmental Health Warehouse database and Map Viewer at http://eha-web.doh.hawaii.gov/ehw/MapViewer/Default.aspx?#.

[1] The OSHA Chemical Sampling Information file contains listings for approximately 1,500 substances; EPA’s *Toxic Substance Control Act* Chemical Substances Inventory lists information on more than 62,000 chemicals or chemical substances.

States primarily regulate aboveground storage tanks. However, Hawaiʻi does not have any specific requirements. The Hawaiʻi Water Pollution Control Law does prohibit the discharge of any pollutant into State waters without a permit. In addition, the Hawaiʻi Environmental Response Law requires immediate reporting of any hazardous substance release. Hawaiʻi also requires that the owner or operator of a tank control air pollutant emissions from each tank.

3.14.1.1.7 Pesticides

The Federal *Insecticide, Fungicide and Rodenticide Act of 1972* (as amended by Title 7 U.S.C. §§ 136–136y) regulate registration and use of pesticides. Pesticide management activities are subject to Federal regulations contained in 40 CFR Parts 162, 166, 170 and 171 (1998) and the Hawaiʻi Pesticides Law. Hawaiʻi Code Division 1 Title 11 Chapter 149A is the State of Hawaiʻi's law that authorizes the Hawaiʻi Department of Agriculture to make and enforce pesticide rules for Hawaiʻi.

3.14.1.1.8 Asbestos

Asbestos is a mineral fiber that can cause cancer or asbestosis when inhaled; it has the potential to pollute air and water. The EPA regulates asbestos with the authority promulgated by OSHA (29 U.S.C. §§ 669 *et seq*.). Emissions of asbestos fibers to ambient air are regulated under Section 112 of the *Clean Air Act*. EPA has banned the use of asbestos in manufacturing or construction; however, asbestos-containing materials may be present in buildings constructed before 1973 based on the type of insulation materials that were used at the time. HAR Title 11 Chapter 501-7 provides standards for demolition and renovation work in Hawaiʻi with regard to asbestos, and requires surveys and notices to document work in which asbestos-containing building materials may be a concern. Asbestos abatement is frequently an issue of concern when remodeling older buildings to make them more energy efficient.

3.14.1.1.9 Lead-Based Paint

On October 28, 1992, Congress passed the *Residential Lead-Based Paint Hazard Reduction Act of 1992* (42 U.S.C. §§ 4851–4856, commonly called Title X). This Act along with associated EPA rules provide for lead-based paint hazard reduction and worker and resident notification and protection. Lead-based paint may be present in buildings constructed before 1992 based on the type of building materials that were used at the time. Lead-based paint can sometimes be an issue of concern when remodeling older buildings to make them more energy efficient.

3.14.1.1.10 Polychlorinated Biphenyls

The *Toxic Substances Control Act* became law in 1976. This Act authorized EPA to secure information on all new and existing chemical substances, as well as to control any substances that were determined to cause unreasonable risk to public health or the environment. Current PCB regulations can be found at 40 CFR Part 761. PCBs have been used in a wide variety of materials, including electrical equipment such as transformers and caulking around doors and windows.

3.14.1.1.11 Arsenic

Arsenic is a naturally occurring element in the earth's crust. In Hawaiʻi, low levels of arsenic are found naturally in native soils and are also naturally present in most produce. However, elevated levels of arsenic have been identified in soils at former sugar cane fields, former pesticide mixing areas, former sugar cane plantation camps, a former cane production plant, wood-treatment plants, and at least one former golf course. The State has also indicated that arsenic may be present in canec building materials, which were manufactured in Hawaiʻi from the early 1930s to the early 1960s. Canec is the common name for a fiberboard building material that was made from sugar cane bagasse, the residual fiber that remained after the juice was extracted from the sugarcane. Canec was treated with inorganic arsenic compounds as an anti-termite agent. Canec was used for interior ceilings and walls in many residential and commercial structures throughout the State of Hawaiʻi. As such, the HDOH published technical guidance for soils and for safe management practices during the handling, demolition, and disposal of soils or materials with arsenic. In addition, the HDOH published maps of sugar cane lands from 1920 to 1937 that indicate sugar plantations that could have used arsenic herbicides. It is important to note that while a plantation may be included on the maps, it is not positively identified as having used arsenic. HDOH generally advises to test these areas soil for arsenic residues, prior to redeveloping the land. This map can be found online at http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/soil-arsenic-guidance-and-information.

3.14.1.2 Munitions and Explosives of Concern

As a result of the large military presence in Hawaiʻi over the past hundred years, the potential exists for encountering Munitions and Explosives of Concern (MEC) on both land and in the ocean. MECs are military munitions that pose an explosive safety risk and include unexploded ordnance (UXO) and discarded military munitions (DMM). Until 1972, munitions disposal included burning, burial, on-land or disposal at sea, with sea disposal considered one of the safest alternatives until Congress prohibited the practice by passing the *Marine Protection, Research, and Sanctuaries Act*. Today, MEC is considered a threat to public health since it may detonate if disturbed, and may also threaten soil, surface water, and groundwater.

MEC's are regulated by the *Federal Facility Compliance Act* (FFCA), which requires that the EPA, in consultation with DoD and the states, publish regulations [thereafter named the Military Munitions Rule (62 FR 6621, February 12, 1997)] that identify when conventional and chemical military munitions (waste military munitions) become hazardous waste (and subject to Subtitle C of RCRA), and provide for the safe storage and transportation of such waste. There are many policies and guidelines that govern most aspects of military munitions and military munitions siting; cleanup operations and standards; and transport of UXO, UXO workers, and property transfers under the Military Munitions Rule. These include DoD and service-specific directives, policies, and guidelines. The service-specific policies usually reiterate the DoD policies and directives but may also provide additional details and specific policies usually reiterate the DoD policies and directives but may also provide additional details and requirements pertinent to that service. Specific services include the U.S. Army, U.S. Navy, and the U.S. Air Force. U.S. Marine Corps ranges tend to follow U.S. Navy guidelines while Army National Guard Ranges tend to follow U.S. Army policies. Most munitions-related investigations and cleanup are performed by or in conjunction with various DoD agencies. DoD is responsible for all military munitions.

The WMM is managed to minimize health hazards and environmental damage caused by the use or misuse of hazardous material. Under RCRA, MECs are considered hazardous waste when such munitions are used, fired or disposed of. In order to improve public safety and reduce the risk that munitions pose to present and future generations, the DoD developed the Military Munitions Response Program (MMRP), which addresses potentially hazardous military munitions located in former on- and offshore disposal sites around the nation. Those properties known or suspected to contain MECs, UXO, or DMM are referred to as Munition Response Sites (MRSs).

3.14.1.3 Affected Environment

The biggest location-specific hazardous materials concerns are associated with the presence of contaminated soil and/or groundwater. To evaluate areas where these hazardous materials may be present, two main sources of information were queried: the EPA Superfund Information System (http://cumulis.epa.gov/supercpad/cursites/srchsites.cfm) and the HDOH Office of Hazard Evaluation and

Emergency Response lookup spreadsheets (HDOH 2012c). The Superfund database contains information on hazardous waste sites, potentially hazardous waste sites, and remedial activities across the nation, including sites that are on the NPL or being considered for listing. The database was frozen on November 12, 2013, to allow EPA to develop and deploy the new Superfund Enterprise Management System (expected in early 2014). The HDOH spreadsheets list environmental interests that Hazard Evaluation and Emergency Response Office has investigated or may investigate. The Emergency Preparedness and Response or Site Discovery, Assessment and Remediation sections within that Office manage environmental interests. These databases are updated by the EPA and the State, respectively. Readers are directed to the following websites for additional information: http://cumulis.epa.gov/supercpad/cursites/srchsites.cfm and http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/public-records.

In the event any of the identified areas should be chosen for development, it would be necessary to perform detailed investigations including a site-specific environmental assessment in conformance with ASTM Method E 1527 05 (ASTM 2005), which would provide for detailed review of accessible public records and require site inspections to confirm the presence of affected sites at or near the project-specific location.

Additional location-specific hazardous material concerns are associated with the presence of munition and explosives of concern sites, which are designated as Munitions Response Sites by the military. To evaluate areas where these hazardous materials may be present, the Munitions Response Sites Inventory was queried (DENIX 2014a). A total of 55 munitions response sites were identified within the State, including one in American Samoa, and six offshore sites or sea disposal military munition sites as shown in Figure 3-77. Four sites did not have maps to show exact locations. Information regarding these munitions response sites, particularly MECs are listed below.

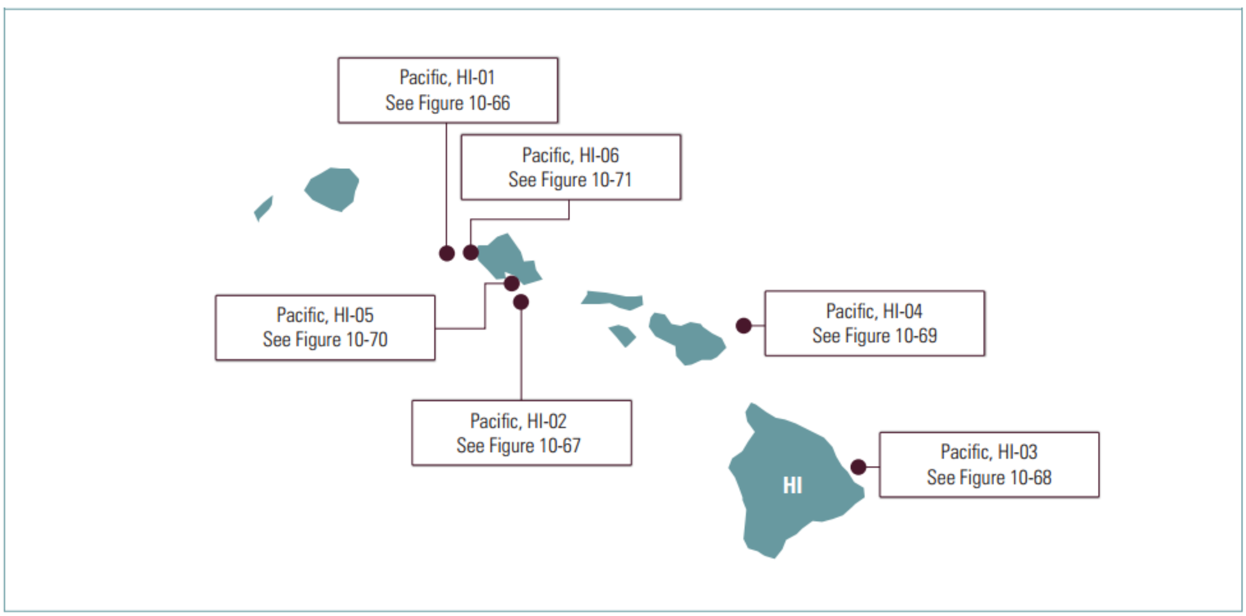


Figure 3-77. Approximate Locations of Munitions Disposals in Hawai‘i (Source: DENIX 2014b)

Once the locations of a project are determined, it would be necessary to perform detailed investigations including a site-specific Environmental Site Assessment in conformance with the ASTM Method E 1527-05 (ASTM 2005) including an evaluation of the presence of MEC at the project-specific locations and along possible project location alignments as the presence of dumped materials could impact project alignment, construction, and maintenance.

3.14.1.3.1 Kaua‘i

A review of the EPA Database for Kaua‘i identified five Superfund sites, as shown in Table 3-63; none is on the NPL.

A total of 389 Emergency Preparedness and Response and 85 Site Discovery, Assessment and Remediation sites are listed on the Lookup Spreadsheets for Kaua‘i. Two 290 Site Discovery, Assessment and Remediation sites were identified as a State High Priority Contamination Site: the Grace Pacific Corporation - Hanamaulu Facility and the Lihue Plantation Combined Sites Facility.

Table 3-63. Superfund Sites on Kaua‘i

Site Name	City	County
Brewer Chemical Corp	Lihue	Kaua‘i
Kaua‘i Agricultural Research Center	Wailua	Kaua‘i
Kekaha Sugar Co., Ltd - Former Wood Treatment And Herbicide Mixing Plant	Kekaha	Kaua‘i
Kekaha Sugar Co., Ltd.	Kekaha	Kaua‘i
Lihue Plantation Company, Ltd.	Lihue	Kaua‘i

Source: EPA 2013b.

Four munitions response sites were identified on and around the island of Kaua‘i as shown in Table 3-64.

Table 3-64. Munitions Response Site Inventory Search Results/MEC Sites – Kaua‘i

Site Name	Installation Type
Ahukini	Formerly Used Defense Site
Waimea Training Site	Formerly Used Defense Site
Grove Farm Arty Imp	Formerly Used Defense Site
Barking Sands PMRF	Navy

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

3.14.1.3.2 O‘ahu

A review of the EPA Database for O‘ahu identified 70 Superfund sites (see Table 3-65); three of which are on the Final NPL (NPL Status Code “F”): the Del Monte Corporation (O‘ahu Plantation) site, the Naval Computer and Telecommunications Area Master Station Eastern Pacific site, and the Pearl Harbor Naval Complex site; 13 of which are a part of a NPL site (NPL Status Code “A”); two of which were removed from the proposed NPL (NPL Status Code “R); and one that was deleted from the Final NPL (NPL Status Code “D”). Figure 3-78 shows the location of the three sites that are on the Final NPL (listed in bold in the table below).

Table 3-65. Superfund Sites on O‘ahu

Site Name	City	County
Aloha Tower Development	Honolulu	Honolulu
Barbers Point Naval Air Station	Barbers Point	Honolulu
Bellows Air Force Station	Waimanalo	Honolulu
Brewer Chemical Corp	‘Ewa Beach	Honolulu
Chemwood Treatment Co, Inc.	‘Ewa Beach	Honolulu
Cyprus Hawaiian Cement Corp	‘Ewa Beach	Honolulu
Defense Reutilization & Mktg Reg-Pac	Pearl City	Honolulu

Table 3-65. Superfund Sites on O‘ahu (continued)

Site Name	City	County
Del Monte Corp. (O‘ahu Plantation)	**Kunia**	**Honolulu**
‘Ewa Sugar Mill/O‘ahu Sugar Co.	‘Ewa Beach	Honolulu
‘Ewa Sugar Mill/O‘ahu Sugar Co. - Coral Waste Pit	‘Ewa Beach	Honolulu
‘Ewa Sugar/O‘ahu Sugar Co. - Pesticide Mixing And Loading Site	‘Ewa Beach	Honolulu
Farrington High School	Honolulu	Honolulu
Fort Kamehameha Disposal Site	Hickam AFB	Honolulu
Fort Shafter	Fort Shafter	Honolulu
Golden Melon Farms	Waimanalo	Honolulu
Hawai‘i Mercury	Honolulu	Honolulu
Hawai‘i Metals Recycling Co.	‘Ewa Beach	Honolulu
Hawai‘i Project Management	‘Ewa Beach	Honolulu
Hawai‘i Staging and Lighting	Honolulu	Honolulu
Hickam Air Force Base	Honolulu	Honolulu
Honolulu International Airport	Honolulu	Honolulu
Honolulu Skeet Club	Kailua	Honolulu
Jackson Construction Landfill	‘Ewa Beach	Honolulu
Kapa‘a Landfill	Kailua	Honolulu
Kapalama Incinerator	Honolulu	Honolulu
Keehi Lagoon Canoe Facility	Honolulu	Honolulu
Kipapa Fuel Storage Annex	Mililani	Honolulu
Kure Atoll, U.S. Coast Guard	Honolulu	Honolulu
Leeward Auto Wreckers, Inc.	‘Ewa Beach	Honolulu
Maili Kai Emergency Access Road Site	Wai‘anae	Honolulu
Maipalaoa Road	Wai‘anae	Honolulu
Mākua Military Reservation Ordn Disp	Wai‘anae	Honolulu
Marine Corps Base Hawai‘i	Kāne‘ohe	Honolulu
Mount Ka‘ala Natural Area Reserve	Waialua	Honolulu
Naval Computer And Telecommunications Area Master Station Eastern Pacific	**Wahiawa**	**Honolulu**
Naval Magazine Lualualei	‘Ewa Beach	Honolulu
Naval Submarine Base	Pearl Harbor	Honolulu
NRTF Lauluafei	Wahiawa	Honolulu
Opana	Wahiawa	Honolulu
Pahe Plantation	Waimanalo	Honolulu
Pearl City Fuel Annex	Pearl City	Honolulu
Pearl Harbor Naval Complex	**Pearl Harbor**	**Honolulu**
Pearl Harbor Naval Shipyard	Pearl Harbor	Honolulu
Pearl Harbor Naval Station	Pearl Harbor	Honolulu
Pearl Harbor Naval Supply Center	Pearl Harbor	Honolulu
Pearl Harbor Navy Public Works Center	Pearl Harbor	Honolulu
Pearl Harbor PWC Makalapa Pesticide Pit	Pearl Harbor	Honolulu
Poamoho Rag Disposal Area	Schofield	Honolulu
Pukoloa Wood Treating Site	Honolulu	Honolulu
Schofield Barracks (US Army)	Schofield	Honolulu
Schofield Barracks San Landfill	Wahiawa	Honolulu
Scott’s Plating	Kāne‘ohe	Honolulu
Shore Intermediate Maintenance Activity	Pearl Harbor	Honolulu
Takamiya Property	Honolulu	Honolulu
Tripler Army Medical Center	Tripler Amc	Honolulu

Table 3-65. Superfund Sites on Oʻahu (continued)

Site Name	City	County
U S Navy Exchange Laundry Facility	Pearl Harbor	Honolulu
U.S. Coast Guard Omega Station	Kāneʻohe	Honolulu
Unocal/Iwile Tank Farm	Honolulu	Honolulu
U.S. Air Force Waikakalaua Fuel Storage Annex	Wheeler Army Airfield	Honolulu
U.S. Navy Fleet Training Group	Pearl Harbor	Honolulu
Vermiculite of Hawaiʻi, Inc.	Honolulu	Honolulu
Waialua Sugar Mill	Waialua	Honolulu
Waiʻanae PERC and PCBs Site	Waiʻanae	Honolulu
Waiawa Gulch	Pearl City	Honolulu
Waiawa Gulch-Industrial Park/Stream	Pearl City	Honolulu
Waiawa Shaft	Oʻahu	Honolulu
Waimanalo Groundwater Investigation	Waimanalo	Honolulu
Waipahu Ash Dump	Waipahu	Honolulu
Waipahu Wells	Oʻahu	Honolulu
Wheeler Air Force Base	Wheeler Army Airfield	Honolulu

Source: EPA 2013b.

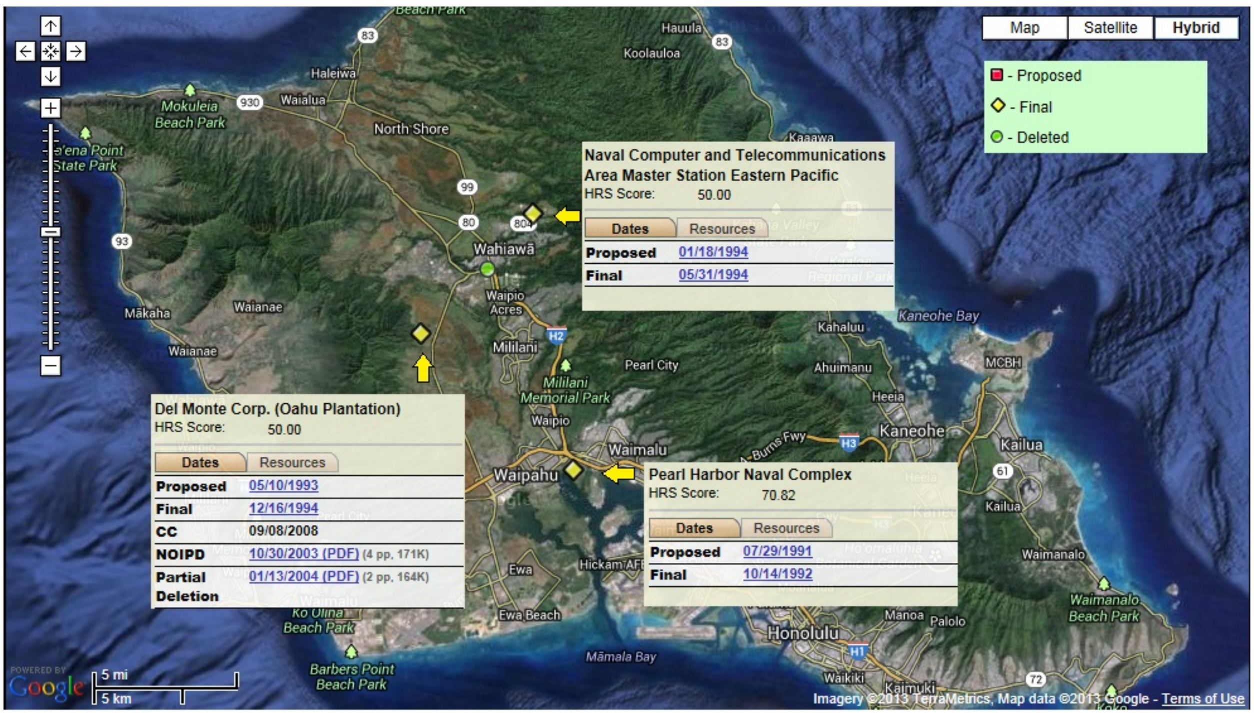


Figure 3-78. Final NPL Sites on Island of Oʻahu (Source: EPA 2013b)

A total of 8,400 Emergency Preparedness and Response and 1,290 Site Discovery, Assessment and Remediation sites were listed on the Lookup Spreadsheets for the island of Oʻahu. Ninety-four are identified as a State High Priority Contamination Site; approximately half of which are owned by the U.S. Air Force and associated with multi-family housing at Hickam Air Force Base, the rest of the sites are spread out across the island.

A total of 25 munitions response sites were identified on or around the island of Oʻahu as shown in Table 3-66. Among the 25, four were identified as sea munition disposal sites as shown in Table 3-67.

Table 3-66. Munitions Response Site Inventory Search Results/MEC Sites – Oʻahu

Site Name	Installation Type
Bellows Air Force Station	Air Force
Fort Shafter	Formerly Used Defense Sites
Mākua Military Reservation	Formerly Used Defense Sites
Schofield Barracks	Formerly Used Defense Sites
Waikakalaua Ammo Storage Tunnels	Formerly Used Defense Sites
Wheeler Army Airfield	Formerly Used Defense Sites
Hickam Mil AF	Formerly Used Defense Sites
Dillingham Air Force Base	Formerly Used Defense Sites
Gun Battery	Formerly Used Defense Sites
Heeia Combat Training Camp	Formerly Used Defense Sites
Kahuku Training Camp	Formerly Used Defense Sites
Makapuʻu Light House Res	Formerly Used Defense Sites
Oʻahu Island Target	Formerly Used Defense Sites
Pacific Jungle Combat	Formerly Used Defense Sites
Pali Training Camp	Formerly Used Defense Sites
Rabbit Island	Formerly Used Defense Sites
Waikane Training Area	Formerly Used Defense Sites
Site 3	Formerly Used Defense Sites
Site 3A	Formerly Used Defense Sites
Waimea Falls Park	Formerly Used Defense Sites
Offshore Waiʻanae Sewage Outfall	Formerly Used Defense Sites
Lualualei Navmag	Navy
Pearl Harbor NS	Navy
Kāneʻohe Bay MCB	Navy
Camp H.M. Smith Oʻahu	Navy

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

Table 3-67. Sea Munition Disposal Sites – Oʻahu

Site	Distance from Shore (nautical miles)	Depth (feet)	Item/Fill
HI-01	11	> 6,000	Mustard projectiles, Lewisite container, Cyanogen Chloride and Cyanide bombs, and other materials (including small arms, explosives, incendiary, propellants, and inert items)
HI-02	10	> 1,500	Mustard projectiles, small arms ammunition, explosives, incendiary, and propellants
HI-05	> 5	> 2,000	Mustard bombs and stokes mortar
HI-06	1	>25	Small arms ammunition, explosives, and ammunition boxes.

Source: DENIX 2014a.

3.14.1.3.3 Molokaʻi

A review of the EPA Database for Molokaʻi identified one Superfund site: the Kīlauea Pesticides site, which is not on the NPL. This site is being addressed only by the Federal Superfund removal program and not by the Site assessment program; therefore, no site assessment work is required.

A total of 64 Emergency Preparedness and Response and 28 Site Discovery, Assessment and Remediation sites were listed on the Lookup Spreadsheets on Molokaʻi. None are identified as a State

High Priority Contamination site. One munitions response site was identified on or around the island of Molokaʻi as shown in Table 3-68.

Table 3-68. Munitions Response Site Inventory Search Results/MEC Sites – Molokaʻi

Site Name	Installation Type
Molokaʻi Bombing Targets	Formerly Used Defense Site

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

3.14.1.3.4 Lānaʻi

A review of the EPA Database for Lanaʻi identified no Superfund sites.

A total of 29 Emergency Preparedness and Response sites were listed in the Lookup Spreadsheets. None was listed as a Site Discovery, Assessment and Remediation site. None was identified as a State High Priority Contamination site. One munitions response site was identified on around the island of Lānaʻi as shown in Table 3-69.

Table 3-69. Munitions Response Site Inventory Search Results/MEC Sites – Lānaʻi

Site Name	Installation Type
Lānaʻi Bombing Targets	Formerly Used Defense Site

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

3.14.1.3.5 Maui

A review of the EPA Database for Maui identified eight Superfund sites (shown in Table 3-70); none is on the NPL.

Table 3-70. Superfund Sites on Maui

Site Name	City	County
Bird Builders	Kahului	Maui
F & M Contractors, Inc.	Kahului	Maui
Ilio Point Former Loran Station Dump Site	Molokaʻi	Maui
Kahoʻolawe Island	Kihei	Maui
Kalamaula Landfill	Kaunakakai	Maui
Kanaha Pond West	Kahului	Maui
Paia Sugar Mill	Paia	Maui
Pioneer Mill Company	Lahaina	Maui

Source: EPA 2013b.

A total of 808 Emergency Preparedness and Response and 137 Site Discovery, Assessment and Remediation sites were listed in the Lookup Spreadsheets for Maui. Two are identified as a State High Priority Contamination Site: the Maui Corn Mill Camp and the Wailuku Sugar Company Pesticide Mixing Area. One munitions response site located offshore in Maui County was found to be associated with MEC sites as shown in Table 3-71.

Table 3-71. Munitions Response Site Inventory Search Results/MEC Sites – Maui

Site	Distance from Shore (nautical miles)	Depth (feet)	Item/Fill
HI-04	10	> 5,500	Mustard projectiles

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

3.14.1.3.6 Hawai‘i

A review of the EPA Database for Hawai‘i island identified 18 Superfund sites (shown in Table 3-72); none is on the NPL.

Table 3-72. Superfund Sites on Hawai‘i

Site Name	City	County
Army Aviation Support Facility #2	Hilo	Hawai‘i
Hakalau Plantation Company	Hakalau	Hawai‘i
Hakimo Road Aka Botelho	Wai‘anae	Hawai‘i
Hilo Arsenic Spill Site	Hilo	Hawai‘i
Hilo Burrito	Hilo	Hawai‘i
Kailua-Kona Landfill	Kailua Kona	Hawai‘i
Kea‘au Arsenic Sites	Kea‘au	Hawai‘i
Kīlauea Volcano Air Monitoring	Hilo	Hawai‘i
Kohala Sugar Company - Pesticide Mixing Area	Kapaau	Hawai‘i
Mauna Kea Sugar Co. - Hilo Pesticide Mixing Area	Hilo	Hawai‘i
Old Kona Landfill	Kailua	Hawai‘i
Paauhau Sugar Plantation	Paauhau	Hawai‘i
Pohakuloa Training Area	Hilo	Hawai‘i
Puna Geothermal Venture	Pahoa	Hawai‘i
Puna Sugar Mill	Kea‘au	Hawai‘i
Waiakea Pond/Hawaiian Cane Products Plant	Hilo	Hawai‘i
Waimanalo Gulch Sanitary Landfill Site	O‘ahu	Hawai‘i
Waipunalei Seed Cane Dipping Plant	Laupahoehoe	Hawai‘i

Source: EPA 2013b.

A total of 808 Emergency Preparedness and Response and 206 Site Discovery, Assessment and Remediation sites were listed in the Lookup Spreadsheets for the island of Hawai‘i. Thirteen Site Discovery, Assessment and Remediation sites were identified as a State High Priority Contamination Site; the majority of which were found to have arsenic soil contamination. One munitions response site located off the coast of the Hawai‘i County was found to be associated with MECs as shown in Table 3-73.

Table 3-73. Munitions Response Site Inventory Search Results/MEC Sites – Hawai‘i

Site	Distance from Shore (nautical miles)	Depth (feet)	Item/Fill
HI-03	11	>6,000	Explosives

Source: DENIX 2014a.
MEC = Munitions and Explosives of Concern.

3.14.2 WASTE MANAGEMENT

Waste management involves the collection, handling, storage, and disposal of various waste streams including residential, commercial, industrial, and special waste. In an island state like Hawaiʻi, waste management options are severely limited by the shortage and expense of available land. Burying wastes in island landfills is not a sustainable strategy for the long term. As such, new waste management approaches and technologies are continuously being identified, including harnessing waste streams as potential sources of biomass energy. This section includes a discussion of the quantities and types of waste generated and current management practices (treatment, storage, and disposal) by island. The following sections also discuss the status of existing recycling and zero waste programs on each island. This PEIS provides a separate discussion on hazardous waste in Section 3.14.1.

3.14.2.1 Regulatory Setting

3.14.2.1.1 Resource Conservation and Recovery Act

In addition to its regulation of hazardous materials, RCRA also includes waste management provisions. Subtitle D of the RCRA encourages environmentally sound solid waste management practices that maximize the reuse of recoverable materials and foster resource recovery. Additional regulations governing solid waste management are often adopted by states and tribes.

3.14.2.1.2 State of Hawaiʻi

HRS 342-G, “Integrated Solid Waste Management,” HRS 342-H, “Solid Waste Pollution,” HRS 342-I, “Special Waste Management,” and HRS 342-J, “Hazardous Waste,” regulate waste management in the State. In addition, HAR 11-58.1, “Solid Waste Management Control,” governs the design, construction, installation, operation, and maintenance of solid waste disposal, recycling, reclamation, and transfer systems, as well as of special waste in the State. The Solid Waste Management section within the HDOH Solid and Hazardous Waste Branch enforces these rules and regulations.

3.14.2.1.3 Hawaiʻi Revised Statutes on Integrated Solid Waste Management

HRS 342-G, “Integrated Solid Waste Management,” requires each county to develop an integrated solid waste management plan and revise the Plan once every five years. Beyond the State of Hawaiʻi’s solid waste management planning requirement, the City and County of Honolulu adopted legislation that requires the development of a 25-year plan, which is updated every five years.

3.14.2.1.4 Kauaʻi County Code

Kauaʻi County Code Chapter 21, “Integrated Solid Waste Management,” establishes the minimum standards governing the refuse collection services for the county, and the handling, proper disposal processing, disposal, recycling, reuse, and salvage of solid waste at refuse transfer stations, debris recycling stations, temporary emergency debris receiving sites, residential drop-off recycling centers, and landfills the County of Kauaʻi owns or operates.

In August 2010, the County of Kauaʻi adopted Ordinance 902, banning the landfill disposal of commercially generated loads exceeding 10-percent corrugated cardboard, 10-percent ferrous and non-ferrous metal, or 10-percent greenwaste by volume. Businesses and garbage haulers that exceed the 10-percent limit by volume are subject to load rejection and penalties. In addition, businesses and haulers are required to collect and store cardboard separately from waste to keep it clean and dry and to prevent contamination.

3.14.2.1.5 The City and County of Honolulu Revised Ordinances

Waste disposal services and recycling is governed on Oʻahu by the City and County of Honolulu's Revised Ordinances of Honolulu: Chapter 9, "Collection and Disposal of Refuse" (City and County of Honolulu 2013b). The Ordinance includes general provisions regarding the collection and disposal of refuse, licensing regulations to collect refuse, regulations applicable to businesses, private dwellings, and government facilities, collection and disposal charges, enforcement provisions and arrest, the recycling of glass containers, glasphalt paving, and the regulation of bags provided to customers.

3.14.2.1.6 Maui County Code

Maui County Code Chapter 8.04, "Refuse Collection and Landfills," establishes the means by which all solid waste in the County of Maui is collected, disposed of, and/or recycled. The Code includes regulations on collection arrangements, private disposal dumps, collection charges, disposal permits and charges, the rulemaking authority, and the penalties that would be imposed for violations. Rules for refuse collection for the island of Lānaʻi are authorized by the existing director of the Maui County Department of Environmental Management. There are no specific regulations in the Maui County Code for refuse collection and landfills for the island of Molokaʻi.

3.14.2.1.7 Hawaiʻi County Code

County laws and regulations associated with waste management in Hawaiʻi County include Hawaiʻi County Code, Chapter 20, "Refuse," and the County of Hawaiʻi Administrative Rules for Solid Waste Refuse Control and Disposal Fees. In addition, in 2007, the Hawaiʻi County Council adopted resolution 356-07 on a mission to reduce the county's ecological footprint. In February 2009, the County of Hawaiʻi revised the *Draft Zero Waste Implementation Plan*, which promotes the reduction, reuse, and recycling of waste in the county (County of Hawaiʻi 2009).

3.14.2.2 Affected Environment

All solid waste generated across the Hawaiian Island chain is managed within each island. Across the islands, various city and county landfills, transfer stations, and privately owned solid waste operations exist to manage the ever-growing production of solid waste.

3.14.2.2.1 Kauaʻi

For the fiscal year 2010–2011, the island of Kauaʻi generated approximately 93,000 tons of waste (HDOH 2011b). This was projected to increase to more than 157,000 tons through 2013 (R.W. Beck 2009). The Kauaʻi County integrated solid waste management plan did not include projections beyond 2013. Of the 93,000 tons of waste that was generated in Kauaʻi, approximately 23.8 percent (22,000 tons) was diverted from Kauaʻi's landfills for reuse and recycling activities. The County of Kauaʻi Department of Public Works, Solid Waste Division is responsible for the collection and disposal of garbage and refuse. Figure 3-79 shows a map of the solid waste facilities including the landfills that serve the County of Kauaʻi.

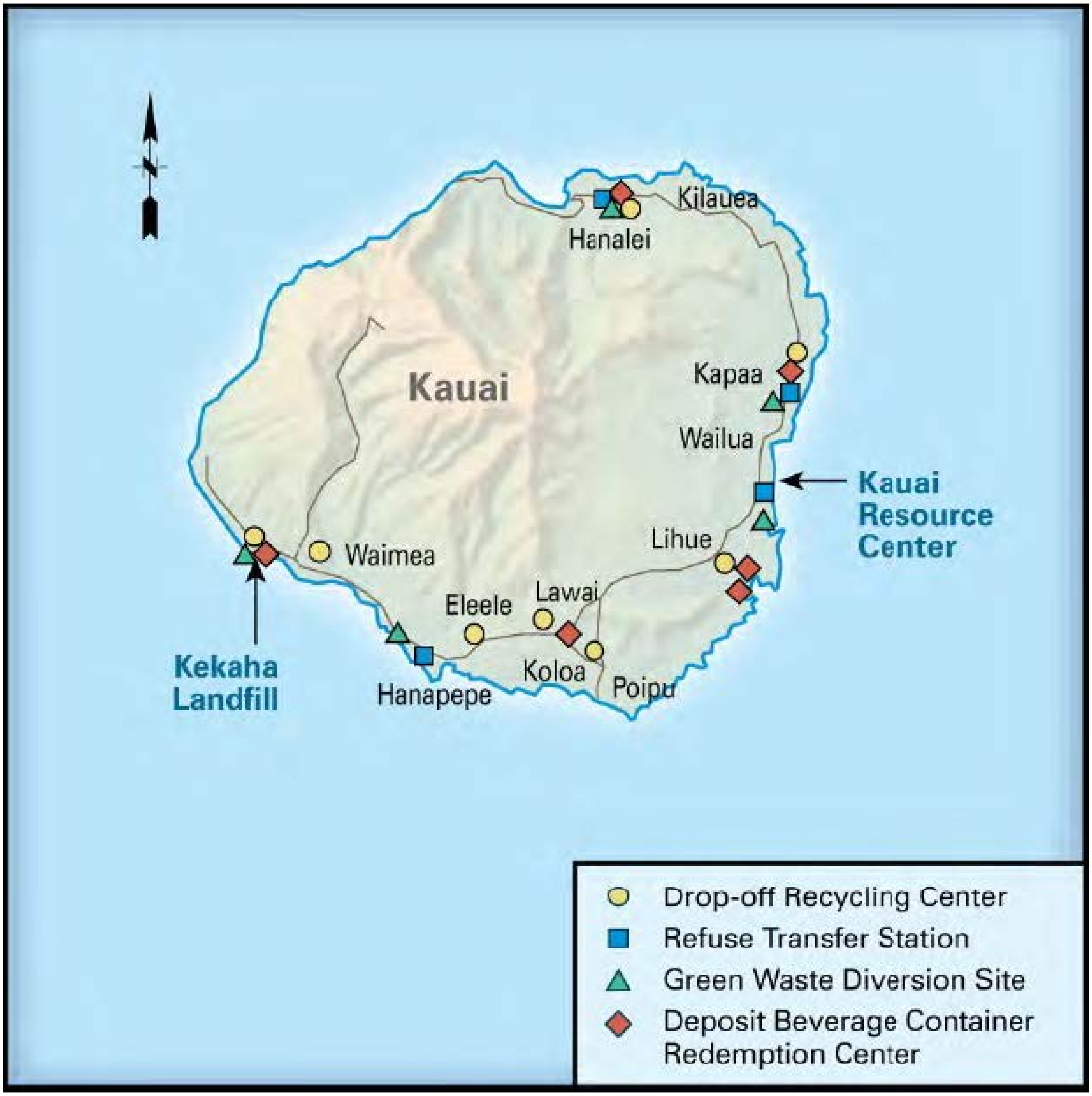


Figure 3-79. County of Kaua'i Solid Waste Management Facilities (Source: R.W. Beck 2009)

Kaua'i is served by the Kekaha Phase II Landfill, which accepts residential and RCRA Subtitle D commercial solid waste. Subtitle D includes nonhazardous solid wastes and certain hazardous wastes that are exempt from the Subtitle C regulations, such as hazardous wastes from households and from conditionally exempt small quantity generators. Subtitle D also includes garbage (e.g., food containers, coffee grounds); non-recycled household appliances; residue from incinerated automobile tires; refuse such as metal scrap and construction materials; and sludge from industrial and municipal wastewater facilities and drinking water treatment plants.

The landfill is projected to reach capacity in mid-2014. Therefore, the County of Kaua'i currently is in the process of designing and permitting a vertical expansion to increase the landfill's permitted height to 120 feet, which would provide an additional estimated 317,000 cubic yards of airspace (County of Kaua'i

2013a and County of Kaua‘i 2013b). The vertical expansion is projected to allow landfill operations for up to 5 years, or when the county anticipates having a new landfill in operation.

The new landfill project would involve the construction and operation of a new municipal solid waste landfill and a resource recovery park, intended to provide a comprehensive and integrated set of waste management programs and facilities to help maximize the diversion of waste from the landfill via reuse, recycling, and recovery. In July 2012, a new landfill siting study evaluated the suitability of eight sites for the proposed landfill. At the time of preparation of this PEIS, Kaua‘i County was preparing an environmental impact statement for the new landfill, which will include a preliminary design of the proposed resource recovery park. More information on the new landfill is online at http://www.Kaua‘i.gov/Government/Departments/PublicWorks/SolidWaste/NewLandfillSite/tabid/71/Default.aspx.

Refuse Transfer Stations

Waste transfer stations are facilities where municipal solid waste is unloaded from collection vehicles and briefly held while it is reloaded onto larger transport vehicles for shipment to landfills or other treatment or disposal facilities. The island is served by four refuse transfer stations: Hanalei, Kapa‘a, Hanapepe, and Lihue stations. Collection crews deliver refuse to the refuse transfer stations, where it is loaded into high cube (65 to 75 cubic yard capacity) trailers and delivered to the Kekaha Landfill.

Recycling

As part of Kaua‘i County’s Recycling and Waste Management Program, the following are implemented: (1) Source reduction, reuse, and recycling programs; (2) Special waste management programs including junk vehicle, appliance, tire, lead-acid battery, used oil, and household hazardous waste disposal; and (3) A public education/awareness program. The Kaua‘i Resource Center will accept prohibited materials as long as they are first cleaned. The Garden Isle Disposal facility in Lihue accepts larger loads. Ferrous metal is accepted for recycling at Puhi Metals Recycling in Puhi. Non-ferrous metal is accepted for recycling at Reynold’s Recycling in Lihue.

Greenwaste Program

The greenwaste program in Kaua‘i was created to divert residential and commercial greenwaste from the Kekaha landfill. The County currently accepts separated greenwaste for diversion at all four transfer stations and at the landfill. There are six collection crews servicing the entire island.

Greenwaste may be deposited at Heart and Soul Organics in Moloaa, and clean loads of greenwaste may be deposited at Kaua‘i Nursery in Puhi.

3.14.2.2.2 O‘ahu

For the fiscal year 2010-2011, the island of O‘ahu generated approximately 1.2 million tons of waste (City and County of Honolulu 2013c). This is projected to double to approximately 2.4 million by 2030 (R.W. Beck 2008). Of the 1.2 million tons of waste that was generated on O‘ahu, approximately 37 percent (766,000 tons) was diverted from O‘ahu’s landfills. This amount is even higher (up to 73 percent) when the amount of waste converted for energy is taken into account (City and County of Honolulu 2013c). Waste on the island is primarily disposed of at two landfills, the Waimanalo Gulch Sanitary Landfill and the Nanakuli Landfill, three transfer stations, 10 public refuse drop-off centers, and six convenience centers. Figure 3-80 shows a map of the solid waste facilities that serve the island of O‘ahu.

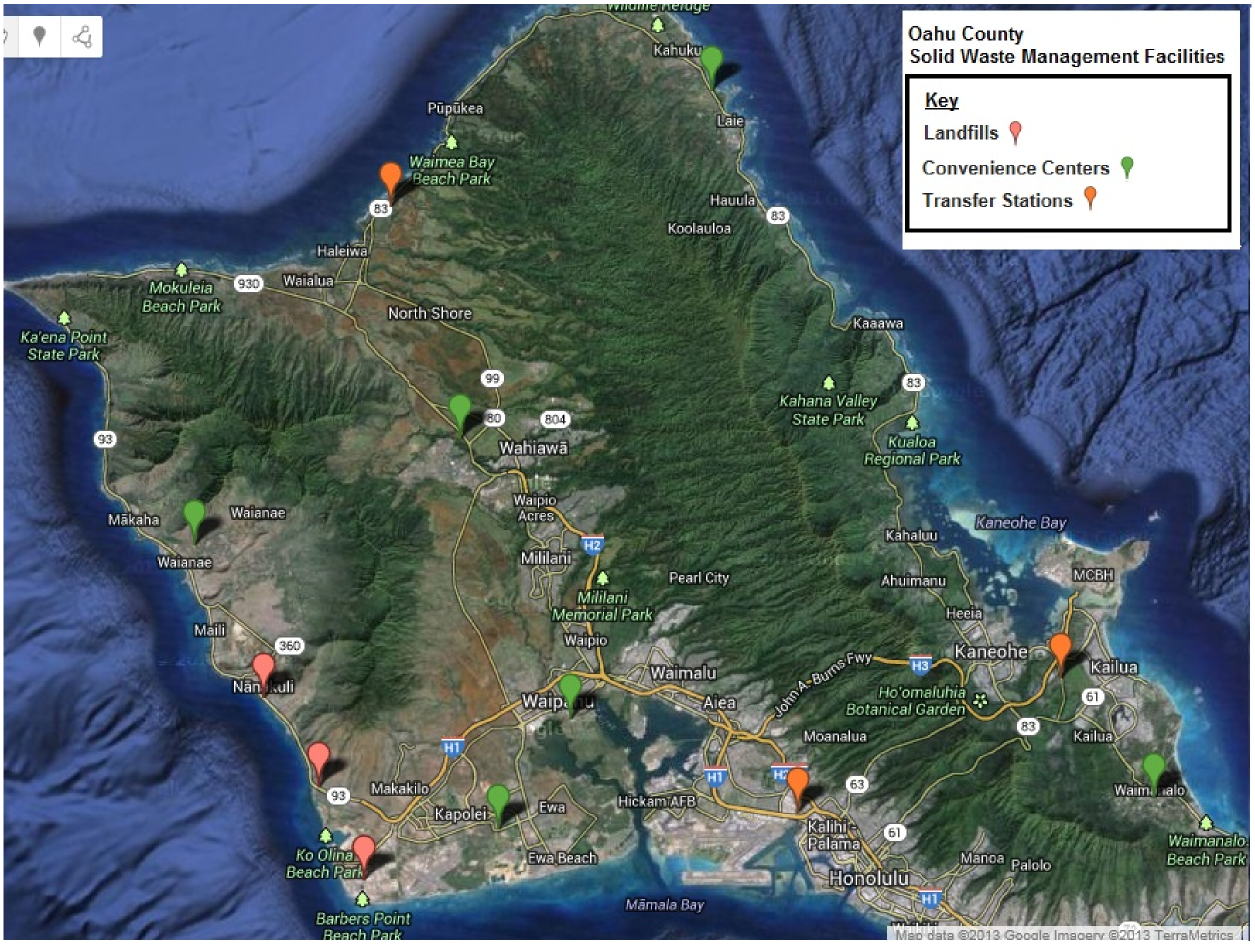


Figure 3-80. Solid Waste Management Facilities on O‘ahu (Source: City and County of Honolulu 2013d)

The City and County of Honolulu owns the Waimanalo Gulch Sanitary Landfill and Waste Management of Hawai‘i operates the landfill. The landfill covers 200 acres and accepted 400,000 tons of municipal solid waste annually. To date, the continued use of the Waimanalo Gulch Sanitary Landfill is being determined. The City and County of Honolulu estimates the physical capacity of the landfill would enable it to continue to receive waste materials for at least the next 15 years. However, in 2009, in response to community opposition to the landfill, the State Land Use Commission (LUC) issued an order requiring the City to begin the process of identifying one or more landfill sites to supplement or replace the landfill by November 2010 (the City’s own integrated solid waste management plan called for the City to identify a new municipal solid waste landfill by 2012). The LUC order acknowledged that it would take the City at least seven years to construct and open a new landfill, but conditioned that the Waimanalo Gulch Sanitary Landfill stop accepting municipal solid waste as of July 2012. The City litigated the condition with the courts, with the Supreme Court striking down the LUC’s condition imposing the MSW deadline. The action was then remanded to the LUC, who remanded the case to the Planning Commission. At this time, the landfill is continuing operations under the current Special Use Permit, while the deadline for receipt of MSW is resolved by the Planning Commission and the LUC (Honolulu City Council 2013). In addition, the City and County of Honolulu is currently evaluating potential landfill sites to supplement or replace the Waimanalo Gulch Sanitary Landfill. Based on a recent Landfill Site Selection Committee report, the Upland Kahuku 2 site is ranked highest of 11 potential sites for a new landfill (City and County of Honolulu 2012c).

The Nanakuli Landfill is a privately owned landfill (owned by PVT Land Company, Ltd.) and only accepts construction and demolition waste and petroleum-contaminated soils (Waste Management 2007; R.W. Beck 2008). Information on the specific annual quantity of materials received at the Nanakuli Landfill is not available; however, it is estimated at approximately 200,000 tons per year. The Nanakuli Landfill reportedly had approximately 18 years of remaining permitted capacity (as of 2008) at its existing fill rate (R.W. Beck 2008). Therefore, it is anticipated that the Nanakuli Landfill has capacity until 2026.

Recycling and Waste-to-Energy

In addition to landfills, Oʻahu employs Covanta Honolulu, known as H-POWER[2], a waste-to-energy facility located in the Campbell Industrial Park, to discard solid waste. According to the City and County of Honolulu, the majority of residential and commercial municipal solid waste discarded on Oʻahu is delivered to H-POWER. Approximately 90 percent of the volume and 70 to 75 percent of the weight of the solid waste processed at H-POWER is diverted from the Waimanalo Gulch Sanitary Landfill to generate electricity. The ash and residue from H-POWER is delivered to the landfill for disposal. In fiscal year 2006, over 600,000 tons of waste were recycled for energy at H-POWER (R.W. Beck 2008). The facility currently processes up to 3,000 tons per day of municipal solid waste and generates up to 90 megawatts of energy for HECO, enough to meet approximately 8 percent of Oʻahu's energy needs. In 2012, the facility completed a 900-ton-per-day expansion, which is expected to increase H-POWER's annual processing capacity by at least 300,000 tons (Covanta 2013). Section 2.3.3.8 of this PEIS discusses the H-POWER facility.

Transfer Stations

The City and County of Honolulu operates three transfer stations in Kapaʻa, Keehi, and Kawailoa that consolidate waste from municipal solid waste collection trucks into large transfer trailers for more efficient and economical transport to H-POWER or the Waimanalo Gulch Sanitary Landfill. In addition to the three municipal transfer stations, two additional private transfer stations operate on Oʻahu: the Honolulu Disposal Transfer Station and the Island Demo Transfer Station. The Honolulu Disposal Transfer Station accepts municipal solid waste from its own company's trucks. The Island Demo facility receives construction and demolition waste, sorts materials for recycling, and transfers the non-recyclable portion to H-POWER or the Nanakuli Landfill (R.W. Beck 2008).

3.14.2.2.3 Molokaʻi

The County of Maui's Molokaʻi-Laiwa Landfill and Recycling Center serves the island of Molokaʻi. It accepts municipal solid waste and recycling wastes from commercial and residential customers. The landfill accepts 17.6 tons of trash per day (GBB 2009). Annually, 6,570 tons of trash is disposed of at the landfill (GBB 2009). The Molokaʻi Landfill has a design capacity of 387,000 cubic yards with approximately 166,400 cubic yards of capacity currently remaining (GBB 2009). This capacity is projected to be filled in 2015 (GBB 2009).

The island includes the Molokaʻi Metals Facility located on Mauna Loa Highway at the Molokaʻi-Naiwa Landfill. The Molokaʻi Metals Facility accepts vehicles, motorcycles, appliances, vehicle tires and batteries, metal items such as roofing, gutters, tubs, sinks, faucets, pipes, metal furniture, bicycles, mowers, engine parts, tools, fencing, propane tanks, and ferrous and non-ferrous scrap metals (County of Maui 2013b).

[2] H-POWER stands for the Honolulu Program of Waste Energy Recovery.

3.14.2.2.4 Lānaʻi

The County of Maui's Lānaʻi Landfill, located 4 miles west of Lānaʻi City, serves the island of Lānaʻi. Lānaʻi Landfill accepts commercial and residential waste. The landfill has a disposal capacity of 178,000 cubic yards (GBB 2009). Annually, the landfill has a capacity usage of 13,400 cubic yards, and disposes of 5,127 tons of waste. Per operating day, 19.7 tons of waste is disposed of at the landfill. Lānaʻi Landfill has 178,000 cubic yards of remaining capacity and is projected to reach capacity in 2020 (GBB 2009).

3.14.2.2.5 Maui

Maui County comprises the islands of Maui, Molokaʻi, and Lānaʻi. For the fiscal year 2010- 2011, the islands of Maui County generated approximately 244,000 tons of waste (HDOH 2011b). This is projected to increase to 250,000 tons by 2015 and to approximately 306,000 by 2030 (GBB 2009). Of the 244,000 tons of waste generated in Maui County, approximately 36.6 percent (89,000 tons) was diverted from Maui's landfills. The County of Maui owns and operates two municipal solid waste landfills on Maui, one landfill on Lānaʻi, and one landfill on Molokaʻi. The County Solid Waste Division within the Maui County Department of Environmental Management plans, operates, and maintains the county landfills. Figure 3-81 shows a map of the solid waste facilities including the landfills and recycling centers that serve the County of Maui.

Figure 3-81. Maui County Solid Waste Management Facilities (County of Maui 2013c)

- Central Maui Landfill – The County owns and operates this landfill. It accepts municipal solid waste and serves the entire island of Maui. It is located approximately 3 miles from Kahului Airport. Central Maui Landfill accepts an average of 500 tons of waste per day (County of Maui 2012d). Its existing capacity is 11.6 million cubic yards (County of Maui 2012d). The projected demand of 2030 is 12.4 million cubic yards. Therefore, a shortage of 0.8 million cubic yard will occur if additional space is not created (County of Maui 2012d). Central Maui Landfill is projected to reach capacity in 2026.

- Hana Landfill – This landfill is a 35-acre facility that serves the Hana Community Plan area. The Hana Landfill accepts residential, commercial, and greenwaste.

- Olowalu Recycling and Refuse Convenience Center – This center accepts self-hauled residential waste and is then transferred to the Central Maui landfill.

- Maui Construction and Demolition Landfill – This landfill is the only operating facility in the county that currently accepts construction and demolition debris for recycling. It is privately owned and located near Ma‘alaea. The Maui Construction and Demolition Landfill has a capacity of 872,000 cubic yards of waste. Currently, it accepts approximately 3,000 to 5,000 tons of waste per month (Hart 2007). The facility may cease operations in the near future; however, there are plans for another construction and demolition recovery facility to open on Maui.

Greenwaste and Food Waste

Commercial and residential greenwaste is accepted at the Central Maui Landfill, EKO Compost, Hana Landfill, Maui Earth Compost Company, the Moloka‘i Landfill, and the Olowalu Recycling and Refuse Convenience Center. EKO Compost has the current contract to process greenwaste collected through the County of Maui curbside collection program. Following co-composting with biosolids, the facility sells the compost to contractors and residents on Maui.

Food waste generated at resorts is recycled by Puaa Food Waste. The company uses the food waste at pig farms. The pigs are in turn sold to resorts to be used in luau.

Recycling

There are currently 17 Hawai‘i Deposit Beverage Container Program (HI-5) redemption centers in Maui County. Following collection of HI-5 beverage containers, the materials are transported to either of two materials recycling facilities on Maui, operated by Aloha Recycling and Maui Disposal. The materials recycling facilities bale the HI-5 materials and broker them in out-of-state markets.

The majority of metals recycling on Maui is provided by the Hammerhead Metals Recycling Facility and Maui Tow and Transport. Hammerhead Metals has the current contract with Maui County to process large appliances and disposed-of vehicles from residential sources. Hammerhead Metals also buys valuable metals, such as copper and brass, from the general public. Maui Tow and Transport processes scrap metal, mainly from commercial sources. Several other facilities on Maui accept scrap metal for recycling, including the Central Maui Landfill and Maui Tire Recycling LLC. Following collection, the materials are shipped to various end recyclers.

3.14.2.2.6 Hawai‘i

For the fiscal year 2010-2011, the island of Hawai‘i generated approximately 234,000 tons of waste. This is projected to increase to 316,000 tons by the end of fiscal year 2012-2013 and to approximately 452,000 by fiscal year 2027-2028 (CH2MHill, et al. 2009). Of the 234,000 million tons of waste generated in the County of Hawai‘i, approximately 28.9 percent (68,000 tons) was diverted from the county’s landfills. Waste on the island is served by two County-owned and operated landfills: the South Hilo Sanitary Landfill and the West Hawai‘i Sanitary Landfill, located in Puuanahulu. For residents, the common forms of residual materials sent to either landfill is household refuse, municipal solid waste, and do-it-yourself construction and demolition waste. Businesses and institutions send a wide range of different nonhazardous residual materials from their daily operations (CH2MHill et al. 2009). Commercial disposal of residual waste generally requires a landfill disposal permit through the Hawai‘i County Department of Environmental Management. Figure 3-82 shows a map of the solid waste facilities including the landfills and transfer stations that serve the County of Hawai‘i.

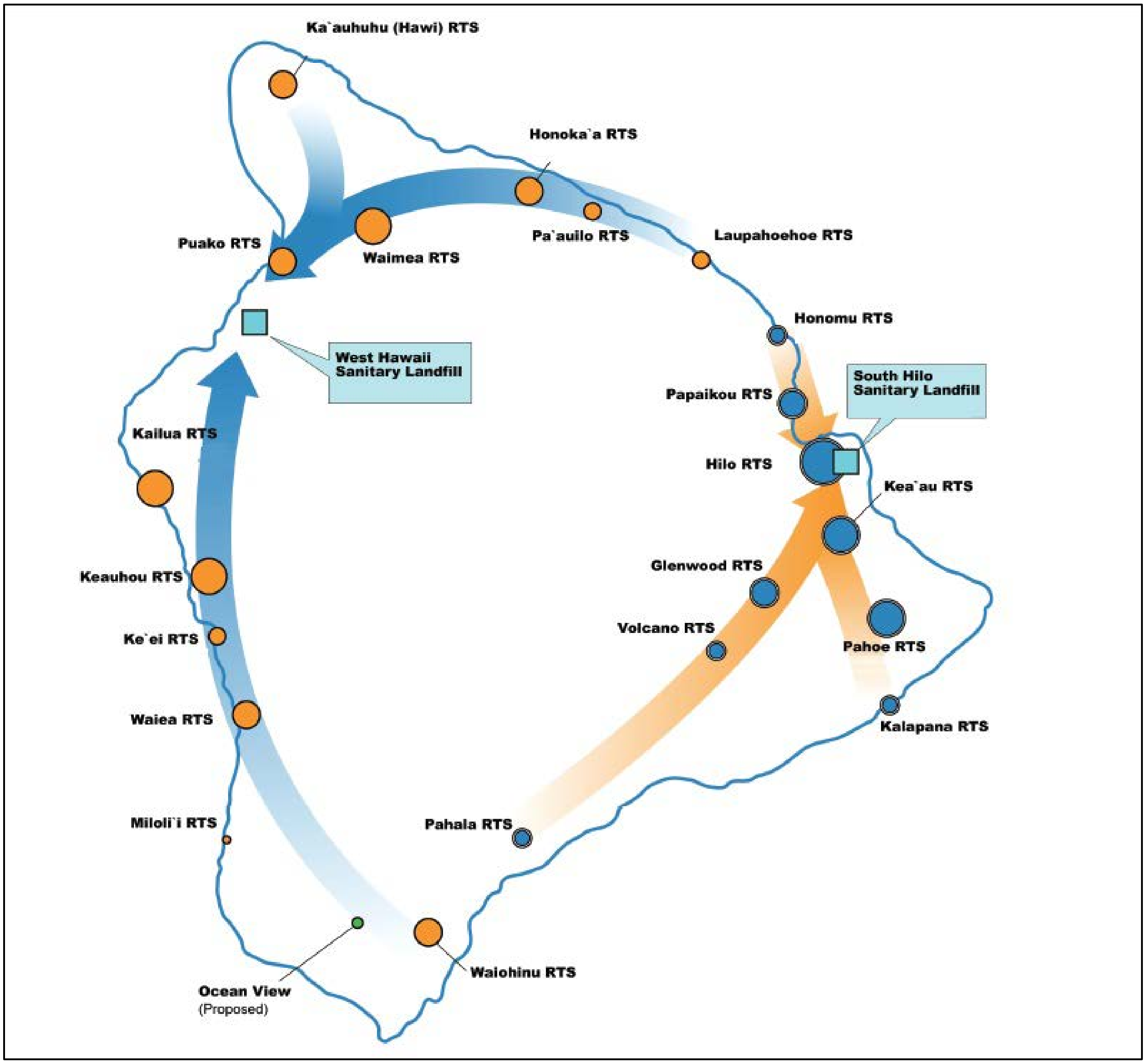


Figure 3-82. Hawai‘i County Landfills and Transfer Stations (Source: CH2MHill et al. 2009)

The South Hilo Sanitary Landfill is located on approximately 40 acres of land in Hilo. Owned and operated by the County of Hawai‘i, the landfill currently accepts waste from the eastern part of the county. The Department of Environment Management estimates that the landfill has been in operation since the 1970s, and was established on a former quarry (currently unlined). In 2003,Hawai‘i County began a focused evaluation of potential options for future disposal of residual waste on the east side of the island because the South Hilo Sanitary Landfill was near its permitted capacity and planned closure date (2006). Unfortunately, the costs of a waste recovery/treatment process proved too costly and the proposed project was abandoned. As such, the capacity of the landfill has been extended by implementing a “sliver fill.” Based on current disposal and recycling rates, the South Hilo Sanitary Landfill is estimated to have capacity through 2015 (R.W. Beck 2012). The 2009 integrated solid waste management plan recommended building a new landfill within the quarry, adjacent to the landfill (if cost-effective) or to transport waste to the West Hawai‘i Sanitary Landfill, another island, or the mainland. The County is currently exploring potential projects that will provide additional recycling or reuse programs that will divert waste from disposal in the South Hilo Sanitary Landfill, including diversion of organics from the waste stream. Therefore, until further information is gained, it is difficult to accurately estimate the year capacity would be reached and how any diversion program would lengthen the life of the landfill (R.W. Beck 2012).

The West Hawaiʻi Sanitary Landfill is located southwest of Waikoloa at Puuanahulu in the North Kona District, and accepts waste from the western part of the county. Waste Management of Hawaiʻi operates the landfill under a contract with Hawaiʻi County, and is currently responsible for construction and development of new landfill cells, environmental monitoring, and closure and post-closure activities. The landfill has been in operation since its construction in 1993, and is located on approximately 300 acres of land, of which 149 acres are currently permitted for landfill activities. The West Hawaiʻi Sanitary Landfill is a RCRA Subtitle-D landfill, lined with a geomembrane and has an engineered leachate collection system. A landfill gas collection and control system was installed in 2006. The landfill accepts approximately 12,000 tons of waste per month, approximately 140,000 tons per year. The landfill has 23 cells currently permitted, of which seven have been filled and two are active. According to the County of Hawaiʻi's *Integrated Solid Waste Management Plan* prepared in 2009, the West Hawaiʻi Sanitary Landfill has an estimated 38 years of life remaining at current recycling rates (R.W. Beck 2012).

Special Waste

Some types of special waste (such as hazardous waste) are not allowed to be disposed of in either landfill and require transport to separate recycling, processing, or disposal facilities. The County manages many types of special wastes by establishing drop-off or collection points, and then transporting the waste materials to either the landfill or other recycling or disposal facilities.

Recycling Transfer Stations

Residential residual waste is accepted (at no charge) at 21 transfer stations and transported by County Solid Waste Division staff for disposal at both landfills. These 21 residential recycling transfer stations include Glenwood, Hawaiian Ocean View Estates, Hawi, Hilo, Honokaʻa, Honomu, Kailua-Kona, Kalapana, Keeau, Keauhou, Keei, Laupahoehoe, Milolii, Paauilo, Pahala, Pahoa, Papaikou, Puako, Volcano, Waiea, Waimea, and Waiohinu. No commercial or farm waste is allowed.

Scrap Metal Recycling Facilities

The County operates two scrap metal and recycling facilities: the Hilo and Kealakehe/Kailua-Kona Scrap Metal facilities. However, as of March 28, 2013, the facilities accept only self-hauled residential loads.

Greenwaste Recycling Facilities

Several greenwaste recycling facilities serve Hawaiʻi County, including the East Hawaiʻi Organics Facility, the West Hawaiʻi Organics Facility, and the Kealakehe Greenwaste Facility. The greenwaste facility accepts materials from both households and commercial businesses.

3.14.3 WASTEWATER

Wastewater (sewage) is generated from many daily activities such as washing clothes and dishes, preparing food, taking a bath or shower, washing our hands, and using the bathroom. Management of the wastewater stream is important to help safeguard the water supply from contamination, protects the environment, and also aids in water conservation by allowing reclaimed water to be used for non-potable water purposes. Proper disposal of the millions of gallons of wastewater produced protects the drinking water supply, coastal water quality, and other important environmental resources.

Most wastewater in the State (approximately 62 percent) is managed via collection and conveyance of wastewater facilities by each county's public sewer system. The county typically treats the collected wastewater in a centralized facility and either beneficially reuses the effluent or disposes of it in subsurface soil systems or ocean outfalls. County staff manages, operates, and maintains the collection, treatment, and disposal systems year-round (WRRC 2008). In some locations, however, there are no public sewers, and homeowners or developers assume the responsibility of wastewater management. The tasks involved include selecting, designing, constructing, operating, and maintaining the appropriate treatment and disposal systems including onsite wastewater treatment systems or individual wastewater treatment systems. An individual wastewater treatment system is a decentralized system that receives and disposes of domestic wastewater from one or multiple buildings that are not connected to a centralized wastewater treatment plant. Some systems treat wastewater by removing pollutants such as solids, organic matter, nutrients and bacteria. Not all systems provide equal levels of treatment. Suspended growth aerobic treatment systems provide secondary levels of treatment, for example, while others (such as septic tanks) only provide primary treatment of wastewater. Other systems only dispose of wastewater (e.g., cesspools). With an individual wastewater treatment system, wastewater is dispersed or reused very close to where it was generated. If several adjacent parcels are serviced by a single system, the treatment and water dispersal system can also be referred to as a cluster system.

3.14.3.1 Regulatory Setting

3.14.3.1.1 Federal

Clean Water Act of 1977 as Amended (Public Law 95-217, Title 33 U.S.C. §§ 1251 *et seq*.)

The *Clean Water Act* is the major Federal legislation concerning improvement of the nation’s water resources. The Act was amended in 1987 to strengthen enforcement mechanisms and to regulate storm water runoff. The Act provides for the development of municipal and industrial wastewater treatment standards and a permitting system to control wastewater discharges to surface waters. Through Part 503, “Rules of the Federal Clean Water Act,” the EPA regulates the Underground Injection Control (UIC) program (Part C of the *Safe Drinking Water Act*) involving injection wells, large capacity cesspools, and the management, reuse, and/or disposal of wastewater sludge or biosolids, areas that impact onsite wastewater treatment systems.

NPDES Permit Compliance

NPDES permits are issued by the EPA or an authorized tribal government. The permit establishes effluent limits, including type and quantity restrictions, and pollutant monitoring, record keeping, and reporting requirements. Each publicly owned treatment work (POTW) (or other dischargers into surface water) that intends to discharge into the nation’s waters must obtain an NPDES permit prior to initiating discharge. State NPDES requirements are discussed below.

3.14.3.1.2 State of Hawai‘i

The EPA has relinquished authority to the State of Hawai‘i Department of Health (HDOH) for the regulation, oversight, and enforcement of onsite wastewater treatment system planning, design, construction, inspection, and maintenance in Hawai‘i. The HDOH Wastewater Branch formulates and enforces all wastewater rules and regulations in Hawai‘i including the review and approval of all new waste systems including septic tanks and wastewater works through HAR 11-62, “Wastewater Systems” (HDOH 2013b), as well as through HAR 11-55, “National Pollutant Discharge Elimination System Permitting,” HAR 11-23, “Underground Injection Control,” and HAR 11-54, “Water Quality Standards.”

HAR 11-63 codifies these regulations and covers all public wastewater treatment and disposal systems as well as private wastewater treatment plants and onsite wastewater treatment systems throughout the State (from individual cesspools to major municipal wastewater treatment plants).

HAR 11-55 regulates the permitting of minor and major wastewater treatment facilities including the following provisions for onsite wastewater treatment systems:

- Selection of appropriate, conventional wastewater treatment and disposal systems is outlined in the regulations. No effluent requirements are specified. However, National Sanitation Foundation (NSF) class certification is required for aerobic treatment units. There are provisions in the rules allowing approval for innovative and alternative technologies based on testing and monitoring on a case-by-case basis.

- The State of Hawaiʻi does not require permits for onsite wastewater systems. Hawaiʻi rules require that new onsite wastewater treatment system plans be reviewed and approved by the HDOH prior to construction. Once constructed, written authorization for use must also be obtained from the HDOH. The actual construction permits are integral to the individual county building permit processes. It is important to note that the design of onsite wastewater treatment systems must be carried out by a State-licensed professional engineer, and the system must be installed by a licensed contractor.

- Routine inspections of onsite wastewater treatment systems are not required following construction. However, HDOH requires the engineer-of-record to submit a final inspection report, certifying the onsite wastewater treatment system was constructed in accordance with approved plans. HDOH also requires an operation and maintenance manual and owner certification that they will follow the manual. HDOH then issues a written approval for use of the onsite wastewater treatment system.

HAR 11-62 also designates on all six islands critical wastewater disposal areas (CDWA). A CWDA is defined as an area where the disposal of wastewater has or may cause adverse effects on human health or the environment due to existing hydrogeological conditions (e.g., high water table, impermeable soil, steep terrain, flood zone, protected coastal water, high rate of cesspool failure, and/or protected groundwater resource). Identification of critical wastewater disposal areas for each of the islands is a critical component for any new development without convenient access to public sewer systems as onsite wastewater treatment systems may be constructed in these areas. In the event onsite wastewater treatment systems are to be constructed in these areas, more stringent requirements may be required than those for other onsite wastewater treatment systems located outside of these areas. CWDA maps are included in HAR 11-62 as Appendix E, Pages E-1 through E-6 and show the boundaries of the critical wastewater disposal areas. Current, more detailed, and user friendly maps are available through the HDOH Wastewater Branch, which should be contacted whenever planning a new project. The HDOH maps may be more up to date versus the maps in the HAR.

3.14.3.1.3 County

In 1985, the State Legislature enacted Act 282, Relating to Environmental Quality, which reassigns the County of Hawaiʻi, effective July 1, 1987 (or upon receipt of State funds), to assume complete administration and implementation for the regulation of sewerage and wastewater treatment system programs

3.14.3.2 Affected Environment

3.14.3.2.1 Kauaʻi

The Kauaʻi Department of Public Works - Division of Wastewater Management, Wastewater Treatment Facilities Program is responsible for the operation, maintenance and repair of all County wastewater collection, treatment and disposal facilities in order to provide consistent and reliable level of performance necessary to protect health and the environment. Activities include preventive maintenance, treatment process control, wastewater effluent reuse, solids management, safety and training, laboratory monitoring for regulatory compliance. The County manages four sanitary sewerage facilities: Wailua, Lihue, Eleele, and Waimea (design capacity 0.30 million gallons per day) currently operating at 0.25 million gallons per day (County of Kaua‘i 2000b and Pruder 2013), and operates approximately 5,500 service connections via 19 sewage pump stations, 43 miles of gravity sewer lines, 7 miles of force main pipelines, and 1,200 manholes (County of Kaua‘i 2009). Figure 3-83 shows the location of the Kaua‘i County's wastewater treatment systems.

Other locations in Kaua‘i are served by private sewage treatment plants that serve small and large developments. However, according to the County of Kaua‘i, most residential areas and some commercial areas are not sewered and rely instead on individual wastewater systems, administered by the State. Most individual wastewater systems were historically constructed as cesspools. However, HDOH changed the regulations so that septic tank systems are now required. There are no communities with cesspool problems threatening public health, but some areas with poor subsurface conditions experience overflow problems.

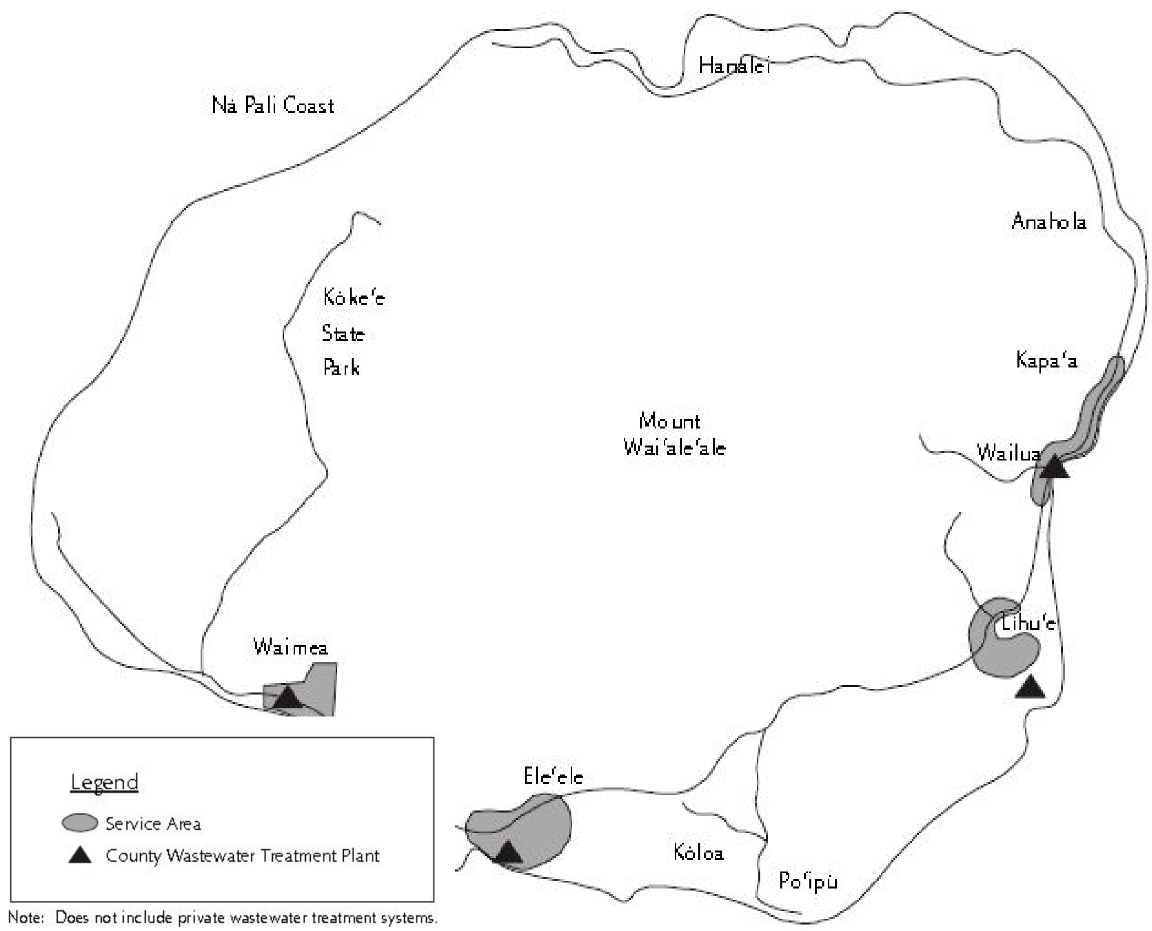


Figure 3-83. Wastewater Systems in the County of Kaua‘i

Table 3-74 shows the existing wastewater flows and treatment capacity for all four Kaua‘i County wastewater facilities. As shown, the County of Kaua‘i has approximately 3.3 million gallons per day of estimated remaining capacity (R.W. Beck 2010).

Table 3-74. Kaua‘i County Wastewater Treatment Plant Capacity, 2010 to 2013

Wastewater Facility	Design Flow (gpd)	Actual Flow (gpd)	Estimated Remaining Capacity (gpd)
Wailua	1,500,000	370,000	1,130,000
Lihue	2,500,000	1,100,000	1,400,000
Eleele	800,000	300,000	500,000
Waimea	300,000	200,000	300,000
TOTALS	**5,100,000**	**1,970,000**	**3,330,000**

Source: Pruder 2013.

3.14.3.2.2 O‘ahu

The City and County of Honolulu Environmental Services Division manages 9 wastewater treatment plants: Honouliuli, Kahuku, Kailua, Laie, Paalaa Kai, Sand Island, Wahiawa, Waianawe, and the Waimanolo; a 2,100-mile collection system, and 70 pump stations (City and County of Honolulu 2013e and City and County of Honolulu 2013f). In addition, the City and County of Honolulu provides cesspool services to those residential properties where municipal sewers are not available or accessible. Figure 3-84 shows the locations of the City and County’s wastewater treatment plants and infrastructure. Table 3-75 shows the existing wastewater flows and treatment capacity for all the City and County’s wastewater facilities. As shown, the City and County has an estimated remaining capacity of 56 million gallons per day.

The City and County of Honolulu is currently undertaking long-range sewer rehabilitation to improve the sewer system to meet the City’s goals for environmental improvement. More than 165 projects have been identified which needed to start between 2000 and 2019 and additional projects are occurring as a result of several consent decrees agreed to the by the City and County with the EPA. Approximately 43 percent of the projects have been started (City and County of Honolulu 2013g). A list of the current sewer construction projects can be found online at http://www1.honolulu.gov/env/wwm/sewerconstructionprojects.htm.

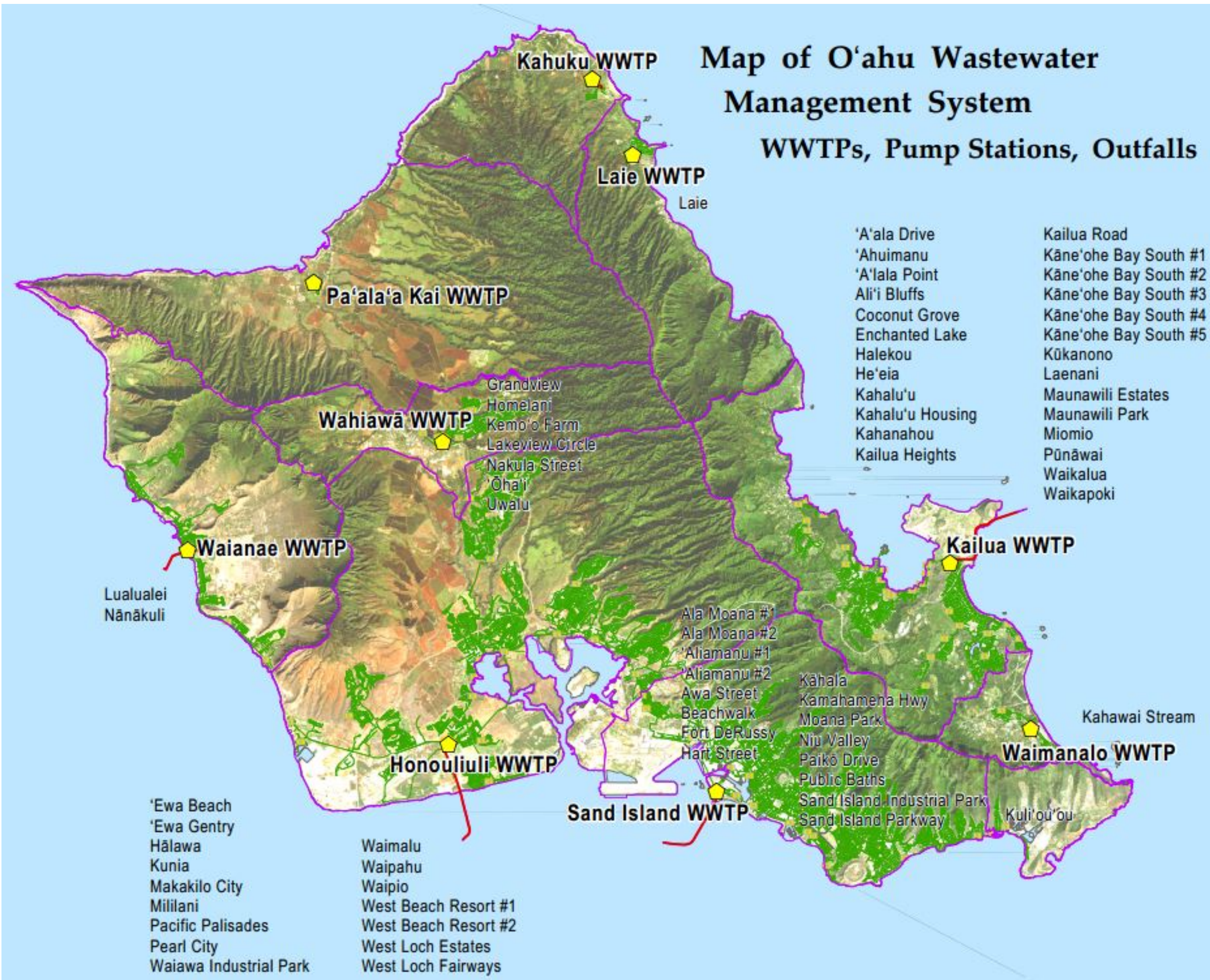


Figure 3-84. Oʻahu Island Wastewater Management System (City and County of Honolulu 2013h)

Table 3-75. Island of Oʻahu Wastewater Treatment Plant Capacities, 2010 to 2013

Wastewater Facility	Design Flow (gpd)	Actual Flow (gpd)	Estimated Remaining Capacity (gpd)
Honouliuli	38,000,000	26,900,000	11,100,000
Kahuku	400,000	189,000	211,000
Kailua	15,250,000	6,930,000	8,320,000
Laie	900,000	600,000	300,000
Paalaa Kai	144,000	82,000	62,000
Sand Island	90,000,000	56,500,000	33,500,000
Wahiawa	2,500,000	1,970,000	530,000
Waiʻanae	5,200,000	3,250,000	1,950,000
Waimanalo	1,100,000	540,000	560,000
TOTALS	**153,494,000**	**96,961,000**	**56,533,000**

Source: Pruder 2013.
gpd = gallons per day.

3.14.3.2.3 Molokaʻi

Wastewater services to the island of Molokaʻi are provided by the County of Maui. Molokaʻi includes one wastewater reclamation facility, Kaunakakai, which is a secondary treatment plant with effluent disposal by underground injection. Two injection wells are located on the treatment plant site, but are no longer in use. A third injection well, located approximately one-half mile northeast of the treatment plant, currently provides disposal for plant effluent (County of Maui 1990).

3.14.3.2.4 Lānaʻi

Wastewater collection and treatment services to the island of Lānaʻi are provided by the County of Maui. A discussion of these services is discussed below.

3.14.3.2.5 Maui

The County of Maui Wastewater Facilities Program is responsible for the management, operation, maintenance, and repair of all County wastewater and pumping facilities in order to provide the consistent and reliable level of performance necessary to protect public health and the environment. The Wastewater Facilities Program includes preventative maintenance, wastewater reuse/reclamation, safety and training, solids management, regulatory compliance, and other services for Maui County.

The island of Maui has three wastewater reclamation facilities: Lahaina, Wailuku-Kahului, and Kihei (Freitas 2011). The three wastewater management systems operating on the island of Maui roughly correspond to the island's Community Plan Districts. Two of the Community Plan Districts are mainly served by Maui County's wastewater management system. The third district, the Makawao-Pukalani-Kula Community Plan area, is served by individual cesspools and septic tanks, with the exception of a portion of Pukalani that is served by a privately owned wastewater reclamation facility.

In addition to the three wastewater reclamation facilities on the island of Maui, the County of Maui manages all wastewater treatment facilities and conveyance systems in Molokaʻi and Lānaʻi. Altogether, the County manages 5 reclamation facilities, 42 pump stations, 222 miles of gravity transmission lines, and 25 miles of County-owned force main pipelines. Figure 3-85 shows a map of the county's wastewater facilities. Table 3-76 shows the capacity of the County of Maui's wastewater management system. As shown, the County of Maui has approximately 14.6 million gallons per day of estimated remaining capacity.

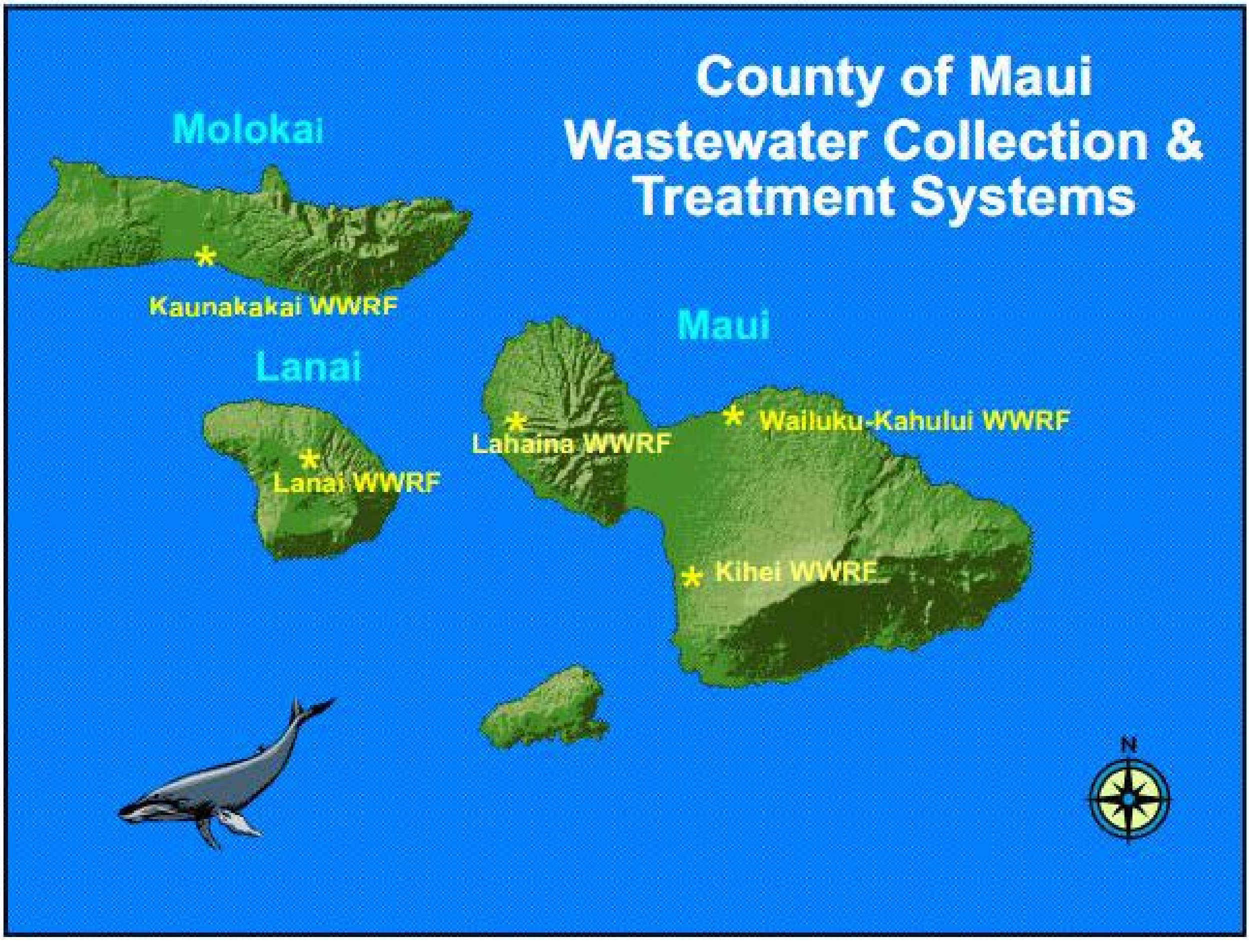


Figure 3-85. County of Maui Wastewater Collection and Treatment Systems

Table 3-76. Maui County Wastewater Treatment Plant Capacity, 2010 to 2013

Wastewater Facility	Design Flow (gpd)	Actual Flow (gpd)	Estimated Remaining Capacity (gpd)
Kaunakakai	300,000	220,000	80,000
Lānaʻi	540,000	310,000	230,000
Lahaina[a]	9,000,000	4,230,000	4,770,000
Wailuku Kahului[b]	7,900,000	3,950,000	3,950,000
Kihei[c]	9,000,000	3,440,000	5,560,000
TOTALS	**26,740,000**	**12,150,000**	**14,590,000**

a. If regulatory constraints and requirements remain unchanged, adequate treatment capacity should be available to serve the projected population growth through the 2030 planning horizon.
b. Based on population growth to 2030, the capacity of the treatment facility will not be reached by the end of the planning horizon.
c. Based on projected population growth between 2005 and 2030, the capacity of the treatment facility will be sufficient to meet projected demand over the planning period. According to WWRD, there are no near-term concerns with the capacity of the Kihei Wastewater Reclamation Facility. However, should larger projected developments connect to the County of Maui system they will have a long-term impact on plant capacity.

Sources: Pruder 2013; County of Maui 2012d.
gpd = gallons per day.

The County also manages 15 injection wells on Maui: 8 in Kahului, 4 in Lahaina, and 3 in Kihei. In addition to the publicly maintained wells, there are numerous privately owned and operated injection wells in the county. Many privately owned condominiums and businesses in areas that were built outside of existing county sewer service have their own injection well(s). These privately owned and operated facilities can treat wastewater to a level of quality that meets Federal, State, and county requirements (County of Maui 2012d).

According to the *Maui Island Plan: General Plan 2030*, adopted in December 2012, the County-operated wastewater treatment facilities and collection systems are aging and will require increased maintenance through the 2030 planning horizon (County of Maui 2012d). In order to meet the projected wastewater treatment demand, the island's wastewater facilities will require upgrade and maintenance.

Repeated raw sewage spill incidents on Maui prompted the State to issue administrative orders to the County to reduce spills since 1992. Due to repeated spills, the EPA and HDOH filed two lawsuits against the County of Maui. The County of Maui entered into a Consent Decree in 1999 with the EPA and HDOH. As a requirement under the Consent Decree, the County is required to submit to EPA and the HDOH quarterly compliance reports. The quarterly reports includes steps taken by the County to develop and implement the various goals, plans, programs, procedures, schedules and budgets required pursuant to the Consent Decree including a spill reduction plan, a sewer rehabilitation program, a fats, oil, and grease (FOG) control program, preventative maintenance, and an information management system (automated reporting software GIS application) to monitor and access sewer collection data. Although Maui County has reduced its sewage spills, spills have continued to occur.

There has also been a growing public concern that wastewater may be leaching from injection wells into the ocean. As such, the County is planning upgrading the wastewater reclamation reuse systems, improving the current level of water treatment, or phasing out injection wells entirely; albeit these upgrades and improvements require significant financial investment to implement. Over the last several years, in order to reduce wastewater flows, water saving projects were implemented throughout the County. More recently, the County's mayor set a goal of 100 percent recycling of Maui's wastewater. The water saving projects have alleviated some of the County's overflows. However, some of the County's facilities currently require upgrades. Additional information on the reach of the Mayor's goal is currently not available.

3.14.3.2.6 Hawai‘i

The Department of Environmental Management currently operates and is responsible for the operation and maintenance of 5 sewer systems: Hilo, 5 million gallons per day; Papaikou, 0.35 million gallons per day; Kulaimano, 0.5 million gallons per day; Kapehu, 0.016 million gallons per day; and Kealakehe, 5.3 million gallons per day; 17 pump stations; 90 miles of gravity mains; and 11 miles of force main pipelines (D. Beck 2009). Those residents or commercial entities located in the vicinity of one of the five existing wastewater treatment facilities are served by these sewer systems; however, those areas not served by these sewer systems are served by private wastewater treatment facilities or individual facilities such as cesspools or septic tanks. It is estimated that less than 16 percent of housing units are served by the Hawai‘i County wastewater systems and are operating well below their theoretical capacity. Table 3-77 shows the capacity of the County of Hawai‘i wastewater management system. As shown, the County has approximately 5.9 million gallons per day of estimated remaining capacity.

In 2005, the County estimated that approximately 77 percent of the County's population was served by cesspools (County of Hawai‘i 2005). However, as most soil on the island is volcanic and permeable (with widespread underground lava tubes), seepage from cesspools have been known to contribute to the pollution of coastal waters and pose a threat to underground drinking water sources.

In addition, the EPA required that all cesspools be eliminated by April 5, 2005. Thus, in response to the EPA regulation, the County of Hawaiʻi entered into consent agreement and final order with the EPA to complete and prepare a preliminary engineering report and environmental assessment that identified alternatives to cesspools or recommended solutions to satisfy the EPA regulation.

Table 3-77. Hawaiʻi Wastewater Treatment Capacity, 2010 to 2013

Wastewater Treatment Facility	Design Flow (gpd)	Actual Flow (gpd)	Estimated Remaining Capacity (gpd)
Hilo	5,000,000	3,400,000	1,600,000
Kealakehe	5,310,000	1,670,000	3,640,000
Kapehu	16,000	7,000	6,000
Kulaimano	500,000	90,000	410,000
Papaikou	350,000	90,000	260,000
TOTALS	**11,176,000**	**5,257,000**	**5,916,000**

Source: Pruder 2013.
Gpd = gallons per day.

3.14.4 COMMON CONSTRUCTION AND OPERATION IMPACTS

3.14.4.1 Hazardous Materials

The siting of a project would likely require new construction which could result in potential hazardous material impacts. To minimize impacts, it is recommended that proposed project locations be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at the proposed development locations. Once the project location is determined, it will be necessary to perform detailed investigations including a site-specific Environmental Site Assessment in conformance with ASTM Method E 1527 05 (ASTM 2005), which would provide a detailed review of accessible public records and require site inspection to identify the classes of land uses and/or hazardous materials that may be present at these sites. In the event that the project location is sited in a contaminated site, abatement and remediation activities by trained and certified professionals would be required before construction can occur.

Potential impacts could also result if project construction were proposed in an area with munitions response sites, however, BMPs have been provided below to ensure that munitions response sites are avoided and that no hazardous wastes are encountered.

Potential hazardous material impacts could result from those projects that were proposed in an existing structure or facility. To minimize impacts, such projects would be required to perform site surveys to identify any areas within the structure or facility containing asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic. If a structure or facility is found to be contaminated, proper abatement procedures and activities would be required to comply with State and Federal OSHA, and the county air quality district requirements. Only personnel trained and certified in abatement and remediation would be allowed to perform these activities; and materials would be handled and disposed of appropriately.

Construction activities could also involve the use of hazardous materials such as fuels, oils, solvents, and adhesives. In addition, inadvertent spills could occur during onsite fueling of equipment or by accident (e.g., puncture of a fuel tank through operator error or slope instability). Therefore, the use of hazardous materials onsite would be required to comply with developed site-specific BMPs related to fueling, vehicle washing and handling, use, and storage of chemicals to minimize any risk to workers or the public..

3.14.4.2 Waste Management

Project construction could require land clearing, the possible demolition of existing structures, excavation, drilling, and other related construction activities. These activities would generate construction and demolition waste consisting of wooden beams, asphalt, concrete glass, brick, metal soil, vegetation, and other miscellaneous building and landscaping materials. Potential impacts to landfills accepting these wastes can be minimized through recycling efforts and resultant diversion of generated wastes. During design and construction phases, consideration should be given to development and implementation of a recycling plan. In addition, a recycling program would effectively recover building materials that could contain potentially hazardous substances (e.g., liquid wastes, paints, oil, solvents). Proper handling, transport, and disposal of hazardous materials or substances would be required to comply with State and Federal OSHA, and county requirements. This would include proper handling and transport for disposal at the appropriate hazardous material facility to ensure that no hazardous materials were disposed of at landfills and that hazardous materials do not enter the waste stream.

It is noted that several landfills in the islands of O‘ahu and Hawai‘i are currently at capacity. As such, depending on the proposed project location, the disposal of non-recyclable materials may add to existing landfill capacity constraints. The resolution of landfill siting and expansion on several islands are pending or are in the process. Therefore, additional waste produced in the islands of O‘ahu and Hawai‘i may result in potentially significant impacts, pending the resolution of existing landfill capacity constraints.

3.14.4.3 Wastewater

During construction, wastewater generation from construction activities would result in a nominal increase in wastewater flows as construction activities and staff would generate a small amount of wastewater. It is anticipated that portable toilets would be provided by a private company and the associated waste disposed of off-site. As such, during construction, the project would not constrain the existing wastewater infrastructure or treatment plants.

Primary wastewater impacts could occur as result of project operations that require conveyance and or treatment at the appropriate wastewater treatment plant or on-site. Therefore, each project would be required to ensure that that wastewater connections and treatment systems, as well as maintenance of pipes and screens (including potential manual cleaning) are performed regularly to prevent clogging and ensure that proper discharge and wastewater conveyance or treatment occurs. All wastewater discharge would be required to comply with Federal, State, and county requirements, including the NPDES permit requirements. In addition, it is anticipated that projects would incorporate BMPs to ensure that proper treatment and discharge of effluent meet general water quality and toxic contaminant parameter requirements.

3.14.5 COMMON BEST MANAGEMENT PRACTICES

3.14.5.1 Hazardous Materials

The following general mitigation measures would be applicable to all construction and operation activities associated with a clean energy project, regardless of location.

A comprehensive Phase I Environmental Site Assessment should be conducted prior to acquiring a property for development. The site assessment will assess the property for any environmental contamination. This will reduce the possibility that construction project footprints would encounter sites contaminated with hazardous materials, substances, or waste including military munitions. If MECs are discovered during site activities, the following procedures will be followed:

- Visually identify the item discovered without disturbance.
- Establish its location at the site and retreat from the location.
- Contact local authorities to address the item of concern.

If development were to occur in active military facilities, all work would need to be coordinated with proper base authorities.

Military munitions could also be present on the seafloor throughout the State. Therefore, additional consideration should be given to areas of dense concentrations where it may be difficult for workers to completely avoid munitions. As such, construction and mitigation measures for MEC areas would be avoidance to ensure that personnel and equipment would not be adversely impacted and safety hazards are avoided.

For those areas where it has not been determined whether previous marine dumping sites as identified in NOAA nautical charts contain non-MEC hazardous materials. The presence of dumped materials could impact offshore construction projects. Therefore, construction in those marine dumping sites should be avoided to ensure no safety hazards occur.

Construction activities could involve use of hazardous materials such as fuels, oils, solvents, and adhesives during construction. Inadvertent spills could occur during on-site fueling of equipment or by accident (e.g., puncture of a fuel tank through operator error or slope instability). Use of hazardous materials on-site would be required to comply with developed site-specific BMPs related to fueling, vehicle washing and handling, use, and storage of chemicals, which would minimize any risk to either workers or the public.

Site construction and demolition should be performed in accordance with a site-specific safety and health plan. The plan would identify safe working conditions for construction areas. Safety measures would include proper techniques for personal protective equipment, use of allowable tools, and mechanical measures as appropriate. Potential adverse impacts to construction personnel include possible exposure to both known and unknown hazardous materials and wastes present in existing structures or surrounding environment.

3.14.5.2 Waste Management

Proposed project locations could require land clearing, possible demolition of existing structures, excavation, drilling, and other related construction activities. These activities would generate construction and demolition waste consisting of wooden beams, asphalt, concrete glass, brick, metal soil, vegetation, and other miscellaneous building and landscaping materials. Potential impacts to landfills accepting these wastes could be minimized through recycling efforts and resultant diversion of generated wastes. During design and construction phases of the proposed project, consideration should be given to development and implementation of a recycling plan. A recycling program would minimize wastes requiring permanent disposal.

3.14.5.3 Wastewater

The project proponent should establish a program to provide beneficial reuse of wastewater.

For those locations without wastewater treatment conveyance systems, project proponents should install septic tank systems or on-site wastewater treatment facilities.

3.15 Socioeconomics

The socioeconomic environment potentially affected by the development of any of the analyzed technologies encompasses the State of Hawai‘i generally, and potentially each of the four State-recognized counties. Data for a fifth county, Kalawao, generally is not independently cited in this analysis but is occasionally included in data presented for Maui County (as noted herein). The 2012 population in Kalawao County was 90 people (American FactFinder 2012).

NOTE ABOUT DATA COLLECTION

Numbers for the same demographic variable (e.g., population, employment, jobs), year, and geographic area presented in this section of the PEIS may vary because they were generated by differing reference sources.

Some variables in the socioeconomic environment potentially affected include resident population; employment and the related unemployment rate and employment-specific sectors; housing; and personal income, the resulting income and sales tax consequences, and the expenditure of those revenues by State government. Electricity consumption and prices could also be affected. A profile of these variables is presented to establish a baseline from which changes associated with the implementation of analyzed technologies could be described and analyzed.

3.15.1 POPULATION

The total population in the State was about 1,364,000 in 2010, estimated at 1,392,000 in 2012, projected to be 1.5 million in 2020 and 1.6 million by 2030 (Table 3-78). Approximately 70 percent of the 2012 State population was reportedly concentrated in the City and County of Honolulu, and approximately 14 percent of the population was a resident of Hawai‘i County. Population projections to 2020 and 2030 indicate a more rapidly growing population in Hawai‘i County than the other three counties, with a markedly slower population growth in the City and County of Honolulu.

3.15.2 EMPLOYMENT

Most jobs in Hawai‘i are in the civilian sector. Approximately 7 percent of the jobs in the State are military positions (BEA 2013). Approximately 71 percent of the civilian jobs within the State are in the City and County of Honolulu, and about 12 percent are in Hawai‘i County and Maui County each. Kaua‘i County has approximately five percent of the civilian jobs. Kalawao County has about 43 agricultural positions. The number of civilian jobs is expected to grow at approximately the same rate as the population is projected to increase in the periods from 2010 to 2020 and from 2020 to 2030. The projected growth rate of jobs in Hawai‘i County is almost twice that of the State’s most populated county and is almost twice that of the State’s projected growth rate. Table 3-79 summarizes historical and projected civilian jobs in the State and each county.

Table 3-78. State and County Population, 1990 to 2030

Year	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
1990[a]	1,113,491	121,572	838,534	51,676	101,709
2000[a]	1,213,519	149,244	876,629	58,568	129,078
2003[a]	1,251,154	158,442	894,311	60,805	137,596
2008[a]	1,332,213	181,506	933,680	65,603	151,424
2010[b]	1,363,359	185,381	955,936	67,217	155,125
2011[b]	1,378,810	187,738	963,607	67,701	156,764
2012[c]	1,392,313	189,191	976,372	68,434	158,226
2020[d]	1,481,240	220,880	1,003,710	75,640	181,020
2030[d]	1,602,340	258,510	1,052,130	84,380	207,310
Average Annual Growth Rates (percent)					
1990 to 2000	0.9	2.1	0.4	1.3	2.4
2003 to 2010	1.2	2.3	1.0	1.4	1.7
2008 to 2012	1.1	1.0	1.1	1.1	1.1
2010 to 2020	0.8	1.8	0.5	1.2	1.5
2020 to 2030	0.8	1.6	0.5	1.1	1.4

a. Source: DBEDT 2012c, Table A-1.
c. Source: American FactFinder 2012.
d. Source: DBEDT 2012c, Tables A-2 to A-6.
b. Source: DBEDT TBD.

Table 3-79. Civilian Jobs in the State and Counties, 2003 to 2030

Year	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
2003[a]	739,212	83,630	529,123	38,364	88,095
2008[a]	823,540	99,194	579,613	43,098	100,921
2010[a.b]	792,057	93,920	562,830	40,940	94,360
2020[b]	881,410	112,230	611,780	46,520	110,890
2030[b]	964,600	131,430	653,450	51,990	127,730
Annual Average Growth Rate (percent)					
2003 to 2010	1.0	1.7	0.9	0.9	1.0
2010 to 2020	1.1	1.8	0.8	1.3	1.6
2020 to 2030	0.9	1.6	0.7	1.1	1.4

a. Source: DBEDT 2012c, Tables A-37 to A-41.
b. Source: DBEDT 2012c, Tables A-47 to A-56.

3.15.3 UNEMPLOYMENT

Unemployment rates in the State and in all counties were higher in January 2013 than the annual average rate from 2003 to 2008 (Table 3-80). Unemployment rates in the State and counties peaked in 2009 and 2010 and have been steadily declining. Each county's and the State's unemployment rates were lower each year, including January 2013, than the comparable national unemployment rates (BLS 2013c).

Table 3-80. State and County Unemployment Rates, 2003 to January 2013

	2003[a]	2008[a,b]	2010[a,c]	January 2013[d,e]
Hawai'i State	3.9	4.1	6.8	5.4
Hawai'i County	4.6	5.7	10	7.6
City and County of Honolulu	3.7	3.7	5.8	4.8
Kaua'i County	4	4.6	9	6.5
Maui and Kalawao Counties	3.7	4.6	8.6	5.7

a. Source: BLS 2013a.
b. Statewide number reflects model estimations.
c. Reflects revised population controls and model estimation.
d. Source: BLS 2013b.
e. Preliminary.

3.15.4 STATE AND COUNTY GOVERNMENT EMPLOYMENT

Jobs classified as "State and Local Government" in the National Association of Industrial Classification industrial sector represent approximately 10 percent of the State's and each county's total employment. Employment in the State and county government sector in each county is approximately equal to the county's proportion of the State's population (see Table 3-78). With the exception of the Maui/Kalawao area, growth in the number of State and local jobs has been markedly slower than the growth in the number of jobs during the 2003 to 2011 era. Historical information about employment in the State and county government sector is displayed in Table 3-81.

Table 3-81. State and County Total Employment and State/County Government Employment, 2003 to 2011[a]

Area	Description	2003	2008	2010	2011	Average Annual Growth 2003 to 2011 (percent)	2011 State and County Government Jobs of Total Area Jobs
Hawai‘i State	Total employment	774,603	862,887	831,946	843,431	1.1	
Hawai‘i State	State and county governments	87,160	92,088	90,818	90,555	0.5	10.7
Hawai‘i County	Total employment	83,672	100,019	94,099	94,907	1.6	
Hawai‘i County	State and county governments	10,178	11,259	11,119	11,049	1.0	11.6
City and County of Honolulu	Total employment	564,355	618,512	602,494	610,988	1.0	
City and County of Honolulu	State and county governments	65,171	68,242	66,911	66,778	0.3	10.9
Kaua‘i County	Total employment	38,460	43,066	40,570	41,018	0.8	
Kaua‘i County	State and county governments	3,813	3,923	3,950	3,942	0.4	9.6
Maui and Kalawao Counties	Total employment	88,116	101,290	94,783	96,518	1.1	
Maui and Kalawao Counties	State and county governments	7,998	8,664	8,838	8,786	1.2	9.1

Source: BEA 2013.

a. The estimates of employment for 2001-2006 are based on the 2002 North American Industry Classification System (NAICS). The estimates for 2007 to 2010 are based on the 2007 NAICS. The estimates for 2011 forward are based on the 2012 NAICS.

3.15.5 VACANT RENTAL HOUSING

Table 3-82 presents select housing characteristics for Hawai‘i and the Hawai‘i counties. Growth in the size of an area’s labor force, when the change is attributed to in-migration of workers associated with new energy initiatives, for example, can impact a community’s rental housing market. In 2011, the City and County of Honolulu with approximately 70 percent of the State population, had less than 65 percent of the total housing units. Vacancy rates among rental housing units varied among the counties. For comparison purposes, the 2011 national rental housing vacancy rate was 7.4 percent (American FactFinder 2013a).

Table 3-82. State and County Housing Characteristics, 2011

Area	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
Total Housing Units	522,314	83,183	337,528	30,273	71,213
Occupied Housing Units	448,563	64,605	308,495	22,874	52,549
Vacant Housing Units	73,751	18,578	29,033	7,399	18,664
Rental Vacancy Rates (percent)	8.4	9.2	4.9	16	22.5

Source: American FactFinder 2013b.

3.15.6 PERSONAL INCOME

In 2011, Hawai‘i residents generated about $59.0 billion in personal income. Residents of the City and County of Honolulu, with approximately 70 percent of the State population, contributed about 76 percent of the total personal income. Hawai‘i County, with approximately 14 percent of the State population, accounted for 10 percent of the total personal income generated in 2011. Historical annual growth in personal income was nearly evenly distributed among the counties. Per capita personal income varies widely: the State per capita personal income was $42,925 in 2011; Hawai‘i County’s was $31,749; the City and County of Honolulu was $46,624; Kaua‘i County was $36,520; and Maui and Kalawao Counties was $36,272 (BEA 2012). Table 3-83 summarizes historical personal income by county.

Table 3-83. Aggregate State and County Personal Income, 2003 to 2011[a]

Area	2003	2008	2010	2011	Average Annual Growth 2003 to 2011 (percent)
State of Hawai‘i	39,032,023	55,313,744	55,832,057	59,014,071	5.3
Hawai‘i County	3,869,362	5,899,236	5,682,107	5,928,662	5.5
City and County of Honolulu	29,704,539	41,474,816	42,397,145	44,926,809	5.3
Kaua‘i County	1,618,576	2,371,963	2,356,206	2,472,457	5.4
Maui + Kalawao Counties	3,839,546	5,567,729	5,396,599	5,686,143	5.0

Source: BEA 2012.
a. In thousands of dollars.

3.15.7 INDIVIDUAL INCOME TAX REVENUES

The State of Hawai‘i collects tax from several sources of individuals’ income. Generally, the State’s tax laws reflect income tax laws of the Federal Government, but the State does not tax social security benefits, many pension distributions, and several other sources of income (DET 2005). The State does tax wages and salaries. Wages and salaries, and hence individual income tax revenues, could be impacted if a community experienced a change in economic activity associated with new energy initiatives. Net revenues collected from individual income tax declarations grew at varying rates among the counties between 2003 and 2010. The City and County of Honolulu accounted for more than 90 percent of the income tax collected within the State in 2010. In 2012, individual income tax revenues comprised 31.4 percent of the general funds distributed to the State (DBEDT 2013c). Table 3-84 summarizes historical collections of individual income tax revenues by county.

Table 3-84. State and County Net Individual Income Tax Revenues, in thousands of dollars, 2003 to 2012

Year	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
2003 [1]	1,071,360	53,650	952,227	17,473	48,011
2008 [1]	1,564,708	84,829	1,367,113	37,467	75,299
2010 [1]	1,375,120	60,884	1,244,011	20,068	50,157
2011 [2]	1,460,621	63,086	1,314,949	22,548	60,037
2012 [2]	1,651,210	NA	NA	NA	NA
Average Annual Growth Rate (percent)					
2003 to 2010	3.6	1.8	3.9	2.0	0.6
2010 to 2012	9.6	NA	NA	NA	NA

a. DBEDT 2013d, Table C-13.
b. DBEDT 2013c, Table C-4.
NA = not available.

3.15.8 GENERAL EXCISE AND USE TAX REVENUES

Hawai‘i does not have a sales tax. It does have a gross receipts tax, known as general excise tax, which applies to almost all sales of goods and services. The general excise tax is charged to the business rather than the customer, but the business may pass some or all of the tax on to its customers similar to a traditional sales tax. The State general excise tax rate is 4 percent and county entities may impose additional taxes. In addition, Hawai‘i strictly imposes a use tax on products and services that are purchased from other states but used in Hawai‘i. This includes nontangible products or services such as engineering services (Tax-Rates.org 2013). Table 3-85 summarizes historical general excise and use tax revenues for the State by county.

Table 3-85. State and County General Excise and Use Tax Revenues, in thousands of dollars, 2003 to 2010

Year	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
2003	1,820,498	137,257	1,478,293	55,011	149,937
2008	2,567,818	161,024	2,141,374	69,723	195,696
2010	2,379,942	133,627	2,019,244	60,950	166,122

Source: DBEDT 2013d, Table C-10.

Generally, annual growth rate in revenues collected from the general excise and use taxes and from the individual income tax have paralleled the State’s annual growth in personal income (see Table 3-82). Collections of corporate income taxes have been volatile. Table 3-86 presents information about major revenues components collected by the State.

Table 3-86. State General Fund Tax Revenues, by Component, 2003 to 2012

Year	General Use and Excise Tax	Net Individual Income Tax	Net Corporate Income Tax
2003	1,820,498	1,071,360	5,189
2008	2,567,821	1,564,708	76,602
2010	2,379,942	1,375,120	52,815
2011	2,588,488	1,460,621	19,548
2012	2,844,741	1,651,210	112,695
Average Annual Growth Rate (percent)			
2003 to 2012	5.1	4.9	40.8

Source: DBEDT 2013c, Tables C-3, C-4, and C-9.
a. In thousands of dollars.

3.15.9 STATE GOVERNMENT EXPENDITURES

Expenditures to support education represent about one-third of the State's general fund obligations. Expenses associated with public welfare represent about 20 percent of the annual budget, and insurance trust expenditures comprise about 15 percent of the general fund. Table 3-87 summarizes the 2010 State general fund budget by function.

Table 3-87. State Government Expenditures[a] by Function, 2010

General Expenditures	**9,710,283**
Education	3,254,387
Public welfare	1,960,542
Hospitals	609,893
Health	545,908
Highways	468,922
Police protection	34,211
Correction	206,695
Natural resources	104,865
Parks and recreation	91,156
Government administration	412,863
Interest on general debt	308,715
Other and unallowable	1,712,126
Direct expenditure	9,553,402

Source: DBEDT 2012b, Table 9.12.
a. Thousands of dollars.

3.15.10 UTILITIES

Energy is a major component of the State's gross domestic product. Energy expenditures accounted for almost 9 percent of the gross domestic product in 2010. Petroleum accounted for almost 97 percent of Hawai‘i's primary energy expenditures in 2010. Heavy fuel oil for electrical generation, jet fuel, and gasoline remain the primary fuels in the State demand profile (DBEDT 2012d).

Table 3-76 reflects energy consumption by source. In 2010, renewable energy represented about 7.6 percent of the total energy consumption. In 2010, about 37 percent of the State's total energy was used to generate electricity. Fossil fuels accounted for about 95 percent of the total energy consumption, while renewable energy sources provided about 4.9 percent of the total electric power energy consumption.

In 2010, Hawai‘i had the third lowest per capita energy use in the nation. Hawai‘i's military presence and tourism industry's consumption of aviation fuel resulted in the transportation sector leading the demand for energy. Energy production is derived from imported petroleum. Petroleum-fired plants supply more than three-fourths of Hawai‘i’s electricity generation. Due to the mild climate, most households do not use any electricity for home heating, a major source of energy consumption nationwide. Yet in 2010, Hawai‘i led the nation in electricity costs. The residential cost per million Btu, $101.64, was almost three times more than the average national cost of $34.34 (SEDS 2013). In 2010, the average household in Hawai‘i spent $1,969 annually for energy, $1,805 of which was for electricity (DBEDT 2012d).

Historical analysis indicates that Hawai‘i energy consumers do not alter consumption habits as the price of electricity and gasoline fluctuate. Historically, energy consumption in Hawai‘i has not changed in tandem with changes in income. Price elasticity (changes in quantity demanded of a product as a result of changes in its price) of energy tends to be low because there is little room for substitution; that is, there is no real substitute yet for electricity or gasoline (DBEDT 2011).

Table 3-88 demonstrates that electricity consumption is evenly distributed over the residential, commercial, and industrial sectors. Table 3-89 displays information about selected renewable energy sources. The increased share of renewable source electricity since 2000 is attributable to additional wind generation.

Fuel costs for operating transportation vehicles, other than airplanes, are relatively high in Hawai‘i. On May 27, 2013, the average price for regular, unleaded gasoline in the nation was $3.645 a gallon (SEDS 2013), while the average price for the same in Honolulu was $4.24 a gallon (Hawaii Reporter 2013).

Table 3-88. Hawai‘i’s Electricity Consumption by Sector, 1990 to 2010

	Electricity Consumption by Sector				Percent of Total		
Year	Residential Million (kWh)	Commercial Million (kWh)	Industrial Million (kWh)	Total Million (kWh)	Residential	Commercial	Industrial
1990	2,324	2,253	3,734	8,311	28.0	27.1	44.9
2000	2,765	3,092	3,834	9,691	28.5	31.9	39.6
2010	2,989	3,355	3,672	10,016	29.8	33.5	36.7

Source: DBEDT 2012d; Table 2.7

Table 3-89. Hawai‘i’s Primary Energy Consumption by Source, 1990 to 2010

Year	Total Energy Consumption Billions (Btu)	Energy Consumption by Source % of Total			
		Petroleum	Coal	Natural Gas	Renewable
1990	321,434	91.1	0.2	0.0	8.7
2000	273,488	86.0	6.5	0.0	7.5
2010	272,156	86.1	6.3	0.1	7.6
Year	Renewable Energy % of Total				
	Biomass	Geothermal	Hydro	Solar	Wind
1990	8.1	0.0	0.3	0.3	0.1
2000	5.6	1.0	0.4	0.5	0.3
2010	4.4	0.7	0.3	1.3	0.9

Source: DBEDT 2012d, Table 2.1.

Readers interested in detailed historical and current information about Hawai‘i’s energy consumption are encouraged to access the Energy Resources Coordinator’s Annual Reports, available from the “All Energy” tab of the following web page: http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications.

3.15.11 COMMON CONSTRUCTION AND OPERATION IMPACTS

In general, socioeconomic impacts that could result from the construction and operation of any specific clean energy project would be minimal. At a Statewide level, and within each county jurisdiction, project related impacts to the key socioeconomic variables, population, employment, and housing would be very small. However, modest employment opportunities are common impacts that could be recognized at the local community level.

3.15.12 COMMON BEST MANAGEMENT PRACTICES

The existing labor force in the State would be likely to provide the required workers to construct, install, operate, and maintain any clean energy project represented in this PEIS. Best management practices dictate that project management personnel anticipate needs for unskilled, skilled and professional workers and then co-ordinate with public and private employment agencies and with organizations responsible for post-secondary education and training to fill those needs.

3.16 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," directs Federal agencies to incorporate environmental justice as part of their missions (59 FR 7629, February 16, 1994) by identifying and addressing, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

ENVIRONMENTAL JUSTICE TERMS

Minority: Persons are included in the minority category if they identify themselves as belonging to any of the following groups (1) Hispanic or Latino, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander. In addition, individuals who categorize themselves as being of multiple racial or ethnic origins are minorities.

Low-income: Individuals who fall below the poverty line are categorized as low-income. The poverty line takes into account family size and the age of individuals in the family. For any given family below the poverty line, all family members are considered to be below the poverty line for analysis. In 2013, for example, the poverty line for a family of four in Hawai'i is $27,090. For comparison, the poverty line in the contiguous United States for the same period is $23,550 (HHS 2013).

The racial composition of the population of Hawai‘i, where no single group represents a majority, differs markedly from the population of the continental United States (not including the District of Columbia or any U.S. Territories), where whites constitute a clear majority (nearly 80 percent) (U.S. Census Bureau QuickFacts http://quickfacts.census.gov/qfd/states/00000.html). In 2011, for example, the largest racial group was Asians who compromised approximately 38 percent of the State's population.

In recognizing the unique racial characteristic of Hawai‘i's population, where minority racial groups collectively represent a majority of the population, the State enacted legislation, Act 294, that in turn resulted in *The Hawai‘i Environmental Justice Initiative*. The Act determined that analysis of Federally defined environmental justice populations (minority and low-income populations) will include a special emphasis on the Native Hawaiian population (HEC 2008).

Table 3-90 shows the racial and ethnic composition of the total population and the percent of low-income persons in Hawai‘i and each of its counties based on the United States Census Bureau’s 2011 American Community Survey one-year estimates (hence, numbers presented in this section may vary from numbers for the same year, same geographical area, generated by other referenced sources). Race and ethnicity is a self-reported variable. Individuals identifying themselves as Hispanic or Latino are listed in the table as a single entry. However, because Hispanics can be of any race, this number could include individuals also identifying themselves as part of another minority population groups listed in the table.

Table 3-90. State and County Minority and Low-Income Populations, 2011

Category	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
Total population	1,374,810	186,738	963,607	67,701	156,693
Hispanic or Latino (any race)	126,419	21,991	81,570	6,557	16,301
Non-Hispanic or Latino	1,248,391	164,747	882,037	61,144	140,392
One race					
White	314,810	57,853	186,667	20,570	49,703
Black or African American	24,969	1,415	22,138	366	1,050
American Indian and Alaska Native	2,875	667	2,108	13	87
Asian	512,081	39,140	410,487	24,156	38,289
Native Hawaiian or Other Pacific Islander	121,824	18,554	85,436	6,001	11,788
Some other race	1,071	66	1,005	0	0
Two or more races	270,761	47,052	174,196	10,038	39,475
Total minority	1,060,000	128,885	776,940	47,131	106,990
Percent minorities	77.1	69.0	80.6	69.6	68.3
Percent total population low-income	12.0	21.5	10.1	12.3	12.3

The Council on Environmental Quality guidelines (CEQ 1997) propose that minority populations should be identified where either (1) the minority population exceeds 50 percent or (2) the minority population percentage of the potentially affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis; that is, a “geographic comparison area” (generally the State as a whole). Hawai‘i’s minority population in 2011 was 77.1 percent of the total State population. It is the only state in the nation with an aggregate minority population greater than 50 percent and the only state where each county’s aggregate minority population exceeds 50 percent. For purposes of analysis, this PEIS uses the State of Hawai‘i as the comparison geographical unit. The “general population” of Hawai‘i is a “minority” and each county’s population is “minority.”

Table 3-91 presents specific data about the Native Hawaiian and other Pacific Island population in the State and in each county. Native Hawaiians represent about 7.5 to 9.9 percent of the population in the State and each county. Of the aggregate minority population, Native Hawaiians comprise 11 to 14.4 percent of the population.

In 2011, Hawai‘i County had a much higher proportion of residents living below the poverty line, 21.5 percent, than the other three counties. In the City and County of Honolulu, with approximately 70 percent of the State’s population, 10.1 percent of the residents were reported as living below the poverty line. For comparison, the national rate of low-income persons was 15.9 percent for the same period (American FactFinder 2013c).

Table 3-91. State and County Native Hawaiian or Other Pacific Islander Population, 2011

	State of Hawai‘i	Hawai‘i County	City and County of Honolulu	Kaua‘i County	Maui County
Native Hawaiian or Other Pacific Islander as a percentage of area population	8.9	9.9	8.9	8.9	7.5
Native Hawaiian or Other Pacific Islander as a percentage of area minority population	11.5	14.4	11.0	12.7	11.0

Source: American FactFinder 2013d.

Any site selection process for any technology must recognize that there could be environmental justice impacts; namely, disproportionately high and adverse environmental or human health effects on minority and low-income populations. Future documents evaluating proposed clean energy projects in Hawai‘i must be mindful during the site selection process and in the analysis of impacts once a site has been selected of the potential disproportionately high and adverse effects on human health on minority and low-income populations, specifically Native Hawaiians. A careful analysis would be warranted for four reasons:

- There are pockets of low-income populations throughout the State (Hawaii County, in particular, has a rate of poverty almost twice that of the State);
- Approximately 77.1 percent of the residents of the State are racial or ethnic minorities, hence any location would likely be populated by minorities;
- Cultural traditions suggests that many locations could host populations dependent on subsistence hunting and fishing; and
- It is the law (Executive Order 12898 and HI Act 294).

3.16.1 COMMON CONSTRUCTION AND OPERATION IMPACTS

Construction and operation of any of the clean energy technologies in the State could have environmental justice impacts if it results in disproportionately high and adverse human health or environmental effects on minority or low-income populations. The various resource areas in Chapter 3 address typical environment-related impacts to the general population; potentially high and adverse effects to the general population are identified separately in respective sections Chapters 4 through 8. Typically, the construction-related impacts for clean energy projects have not been shown in previous sections of Chapter 3 to be high and adverse; however, the specific project location would need to be evaluated to make the final determination.

3.16.2 COMMON BEST MANAGEMENT PRACTICES

The primary BMP associated with environmental justice impacts would be for the project proponent to design the project to minimize or prevent environmental impacts such that it would not result in any high or adverse impacts to the general population.

3.17 Health and Safety

This section describes existing public and occupational safety conditions in Hawai‘i, including information on health and safety regulations, toxicity characteristics for relevant gases, worker safety and injury data, and data on populations that could potentially be affected by accidents and/or intentional destructive acts.

3.17.1 REGULATORY SETTING

3.17.1.1 Occupational Safety and Health

Occupational safety and health are regulated under the *Federal Occupational Safety and Health Act* (OSH Act; 29 U.S.C. § 651 *et seq.*) and enforced by OSHA through the implementing regulations under 29 CFR. OSHA regulations are intended to assure that employers maintain safe and healthful workplaces by setting and enforcing standards, and by providing training, outreach, education and assistance. Employers must comply with all applicable OSHA standards and must also comply with the General Duty Clause of the OSH Act, which requires employers to keep their workplace free of serious recognized hazards. The regulations, accessible at the U.S. Department of Labor Website (https://www.osha.gov/law-regs.html), establish standards that are applicable to potential projects for the HCEI, including standards applicable to general industry (29 CFR Part 1910), construction (29 CFR Part 1926), and recordkeeping (29 CFR Part 1904).

In Hawai‘i, OSHA regulations are implemented by the Hawai‘i Occupational Safety and Health Division of the Department of Labor and Industrial Relations through the Hawai‘i State Plan. Hawai‘i has adopted the majority of the OSHA regulations verbatim; although some standards differ and some have no Federal counterpart, such as requirements for safety and health programs and for certification of hoisting equipment operators not found in standard OSHA rules. The Hawai‘i Occupational Safety and Health standards are online at http://labor.hawaii.gov/hiosh/standards/.

3.17.1.2 Public Health and Safety

Numerous Federal and State laws and regulations, as well as local ordinances, have been established to protect public health and safety. Many of these are also intended to protect environmental quality associated with resources discussed throughout this chapter and are described in respective sections. For example, regulations under the CAA described in Section 3.2 establish standards for maintaining public health with respect to air emissions, regulations under the CWA and *Safe Drinking Water Act* discussed in Section 3.3 are intended to protect water sources and public water supplies, traffic regulations and ordinances discussed in Section 3.10 enforce traffic safety, noise ordinances discussed in Section 3.12 protect the public from harmful noise impacts, and hazardous materials and waste regulations discussed in Section 3.14 implement standards to protect the public from harmful exposures. Ultimately, the maintenance of public health and safety is an objective of most environmental laws and regulations discussed in this PEIS.

3.17.2 AFFECTED ENVIRONMENT

3.17.2.1 Occupational Safety and Health

The U.S. Department of Labor, Bureau of Labor Statistics collects and maintains statistics on workplace injuries, illnesses, and fatalities. Table 3-92 summarizes the occupational injury and fatality statistics for the United States in 2012 for selected industries based on the North American Industry Classification System (NAICS). Industries in this table were selected to represent occupational injury and fatality statistics during construction and operation, both in industries associated with energy systems, as well as with other comparable industries. The table presents the total numbers of recordable injuries or illnesses per 100 workers, the numbers of injury or illness cases involving days lost (away from work) per 100 workers, and the total numbers of fatalities in the year for each NAICS industry considered. The table also provides the rates of fatalities in all construction industries and all utility industries per 100 full-time equivalent workers (based on 2,000 hours each) for the year.

Table 3-92. Occupational Injury and Fatality Data for Selected Industries in United States, 2012

Industry	NAICS Code[a]	Total Recordable Injury Cases per 100 Workers	Injury Cases with Lost Days per 100 Workers	Total Fatal Injuries	Fatal Injury Rate per 100 Full-time Equivalent Workers
Construction	**23**	**3.7**	**1.4**	**775**	**0.0095**
Construction of buildings	236	3.4	1.4	133	-
Heavy and civil engineering construction	237	3.2	1.1	169	-
Utility system construction	2371	2.8	1.0	68	-
Power and communication line and related structures construction	23713	3.1	1.1	26	-
Highway, street, and bridge construction	2372	4.2	1.3	84	-
Utilities	**22**	**2.8**	**0.8**	**11**	**0.0025**
Electric power generation, transmission and distribution	2211	2.5	0.7	3	-
Electric power generation	22111	1.7	0.4	0	-
Fossil fuel electric power generation	221112	2.1	0.5	0	-
Nuclear electric power generation	221113	0.3	0.1	0	-
Other electric power generation	221119	4.4	1.3	0	-
Electric power transmission, control, and distribution	22112	3.1	0.9	3	-
Natural gas distribution	2212	2.9	0.9	0	-
Water, sewage, and other systems	2213	4.9	1.8	8	-

a. Industry data are based on the North American Industry Classification System 2007.
Sources: BLS 2013d, BLS 2013e, and BLS 2013f.

Occupational data related to the construction and operation of renewable energy facilities would include a combination of many of these table entries, The project-specific evaluation of potential health and safety impacts to workers could be developed using these data once the specific work activities, and projected staffing were known.

3.17.2.2 Public Health and Safety

Hawai‘i recorded the lowest age-adjusted mortality rate of any state in the nation in 2010, with 589.6 deaths per 100,000 population compared with 747 deaths per 100,000 population in the United States as a whole (Murphy et al. 2013). Hawai‘i’s mortality rate also declined from 620.8 deaths per 100,000 population in 2009. The age-adjusted mortality rates from accidents and motor vehicle accidents in Hawai‘i (29.6 and 9.1 per 100,000 population, respectively) were lower than the national rates (38 and 11.3) in 2010. Hawai‘i’s age-adjusted mortality rate from chronic lower respiratory diseases, 18 deaths per 100,000 population, was also substantially lower than the national rate of 42.2 in 2010.

3.17.2.3 Public Health and Safety Services

3.17.2.3.1 Police

In aggregate, Hawaiʻi has seven State and local law enforcement agencies with 4,097 total employees, including 3,234 sworn officers for a ratio of 2.51 officers per 1,000 population (in 2008). Hawaiʻi's ratio ranked 19th in the United States and equaled the national average ratio in 2008 (Reaves 2011). The Hawaiʻi Department of Public Safety is a State agency headquartered in Honolulu with divisions responsible for administration, correctional facilities, and law enforcement. The two law enforcement divisions include the sheriff division and narcotics enforcement division.

Separate county police departments serve the islands of Hawaiʻi. The Honolulu Police Department, serving the island of Oʻahu, is the largest with 1,933 officers and 463 civilians in 29 divisions. The department was ranked 20th in the number of full-time sworn officers among all State and local law enforcement agencies in the United States in 2008 (Reaves 2011). The department has approximately 2.1 officers per 1,000 population (City and County of Honolulu 2014a). The Kauaʻi Police Department operates three district stations serving Lihue, Waimea, and Hanalei, plus a traffic safety unit (County of Kauaʻi 2014a). The Maui Police Department operates six district stations serving Hana, Kihei, Lahaina, Lānaʻi, Molokaʻi, and Wailuku (County of Maui 2014a). The Hawaiʻi County Police Department serves the island of Hawaiʻi and includes two areas of operation bureaus. Area I includes the South Hilo Patrol, the North Hilo District, Hāmākua District, Puna District, and investigative, traffic, and community units. Area II includes the Kona Patrol, South Kohala District, North Kohala District, Kau District, and investigative and community units (County of Hawaiʻi 2014a).

3.17.2.3.2 Fire and Rescue

The City and County of Honolulu Fire Department, serving Oʻahu, is the largest fire protection service in the State, with more than 1,100 firefighters. The department has 45 fire stations in 5 battalions and operates 43 engine companies, 13 ladder companies, 2 rescue companies, 2 hazardous materials companies, 2 tower companies, 1 fireboat company, 6 tankers, 2 helicopters, and 3 rescue boats. The department provides response for fire and rescue, emergency medical service (EMS), and first response to hazardous materials incidents. The Honolulu Fire Department has been accredited by the Commission on Fire Accreditation International (City and County of Honolulu 2014b). The Kauaʻi Fire Department has eight stations serving the island and provides fire protection and suppression, rescue (ocean and land), hazardous materials response and EMS (County of Kauaʻi 2014b). The Maui Fire Department has 14 stations serving the islands of Maui, Lānaʻi, and Molokaʻi. The department provides response for fire and rescue, EMS, and hazardous materials incidents with 279 personnel and operates 14 engine companies, 2 ladder companies, 1 rescue company, 1 hazardous materials company, 4 tankers, 3 mini-pumpers, 1 helicopter, 3 rescue boats, and 11 utility vehicles (County of Maui 2014b). The Hawaiʻi County Fire Department provides fire protection and suppression, pre-hospital EMS, land and sea search and rescue, hazardous materials response, ocean safety, and fire prevention and public education for the County of Hawaiʻi (County of Hawaiʻi 2014b). The U. S. Fire Administration did not include Hawaiʻi in its computation of the relative risk of death by fire among states nationwide in 2010 because of the small number of fire deaths in the State (USFA 2014).

3.17.2.3.3 Medical

In addition to the EMS response provided by the respective county fire departments, medical facilities in Hawaiʻi include more than 20 acute care hospitals, as well as numerous clinics and non-acute facilities. Most hospitals are located on the island of Oʻahu, but Kauaʻi, Maui, and Hawaiʻi have at least three hospitals each (USA Hospitals 2014).

3.17.3 COMMON CONSTRUCTION AND OPERATION IMPACTS

3.17.3.1 Occupational Safety and Health

Potential activities and technologies evaluated in this PEIS range from measures that would require limited new construction or facilities, as in the case of energy efficiency alternatives, to measures that may change existing construction and operational practices, as in the case of distributed renewable energy sources or alternative transportation fuels and modes, to measures that may involve substantial new construction and operation of facilities, as in the case of utility-scale renewable energy and electrical transmission and distribution systems. Therefore, the potential effects of these technologies on occupational health and safety would relate directly to the size of the workforce needed for particular projects and activities. Projects having associated major construction activities, such as site preparation and installation of components and equipment, and resulting in the need for operation of complex utility systems would pose the greatest risks to occupational health and safety. Construction and operation workers at any facility are subject to risks of injuries and fatalities from physical hazards. While such occupational hazards can be minimized when workers adhere to safety standards and use appropriate protective equipment, fatalities and injuries from on-the-job accidents can still occur.

Many of the occupational hazards associated with the analyzed technologies are similar to those of the heavy construction and electric power industries (i.e., working at heights, exposure to weather extremes and high winds, exposure to dangerous animals and plants, working around energized systems, working around lifting equipment and large moving vehicles, and working in proximity to rotating/spinning equipment). Therefore, the potential occupational safety and health impacts of specific projects can be estimated using the statistics for the power and communication line and related structures construction NAICS code in Table 3-91. The statistics for worker injuries and fatalities in this industry do not indicate risks greater than those for construction of buildings, highways, or bridges.

The operation of the most complex of facilities for the analyzed technologies would involve activities comparable to those performed in electric power generation, transmission, and distribution utilities (i.e., working around energized systems, working around heavy equipment and large moving vehicles, working in proximity to rotating/spinning equipment, and potentially working on exposed towers or with hazardous materials). These activities would involve risks to workers comparable to those summarized for respective NAICS codes in Table 3-91 and can be used to predict occupational safety and health impacts of specific projects. The statistics for worker injuries and fatalities in this industry do not indicate risks greater than those for water, sewage, and other utilities. Operational requirements for some analyzed technologies, such as energy efficiency alternatives or alternative transportation fuels or modes, would likely require substantially fewer workers than for utility-scale projects and facilities and thus would have fewer predicted injuries or fatalities.

3.17.3.2 Public Health and Safety

With the expected establishment of adequate access controls that would prevent entry to hazardous areas by unauthorized individuals, the great majority of adverse impacts during construction, operation, and future decommissioning of the analyzed technologies would be limited to the respective workforces involved. However, both beneficial and adverse impacts to public health and safety may result from specific projects. Beneficial impacts may result from the displacement of older and less-efficient, conventional oil-fueled electric generation facilities that emit higher amounts of pollutants to air and water. Such benefits are diffuse and may or may not be realized within the areas immediately adjacent to specific projects. Conversely, adverse impacts from operation of facilities the analyzed technologies may be experienced by individuals living within the immediate vicinity of a project, such as a wind farm, photovoltaic array, thermal facility, biomass facility, or geothermal facility. Therefore, potential adverse impacts on public health and safety are addressed for specific technologies in the impacts chapters (Chapters 4 through 8).

Accidents or incidents may occur during construction or operation of facilities that would require police, fire, or EMS response. Demands on these services by particular projects could affect service capacities and their ability to respond to concurrent needs of the community. Such adverse impacts on public health and safety may have greater potential to occur in cases where a project would be located distant from a service provider and, because of the emergency needs of the project, the capacity of the provider to serve the needs of residents may be impaired. For example, in rural locations, competing demands on service providers may result in increased time for emergency units to respond to serious events, such as a heart attack. Projects in remote, rural locations could also create situations where it may not be feasible for emergency units to respond using standard procedures, such as use of fire trucks to fight an onsite grass fire.

Effects on the public health and safety services of each island from the addition of construction workers for typical potential projects would generally be small, as the workers needed to construct most projects are expected to be drawn from the island's existing workforce (see Section 3.15.11). Police, fire, and medical services would not be adversely affected by small changes in local populations.

Additional concerns may be caused by inadequate infrastructure or roads that are unpaved or undersized for fire and rescue vehicles. Also, there may not be sufficient manpower and equipment available from a single station to respond to an emergency during project construction or operation. Other fire stations may provide support, but distance and travel time may impair efficiency. Also, limited medical facilities in remote locations could adversely affect public health and safety in the event of a major accident or emergency during construction or operation of a specific project.

3.17.4 ACCIDENTS AND INTENTIONAL DESTRUCTIVE ACTS

Owners and operators of critical infrastructure are responsible for ensuring the operability and reliability of their systems. To do so, they must evaluate the impacts on their system from all credible events, including natural disasters as well as mechanical failure, human error, or deliberate destructive acts of both domestic and international origin, recognizing intrinsic system vulnerabilities, the realistic potential for each event/threat, and the consequences.

3.17.4.1 Regulatory Setting

Various regulations promulgated by Federal and State agencies confirm project developers' responsibilities for protecting critical infrastructure through a variety of prescribed actions and system performance requirements designed to protect the public and/or the environment from adverse consequences of disruptions or failures, and to provide for system reliability and resiliency. Regulations and directives promulgated by the Federal Energy Regulatory Commission are an example of such a regulatory program. Special system designs, construction techniques, advanced communication and system-monitoring capabilities, and other preemptive protective measures have been developed to meet the requirements of those regulations. BMPs that have also been developed are designed to further ensure system reliability and to minimize interruptions in service (e.g., security measures, fencing, personnel policies). Future projects associated with the analyzed technologies would be expected to conform to all applicable regulations and best industry practices.

Homeland Security Presidential Directive 7 (HSPD-7), signed on December 21, 2003, establishes a national policy that affirms the responsibility of Federal departments and agencies to identify and prioritize U.S. critical infrastructure and key resources and to protect them from terrorist attacks (DHS

2003). Under that Directive, "Federal departments and agencies will identify, prioritize, and coordinate the protection of critical infrastructure and key resources in order to prevent, deter, and mitigate the effects of deliberate efforts to destroy, incapacitate, or exploit them. Federal departments and agencies will work with State and local governments and the private sector to accomplish this objective."

HSPD-7 resulted in the June 2006 publication of the *National Infrastructure Protection Plan* (DHS 2006), the development of which was coordinated by the U.S. Department of Homeland Security. The current *National Infrastructure Protection Plan* (DHS 2009) comprises 18 sector-specific plans, each addressing a category of critical infrastructure and key resources. The DOE Office of Energy Efficiency and Electricity Reliability serves as the sector-specific agency for energy and is primarily responsible for the development and implementation of the energy plan. The Transportation Security Administration of the Department of Homeland Security serves a similar function for the transportation plan.

The energy sector-specific plan addresses the production, refining, storage, and distribution of oil and gas and electricity. The transportation sector-specific plan addresses the movement of people and the transport of goods by all modes of transportation, and especially addresses the transport of hazardous materials (including crude oil, natural gas, and refined petroleum products) by all modes of transport, including pipelines. Pipelines are addressed in the transportation sector-specific plan as a mode of transportation; however, pipelines are also an integral part of the energy sector. As a result, unique partnerships have been struck between private-sector representatives and representatives of both sector-specific agencies to ensure coordinated implementation of both plans. The energy and transportation plans establish appropriate risk management frameworks to meet their respective goals and objectives. Although the DOE and the Transportation Security Administration are the agencies explicitly directed to develop and implement the plans that most directly address critical infrastructure and key resources for utility-scale facilities, HSPD-7 obligates all Federal agencies to cooperate with those efforts. Utility-scale project developers for the HCEI would also be full participants in the implementation of applicable plan objectives and programs.

Although it is important for the public to be informed as to the commitment and basic structural approach of the national integrated effort to address terrorism, the specific strategies and tactics that emerge cannot be shared. Thus, while some protective measures and activities are obvious (e.g., fencing around electric substations and switchyards, routine surveillance and inspections), other measures must remain under cover to maintain their effectiveness.

3.17.4.2 Credible Events

3.17.4.2.1 Natural Occurrences

There is a potential for natural events to affect human health and the environment during all phases of development of projects and facilities. Such events include severe storms, fires, volcanic activity, earthquakes, and tsunamis. Depending on the severity of the event, fixed components of a facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. The probability of a natural event occurring is location-specific and differs among the locations for potential projects in Hawaii. Such differences should be taken into account during project-specific studies and reviews.

The consequences of natural events could include injuries, loss of life, and the release of hazardous materials to the environment. The likelihood of injuries and loss of life may be decreased by emergency planning (e.g., fire drills) and onsite first-aid capabilities. For hazardous materials releases, the potential types and quantities of materials that would be present at a facility and that potentially could be released to the environment during a natural event are discussed in the Hazardous Materials and Waste Management sections of Chapters 4 through 8 for the various technologies.

3.17.4.2.2 Intentional Destructive Acts

In addition to the natural events described above, there is a potential for intentional destructive acts to affect human health and the environment. In contrast to natural events, for which it is possible to estimate event probabilities based on historical data and information, it is not possible to accurately estimate the probability of sabotage or terrorism. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the measures taken to prevent occurrence and the potential consequences of such events.

The consequences of a sabotage or terrorist attack on a facility could be comparable to those discussed above for natural events. Additionally, a cyber-attack on computerized control and communications systems could have similar effects by causing equipment failures or overloads. Depending on the severity of the event, fixed components of a facility could be damaged or destroyed, and releases of hazardous materials or toxic substances may occur, resulting in economic, safety, and environmental harm. The population at most risk in any such event would consist primarily of the operational staff at the facility. The potential consequences of such events should be evaluated on a project- and site-specific basis.

3.17.5 COMMON BEST MANAGEMENT PRACTICES

3.17.5.1 Occupational Health and Safety

The degree to which best management practices for occupational health and safety are implemented would depend on the potential hazards involved in the specific project. The following best management practices to protect project workers are recommended for implementation during all phases associated with a large-scale project. Many of these practices may not be necessary for specific projects with lower risks.

- Conduct site characterization, construction, operation, and decommissioning activities in compliance with applicable Federal and State occupational safety and health standards (e.g., Occupational Health and Safety Standards, 29 CFR Parts 1910 and 1926, and the Hawaiʻi State Plan).

- Conduct a safety assessment to describe potential safety issues and the means that would be taken to mitigate them, covering issues such as site access, construction, safe work practices, security, heavy equipment transportation, traffic management, emergency procedures, and fire control.

- Develop a health and safety program to protect workers during site characterization, construction, operation, and decommissioning of a project. The program would identify all applicable Federal and State occupational safety standards and establish safe work practices addressing all hazards, including requirements for developing the following plans: general injury prevention; personal protection equipment requirements and training; respiratory protection; hearing conservation; electrical safety; hazardous materials safety and communication; housekeeping and material handling; confined space entry; hand and portable power tool use; gas-filled equipment use; and rescue response and emergency medical support, including onsite first-aid capability.

  The health and safety program would address OSHA standard practices for the safe use of explosives and blasting agents where applicable; measures for reducing occupational EMF exposures; the establishment of fire safety evacuation procedures; and required safety performance standards (e.g., electrical system standards and lighting protection standards). The program would include training requirements for applicable tasks for workers and establish procedures for providing required training to all workers. Documentation of training and a mechanism for reporting serious accidents to appropriate agencies would be established.

- Prepare a health risk assessment to evaluate potential cancer and non-cancer risks to workers from exposure to facility emission sources during construction and operations. If potential risks are found to exceed applicable threshold levels, measures should be taken to decrease emissions from the source.

- Design electrical systems to meet all applicable safety standards (e.g., National Electrical Code) and should comply with the interconnection requirements of the transmission system operator.

- In the event of an accidental release of hazardous substances to the environment, project developers should document the event, including a root cause analysis, a description of appropriate corrective actions taken, and a characterization of the resulting environmental or health and safety impacts. Documentation of the event should be provided to the permitting agencies and other Federal and State agencies within 30 days, as required.

- For the mitigation of explosive hazards where applicable, workers should be required to comply with the OSHA standard (29 CFR 1910.109) for the safe use of explosives and blasting agents.

- Consider measures to reduce occupational EMF exposures, such as backing electrical generators with iron to block the EMF, shutting down generators when work is being done near them, and otherwise limiting exposure time and proximity while generators are running.

- During construction and operation, proposed sites should have an emergency response plan and be equipped with onsite emergency first aid and fire-fighting equipment.

3.17.5.2 Public Health and Safety

Similar to occupational health and safety, the degree to which BMPs for public health and safety are implemented would depend on the potential hazards involved in the specific project. The following BMPs for the protection of public health and safety are recommended for implementation during all phases associated with a large-scale project. Many of these practices may not be necessary for specific projects with lower risks.

- Ensure the project health and safety program addresses protection of public health and safety during site characterization, construction, operation, and decommissioning for a project. The program would establish a safety zone or setback for project facilities and associated transmission lines from residences and occupied buildings, roads, rights-of-way, and other public access areas that is sufficient to prevent accidents resulting from various hazards during all phases of development. It would identify requirements for temporary fencing around staging areas, storage yards, and excavations during construction or decommissioning activities. It would also identify measures to be taken during the operations phase to limit public access to facilities (e.g., equipment with access doors should be locked to prevent public access, and permanent fencing should be installed around sensitive or potentially dangerous equipment).

- Prepare a traffic management plan for the site access roads to control hazards that could result from increased truck traffic (most likely during construction or decommissioning), to ensure that traffic flow would not be adversely affected and that specific issues of concern (e.g., the locations of school bus routes and stops) are identified and addressed. This plan should incorporate measures such as informational signs, flaggers (when equipment may result in blocked throughways), and traffic cones to identify any necessary changes in temporary lane configurations. The plan should be developed in coordination with local planning authorities.

- Prepare a health risk assessment to evaluate potential cancer and non-cancer risks to the general public from exposure to facility emission sources during construction and operations. If potential risks are found to exceed applicable threshold levels, measures should be taken to decrease emissions from the source.

- Use proper signage and or engineered barriers (e.g., fencing) to limit access to electrically energized equipment and conductors in order to prevent access to electrical hazards by unauthorized individuals or wildlife.

- Project developers should work with appropriate agencies (e.g., DOE and the Transportation Security Administration) to address critical infrastructure and identify key resource vulnerabilities at utility-scale facilities to minimize and plan for potential risks from natural events, sabotage, and terrorism.

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3.19 Glossary

Affected Environment: In accordance with CEQ NEPA regulations, the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with the environment." The descriptions of the affected environment serve as a baseline – or description of existing environmental conditions – against which the impacts of potential future actions may be evaluated and compared.

Air Pollutant: Generally an airborne substance that could, in high enough concentrations, harm living things or cause damage to materials. From a regulatory perspective, an air pollutant is a substance for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established due to potential harmful effects on human health and welfare. In Hawaiʻi, under HRS Chapter 342B, the term "air pollutant" has the same meaning as under the Clean Air Act. *Related terms: air pollution, ambient air.*

Air Pollution: Under Hawaii law (HRS Chapter 342B), refers to the presence in the outdoor air of substances in quantities and for durations which may endanger human health or welfare, plant or animal life, or property or which may unreasonably interfere with the comfortable enjoyment of life and property throughout the State and in such areas of the State as are affected thereby, but excludes all aspects of employer-employee relationships as to health and safety hazards. *Related terms: air pollutant, ambient air.*

Air Quality: The cleanliness of the air as measured by the levels of air pollutants relative to standards or guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150% of its standard, even if levels of other pollutants are well below their respective standards). *Related terms: air pollutant, air pollution.*

Alien (Introduced) Species: Organisms that were not brought to that location naturally but by man. *Related terms: Endemic species, indigenous species, native species.*

Ambient Air: The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to an emission source. Under Hawaii Administrative Rules (HAR) Title 11 Chapter 59, ambient air is defined as the general outdoor atmosphere to which the public has access. *Related terms: air pollutant, air pollution, criteria pollutant, National Ambient Air Quality Standards (NAAQS).*

Anchialine Pond: This term, pronounced "AN-key-ah-lin," comes from a Greek word meaning "near the sea." These typically small pools, which form in limestone or volcanic rock, are located throughout the world but are most common in the Hawaiian Islands where over half the world's known anchialine pools are found. They are often found in underground cave systems. Anchialine pools have their own unique ecosystems populated by tiny and often rare species of crustaceans, fish, and eels. Water levels in the pools can fluctuate in response to ocean tides. Due to their subterranean connection to the ocean, anchialine surface waters are often brackish and become more saline (salty) with increasing depth.

Aquifer: Water-bearing geologic formation(s) with sufficient saturated, permeable material to yield significant quantities of water to wells or springs.

Best Management Practices (BMPs): Policies, practices, and measures that reduce the environmental impacts of designated activities, functions, or processes. BMPs are distinguished from mitigation measures because mitigation measures are required as a result of the NEPA/HEPA environmental review process.

Carbon Dioxide Equivalent (CO_2Eq): A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents ($MMTCO_2Eq$)." The carbon dioxide equivalent for a greenhouse gas is derived by multiplying the tons of the gas by the associated global warming potential (GWP):

$$MMTCO_2Eq = (\text{million metric tons of a gas}) * (\text{GWP of the greenhouse gas})$$

Related terms: global warming potential, greenhouse gases.

CEQ (Council on Environmental Quality): A division within the Executive Office of the President that coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. Established under the National Environmental Policy Act (NEPA) of 1969, CEQ is tasked with ensuring that Federal agencies meet their obligations under NEPA by overseeing Federal agency implementation of the environmental impact assessment process and to act as a referee during agency disagreements.

Climate Change: (1) Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer. (2) A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Among these human activities are burning fossil fuels as oil, coal, and natural gas (for electricity and transportation); farming (agriculture); deforestation; and other land use changes that result in the release of substantial amounts of greenhouse gases into the atmosphere that most climate scientists believe is contributing to human-induced climate change. The term "global warming" is often used in public discourse when referring to this human-induced climate change. *Related terms: carbon dioxide equivalent, greenhouse gases, global warming potential.*

Convection: Generally, transport of heat and moisture by the movement of a fluid. In meteorology, the term is used specifically to describe vertical transport of heat and moisture in the atmosphere, especially by updrafts and downdrafts in an unstable atmosphere. The terms "convection" and "thunderstorms" often are used interchangeably, although thunderstorms are only one form of convection. However, convection is not always made visible by clouds. Convection which occurs without cloud formation is called dry convection, while the visible convection processes referred to above are forms of moist convection.

In the case of the Hawaiian Islands, trade winds interact with the mountainous terrain, resulting in convection as the air cools and the moisture in it condenses to form clouds and rain. This convective rainfall is most pronounced on the windward sides of the more mountainous islands at elevations between 2,000 and 3,000 feet where annual amounts are as much as 15 times the statewide sea level average of 25 to 30 inches. There are places in the Hawaiian Islands where annual rainfall top 450 inches (37-1/2 feet) per year such as Mount Wai‘ale‘ale on Kaua‘i and Big Bog on Maui where at least 450 inches of rain a year fall on average.

Covered Source: In the State of Hawai‘i under HRS Chapter 342B, this refers to any sources of air pollution that includes is any major source, any source subject to a standard or other requirements under

Section 111, “Standards of performance for new stationary sources,”, of the Clean Air Act, or any source subject to an emissions standard or other requirements for hazardous air pollutants under Section 112, “Hazardous air pollutants”, of the Clean Air Act (with specified exceptions). HRS Chapter 342B defines five different meanings of covered sources. *Related terms: air pollutant, air pollution, hazardous air pollutant, major source, stationary source, non-covered source.*

Criteria Pollutant: An air pollutant that is regulated by the Environmental Protection Agency (EPA) under the Clean Air Act through the National Ambient Air Quality Standards (NAAQS) on the basis of specific criteria of human health-based and/or environmentally-based criteria. EPA has set NAAQS standards for six criteria air pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter, less than 10 micrometers (0.0004 inch) in diameter, and less than 2.5 micrometers (0.0001 inch) in diameter. *Related terms: air pollutant, air pollution, ambient air, hazardous air pollutant, National Ambient Air Quality Standards (NAAQS).*

Critical Habitat: Areas deemed necessary to a species’ conservation and officially designated under the Endangered Species Act; provided that the species is legally protected. *Related terms: endangered species, threatened species.*

Cultural Landscape: Cultural properties that represent the combined works of nature and of man. They can be sites associated with a significant event, activity, person or group of people; can range in size from thousands of acres of rural land to historic homesteads; can be grand estates, farmlands, public gardens and parks, college campuses, cemeteries, scenic highways, and industrial sites; and can be works of art, narratives of cultures, and expressions of regional identity. *Related terms: Hawaiʻi Register of Historic Places (HRHP), National Register of Historic Places (NRHP).*

Emperor Seamounts: A chain of submerged mountains (primarily guyots) that rise from the Pacific Ocean floor but do not reach the sea surface that run on a north-northwesterly direction toward, terminating near the Kamchatka Peninsula in a subduction trench off the western Aleutian Islands. It is believed the Emperor Seamounts were formed approximately 80 million years ago as the Pacific plate moved over the same hotspot that formed the Hawaiian Archipelago. In this way, these submerged mountains are the oldest portion of the combined Emperor Seamounts – Hawaiian Archipelago (sometimes called the “Hawaiian Ridge – Emperor Chain”). *Related terms: See hotspots, guyot, Hawaiian Archipelago.*

Emperor Seamounts – Hawaiian Archipelago (also called the Hawaiian Ridge – Emperor Chain): The entire chain of approximately 130 volcanic mountains including submerged seamounts that spans about 3,800 miles from the Island of Hawaii (the Big Island) to near the Kamchatka Peninsula where they terminate in a subduction trench off the western Aleutian Islands. The complex consists of the older submerged Emperor Seamounts and the younger Hawaiian Archipelago that make up the Hawaiian Islands including the six that are the focus of this PEIS – Hawaiʻi (“Big Island”), Maui, Oʻahu, Kauaʻi, Molokaʻi, and Lānaʻi – as well as Niʻihau and Kahoʻolawe, and the smaller Northwestern Hawaiian Islands.

The entire complex was formed by the motion of the Pacific Plate over a relatively fixed hotspot that is presently under Hawaiʻi Island (i.e., “Big Island”). There is a sharp bend in the chain with the Emperor Seamounts aligned south-southeast to north-northwest while the Hawaiian Archipelago is aligned east-southeast to west-northwest. *Related terms: Emperor Seamounts, Hawaiian Archipelago, hotspots.*

Endangered Species: Any species in danger of extinction throughout all or a significant portion of its range. *Related terms: listed species, proposed species, threatened species, and taking.*

Endemic Species: Organisms that are native and can be found only in that location. Examples of organisms that are endemic to Hawaiʻi are the spectacled parrotfish and Hawaiian Monk Seal. *Related terms: Alien (or introduced) species, indigenous species, native species.*

Evapotranspiration: Loss of water to the atmosphere by a combination of transpiration of plants and direct evaporation.

Floodplain: The lowlands and relatively flat areas adjoining inland and coastal waters and the flood prone areas of offshore islands. Floodplains include, at a minimum, that area with at least a 1.0 percent chance of being inundated by a flood in any given year (that is, experiencing a 100-year flood). Floodplains include the base floodplain (those areas subject to 100-year floods) and the critical action floodplain (those areas with at least a 0.2 percent chance of being flooded in any given year, also known as a 500-year flood). *Related term: National Flood Insurance Program.*

Global Warming Potential (GWP): A measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide. In this way, GWP of a gas provides a relative basis for calculating the equivalent warming it produces as carbon dioxide. For reference carbon dioxide has a GWP of 1, and is therefore the standard by which all other greenhouse gases are measured. The term “global warming” is synonymous with climate change (see climate change). *Related terms: carbon dioxide equivalent, climate change, greenhouse gases.*

Greenhouse Gases: Those natural or manmade gaseous constituents of the atmosphere that absorb and re-emit infrared radiation. Such gases allow sunlight to enter the atmosphere freely but absorb the resulting infrared or thermal radiation (heat) that is reradiated by the ground, objects on it, or even the air itself. In this way, such gases “trap” the heat in the atmosphere, causing the air warm. There are many greenhouse gases in nature including water vapor, carbon dioxide, methane, and nitrous oxide, as well certain manmade ones such as aerosols and chlorofluorocarbons (CFCs). Each gas had a specific ability to warm the air that is measured versus the warming potential of carbon dioxide. *Related terms: Carbon dioxide equivalent, climate change, global warming potential.*

Groundwater: Water below the ground surface in a zone of saturation. *Related terms: streams (classifications), waters of the United States, watershed, wetlands.*

Guyot: An underwater, flat-topped, coral-capped volcanic mountain (seamount). Nearly all the volcanoes in the Hawaiian-Emperor seamount chain older than 30 million years old are guyots, although some never actually reached the sea surface. *Related terms: Hawaiian Archipelago (Hawaiian Ridge), Emperor Seamounts.*

Hawaiʻi Register of Historic Places (HRHP): A list officially maintained by the State Historic Preservation Division of the State of Hawaiʻi. The list formally recognizes districts, sites, structures, buildings, and objects and their significance in Hawaiʻi’s history, architecture, archaeology, engineering, and culture. *Related terms: Cultural landscape, National Register of Historic Places (NRHP).*

Hawaiian Archipelago (Hawaiian Ridge): Refers to the principal islands of the State of Hawaiʻi including the six that are the focus of this PEIS – Hawaiʻi (“Big Island”), Maui, Oʻahu, Kauaʻi, Molokaʻi, and Lānaʻi – as well as Niʻihau and Kahoʻolawe, and also the various lesser islands, atolls, reefs, and submerged volcanic seamounts of the Northwestern Hawaiian Islands. The former are sometimes referred to as the Hawaiian Windward Islands, and the latter is sometimes called the Hawaiian Leeward Islands. The Hawaiian Archipelago rises off the Pacific Ocean floor and was created by the west-northwesterly motion of the Pacific plate over a relatively stationary hotspot with the oldest portions approximately 30 million years old. The Hawaiian Archipelago terminates at the Emperor Seamounts, a chain of submerged volcanoes that terminates off the western Aleutian Islands. Together the two features are known as the Emperor Seamounts – Hawaiian Archipelago. *Related terms: Emperor Seamounts, Emperor Seamounts – Hawaiian Archipelago, hotspots, guyot*.

Hazardous Air Pollutant: Also known as toxic air pollutants or air toxics, these are pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. Section 112 of the Clean Air Act addresses the emissions of hazardous air pollutants. Under the Clean Air Act Amendments of 1990, EPA is required to control 187 hazardous air pollutants. Through appropriate rulemaking, the pollutants on the list can be modified. A current list of modifications is available on the EPA website along with clarifications on certain pollutant aggregation. Additional information is available at http://www.epa.gov/ttn/atw/pollsour.html. The State of Hawaiʻi defines hazardous air pollutant to include those listed in Section 112 of the Clean Air Act Amendments of 1990. *Related terms: hazardous material, hazardous waste.*

Hazardous Material: Any item or agent (biological, chemical, physical) that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. *Related terms: Hazardous air pollutant, hazardous waste, nonhazardous waste, solid waste.*

Hazardous Waste: (1) As defined in this PEIS, a hazardous waste refers to any *hazardous material* that can be characterized by ignitability, corrosiveness, reactivity, and toxicity. Those solid wastes that exhibit one or more of these characteristics is are classified as a hazardous wastes, and/or as a hazardous substances, including discarded military munitions. (2) As defined by EPA, a hazardous waste is any waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. *Related terms: Hazardous air pollutant, hazardous material, nonhazardous waste, solid waste.*

Hotspots: Locations where massive plumes of hot rock have risen through Earth's mantle toward the lithosphere, where the lower pressures at the base of the lithosphere cause the rock to melt along its upper margins. The resulting molten rock can rise into Earth's crust and generate active volcanism.

In the case of the Hawaiian Islands, the entire island Hawaiian Archipelago as well as the older Emperor Seamounts were formed by the motion of the Pacific plate over a hotspot that has been more or less stationary hotspot for the past 40 million years. The hotspot is currently under the Big Island of Hawaiʻi, which is the youngest of the islands along with the nearby submerged volcano (seamount) called Lōʻihi. The northwestern part of the Hawaiian chain is the oldest part at roughly 30 million years ago. *Related terms: Emperor Seamounts, Emperor Seamounts – Hawaiian Archipelago, Hawaiian Archipelago (Hawaiian Ridge), lithosphere, Lōʻihi, seamount.*

Indigenous Species: Organisms that are native but can be found elsewhere. An example of this is the Hawaiian Green Sea Turtle. *Related terms: Alien (introduced) species, endemic species, native species.*

Listed Species: Any species of fish, wildlife, or plant determined to be endangered or threatened under Section 4 of the Endangered Species Act. *Related terms: Critical habitat, endangered species, threatened species*.

Lithosphere: The outer layer of the Earth consisting of the crust and the rigid, upper part of the mantle. It is 25 to 125 miles thick under the continents and 30 to 60 miles thick under the oceans. The lithosphere is divided into tectonic plates consisting of continents and ocean basins (with the two types consisting of distinct types of rocky materials). The Hawaiian Islands exist as a result of a hotspot underneath the Pacific plate. *Related term: hotspots.*

Lōʻihi: An active submerged volcanic seamount located approximately 16 miles off the southeast coast of the Big Island of Hawaiʻi. The top of the volcano is approximately 3,200 feet below sea level. It is not expected to break the sea surface for possibly 200,000 years. Together with the Big Island, Lōʻihi is the youngest islands in the Hawaiian Archipelago and sits atop the stationary hotspot above which the Pacific plate is slowly moving. *Related terms: hotspots, Hawaiian Archipelago (Hawaiian Ridge).*

Low-Income: Individuals who fall below the poverty line are categorized as low-income. The poverty line takes into account family size and the age of individuals in the family. For any given family below the poverty line, all family members are considered to be below the poverty line for analysis. *Related term: minority.*

Major Source: In the State of Hawaiʻi under HRS Chapter 342B, this refers to a source of air pollution or a group of stationary sources of air pollution located on one or more contiguous or adjacent properties that is under common control of the same person or persons and that emits or has the potential to emit:

- 10 tons or more per year of any single hazardous air pollutant or 25 tons or more per year of any combination of hazardous air pollutants;
- 100 tons or more per year of any other air pollutant; and
- Any amount specified by the Hawaiʻi Department of Health for radionuclides.

Related terms: air pollutant, covered source, hazardous air pollutant, stationary source, non-covered source.

Minority: Persons are included in the minority category if they identify themselves as belonging to any of the following groups (1) Hispanic or Latino, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander. In addition, individuals who categorize themselves as being of multiple racial or ethnic origins are minorities. *Related term: low-income.*

Mitigation: As defined by the Council on Environmental Quality (CEQ) in 40 CFR 1508.20, this refers to (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

Mitigation Measures: Refers to any required plan or course of action (i.e., a measure) for purposes of mitigation. Such measures are required as a result of the National Environmental Policy Act / Hawaiʻi Environmental Policy Act (NEPA/HEPA) environmental review process for future proposed actions to support the State of Hawaiʻi in achieving the goals established in the HCEI.

National Ambient Air Quality Standards (NAAQS): Refers to the standards established under the Clean Air Act (42 U.S.C. § 7401 *et seq.*) and implementing Environmental Protection Agency (EPA) regulations (40 CFR Part 50) defining the highest allowable levels of certain pollutants in the ambient air (i.e., the outdoor air to which the public has access). Primary standards are established to protect public health; secondary standards are established to protect public welfare (for example, visibility, crops, animals, buildings). EPA is required to establish the criteria for setting these standards, and therefore the regulated pollutants are called criteria pollutants. EPA has set standards for six principal criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter, less than 10 micrometers (0.0004 inch) in diameter, and less than 2.5 micrometers (0.0001 inch) in diameter. *Related terms: air pollutant, air pollution, ambient air, criteria pollutant.*

National Flood Insurance Program (NFIP): Created by Congress originally in 1968, this is a flood insurance program administered by the Federal Emergency Management Agency (FEMA). NFIP provides flood insurance to homeowners, renters, and business owners to participating communities that agree to adopt and enforce ordinances that meet or exceed FEMA requirements to reduce the risk of flooding (refer to 44 CFR Parts 1 - 399). The basis of the insurance coverage is the Flood Insurance Rate Map (FIRM), the official map that delineates both the Special Flood Hazard Area (SFHA) and the risk premium zones applicable to the community. The maps show areas prone to inundation by 100-year floods. The NFIP also includes a voluntary Community Rating System (CRS) that is intended to provide incentives in the form of premium discounts for communities to go beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding. In the Hawaiian Islands, the Department of Land and Natural Resources (DLNR) has been designated as the State Coordinating Agency responsible for assisting the coordination of the program between the Federal and County agencies in Hawaii.

National Pollutant Discharge Elimination System (NPDES): A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation. The NPDES permit lists either permissible discharges, the level of cleanup technology required for wastewater, or both.

National Priorities List (NPL): The list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation. The Superfund law (CERCLA) enabled revisions to the existing National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300), commonly known as the National Contingency Plan (NCP). It is the NCP that is established the NPL. *Related terms: Superfund and Superfund site.*

National Register of Historic Places (NRHP): The official list of the Nation’s cultural resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the National Register for their importance in American history, architecture, archeology, culture, or engineering. Properties included on the National Register range from large-scale, monumentally proportioned buildings to smaller scale, regionally distinctive buildings. The listed properties are not just of nationwide importance; most are significant primarily at the state or local level. Procedures for listing properties on the National Register are found in 36 CFR 60. *Related terms: Cultural landscape, Hawai‘i Register of Historic Places*.

Native Species: Organisms brought to a location without the help of man, such as by wind, wave and or birds. Hawai‘i’s state bird, the nēnē or Hawaiian goose, is an example. *Related terms: Alien (or introduced) species, endemic, indigenous.*

Non-covered source: Any stationary source of air pollution constructed, modified, or relocated after March 20, 1972, that is not a covered source. *Related terms: air pollutant, air pollution, covered source, hazardous air pollutant, major source, stationary source*.

Nonhazardous Waste: Wastes that do not meet the EPA definition of hazardous waste. In general, it includes certain kinds of municipal solid waste and industrial waste. The nonhazardous secondary material (NHSM) regulations under the Resource Conservation and Recovery Act (RCRA) identifies which nonhazardous secondary materials are, or are not, solid wastes when burned in combustion units. *Related terms: Hazardous waste, solid waste.*

Proposed Species: Any species of fish, wildlife or plant proposed in the *Federal Register* to be listed under Section 4 of the Endangered Species Act. *Related terms: endangered species, listed species, threatened species, take (taking).*

Solid Waste: As defined by the U.S. Environmental Protection Agency (EPA), any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. Solid waste includes both hazardous waste and nonhazardous waste. EPA regulations at 40 CFR §261.2 provide the conditions for whether the discarded material meets the "Definition of Solid Waste" (DSW) under RCRA Subtitle C Hazardous Waste. *Related term: hazardous waste*.

Stationary Source: In the State of Hawaiʻi under HRS Chapter 342B, this refers to any piece of equipment or any activity at a building, structure, facility, or installation that emits or may emit any air pollutant. *Related terms: air pollutant, air pollution, covered source, major source, non-covered source.*

Streams (Classifications): There are three distinct classifications of streams including perennial stream, intermittent stream, and ephemeral stream.

> <u>Perennial Stream:</u> A stream that flows continuously throughout the year over at least a portion of its course. In Hawaii, perennial streams are continuous if they normally flow all the way to the sea, but often they are termed interrupted because they flow year-round in upper portions and intermittently at lower elevation under normal conditions. Interruptions may be natural or manmade. A perennial stream is also called a year-round stream.
>
> <u>Intermittent Stream:</u> A stream, or part of a stream, that flows only at certain times of year, generally for several weeks or months in response to seasonal precipitation and subsequent groundwater discharge. An intermittent stream is also called a seasonal stream.
>
> <u>Ephemeral Stream:</u> A stream with little or no groundwater influence that flows only a few hours or days in direct response to rainfall. These streams typically are manifest by dry gulches and in Hawaii are generally found on the leeward side of mountainous areas. An ephemeral stream is also called a rain-dependent stream.

Superfund: The common name of the Federal Government's program to clean up the nation's uncontrolled hazardous waste sites. The Superfund program was enacted under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980. *Related term: Superfund site.*

Superfund Site: An uncontrolled or abandoned place where hazardous waste is located, possibly affecting local ecosystems or people. The Environmental Protection Agency lists Superfund sites on the National Priorities List (NPL) upon completion of Hazard Ranking System (HRS) screening, public solicitation of comments about the proposed site, and after all comments have been addressed.

There are presently three Superfund sites on the NPL in Hawaiʻi. One additional site has been cleaned up and removed from the NPL. No sites are currently proposed for addition. All of these sites are on the island of Oʻahu. *Related terms: National Priorities List, Superfund site.*

Take (Taking): As defined under the Endangered Species Act in relation to threatened or endangered species, to "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such contact. *Related terms: Endangered species, listed species, threatened species.*

Thermocline: (1) A zone of water in the ocean where temperature decreases rapidly with depth. (2) A region in a thermally stratified body of water which separates warmer surface water from cold deep water and in which temperature decreases rapidly with depth.

Threatened Species: Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. *Related terms: Endangered species, Listed species, Proposed species, Take (taking).*

Waters of the United States: A legal term from the Clean Water Act and defined in 40 CFR 122.2 that includes "navigable waters of the United States" (see Chapter 2 glossary definition); interstate waters including interstate wetlands; other waters used for interstate travel, commercial, or recreational purposes; impoundment waters; associated tributaries; territorial seas, and wetlands adjacent to these waters. Excluded from this definition are waste treatment systems including treatment ponds or lagoons designed to meet the requirements of the Clean water Act. See http://www.epa.gov/earth1r6/6en/w/watersus.htm. *Related terms: groundwater, streams (classifications), watershed, wetlands.*

Watershed: An area that drains into a body of water, such as a river, lake, reservoir, estuary, sea, or ocean. It includes the rivers, streams, and lakes that convey the water, as well as the land surfaces from which water runs off. In the Hawaiian Islands, the primary inland surface water features are streams that drain watersheds. By contrast, there are very few natural lakes in the Hawaiian Islands. *Related terms: groundwater, streams (classifications), wetlands.*

Wetlands: For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" [40 CFR 230.3(t)]. In the case of Hawai‘i, there are four distinct types of wetlands:

> Riverine wetlands – These are the surface water systems found along the edges of rivers and streams.
>
> Palustrine wetlands – These include marshes and bogs and generally are found in depressions where rain and groundwater collect. Hawai‘i's rare montane bogs, which take millions of years to form, are in this group.
>
> Estuarine wetlands – These include swamps and mudflats that occur on coasts where streams empty to the ocean. These areas typically are influenced by tides, are brackish, and provide habitat for fish, shellfish, and water birds.
>
> Marine wetlands – These include intertidal shorelines, seagrass beds, and tide pools. They are saltwater systems that often provide habitat for many species harvested by humans for food.

Related terms: groundwater, waters of the United States, watershed.

CHAPTER 4

Environmental Impacts from Energy Efficiency

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LIST OF TABLES

4 ENVIRONMENTAL IMPACTS FROM ENERGY EFFICIENCY

This chapter presents the potential environmental impacts that could be expected from the energy efficiency activities and technologies presented in Chapter 2, Section 2.3.1. This chapter includes discussion of only those energy efficiency activities and technologies with the potential for environmental impacts, as presented in Sections 2.3.1.2, 2.3.1.3, and 2.3.1.4: Energy Efficient Buildings, Sea Water Air Conditioning, and Solar Water Heating, respectively. The representative projects described in Section 2.3.1 were used to estimate the potential environmental impacts for each activity and technology. Each of the sections below includes a summary table of the potential environmental impacts and best management practices (BMPs) for that activity or technology. The potential impacts are presented for each environmental resource area. As was described in Chapter 3, many of the activities and technologies could result in environmental impacts that would be common of typical construction projects and may not be unique to the specific activity or technology. In these cases, the presentation of potential impacts in this chapter refers the reader to the appropriate section in Chapter 3 that presents these common impacts for that resource area. Therefore, the details in this chapter deal primarily with those impacts that would be unique to the specific activity or technology being evaluated. Not all activities and technologies have the potential to impact all environmental resource areas analyzed in this document. Therefore, the summary table also identifies and screens those resources areas that are not expected to be impacted by the activity/technology.

4.1 Energy Efficient Buildings

The energy efficient buildings representative project would retrofit all existing homes in the City and County of Honolulu (as of 2015) to bring them into compliance with the 2009 IECC. The representative project also involves the replacement of incandescent light bulbs inside homes with energy efficient lighting (i.e., LED lamps) beyond what is required to comply with the 2009 IECC.

Table 4-1 presents a summary of the potential environmental impacts for energy efficient buildings, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of a retrofit activity and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 4-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Efficient Buildings

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; retrofitting buildings, would not cause any additional land disturbance that could result in impacts to geology and soils.	N/A
Climate and Air Quality		
Air Quality	Minor impacts during construction. Reductions in criteria pollutants as a result of reduction of electricity generation using fossil fuels.	None.

Table 4-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Efficient Buildings (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate Change	Minor impacts during construction. Reductions in GHG emissions as a result of reduction of electricity generation using fossil fuels.	None.
Water Resources		
	None; retrofitting buildings would not cause any additional land disturbance or increased water demand that could result in impacts to water resources, including surface water, groundwater, floodplains, and wetlands.	N/A
Biological Resources		
	None; retrofitting buildings would not cause any additional land disturbance that could result in impacts to biological resources.	N/A
Land and Submerged Land Use		
	None; retrofitting buildings would not cause any changes to land or submerged land use.	N/A
Cultural and Historic Resources		
	Potentially adverse visual or architectural context impact to historic properties.	Prior to construction, evaluate all potential resources for eligibility to the HRHP and the NRHP. In accordance with State law, if a historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for building retrofits, the project proponent must complete and submit a Historic Preservation Review Form to the State Historic Preservation Office (SHPO) in compliance with Hawai‘i Revised Statutes (HRS) Chapter 6E such that the modifications may be reviewed and approved prior to project implementation. Such measures would avoid impacts to an affected property. Review the State Inventory of Historic Properties (SIHP) prior to project startup to determine whether a property is historic. While the SIHP identifies 143 historic buildings or districts on O‘ahu, simply relying on this database alone is not adequate to determine whether a prospective property is historic.

Table 4-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Efficient Buildings (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Comply with *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (DOI 2011).
Coastal Zone Management		
	None; retrofitting buildings would not cause any changes that would have to be reviewed for coastal zone management.	N/A
Scenic and Visual Resources		
	Potential short-term effects due to visibility of construction activities and personnel. Potential long-term visual impacts (project-specific).	Design the installation of energy retrofits to limit visibility and reduce potential visual impacts.
Recreation Resources		
	None; retrofitting buildings, would not cause any additional land disturbance or impacts to recreation resources.	N/A
Land and Marine Transportation		
	None; retrofitting buildings would not cause any changes or impacts to land or marine transportation.	N/A
Airspace Management		
	None; retrofitting buildings would not result in any tall structures or other potential impacts to airspace.	N/A
Noise and Vibration		
	Typical construction noise, as identified in Section 3.12.5.	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
	Potential reduction in energy consumption. See Section 2.3.5.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impact from exposure to hazardous materials including: asbestos materials, lead-based paint, polychlorinated biphenyls, arsenic; and/or mercury (site-specific).	Prior to renovation, perform surveys to identify any areas in homes containing asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic. The EPA recommends proper cleanup and disposal to ensure best practices for mercury handling during building retrofitting.

Table 4-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Efficient Buildings (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Waste Management	Potential impacts to waste management services could occur during project construction/retrofitting, as special handling and disposal of building materials and retrofits may be required. Retrofit work to bring buildings up to code with the 2009 IECC may result in the discovery of asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. The replacement of incandescent light bulbs and/or compact fluorescent bulbs with LED lamps would require special handling and disposal requirements, as certain fluorescent bulbs contain a small amount of mercury. Potential landfill impacts. After completion, building retrofits would not result in waste management impacts.	Consideration should be given to development and implementation of a recycling plan. A recycling program would effectively recover building materials that could contain potentially hazardous substances (e.g., liquid wastes, paints, oil, solvents).
Wastewater	Common impacts from typical construction activities are identified in Section 3.14.4.	None.
Socioeconomics		
	Beneficial – few jobs created.	None.
Environmental Justice		
	None; no disproportionately high and adverse human health or environmental effects on minority and low-income populations.	N/A
Health and Safety		
	During building retrofits, workers may encounter asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. Exposure to such hazardous materials could result in harmful health effects, the severity of which would depend on the level of exposure.	Retrofit projects should begin with an audit performed by a licensed and experienced contractor. The audit involves inspecting, evaluating, and analyzing the building. This evaluates for the presence of potentially hazardous materials.

4.1.1 GEOLOGY AND SOILS

As identified in Table 4-1, there would be no potential impacts to geology and soils from the representative energy efficient building.

4.1.2 CLIMATE AND AIR QUALITY

4.1.2.1 Potential Impacts

Energy retrofits for all existing homes in the City and County of Honolulu would produce beneficial impacts in the form of substantial energy savings. Retrofitting homes to bring them into compliance with the 2009 IECC would reduce energy consumption by 15 percent per year, or about 1,200 kilowatt-hours per home per year. In addition, replacing the remaining 50 percent of the 50-watt incandescent light bulbs with LEDs would reduce energy consumption by about 400 kilowatt-hours per home per year, respectively. Applying these savings to the projected 400,000 residential units in the City and County of Honolulu would produce annual energy savings of about 620,000 megawatt-hours. This reduction in electricity would reduce oil consumption from electricity generation by about 41 million gallons [assuming 66.7 gallons of oil per megawatt-hour of electricity (calculated from DBEDT 2013)]. On O‘ahu, this would correspond with an annual reduction in greenhouse gas emissions of about 0.45 million metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors (http://www.epa.gov/egrid).

No adverse impacts to air quality would be expected from the representative energy efficient building.

4.1.2.2 Best Management Practices and Mitigation Measures

None noted.

4.1.3 WATER RESOURCES

As identified in Table 4-1, there would be no potential impacts to water resources, including surface water, groundwater, and floodplains and wetlands, from the representative energy efficient building.

4.1.4 BIOLOGICAL RESOURCES

As identified in Table 4-1, there would be no potential impacts to biological resources from the representative energy efficient building.

4.1.5 LAND AND SUBMERGED LAND USE

As identified in Table 4-1 there would be no potential impacts to land or submerged land use from the representative energy efficient building.

4.1.6 CULTURAL AND HISTORIC RESOURCES

4.1.6.1 Potential Impacts

The representative project involves energy retrofits to existing residences, so no impacts to archaeological sites would be expected. There would be no reason for land disturbance during retrofit actions, so there would be no site grading or excavations that could increase the potential for encountering buried cultural resources. There is the possibility that building retrofits (e.g., window replacement) to existing buildings or residences that are listed or eligible for listing on the *Hawai‘i Register of Historic Places* (HRHP) or the *National Register of Historic Places* (NRHP), and/or are located in an historic district, would change the characteristics of the property such that the historic nature of the property would be altered. The alterations may have an adverse visual or architectural context impact to the historic property. When modifying historic buildings to retrofit for energy sustainability, the Department of Interior provides standards and guidelines to help guide project proponents (DOI 2011). Additionally, energy retrofits could affect residences and other buildings that not only qualify as historic properties but also as cultural resources whose alterations may require coordination with the OHA’s Native Hawaiian Historic Preservation Council in accordance with applicable regulatory consultation requirements.

4.1.6.2 Best Management Practices and Mitigation Measures

The following BMPs could prevent or reduce the above-discussed impacts:

- Prior to construction, evaluate all potential resources for eligibility to the HRHP and the NRHP. In accordance with State law, if an historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for building retrofits, the project proponent must complete and submit an Historic Preservation Review Form to the State Historic Preservation Office (SHPO) in compliance with Hawai‘i Revised Statutes (HRS) Chapter 6E such that the modifications may be reviewed and approved prior to project implementation. Such measures would avoid impacts to an affected property.

- Review the State Inventory of Historic Properties (SIHP) prior to project startup to determine whether a property is historic. While the SIHP identifies 143 historic buildings or districts on O‘ahu, simply relying on this database alone is not adequate to determine whether a prospective property is historic.

- Comply with *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (DOI 2011).

4.1.7 COASTAL ZONE MANAGEMENT

As identified in Table 4-1, there would be no potential impacts to coastal zone management from the representative energy efficient building.

4.1.8 SCENIC AND VISUAL RESOURCES

4.1.8.1 Potential Impacts

Construction, including installation of light bulbs and associated construction activities, may be visible during such activities. Visual impacts from building retrofits, such as installation of incandescent light bulbs and associated construction activities, would be short term and minimal.

Long-term visual impacts from the building retrofits could be unlikely; however, potential visual impacts from retrofits such as lighting and window replacement would need to be evaluated on a site-specific basis, as changes in building appearances could be visible.

4.1.8.2 Best Management Practices and Mitigation Measures

Install building retrofits to limit visibility to reduce potential visual impacts. Homeowners could install tall vegetation or use screening to hide retrofits.

4.1.9 RECREATION RESOURCES

As identified in Table 4-1, there would be no potential impacts to recreation resources from the representative energy efficient building.

4.1.10 LAND AND MARINE TRANSPORTATION

As identified in Table 4-1, there would be no potential impacts to land or marine transportation from the representative energy efficient building.

4.1.11 AIRSPACE MANAGEMENT

As identified in Table 4-1, there would be no potential impacts to airspace management from the representative energy efficient building.

4.1.12 NOISE AND VIBRATION

4.1.12.1 Potential Impacts

The representative energy efficient buildings project would involve retrofitting existing buildings and could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

4.1.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across construction projects. See Section 3.12.6.

4.1.13 UTILITIES AND INFRASTRUCTURE

4.1.13.1 Potential Impacts

If all residents in the City and County of Honolulu implemented the energy efficiency measures by 2030, then approximately 620,000 megawatt-hours per year of energy would be saved. For O‘ahu, with an annual consumption of 7 million megawatt -hours in 2012 (see Section 3.13.1), the change would represent a 9-percent decrease in power demand. The other islands (i.e., Kaua‘i, Moloka‘i, Lāna‘i, Maui, and Hawai‘i) would have similar impacts if energy efficient measures were implemented. These changes would contribute to meeting about 14 percent of HCEI’s goal of 4,300 gigawatt-hours per year by 2030. This decrease in annual electricity consumption would result in an impact to the utilities and infrastructure as described in Section 2.3.5. On all islands, such changes would contribute to the need to modify the overall utility structure to meet the Renewable Portfolio Standard (RPS) (HECO 2013).

4.1.13.2 Best Management Practices and Mitigation Measures

None noted.

4.1.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

4.1.14.1 Potential Impacts

4.1.14.1.1 Hazardous Materials

The replacement of incandescent light bulbs and or compact fluorescent bulbs with LED lamps would require special handling and disposal requirements, as certain fluorescent bulbs contain a small amount of mercury, a hazardous substance. After completion, building retrofits would not result in hazardous material exposure impacts.

4.1.14.1.2 Waste Management

Potential impacts to waste management services could occur during project construction/retrofitting, as special handling and disposal of building materials and retrofits may be required. Retrofit work to bring buildings up to code with the 2009 IECC may result in the discovery of asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. In addition, the replacement of incandescent light bulbs and/or compact fluorescent bulbs with LED lamps would require special handling and disposal requirements, as certain fluorescent bulbs contain a small amount of mercury.

After completion, building retrofits would not result in waste management impacts.

4.1.14.1.3 Wastewater

Minimal wastewater would be produced during retrofits of buildings. Therefore, wastewater impacts would be minimal.

4.1.14.2 Best Management Practices and Mitigation Measures

4.1.14.2.1 Hazardous Waste

Prior to renovation, perform surveys to identify any areas in homes containing asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic. To minimize exposure to mercury vapor, the EPA recommends that proper cleanup and disposal steps be taken to ensure best practices during building retrofitting occurs (see http://www.epa.gov/hg/mgmt_options.html; EPA 2013).

4.1.14.2.2 Waste Management

Follow proper handling, abatement, and disposal procedures and activities to comply with State and Federal OSHA regulations and county air quality district requirements. This includes proper handling and transport for disposal at the appropriate waste facility to ensure no hazardous wastes were disposed of in landfills. If feasible, building material waste would be recycled in accordance with construction and demolition waste guidelines.

4.1.14.2.3 Wastewater

None noted.

4.1.15 SOCIOECONOMICS

4.1.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from building retrofits in the City and County of Honolulu would be very small. However, with about 400,000 housing units in the county, net new jobs created for electricians, Heating, Ventilation, and Air Conditioning (HVAC) technicians, plumbers, home inspectors, and other related service personnel, would be small in comparison to the existing workforce. In January 2013, the City and County of Honolulu had a labor force of 456,765; of which approximately 22,000 persons were unemployed. Jobs directly associated with the building retrofits likely would be filled by individuals already residing within the region of influence (the City and County of Honolulu) and not by in-migrating workers. While any new jobs created would be considered “green industry” jobs (which meets the HCEI goals), the total new jobs would equal less than 0.1 percent of the existing jobs in the City and County of Honolulu.

4.1.15.2 Best Management Practices and Mitigation Measures

None noted.

4.1.16 ENVIRONMENTAL JUSTICE

4.1.16.1 Potential Impacts

As identified in Table 4-1, there would be no environmental justice impacts from the representative energy efficient buildings project.

4.1.16.2 Best Management Practices and Mitigation Measures

None noted.

4.1.17 HEALTH AND SAFETY

4.1.17.1 Potential Impacts

Common potential impacts from typical construction activities are identified in Section 3.17.3. New building energy efficiency designs and construction are governed by national and county building codes, which are protective of human health and safety. Retrofits fall under the same codes but require additional evaluation to assist in developing designs and the associated retrofit installations that are protective of human health and safety.

During building retrofits, workers may encounter asbestos, lead-based paint, polychlorinated biphenyls, and arsenic. Exposure to such hazardous materials could result in harmful health effects, the severity of which would depend on the level of exposure. For example, if a bulb were to break, some of the mercury would release as mercury vapor. Exposure to high levels of mercury can result in harmful health effects to both humans and the environment.

The representative project could result in minor health effects from exposure to hazardous materials and substances. Retrofitting buildings would not introduce any unique accident scenarios.

4.1.17.2 Best Management Practices and Mitigation Measures

Common BMPs for typical construction activities are identified in Section 3.17.5. The following best management practice could prevent or reduce the above-discussed impacts:

- Any retrofit project should begin with an audit performed by a licensed and experienced contractor to inspect, evaluate, and analyze the building. Such audit would identify the presence of potentially hazardous materials such as asbestos, lead-based paint, polychlorinated biphenyls, and/or arsenic; the potential for pressure imbalances that can result in the back drafting of pollutants into the building; and appropriate ventilation to prevent moisture build-up and potential mold and/or mildew issues.

- The retrofit contractor should incorporate the audit results into the design, processes, and procedures of the building-specific retrofit work plan.

- The contractor should also conduct a close-out audit once the retrofit is completed to ensure that the actual retrofit met the design goals.

- Homeowners and otherwise non-construction personnel should remain away from the building during all retrofit activities when there is a potential for adverse health and safety impacts.

4.2 Sea Water Air Conditioning

The representative sea water air conditioning project would be a new facility located close to an existing district cooling system that supplies electrically chilled air to a population center or facilities that require significant cooling requirements. The air conditioning system would use a 63-inch-diameter screened pipe, 4 to 5 miles long, with intake at a depth of 1,770 feet to access water at 44º to 45ºF. The effluent pipe would be placed where the average water temperature is closest to the temperature of the wastewater exiting the cooling station, approximately 53ºF. This depth could be fairly close to the surface, possibly as high as about 150 feet below the surface, or as deep as 650 feet, depending on the actual location (NREL 2013). Pumping the effluent sea water into the ocean in this manner would avoid altering the local temperature gradient (Makai 2013).

The cooling station would be close enough to the shoreline to ensure minimal change in the incoming seawater's temperature. Two sets of pumps located in the cooling station would be connected to the electrical grid; each would require between 300 and 450 kilowatts of power.

Table 4-2 presents a summary of the potential environmental impacts for sea water air conditioning, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of this technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
Onshore	Potential soil erosion and contamination during construction (short - term). See Section 3.1.3.	Same as those common across construction projects. See Section 3.1.4.
Offshore	Potential disturbance of marine sediments during construction (short-term) and operations.	Same as those associated with construction of land-sea transition sites for undersea cables. See Section 8.2.1.
Climate and Air Quality		
Air Quality	General impacts during construction (short-term). See Section 3.2.4. The use of a sea water air conditioning system would require 75 percent less electricity than a standard cooling system, therefore, there would be a beneficial impact to air quality from a reduction of criteria pollutants resulting from electricity generated by fossil fuels.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Potential benefits – Greenhouse Gas (GHG) emission reduction.	Same as those common across construction projects. See Section 3.2.5.
Water Resources		
Surface Water – Land-Based	General impacts during construction (short-term). See Section 3.3.5. No operational impacts.	Same as those common across construction projects. See Section 3.3.6.
Surface Water – Marine-Based	Sediment disturbance/ dispersal and increased turbidity. Potential site-specific impacts may occur to habitats or communities of concern. Potential increase in nutrient levels (nitrate and phosphates). Potential for sea water temperature variability impact.	Devices such a silt curtains could be deployed at the HDD breakout point to help reduce potential impacts. Schedule project activities (sea floor disturbance) during seasonal periods when wave, current, and wind is expected to be at a low. Establish a zone of mixing (per HAR 11-54-9) in accordance with permit requirements for the system’s water discharge or if infeasible, treat water (for example, nutrient removal or temperature adjustment) before discharge.

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Groundwater	General construction impacts. See Section 3.3.5. No adverse operational impacts. Potential fresh water (groundwater) savings if wastewater is used as the cooling medium. Potentially beneficial; fresh water savings with an open cooling system.	Same as those common across construction projects. See Section 3.3.6.
Floodplains and Wetlands	Potential short-term impacts during construction. See Section 3.3.5. Potential effects during operations (site specific; i.e., if project were located in a floodplain/wetland).	Consideration of permitting requirements and building restrictions.
Biological Resources		
	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Localized impacts to marine organisms from water discharge temperature. Potential increase in nutrient levels resulting in increased marine productivity. Potential localized disturbance impacts to benthic communities at discharge point. Potential entrainment of smaller organisms at the intake pipe.	Direct outflow upward into the water column away from the ocean floor. Establish a zone of mixing (per HAR 11-54-9) in accordance with permit requirements for the system's water discharge or if infeasible, treat water (for example, nutrient removal or temperature adjustment) before discharge.

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
	Short-term land disturbance impacts at the cooling station locations and along distribution line routes during construction. Potential land use impacts related to expansions/maintenance of the cooling stations and/or distribution network.	The project may be required to obtain the necessary right-of-ways/easements and approvals to for construction near and around existing subsurface utilities. The project may also require a lease for submerged lands from the Hawai‘i Department of Natural Resources.
Cultural and Historic Resources		
	Potential adverse impacts to cultural, historic, and related natural resources during construction and operation (both on and offshore).	Same as those common across construction and operational projects. See Section 3.6.7.
Coastal Zone Management		
	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project- and/or site-specific).	During site selection, avoidance of the beach and near offshore areas would minimize impacts to the shoreline. The use of horizontal directional drilling to avoid the beach and near offshore areas would minimize impacts to the shoreline.
Scenic and Visual Resources		
	Short-term impacts to visual resources during construction. See Section 3.8.3. Long-term visual impacts associated with the new cooling station.	Same as those common across construction projects. See Section 3.8.4.
Recreation Resources		
	General impacts during construction. See Section 3.9.5. Potential short-term impacts to offshore recreation during installation of the subsurface piping. The short-term impacts could include: (1) restricted access to recreation areas near the area of installation of the underwater piping and on-shore facility and (2) possible visual impairment from areas near the construction of the facilities that could have a negative effect on the ongoing recreational activities. No operational impact.	Sensitive locations should be considered and avoided when locating a cooling station.

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
	General impacts including localized short term traffic impacts during construction and/or if road crossings are needed. Potential short-term (temporary) impacts on harbor operation, local marine transportation, and military marine operations Potential impacts to military submarine operations.	Coordinate with DOD to ensure military submarine operations to minimize or avoid impacts.
Airspace Management		
	None; construction and operation of sea water air conditioning would not require any tall structures and therefore would not impact airspace management.	N/A
Noise and Vibration		
	Short-term noise and vibration impacts during construction. Noise levels could temporarily exceed regulatory levels. Exposure to elevated noise and vibration levels may result in temporary impacts to marine & mammal behavior and marine mammal prey species. No long-term ambient noise or vibration impacts are expected during operation. A positive benefit could be the elimination of noise currently generated from cooling towers as buildings convert to sea water air conditioning systems.	Avoid sensitive receptors for noise and vibration identified in Section 3.12. Restrict loud activities to daytime hours and use mufflers on gas- or air-powered equipment. To reduce the potential for disturbance from acoustic stimuli associated with construction of the sea water intake and effluent pipelines, the following mitigation and monitoring measures for marine mammals could be implemented: • temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i) • establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species). • pile driving shutdown and delay procedures (if a marine mammal approaches or enters an exclusion zone); • soft-start procedures (a technique that allows marine mammals to leave the immediate area before sound sources reach maximum noise levels); • in-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving); and

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		• visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during pile driving).
Utilities and Infrastructure		
	Potential reduction in energy consumption (may require modification of the utility structure to meet the RPS).	None
Hazardous Materials and Waste Management		
Hazardous Materials	General impacts from exposure to hazardous materials during construction. See Section 3.14.4. No adverse operational impacts.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	General waste management impacts during construction. See Section 3.14.4. No adverse operational impacts.	
Wastewater	General wastewater impacts during construction. No adverse operational impacts. Potential beneficial impacts may occur if wastewater were utilized in place of sea water. This would minimize the amount of wastewater from other sources that would have to be treated by the local municipality.	
Socioeconomics		
	Because construction and operations of a sea water air conditioning system would require a minimal number of workers, there would be no measurable impacts to socioeconomic variables.	None
Environmental Justice		
	Depending on siting, impacts to visual and scenic resources could have the potential to be disproportionately high and adverse with respect to environmental justice communities. The likelihood of significant environmental impacts from this technology is small. The likelihood for environmental justice impacts would equally be small.	Conduct an evaluation of potential effects to low-income and minority populations.

Table 4-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Sea Water Air Conditioning (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Health and Safety		
	General construction and operation impacts. See Section 3.17.3.	Same as those common across construction and operation activities, See Section 3.17.5.

4.2.1 GEOLOGY AND SOILS

4.2.1.1 Potential Impacts

4.2.1.1.1 Onshore

Potential effects on geology and soils from construction of a sea water air conditioning project would be the same as those expected for common construction actions as described in Section 3.1.3. Drilling or tunneling actions might not be considered common construction actions, but the potential to impact soils through erosion or contamination would be similar, as would the BMPs (Section 3.1.4) that would be implemented to minimize the potential for adverse impacts.

4.2.1.1.2 Offshore

Offshore impacts to geology and soils primarily would be those associated with the disturbance of marine sediments where the trenchless technology used to bury the pipe or pipes opened into the ocean. Impacts to sediments would be expected to be similar to those described in Section 8.2.1 for construction of the land-sea transition zone for undersea cables.

During operations there would be no activities that would have the potential to affect geology and soils of the area, other than the possible disturbance of sediments from the discharge pipe. However, if the discharge pipe were in a location where sediments could be disturbed, it would be expected to occur for only a short period before all sediments that could be affected were moved and a new equilibrium was reached.

4.2.1.2 Best Management Practices and Mitigation Measures

For onshore elements of the technology, the BMPs would be the same as those common across construction projects. See Section 3.1.4.

For offshore elements, the BMPs would be similar to those recommended for construction of the land-sea transition zone for undersea cables. See Section 8.2.1.

4.2.2 CLIMATE AND AIR QUALITY

4.2.2.1 Potential Impacts

Potential impacts to climate and air quality from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.2.4.

A sea water air conditioning system would use electricity from the existing electrical grid to supply power to its pumps, so it would not directly burn fossil fuel.

The use of a sea water air conditioning system would require 75 percent less electricity than a standard cooling system; therefore, there would be a beneficial impact to air quality from a reduction of criteria pollutants resulting from electricity generated by fossil fuels.

All counties within Hawaiʻi are in attainment with all criteria air pollutants. However, air quality within Hawaiʻi is subject to a variety of Federal and State regulations pertaining to the construction and operation of air emission sources. See the "Air Quality Permits" section within Section 3.2.

4.2.2.2 Best Management Practices and Mitigation Measures

The BMPs for climate and air quality would be the same as those common across construction projects. See Section 3.2.5.

4.2.3 WATER RESOURCES

4.2.3.1 Potential Impacts

4.2.3.1.1 Surface Water

Land-Based Surface Water

Land disturbing actions during project construction would include construction of a cooling station, installation of water delivery and return lines from the cooling station to a drilling site near the ocean, preparation of equipment staging sites, and disturbances at the tunneling or drilling site. These actions would involve disturbance of more than one acre. As a result, potential impacts on land-based surface water from construction of a sea water air conditioning project would be the same as those expected for common construction actions as described in Section 3.3.5.

During operation, there would be no activities that would have the potential to affect surface waters. Due to the nature of the sea water air conditioning system, such a system would only be feasible in an area already built up with nearby facilities that could make use of the cold water product. Accordingly, it is reasonable to assume that the area would already be one with a heavy percentage of impermeable surfaces and the representative project would not be expected to involve any notable change in the amount of runoff generated from the area. Additionally, because the effluent from the cooling system would be discharged back into the marine environment at an appropriate depth, there would not be any expected discharges to surface water associated with normal operations.

Marine-Based Water

At the locations where the submarine breakout pit would be constructed and drilling or tunneling activities reached the ocean, where pipe anchoring devices would be placed, and, as applicable, where pile driving would be performed, ocean sediments would be disturbed and dispersed to some degree. Potential impacts to marine waters from these actions would be similar to those described in Section 8.2.3 for construction of the land-sea transition zone for undersea cables.

During operation, the sea water air conditioning system would pull cold water from a depth of almost 1,800 feet below the surface, use it for cooling (via a heat exchanger), and return the warmed water to a depth where the sea water would be of similar temperature, possibly as high as about 150 feet below the surface. Although the process would return ocean water back to the ocean with no additives, there could still be issues with the discharge meeting water quality criteria for coastal waters because the ocean water at 1,800 feet below the surface does not meet the criteria. A primary example would be nutrient levels as indicated by nitrite plus nitrate ($NO_2 + NO_3$) values. As shown in Figure 3-36, nitrite plus nitrate values at a depth of 1,800 feet would be about 30 micromoles per kilogram, which converts to about 420 micrograms per liter (as nitrogen). The water quality standard set by State regulation (HAR 11-54) for nitrite plus nitrate is 5.0 micrograms per liter (as nitrogen) in coastal waters where there are significant contributions from fresh water discharges, and 3.5 micrograms per liter (as nitrogen) in areas without significant fresh water contributions. (The standards also set higher concentrations not to be exceeded for specific percentages of the time.) In either case, the discharge from the sea water air conditioning system would be well over the standard and would be expected to be over the standard on a continuous basis.

As indicted in Section 3.3.4.2, other parameters such as phosphate levels would be expected to have vertical distributions similar to that of nitrite plus nitrate nutrients; that is, there would be depleted or very low concentrations in the upper layers where photosynthesis takes place. The State water quality standards include criteria for total phosphorus, so it could also be an issue. Other parameters would have to be similarly evaluated. Increased nutrient levels at depths where photosynthesis occurs could result in changes such as unusual algal blooms (Konan and Grau 2012). Although algae is a normal component of marine life, increased density in an area (because of increased nutrients) has the potential to affect the existing balance of the area's ecosystem as well as recreational and other uses of the area. As indicated in Section 2.3.1.5, studies are currently underway by the Center for Microbial Oceanography Research and Education to better understand the effects that might be expected from a high nutrient discharge of this nature. Changes in temperature and chlorine levels, as described below, could also affect existing conditions by other mechanisms (see Section 4.2.4 for potential impacts to biological resources).

Temperature would also be a potential problem for the discharge because the ocean's surface mixing layer can vary from less than 100 to nearly 400 feet in thickness depending on the season (see Section 3.3.4.2). At a temperature of about 53ºF, the discharge would have to be targeted to a portion of the thermocline below the mixing layer in order to hit ocean water near the same temperature. The temperature of the mixing layer is in the mid to upper 70s ºF or higher, and as the thickness of that layer changes (by roughly 300 feet over the course of the year) the thermocline position and gradient changes accordingly. As a result, it is unlikely that any stationary discharge depth could match the ocean temperature year-around and it definitely could not if the discharge point was ever within the mixing layer. The State's water quality standard for coastal waters is that temperatures not vary by more than one degree Celsius (or about two degrees Fahrenheit) from ambient conditions.

In order to meet the State's water quality standards, a zone of mixing (per HAR 11-54-9) would have to be established and approved under the permitting process for the system's water discharge (that is, under the State's NPDES program per HAR 11-55). The zone of mixing is a limited area around the discharge outfall where dilution would be allowed. The permit would then stipulate that applicable standards be met at the boundary of the zone of mixing and generally require some type of monitoring for verification. As part of the permitting process, the action proponent would likely have to design a diffuser system for the discharge outfall in order to minimize the size of the zone of mixing and perform modeling to demonstrate compliance could be achieved (with the specific diffuser design and proposed zone of mixing) under all reasonable conditions. If an acceptable zone of mixing could not be established, alternatives such as treating the water (for example, nutrient removal or temperature adjustment) before discharge would be a consideration (if economically feasible).

4.2.3.1.2 Groundwater

Potential impacts to groundwater from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the sea water air conditioning system, impacts to groundwater would be limited to the water needs to operate the freshwater system side of the cooling system. That is, the building in the representative project would have a closed-loop, freshwater cooling system that would transfer its heat to the sea water through a non-contact heat exchanger. Since groundwater is the primary source for municipal water systems on the islands, it is assumed the freshwater needs of the project would ultimately come from groundwater, although a cooling system could potentially use water from another source such as gray water or treated wastewater. The amount of freshwater needed by the system would depend on the number and size of connected buildings. Although the initial water demand could be sizeable, it would basically be a one-time need, since the freshwater system would be designed to be a closed loop. This type of water demand would not adversely impact groundwater resources. Occasional freshwater demands resulting from system repairs or expansions would similarly not be expected to have adverse impacts on water availability. If the facility being modified had an open water cooling system, such as one involving use of a water cooling tower to remove heat, there could be significant fresh water savings during operation of a sea water air conditioning system.

4.2.3.1.3 Floodplains and Wetlands

Land activities associated with the representative project would be expected to take place in areas already heavily developed. There would have to be substantial commercial or industrial facilities nearby in order to make a sea water air conditioning system feasible. As a result, if there were floodplains or wetlands in the area, it is unlikely they would be floodplains or wetlands in natural settings or conditions. With regard to floodplains, the project could easily be within or near a beach flood zone, but potential effects and construction considerations would still be those described for common construction actions in Section 3.3.5.

In the unlikely event wetlands were present in the area, it is reasonable to assume they would be avoided if at all possible, but if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

Depending on the specific design of the project, a Section 404 permit from the Corps of Engineers would likely also be required for the placement of the delivery and discharge lines on the ocean side of the system. Activities involving discharges of dredged or fill materials into the waters of the U.S. require a Section 404 permit. Although placement of pipes may not be a traditional dredge or fill action, the breakout point for the lines (from the tunneling or drilling actions) could require placement of fill material to stabilize the location and areas along the ocean floor could require similar actions to ensure the pipes were supported and stable. The project would also have to consider Federal Guidelines promulgated at 40 CFR Part 230 under Section 404(b)(1) of the Clean Water Act and if a project requires a Section 404 permit, only the Least Environmentally Damaging Practicable Alternative (LEDPA) could be permitted. If there was any question about the applicability of a Section 404 permit, discussion with the Corps of Engineers would be the appropriate course of action.

4.2.3.2 Best Management Practices and Mitigation Measures

4.2.3.2.1 Surface Water

Land-Based Surface Water

BMPs for land-based surface water would be the same as those common across construction projects. See Section 3.3.6.

Marine-Based Water

The following BMPs could prevent or reduce the above-discussed impacts:

- Deploy devices at the HDD breakout point, such a silt curtains.
- Schedule project activities (sea floor disturbance) during seasonal periods when wave, current, and wind are expected to be low.
- Establish a zone of mixing (per HAR 11-54-9) in accordance with permit requirements for the system's water discharge or if infeasible, treat water (for example, nutrient removal or temperature adjustment) before discharge.

4.2.3.2.2 Groundwater

BMPs for groundwater would be the same as those common across construction projects. See Section 3.3.6.

4.2.3.2.3 Floodplains

As identified in Section 4.2.3.1.1, discharges back to the ocean from the representative project would require a discharge permit with a zone of mixing stipulation because the discharge would not meet all water quality standards set for coastal waters. Within the zone of mixing, sufficient dilution (from mixing with surrounding water) would occur to ensure water quality standards were maintained outside the zone. According to State Water Quality Standards (HAR 11-54), there are limitations on establishing mixing zones within marine waters designated as class AA waters. This is more protective of the marine environment (i.e., biota, designated uses) because, if applicable, permitted discharges must meet water quality standards at the point of discharge. Class AA marine waters are not permitted to have zones of mixing in the following instances:

1. At depths of less than 18 meters (59 feet) where there is a defined reef; or
2. At depths greater than 18 meters (59 feet) out to 1,000 feet offshore if there is no defined reef area.

Each of the primary islands addressed in this PEIS includes coastal water designated as class AA water, some of the islands more than others. For example, all of Lāna‘i's coastal water has a class AA designation. By percentage of its shore line, O‘ahu has the least amount of class AA coastal water. The class AA waters were discussed in Section 3.3.1 and the individual island discussions (Sections 3.3.1.2 through 3.3.1.7) include figures showing the islands with their coastal water designations.

Offshore areas designated class AA waters and meeting either of the criteria identified above would be considered sensitive locations with regard to sea water air conditioning systems because they would not be allowed by regulation. By definition, marine waters given class AA designations are considered pristine waters deserving additional protective measures. This also means such waters are generally in areas that have had less development on the adjacent land areas, so they may not be areas ever considered for sea water air conditioning systems.

4.2.4 BIOLOGICAL RESOURCES

4.2.4.1 Potential Impacts

Potential impacts to biological resources from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.4.5.

Operational impacts would include discharge of warmed sea water after the heat exchange process. The warmed sea water would be discharged at a depth where the ocean water is approximately the same temperature as the effluent water to avoid altering the local temperature gradient. However, as described in Section 4.2.3.1.1, the depth of the ocean surface mixing layer can vary by approximately 300 feet and therefore the natural ocean temperature would fluctuate. If a fixed outflow pipe occurred within the mixing layer, it would be difficult to match the water temperature of the discharge water with the ocean water throughout the year. The potential extent of temperature effects would depend on the volume of discharge water, the temperature difference between the ocean and discharge water, and the ocean currents that could help effectively dilute the discharge water. Any impact on marine organisms from differences in temperature between the ocean water and discharge water would likely be localized and small. Warmer water temperatures typically increase physiological and biochemical rate processes.

The quality of the discharge water could also be different than that of the surrounding ocean water, causing localized impacts to marine habitats and organisms. The nutrient level (e.g., nitrogen and phosphorus) of the cold intake water at approximately 1,800 feet would be higher than the nutrient level of ocean water at the shallower discharge level. An influx of nutrient rich discharge water could create an area of increased marine productivity. How large of an effect nutrient enrichment could have on the marine ecosystem would depend on the surrounding marine communities, the volume of discharge water, and the rate of dilution and dispersal of nutrients in the larger volume of ocean water. How ocean microbes, and in turn other higher trophic levels, would respond to an influx of nutrients is an area of active research (http://cmore.soest.hawaii.edu/microbes.htm; C-MORE 2014).

As discussed in Section 4.2.3.1.1, the quality of the discharge water, both temperature and chemistry, would be subject to regulatory standards and permitting. The discharge of seawater could also disturb benthic communities through the physical force of the water in the immediate vicinity of the outflow pipe. This impact would be localized and could be mitigated by directing the outflow upward into the water column away from the ocean floor.

The intake pipe would be screened to prevent entrainment of biological organisms in the pipes. Although larger organisms should be effectively excluded, some entrainment of smaller organisms could occur. The actual mesh size for the intake screen is unknown but would likely exclude all but the smallest (e.g., less than an inch) marine organisms.

Sea water air conditioning systems require access to relatively cold waters that usually occur at depths of at least 1,500 feet; therefore, such project should not impact the Hawaiian Islands Humpback Whale National Marine Sanctuary, which is in relatively shallow waters (about 600 feet deep). However, temporary disturbance to benthic communities and marine mammals could occur if the intake pipe were laid through sanctuary waters to access deep water.

4.2.4.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- The discharge piping should be designed to direct the outflow upward into the water column, away from the ocean floor.

- Establish a zone of mixing (per HAR 11-54-9) in accordance with permit requirements for the system’s water discharge or if infeasible, treat water (for example, nutrient removal or temperature adjustment) before discharge.

- During installation of intake and outflow pipes, avoid sensitive marine habitats such as the Humpback Whale National Marine Sanctuary and coral reefs. However, if an acceptable, alternative seafloor route was not feasible, use of HDD could reduce potential impacts. Select an HDD location onshore that would not impact anchialine pools that have an underground ocean connection and may contain threatened and endangered species.

4.2.5 LAND AND SUBMERGED LAND USE

4.2.5.1 Potential Impacts

The cooling stations could result in some minor changes in land use in the form of converting unused land for the use of the cooling stations, the demolition of existing structures to construct the cooling stations, and/or to repurpose existing structures or parking lots. During project construction, there would be temporary land disturbance at the location of the new cooling stations and along the route of the distribution lines to the end users. Once the system is operational, there would be no operational impacts to land use except as related to potential expansions/maintenance of the cooling stations and/or distribution network.

The potential environmental impact to submerged land uses begins with the nexus between the land and the sea. There would be temporary land and sea disturbances during the installation of the deep water intake and the shallower warm water effluent discharge. Maintenance of the pipe and screen would be performed regularly to prevent excessive biofouling and clogging. Automated systems are available for the pipe itself.

4.2.5.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- The project may be required to obtain the necessary right-of-ways/easements and approvals for construction near and around existing subsurface utilities. The project may also require a lease for submerged lands from the Hawai‘i Department of Natural Resources.

- When siting the cooling station and support structures, consider the existing State land use designations and any overlying county zoning districts, including county planning restrictions or guidelines to scenic resources and Coastal Zone Management Area guidelines.

- Given the possible pipeline lengths to meet the cold water temperature requirements, consideration of sensitive locations could include designated aquaculture and fishing areas, coral reefs, dump sites for munitions, undersea cables, and protected natural areas.

- The general designation of Hawai‘i’s commercial marine fisheries is based on geographic areas described in Section 3.5.3.2. Most of the known munitions dump sites are around the island of O‘ahu (see Section 3.5.3.4). Avoidance of such sites would reduce related impacts.

- Avoid or take necessary precautions when siting a project in the vicinity of a submarine telecommunication cable landing. Section 3.5.3.6 and Figure 3-66 provide general locations of these cables and where they make landfall.

- Avoid or take necessary precautions when siting a project in the vicinity of a protected natural area (see Section 3.5.3.7 and Figure 3-67).

- Use bathymetric analyses to help determine the shortest distance to the desired depth, as well as how to avoid interfering with sensitive habitats, including coral reefs, and assist in avoiding or minimizing impacts to fishing and recreational areas and recognizing the locations of undersea cables and munitions dumps.

4.2.6 CULTURAL AND HISTORIC RESOURCES

4.2.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operation of the representative project. In many locations, it is reasonable to expect that onshore surface and offshore archaeological and historic features are present. Sea water air conditioning projects could impact cultural and historic resources in the same manner as general construction and operational activities, which are addressed in Section 3.6.6.

4.2.6.2 Best Management Practices and Mitigation Measures

BMPs for cultural and historic resources are the same as those common across construction and operational projects. See Section 3.6.7.

4.2.7 COASTAL ZONE MANAGEMENT

4.2.7.1 Potential Impacts

A sea water air conditioning system would be of special concern under the Coastal Zone Management Program because it transects across both near onshore and offshore areas, potentially affecting the coastal zone. Assuming the representative project involves Federal agency activities, Federal license or permit activities, and Federal financial assistance activities, the representative project would require a Federal consistency review to ensure that it is consistent with the policies and regulations governing the management and development of the coastal zone. Because the representative seawater air conditioning project would be constructed in the vicinity of relatively large population centers to be economically feasible, the project would likely be consistent with existing uses. Depending on the location of the project, water pipeline installation across the coastline could disturb special management areas that were established to protect specific coastline resources and limit shorefront access.

4.2.7.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- During site selection, avoid the beach and near offshore areas to minimize impacts to the shoreline.

- Use HDD to avoid the beach and near offshore areas and minimize impacts to the shoreline.

4.2.8 SCENIC AND VISUAL RESOURCES

4.2.8.1 Potential Impacts

Potential impacts to scenic and visual resources from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.8.3. The project may require construction of distribution lines, which would be installed beneath city streets and, therefore, cause short-term impacts to visual resources during construction of the lines.

Long-term visual impacts would be associated with operation of the new cooling station. The representative project would be constructed in an area already near facilities that could make use of the air conditioning. Potential sites for cooling stations include parking lots and unused buildings. For efficiency, the cooling station would be built close to the shoreline to ensure minimal change in the intake seawater temperature. Security lighting would be present but would need to be designed to be compatible with the existing setting.

4.2.8.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- During site selection, consider sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; and reserves protected by the Natural Area Reserves System.

- Refer to the various land use plans and associated implementation tools, such as zoning ordinances and development standards, for each island for information regarding protecting and maintaining open space and scenic resources.

4.2.9 RECREATION RESOURCES

4.2.9.1 Potential Impacts

Potential impacts to recreation resources from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.9.3. In addition, depending on its location, some short-term impacts to offshore recreation could occur during installation of the subsurface piping. The short-term impacts could include: (1) restricted access to recreation areas near the area of installation of the underwater piping and on-shore facility and (2) possible visual impairment from areas near the construction of the facilities that could have a negative effect on the ongoing recreational activities.

Long-term impacts to recreation associated with the new cooling station or seawater intake are not anticipated.

4.2.9.2 Best Management Practices and Mitigation Measures

During site selection, consider locations of land-based and water-based recreation activities (Tables 3-47 and 3-48, respectively). The *State Comprehensive Outdoor Recreation Plan* (SCORP) provides detailed matrixes of all recreation areas on each island and the recreational activities that take place at each area (DLNR 2009).

4.2.10 LAND AND MARINE TRANSPORTATION

4.2.10.1 Potential Impacts

Potential impacts to land and marine transportation from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.10.3.

Any impacts to land transportation systems would be localized around the specific construction site and could involve temporary disruption of traffic if road crossings were needed. Depending on the specific project location, there could be temporary impacts on harbor operation, local marine transportation, and military marine operations during installation of the deep seawater intake pipe and the shallower outflow pipe.

Because the intake and outflow pipes would be near or on the ocean floor, no impacts to surface marine transportation would occur during operation of the seawater air conditioning system. However, the pipes would be taking in and releasing relatively large volumes of water and could potentially impact U.S. military submarine operations; any such impact would need to be coordinated with DoD dependent on the specific siting of the facility and associated piping.

4.2.10.2 Best Management Practices and Mitigation Measures

Coordinate with the U.S. Department of Defense to avoid or minimize potential impacts to military submarine operations.

4.2.11 AIRSPACE MANAGEMENT

As identified in Table 4-2, there would be no potential impacts to airspace management from the representative sea water air conditioning project.

4.2.12 NOISE AND VIBRATION

4.2.12.1 Potential Impacts

Short-term noise and vibration impacts could result from the construction of a sea water air conditioning cooling station and associated underwater intake and outflow pipes. Local noise ordinances described in Section 3.12 could be temporarily exceeded during construction, which would require a permit variance, and construction noise outside of permitted hours could occur (DBEDT 2009). Offshore construction noise from equipment and vessels used to place pipes, and vibration caused by pile-driving, could exceed regulatory levels. Such noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Further, according to the Incidental Harassment Authorization (77 FR 43259; July 24, 2012) exposure to elevated sound levels from vibratory and impact pile driving may result in temporary impacts to marine mammal hearing and behavior. However, in its Biological Opinion for the Issuance of an Incidental Harassment Authorization to Honolulu Seawater Air Conditioning, LLC to Take Marine Mammals by Harassment Incidental to Pile Driving Offshore Honolulu, the NMFS stated that it does not expect any takes of marine mammals by injury, serious injury, or mortality. Marine mammal prey species, such as fish, may also be temporarily impacted (NMFS 2012).

No long-term ambient noise or vibration impacts are expected during operation of the representative seawater air conditioning system. A positive benefit could be the elimination of noise currently generated from cooling towers as buildings convert to seawater cooling systems (DBEDT 2009).

4.2.12.2 Best Management Practices and Mitigation Measures

The following recommended BMPs could reduce the potential disturbances from noise and vibration (NMFS 2012):

- Temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i);
- Establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species);
- Pile driving shutdown and delay procedures (if a marine mammal approaches or enters an exclusion zone);
- Soft-start procedures (a technique that allows marine mammals to leave the immediate area before sound sources reach maximum noise levels);
- In-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving); and
- Visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during pile driving).

Additional BMPs include the following:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Restrict loud activities to daytime hours and use mufflers on gas- or air-powered equipment to reduce impacts from noise exceedances.

4.2.13 UTILITIES AND INFRASTRUCTURE

4.2.13.1 Potential Impacts

Pumps and other equipment in the cooling station would require relatively small amounts of electricity. Localized electricity demands would increase and impacts would depend on the capacity available at proposed site locations. However, a typical sea water air conditioning project integrated into a district cooling system would reduce regional electricity demands for air conditioning by up to 75 percent (77.5 million kilowatts per year) (see Section 2.3.1.5.2). The overall impact from the representative sea water air conditioning project would be a beneficial decrease in total electrical power consumption by the facilities that connected to the sea water air conditioning system.

4.2.13.2 Best Management Practices

None noted.

4.2.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

4.2.14.1 Potential Impacts

4.2.14.1.2 Hazardous Materials

Potential impacts from exposure to hazardous materials from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.14.4.

Impacts during operation of the representative sea water air conditioning facility are not anticipated to involve hazardous materials. As opposed to conventional cooling, which may employ refrigerants; sea water air conditioning systems require only sea and fresh water. As such, it is not anticipated that chemicals would be used during project operations.

4.2.14.1.3 Waste Management

Potential impacts to groundwater from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.3.5.

Impacts related to waste management would be from the construction and installation of the pipeline, distribution lines, and the cooling station. Such impacts are typical of pipeline construction projects and are discussed in Section 3.14.4.

4.2.14.1.4 Wastewater

Potential wastewater impacts would occur during the release of effluent during operation of the sea water air conditioning facility. As noted in Section 2.3.1.5, the representative project would be in a zone of mixing,[1] which would require diluting the return sea water to a specified water quality standard. All wastewater discharge would be required to comply with applicable, Federal, State, and County requirements including NPDES permit requirements.

A potential beneficial impact of the sea water air conditioning facility is the ability to reuse treated wastewater discharge in its closed-loop system (in place of fresh water); it could therefore reduce the volume of wastewater discharged from cooling towers that would otherwise require processing at a municipal treatment plant.

4.2.14.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- During the siting process, review public records and perform site inspections to identify possible hazardous materials that may be present. See Section 3.14.1.2 for a list of known contaminated sites.
- Remove suspended particulates from the effluent and meet all other permit requirements prior to discharge.
- Treat wastewater using settling ponds or tanks, filtration systems, or both and test the effluent to ensure that discharges meet general water quality and toxic contaminant parameter requirements. See Section 4.2.3 above for the discussion on discharge requirements.

[1] The purpose of a “zone of mixing” is to allow a discharge that would not initially meet water quality standards to be diluted to comply with appropriate standards within a reasonable distance. Without a “zone of mixing” no wastewater outfalls or discharges of generating station cooling waters would be permitted.

- Perform regular maintenance on pipes and screens to prevent excessive biofouling and clogging.

4.2.15 SOCIOECONOMICS

4.2.15.1 Potential Impacts

Socioeconomic impacts in Hawaiʻi arising from a sea water air conditioning system would be very small. The 63-inch pipe, the cooling station apparatus, and the cooling station pumps likely would be manufactured outside of the State. Installation of the pipelines and construction of the cooling stations would require about 20 temporary positions and operation of the facility would require about 5 full-time workers. These positions likely would be filled by individuals residing within the State of Hawaiʻi and not by in-migrating workers. There would be little to no impact on population employment variables, such as the size of the labor force, unemployment rates, and employment in the State and county government sector; housing and living conditions; and personal income.

Long-term impacts to the State’s tourism industry from the presence of a cooling station near the beach of population-dense areas are unknown.

4.2.15.2 Best Management Practices

None noted.

4.2.16 ENVIRONMENTAL JUSTICE

4.2.16.1 Potential Impacts

Depending on siting, impacts to visual and scenic resources could have the potential to be disproportionately high and adverse with respect to environmental justice communities.

The likelihood of significant environmental impacts from this technology is small. The likelihood for environmental justice impacts would equally be small.

4.2.16.2 Best Management Practices and Mitigation Measures

During site selection, conduct a study to determine the specific location of low-income and minority populations, specifically Native Hawaiians, and determine whether there would be disproportionately high and adverse impacts to such populations.

4.2.17 HEALTH AND SAFETY

4.2.17.1 Potential Impacts

Common potential impacts from typical construction activities are identified in Section 3.17.3. There would be no unique hazards or accident scenarios for sea water air conditioning.

4.2.17.2 Best Management Practices and Mitigation Measures

Common BMPs for typical construction activities are identified in Section 3.17.5.

4.3 Solar Water Heating

The solar water heating representative project is the installation of a residential solar water heater system with a 40-square-foot collector. The water would circulate between the collector and a 120-gallon storage tank located in the home, in place of the conventional water tank. Since freezing is not a concern in Hawaiʻi, the system would utilize direct circulation, where the water itself is heated, rather than indirect circulation, which uses a heat-transfer fluid and a heat exchanger. Because the system itself would require electricity to run its pumps and control system, the collector would use photovoltaic modules to power the pumps and controls. The components for the representative project would be on the roof and interior of the house. Pipes would run from the rooftop collector to the tank through existing crawlspaces or under the eaves of the roof, and the tank would connect to existing plumbing.

Table 4-3 presents a summary of the potential environmental impacts for solar water heating, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of this technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 4-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Water Heating

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to geology and soils.	N/A
Climate and Air Quality		
Air Quality	Beneficial – potential air emissions reductions.	None.
Climate Change	Beneficial – greenhouse gas emissions reduction.	None.
Water Resources		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to water resources.	N/A
Biological Resources		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to biological resources.	N/A
Land and Submerged Land Use		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to land use.	N/A

Table 4-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Water Heating (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	Potentially adverse visual or architectural context impact to historic properties.	Prior to installation of a solar water heater, resources should be identified and evaluated for their eligibility to the HRHP and the NRHP. In accordance with State law, if a historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for energy retrofits, the project proponent must complete and submit a Historic Preservation Review Form in compliance with HRS Chapter 6E such that the modifications may be reviewed and approved prior to project implementation.
Coastal Zone Management		
	None; installation of solar water heating units would typically be done on rooftops and therefore would be required to comply with CZMA.	N/A
Scenic and Visual Resources		
	Potential visual impacts due to visibility including to historic resources (site-specific).	Solar modules should be located to limit visibility and reduce potential visual impacts.
Recreation Resources		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to recreation resources.	N/A
Land and Marine Transportation		
	None; installation of solar water heating units would typically be done on rooftops and therefore would have no impacts to land and marine transportation.	N/A
Airspace Management		
	None; installation of solar water heating units would typically be done on rooftops but not result in any tall structures that could impact airspace.	N/A

Table 4-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Water Heating (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	Same as those common among construction and operation projects. See Section 3.12.5.	Same as those common across construction projects. See Section 3.12.5.
Utilities and Infrastructure		
	Decrease in energy consumption. No significant impacts to utilities or infrastructure.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impacts from exposure to hazardous materials encountered during installation including: asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic.	Perform surveys prior to installation to identify any areas in homes containing asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic. Perform all installations by trained and certified professionals. If areas are found to be contaminated, trained and certified abatement personnel would follow proper abatement procedures and remediation activities to comply with State and Federal OSHA and county air quality district requirements.
Waste Management	Potential impacts to waste management services from hazardous demolition debris waste during installation. Potential landfill impacts.	Consideration should be given to development and implementation of a recycling plan. A recycling program would effectively recover building materials that could contain potentially hazardous materials and substances (e.g., liquid wastes, paints, oil, and solvents).
Wastewater	None.	N/A
Socioeconomics		
	Beneficial – few jobs created.	None.
Environmental Justice		
	None; negligible adverse impacts to environmental resources. Therefore, no disproportionately high and adverse impacts to minority or low-income population.	N/A
Health and Safety		
	Potential worker exposure to hazardous materials including: asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic.	Handle and dispose of materials appropriately to ensure minimal exposure to hazardous materials.

4.3.1 GEOLOGY AND SOILS

As identified in Table 4-3, there would be no potential impacts to geology and soils from the representative solar water heating project.

4.3.2 CLIMATE AND AIR QUALITY

4.3.2.1 Potential Impacts

The representative solar water heating system could save up to 90 percent of the electricity used in a conventional electrical water heating system, translating to an annual energy savings of about 2,800 kilowatt-hours per house (90 percent of 3,120 kilowatt-hours per year). A reduction of 2.8 megawatt-hours of electricity per year would reduce oil consumption from electricity generation by about 190 gallons per residential unit. On O‘ahu, this would correspond with an annual reduction in greenhouse gas emissions of about 2.0 metric tons carbon dioxide equivalent per house based on EPA eGrid2012 emission factors. On other islands, an annual reduction of 2,800 kilowatt-hours of electricity usage per house would correspond to an annual reduction in greenhouse gas emissions of about 1.7 metric tons carbon dioxide equivalent due to a cleaner mix of technologies used to produce electricity on the islands.

4.3.2.2 Best Management Practices and Mitigation Measures

None noted.

4.3.3 WATER RESOURCES

As identified in Table 4-3, there would be no potential impacts to water resources from the representative solar water heating project.

4.3.4 BIOLOGICAL RESOURCES

As identified in Table 4-3, there would be no potential impacts to biological resources from the representative solar water heating project.

4.3.5 LAND AND SUBMERGED LAND USE

As identified in Table 4-3, there would be no potential impacts to land or submerged land use from the representative solar water heating project.

4.3.6 CULTURAL AND HISTORIC RESOURCES

4.3.6.1 Potential Impacts

The representative solar water heating project involves installation on existing residences, so no impacts to archaeological sites would be expected. There is the possibility that installing a solar water heater in buildings or residences that are listed or eligible for listing on the *Hawai‘i Register of Historic Places* (HRHP) or the *National Register of Historic Places* (NRHP), and/or are located in an historic district, would change the characteristics of the property such that the historic nature of the property would be altered. The alterations may have an adverse visual or architectural context impact to the historic property. Solar water heater system installation could affect residences and other buildings that not only qualify as historic properties but also as cultural resources whose alterations may require coordination with the OHA's Native Hawaiian Historic Preservation Council in accordance with applicable regulatory consultation requirements.

4.3.6.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- Prior to installation of a solar water heater, identify and evaluate resources for eligibility to the HRHP and the NRHP.
- In accordance with State law, if an historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for installation of a solar water heater, the project proponent must complete and submit an Historic Preservation Review Form in compliance with HRS Chapter 6E such that the modifications may be reviewed and approved prior to project implementation.
- Historic resources that are listed on the HRHP or NRHP, such as buildings, sites, and structures would be considered sensitive locations regarding possible modifications from energy efficiency retrofits and may require retrofit design approval in coordination with the SHPO.

4.3.7 COASTAL ZONE MANAGEMENT

As identified in Table 4-3, there would be no potential impacts to coastal zone management from the representative solar water heating project.

4.3.8 SCENIC AND VISUAL RESOURCES

4.3.8.1 Potential Impacts

A residential solar water heating system can typically be installed in one day without any disruptions to the property and limited onsite construction. Therefore, visual impacts during installation of a system would be minimal.

Long-term visual impacts from the installation could include the sight of solar modules on rooftops and required piping along external walls. However, because solar water heating systems are common in Hawai‘i, visual sensitivity to these systems is likely lower than in areas where they are not common. Further, the State of Hawai‘i has mandated that all newly constructed single-family homes include solar water heaters (Act 204). Therefore, installers are more accustomed to placing solar heaters and associated hardware inconspicuously; i.e., under eaves, in the attic crawl spaces, or elsewhere that would lessen the visibility of these project components to the public.

The site of solar water heaters on residences near National and State parks would be unlikely to adversely impact park visitors or administration because these parks use such water heaters.

4.3.8.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- The solar modules should be placed to limit visibility and reduce potential visual impacts, while remaining optimally positioned to receive the maximum solar exposure.

- During placement, consider the proximity to listed or eligible historic sites and the potential for solar water heating systems to change the historic character of an area. Section 4.3.6 provides impact information for cultural and historic resources. Solar water heaters are used in National Parks and State Parks in Hawaiʻi. Thus, the visual impact of residential solar equipment on parks is likely to be negligible as it would be similar to having it in the park itself, which is acceptable to the park administration.

4.3.9 RECREATION RESOURCES

As identified in Table 4-3, there would be no potential impacts to recreation resources from the representative solar water heating project.

4.3.10 LAND AND MARINE TRANSPORTATION

As identified in Table 4-3, there would be no potential impacts to land or marine transportation from the representative solar water heating project.

4.3.11 AIRSPACE MANAGEMENT

As identified in Table 4-3, there would be no potential impacts to airspace management from the representative solar water heating project.

4.3.12 NOISE AND VIBRATION

4.3.12.1 Potential Impacts

The representative solar water heaters project would involve installation on a rooftop and could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

4.3.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across construction projects. See Section 3.12.6.

4.3.13 UTILITIES AND INFRASTRUCTURE

4.3.13.1 Potential Impacts

For all Hawaiian islands, the impact of converting each home to solar water heating would be a savings of up to approximately 2.8 megawatt-hours per year (see Section 2.3.1.6) and corresponding drop in overall demand for the local utility. These changes would contribute to the downward trend in the total annual electricity consumption and, by themselves, would not result in a significant impact to the utilities and infrastructure. On all islands, such changes would contribute to the need to modify the overall utility structure to meet the requirements of Hawaiʻi's RPS (See HECO 2013).

4.3.13.2 Best Management Practices and Mitigation Measures

None noted.

4.3.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

4.3.14.1 Potential Impacts

4.3.14.1.1 Hazardous Materials

The representative project involves the installation of solar water heaters in existing homes; therefore, there would be no impacts from new construction.

There would be no exposure to hazardous materials associated with operation of a solar water heater system.

4.3.14.1.2 Waste Management

The representative project would involve new construction that could result in demolition debris. Potential impacts to waste management services could occur during project construction/retrofitting, as special handling and disposal of materials may be required.

There would be no waste generated during operation of a solar water heater system.

4.3.14.1.3 Wastewater

The representative project would not result in impacts from or to wastewater.

4.3.14.2 Best Management Practices and Mitigation Measures

The following best management practice could prevent or reduce the above-discussed impacts:

- Prior to installation of the solar water heaters, perform surveys to identify any areas in homes containing asbestos materials, lead-based paint, polychlorinated biphenyls, and/or arsenic.

- Have solar water heaters installed by trained and certified professionals. If areas are found to be contaminated, trained and certified abatement personnel would follow proper abatement procedures and remediation activities to comply with State and Federal OSHA and county air quality district requirements.

- Follow proper handling, abatement, and disposal procedures and activities to comply with State and Federal requirements.

4.3.15 SOCIOECONOMICS

4.3.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from the expanded use of solar water heating systems would be very small. The collection apparatus, pumps and controls, water tanks, piping, and, if used, photovoltaic modules could be manufactured within the State and, if so, the economic benefits associated with manufacturing would be small and accrue locally. Although Hawai‘i has a very small manufacturing base, light industry production of related equipment is feasible. As the number of households utilizing solar water heating systems increases, the number of jobs associated with installation and maintenance of the systems would grow too, but net new jobs created would be small. Jobs directly associated the manufacture of system components, installation of the system, and maintenance of solar water heating systems likely would be filled by individuals residing within the State of Hawai‘i and not by in-migrating workers. There would be little to no impacts on population employment variables, such as the size of the labor force, unemployment rates, and employment in the State and county government sector; housing and living conditions; and personal income. There would be beneficial impacts to the homeowner since, over time, their initial cost investment for the solar water heating system would be recouped and they would then realize cost savings from reduced power usage.

4.3.15.2 Best Management Practices and Mitigation Measures

None noted.

4.3.16 ENVIRONMENTAL JUSTICE

As identified in Table 4-3, there would be no environmental justice impacts from the representative solar water heating project.

4.3.17 HEALTH AND SAFETY

4.3.17.1 Potential Impacts

Installation would require minor construction on the roof and the interior of a house, during which workers may encounter asbestos, lead-based paint, polychlorinated biphenyls, and/or arsenic. Exposure to such hazardous material could result in harmful health effects including cancer. Common potential impacts from typical construction activities are identified in Section 3.17.3.

4.3.17.2 Best Management Practices and Mitigation Measures

Common potential BMPs for typical construction activities are identified in Section 3.17.3. Additionally, contractors involved in the installation should handle and dispose of materials appropriately to ensure minimal exposure to hazardous materials.

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CHAPTER 5

Environmental Impacts from Distributed Renewables

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5 ENVIRONMENTAL IMPACTS FROM DISTRIBUTED RENEWABLES

This chapter presents the potential environmental impacts from the distributed renewable energy technologies presented in Chapter 2, Section 2.3.2. Distributed scale projects could range from single family residences to larger commercial uses. The representative projects described in Section 2.3.2 were used to estimate the potential environmental impacts for each technology. The description of each technology within Section 2.3.2 includes a discussion of the differences between nameplate capacity and actual capacity based on efficiency and the range of typical capacity factors for that technology. Chapter 5 discusses how the impacts would scale (for example, linearly, exponentially, or not at all) for the range of potential technology applications to aid the reader in understanding the effects of smaller or larger projects and how impacts could change based on the size of the technology implemented.

The potential impacts are presented for each environmental resource area. As was described in Chapter 3 of this PEIS, many of the activities and technologies could result in environmental impacts that would be common of typical construction projects and may not be unique to the specific activity or technology. In these cases, the presentation of potential impacts in this chapter refers the reader to the appropriate section in Chapter 3 that presents these common impacts for that resource area. Therefore, the details in this chapter deal primarily with those impacts that would be unique to the specific activity or technology being evaluated.

Each of the sections below includes a summary table of the potential environmental impacts and best management practices for that technology. Not all technologies have the potential to impact all environmental resource areas analyzed in this document. Therefore, the summary table for each technology also identifies and screens those resource areas that are not expected to be impacted by that technology. This approach is consistent with DOE's sliding scale approach to the preparation of NEPA analyses.

5.1 Biomass

The representative distributed biomass energy project would involve the direct combustion of biomass in a steam boiler to produce steam for electricity generation and industrial steam (see Section 2.3.2.1). Biomass projects typically would not be used for residential applications; therefore, the representative project would produce about 50 kilowatts (0.05 megawatt) of electricity for commercial/industrial use. Construction of a 50-kilowatt project plant would require clearing, grading, and leveling an area of about 2 to 4 acres for the boiler and turbine building, biomass handling and feed system, and construction space, with an additional 1 to 2 acres for the extension of water and sewer lines and possibly new access road.

The boiler unit(s) would use a fibrous residue biomass material from either an agricultural or forest source. Biomass feedstock would be supplied by nearby sources either produced specifically for the electricity end user or from local commercial biomass producers. In either case, this PEIS assumes that the biomass is a crop residue produced as part of an existing operation and does not consider potential impacts from the biomass production, nor impacts from agricultural conditions related to water, fertilizer runoff, pesticide and herbicide use, or air emissions. (These impacts are evaluated for a larger scale project in Section 6.1 for utility-scale biomass projects.) Transportation of the biomass feedstock from the supplier to the biomass plant would be local and for relatively short distances (up to 5 miles).

Table 5-1 presents a summary of the potential environmental impacts for biomass energy projects, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and best management practices and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 5-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General impacts during construction (short-term). See Section 3.1.3. No impacts during operation.	Same as those common across construction projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	Burning of biomass at a biomass energy project would emit criteria pollutants. Additionally, the transport of the biomass feedstock would result in emissions from trucks and harvesting equipment.	Project design should incorporate a high efficiency combustion and boiler system to operate at or near design capacity.
Climate Change	Potential greenhouse gas impacts pending EPA ruling and dependent on project size (project-specific). Potentially beneficial impacts as a result of replacing fossil fuels for the production of electricity; thereby reducing greenhouse gas emissions.	Application of control technology to the project to reduce emissions during project operations (example: dust collectors to reduce particulate matter emissions).
Water Resources		
Surface Water	General impacts during construction (short-term). See Section 3.3.5. Potential surface water impacts during operations (increased stormwater runoff).	Same as those common across construction projects. See Section 3.3.6.
Groundwater	General impacts during construction (short-term). See Section 3.3.5. Potential water resource impacts depending on design and use of groundwater.	Same as those common across construction projects. See Section 3.3.6.
Floodplains and Wetlands	Minimal to no potential for common construction impacts. See Section 3.3.5.	None.
Biological Resources		
	Impacts common to construction and operations activities are identified in Section 3.4.5. Potential impacts to terrestrial wildlife and protected plants and animals during construction of the boiler, turbine, and local infrastructure. Potential impacts to terrestrial plants and wildlife from biomass production. Potential lighting impacts on flights of marine birds, such as shearwaters and petrels (site-specific).	Best management practices common to construction and operations activities are identified in Section 3.4.6. Design lighting and routine operations to minimize lighting needs.

Table 5-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	Potential land use impacts (site-specific).	During site selection, evaluate the State land use designations and county overlay zones.
Submerged Land Use	None; this technology would be terrestrial based and would not involve submerged lands.	N/A
Cultural and Historic Resources		
	General impacts during construction and operation. See Section 3.6.6.	Same as those common across construction projects. See Section 3.6.7.
Coastal Zone Management		
	Potential coastal zone impacts to special management areas, shorefront access, or shoreline erosion (project/site-specific).	Specific project locations should be evaluated to determine if impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion would occur.
Scenic and Visual Resources		
	General impacts during construction (short-term). See Section 3.8.3. Potential long-term visual impacts from outdoor and security lighting and visual character of project location (site-specific).	Same as those common across construction projects. See Section 3.8.3.
Recreation Resources		
	None; the biomass facility would be located near the commercial/industrial electricity users and would be compatible with existing land uses, which would not include recreation.	N/A
Land and Marine Transportation		
Land Transportation	Potential localized roadway and traffic impacts from increased truck traffic associated with biomass feedstock.	To the extent feasible, private roads should be utilized to minimize traffic impacts. Cover trucks to contain dust and to keep biomass material from falling out.
Marine Transportation	None; a small distributed biomass energy power generation project would not be expected to require nor effect marine transportation. Biomass would be obtained locally.	N/A

Table 5-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Airspace Management		
	None; a small distributed biomass energy power generation facility would not have an emission stack tall enough or produce a thermal plume large enough to cause an aviation hazard.	N/A
Noise and Vibration		
	Industrial noise would be produced from operation of the biomass handling facilities and removal of ash waste. Noise from the steam boilers and turbines mostly would be contained within the buildings.	Best management practices would be the same as those commonly implemented for construction and operation. See Section 3.12.6.
Utilities and Infrastructure		
	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General exposure impacts during construction and operation. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	Potential waste management impacts related to ash disposal.	Same as those common across construction projects. See Section 3.14.5
Wastewater	Potential wastewater contamination from trace chemicals and elevated temperatures.	Use settling ponds or filtration systems to meet NPDES wastewater discharge permit requirements.
Socioeconomics		
	Few operation and construction jobs created and economic benefits.	None.
Environmental Justice		
	Dependent on potentially adverse impacts to other resources in adjacent and nearby areas (site-specific).	Conduct an evaluation of potential effects to low-income and minority populations.
Health and Safety		
	General impacts during construction and operation. See Section 3.17.3.	None.

5.1.1 GEOLOGY AND SOILS

5.1.1.1 Potential Impacts

Potential impacts on geology and soils from construction of the 50-kilowatt steam boiler and associated facilities for the representative distributed biomass energy project would be the same as those expected for common construction actions as described in Section 3.1.3. The project would involve disturbance of 3 to 6 acres of land, so the permitting requirements described in Section 3.1.3 would be fully applicable.

Operation of the biomass boiler and steam turbine would not involve activities that would have the potential to affect geology and soils of the area.

Potentially sensitive areas with regard to impacting geology and soils or for the project to be affected by geology-related hazards would be the same as those described in Section 3.1.3.

5.1.1.2 Best Management Practices and Mitigation Measures

Best management practices for geology and soils would be the same as those common across construction projects. See Section 3.1.4.

5.1.2 CLIMATE AND AIR QUALITY

5.1.2.1 Potential Impacts

Potential impacts to climate and air quality from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.2.4.

5.1.2.1.1 Air Quality

The burning of biomass at a biomass energy project would emit nitrogen dioxide, particulate matter, carbon monoxide, sulfur dioxide, and carbon dioxide. The total amount of emissions would vary depending on the amount of material burned and its heating value. According to the EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) Section 1.6, "Wood Residue Combustion in Boilers," the emission factors for nitrogen oxide range from 0.22 to 0.49 pounds per million British thermal unit (MMbtu) of heat input (EPA 2014). The maximum emission factors for particulate matter, carbon monoxide, sulfur dioxide, and carbon dioxide are 0.56, 0.60, 0.025, and 195 pounds per MMbtu of heat input, respectively.

In many cases, the biomass would be prepared (e.g., ground, chipped, dried, and sorted) offsite as part of the biomass production process and delivered to the power plant as a finished product. Onsite handling of biomass would be limited to storage and furnace/boiler feeding systems. Consequently, the impacts related to particulate matter emissions would need to be considered at the specific offsite locations.

Transport of the biomass feedstock from its source to the boilers would produce criteria pollutants from trucks and harvesting equipment. The total amount of emissions from transport of feedstock would depend upon the number and types of trucks used and the miles traveled. Published data for heavy duty diesel trucks show emission factors of 0.028, 0.0013, 0.0093, 0.000041, and 4.2 pounds per mile traveled for nitrogen oxide, particulate matter, carbon monoxide, sulfur dioxide, and carbon dioxide, respectively (http://www.aqmd.gov/ceqa/handbook/onroad/onroad.html; AQMD 2008).

5.1.2.1.2 Climate Change

Operation of a biomass facility would generate carbon dioxide, a greenhouse gas. Historically, carbon dioxide emissions from biomass facilities have been considered to be carbon neutral, but the premise of carbon neutrality during the burning of biomass is an unsettled issue. The basis for the premise is that as long as biomass resources are managed sustainably (that is, the annual amount of the biomass resource grown is greater or equal to the annual amount burned), the combustion of harvested materials presents no net increase of carbon to the ongoing carbon cycle. Therefore, the burning of biomass would not be considered an increase in greenhouse gas emissions. By comparison, the combustion of fossil fuels such as oil emits carbon that has been out of the current carbon cycle for millennia and therefore would contribute to an increase in greenhouse gas emissions. In January 2011, the EPA announced its plans to defer for three years the greenhouse gas permitting requirements for carbon dioxide emissions from biomass-fired boilers in order to seek further independent scientific analysis of the complex issue. On July 12, 2013, the U.S. Court of Appeals, D.C. Circuit, Case No. 11-1101 (*Center for Biological Diversity vs EPA 2013*) vacated the deferral by ruling that it could not be justified under any of the administrative law doctrines relied on by EPA (CADC 2013). Consequently, EPA is developing final permitting rules for biogenic carbon dioxide emissions. With the continuing lack of permitting rules concerning burning biomass and the uncertainty of the carbon neutrality of biomass energy, this PEIS includes, as one part of the impact analysis, the assumption that all reductions in the amount of oil burned will be reflected in a reduction of carbon dioxide and greenhouse gas emissions.

Under the representative project, a replacement of 350 megawatt-hours of electricity per year (Chapter 2) from the baseline electrical grid would reduce oil consumption from electricity generation by about 23,000 gallons. On O‘ahu, the annual replacement of 350 megawatt-hours of electricity from the baseline grid and the corresponding reduction in the use of oil would correspond with an annual reduction in greenhouse gas emissions of about 250 metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012). On other islands, similar annual replacement of electricity usage from the baseline grid would see an annual reduction in greenhouse gas emissions of about 220 metric tons carbon dioxide equivalent due to a different mix of technologies used to produce electricity on the other islands.

Note: The EPA eGrid2012 “Year 2009 GHG Annual Output Emission Rates” lists emission factors for estimating greenhouse gas emissions from electricity generation (EPA 2012). The site contains one set of emission factors for the island of O’ahu and a different set of emission factors for the other islands due to their different mix of technologies used in electricity production.

5.1.2.2 Best Management Practices and Mitigation Measures

Best management practices that could minimize potential air impacts include using a boiler system that is designed to achieve high combustion and boiler efficiency and can operate close to its design capacity and applying control technology to reduce emissions during operation of the facility (such as dust collectors to reduce particulate matter emissions). Air quality permits would be required before construction and operation of a biomass steam boiler to insure compliance with all local and Federal air quality regulations.

The following mitigation measures should be taken to minimize the identified potential impacts:

- Project design should incorporate a high-efficiency combustion and boiler system to operate at or near design capacity.

- The project would apply control technology to reduce emissions during project operations (example: dust collectors to reduce particulate matter emissions).

5.1.3 WATER RESOURCES

This section addresses potential environmental impacts to water resources from the representative distributed biomass energy project. The impacts are presented in terms of surface water, groundwater, and floodplains and wetlands.

5.1.3.1 Proposed Impacts

5.1.3.1.1 Surface Water

Effects on surface water from construction of the 50-kilowatt steam boiler and associated facilities would be the same as those expected for common construction actions as described in Section 3.3.5. The project would involve disturbance of 3 to 6 acres of land, so the permitting requirements described in Section 3.3.5 would be fully applicable.

During operation there likely would be no activities that would have the potential to affect surface waters other than possibly increasing storm water runoff from the site. The effects of facility construction generally involve increases in the amount of impervious surfaces with associated increases in runoff. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns. If operation of the boiler system involved discharges of industrial wastewater, such as blowdown from an open cooling water system, it likely would go to a sanitary sewer system with formal approval of the treatment plant operator, or it would go through a discharge point with appropriate permits (such as an NPDES permit or a permit from the local municipal storm water system operator) and applicable monitoring and water quality requirements.

5.1.3.1.2 Groundwater

Potential impacts to groundwater from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the biomass boiler and turbine facility, impacts to groundwater would be limited primarily to the water needs to operate the facility. Consistent with best management practices for construction projects (see Section 3.3.6), water going through the boiler and then steam to the turbine would be expected to be on a loop, recycling as much of the water as reasonable. Depending on the type of cooling system involved, there would be continuous losses from evaporation and blowdown that would have to be replenished from the local water supply (likely from groundwater as noted previously). The amount of fresh water needed for the system would not be expected to result in water availability issues, but would have to be evaluated on a case-by-case basis. Water required by the facility operators or other activities, such as biomass handling, likely would be minor in comparison with the requirements of the steam boiler system.

The long-term presence and operation of the biomass facility would be associated with increased runoff (as described previously) and potentially an associated decrease in groundwater recharge. However, the area involved would be relatively small and, depending on where storm water runoff from the facility would go or how it would be managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge.

5.1.3.1.3 Floodplains and Wetlands

The proponent of a distributed biomass facility would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

5.1.3.2 Best Management Practices and Mitigation Measures

Because it is assumed the representative biomass boiler and turbine facility would have access to a sewer system (Chapter 2), there would be no sanitary or process wastewater issues associated with facility operation and there would be no basis for avoiding areas with sensitive receiving waters. With regard to water resources to support the facility’s water needs, most of O‘ahu and all of Moloka‘i have been designated Groundwater Management Areas (see Sections 3.3.2.3 and 3.3.2.4 in Chapter 3) because of concerns over the long-term availability of groundwater. This designation authorizes the State to manage groundwater through a permitting process. This does not mean the project could not be implemented on either island due to lack of water, it does identify a heightened level of concern that would have to be evaluated for a proposed action that involved any water demand.

5.1.4 BIOLOGICAL RESOURCES

5.1.4.1 Potential Impacts

Common impacts to biological resources from typical construction and operation activities are identified in Section 3.4.5.

Impacts to biological resources from the representative distributed biomass energy project would potentially occur through the biomass production and harvesting process and construction of the biomass facility. Up to 6 acres of land could be cleared of vegetation during construction. Impacts to terrestrial wildlife and protected plants and animals from construction of the boiler, turbine, and local infrastructure (i.e., access roads, water lines, and electrical lines) are expected to be minimal because the project would be part of an existing facility. Potential facility lighting during operation could have impacts on flights of marine birds, such as shearwaters and petrels, depending on the specific project location.

5.1.4.2 Best Management Practices and Mitigation Measures

Common best management practices associated with typical construction and operation activities to protect biological resources are identified in Section 3.4.6.

These additional best management practices could also be taken to minimize the identified potential impacts:

- Use lighting designs and operation routines to minimize lighting needs to avoid or reduce potential impacts to birds in flight.

- Select an existing agricultural operation, such as sugarcane or similar energy crop, to produce and harvest the biomass feedstock to minimize potential impacts to terrestrial plants and wildlife. The reasoning is that production fields that have been previously disturbed contain little wildlife or wildlife habitat.

5.1.5 LAND AND SUBMERGED LAND USE

5.1.5.1 Proposed Impacts

5.1.5.1.1 Land Use

The representative biomass energy facility would be adjacent to the commercial or industrial facility where the electrical power would be used and would need to be compatible with existing land uses. The State land use designations and county overlay zones would need to be evaluated for each specific project. However, changes in land ownership patterns would not be expected.

Operational impacts would involve facility maintenance and repair.

5.1.5.1.2 Submerged Land Use

As identified in Table 5-1, no impacts to submerged land use would be expected from a distributed biomass energy project.

5.1.5.2 Best Management Practices and Mitigation Measures

During site selection, evaluate the State land use designations and county overlay zones.

5.1.6 CULTURAL AND HISTORIC RESOURCES

5.1.6.1 Potential Impacts

Potential impacts on cultural and historic resources from the representative distributed biomass energy project would be the same as those expected for common construction actions as described in Section 3.6.6.

5.1.6.2 Best Management Practices and Mitigation Measures

Best management practices for cultural and historic resources would be the same as those common across construction and operational projects. See Section 3.6.7.

5.1.7 COASTAL ZONE MANAGEMENT

5.1.7.1 Potential Impacts

Impacts to the coastal zone from the representative distributed biomass energy project could involve impacts to special management areas and shorefront access, depending on the project location. Because the entire State of Hawai‘i is considered part of the coastal zone, a Federal consistency review may be required if the representative project involves Federal agency activities, Federal license or permit activities, and Federal financial assistance activities (see Section 3.7.4).

5.1.7.2 Best Management Practices and Mitigation Measures

Specific project locations would require evaluation to determine if impacts would occur to special management areas designated under the State Coastal Zone Management Program, shorefront access, and shoreline erosion.

5.1.8 SCENIC AND VISUAL RESOURCES

5.1.8.1 Potential Impacts

Potential impacts to scenic and visual resources from construction of the representative distributed biomass energy project would be the same as those expected for common construction actions as described in Section 3.8.3.

Potential visual impacts during operation of the biomass energy plant would be from outdoor safety and security lighting. The magnitude of visual impacts would be location-dependent; that is, if the biomass steam boiler generator were located in an existing commercial or industrial setting, without adjacent sensitive viewsheds, impacts would be minimal.

5.1.8.2 Best Management Practices and Mitigation Measures

Best management practices for scenic and visual resources would be the same as those common across construction projects. See Section 3.8.4.

The following mitigation measures would reduce the identified potential impacts:

- When possible, locate the facility in areas without adjacent sensitive viewsheds.
- Redirect lighting away from external views.

5.1.9 RECREATION RESOURCES

As identified in Table 5-1, there would be no potential impacts to recreation resources from the representative distributed biomass energy project.

5.1.10 LAND AND MARINE TRANSPORTATION

5.1.10.1 Potential Impacts

5.1.10.1.1 Land Transportation

Impacts to land transportation considered potential effects on traffic, alterations to existing roads, requirement for additional roads (excluding temporary or project specific access roads), and infrastructure. Potential impacts would occur from increased truck traffic for hauling biomass from the production facility to the biomass power plant. Because the biomass production would be close (up to 5 miles) to the power plant, any impact would be localized. In a worst-case scenario, truck traffic would occur on existing public access roads and impact traffic conditions (e.g., reduced traffic flow, added wear and tear on the roads). Because the representative distributed biomass energy project would be produced as part of an existing agricultural or forestry operation, some of the truck traffic could occur on private roads, minimizing or avoiding any traffic impacts.

5.1.10.1.2 Marine Transportation

As identified in Table 5-1, there would be no potential impacts to marine transportation from the representative distributed biomass energy project.

5.1.10.2 Best Management Practices and Mitigation Measures

The following mitigation measures should be taken to minimize the identified potential impacts:

- Cover trucks hauling biomass to contain dust and to keep biomass material from falling out.
- To the extent feasible, private roads should be utilized to minimize traffic impacts.

5.1.11 AIRSPACE MANAGEMENT

As identified in Table 5-1, there would be no potential impacts to airspace management from the distributed biomass energy project.

5.1.12 NOISE AND VIBRATION

5.1.12.1 Potential Impacts

Construction of the representative biomass project over 9-months could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

During operation, noise from the steam boilers and turbines mostly would be contained within the buildings and the energy facility would be adjacent to an existing commercial or industrial facility where the electrical power would be used. Long-term operational noise would be produced from operation of the biomass handling facilities and removal of ash waste. The representative biomass would have negligible long-term impact to existing noise and vibration levels. Noise levels would increase during short term steam blow events.

5.1.12.2 Best Management Practices and Mitigation Measures

Best management practices for noise would be the same as those commonly implemented for construction and operation. See Section 3.12.6.

5.1.13 UTILITIES AND INFRASTRUCTURE

5.1.13.1 Potential Impacts

The potential impact of adding 50 kilowatts of power generation capacity to each island’s electricity service would be minimal. For O‘ahu, with the largest island net capacity of 1,756 megawatts, the addition would equate to about 0.003 percent of its total capacity. For Lāna‘i and Moloka‘i with the smallest net capacities of 10 and 12 megawatts, respectively, the addition would equate to about 0.5 and 0.4 percent of their respective capacities (see Section 3.13.1).

Potential impacts to utilities and infrastructure from construction and operation of the 50-kilowatt generating plant would be the same as those described in Section 3.13.3.1.

5.1.13.2 Best Management Practices and Mitigation Measures

Best management practices for utilities and infrastructure would be the same as those common across construction projects. See Section 3.13.4.

5.1.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

5.1.14.1 Potential Impacts

5.1.14.1.1 Hazardous Materials

Potential impacts associated with exposure to hazardous materials from the representative distributed biomass energy project would occur during construction, if at all. Such potential impacts would be the same as those described in Section 3.14.4. There would be no operations impacts associated with exposure to hazardous materials.

5.1.14.1.2 Waste Management

Potential impacts to waste management from construction of the representative distributed biomass energy would be the same as those discussed in Section 3.14.4.

During project operation, combustion of biomass would result in about 18 tons of ash waste as a byproduct (with 3 percent ash content). Therefore, the representative project would integrate ash-handling facilities into the biomass energy facility. Ash residue typically is considered a hazardous waste and regulated by EPA; however, the ash residue for the representative project would come from sugarcane bagasse, which is not considered hazardous. Therefore, the ash waste could be transported to nearby agricultural fields for use as fertilizer. Leftover ash waste not used as fertilizer would be disposed of in a landfill, used as landfill cover, added to concrete mixtures for roads, or other acceptable uses. As such, potential waste management impacts during project operation would be minimal.

5.1.14.1.3 Wastewater

Potential wastewater impacts likely would be minimal during construction of the project and would be limited to wastewater generated by construction workers onsite.

During project operation, wastewater could discharge from the steam cycle and cooling system blowdown, and likely contain trace amounts of chemicals. However, the wastewater likely would go to a sanitary sewer system or discharge point. Section 5.1.3.1.1 discusses permit requirements for wastewater release.

5.1.14.2 Best Management Practices and Mitigation Measures

Potential wastewater impacts could be mitigated by the use of settling ponds or filtration systems in order to meet NPDES wastewater discharge permit requirements.

5.1.15 SOCIOECONOMICS

5.1.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from construction and operation of the representative distributed biomass energy project would be very small. The turbines and supporting apparatus and appliances likely would be manufactured outside the State, and the economic benefits associated with the manufacturing would accrue elsewhere. Construction would require approximately 30 workers for about 9 months. Operations would require 2 employees per shift. The biomass would be provided by an existing agricultural operation, so very few new jobs would be created for that purpose. A few jobs in the transportation field would be created to transport the biomass from the supplier to the production facility, and to transport the ash from the biomass facility to the landfill, as necessary.

Jobs directly associated with the biomass facility likely would be filled by individuals residing within the region of influence (the State of Hawai‘i) and not by in-migrating workers. There would be little to no impact on population employment variables, such as the size of the labor force, unemployment rates, and employment in the State and local government sector; housing and living conditions; and personal income.

5.1.15.2 Best Management Practices and Mitigation Measures

None noted.

5.1.16 ENVIRONMENTAL JUSTICE

5.1.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative distributed biomass energy project are expected to be small. The potential for environmental justice impacts also would be small.

5.1.16.2 Best Management Practices and Mitigation Measures

During site selection, conduct a study to determine the specific location of low-income and minority populations, specifically Native Hawaiians, and determine whether there would be disproportionately high and adverse impacts to such populations.

5.1.17 HEALTH AND SAFETY

5.1.17.1 Potential Impacts

Potential impacts to health and safety from construction and operation of the representative project would be the same as those expected for common construction and operation actions.

5.1.17.2 Best Management Practices and Mitigation Measures

None noted.

5.2 Hydroelectric

The representative distributed hydroelectric power project is characterized by two delivery methods: diversion, or redirecting water flow, and conduit systems (see Section 2.3.2.2). The representative diversion project would be located at a site identified with sufficient head and flow characteristics to sustain regular power generation, ideally on a steep slope or very close to a waterfall. Typically, this would be a rural area, on a farm, park, or similarly developed site. The hydropower plant would be designed to generate up to 10 megawatts of electricity, utilizing either pelton or turgo wheel technology, and require a shorter penstock due to the relative slope of the ideal deployment location. System configuration sizes may vary, depending on the river resource as well. Depending on the location, these power plants may also require construction of transmission or distribution lines to ensure grid connectivity.

The representative conduit hydropower project would be composed of a kinetic turbine and generator system rated from small kilowatt sizes up to 6 megawatts; sized to meet the municipal water flow of the chosen site. This technology would be installed at a water distribution/pressure control facility. The representative project would be located on an existing site; therefore, no new transmission or distribution lines would be needed.

As identified in Section 2.3.3.2, the river resources in Hawaiʻi are not suitable for large hydroelectric impoundments; therefore, the PEIS only considers distributed hydroelectric facilities and will not evaluate hydroelectric projects in Chapter 6, Utility-Scale Renewables. This section evaluates the two representative projects (diversion and conduit) for a generating range from 6 megawatts to 10 megawatts.

Table 5-2 presents a summary of the potential environmental impacts for hydroelectric projects, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and best management practices and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 5-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydroelectric

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	Diversion System General impacts during construction. See Section 3.1.3. No impacts during operation. **Conduit System** None; the conduit system would be installed at an existing facility and not disturb additional land.	Special consideration should be given to locations or receptors with sensitive geology or soil conditions to minimize erosion.
Climate and Air Quality		
Air Quality	General impacts during construction. See Section 3.2.4.	None.
Climate Change	Beneficial; potential reductions in greenhouse gas emissions.	N/A
Water Resources		
Surface Water	**Diversion System** Potentially adverse impacts to water quality (decreased dissolved oxygen content and increased temperature), water supply, and existing uses (e.g., irrigation fisheries, and recreation). **Conduit System** None; the conduit system would be installed at an existing facility and not incrementally impact surface water.	To the extent feasible, divert a smaller portion of the stream or decrease the volume of water diverted (and the amount of electricity produced during periods of low river flow) to reduce impacts.

Table 5-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydroelectric (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Groundwater	**Diversion System** General impacts during construction. See Section 3.3.5. No impacts during operation. **Conduit System** None; the conduit system would be installed at an existing facility and not incrementally impact groundwater.	None.
Floodplains and Wetlands	**Diversion and Conduit Systems** Potential impacts during construction (site-specific) No impacts during operation.	None.
Biological Resources		
	Diversion System General construction impacts. See Section 3.4.5.1. Potential impacts from access roads during construction. Potentially adverse impacts to freshwater fish species. **Conduit System** Impacts are unlikely due to the use of an existing conduit flow system.	Minimize stream flows to allow for movement of fish. Include screens on diversion channels to prevent entrainment of aquatic species.
Land and Submerged Land Use		
Land Use	**Diversion System** Potential land disturbance during construction. Potential land use compatibility impacts. **Conduit System** General construction impacts. See Section 3.5.4.	Follow appropriate outreach and consultation practices for those areas designated as conservation areas or parks or that may have sacred meaning to Native Hawaiians (wahi pana or wahi kapu).
Submerged Land Use	None; the projects are for installations on the interior of the islands and make use of rivers and stream rather than the ocean.	N/A

Table 5-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydroelectric (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	Diversion and Conduit Systems General impacts during construction and operation. See Section 3.6.6.	Same as those common across construction and operational projects. See Section 3.6.7.
Coastal Zone Management		
	None; the projects are for installations on the interior of the islands and would not affect the shoreline.	N/A
Scenic and Visual Resources		
	Diversion System General impacts during construction (short-term). See Section 3.8.3. Potential long-term visual impacts (site-specific). **Conduit System** None.	Same as those common across construction projects. See Section 3.8.3.
Recreation Resources		
	Diversion System General short-term construction impacts. See Section 3.9.4. Potential impacts to river-based recreation activities, such as fishing and kayaking. **Conduit System** None.	Same as those common across construction projects. See Section 3.9.5.
Land and Marine Transportation		
	Diversion and Conduit Systems None; construction and operation of hydroelectric facilities would be unlikely to have any impacts to land and marine transportation.	N/A
Airspace Management		
	Diversion and Conduit Systems None; construction and operation of hydroelectric facilities would not affect airspace.	N/A

Table 5-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydroelectric (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	Diversion System General impacts during construction (short-term). See Section 3.12.5. Potential long-term noise and vibration impacts during operation (site-specific) **Conduit System** General impacts during construction (short-term). See Section 3.8.3. No impacts during operation.	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
	Diversion and Conduit Systems General impacts during construction and operation. See Section 3.13.3.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials and Waste Management	**Diversion and Conduit Systems** General exposure impacts during construction and operation. See Section 3.14.3.	None.
Wastewater	**Diversion and Conduit Systems** General impacts during construction. See Section 3.14.3.	Same as those common across construction projects. See Section 3.14.5.
Socioeconomics		
	Diversion and Conduit Systems A few operation and construction jobs created. No operational impacts.	None.
Environmental Justice		
	Diversion and Conduit Systems Dependent on potentially adverse impacts to other resources in adjacent and nearby areas (site-specific).	Conduct an evaluation of potential effects to low-income and minority populations.
Health and Safety		
	Diversion and Conduit Systems General impacts during construction and operation. See Section 3.14.3.	None.

5.2.1 GEOLOGY AND SOILS

5.2.1.1 Potential Impacts

Construction of the representative diversion hydropower plant would disturb about 1 acre of land for installation of the upstream intake channel or pipe, a forebay structure or tank, a penstock, a powerhouse, and a tailrace or outlet. Construction of an access road might be needed to access the construction areas; although this access road would be temporary and reclaimed once construction was completed. Permitting requirements would be the same and potential impacts on geology and soils would be as described for common construction actions in Section 3.1.3. One of these common impacts that could be greater with diversion hydropower systems is the potential for erosion, which would increase as the slope of the specific project site increased.

Since the conduit hydroelectric power system would be installed at an existing water facility, there would be little if any construction or land disturbance required; therefore, no impacts to geology or soils would be expected.

Long-term operation of either hydroelectric power system is not expected to impact geology or soils.

5.2.1.2 Best Management Practices and Mitigation Measures

Potential impacts to geology and soils and their severity would be dependent on project location; therefore, consideration should be given to locations with sensitive geology or soil conditions, such as areas with highly erodible soils and high slopes. Since locations potentially suitable for diversion hydroelectric power systems would be expected to include elevation changes, erosion issues would likely be of particular concern and could require additional measures to minimize erosion.

5.2.2 CLIMATE AND AIR QUALITY

5.2.2.1 Potential Impacts

A representative 10-megawatt hydroelectric project could reduce electricity requirements from the baseline electrical grid by 88,000 megawatt-hours per year if the turbine were run at full capacity every day for an entire year. Although a 100-percent capacity factor would not be achievable due to maintenance of the facility and potential periods of low water volume, it provides a theoretical maximum amount of electricity that could be generated per year if sufficient water were available. A realistic capacity factor of 44 percent (DBEDT 2013), which assumes seasonal shortages of water, would replace electricity requirements from the baseline electrical grid by 39,000 megawatt-hours per year.

Potential impacts to climate and air quality from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.2.4.

A replacement of 39,000 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 2.6 million gallons (assuming 66.7 gallons of fuel oil per megawatt-hour of electricity). On O‘ahu, this annual replacement of electricity from the baseline grid and the corresponding reduction in the use of oil would correspond to an annual reduction in greenhouse gas emissions of about 28,000 metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012). On other islands, this same theoretical annual replacement of electricity usage from the baseline grid would see an annual reduction in greenhouse gas emissions of

24,000 metric tons carbon dioxide equivalent due to a different mix of technologies used to produce electricity on the other islands.

5.2.2.2 Best Management Practices and Mitigation Measures

None noted.

5.2.3 WATER RESOURCES

This section addresses potential environmental impacts to water resources from the representative hydroelectric power project. The impacts are presented in terms of surface water, groundwater, and floodplains and wetlands. The diversion project may also require construction of a transmission line to reach the nearest grid connection, but potential impacts associated with such an action are addressed under the On-Island Electrical Transmission technology in Chapter 8 and are not discussed here.

5.2.3.1 Potential Impacts

5.2.3.1.1 Surface Water

As described in Section 5.2.1.1, construction of a diversion hydropower system would disturb about 1 acre of land. As such, potential impacts on surface water and associated permitting requirements would be the same as described in Section 3.3.5.

During operation of the diversion system, a portion of the stream flow would be diverted through the power plant and then be returned to the stream at a lower, downstream location. This type of action would require a stream channel alteration pursuant to HAR 13-169, Protection of Instream Uses of Water, which requires that any stream channel alteration obtain a permit from DLNR’s Commission on Water Resources Management. In its decision to grant or deny such a permit, the Commission considers the following (from HAR 13-169-52):

- Alterations that would adversely affect quantity and quality of the stream water or the stream ecology should be minimized or not allowed;
- If in-stream flow standards have been set for the applicable stream, no permit should be allowed that would diminish the quantity or quality of stream water below the minimum established standards; and
- A channel alteration should not interfere with existing in-stream or non-in-stream uses.

As identified in the above regulatory considerations, primary concerns for adverse impacts from a diversion system would be to water quality and quantity and to existing uses of the stream water. The severity of impacts in each of these areas would depend on the characteristics of the project location, particularly the size of the natural flow in the river and the amount of flow that would be diverted. Concerns with water quantity and existing uses likely would be greatest in the stretch of river that would have reduced flow due to the diversion, although water uses could also be affected further downstream. The decreased water flow in this portion of the river could adversely impact uses such as irrigation, fisheries, and recreation.

Water quality concerns likely would be greatest at the point the diverted water was put back into the stream. The primary concerns would be decreased dissolved oxygen content and increased temperature.

Since the representative conduit hydroelectric power system would be installed at an existing water facility, there would be little if any construction or land disturbance; any impacts to surface water would be avoided or mitigated (see Section 3.3.6). Likewise, operation of the conduit system would not be anticipated to impact surface water resources.

5.2.3.1.2 Groundwater

Potential impacts to groundwater from construction and operation of the representative diversion hydroelectric power system would be expected to be the same as described from common construction actions in Section 3.3.5.

Since the representative conduit hydroelectric power system would be installed at an existing water facility, there would be little if any construction or land disturbance; no impacts to groundwater would be expected. Likewise, operation of the conduit system would not be anticipated to impact groundwater.

5.2.3.1.3 Floodplains and Wetlands

The proponent of a diversion hydroelectric power system would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if such areas could not be avoided, construction considerations would be the same as those described for common construction actions in Section 3.3.5. Since the conduit system would involve installing equipment at an existing water facility, floodplains or wetlands would not be affected.

5.2.3.2 Best Management Practices and Mitigation Measures

As described in Section 5.2.3.1.1, locations with low water flow or other water quantity issues would likely be the most susceptible to impacts. Since flow in most streams can vary significantly over the course of a year, concerns over water quantity in the diversion areas may be periodic in nature.

The smaller the portion of the stream is diverted, the lower the potential for serious water quality concerns. These considerations and the severity of impacts would be evaluated in the permitting process and it is reasonable to assume that a proposed diversion system would not be permitted unless the regulatory agency felt impacts were minor or at acceptable levels to warrant the benefit that would be gained.

In general, the smaller the portion of the stream is diverted, the lower the potential for serious adverse impacts. Decreasing the volume of water diverted (and the amount of electricity produced) during periods of low river flow would also be an important means of reducing the severity of impacts.

5.2.4 BIOLOGICAL RESOURCES

5.2.4.1 Potential Impacts

Construction of the representative diversion hydropower system would disturb about 1 acre of land in a rural area, farm setting, park, or similar site for installation of the upstream intake channel or pipe, a forebay structure or tank, a penstock, a powerhouse, and a tailrace or outlet. The primary impact to biological resources would be the construction of access roads to construct the power system.

Threatened and endangered plant and animal species and designated critical habitat and protected land areas occur in many areas where streams or waterfalls are conducive to distributed hydroelectric power development. Common impacts from the development of renewable energy technologies such as land disturbances and associated impacts to such biological resources are discussed in Chapter 3, Section 3.4.5.1.

The representative project would potentially impact freshwater fish species through a reduction in stream flow between the point of flow diversion to the downstream release point. Types of impacts could include life history of the species (e.g., feeding, suitable habitat, reproduction ability, and mortality from increased water temperatures). The extent of impacts would depend on the remaining stream flow after diversion and the length of stream in which the flow is reduced.

Potential impacts to biological resources from a conduit hydroelectric system are expected to be less than those for a diversion system. A conduit system would be installed in an existing flow of water such as an irrigation or municipal water delivery system. Installation of a conduit system would require very little modification of vegetation or wildlife habitat and would most likely be installed in a previously developed area.

5.2.4.2 Best Management Practices and Mitigation Measures

The following best management practices could prevent or reduce the identified potential impacts:

- Reclaim land disturbances not required for operation or maintenance with native vegetation to minimize impacts following construction.
- Prior to site selection, review specific project locations to ensure the project would not adversely impact sensitive biological resources ranging from avian and land species to aquatic anadromous-amphidromous species with diadromous life-cycle patterns (see Section 3.4.1.3.3).
- Establish minimum stream flows to allow movement of fresh water fish through the impacted stream segment.
- Install screens on diversion channels to help prevent entrainment of aquatic species through the forebay reservoir, penstock pipe, and power station.

5.2.5 LAND AND SUBMERGED LAND USE

This section discusses the potential environmental impacts to land use from two representative hydroelectric projects: diversion system and a conduit system.

5.2.5.1 Potential Impacts

5.2.5.1.1 Land Use

Land disturbance from the representative diversion hydroelectric project would occur during construction of the system. Depending on the locations and linear distances between the water source and the powerhouse and then to the transmission grid, there could be changes in land use and ownership. Potential impacts associated with any required transmission lines are addressed in Section 8.1.

The representative conduit hydropower system would be installed at an existing water distribution/pressure control facility and is not anticipated to result in a change to land use. Therefore, impacts to land use from construction and operation of the representative project would be the same as those expected for common construction actions as described in Section 3.4.5.

5.2.5.1.2 Submerged Land Use

As identified in Table 5-2, there would be no potential impacts to submerged land use from the representative hydroelectric power project.

5.2.5.2 Best Management Practices and Mitigation Measures

During site selection, the project proponent should evaluate the State land use designations and county overlay zones.

Because hydroelectric systems are, by necessity, in areas that include sloping terrain with surface water features, the potential exists that areas identified for development could include conservation areas or parks; some may have sacred meaning to Native Hawaiians (e.g., wahi pana or wahi kapu). Project proponents should include public outreach and tribal consultations as part of their siting process. Many sections of this PEIS address traditional and Native Hawaiian practices and rights (e.g., Section 3.6 and throughout Chapters 4 through.8).

5.2.6 CULTURAL AND HISTORIC RESOURCES

5.2.6.1 Potential Impacts

Potential impacts to cultural and historic resources from construction and operation of the representative project would be the same as those expected for common construction and operations actions as described in Section 3.6.6.

5.2.6.2 Best Management Practices and Mitigation Measures

Best management practices for cultural and historic resources would be the same as those common across construction and operational projects. See Section 3.6.7.

5.2.7 COASTAL ZONE MANAGEMENT

As identified in Table 5-2, there would be no potential impacts to coastal zone management from the representative hydroelectric power project.

5.2.8 SCENIC AND VISUAL RESOURCES

5.2.8.1 Potential Impacts

Potential impacts to scenic and visual resources from construction and operation of the representative project would be the same as those expected for common construction actions as described in Section 3.8.3.

Operational impacts would be location-dependent but most certainly would introduce a new facility and would impact visual and scenic resources. The visibility of the new plant would depend on the terrain. The components of most diversion systems include an upstream intake, a forebay tank, a penstock for transporting the water to the powerhouse, the powerhouse itself (which includes all the necessary power generation and conversion equipment), and an outlet (or tailrace), where the water returns to the river (Figure 2-6 in Chapter 2). Some exterior lighting likely would be present for safety and security purposes.

The representative project would be designed to generate up to 10 megawatts of electricity. As a point of reference, a powerhouse for a 4-megawatt generator and associated equipment would be roughly the size of a 1-room cabin (16 × 28 feet). In addition to the plant footprint, the representative diversion hydroelectric power facility would require transmission or distribution lines to connect to the power grid. For remote locations, new access roads may be required to transport equipment and construction workers.

Because the conduit hydroelectric power project would be located within an existing water distribution system, impacts to visual and scenic resources would not be expected.

5.2.8.2 Best Management Practices and Mitigation Measures

Because hydroelectric power plants require a water source in a geographic area generally characterized by uneven terrain, such as hills or mountains, to have sufficient power-generation potential, protected lands and tourism considerations may block access to otherwise ideal water resource sites. Consideration should be taken to avoid siting a hydroelectric power plant in an area where lack of manmade features is an important contribution to the scenic value of the area.

Best management practices to minimize impacts to visual resources, including those from lighting, would be the same as those common across construction projects. See Section 3.8.4.

5.2.9 RECREATION RESOURCES

5.2.9.1 Potential Impacts

Potential impacts to recreation resources from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.9.4.

During project operation, there could be impacts to river-based recreation activities, such as fishing and kayaking.

A conduit hydroelectric power system would be located in an existing water distribution system and therefore have no incremental impacts to recreation resources.

5.2.9.2 Best Management Practices and Mitigation Measures

During project siting, consider avoiding areas where the lack of manmade features is an important contribution to the recreational value of the area or where the plant would impact river recreation. Tables 3-47 and 3-48 (in Chapter 3) list popular land-based and water-based recreation activities, respectively.

Project proponents should review the *State Comprehensive Outdoor Recreation Plan* (SCORP) for detailed matrixes of all recreation areas on each island and the recreational activities that take place at each area (DLNR 2009).

General best management practices to minimize impacts to recreation resources would be the same as those common across construction projects. See Section 3.9.5.

5.2.10 LAND AND MARINE TRANSPORTATION

As identified in Table 5-2, there would be no potential impacts to land or marine transportation from the representative hydroelectric power project.

5.2.11 AIRSPACE MANAGEMENT

As identified in Table 5-2, there would be no potential impacts to airspace management from the representative hydroelectric power project.

5.2.12 NOISE AND VIBRATION

5.2.12.1 Potential Impacts

The representative hydroelectric project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

Long-term noise and vibration impacts would depend on the locations of new infrastructure and their compatibility with the existing noise levels and land uses. Depending on the location, noise and vibration impacts could result from operation of a diversion hydroelectric power system introduced in a relatively rural area, on a farm, or in a park. The representative conduit hydroelectric power system would be installed at an existing water distribution/pressure control facility and would have negligible long-term impact to existing noise and vibration levels.

5.2.12.2 Best Management Practices and Mitigation Measures

Best management practices for noise and vibration would be the same as those common across projects for construction and operation. See Section 3.12.6.

5.2.13 UTILITIES AND INFRASTRUCTURE

5.2.13.1 Potential Impacts

The potential impact on each island’s electric utilities would be small to moderate from the addition of 6 to 10 megawatts of power generation to the power grid. For O‘ahu, with the largest island net capacity of 1,756 megawatts, the addition would equate to about 0.6 percent of its total capacity. If feasible, the addition for Lāna‘i, with the smallest net capacity of 10 megawatts, would equate to about 100 percent of its total capacity (see Section 3.13.1) and require major utility adjustments.

Potential impacts from connection to utilities for construction and operation of the representative project would be the same as those expected for common construction actions described in Section 3.13.3.1.

5.2.13.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to utilities, infrastructure, and public safety would be the same as those common across construction projects. See Section 3.13.4.

5.2.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

5.2.14.1 Potential Impacts

Potential impacts from exposure to hazardous materials and to waste management from construction and operation of the representative project would be the same as those expected for common construction actions as described in Section 3.14.3.

5.2.14.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to wastewater would be the same as those common across construction projects. See Section 3.14.5. In addition, the representative project would comply with NPDES wastewater discharge permit requirements.

5.2.15 SOCIOECONOMICS

5.2.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from construction and operation of the representative hydroelectric system would be very small. The generator and the supporting apparatus and appliances likely would be manufactured outside the State and any economic benefit associated with manufacturing would accrue elsewhere. The number of temporary jobs associated with the construction of the system and the number of jobs to operate and maintain it would be very small, perhaps 10 workers for a 6-month construction period and 1 permanent position for operations.

Jobs directly associated the hydroelectric station would be likely filled by individuals residing within the State of Hawai‘i and not by in-migrating workers. There would be little to no impact on population employment variables, such as the size of the labor force, unemployment rates, and employment in the State and local government sector; housing and living conditions; and personal income.

5.2.15.2 Best Management Practices and Mitigation Measures

None noted.

5.2.16 ENVIRONMENTAL JUSTICE

5.2.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative hydroelectric power project are expected to be small. The potential for environmental justice impacts also would be small.

5.2.16.2 Best Management Practices and Mitigation Measures

During site selection, conduct a study to determine the specific location of low-income and minority populations, specifically Native Hawaiians, and determine whether there would be disproportionately high and adverse impacts to such populations.

5.2.17 HEALTH AND SAFETY

Potential impacts to health and safety from construction of the representative project would be the same as those expected for common construction actions.

5.3 Hydrogen Fuel Cells

This PEIS analyzes a representative hydrogen fuel cell project for both residential and commercial use (see Section 2.3.2.3). The representative residential project would be a 5-kilowatt fuel cell power system designed for use by a single-family residence. The power system would be housed in a container either inside or outside the residence and would use stacks of fuel cells in a modular system to produce the power output specified. The hydrogen would be produced onsite as part of the modular system using water and electricity for the electrolysis process or be purchased from a centralized hydrogen production facility. Electricity could be supplied either via the existing electrical grid or via renewable resources at the site such as solar or wind.

This PEIS also analyzes a representative commercial hydrogen fuel cell project with a 50-kilowatt capacity. The operational parameters for fuel cell systems of increasing size tend to be linear with respect to size. For example, each individual 5-kilowatt fuel cell system would produce the same amount of electricity, consume the same amount of hydrogen, and have the same emissions, whether a single fuel cell system is used or 10 fuel cell systems are grouped for a 50-kilowatt system. Likewise, the space required for the fuel cell stacks of a 5-kilowatt system would increase linearly for larger systems (even though the required space may vary slightly due to specific system layouts). Therefore, the operational parameters for a 50-kilowatt fuel cell system would be about 10 times that of a 5-kilowatt system.

Table 5-3 presents a summary of the potential environmental impacts for hydrogen fuel cell projects, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and best management practices and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 5-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydrogen Fuel Cells

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General impacts during construction and operation. See Section 3.1.3.	Same as those common across construction projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	General impacts during construction. See Section 3.2.4.	None.
Climate Change	Minimal greenhouse gas emissions (unless supplied from a renewable energy source, in which case impacts would be lower).	None.
Water Resources		
	General impacts during construction and operation. See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6.
Biological Resources		
	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to biological resources.	N/A
Land and Submerged Land Use		
	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to land and submerged land use.	N/A
Cultural and Historic Resources		
	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to cultural and historic resources.	N/A

Table 5-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydrogen Fuel Cells (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Coastal Zone Management		
	None; since there would be no land disturbance associated with hydrogen fuel cells, there would be no impacts to coastal zone management.	N/A
Scenic and Visual Resources		
	None; since there would be no external facilities associated with hydrogen fuel cells, there would be no impacts to scenic and visual resources, the containers would be located either indoor or outdoor adjacent to existing facilities, negligible impacts to visual resources are expected.	N/A
Recreational Resources		
	None; since the containers would be located either indoor or outdoor adjacent to existing facilities, no impacts to recreation resources are expected. There would be no land disturbance or external facilities associated with hydrogen fuel cells. There would be no impacts to scenic and visual resources.	N/A
Land and Marine Transportation		
	None; Since there would be no land disturbance or external facilities associated with hydrogen fuel cells, there would be no impacts to land and marine transportation.	N/A
Airspace Management		
	None; since there would be no external facilities associated with hydrogen fuel cells, there would be no impacts to airspace management.	N/A
Noise and Vibration		
	None; since there would be no land disturbance or external facilities associated with hydrogen fuel cells and the fuel cells do not generate noise, there would be no impacts to noise and vibration.	N/A

Table 5-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Hydrogen Fuel Cells (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Utilities and Infrastructure		
	Negligible impacts to electricity generating capacities.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	No exposure impacts during construction Minimal exposure impacts during operation.	Implement an emergency action plan to include training and proper procedures as well as the use of protective gear for workers in the event of an emergency.
Waste Management	None; no waste management impacts from construction or operation of hydrogen fuel cells.	N/A
Wastewater	None.	N/A
Socioeconomics		
	None; installation and use of hydrogen fuel cells would result in few jobs and would not impact socioeconomics.	N/A
Environmental Justice		
	None; since there would be no measurable impacts to the human environment, there would be no environmental justice impacts.	N/A
Health and Safety		
	Potential impacts related to hydrogen explosions are extremely unlikely.	Ensure proper handling, monitoring, and maintenance of the hydrogen system in accordance with operating system specifications.

5.3.1 GEOLOGY AND SOILS

5.3.1.1 Potential Impacts

The representative 5-kilowatt hydrogen fuel cell project would not require construction of a new facility, and there would be no land disturbance. If the project were increased to accommodate 50 kilowatts of power, potential impacts to geology and soils from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.1.3.

5.3.1.2 Best Management Practices and Mitigation Measures

If warranted by the project location, design the hydrogen fuel cell or its housing so that the probability of damage during an earthquake is low. Such measure could require a cost benefit analysis before finalizing site selection.

5.3.2 CLIMATE AND AIR QUALITY

5.3.2.1 Potential Impacts

Hydrogen fuel cells use the chemical energy of hydrogen combining electrochemically with oxygen to produce electricity and can be used for almost any application typically powered by batteries or internal combustion engines. Hydrogen fuel cells produce no criteria air pollutants or greenhouse gas emissions at the point of operation. A 5-kilowatt fuel cell would be a size appropriate for the average residential system.

5.3.2.1.1 Air Quality

Onsite air quality impacts associated with construction of a hydrogen fuel cell system would be short term, intermittent, and limited to the duration of the construction project. Criteria pollutant and greenhouse gas emissions would be minimal due to the small footprint of construction and the modular nature of fuel cell equipment. Most units of the system would be manufactured off-site and moved into position at the site.

An onsite hydrogen electrolyzer system that produces enough hydrogen for a 5-kilowatt fuel cell would require about 28 kilowatt-hours of electricity. Hydrogen produced using electricity from the existing electrical grid would not reduce overall air emissions because more electricity (with its resulting air emissions) would be required by the electrolyzer than would be produced by the fuel cell system. However, hydrogen produced using electricity from renewable resources such as wind power, solar, or geothermal would not use electricity from the grid. Such a 5-kilowatt fuel cell system would reduce electricity consumption from the baseline grid by 5 kilowatt-hours every hour during peak periods of the day.

5.3.2.1.2 Climate Change

A residential fuel cell system could replace the 600 kilowatt-hours of an average monthly residential electricity use. A replacement of 7.2 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 480 gallons per residential unit. On O‘ahu, the annual replacement of 7.2 megawatt-hours of electricity per residential unit would correspond to an annual reduction in greenhouse gas emissions of about 5.2 metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors (http://www.epa.gov/egrid; EPA 2012). On other islands by comparison, an annual replacement of 7.2 megawatt-hours of electricity usage would correspond to an annual reduction in greenhouse gas emissions of about 4.4 metric tons carbon dioxide equivalent due to a different mix of technologies used to produce electricity.

A commercial fuel cell system would produce linearly scaled impacts to air quality. For example, the 50-kilowatt fuel cell suitable for commercial buildings could reduce electricity use from the grid by ten times that of a 5-kilowatt fuel cell. The corresponding reduction in greenhouse gas emissions would be 10 times that of a 5-kilowatt fuel cell.

5.3.2.2 Best Management Practices and Mitigation Measures

None note.

5.3.3 WATER RESOURCES

5.3.3.1 Potential Impacts

The representative 5-kilowatt hydrogen fuel cell would not be expected to impact water resources during construction. However, potential impacts could occur from a 50-kilowatt project if land disturbance was necessary, in which case potential impacts to water resources would be the same as those for common construction actions described in Section 3.3.5.

It is estimated the 5-kilowatt hydrogen fuel cell would require 1 gallon of water per hour for its operation. This would represent a very minor increase in water demand for an average household (for the representative project). Even scaling the project up by an order of magnitude or more would involve relatively minor water demands and have negligible effects on water resources.

5.3.3.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to water resources would be the same as those common across construction projects. See Section 3.3.6.

5.3.4 BIOLOGICAL RESOURCES

As identified in Table 5-3, there would be no potential impacts to biological resources from the representative hydrogen fuel cells project.

5.3.5 LAND AND SUBMERGED LAND USE

As indicated in Table 5-3, there would be no potential impacts to land use from the representative hydrogen fuel cells project.

5.3.6 CULTURAL AND HISTORIC RESOURCES

As indicated in Table 5-3, there would be no potential impacts to cultural and historic resources from the representative hydrogen fuel cells project.

5.3.7 COASTAL ZONE MANAGEMENT

As identified in Table 5-3, there would be no potential impacts to coastal zone management from the representative hydrogen fuel cells project.

5.3.8 SCENIC AND VISUAL RESOURCES

As indicated in Table 5-3, there would be no potential impacts to scenic or visual resources from the representative hydrogen fuel cells project.

5.3.9 RECREATION RESOURCES

As indicated in Table 5-3, there would be no potential impacts to recreation resources from the representative hydrogen fuel cells project.

5.3.10 LAND AND MARINE TRANSPORTATION

As identified in Table 5-3, there would be no potential impacts to land or marine transportation resources from the representative hydrogen fuel cells project.

5.3.11 AIRSPACE MANAGEMENT

As identified in Table 5-3, there would be no potential impacts to airspace management resources from the representative hydrogen fuel cells project.

5.3.12 NOISE AND VIBRATIONS

As indicated in Table 5-3, there would be no potential impacts to noise and vibration from the representative hydrogen fuel cells project.

5.3.13 UTILITIES AND INFRASTRUCTURE

5.3.13.1 Potential Impacts

The potential impact on each island's electric utilities would be small from the addition of 5 kilowatts of hydrogen fuel cell generation to an individual household. The potential impacts for adding 50 kilowatts of hydrogen fuel cell generation to an existing industrial facility would be even lower, as the facility would remain connected to the grid to use utility power to run the facility when the renewable source was not sufficient.

As identified in Section 2.3.2.3, no large-scale use of stationary hydrogen fuel cells exists within the State of Hawai‘i. This is due, in part, to the high cost of producing hydrogen as a fuel source. Although natural gas is used as a primary fuel for fuel cells in the continental United States and other countries, natural gas is not readily available in Hawai‘i. As a result, the likely approach for hydrogen development in Hawai‘i is electrolysis using renewable energy. As can see by the description in Section 2.3.2.3, it requires more electricity to generate the hydrogen through electrolysis than is generated from the fuel cells themselves. Therefore, until the production and distribution of hydrogen is better developed (perhaps using geothermal or wind power), the use of hydrogen fuel cells would not be an efficient renewable energy technology for use in Hawai‘i.

5.3.13.2 Best Management Practices and Mitigation Measures

None noted.

5.3.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

5.3.14.1 Potential Impacts

5.3.14.1.1 Hazardous Materials

Potential impacts associated with exposure to hazardous materials from construction of the representative hydrogen fuel cell project would be the same as those expected for common construction actions as described in Section 3.14.4.

During project operations, hydrogen would be produced onsite as part of the modular system using water and electricity for the electrolysis process and could potentially leak. In addition, some fuel cells contain flammable liquids, including methanol, formic acid, certain borohydride materials, and butane. Businesses that are classified as Small or Large Quantity Generators of hazardous material (pursuant to the *Resource Conservation and Recovery Act*; RCRA) must comply with Federal waste disposal regulations, as specified in the following section.

5.3.14.1.2 Waste Management

As identified in Table 5-3, there would be no waste management impacts from the representative hydrogen fuel cells project.

Secondary impacts may result from byproducts during the manufacturing and decommissioning of fuel cells. However, it is not anticipated that the fuel cells would be manufactured in Hawaiʻi. Proper decommissioning of fuel cells would occur at the end-of-life, including reuse of useful materials (e.g., platinum, ruthenium or palladium) for manufacturing new fuel cells and the proper handling and treatment of hazardous waste in accordance with Federal State, and county laws and regulations. Nonhazardous components would be disposed of appropriately at the local landfill.

Hazardous waste generated by homeowners and contractors is not regulated by Federal hazardous waste regulations, such as RCRA. Thus, homeowners and contractors may dispose of discarded fuel cells as general refuse in a properly permitted municipal landfill. Retailers, commercial, and governmental entities, however, are subject to full RCRA regulation depending on the generator status of their business. Under RCRA, fuel cells discarded by businesses that are Conditionally Exempt Small Quantity Generators of hazardous waste may dispose of such waste in a properly permitted municipal landfill unless a State or local regulation prohibits or restricts such disposal. To qualify as a Conditionally Exempt Small Quantity Generator, a business must not generate more than 220 pounds of hazardous waste in any one month and must not accumulate more than 2,200 pounds of hazardous waste onsite at any one time. Those businesses that generate between 220 pounds and 2,200 pounds (about 100 to 1,000 kilograms) of hazardous waste in any one month are considered Small Quantity Generators. Those that generate more than 2,200 pounds of hazardous waste in any one month are considered Large Quantity Generators. Small and Large Quantity Generators of hazardous waste must dispose of discarded fuel cells at a properly permitted hazardous waste treatment, storage, or disposal facility.

5.3.14.1.3 Wastewater

As identified in Table 5-3, there would be no wastewater impacts from the representative hydrogen fuel cells project. However, beneficial impacts could be realized if wastewater was used to produce hydrogen; i.e., use of wastewater for the production of hydrogen would decrease the load on existing wastewater treatment facilities.

5.3.14.2 Best Management Practices and Mitigation Measures

In the event of a hydrogen leak, all workers would be required to respond according to an emergency action plan, including wearing protective gear to protect workers from invisible flames and potential explosion hazards. Additional State and possibly Federal regulations would apply.

5.3.15 SOCIOECONOMICS

As identified in Table 5-3, there would be no potential impacts to socioeconomics from the representative hydrogen fuel cells project.

5.3.16 ENVIRONMENTAL JUSTICE

As identified in Table 5-3, there would be no potential environmental justice impacts from the representative hydrogen fuel cells project.

5.3.17 HEALTH AND SAFETY

5.3.17.1 Potential Impacts

Like many fuels, hydrogen is a flammable gas and can form explosive mixtures with air. Hydrogen is non-toxic and non-poisonous, is lighter than air and diffuses rapidly. An explosion cannot occur in a tank that contains only hydrogen. An oxidizer, such as oxygen (air) must also be present.

5.3.17.2 Best Management Practices and Mitigation Measures

Ensure proper handling, monitoring, and maintenance of the hydrogen system in accordance with the manufacturer's recommendations.

5.4 Photovoltaics

The representative distributed photovoltaic (PV) project is characterized by two applications: installation of a rooftop 5-kilowatt PV system in a residence and installation of a rooftop 50-kilowatt PV system at a business (see Section 2.3.2.4). A typical home installation would cover about 350 square feet, and a typical business installation would cover about 3,500 square feet. The required number of solar modules for the system and the associated electrical equipment and wiring would depend on the power of the system (i.e., the 5-kilowatt system would have fewer modules and associated wiring than the 50-kilowatt system). Depending on the capacity of PV system there may also be batteries for storage or the system may be tied into the local utility distribution grid.

Table 5-4 presents a summary of the potential environmental impacts for PV projects, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and best management practices and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 5-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Photovoltaics

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; installation and use of rooftop solar modules would not involve land disturbance and therefore would not impact geology and soils.	N/A
Climate and Air Quality		
Air Quality	General impacts during construction. See Section 3.2.4.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Beneficial; reduced oil consumption by use of renewable energy.	None.
Water Resources		
	None; installation and use of rooftop solar modules would not involve land disturbance, would involve only minor water demand, and therefore would not impact water resources.	N/A
Biological Resources		
	None; installation and use of rooftop solar modules would not involve land disturbance or sensitive habitat and therefore would not impact biological resources.	N/A
Land and Submerged Land Use		
	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact land and submerged land use.	N/A
Cultural and Historic Resources		
	Potential adverse visual or architectural context impact to an historic property/resource.	In accordance with State law, submit an Historic Preservation Review Form in compliance with HRS 6E.
Coastal Zone Management		
	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact coastal zone management.	N/A

Table 5-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Photovoltaics (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Scenic and Visual Resources		
	Short-term visual resource impacts during installation. Potential long-term visual impacts (site-specific). Potential impacts to natural scenic and visual resources, or historic character of an area.	As feasible, solar modules should be installed to limit visibility and reduce impacts. Approval from the FAA and HDOT Airports Division may be required to ensure module glare would not interfere with nearby aircraft. Consider placement of PV system away from public or street views to minimize changes in viewsheds.
Recreation Resources		
	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact recreation resources.	N/A
Land and Marine Transportation		
	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact land and marine transportation.	N/A
Airspace Management		
	None; although installation of rooftop solar modules could cause some glare and reflection, which could be seen by pilots, installations at a distributed scale would typically not require consultations on airspace management.	N/A
Noise and Vibration		
	None; installation and use of rooftop solar modules would not involve land disturbance or new facility construction and therefore would not impact noise and vibration.	N/A

Table 5-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Photovoltaics (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Utilities and Infrastructure		
	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General exposure construction impacts. See Section 3.14.4. Potential exposure impacts from end-of-life of the photovoltaic system and the battery energy storage.	Same as those common across construction projects. See Section 3.14.5. Ensure proper disposal of hazardous materials at end-of-life.
Waste Management	General construction impacts. See Section 3.14.4. Potential exposure to hazardous waste (i.e., potential for cadmium). Potential landfill impacts.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	Potential impacts from the disposal of PV modules (i.e., potential for cadmium-contaminated wastewater).	Employ proper handling and transport of discarded PV systems at the appropriate hazardous waste facility to ensure that contaminated wastewater is disposed of appropriately.
Socioeconomics		
	None; installation and use of PV modules would result in few jobs and would not impact socioeconomics.	N/A
Environmental Justice		
	None; since there would be no measurable impacts to the human environment, there would be no environmental justice impacts.	N/A
Health and Safety		
	General impacts during construction and operation.	None.

5.4.1 GEOLOGY AND SOILS

As identified in Table 5-4, there would be no potential impacts to geology and soils from the representative distributed PV project.

5.4.2 CLIMATE AND AIR QUALITY

Photovoltaic technology converts solar energy into electricity. The representative distributed 5-kilowatt PV project would be installed at a residence. Assuming a 20-percent capacity factor (DBEDT 2013), the project would provide base load electricity of about 8.8 megawatt-hours per year and could replace electricity requirements from the existing baseline electrical grid by that same amount. For comparison purposes, the average residential electricity use on Oʻahu in 2011 was 7.3 megawatt-hours (DBEDT 2013).

5.4.2.1 Potential Impacts

5.4.2.1.1 Air Quality

Air quality impacts from the representative project would be minimal, short-term, and limited to the duration of the construction project. Because the PV system would be installed on a rooftop, construction-related impacts to air quality would not be extensive. Fugitive dust should not be generated during construction. Large construction equipment, such as earth-moving equipment, cranes, and trucks, would not be required.

5.4.2.1.2 Climate Change

A residential PV system could replace 8.8 megawatt-hours of annual residential electricity usage. A replacement of 8.8 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 580 gallons per residential unit. On O’ahu, the annual replacement of 8.8 megawatt-hours of electricity per residential unit would correspond with an annual reduction in greenhouse gas emissions of about 6.4 metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012). On other islands, for comparison, an annual replacement of 8.8 megawatt-hours of electricity usage would achieve an annual reduction in greenhouse gas emissions of about 5.4 metric tons carbon dioxide equivalent due to a different mix of technologies used to produce electricity on the other islands.

A commercial PV system would produce linearly scaled impacts to air quality. For example, the 50-kilowatt commercial PV system could reduce electricity use from the grid by ten times that of a 5-kilowatt system. The corresponding reduction in greenhouse gas emissions would be 10 times that of a 5-kilowatt system.

5.4.2.2 Best Management Practices and Mitigation Measures

None noted.

5.4.3 WATER RESOURCES

As indicated in Table 5-4, there would be no potential impacts to water resources, including surface water, groundwater, floodplains, and wetlands, from the representative distributed PV project.

5.4.4 BIOLOGICAL RESOURCES

As identified in Table 5-4, there would be no potential impacts to biological resources from the representative distributed PV project.

5.4.5 LAND AND SUBMERGED LAND USE

As identified in Table 5-4, there would be no potential impacts to land use from the representative distributed PV project.

5.4.6 CULTURAL AND HISTORIC RESOURCES

5.4.6.1 Potential Impacts

The representative 5-kilowatt PV system installed on a building or residence listed or eligible for listing on the HRHP or the NRHP, and/or is located in an historic district, could change the characteristics of the property such that the historic nature of the property would be altered. The alterations may have an adverse visual or architectural context impact to the historic property. When modifying historic buildings to retrofit for energy sustainability, the Department of the Interior provides standards and guidelines to help guide project proponents (DOI 2011). Additionally, PV system installation could affect residences and other buildings that not only qualify as historic properties, but also as cultural resources whose alterations may require coordination with the OHA’s Native Hawaiian Historic Preservation Council in accordance with applicable regulatory consultation requirements.

5.4.6.2 Best Management Practices and Mitigation Measures

Historic resources that are listed on the HRHP or NRHP, or are potentially eligible for inclusion in the NRHP, such as buildings, sites, and structures would be considered sensitive locations regarding possible modifications from PV installations and may require retrofit design approval in coordination with the Hawai‘i State Historic Preservation Department.

If an historic property or structure that is listed or eligible for listing on the HRHP and/or NRHP is proposed for a PV installation, in accordance with State law, the project proponent must complete and submit an Historic Preservation Review Form in compliance with HRS Chapter 6E so the modifications can be reviewed and approved prior to project implementation.

5.4.7 COASTAL ZONE MANAGEMENT

As identified in Table 5-4, there would be no potential impacts to coastal zone management resources from the representative distributed PV project.

5.4.8 SCENIC AND VISUAL RESOURCES

5.4.8.1 Potential Impacts

5.4.8.1.1 Scenic Resources

The representative distributed PV project, regardless of its capacity (i.e., 5 or 50 kilowatts), could impact scenic resources if the installation was in proximity to sites listed or eligible for listing in the HRHP or NRHP.

5.4.8.1.2 Visual Resources

Visual resources impacts during construction of the representative project would be from the installation of the PV modules on the rooftop of a residence or commercial unit. Such impacts would be short-term and intermittent.

Rooftop PV systems would result in long-term visual impacts from the PV modules and required infrastructure. The magnitude of potential visual impact of the PV systems would depend upon their visibility and the particular locations from where they are visible. However, because rooftop PV systems are common in Hawaiʻi, visual sensitivity to these systems is likely lower than in areas where they are not common. Some individuals consider PV modules as modernistic and a sign of progress toward renewable energy goals, while others feel they are an unnatural intrusion to the natural scenery and viewshed.

Visual impacts of a distributed PV system for a commercial facility could cause glaring that might be detected from a distance.

5.4.8.2 Best Management Practices and Mitigation Measures

The following best management practices should be used to reduce the identified potential impacts:

- Before installation, consider whether placement of PV system would change the historic character of an area.
- Carefully consider where the PV module would be placed on the residence. Use shrubbery to screen visual impacts from neighbors, while ensuring enough sunlight to enable the module to produce electricity.
- Coordinate with the FAA and HDOT, as appropriate, to address potential impacts to aircraft from PV module glare.
- Consider placement of PV system away from public or street views to minimize changes in viewsheds.

5.4.9 RECREATION RESOURCES

As indicated in Table 5-4, there would be no potential impacts to recreation resources from the representative distributed PV project.

5.4.10 LAND AND MARINE TRANSPORTATION

As indicated in Table 5-4, there would be no potential impacts to land or marine transportation from the representative distributed PV project.

5.4.11 AIRSPACE MANAGEMENT

As indicated in Table 5-4, there would be no potential impacts to airspace management from the representative distributed PV project.

5.4.12 NOISE AND VIBRATION

As indicated in Table 5-4, there would be no potential impacts to noise and vibration from the representative distributed PV project.

5.4.13 UTILITIES AND INFRASTRUCTURE

5.4.13.1 Potential Impacts

The potential impact on each island's electric utilities would be small from the addition of 5 kilowatts of PV cell generation to an individual household. The potential impacts for adding 50 kilowatts of PV cell generation to an single, existing industrial facility would also be small, as the facility would remain connected to the grid to use utility power to run the facility when the renewable source was not sufficient. Also, any excess power generated by the renewable source could be sold to the utility to balance the grid demand.

For O‘ahu, with the largest island net capacity of 1,756 megawatts, the 5-kilowatt addition would equate to about 0.0003 percent of its total capacity. For Lāna‘i and Moloka‘i, with the smallest net capacity of 10 and 12 megawatts, respectively, the addition would equate to about 0.05 and 0.04 percent of their respective total capacities (see Section 3.13.1). Increased capacity (i.e., the 50-kilowatt commercial application) would be a linear increase of renewable power generated and similar decrease in the electricity needed from the local utility.

Potential impacts from connection to utilities for construction and operation of the representative project would be the same as those expected for common construction actions described in Section 3.13.3.1.

While an individual residential or commercial PV system would not have significant impacts to the utilities and existing infrastructure, there are potential impacts to utilities and infrastructure from large-scale use of residential or commercial PV systems. According to HECO, "the unprecedented rapid growth in rooftop solar in Hawai‘i has resulted in some neighborhood circuits reaching extremely high levels of photovoltaic systems. An increasing number of distribution level circuits have rooftop PV capacity exceeding 100 percent of the daytime minimum load, the trigger for interconnection studies and possible implementation of safety measures or upgrades before new PV systems on that circuit can be interconnected to the grid. This condition slowed the pace of rooftop solar growth in the last quarter of [2013]" (HECO 2014). As noted in Section 3.13.1, interconnection policies are rapidly evolving and are subject to change as more variable renewable energy comes online. For example, in February 2014, HECO announced updates to the 100 percent of the daytime minimum load threshold policy to allow more PV projects to proceed without an interconnection requirements study.

As a result, while an individual, residential, or commercial PV system would not have significant impacts to the utilities and existing infrastructure, there are potential cumulative impacts to utilities and infrastructure from a much larger use of this technology. The utility companies are aware of the challenges that are associated with a higher percentage of variable power sources.

5.4.13.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to utilities, infrastructure, and public safety would be the same as those described in Section 3.13.3

5.4.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

5.4.14.1 Potential Impacts

5.4.14.1.1 Hazardous Materials

Potential impacts from exposure to hazardous material from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.14.4. No construction would be required for storage of energy in batteries.

The use of PV systems or battery storage systems would not require the use of hazardous materials and would not result in hazardous material releases or spills. As such, no impacts would occur during project operations.

Hazardous material exposure impacts may result at the end-of-life of the PV system and the battery energy storage system. Associated impacts are discussed below.

5.4.14.1.2 Waste Management

Potential impacts related to waste management from construction of the representative project would be the same as those expected for common construction actions as described in Section 3.14.4.

To the extent feasible, it is anticipated that most components of PV modules, such as glass, aluminum, and semiconductor materials, would be successfully recovered and reused either for new PV modules or other products. However, some PV systems may need to be managed and disposed of as hazardous waste. In particular, the manufacturing, decommissioning, and disposal of some PV modules (some thin film PV products) may involve cadmium. Cadmium is a heavy metal that is considered a probable carcinogen in humans and animals and can accumulate in plant and animal tissues. While cadmium does not pose health risks when a PV module is in operation, the production of some PV modules can result in waste sludge and cadmium contaminated wastewater which would need to be properly disposed of at the appropriate hazardous waste facility (see below).

5.4.14.1.3 Wastewater

As identified in Table 5-4, no impacts to wastewater services are expected from the installation and operation of PV systems.

Secondary impacts may result as the production of some PV modules can result in cadmium contaminated wastewater which would need to be properly disposed of at the appropriate hazardous waste facility. Although PV modules are not anticipated to be manufactured in the State, proper disposal of those PV modules at the appropriate hazardous waste facility would be required at its end-life, to ensure no leaching or contamination from cadmium occurs. As such, PV modules would require proper handling and transport of these materials for disposal at the appropriate hazardous material facility to ensure that hazardous substances do not leach or contaminate wastewater.

5.4.14.2 Best Management Practices and Mitigation Measures

As feasible, develop and implement a recycling plan including effectively recovering building materials that could contain potentially hazardous substances (e.g., liquid wastes, paints, oil, or solvents). This includes proper handling and transport for disposal at the appropriate hazardous material facility to ensure that no hazardous materials are disposed of at landfills and that no hazardous materials enter the waste stream.

Although PV modules are not anticipated to be manufactured in the State, proper disposal of some PV modules at the appropriate hazardous waste facility would be required at its end-life to ensure no leaching or contamination from cadmium. As such, PV modules would require proper handling and transport of these materials for disposal at the appropriate hazardous material facility to ensure no hazardous materials were disposed of at landfills and that hazardous materials did not enter the waste stream.

5.4.15 SOCIOECONOMICS

As indicated in Table 5-4, there would be no potential impacts to socioeconomics from the representative distributed PV project.

5.4.16 ENVIRONMENTAL JUSTICE

As identified in Table 5-4, there would be no environmental justice impacts from the representative distributed PV project.

5.4.17 HEALTH AND SAFETY

Potential impacts to health and safety from construction and operation of the representative distributed PV project would be the same as those expected for common construction actions.

5.5 Wind

The representative distributed wind project involves the construction and operation of a single 100-kilowatt wind turbine. It is further assumed that the turbine is a horizontal-axis unit, with a 60-foot rotor diameter (that is, it has blade lengths of about 30 feet), and is mounted on a 120-foot monopole. Details about these wind turbines can be found in Chapter 2, Section 2.3.2.5.

Table 5-5 presents a summary of the potential environmental impacts for distributed wind projects, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and best management practices and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 5-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General impacts during construction. See Section 3.1.3.	Same as those common across construction projects. See Section 3.1.4. Minimize the potential for loose soil or contaminants to leave the site by wind or stormwater runoff.
Climate and Air Quality		
Air Quality	General impacts during construction. See Section 3.2.4.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Beneficial; reduced oil consumption by use of renewable energy.	None.
Water Resources		
	General impacts during construction. See Section 3.1.3.	Same as those common across construction projects. See Section 3.1.4.
Biological Resources		
	General impacts during construction. See Section 3.4.5. Potential adverse impacts to the Hawaiian Hoary bat and a variety of bird species	During project siting, consideration should be given to the location of the wind turbine in relation to suitable bat roosting habitat and foraging areas (i.e., identify factors such as roost trees and foraging areas, proximity of bird habitats, and flight pathways for water birds, sea birds, and migratory species). Any lighting required on the wind turbine should be minimized to avoid attracting seabirds. During project design, early coordination with State and Federal wildlife agencies. To the extent feasible, the project should consider designing the wind turbine with rotor cutoff at low speeds.
Land and Submerged Land Use		
Land Use	Potential change in land use.	Consider State land use designations and county overlay zones.
Submerged Land Use	None; the wind turbine would be installed on land and would not impact the marine environment.	N/A

Table 5-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	General impacts during construction and operation. See Section 3.6.6. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	Same as those common across construction and operational projects. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to special management areas designated as a Coastal Zone Management Program, shorefront access, and shoreline erosion.	Specific project locations should be evaluated to determine if impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion would occur.
Scenic and Visual Resources		
	Short-term visual resource impacts during installation. Potential long-term visual impacts (site-specific). Potential impacts to natural scenic and visual resources, or historic character of an area. Potential lighting and shadow flicker impacts (site-specific).	During project design, consider the use of setbacks or vegetative buffers. Conduct computer modeling to determine if specific buildings near turbines would experience shadow flicker. Chose color of the wind turbine to best blend into the background and the sky (white is often more intrusive than a muted gray). Prohibit the use of commercial markings, messages, or banners on the turbine or tower. Work with park units within the viewshed of the turbine. Consider potential impacts on visual resources in the project planning and siting phase, for example, when siting structures, consider landscape characteristics, lighting and glare from facility components, minimizing structure profiles, views from key observation points and nearby recreation lands, and integration of project components with natural land contours and colors. Consider potential visual impacts on the nature and character of nearby culturally sensitive and historic structures.

Table 5-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Consider visual effects of project location and components on nearby units of the National Park System and other areas under NPS management, including effects of light pollution. Consider visual effects of project components on local infrastructure facilities such as schools, hospitals, and housing developments in urban and rural communities. Consider the importance of dark night skies in the short term during construction and in the long term. Use low lumen lighting, on demand lighting, and well-directed lighting. Use the minimum amount of light necessary; select lamps using long-wavelength light [greater than 560 nm (in vacuum)]. Limit the hours of construction at night, limit total lumen output of artificial lighting, and direct lighting downward and shield fixtures to reduce impacts from construction lighting. Provide accurate day and night visual simulations of the proposed project to local community and regulatory stakeholders (e.g., neighborhood boards) to adequately inform the community of what can be expected.
Recreation Resources		
	Potential visual impacts to recreation resources (e.g., scenic lookouts and views).	See BMPs for Scenic and Visual Resources.
Land and Marine Transportation		
	None; construction and operation of a small wind turbine would not impact land and marine transportation.	N/A
Airspace Management		
	Potential impacts on airspace including military training airspace (site-specific).	Prior to site selection, consultation with the FAA and DoD to identify special use airspace.

Table 5-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	Minimal noise and vibration impacts during construction. Potential long-term noise and vibration impacts (site-specific)	A noise study should be conducted prior to turbine installation to develop expectations regarding operational noise levels. A separation distance of a minimum of 1,000 feet is recommended. Use turbines designed with soundproofing techniques.
Utilities and Infrastructure		
	Minor impacts to electricity generating capacities. General impacts during construction and operation. See Section 3.13.3.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General construction exposure impacts. See Section 3.14.4. Potential for hazardous material exposure resulting from handling and disposal of batteries (project-specific).	Ensure proper handling and disposal of battery systems.
Waste Management	General construction impacts. See Section 3.14.4. Potential waste management impacts from toxic and hazardous waste contamination during disposal of batteries at their end-life (project specific)	Same as those common across construction projects. See Section 3.14.5. Ensure proper disposal of hazardous materials at end-of-life.
Wastewater	General construction and operation impacts. See Section 3.14.4.	None.
Socioeconomics		
	None; construction and operation of a small wind turbine would result in few jobs and would not impact socioeconomics.	N/A
Environmental Justice		
	None; since there would be no measurable impacts to the human environment, there would be no environmental justice impacts.	N/A
Health and Safety		
	General impacts during construction and operation.	None.

5.5.1 GEOLOGY AND SOILS

5.5.1.1 Potential Impacts

Potential impacts on geology and soils from construction and operation of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.1.3.

Although the foundation for a 100-kilowatt wind turbine is still a substantial structure, it is reasonable to assume it would require less than 1 acre of land disturbance. The wind turbine foundation would be expected to have a footprint size similar to, or smaller than, a single car garage and whether the foundation involved excavation/boring or pile driving, disturbances would not require an acre, particularly since the representative project does not assume an access road would be needed. Similarly, land disturbance for installation of two or three poles for 300 feet of power lines would be minor.

Further, because land disturbance would be expected to be less than an acre, construction of the turbine would not require a stormwater discharge permit (construction actions that will disturb one acre or more are required to obtain such a permit as described in Section 3.1.3). Without the discharge permit requirement, there may be fewer precautions taken during construction to ensure loosened soil was not carried off by wind or stormwater run-off. There may also be fewer assurances that the construction crew would pay particular attention to drips or leaks from their equipment or have materials and procedures in place for dealing with drips, leaks, or spills, should they occur. However, the relatively small amount of land disturbance and project scale would tend to minimize the potential for serious adverse impacts. Furthermore, the scope of the foundation work would require skilled workers, most likely working under procedures to minimize the potential for any loose soil or contaminants to leave the site by wind or stormwater runoff.

5.5.1.2 Best Management Practices and Mitigation Measures

The following mitigation measures should be followed to reduce the identified potential impacts:

- Work should be performed to mitigate drips or leaks from equipment and procedures followed for dealing with drips, leaks, and spills.
- Due diligence should be taken to ensure loosened soil was not carried off by wind or stormwater run-off.

5.5.2 CLIMATE AND AIR QUALITY

5.5.2.1 Potential Impacts

Wind turbines convert the kinetic energy of the wind to mechanical power. A representative 100-kilowatt wind turbine could have a capacity factor between 45 and 65 percent depending on site-specific conditions (DBEDT 2013). The representative wind turbine could replace electricity requirements from the baseline electrical grid by between 390 and 570 megawatt-hours per year when using those capacity factors as minimum and maximum values.

5.5.2.1.1 Air Quality

Potential impacts on air quality from construction and operation of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.2.4.

5.5.2.1.2 Climate Change

A replacement of between 390 and 570 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by between 26,000 and 38,000 gallons (assuming 66.7 gallons of fuel oil per megawatt-hour of electricity). On Oʻahu, this annual replacement of electricity from the baseline grid would correspond to an annual reduction in greenhouse gas emissions of between 290 and 410 metric tons carbon dioxide equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012). On other islands, by comparison, this same annual replacement of electricity usage would see an annual reduction in greenhouse gas emissions of between 240 and 350 metric tons carbon dioxide equivalent due to a different mix of technologies used to produce electricity.

5.5.2.2 Best Management Practices and Mitigation Measures

None noted.

5.5.3 WATER RESOURCES

As identified in Table 5-5, there would be no potential impacts to water resources, including surface water, groundwater, floodplains, and wetlands, from the representative distributed wind project.

5.5.4 BIOLOGICAL RESOURCES

5.5.4.1 Potential Impacts

The representative distributed wind project would require approximately 1 acre of land, most of which could be revegetated with low stature plants following construction. In addition to the common construction-related impacts discussed in Section 3.4.5.1, the wind turbine impacts would include potential mortality of the Federally listed Hawaiian hoary bat and a variety of bird species from collisions with the turbine blades. Depending on the specific project locations, these could include Federally or State-listed species. Specific islands also may have higher potential for impacts (e.g., Kauaʻi and Hawaiʻi) because of larger populations of bats. Similar mortality impacts could occur to bird species depending on the location of the wind turbine and surrounding habitats. Locations near wetlands or the coast could impact greater numbers of water birds, shorebirds, and migratory birds. Marine birds are far ranging and fly between terrestrial nesting sites and offshore foraging areas and may be vulnerable depending on the project location. Even though a single distributed wind turbine has a smaller rotor swept area than larger utility-scale wind turbines, a key factor in the probability of mortality is location and position of the wind turbine within the landscape and the surrounding habitat. The number and types of potentially affected species will be heavily dependent on the specific project siting.

5.5.4.2 Best Management Practices and Mitigation Measures

The following mitigation measures should be taken to reduce the identified potential impacts:

- Consider the location of the wind turbine in relation to suitable bat roosting habitat and foraging areas.
- Minimize any lighting required on the wind turbine to avoid attracting seabirds.
- During site selection, identify factors such as proximity of bat roost trees and foraging areas, proximity of bird habitats (e.g., forests, wetlands, nesting colonies), and flight pathways for water birds, sea birds, and migratory species when evaluating potential impacts. Coordinate with State and Federal wildlife agencies early in the project design process to assist in identifying these factors at the landscape level.
- Design the wind turbine with rotor cutoff at low speeds to help mitigate potential mortality impacts.

5.5.5 LAND AND SUBMERGED LAND USE

5.5.5.1 Potential Impacts

Siting of distributed wind turbines requires sufficient average wind speed and frequency to allow the turbine to operate efficiently. There should be no land obstacles with 300 feet of the tower. There would be temporary land disturbance due to site preparation and turbine installation. Depending upon the site, land could be converted from an undeveloped State or other land uses to energy uses.

5.5.5.2 Best Management Practices and Mitigation Measures

During site selection, evaluate the State land use designations and county overlay zones.

5.5.6 CULTURAL AND HISTORIC RESOURCES

5.5.6.1 Potential Impacts

Potential impacts on cultural and historic resources from construction and operation of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.6.6. Of particular importance in Hawai‘i is the potential visual impact of wind turbines that might be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.

5.5.6.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to cultural and historic resources would be the same as those common across construction projects. See Section 3.6.7.

5.5.7 COASTAL ZONE MANAGEMENT

5.5.7.1 Potential Impacts

Impacts to the coastal zone from the representative distributed wind project could involve impacts to special management areas and shorefront access. Because the entire State of Hawai‘i is considered part of the coastal zone, a Federal consistency review may be required (see Section 3.7.4).

5.5.7.2 Best Management Practices and Mitigation Measures

Specific project locations would require evaluation to determine if impacts to special management areas designated under the State Coastal Zone Management Program, shorefront access, and shoreline erosion would occur.

5.5.8 SCENIC AND VISUAL RESOURCES

5.5.8.1 Potential Impacts

Potential impacts on scenic and visual resources from construction of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.8.3.

Operation of the wind turbine would introduce a 150-foot-tall structure into the viewshed of the area. Small turbines are designed to blend in with their surroundings as much as possible. Studies show that turbines best blend into the sky when painted the factory-default color (AWEA 2008). Wind turbines vary in color, depending on the manufacturer, and can include white, gray, blue, and yellow. Turbines that begin a bright silver color soon weather to a muted gray, which helps the turbine blend in with the background or against the sky.

The visual impact of a wind turbine depends, to some extent, on the sensitivity of the viewer. Some individuals consider the aerodynamic design of the turbines graceful and modernistic, while others feel they are an unnatural intrusion to the natural scenery and viewshed. Utility poles, cellular phone towers, and satellite dishes might be considered comparable features of the existing landscape. Shadow flicker occurs when the blades of a turbine pass in front of the sun to create a recurring shadow on an object. Computer models in wind development software can determine the days and times during the year that buildings near turbines may experience shadow flicker (AWEA 2010).

Because of the strobe-like effect of shadow flicker, there have been investigations into whether it might have the potential to produce epileptic seizures in individuals with photosensitivity. It has been determined that modern utility-scale wind turbines do not have the potential to cause these types of problems because of their relatively slow blade rotation. One study (Harding et al. 2008) reported that flickers with a frequency greater than 3 hertz could pose a potential for inducing photosensitive seizures (that is, a light flashing at a rate of more than 3 times per second). The Epilepsy Foundation of America reports that lights flashing in the range of 5 to 30 hertz are most likely to trigger seizures and recommends that flash rates of visual alarms be kept under 2 hertz (Epilepsy Foundation of America 2013). A wind turbine with three blades would have to make a full revolution every second (or 60 revolutions per minute) to reach a frequency of 3 hertz. Any specific wind turbine would be evaluated for flicker frequencies depending on its configuration, rotational speed, and orientation relative to the sun.

Some data suggest that shadow flicker has the potential to cause a disorienting effect on a small segment of the population. The data also suggest that rotor rotation below 2.5 hertz can avoid such effects (BLM 2005).

5.5.8.2 Best Management Practices and Mitigation Measures

The visual impact of wind turbines may be unacceptable in areas with historic significance where aesthetics play an important role in an area’s long-established character. Shadow flicker also can be more than just an irritant to some sensitive segments of the population. Areas of shadow flicker should be minimized or avoided for sensitive locations such as residences, schools, and hospitals.

The following mitigation measures may reduce the identified impacts:

- Consider setbacks or vegetative buffers to avoid shadow flicker. A setback is a distance from a property line within which a turbine cannot be located. Computer modeling can determine if specific buildings near turbines would experience shadow flicker and this information can assist in determining appropriate mitigation measures (AWEA 2010).

- Use a color for the turbine that blends into the background and the sky. White is often more intrusive than a muted gray.

- Prohibit the use of commercial markings, messages, or banners on the turbine or tower.

- Consult any park units within the viewshed of a wind turbine early in the planning process.

- Consider potential impacts on visual resources in the project planning and siting phase, for example, when siting structures, consider landscape characteristics, lighting and glare from facility components, minimizing structure profiles, views from key observation points and nearby recreation lands, and integration of project components with natural land contours and colors.

- Consider potential visual impacts on the nature and character of nearby culturally sensitive and historic structures.

- Consider visual effects of project location and components on nearby units of the National Park System and other areas under NPS management, including effects of light pollution.

- Consider visual effects of project components on local infrastructure facilities such as schools, hospitals, and housing developments in urban and rural communities.

- Consider the importance of dark night skies in the short term during construction and in the long term. Use low lumen lighting, on demand lighting, and well-directed lighting. Use the minimum amount of light necessary; select lamps using long-wavelength light [greater than 560 nm (in vacuum)].

- Limit the hours of construction at night, limit total lumen output of artificial lighting, direct lighting downward, and shield fixtures to reduce impacts from construction lighting.

- Provide accurate day and night visual simulations of the proposed project to local community and regulatory stakeholders (e.g., neighborhood boards) to adequately inform the community of what can be expected.

5.5.9 RECREATION RESOURCES

5.5.9.1 Potential Impacts

The representative distributed wind project could cause an adverse impact to recreation resources if incompatible with the recreational activity, for example, visiting a scenic lookout, hang-gliding, off-road racing, and bird-watching. Some individuals may feel the wind turbine is an unnatural intrusion to the natural scenery, which could adversely affect their recreational experience. Others may find the wind turbine an interesting landmark and a destination for recreation activities, such as picnicking and hiking.

5.5.9.2 Best Management Practices and Mitigation Measures

The visual impact of wind turbines may be unacceptable near recreation areas where aesthetics play an important role in the value of the recreation resource. Consider the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) before siting the turbine to mitigate potential impacts.

5.5.10 LAND AND MARINE TRANSPORTATION

As identified in Table 5-5, there would be no potential impacts to land or marine transportation from the representative distributed wind project.

5.5.11 AIRSPACE MANAGEMENT

5.5.11.1 Potential Impacts

The representative distributed wind project could impact airspace depending on the specific location of the project. Although the height of the turbine (approximately 150 feet) is not considered an FAA obstruction and subject to navigation review, the project may require a Notice of Proposed Construction or Alteration of Airspace depending on the location in relation to airports and defined airspace. Structures that penetrate imaginary surfaces extending outward from runways as defined in FAA regulations require review and evaluation for impacts to airspace. In addition, various special use airspaces for military training could potentially be impacted depending project location.

5.5.11.2 Best Management Practices

Prior to site selection, consult with the FAA and DoD to identify various special use airspace.

5.5.12 NOISE AND VIBRATION

5.5.12.1 Potential Impacts

Potential noise and vibration impacts from construction of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.12.5.

Wind turbines operate when wind conditions are favorable, day or night. Wind turbines generate both aerodynamic sounds (generated by the blades passing through the air) and mechanical noise (generated from the turbine’s internal gears). The mechanical noise generated from small wind turbines, such as the representative project, is minimal. Depending on the wind turbine design and wind speed, the aerodynamic noise produces a repetitive sound that may seem like a buzzing, whooshing, or pulsing. Wind turbine noise is present at all frequencies, which includes infrasound (low frequency sound inaudible to the human ear), frequencies in the audible range for humans, and high frequencies. Infrasound is inaudible to the human ear, but this unheard sound can cause human annoyance, sensitivity, disturbance, and disorientation, and the effects on birds, bats, and other wildlife may be more profound (USFWS 2011). Frequency varies with wind speed, blade pitch, and blade speed, and wind turbines can have different acoustics on different days even at the same wind speed (NREL 2012). Additionally, the noise the human ear can detect from a wind turbine is dependent on background noise levels. Noise would be more audible at lower levels in rural areas compared to urban areas.

Operational noise levels produced by a representative distributed wind turbine project would be 55 dBA at a distance of 130 feet. Continuous and long-term noise levels in excess of 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals (see section 3.12). Long-term noise and vibration impacts could be potentially significant and would depend on the location of the wind turbine and compatibility with the existing land uses.

5.5.12.2 Best Management Practices and Mitigation Measures

Noise and vibration impacts should be considered when siting a distributed wind turbine. Noise and vibration best management practices and mitigation measures are a much bigger consideration for a proposed distributed wind turbine in a residential setting compared to one in a commercial setting. Developers must comply with Federal, State, and local noise regulations and ordinances. Because small wind turbines would be located close to people, homeowners and local authorities could use available noise data or perform a noise study to develop expectations regarding operational noise levels before a wind turbine is installed. Although there are no county or State requirements, an appropriate separation distance is recommended (such as at least three times the height of the turbine). Manufacturers may also mitigate noise levels through the use of noise reduction materials and soundproofing techniques when designing wind turbines.

5.5.13 UTILITIES AND INFRASTRUCTURE

5.5.13.1 Potential Impacts

The potential impact on each island's electric utilities would be small to moderate from the addition of 100 kilowatts of wind project on any island. The existing household or industrial facility would remain connected to the grid to use utility power to run the facility when the renewable source was not sufficient. Also, any excess power generated by the renewable source could be sold to the utility.

For Oʻahu, with largest island net capacity of 1,756 megawatts, the 100-kilowatt addition would equate to about 0.006 percent of its total capacity. For Lānaʻi and Molokaʻi, with the smallest net capacity of 10 and 12 megawatts, respectively, the addition would equate to about 1.0 to 0.8 percent of their respective total capacities (see Section 3.13.1).

Potential impacts from connection to utilities for construction and operation of this representative project would be the same as expected for common construction actions described in Section 3.13.3.1.

5.5.13.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts to utilities, infrastructure, and public safety would be the same as those common across construction projects. See Section 3.13.4.

5.5.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

5.5.14.1 Potential Impacts

5.5.14.1.1 Hazardous Materials

The representative distributed wind project could produce hazardous waste that could result in hazardous material exposure impacts in the event a battery was used for energy storage. Battery impacts would be similar to those discussed in Section 8.5.14. Please refer to Section 8.5.14 for additional discussion.

5.5.14.1.2 Waste Management

Potential impacts could occur from toxic and hazardous waste contamination during disposal of batteries at their end-life.

5.5.14.1.3 Wastewater

Potential wastewater impacts from construction and operation of the representative 100-kilowatt wind turbine would be the same as those expected for common construction actions as described in Section 3.14.3.

5.5.14.2 Best Management Practices and Mitigation Measures

General best management practices to minimize impacts associated with hazardous materials and waste management would be the same as those common across construction projects. See Section 3.14.4.

The following mitigation measures should be taken to prevent battery fires:

- Use insulation boards between blocks in battery module to prevent leaking molten materials from causing a short circuit,
- Use anti-fire boards between battery modules to prevent fires from spreading,
- Implement a monitoring system, the installation of fire prevention equipment and a fire-fighting structure for fire preparedness and safety, as well as a fire evacuation and guidance plan.

5.5.15 SOCIOECONOMICS

As identified in Table 5-5, there would be no potential impacts to socioeconomics from the representative distributed wind project.

5.5.16 ENVIRONMENTAL JUSTICE

As identified in Table 5-5, there would be no environmental justice impacts from the representative distributed wind project.

5.5.17 PUBLIC HEALTH AND SAFETY

Potential impacts to health and safety from construction and operation of the representative distributed wind project would be the same as those expected for common construction actions.

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CHAPTER 6

Environmental Impacts from Utility-Scale Renewables

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LIST OF TABLES

6 ENVIRONMENTAL IMPACTS FROM UTILITY-SCALE RENEWABLES

This chapter presents the potential environmental impacts that could be expected for activities that are associated with utility-scale renewable energy technologies. These activities and technologies were presented in Chapter 2, Section 2.3.3. For each technology evaluated in this chapter, there is a representative project that aids the PEIS in presenting and characterizing the potential environmental impacts. These representative projects are described in detail in Section 2.3.3 and are summarized again here for each technology.

The representative projects were developed to assess the potential impacts (benefit and detriment) of utility-scale renewable energy technology options. In general, for each of the technologies in this section, a standard-sized representative project was identified as one that would generate 5 megawatt of electricity, unless there was a valid reason (feasibility) for a particular technology be a different size. This would allow for comparison of the relative level of environmental impacts across the utility-scale technologies. The description of each technology within Section 2.3.3 includes a discussion of the differences between nameplate capacity and actual capacity based on efficiency and the range of typical capacity factors for that technology. The potential impacts are presented for each environmental resource area. As was described in Chapter 3, many of the activities and technologies could result in environmental impacts that would be common of typical construction projects and may not be unique to the specific activity or technology. In these cases, the presentation of potential impacts in this chapter refers the reader to the appropriate section in Chapter 3 that presents these common impacts for that resource area. Therefore, the details in this chapter deal primarily with those impacts that would be unique to the specific activity or technology being evaluated. Chapter 6 discusses how the impacts would scale (for example, linearly, exponentially, or not at all) for the range of potential technology applications to aid the reader in understanding the effects of smaller or larger projects and how impacts could change based on the size of the technology implemented.

Each of the sections below includes a summary table of the potential environmental impacts and best management practices (BMPs) for that technology. Not all technologies have the potential to impact all environmental resource areas analyzed in this document. Therefore, the summary table for each technology also identifies and screens those resource areas that are not expected to be impacted by that technology. This approach is consistent with DOE's sliding scale approach to the preparation of NEPA analyses.

6.1 Biomass

The biomass technology is a diverse technology with a wide range of applications; therefore this PEIS identifies two representative projects to provide a better perspective of potential impacts. They include the construction and operation of a 10-megawatt-capacity direct combustion power plant and a 10-megawatt-capacity electrical power plant fueled with biodiesel (see Section 2.3.3.1.4). The direct combustion biomass steam generating station (power plant) would use a fibrous biomass source such as sugar cane, banagrass, or wood from dedicated crops or forests to fire steam boilers. Local sources (i.e., typically less than 10 miles from the generating site) would be assumed to supply the biomass feedstock to minimize transportation costs. The biodiesel-fueled power plant would use biodiesel produced from biomass oil crops to fire steam boilers to generate electricity. The PEIS assumed that the biomass used in utility-scale energy applications would be produced by dedicated energy crops. Therefore, the impacts of the biomass production are considered part of the energy technology. Depending on specific, future projects, it would be possible that utility-scale biomass energy development could include interisland transport of feedstock; however, this PEIS does not evaluate that scenario.

Table 6-1 and Table 6-2 present a summary of the potential environmental impacts for biomass energy projects for a direct combustion power plant and a biodiesel power plant, respectively, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts. See Section 3.1.3. Potential soil erosion and degradation from agricultural activities.	Same as those common across construction projects. See Section 3.1.4. In accordance with applicable building codes, the facility design and construction should incorporate seismic provisions appropriate for the project location.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4 Potential increase in criteria pollutant emissions (including nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) during combustion. Potential increase in criteria pollutant emissions (including carbon dioxide) from biomass production (equipment, fertilizer/pesticide application, harvest, and transport).	Same as those common across construction projects. See Section 3.2.5. Projects should use a boiler system designed to achieve high combustion and boiler efficiency and that can operate close to design capacity. Apply control technologies to reduce emissions during project operations (i.e., dust collectors to reduce particulate matter emissions).
Climate Change	Potential impacts from increased biogenic carbon dioxide emissions and increased greenhouse gas. Decreased greenhouse gas emissions from electricity production.	Apply control technologies to reduce emissions during project operations.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Water	General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff. Increased water demand for crop irrigation (ex: sugar cane crop – more water/acre). Potential adverse impacts from runoff contamination associated with fertilizer/pesticide applications.	Same as those common across construction projects. See Section 3.3.6. Fertilizer/pesticide applications should be used appropriately, be approved or licensed for the intended use, and must be handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.
Groundwater	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/pesticide applications via runoff or local recharge.	Same as those common across construction projects. See Section 3.3.6. Fertilizer/pesticide applications should be used appropriately, be approved or licensed for the intended use, and must be handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.
Floodplains and Wetlands	Potential for general construction impacts. See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6.
Biological Resources		
	Potential for general construction impacts. See Section 3.4.5. Potential impacts to vegetation or wildlife (including to the wide-ranging Hawaiian hawk and the Hawaiian hoary bat) species (site-specific). Potential beneficial impacts – may create a market for selective harvesting of invasive woody species, such as albizia trees. Potential impacts from the introduction of new, invasive plant species. Potential impacts associated with use of genetically modified plants	Same as those common across construction projects. See Section 3.4.6. Biomass production sites in proximity to areas with critical habitat and other high value habitats such as wetlands, areas of native vegetation, and protected land areas would need evaluation to ensure that potential impacts to wildlife or protected plant species are minimized or avoided. Screening new plant species for invasive characteristics, conducting field trials prior to commercial production, developing monitoring programs, and designing controls measures, if needed, would be ways to avoid the potential impacts of introduced species.
Land and Submerged Land Use		
Land Use	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential conversion of undeveloped land or land under current land uses.	Consider State designated land uses and county overlay zones.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Submerged Land Use	None.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to special management areas (CZMPs), shorefront access, and shoreline erosion (site-specific) through water runoff and sedimentation.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	Short-term visual impacts during construction. See Section 3.8.3. Long-term visual impacts from introduction of a new facility. Potential impacts from harvest of biomass. Potential visual impacts from truck traffic during delivery.	Same as those common across construction projects. See Section 3.8.4. Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawaiʻi and one on Kauaʻi); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a power generating plant. Consideration should be given to general land use plans and associated implementation tools such as zoning ordinances and development standards to protect and maintain open space and scenic resources, consistent with the State's land use designations.
Recreation Resources		
	General short-term construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	Same as those common across construction projects. See Section 3.9.5. During site selection, consideration should be given to sensitive locations such as the recreation areas listed in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009). During site selection, additional consideration should also be given to each island's general land use plans and associated implementation tools such as zoning ordinances and development standards.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance	Deliveries could be scheduled to avoid peak traffic hours to minimize potential impacts. Using covered trucks would prevent potential hazards of dust and feedstock from falling or blowing onto roadways during transport.
Marine Transportation	None; it is unlikely that bulk biomass would be shipped between islands.	N/A
Airspace Management		
	Potential hazards to aircrafts from emission stacks for those project locations nearby airports.	Project locations near airports would require evaluation to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.
Noise and Vibration		
	Short-term noise and vibration construction impacts. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses Noise impacts from truck traffic delivery (site-specific).	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
Utilities	Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/management of power grids and overall power production.	Same as those common across construction projects. See Section 3.13.4.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Hazardous Materials and Waste Management		
Hazardous Materials	Potential hazardous materials exposure impacts from contaminated sites during construction. Potential exposure to high quantities of fertilizers (primarily nitrogen), herbicides, and pesticides.	Same as those common across construction projects. See Section 3.14.5 Fertilizers, herbicides, and pesticides must be handled, stored, and disposed of in accordance with Federal, State, and county laws and regulations to ensure that hazardous materials are not released into the environment. In the event a spill or release occurs, appropriate safety precautionary measures should be taken including following procedures outlined in safety response plans, EPA materials data and safety sheets, OSHA requirements, and notifying the appropriate authorities including the State DOH and first responders (as necessary).
Waste Management	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5
Wastewater	General construction impacts. See Section 3.14.4. Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during blowdown from the steam cycle and cooling system.	Same as those common across construction projects. See Section 3.14.5 As necessary, treatment using settling ponds or filtration systems could be required in order to meet NPDES wastewater discharge permit requirements.
Socioeconomics		
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	None.
Environmental Justice		
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

Table 6-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Direct Combustion Biomass-Fueled Steam Turbine Generating Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Health and Safety		
	General construction and operation impacts. See Section 3.17.3. Construction and operation of a utility-scale biomass facility would not introduce any unique public health hazards and therefore would not result in any environmental impacts to public health and safety. General construction and operation impacts to public safety services. See Section 3.13.3.1. Construction and operation of a utility-scale biomass facility would not introduce any unique accident scenarios and therefore would not result in any environmental impacts from accidents or intentional destructive acts.	Same as those common across construction projects. See Section 3.17.5

Table 6-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Biodiesel Plant and Electric Power Plant Project)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts. See Section 3.1.3. Potential soil erosion and degradation from agricultural activities.	Same as those common across construction projects. See Section 3.1.4
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Additional criteria pollutant emissions during construction of the biodiesel plant. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxides, and sulfur dioxide, as well as carbon dioxide) from combustion. Increased criteria pollutant emissions (including carbon dioxide) emissions from biomass production.	Apply control technologies to reduce emissions during project operations (i.e., dust collectors to reduce particulate matter emissions).
Climate Change	Potential increase in carbon dioxide emissions would result in increased greenhouse gas. Decreased greenhouse gas from electricity production.	Apply control technologies to reduce emissions during project operations.
Water Resources		
Surface Waters	General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff. Increased water supply demand for crop irrigation. Potential adverse impacts from runoff contamination associated with fertilizer/pesticide applications.	Same as those common across construction projects. See Section 3.3.6. Fertilizer/pesticide applications should be used appropriately, be approved or licensed for the intended use and must be handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

Table 6-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Biodiesel Plant and Electric Power Plant Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Groundwater	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential for groundwater contamination from fertilizer/pesticide applications via runoff or local recharge.	Same as those common across construction projects. See Section 3.3.6. Fertilizer/pesticide applications should be used appropriately, be approved or licensed for the intended use, and must be handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.
Floodplains and Wetlands	Potential for general construction impacts. See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6.
Biological Resources		
	General construction impacts. See Section 3.4.5. Potential for loss of wildlife habitat. Potential impacts from the introduction of new, invasive plant species from commercial feedstock production. Potential impacts associated with use of genetically modified plants (GMO's).	Same as those common across construction projects. See Section 3.4.6. Use land with lower wildlife value (e.g., former abandoned agricultural land). Locate production sites farther from high value native vegetation communities. Screening new plant species for invasive characteristics, conducting field trials prior to commercial production, developing monitoring programs, and designing controls measures, if needed, would be ways to avoid the potential impacts of introduced species.
Land and Submerged Land Use		
Land Use	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Undeveloped land or land under current land uses could be converted to energy uses.	Consider State designated land uses and county overlay zones.
Submerged Land Use	None.	N/A

Table 6-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Biodiesel Plant and Electric Power Plant Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to special management areas (CZMPs), shorefront access, and shoreline erosion through water runoff and sedimentation (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	Short-term visual impacts during construction. See Section 3.8.3 Long-term visual impacts from introduction of a new facility. Potential impacts during crop harvest. Potential visual impacts from truck traffic delivery.	Same as those common across construction projects. See Section 3.8.4 Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a power generating plant. Consideration should be given to general land use plans and associated implementation tools such as zoning ordinances and development standards to protect and maintain open space and scenic resources, consistent with the State’s land use designations.
Recreation Resources		
	General short-term construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual and noise effects. Potential recreational resource impacts from truck traffic.	Same as those common across construction projects. See Section 3.9.5. During site selection, consideration should be given to sensitive locations such as the recreation areas listed in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009). During site selection, additional consideration should also be given to each island’s general land use plans and associated implementation tools such as zoning ordinances and development standards.

Table 6-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Biodiesel Plant and Electric Power Plant Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	Potential increase in truck traffic for biomass delivery. Potential increased wear on paved roads and road maintenance	Deliveries could be scheduled to avoid peak traffic hours to minimize potential impacts. Using covered trucks would prevent potential hazards of dust and feedstock from falling or blowing onto roadways during transport.
Marine Transportation	None; it is unlikely that bulk biomass would be shipped between islands.	N/A
Airspace Management		
	Minimal potential hazards to aircrafts from emission stacks for those project locations nearby airports.	Project locations near airports would require evaluation to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.
Noise and Vibration		
	Short-term noise and vibration construction impacts. Long-term noise and vibration operational impacts (site-specific). Noise impacts from truck traffic delivery (site-specific).	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
	General construction and operational impacts. See Section 3.13.3.1. Varying impacts to utilities (site/island-specific i.e., small effects to Oʻahu, large effects to Lānaʻi), requiring potential adjustment/management of power grids and overall power production.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential hazardous materials exposure impacts from contaminated sites during construction. Potential exposure to high quantities of fertilizers, herbicides, and pesticides. Potential hazardous materials exposure impacts from biodiesel leaks or accidents.	Prior to construction, the proposed project location would be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at the project site. In the event that the project location is sited at one of these sites, site remediation would be recommended prior to project development.

Table 6-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Biomass (Biodiesel Plant and Electric Power Plant Project) (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Fertilizers, herbicides, and pesticides must be handled, stored, and disposed of in accordance with Federal, State, and county laws and regulations to ensure that hazardous materials are not released into the environment. In the event a spill or release occurs, appropriate safety precautionary measures should be taken including following procedures outlined in safety response plans, EPA materials data and safety sheets, OSHA requirements, and notifying the appropriate authorities including the State DOH and first responders (as necessary). Prior to project approval, ensure all project operations are compliant with regulatory requirements related to standards of performance for equipment leaks.
Waste Management	None.	N/A
Wastewater	Potential impacts to wastewater services from trace amounts of chemicals and elevated temperatures during the blowdown from the steam cycle and cooling system.	As necessary, treatment using settling ponds or filtration systems could be required in order to meet NPDES wastewater discharge permit requirements.
Socioeconomics		
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	None.
Environmental Justice		
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3.	Same as those common across construction projects. See Section 3.17.5

6.1.1 GEOLOGY AND SOILS

6.1.1.1 Potential Impacts

Potential impacts on geology and soils from construction of a 10-megawatt biomass plant, of either type (direct combustion or biodiesel), would be the same as those expected for common construction actions as described in Section 3.1.3. Construction of either project would involve disturbance of 6 to 8 acres of land, so the permitting requirements described in Section 3.1.3 would be fully applicable.

Operation of either power plant facility (i.e., a direct combustion biomass fueled steam turbine generator project or a biodiesel plant and electric power project) would not involve activities that would have the potential to affect geology and soils of the area. In accordance with applicable building codes, the facility's design and construction would have required incorporation of seismic provisions appropriate for the project location. As a result, the potential risk of the facility being adversely impacted by the site's geology, from earthquakes, would be at an acceptably low level.

Other operations associated with this technology that could impact geology and soils are the agricultural activities that would be needed to support the biomass power plants. The amount of land needed to support a 10-megawatt direct combustion power plant is estimated at 3,340 acres if all the biomass came from dedicated sugar cane to 5,100 acres if it came from dedicated forest growth. Oil crop acreage required to support a 10-megawatt biodiesel power plant is estimated at 14,000 to 27,000 acres depending on whether precipitation or irrigation allowed two crops per year. Agricultural activities, whether on land already being used for that purpose or on land transitioned from some other use, are associated with soil erosion and degradation impacts. The natural process of erosion by moving water or wind is increased by plowing and the associated periods of no or minimal vegetation covering the ground. Continued agricultural action on the same site also results in soil breakdown and loss of nutrients. Fertilizers and, in some cases, conditioners are added to the soil to help lessen these effects, and pesticides are added to control unwanted vegetation or insects. These soil additives represent potential soil contaminants if they are carried with eroded soils to other locations, particularly to surface waters (Section 6.1.3). Agricultural practices have evolved over time to minimize adverse impacts associated with soil erosion and degradation, but the impacts have not been eliminated.

Construction of a power plant facility larger than the representative 10 MW, of either type, would involve the same types of potential soil erosion concerns as the representative project, but because more land would be disturbed, the amount of erosion that could occur would likely be proportionately greater. Similarly, a larger construction project would involve the same type of potential soil contaminants, but because of more construction equipment and a longer construction period, the probability of a leak or release of fuel or lubricants occurring might also be proportionately greater. The normal precautions and controls implemented during construction (Sections 3.1.3 and 3.1.4) would still appropriately reduce potential for soil erosion or contamination.

Operation of a larger biomass-based power plant would not involve activities that would have the potential to affect geology and soils of the area. However, the larger facility would require a proportionately larger agricultural operation to produce the larger amount of biomass for fuel or biodiesel production. The larger agricultural operation would involve a similar potential for soil, with or without contamination (with fertilizer and pesticides), to erode and leave the site, but with the larger operation it can be assumed that the amount of soil without vegetation cover and more susceptible to erosion would be greater at any given time.

6.1.1.2 Best Management Practices and Mitigation Measures

As discussed above, normal precautionary and control measures should be implemented during construction (Sections 3.1.3 and 3.1.4).

6.1.2 CLIMATE AND AIR QUALITY

6.1.2.1 Potential Impacts

6.1.2.1.1 Air Quality

Direct Combustion Biomass-Fueled Steam Turbine Generator

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

The burning of biomass at a biomass energy project would emit the criteria pollutants of nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide as well as carbon dioxide. The total amount of emissions would vary depending on the amount of material burned and its heating value. According to the EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) Section 1.6, "Wood Residue Combustion in Boilers," the emission factors for nitrogen oxide range from 0.22 to 0.49 pound per million British thermal units of heat input (EPA 2014). The maximum emission factors for particulate matter, carbon monoxide, and sulfur dioxide are 0.56, 0.60, and 0.025 pound per million British thermal units of heat input, respectively. The emission factor for carbon dioxide is 195 pounds per million British thermal units.

Production of the biomass would create criteria pollutant and carbon dioxide emissions. Equipment required for planting, applying fertilizers and pesticides, and harvesting the biomass would typically burn fossil fuels. In addition, transport of the biomass feedstock from its source (within ten miles of the boilers) to the boilers would produce criteria pollutants from truck emissions. The total amount of emissions from transport of feedstock would depend upon the number and types of trucks used and the miles traveled. Published emission factors for heavy duty diesel trucks show emission factors of 0.028 pound per mile traveled for nitrogen oxide. Emission factors for particulate matter, carbon monoxide, sulfur dioxide, and carbon dioxide are 0.0013, 0.0093, 0.000041, and 4.2 pounds per mile traveled, respectively (http://www.aqmd.gov/ceqa/handbook/onroad/onroad.html) (AQMD 2008).

Scaled versions of a direct combustion biomass energy project would produce linearly scaled impacts to air quality. For instance, a 20-megawatt biomass project could replace electricity use from the baseline grid by two times that of a 10-megawatt biomass project. The corresponding reduction in greenhouse gases would be 2 times that of a 10-megawatt biomass project and the increase in criteria pollutants would be about 2 times greater. The biomass feedstock would increase linearly and be acquired from a larger area, so criteria pollutant emissions from growing and transporting the feedstock would also increase.

Biodiesel Plant and Electric Power Plant

Air quality impacts associated with construction of the power plant would be similar to those for the direct combustion plant. Both projects would disturb the same amount of land (fugitive dust) and would require the same amount of construction time. However, this representative project would also require construction of a biodiesel production facility on 6 to 8 acres of land and a construction period of 12 to 18 months. This would result in additional criteria pollutant and carbon dioxide emissions.

Production of the biomass would create criteria pollutant and carbon dioxide emissions. Equipment required for planting, applying fertilizers and pesticides, and harvesting the biomass would typically burn fossil fuels. In addition, transport of biomass feedstock from its source (within ten miles of the project) to the facility would produce criteria pollutants from truck emissions. These emissions would be similar to those for the direct combustion plant. The conversion of biomass to biodiesel would emit the criteria pollutants of nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide.

6.1.2.1.2 Climate Change

Direct Combustion Biomass-Fueled Steam Turbine Generator

Operation of a biomass facility would generate carbon dioxide, a greenhouse gas. Historically, carbon dioxide emissions from biomass facilities have been considered to be carbon neutral, but the premise of carbon neutrality during the burning of biomass is still an unsettled issue. The basis for the premise is that as long as biomass resources are managed sustainably (that is, the resource's rate of carbon absorption is maintained or increased), the combustion of harvested materials presents no net increase of carbon to the on-going carbon cycle. Therefore, the burning of biomass should not be considered an increase in greenhouse gases. By comparison, the combustion of fossil fuels such as oil emits carbon that has been out of the current carbon cycle for millennia and therefore does contribute to an increase in greenhouse gases. In January 2011, the EPA announced its plans to defer, for three years, the greenhouse gas permitting requirements for carbon dioxide emissions from biomass-fired boilers in order to seek further independent scientific analysis of the complex issue. On July 12, 2013, the U.S. Court of Appeals, D.C. Circuit, Case No. 11-1101, vacated the deferral rule. EPA is developing final permitting rules for biogenic carbon dioxide emissions. With the continuing lack of permitting rules concerning the carbon neutrality of biomass energy, this PEIS assumes that, for the purposes of comparing greenhouse gas emissions (under certain provisions of the Clean Air Act) to the baseline of burning oil for electricity, that burning biomass is carbon neutral and that all reductions in the amount of oil burned will be reflected in a reduction of carbon dioxide and greenhouse gases.

A replacement of about 70,000 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 4.7 million gallons. On O‘ahu, the annual replacement of 70,000 megawatt-hours of electricity from the baseline grid and the corresponding reduction in the use of oil would correspond with an annual reduction in greenhouse gas emissions of about 51,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, an annual replacement of 70,000 megawatt-hours of electricity usage would correspond to an annual reduction in greenhouse gas emissions of about 43,000 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity.

Biodiesel Plant and Electric Power Plant

The power plant would produce about 10 megawatt of electricity. Assuming an 80 percent capacity factor, the project would provide base load electricity of about 70,000 megawatt-hours per year. These are the same assumptions used for the direct combustion biomass-fueled turbine generator. Because the same replacement of electricity production from the baseline grid would occur for the biodiesel electric power plant and for the direct combustion plant, the reduction in oil consumption and the corresponding reduction in greenhouse gases would be the same from producing electricity in both representative projects.

6.1.2.2 Best Management Practices and Mitigation Measures

BMPs that could minimize air impacts from a direct combustion biomass-fueled steam turbine generator include using a boiler system that is designed to achieve high combustion and boiler efficiency and can operate close to its design capacity and applying control technology to reduce emissions during operation of the facility (such as dust collectors to reduce particulate matter emissions). Air quality permits would be required before construction and operation of a biomass steam boiler to ensure compliance with all county and Federal air quality regulations.

BMPs that could minimize potential air impacts from a biodiesel gasification plant and electric power plant include designing equipment with low emissions and applying control technology to further reduce emissions during operation of the facilities (such as dust collectors to reduce particulate matter emissions). Similarly, air quality permits would be required before construction and operation of a biodiesel plant and electric power plant to ensure compliance with all county and Federal air quality regulations. These regulations include New Source Performance Standards, National Ambient Air Quality Standards, and Prevention of Significant Air Quality Deterioration.

6.1.3 WATER RESOURCES

6.1.3.1 Potential Impacts

Potential impacts to water resources are similar from both representative projects (i.e., direct combustion biomass fueled steam turbine generator and a biodiesel gasification plant and electric power plant). As such, they are discussed together herein and one or the other is singled out when potential effects would be different.

6.1.3.1.1 Surface Water

Potential impacts on surface water from construction of either type of biomass power plant would be the same as those expected for common construction actions as described in Section 3.3.5. The power plant facilities are both estimated to require 6 to 8 acres of land disturbance, so the permitting requirements described in Section 3.3.5 would be fully applicable.

During operation of the power plant facility, there would be no activities that would have the potential to affect surface waters other than possibly increasing storm water runoff from the site and the possible need for irrigation water to support a dedicated biomass crop. With regard to runoff, if the pre-construction project site was agricultural land or land with natural vegetation, the completed project site would have a significantly higher percentage of impermeable surfaces and accordingly would generate more storm water runoff. Management of this increased volume of runoff would depend on the nature of the specific site (i.e., whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

A primary difference between the direct combustion and biodiesel plants is the amount of water that would be required by the biomass crops and which is part of the environmental impacts evaluation. As presented in the technology description in Chapter 2, sugar cane, an example biomass crop that could be used for direct combustion, requires 180,000 to 250,000 cubic feet of water per acre per year, and 3,340 acres of the crop would be needed to supply the necessary biomass for a 10 megawatt plant. This acreage and water requirement equates to an average water demand of about 12 to 17 million gallons per day. Depending on the location of the crop, a good portion of the water needs could be supplied by precipitation. The example oil crop, the Jatropha tree, described for the biodiesel representative project requires less water per acre, but a larger total acreage to support a 10 megawatt plant. As described in the Chapter 2 technology description, it is assumed 14,000 to 27,000 acres would be needed for Jatropha tree crops and that supplemental irrigation amounting to 20 inches per year would be required with the remaining water needs being provided by precipitation. This acreage and water requirement equates to an average water demand of about 21 to 40 million gallons per day.

It is assumed that whatever supplemental irrigation water was needed for either biomass power plant project would be provided by surface water resources. This was the primary source of irrigation water during the peak of Hawai‘i’s sugar industry and, also as described in Section 3.3.1.1.2, there are still numerous working stream diversions on many of the islands that were constructed for irrigation. Although 800 million gallons of surface water was used each day by the sugar industry in 1920, the amount of surface water used in irrigation over the entire State was down to about 74 million gallons per day in 2005 (see Section 3.3.1.1.4). Accordingly, the 21 to 40 million gallons per day potentially needed to support the representative project would be a large increase in demand for irrigation water, particularly since it would be in localized area. The water need is small in comparison to the average amount of runoff from rain created from the islands each day, which is estimated at 10 to 40 percent of 21 billion gallons per day (see Section 3.3.2.1.2), but there would be existing competing water uses on every island, even if it were only to maintain stream habitat. On a Statewide basis, the water need may appear to be well within the carrying capacity of the resource, but water needs for a dedicated biomass crop would have to be evaluated further on a site-specific basis.

Operation of the dedicated biomass crop would also result in potential for runoff contamination from the fields as a result of fertilizer or pesticide applications. This runoff could then reach surface water resources. Depending on their characteristics and concentrations, fertilizer and pesticide chemicals can produce adverse environmental impacts if they reach surface waters. The potential for such impacts is minimized if the materials used are appropriately approved or licensed for the intended use and they are handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

Water needs for a dedicated biomass crop would have to be evaluated further on a site-specific basis. The substantial amount of water needed for some biomass feedstocks may dictate siting locations because certain sites may not have sufficient water resources.

6.1.3.1.2 Groundwater

Potential impacts on groundwater from construction of either type of biomass power plant would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the power plant, impacts to groundwater would be limited primarily to the water needs to operate the facility. A boiler producing steam which then goes to a power generating turbine is the power plant configuration described for the direct combustion representative project and is an optional configuration for the biodiesel project. In such a configuration, water going through the boiler and then steam to the turbine would be expected to be on a loop, recycling as much of the water as reasonable. But depending on the type of cooling system involved, there would be continuous losses from evaporation and blowdown that would have to be replenished from the local water supply (likely involving primarily groundwater). It is assumed that a steam turbine in either representative project would require a steam flow of about 300,000 pounds per hour to produce 10 megawatts of electricity (EEA-ICFI 2008). This steam flow equates to a water flow of 36,000 gallons per hour or 0.86 million gallons per day. If it is further assumed that the water-steam system must be constantly replenished at a rate of about 10 percent of this flow, then the power production element of the project requires fresh water at a rate of about 90,000 gallons per day. This would include other minor water needs from the plant, including the personal needs of the 25 employees and any biomass handling needs. This amount of additional groundwater demand is minor in comparison to the State’s total groundwater sustainable yield, which is estimated at about 3.6 billion gallons per day. Accordingly, the water needed for the long-term operation of the system would not be expected to result in water availability issues, but would have to be evaluated on a site-specific basis taking into consideration the groundwater sustainable yield for the applicable Aquifer System Area on the affected island and the existing groundwater demand from that area.

The long-term presence and operation of the biomass facility would be associated with increased runoff (as described previously) and potentially an associated decrease in groundwater recharge. However, the area involved is relatively small and, depending on where storm water runoff from the facility goes or how it is managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge.

Operation of the dedicated biomass crop would also represent potential for contamination from fertilizer or pesticide applications to reach groundwater either via runoff or local recharge. Fertilizer and pesticide chemicals potentially can be carried down by infiltrating water and result in groundwater areas where drinking water standards are threatened or even exceeded. The potential for such impacts is minimized if the materials used are appropriately approved or licensed for the intended use and they are handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

6.1.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale biomass energy project (of either type) would be expected to avoid floodplains and wetland areas if only to reduce costs and minimize regulatory requirements. However, if unavoidable, construction considerations would be the same as described for common construction actions in Section 3.3.5.

6.1.3.2 Best Management Practices and Mitigation Measures

Because it is assumed that either type biomass-based power plant would have access to a sewer system, there would be no sanitary or process wastewater issues associated with facility's operation and there would be no basis for avoiding areas with sensitive receiving waters.

With regard to water resources to support the facility's water needs, most of O‘ahu and all of Moloka‘i have been designated Groundwater Management Areas (Sections 3.3.2.3 and 3.3.2.4) because of concerns over the long term availability of groundwater. This designation authorizes the State to manage groundwater through a permitting process. This does not mean the project could not be implemented on either island due to lack of water, but it does identify a heightened level of concern that would have to be evaluated for a proposed action that involved any water demand. Also, Lāna‘i has no surface water resources that could be used to support irrigation of a dedicated biomass crop and groundwater resources are very limited.

Potential BMPs for water resources (surface waters, groundwater, and floodplains and wetlands) from construction or operations of either type of biomass power plant would be the same as those described in Section 3.3.6.

6.1.4 BIOLOGICAL RESOURCES

Potential impacts to biological resources may occur from land clearing and disturbance to construct the power plant, installation of facility lighting, human disturbance during construction, and potential spread of invasive species by creating disturbed areas. Construction of the power plants would be expected to disturb approximately 6 to 8 acres of land. These are impacts that also occur with other renewable energy technologies and are discussed in Section 3.4.5.1. Impacts to biological resources specific to the development utility-scale biomass energy projects based on the representative projects are discussed in the following sections.

6.1.4.1 Potential Impacts

6.1.4.1.1 Direct Combustion Biomass Project

Approximately 3,300 and 5,100 acres would be needed to produce sugar cane (or comparable agricultural crop) and woodchip biomass, respectively, to fuel the steam boilers for a 10-megawatt direct combustion power plant. Growing dedicated biomass feedstock would put existing fallow agricultural cropland into dedicated energy crop production. Alternatively, if woody biomass was selected as a biomass feedstock forest plantations planted with non-native species such as eucalyptus trees would be used to produce the wood biomass. Agriculture energy crops would be harvested annually or biannually. Forest crops would be harvested at longer rotation periods of approximately 6 years. Approximately 850 acres of forest would be harvested annually. Potential impacts to either vegetation or wildlife species would depend on existing vegetation and wildlife habitat on the fallow cropland or in the forest plantation. With the decline of the sugar and pineapple industries, large areas of former cropland are now fallow and some have developed vegetation that could provide habitat to wildlife. Similarly, many forest plantations contain largely introduced species, but still provide habitat to some species of wildlife. Placing either former croplands or forest plantations into energy crop production could impact some species of wildlife that occupy those lands. Potential species that could be impacted include the wide-ranging Hawaiian hawk and the Hawaiian hoary bat. Because energy crops produced on agricultural lands would be harvested either annually or biannually, any existing wildlife value on those lands would be lost. Forest plantations would be harvested less frequently and therefore would retain trees in different age classes and retain some value as wildlife habitat. Biomass production sites in proximity to areas with critical habitat and other high value habitats such as wetlands, areas of native vegetation, and protected land areas would need evaluation to ensure that potential impacts to wildlife or protected plant species are minimized or avoided. Use of forest biomass for energy production would open a potential market for selective harvesting of invasive woody species, such as albizia trees, from surrounding lands and provide a cost effective means for managing and reducing this and other invasive species.

Developing markets for dedicated energy crops to support electrical power production opens the possibility of establishing new energy crops. One potential impact is the introduction of new plant species that may become invasive. Screening new plant species for invasive characteristics, conducting field trials prior to commercial production, developing monitoring programs, and designing controls measures, if needed, would be ways to avoid the potential impacts of introduced species. The other potential impact from a commercial market for energy crops would be the use of genetically modified plants (GMOs) in developing plants with superior characteristics (e.g., increased growth rate, plant size, and oil content) that improve their value as energy crops. However, the impacts of GMOs are not fully understood even though they are widely used in the United States and exist in the Hawaiian Islands. Some counties in Hawaiʻi have or are considering actions to limit the production of genetically modified crops.

6.1.4.1.2 Biodiesel Fueled Biomass Project

The production of biodiesel from oil crops such as the seeds of the Jatropha tree could have many of the same potential impacts as the production of biomass fiber for direct combustion. An estimated 14,000 to 27,000 acres of Jatropha trees would be needed to produce enough biodiesel to fuel a 10 megawatt steam boiler electrical power plant per year. The range of acreage needed depends on the growing conditions and number of seed crops that can be harvested per year. Because Jatropha and many other potential oil crops would be grown in monocultures (cultivation of a single crop in a given area), any wildlife habitat value that existed on those lands dedicated to seed production would be lost. Using land that has lower wildlife value (e.g., former abandoned agricultural land) would minimize potential impacts. Also locating production sites farther from high value native vegetation communities would reduce but not eliminate the potential for invasive plant species.

The same concerns regarding invasive species and potential use of GMOs apply to plant species that could be used as oil crops. The same screening and preventive measures for invasive species used for biomass fiber crops could be used for oil crops.

6.1.4.2 Best Management Practices and Mitigation Measures

In addition to the common BMPs that were identified in Section 3.4.6, the use of dedicated biomass crops could also implement the following measure:

- Screening new plant species for invasive characteristics, conducting field trials prior to commercial production, developing monitoring programs, and designing controls measures, if needed, would be ways to avoid the potential impacts of introduced species.

6.1.5 LAND AND SUBMERGED LAND USE

This section discusses the potential environmental consequences to land use from a utility-scale biomass facility.

6.1.5.1 Potential Impacts

Construction of either representative 10-megawatt project (i.e., direct combustion biomass fueled steam turbine generator or a biodiesel plant and electric power plant) would require clearing, grading, and leveling of an area of 6 to 8 acres. The site would have a boiler and turbine building, biomass handling and feed systems, possibly a transformer station, and construction laydown yards. The site would also include parking areas and access roads. Utilities required would include water and sewer, electrical service, communications, and above ground electrical distribution lines, with connections to the existing electrical grid. Operations would include maintenance and repair activities.

6.1.5.1.1 Land Use

For the direct combustion facility, either sugar cane or wood chips would be used as the feedstock. Land requirements for the production of sugar cane would be approximately 3,340 acres; the land requirements for the production of wood feedstock would be about 5,100 acres. A biodiesel plant is assumed to use the Jatropha tree as the feedstock. The land required to produce Jatropha trees on a sustained basis is estimated at 14,000 to 27,000 acres.

State designated land uses and county overlay zones would need to be considered. There could be a change in landownership patterns if the site is acquired by purchase or land use easement. Undeveloped land or land under current land uses could be converted to energy uses.

6.1.5.1.2 Submerged Land Use

As identified in Tables 6-1 and 6-2, there would be no potential impacts to submerged land use from either representative utility-scale biomass project.

6.1.5.2 Best Management Practices and Mitigation Measures

None noted.

6.1.6 CULTURAL AND HISTORIC RESOURCES

6.1.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility-scale biomass renewable energy project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.1.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.1.7 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawaiʻi Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.1.7.1 Potential Impacts

Because the entire State of Hawaiʻi is considered as part of the coastal zone, a Federal consistency review could be required. Potential impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion would depend on specific locations proposed for either the power plant and the area used for the production of the biomass considering both direct and indirect effects. Large-scale development of energy biomass production could potentially impact soil erosion and impact coastal waters through water runoff and sedimentation.

6.1.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.1.8 SCENIC AND VISUAL RESOURCES

6.1.8.1 Potential Impacts

6.1.8.1.1 Direct Combustion Biomass Fueled Steam Turbine Generator

Construction would require clearing, grading and leveling an area of about 6 to 8 acres for the boiler and turbine building, biomass handling and feed system, possibly an electrical transformer station, and construction space. On final grading, approximately 2 to 3 acres may be landscaped or used for worker parking lots. Construction would last about 18 months. Potential short-term impacts to visual resources from construction activities are described in Section 3.8.3.

Operations of the generating plant would cause long-term visual impacts from introduction of a new facility. The buildings would be approximately 30 feet tall with an emission stack height of approximately 80 feet. The energy facility would be near existing biomass sources (0-10 miles) such as agricultural fields or forests. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Approximately 1 mile of aboveground electrical distribution lines would connect the power plant to the local electrical grid. Exterior lighting for safety and security purposes would be installed on the generating plant facilities. Visual impacts would also occur from harvesting the biomass; however, these activities should be compatible with existing or historic uses of the site for the biomass source. In addition, visual impacts would be caused by truck traffic delivering biomass to the plant.

6.1.8.1.2 Biodiesel Plant and Electric Power Plant

A biodiesel production facility would also require about 6 to 8 acres. The facility would require road access, electrical, sewer, water, and communication utilities. Construction activity would consist of site clearing, grading, excavation for foundations, and trenching and would require approximately 18 months. Construction of a 10 megawatt generating plant would require clearing, grading and leveling an area of about 6 to 8 acres. On final grading, approximately 2 to 3 acres may be landscaped or used for worker parking lots. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Construction would require approximately 18 months. Potential short-term impacts to visual resources from construction activities are described in Section 3.8.3.

Long-term visual impacts would occur from the new facilities. The project would include storage tanks and bulk liquid handling facilities. Exterior lighting for safety and security purposes would be installed on the facilities. Approximately 1 mile of high voltage electrical line would be constructed to connect the power plant to the local utility grid. Visual impacts would also occur from harvesting the oil crop; however, these activities should be compatible with existing or historic uses of the site. Visual impacts would also be caused by truck traffic delivering crops to the plant. In addition, if the biodiesel production facility and the power plant are not co-located, tanker truck transportation would be required to transport the biodiesel from the production facility to the power plant. Assuming the use of 7,500 gallon tanker trucks, approximately 1,066 deliveries would be required annually to transfer the biodiesel from production plant to power plant.

6.1.8.2 Best Management Practice and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a power generating plant.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

Best management impacts to minimize impacts to visual resources, including those from lighting, are provided in Section 3.8.4.

6.1.9 RECREATION RESOURCES

6.1.9.1 Potential Impacts

6.1.9.1.1 Direct Combustion Biomass-Fueled Steam Turbine Generator

Construction would require clearing, grading and leveling an area of about 6 to 8 acres for the boiler and turbine building, biomass handling and feed system, possibly an electrical transformer station, and construction space. On final grading, approximately 2 to 3 acres may be landscaped or used for worker parking lots. Construction would last about 18 months. Potential short-term impacts on recreation resources from construction activities are described in Section 3.9.4.

If the existing land use of a proposed site is recreation, the recreational value of the site would be permanently lost or altered by the new power plant. Operations of the generating plant would cause long-term visual and noise impacts that could affect recreation resources. Potential visual impacts are discussed in Section 6.1.8 and potential noise impacts are discussed in Section 6.1.12. The energy facility would be near existing biomass sources (0-10 miles) such as agricultural fields or forests. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Approximately 1 mile of aboveground electrical distribution lines would connect the power plant to the local electrical grid. In addition, impacts to recreation resources, such as bicycling, could be caused by truck traffic delivering biomass to the plant.

6.1.9.1.2 Biodiesel Plant and Electric Power Plant

Construction of a 10 megawatt generating plant would require clearing, grading, and leveling an area of about 6 to 8 acres. On final grading, approximately 2 to 3 acres maybe landscaped or used for worker parking lots. Road access and utility services such as water and sewer would require extension into the power plant and require disturbance of approximately 2 to 5 acres of land. Construction would require approximately 18 months. Potential short-term impacts to recreation resources from construction activities are described in Section 3.9.4.

Long-term impacts to recreation resources would occur from the new facilities as described above for direct combustion. Approximately 1 mile of high voltage electrical line would be constructed to connect the power plant to the local utility grid. In addition, impacts to recreation resources such as bicycling could be caused by truck traffic delivering oil crops to the biodiesel facility and biodiesel to the power plant.

6.1.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as the recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating a power generating plant. In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. BMPs to minimize impacts to recreation resources are described in Section 3.9.5.

6.1.10 LAND AND MARINE TRANSPORTATION

Impacts to land transportation considered potential effects on traffic, alterations to existing roads, and requirement for additional road (excluding temporary or project specific access roads) infrastructure. Impacts to marine transportation considered potential effects on operation of the harbor systems, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations.

6.1.10.1 Potential Impacts

6.1.10.1.1 Land Transportation

Local impacts could occur from increased truck traffic for hauling biomass from the point of production to the power plant. Because the biomass production would occur in close proximity (up to 10 miles) to the power plant, this impact would be localized. In a worst case scenario, this truck traffic would occur on existing public access roads and require 4 to 5 truck deliveries per day, depending on the size of the power plant. Daily truck traffic could also increase wear on paved roads and increase the need for more frequent road maintenance.

6.1.10.1.2 Marine Transportation

As identified in Table 6-1 and Table 6-2, there would be no potential impacts to marine transportation from either representative utility-scale biomass project.

6.1.10.2 Best Management Practices and Mitigation Measures

- Deliveries of biomass feedstock could be scheduled to avoid peak traffic hours to minimize potential impacts to traffic on local roadways.
- Using covered trucks would prevent potential hazards of dust and feedstock from falling or blowing onto roadways during transport.

6.1.11 AIRSPACE MANAGEMENT

6.1.11.1 Potential Impacts

Construction and operation of a utility-scale biomass power plant is not likely to require an FAA obstruction to navigation evaluation because the height of the emission stack would likely be less than 200 feet. However, project locations near airports would require evaluation to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.

6.1.11.2 Best Management Practices and Mitigation Measures

As discussed above, it is recommended that during project siting, evaluation be conducted to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.

6.1.12 NOISE AND VIBRATION

6.1.12.1 Potential Impacts

Construction of the representative biomass projects over 18 months could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

The representative biomass projects could potentially result in long-term impacts to existing noise and vibration levels. Noise from the steam boilers and turbines would be mostly contained within the building, although noise levels would increase during short term steam blow events. Industrial noise would be produced from operation of the biomass handling facilities, truck deliveries, and removal of ash waste. The representative biomass-fueled steam turbine generating plant would be located near existing biomass sources (0-10 miles) such as agricultural fields or forests, and noise would be generated by truck traffic delivering biomass to the plant. If the representative biodiesel production facility and the power plant are not co-located, tanker truck transportation (approximately 1,066 deliveries annually using 7,500 gallon tanker trucks) would be required to transport the biodiesel from the production facility to the power plant. Such noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Impacts would depend on the location of facilities and compatibility with existing noise levels and land uses.

6.1.12.2 Best Management Practices and Mitigation Measures

BMPs for noise and vibration would be the same as those common across projects for construction and operation. See Section 3.12.6.

6.1.13 UTILITIES AND INFRASTRUCTURE

For utilities and infrastructure, the biomass representative projects would have very similar consequences, therefore they are discussed together and one or the other is singled out when potential effects would be different.

6.1.13.1 Potential Impacts

Effects on each island’s electric utilities would range from small to large from the addition of 10 megawatts of power generation to any island’s overall power grid. For O‘ahu, with the largest island net capacity of 1,756 megawatts, the change would be about 6 percent and for Lāna‘i with the smallest net capacity of 10 megawatts the change would be about 100 percent (see Section 3.13.1). Higher percentage change increases the likelihood that the affected island utility would need to adjust management of power on the grid and overall power production. On all islands, 1 mile of transmission lines was assumed to be installed to connect either biomass facility to the power grid (see Section 8.1 for impacts related to new transmission lines). The distance of the transmission lines would vary for specific situations.

The electricity generated from a biomass facility would be considered “baseload” power because it would be fairly reliable and would not vary as a function of its renewable source (as compared to wind or solar). This attribute provides a benefit to the utilities since it increases their ability to plan on the availability of this generation source. Impacts from connection to utilities for construction and operation of these representative projects would be the same as those described in Section 3.13.3.1, as applicable.

6.1.13.2 Best Management Practices and Mitigation Measures

BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see Section 3.13.4).

6.1.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.1.14.1 Potential Impacts

6.1.14.1.1 Hazardous Materials

Direct Combustion Biomass-Fueled Steam Turbine Generating Plant

Construction of the utility-scale biomass-fueled steam turbine generating plant would likely require clearing, grading and leveling for the boiler and turbine building, biomass handling and feed system, a possible electrical transformer station, and construction space. Road access and utility services such as water and sewer extension lines would likely also be required resulting in land disturbance. Aboveground electrical distribution lines would be constructed to connect the power plant to the local grid. The energy facility would be located near existing biomass sources such as agricultural fields or forests. As such, the proposed project locations would be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present prior to development at the proposed project locations.

Biomass production for the feedstock may require the use of fertilizers, herbicides, and pesticides. Weeds are controlled through applications of pre-emergent herbicides and inter-row herbicides prior to canopy closure. In addition, sugar cane, in particular would require relatively high fertilizer use of nitrogen, potassium, and phosphorus. The forest feedstock (including the eucalyptus forest for the wood chip feedstock) would require fertilizer, primarily nitrogen. In addition, small quantities of hazardous materials would likely be used for cleaning and maintenance of agricultural and logging equipment. These would be handled, stored, and disposed of in accordance with Federal, State, and county laws and regulations to ensure that hazardous materials are not released into the environment. In the event a spill or release occurs, appropriate safety precautionary measures should be taken including following procedures outlined in safety response plans, EPA materials data and safety sheets, OSHA requirements, and notifying the appropriate authorities including the State DOH and first responders (as necessary).

The project would produce ash waste byproducts. As such, ash handling facilities would be integrated into the generating station. The ash waste would be used on nearby agricultural fields or forest plantations as fertilizer with small quantities disposed of in the appropriate landfill. Discussion regarding the disposal of the ash waste in landfills is provided in Section 6.1.14.1.2 Waste Management.

Biodiesel and Electric Power Plants

The representative biodiesel energy system could be comprised of an oil crop production system, a facility to extract and process the plant oils into biodiesel, and an electrical power plant. The power plant would be a 10 megawatt capacity facility that could use either diesel combustion engines or biodiesel –fired steam boilers to generate electricity. Similar construction activities would be required for the biodiesel plant and electric power plant.

Similar handling, storage and disposal requirements would be required for the fertilizer used for the oil crops feedstock as for the biodiesel-fueled plant and electric power plant**.**

During project operations, the potential for hazards exists if a biodiesel leak or accident were to occur. However, prior to approval of the power plant, testing, including inspections and subsequent monitoring, and reporting would be required to ensure that all project operations are compliant with regulatory requirements related to standards of performance for equipment leaks.

Byproducts of a gasification process include char and other solid carbonaceous material that would be disposed of in a landfill if alternative uses of the waste cannot be found. The byproducts from the gasification of the wood chips would not be considered hazardous waste. Discussion regarding the disposal of these byproducts in landfills is provided in Section 6.1.14.1.2, Waste Management.

6.1.14.1.2 Waste Management

Potential impacts from either the biomass fueled steam turbine generating plant or the biodiesel plant or electric power plant would likely occur during the construction phase. A discussion of general construction impacts is provided in Section 3.14.4.

Both types of biomass plants would also produce ash waste and or char/carbonaceous material. Ash residue is considered a hazardous material, depending on the makeup of what is being combusted. As the project would use feedstock from agricultural and forestry operations it is anticipated that the byproducts from the biomass plants would not be considered hazardous wastes. Therefore, it is anticipated that the use of these byproducts for other applications such as fertilizer, landfill cover, and construction uses would not result in waste management impacts. Only leftover byproducts (that is not used for alternative purposes) would be disposed of at the appropriate landfill.

6.1.14.1.3 Wastewater

Wastewater impacts may occur during the operation of the biomass power plant during blowdown from the steam cycle and cooling system, as water discharge would likely contain trace amounts of chemicals and elevated temperatures. However, the project would likely be required to incorporate BMPs to deal with the wastewater, which may include but is not limited to treatment using settling ponds or filtration systems in order to meet NPDES wastewater discharge permit requirements.

6.1.14.2 Best Management Practices and Mitigation Measures

Prior to construction, the proposed project location would be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at the project site. In the event that the project location is sited at one of these sites, site remediation would be recommended prior to project development.

6.1.15 SOCIOECONOMICS

6.1.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from construction and operations of either type biomass energy facility would be very small. The major equipment would likely be manufactured outside the State and, if so, economic benefits associated with the manufacturing would accrue elsewhere. The number of temporary jobs associated with the construction of the plant and the number of jobs to operate and maintain the plant would be very small, perhaps 40 workers for a 9- to 18-month construction period and 3 to 6 positions for operations. The plant would use agricultural and forest residues from existing, nearby agricultural operations so few new agricultural or transportation jobs would be created.

Jobs directly associated either type biomass energy facility would be likely filled by individuals residing within the area of influence (the State of Hawai‘i) and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.1.15.2 Best Management Practices and Mitigation Measures

None identified.

6.1.16 ENVIRONMENTAL JUSTICE

6.1.16.1 Potential Impacts

The potential environmental impacts to the general population associated with representative biomass projects, are expected to be small. The potential for environmental justice impacts also would be small.

6.1.16.2 Best Management Practices and Mitigation Measures

Any biomass-fueled energy facility site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.1.17 HEALTH AND SAFETY

6.1.17.1 Potential Impacts

Common health and safety impacts for typical construction and operations activities are identified in Section 3.17.3. There are no additional potential health and safety risks that would be unique to biomass energy projects.

6.1.17.2 Best Management Practices and Mitigation Measures

Common health and safety BMPs for typical construction and operations activities are identified in Section 3.17.5.

6.2 Geothermal

The representative project for geothermal is the exploration, development, and operation of a 25-megawatt power plant (see Section 2.3.3.2.4). Similar to the existing Puna Geothermal Venture Power Plant on Hawaiʻi Island, the representative power plant would consist of a combined flash and binary system with all geothermal liquids and condensable gases re-injected into the subsurface reservoir.

The amount of land required for such a project would include:

- 5 acres for exploration including access road work and slim holes or coring wells;
- 53 acres for drilling operations and utilization including 15 acres for drilling and well-field development; 8.2 acres of road improvement/construction; 15.5 acres for power plant construction; 4.5 acres for well field equipment and pipelines; and 10 acres for transmission lines.

Table 6-3 present a summary of the potential environmental impacts for the representative geothermal energy project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts including land disturbance. See Section 3.1.3. Potential well blowouts during drilling. Potential for increased risk to personnel and equipment from hot fluids and steam and geothermal gases such as hydrogen sulfide. Potential lava flow hazards and risks during operation associated with active volcanoes.	Same as those common across construction projects. See Section 3.1.3. Implement precautionary measures such as response plans, cleanup equipment, and secondary containment to minimize the potential for on- or offsite soil contamination. Implement standard drilling methods of sealing the upper portions of the boreholes and use blowout prevention devices to reduce the potential for such events to cause damage or injury at the surface. Seal exploratory boreholes not developed into geothermal systems in accordance with well establish methods. To the extent feasible, inject geothermal fluids back into the reservoir under low pressure and in a warm or hot condition. Monitor volcanic activity at all times during construction and project development.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Potential emission of the non-condensable gases during operations. Potential for trace amounts of nitrogen oxides, negligible amounts of sulfur dioxide or particulate matter, and small amounts of carbon dioxide. Potential health impacts from naturally present hydrogen sulfide.	Same as those common across construction projects. See Section 3.2.5. Maintain equipment during exploration and drilling to reduce air emissions. Design equipment and procedures to minimize hydrogen sulfide emissions (including emergency response procedures) during operations. Install control technology to reduce air emissions (such as injecting non-condensable gases into the subsurface or sending the gases to treatment systems). Inject noncondensable gases into the subsurface with used geothermal fluids or have an off-gas treatment system as scavenger or re-generable catalyst systems. Conduct air quality monitoring during operations and implement standard abatement measures to minimize risks associated with hydrogen sulfide release.
Climate Change	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	None.
Water Resources		
Surface Water	General construction impacts. See Section 3.3.5. Potential for minor impacts to surface waters from runoff contaminated with geothermal fluids (“drift”) during operation. Potential impacts to surface waters from leaks or releases of low-boiling point organic working fluids (e.g., isobutene or isopentane) during operations.	Same as those common across construction projects. See Section 3.3.6. Implement precautionary measures such as response plans, cleanup equipment, and secondary containment to minimize the potential for contaminants to reach surface water. Obtain the appropriate discharge permit to ensure that receiving waters are not adversely affected. Remove drilling muds for disposition at a permitted disposal facility or possibly for disposal onsite with appropriate approval. Implement storm water management measures during operations including but

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		not limited to collection ditches or detention ponds.
Groundwater	General construction impacts. See Section 3.3.5 Potential for groundwater contamination/ drinking water supplies from drilling mud used. Potential for increased impacts to water resources from increased water demand (site-specific; i.e., particularly to Maui's Central aquifer sector). Potential groundwater impacts from geothermal fluids removed from the subsurface.	Same as those common across construction projects. See Section 3.3.6. Evaluate the additives used and the toxicity of the drilling mud prior to use during drilling, or use non-toxic formulations, to the extent feasible. Seal off overlying aquifers of fresh water in wells to avoid groundwater impacts and contamination of drinking water supplies. Conduct operational monitoring of the working fluid and the injected geothermal fluid to determine if leaks were occurring. Give consideration to the Central aquifer sector on Maui due to limited availability of groundwater resources.
Floodplains and Wetlands	General construction impacts (site-specific). See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6. To the extent feasible, avoid siting the project location in a floodplain or wetland.
Biological Resources		
	General construction impacts. See Section 3.4.5.1. Potential impacts to biological resources including land disturbance and disturbance by human activity. Potential increase in invasive species establishment in disturbed sites. Potential biological impacts on flights of marine birds (such as shearwaters and petrels) from facility lighting (site-specific).	Same as those common across construction projects. See Section 3.4.6. Restore disturbed areas created by initial exploration and construction with native vegetation following completion of construction to minimize the operational footprint of the project.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	Potential change in land use or ownership by purchase or through land leases. Potential impacts to undeveloped land or land with current uses from conversion to an energy facility. Potential land use easement impacts.	Consider State land use designations and county overlay zones during project siting (particularly on Maui and Hawai‘i, where existing land uses related to parks, known scenic areas, and Native Hawaiian sacred sites are identified).
Submerged Land Use	None.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to ethnographic resources as active volcanoes and rift zones are considered sacred by Native Hawaiians. Potential for adverse viewshed impacts from facility development, transmission lines, and other ancillary facilities; particularly to geothermal resources located within and adjacent to the Hawai‘i Volcanoes National Park.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	Potential short-term construction impacts. See Section 3.8.4. Potential long-term visual impacts from the power plant, night lighting, visibility of the transmission line, and the presence of steam plumes at facilities using water-cooled systems.	Same as those common across construction projects. See Section 3.8.5. Avoid sensitive locations, such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System when locating a power plant. Consider Hawai‘i and Maui’s general land use plans and associated implementation tools such as zoning ordinance and development standards.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		During project design, consider painting the power facility forest green to blend in with the surrounding landscape. Use non-specular conductors to reduce reflection and glare on transmission lines. Use dry-cooling technology to avoid visual impacts from water vapor plumes. Screen pipelines with topography or vegetation to reduce visual impacts.
Recreation Resources		
	General recreation resource impacts during construction. See Section 3.9.4. Potential long-term recreational resource impacts including access restrictions, noise, and visual impacts from the new facilities. Potential permanent loss of recreational values (site-specific). Potential lighting impacts to nearby recreation resources such as campgrounds where dark night sky is valued.	Same as those common across construction projects. See Section 3.9.5. Sensitive locations such as recreation areas in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009) should be considered when locating a geothermal project. Recreation areas that value a dark night sky should also be considered. See Section 6.2.8 and Section 6.2.12 for BMPs related to scenic/visual resources and noise resources.
Land and Marine Transportation		
Land Transportation	Potential short-term impacts on roadway traffic during project construction.	None.
Marine Transportation	None.	N/A
Airspace Management		
	None; the development and operation of a geothermal facility would not result in any tall structures or steam exhausts that would require further consultation on airspace management impacts.	N/A
Noise and Vibration		
	Short-term and long-term noise and vibration impacts would result from exploration, construction, and operation. Potential impacts from noise and vibration would be wholly dependent on sound levels and the proximity of sensitive receptors to the source.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12).

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project. Develop site-specific noise contours that include day and night noise and vibration levels, peak levels, and energy-averaged levels. Proposed drilling near residences and sensitive noise receptors may require mitigation measures to ensure compliance with all State and County laws, rules and ordinances regarding noise (County of Hawai‘i 2014). If blasting or other noisy activities are required during the construction period, notify nearby residents in advance. Only use explosives within specified times and at specified distances from sensitive wildlife or streams and lakes, as established by the Federal and State agencies (BLM 2008). Use equipment with sound-control devices, including use of noise-mitigating drilling technology. Equipment should be adequately muffled and maintained. . Install physical barriers such as walls, earth berms, or vegetation and screening mechanisms between sources of noise and vibration, such as well drilling, and the offsite receptors.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Utilities and Infrastructure		
Utilities	General construction impacts. See Section 3.13.3.1. Potential for minor to moderate impacts to electric utilities (site-specific i.e., moderate effects to Maui and minor effects to Hawai‘i’s utilities). See Section 3.13.3.1.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impact from exposure to hazardous materials if chemicals used during exploration/flow testing or from drilling fluids that were improperly handled or released into the environment. Potential impact from exposure to hazard materials if an accidental spill or chemical release were to occur during operations from lubricating oils, hydraulic fluids, coolants, solvents, and/or cleaning agents. Potential impact from exposure associated with naturally occurring hydrogen sulfide.	Same as those common across construction projects. See Section 3.14.5. Air monitoring for the presence and concentration of hydrogen sulfide by a qualified person using air monitoring equipment, such as hydrogen sulfide detector tubes or a multi-gas meter that detects the gas. Personnel working in areas containing hydrogen sulfide must use appropriate respiratory protection and any other necessary personal protective equipment, rescue, and communication equipment, and be monitored for signs of overexposure.
Waste Management	General construction impacts. See Section 3.14.4. Potentially adverse impacts if additional waste were generated on the island of Hawai‘i. Minor amounts of hazardous waste may be generated including paints, coatings, and spent solvents.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	Potential wastewater impacts in the event of a leak containing geothermal waste fluids.	In the event of leakage, produced geothermal fluids would be routed to sumps or pits and left to evaporate. Remove, transport, and dispose of any remaining sludge to the appropriate disposal facility.
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.

Table 6-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Geothermal (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Environmental Justice		
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	Common health and safety impacts for typical construction and operations activities are identified in Section 3.17.3. Potential health and safety effects from drilling including hydrogen sulfide worker exposure, etc. Potential health and safety impacts from physical, thermal, and chemical hazards such as hydrogen sulfide exposure. Potential well blowouts and/or lava intrusion during drilling.	Common health and safety BMPs for typical construction and operations activities are identified in Section 3.17.5 Develop a health and safety program to protect both workers and the general public during exploration, construction, and operation of geothermal projects. The program should include health and safety training procedures. Prior to any geothermal resource development, prepare a health and safety plan that addresses worker and site safety, emergency response protocols, and procedures for managing hazardous and toxic substances. The plan would identify requirements for notices to State and county emergency response authorities, include emergency response plans and procedures, and define health and safety performance standards. Air monitoring for the presence and concentration of hydrogen sulfide by a qualified person using air monitoring equipment (such as hydrogen sulfide detector tubes or a multi-gas meter that detects the gas). Personnel working in areas containing hydrogen sulfide would be required to wear appropriate respiratory protection and any other necessary personal protective equipment, rescue, and communication equipment, and be monitored for signs of overexposure.

6.2.1 GEOLOGY AND SOILS

6.2.1.1 Potential Impacts

Undertaking drilling or ground-based geophysical surveys in areas of geothermal activity would unlikely have effects on the area's geology. However, drilling into geothermal resources is accompanied by the potential for well blowouts (the uncontrolled flowing of geothermal fluids and gases out of the well) and in areas of active volcanoes, such as Maui and Hawai‘i, there is always the potential that drilling could reach lava or provide a route for lava intrusion. The standard drilling methods of sealing the upper portions of the boreholes and using blow-out prevention devices would reduce the potential for such events to cause damage or injury at the surface. Although today's sophisticated and fast-acting blowout preventers have practically eliminated their occurrence (MIT 2006), well blowouts can present an immediate risk to personnel and equipment at the rig from hot fluids and steam, and geothermal gases such as hydrogen sulfide, if present, could present toxicity concerns to a broader area around the rig. The few worldwide instances where lava has been encountered in, or entered drill holes, including the 2005 event when magma was encountered in a deep borehole on Hawai‘i and a similar occurrence in 2009 in Iceland, have not resulted in problems at or near the surface (Nature News 2008 and UC Davis 2009). There was no indication that the drill hole might provide a route for the magma to reach the surface. Exploratory boreholes not developed into geothermal systems would be sealed in accordance with well establish methods and would not be expected to present any geologic concerns or weak spots.

Potential impacts on geology and soils from surface construction activities associated with a 25-megawatt geothermal power plant would be the same as those expected for common construction actions as described in Section 3.1.3. Construction would involve disturbance of well over one acre of land, so the permitting requirements described in Section 3.1.3 would be fully applicable.

The representative project includes construction of 10 miles of transmission lines to connect the power plant with the nearest electrical grid. Potential impacts associated with those activities are similar to and are addressed in the On Island Electrical Transmission technology in Chapter 8.

Geothermal projects involving injection of water under high pressures or cold or cool water into a geothermal reservoir can result in induced seismicity. The seismicity typically induced in these types of actions is of relatively low magnitudes, with most events not being felt by people (NRC 2012) and not resulting in damage to facilities or infrastructure. In the case of the representative project, however, geothermal fluids would be injected back to the reservoir under relatively low pressures and while still in a warm or hot condition, so induced seismicity would not be an expected issue. In some geologic settings, removal of large quantities of groundwater can cause the formation to consolidate or settle and result in areas of surface subsidence. Again, with the representative project injecting geothermal fluids back into the reservoir, subsidence would not be an expected concern.

Operation of a geothermal power plant as described for the representative project would not be expected to affect geology and soils of the area; that is, other than the inherent mining of heat energy from the area's geologic formation. A primary objective for geothermal projects is to design and operate systems in a manner that makes them as sustainable as possible, so that the power plant can be operated successfully over its designed life. Given this logical intent to minimize the subsurface effects of heat removal (through steady, sustainable heat recovery) and the active, volcanic nature of the energy source, it is reasonable to assume that overall effects on existing subsurface thermal gradients would be relatively minor and localized.

The areas on Maui and Hawai‘i that are identified as having potential geothermal resources are volcanic rift areas on active volcanoes. By their nature, these are also areas associated with lava flow hazards.

Therefore, the long-term operation of a geothermal power plant in any of these areas puts it at some risk from the natural geology of the site. It is assumed that with the volcanic monitoring and the nature of activity associated with these volcanoes that this risk is primarily to facilities and that people would be able to be evacuated if a hazard were to arise, but a risk is still present. This would include the potential release of any hazardous materials that might be stored in facilities in the path of lava flows and which could not be safely relocated.

The construction of a geothermal power plant substantially larger than the representative project would involve disturbance of a greater area of land, but as described for a common construction project, the project would be required to obtain a storm water discharge permit, and to plan and implement measures to minimize erosion and discharge of pollutants. It is expected that the same type of BMPs would be implemented independent of the size of the disturbed area and that the measures would be equally protective. Because the primary concern with regard to pollutants would be spills or leaks of fuel and lubricants from the equipment, the longer construction period and the increased amount of construction equipment may be associated with a higher probability for such an incident to occur. But the types of precautions normally implemented (for example, response plans, cleanup equipment, secondary containment, etc.) would keep potential for on- or offsite soil contamination at a minimum.

The risk of lava flows in areas where geothermal energy is most likely to be available, would not increase with a larger power plant, but the facilities at risk would represent a greater monetary loss if an eruption were to occur.

6.2.1.2 Best Management Practices and Mitigation Measures

The common construction BMPs identified in Section 3.1.3 would apply to general surface construction activities. Additionally, as identified above, the following BMPs would apply to the construction and operation of a geothermal energy facility for the prevention, minimization, or mitigation of impacts to geology and soils:

- Standard drilling techniques involving sealing of the upper borehole and use of blowout prevention equipment.
- Develop response plans, cleanup equipment, and secondary containment to keep on- and off-site contamination to a minimum.

6.2.2 CLIMATE AND AIR QUALITY

6.2.2.1 Potential Impacts

Geothermal energy recovery systems use heat from the Earth to generate electricity. A representative utility-scale geothermal project would consist of the exploration, development, and operation of a 25-megawatt power plant. A representative 25-megawatt geothermal project could theoretically replace electricity requirements from the baseline electrical grid by 188,000 megawatt-hours per year if the representative project has the same 86 percent capacity factor as the existing Puna Geothermal Venture Power Plant on Hawai‘i Island (Gill 2013).

6.2.2.1.1 Air Quality

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

During operations of the representative geothermal project, the non-condensable gases in the geothermal fluid going to the flash systems would be lost or need to be controlled. This could be done by injecting the non-condensable gases into the subsurface with the used geothermal fluids or having off-gas treatment systems as scavenger or re-generable catalyst systems. These systems involve passing the off-gas through beds of materials designed to react with and remove the gas of concern. Emissions of the non-condensable gases could be possible during these processes.

Geothermal power plants release very few air emissions because they do not burn fossil fuels. Geothermal plants emit only trace amounts of nitrogen oxides, almost no sulfur dioxide or particulate matter, and small amounts of carbon dioxide. The primary pollutant at some geothermal plants is hydrogen sulfide, which is naturally present (GEA 2007). Health impacts from high concentrations of hydrogen sulfide include nausea, headache, and eye irritation, while extremely high levels can result in death. As a result of standard abatement measures, geothermal plants typically produce only minimal hydrogen sulfide emissions (GEA 2007). The amount of carbon dioxide released at a geothermal plant varies depending on the amount of carbon dioxide in the geothermal fluid and the plant design.

The air emissions for a combined flash and binary system are 0 pounds per megawatt hour for nitrogen oxide, sulfur dioxide, and carbon dioxide. The air emissions for particulate matter are negligible (GEA 2007). Therefore, the air emissions for the representative project would be zero or negligible for these pollutants.

6.2.2.1.2 Climate Change

A replacement of about 188,000 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 12.6 million gallons. On O‘ahu, the annual replacement of 188,000 megawatt-hours of electricity would correspond to an annual reduction in greenhouse gas emissions of about 140,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, the same annual replacement of electricity usage would see an annual reduction in greenhouse gas emissions of about 120,000 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity.

Scaled versions of a utility-scale geothermal project would produce linearly scaled impacts to air quality. For instance, a 50-megawatt project would replace electricity usage from the baseline grid by two times that of a 25-megawatt project. The corresponding reduction in greenhouse gases also would be two times that of a 25-megawatt project. Air emissions during construction and operations would also be proportional.

6.2.2.2 Best Management Practices and Mitigation Measures

BMPs that could minimize air impacts include maintaining equipment during exploration and drilling to reduce air emissions, designing equipment and procedures to minimize hydrogen sulfide emissions (including emergency response procedures) during operation, and installing control technology to reduce air emissions (such as injecting non-condensable gases into the subsurface or sending the gases to treatment systems). Air quality permits would be required before construction and operation of a geothermal facility to ensure compliance with all county and Federal air quality regulations. During operation, air quality monitoring would be required to determine the quantity of hydrogen sulfide that might be released.

6.2.3 WATER RESOURCES

6.2.3.1 Potential Impacts

This section addresses potential environmental consequences to water resources from development, construction, and operation of a geothermal power plant. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

Construction and drilling may present different types of potential impacts to water resources. Therefore, it is addressed separately as two activities taking place prior to plant operations.

The representative project is also described as including construction of 10 miles of transmission lines to connect the power plant with the nearest electrical grid. Potential impacts associated with those activities are addressed in the "On Island Electrical Transmission" technology in Section 8.1.

6.2.3.1.1 Surface Water

Construction and Drilling

Effects on surface water from surface construction activities associated with a 25-megawatt geothermal power plant would be the same as those expected for common construction actions as described in Section 3.3.5.

As described for common construction actions (Section 3.3.5), the water discharge permit for construction actions includes a requirement to describe the measures that would be taken to minimize the discharge of pollutants to the storm water after construction is complete. So it is reasonable to assume there would be protective measures in place during drilling activities that would be similar to, or the same as, those implemented during construction. However, drilling activities are addressed separately because they would involve process fluids that would be managed separately from runoff from the site. Drilling fluids or muds are used in most geothermal drilling actions. Drilling mud, consisting primarily of water and bentonite clay, is sent down the borehole to cool and lubricate the drill bit, help keep the borehole open, and to carry cuttings back up to the surface. At the surface, the drilling mud is generally screened to remove cuttings, reconditioned as needed, and recycled down the borehole. The drilling muds can also contain small amounts of other chemicals and constituents that are adjusted to control density and viscosity as needed depending on down-hole conditions.

During drilling of exploratory wells, drilling muds are generally managed in mobile tanks brought into the site and which are then hauled away when the drilling is complete. In the drilling of large production wells, larger working capacity is required and the well pads are generally constructed with lined ponds that can be used for drilling muds. Also with regard to production wells, flow testing of the wells is generally performed to characterize the geothermal reservoir and can involve large quantities of the geothermal fluids (groundwater). Drilling muds can ultimately be removed from the site for disposition at a permitted disposal facility or possibly disposed onsite with appropriate approval. Flow test water is often reinjected back into the subsurface. In either case, however, any action to discharge either fluid to the surface would require a separate discharge permit to ensure any receiving waters were not adversely affected.

Operations

During operation of a geothermal power plant, potential impacts to surface water would be expected to be minor. There would be no routine production or discharge of process waters; geothermal fluids brought up from the subsurface would be reinjected. Depending on the nature of the cooling system used in the plant, however, geothermal fluids could possibly be run through cooling tower-type equipment. Small amounts of the fluid, referred to as drift, could be carried out of the equipment as mist and small droplets that can then settle onto nearby ground. Geothermal fluids can often be relatively high in minerals or gases that can then find their way to runoff from areas around the cooling tower equipment. Any contaminants in the runoff from this source would be expected to be very small and would be naturally occurring materials. If there were any geothermal springs in the area, it is very likely they would have higher concentrations of the same constituents than runoff from the plant area. Also with regard to runoff, if the pre-construction project site was land with natural vegetation, the completed project site would likely have a higher percentage of impermeable surfaces and accordingly would generate more storm water runoff. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

The binary cycle portion of the power plant would have a low-boiling point organic working fluid such as isobutene or isopentane. This working fluid is intended to be within a closed system, but if there were leaks or releases during operations, this fluid could represent a contaminant were it to reach runoff or receiving waters.

If a project larger than the representative project were considered, the potential impacts to surface waters during construction and drilling would be as described for the representative project. The amount of land disturbed would increase, but the same requirements would be applicable and the same types of BMPs to control storm water discharge would be equally effective. The longer construction period and the increased number of construction equipment may be associated with a higher probability for spills or leaks of fuel and lubricants from equipment. But the types of precautions normally implemented (for example, response plans, cleanup equipment, secondary containment, etc.) would minimize the potential for contaminants to reach surface water. Drilling mud and other fluids associated with drilling operations such as flow test water, would be greater in volume, but would be associated with a corresponding increase in tanks and ponds to support their proper management. Again, an action to discharge these fluids to surface areas that could affect surface water, would require a separate discharge permit. During operations the larger facilities would tend to generate more runoff, but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

6.2.3.1.2 Groundwater

Construction and Drilling

Potential impacts on groundwater from surface construction activities associated with a 25-megawatt geothermal power plant would include those expected for common construction actions as described in Section 3.3.5.

As described above, drilling performed in geothermal projects typically involves the use of drilling muds. Although geothermal fluids are generally not considered drinking water sources, there could be overlying aquifers that are. It might be noted, however, that the aquifer on the southeastern side of the Kilauea East Rift Zone on Hawaiʻi Island (Figure 2-20) is naturally warm and salty, and not considered potable. In any case, drilling muds represent materials intentionally put down wells and which could come into contact with groundwater used as a drinking water source. One of the functions of drilling mud is to seal the walls of the borehole, keeping formation water out of the borehole and drilling fluids out of the formation. This is consistent with the physical characteristics of the bentonite clay used in drilling muds. The clay solids coat against the walls of the borehole forming a layer with very low permeability, so the drilling mud should not travel far from the borehole. There are, of course, always exceptions to this, for example if large pockets or fissures are encountered, plus groundwater can always come into contact with the outside wall of a clay barrier. As a result, it is important to know the additives using in drilling mud and to evaluate their toxicity in case they were to reach groundwater and ultimately a drinking water source. Non-toxic formulations also make ultimate disposal of the mud easier and likely less expensive.

Formulation of the drilling fluids or mud also involves a demand for water, which is assumed to come from a local groundwater source. The representative project is described as requiring 7 million gallons of water for all of the construction activities, of which drilling represents the largest water demand. Seven (7) million gallons over several months represents only a minor demand. The two islands identified with geothermal resources, Maui and Hawai‘i (see Section 2.3.3.2), have estimated groundwater sustainable yields of 427 and 2,410 million gallons per day, respectively (see Sections 3.3.2.6 and 3.3.2.7, respectively). However, water use records for the Central aquifer sector on Maui indicate current water demand exceeds the sector’s sustainable yield, and one of Maui’s geothermal resource areas extends into the Central aquifer sector. Accordingly, although water demand for the representative project’s construction is minor, water could be an issue if it were to come from Maui’s Central aquifer sector. Water use in all other aquifer sectors in Maui and Hawai‘i are well below their sustainable yield values.

Operations

During operation of the geothermal power plant, impacts to groundwater primarily would be limited to the geothermal fluid removed from the subsurface. Based on several binary geothermal plants in California, it is estimated that the 25-megawatt facility would produce about 9 million gallons of water per day to put through the power plant (Clark et al. 2011). Essentially all of this water would then be injected back into the geothermal reservoir. Geothermal well completion requirements specify that any overlying aquifers of fresh water be sealed off in the well, so either production or injection of the geothermal fluid would not impact groundwater that could be a source of drinking water. Depending on the specific design of the geothermal plant, a small portion of the produced water could be lost to evaporation during cooling processes and could require some make up water to be added to that injected. Again, based on the same binary geothermal plants considered previously, it estimated that up to about 5 percent of the produced water could be lost in the process. So up to about 450,000 gallons of water per day could be required to support the power plant. As described above, this water demand is minor in comparison to the sustainable yield of both Maui and Hawai‘i. However, if this amount of water needed to come from groundwater resources within the Central aquifer sector on Maui, there could be issues because that aquifer sector is already over exploited.

The long-term presence and operation of the geothermal power plant likely would be associated with an increased amount of impermeable surfaces as compared to natural conditions and, as a result, could cause an increased in the amount of runoff from the site. Correspondingly, there potentially could be an associated decrease in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility goes or how it is managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge. As noted above, the working fluid in the binary cycle portion of the power plant would likely be an organic fluid. The normal plant design would have a heat exchanger for transferring heat from the geothermal fluid to the working fluid without having the fluids coming into contact with each other. However, were leaks to occur in the heat exchanger, the organic fluid could find its way into the geothermal fluid that was then injected back into the ground. Operational monitoring of the working fluid and the injected geothermal fluid could be used to determine if leaks were occurring.

For a project larger than the representative project, potential impacts to groundwater during construction and drilling basically would be as described for the smaller project. Water demand for construction and drilling activities would increase proportionally to the size of the power plant, but since the demand would be over several months, it would be expected to be a relatively small amount compared to Maui’s and Hawai‘i’s sustainable yields. However, that demand would have to be evaluated on a site-specific basis because one of the Maui's aquifer sectors is already experiencing groundwater demand that is higher than the sector's sustainable yield. Operation of the larger facility would be expected to require a proportional increase in the amount of geothermal water produced. Again, essentially all of this water would be injected back into the geothermal reservoir. If there were losses because of the type of cooling system included in the plant design, makeup water would be required. On a Maui or Hawai'i island-wide basis, this level of water demand would still appear to be within the sustainable yields of the groundwater resources, but the greater the quantity required, the greater the need for a site-specific evaluation. Groundwater availability can change significantly by location.

6.2.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale, geothermal energy project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

The floodplain and wetlands discussion for common construction impacts (Section 3.3.5) would be independent of project size and applies equally to a potentially larger project.

6.2.3.2 Best Management Practices and Mitigation Measures

Considering the limited areas where geothermal resources are likely to be found and the minimal potential for impacts to water resources from a geothermal project, with a few exceptions there would be no sensitive water resource locations or receptors that should be given special consideration. Floodplains and wetlands are possible exceptions to this, but were addressed above. Areas with limited availability of groundwater resources could be another exception. The Central aquifer sector on Maui is the only identified area fitting this description, but it coincides with an identified geothermal resource area. This does not mean the project could not be implemented due to lack of water, but it does identify a heightened level of concern that would have to be evaluated for a proposed action that involved any water demand from the Central aquifer sector.

A geothermal project should consider the common BMPs identified in Section 3.3.6 to prevent or minimize potential impacts to water resources.

6.2.4 BIOLOGICAL RESOURCES

6.2.4.1 Potential Impacts

Potential impacts to biological resources would be limited to specific areas on Maui and Hawai'i where suitable geothermal resources are available. Potential impacts to biological resources include common construction and operational impacts that with most renewable energy technologies such as land disturbances, potential increase in establishment of invasive species, and facility lighting. These common impacts are discussed in Section 3.4.5.1 and are discussed only briefly here. Construction of a 25-megawatt geothermal plant would disturb approximately 58 acres, including exploration. The location of a geothermal power plant would be largely constrained by the location of the available geothermal resource. Potential impacts to biological resources would be a function of the resources at the location and in the surrounding environment. Threatened and endangered species, critical habitat, and protected land areas occur throughout the islands of Maui and Hawai'i. Native vegetation occurs at upper elevations on both islands. The extent to which the project location overlaps or occurs in close proximity to these resources would determine potential impacts. Impacts would occur primarily from loss of habitat, disturbance by human activity, and possible establishment of invasive species in disturbed sites. Facility lighting during operation could have potential impacts on flights of marine birds such as shearwaters and petrels, depending on the project location. Lighting designs and operation routines to minimize lighting needs could be used to avoid or reduce this potential impact. Ongoing noise associated with construction and operations would have a disturbing impact to species in the immediate vicinity of the project, however, these wildlife would likely relocate to areas away from the source of the noise.

6.2.4.2 Best Management Practices and Mitigation Measures

Many of the disturbed areas created by initial exploration and construction can be restored with native vegetation following completion of construction to minimize the operational footprint of the project. Lighting designs and operation routines to minimize lighting needs could be used to avoid or reduce potential impacts to birds. Additional BMPs are discussed in Section 3.4.6.

6.2.5 LAND AND SUBMERGED LAND USE

This section addresses the potential environmental impacts on land use from a 25-megawatt geothermal facility.

6.2.5.1 Potential Impacts

6.2.5.1.1 Land Use

A 25-megawatt facility would require a total land area of about 58 acres (approximately 5 acres for exploration and 53 acres for drilling operations and utilization, based on estimates provided in Table 2-14 in Chapter 2). Within this area there would be land disturbances related to exploration, access road construction, core drilling and well field development, pipelines, and tie-ins to the existing transmission grid.

Land use impacts could include the change of land use or ownership by purchase or through leases. Undeveloped land or land with current uses could be converted to an energy facility. For the linear aspects of the project (such as the transmission line), land use easements could be required. Operations would include maintaining the production wells, other facilities/structures, and managing waste products.

If the scope of the representative project were increased (by a factor of two for example), it is reasonable to assume the associated impact elements (that is, amount of land disturbance) would increase by a similar factor.

The State’s land use designations would be considered along with the respective county’s overlay zoning.

6.2.5.1.2 Submerged Land Use

As identified in Table 6-3, there would be no potential impacts to submerged land use from the representative geothermal project.

6.2.5.2 Best Management Practices and Mitigation Measures

Maui and Hawai‘i are the only islands with the necessary high temperature resources to support electricity production from geothermal energy. Both islands have existing land uses related to parks, known scenic areas, and Native Hawaiian sacred sites. The State land use designations and the county’s overlay zones should be considered in the siting of any geothermal facility.

6.2.6 CULTURAL AND HISTORIC RESOURCES

6.2.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, geothermal power project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Section 3.6.6. Additionally, active volcanoes and their associated rift zones are considered sacred by Native Hawaiians and geothermal development may negatively affect ethnographic resources. A large portion of geothermal resources available on Hawaiʻi Island are within or adjacent to the Hawaiʻi Volcanoes National Park, which could result in significant viewshed impacts from facility development, transmission lines, and other ancillary facilities.

6.2.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.2.7 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawaiʻi Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.2.7.1 Potential Impacts

Because the entire State of Hawaiʻi is considered as part of the coastal zone, a Federal consistency review could be required. Potential impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion would depend on specific locations selected for a geothermal power plant. Because geothermal development is restricted to the location of geothermal resources, potential impacts to the coastal zone would depend on the proximity of geothermal and coastal resources.

6.2.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.2.8 SCENIC AND VISUAL RESOURCES

6.2.8.1 Potential Impacts

Potential impacts to visual resources from common construction activities are discussed in Section 3.8.4.

Long-term visual impacts related to geothermal development include the power plant, night lighting on the power plant, visibility of the transmission line, and the presence of steam plumes at facilities using water-cooled systems. Geothermal power plants do not require significant storage, transportation, or combustion of fuels that cause visual impacts similar to other types of power plants. These qualities reduce the overall visual impact of geothermal power plants in scenic regions.

6.2.8.2 Best Management Practices and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the three designated scenic byways on Hawai‘i; State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a geothermal power plant.

In addition, the islands of Hawai‘i and Maui have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties' plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State's land use designations.

Detailed site planning, facility design, materials selection, landscaping programs, and adjustment to transmission line routing are key aspects of geothermal operations that can reduce impacts. Developers may paint their power facility forest green to blend in with the surrounding landscape. Additionally, some companies use non-specular conductors, which reduce reflection and glare on transmission lines. Dry-cooling technology could be used to avoid visual impacts from water vapor plumes. Visual impacts of pipelines can often be reduced by screening with topography or vegetation. Additional BMPs to minimize impacts to visual resources, including those from lighting, are discussed in Section 3.8.4.

6.2.9 RECREATION RESOURCES

6.2.9.1 Potential Impacts

A total of approximately 58 acres of land disturbance would occur for the representative project. Potential short-term impacts to recreation from construction activities are provided in Section 3.9.4.

Potential long-term impacts to recreation resources related to geothermal development include access restrictions, noise, and visual impacts of the new facilities. Potential visual and noise impacts of a geothermal facility are discussed in Sections 6.2.8 and 6.2.12. If the existing land use of the proposed site is recreation, the recreational value of the site would be permanently lost or altered by the new power plant. Potential visual and noise impacts from the power plant would affect nearby recreation areas. Lighting on the plant could affect nearby recreation resources, such as campgrounds, where a dark night sky is valued.

6.2.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as recreation resources listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating a power plant. In addition, the Counties of Hawai‘i and Maui have general land use plans and associated implementation tools such as zoning ordinances and development standards. Possible permits that may be required for construction of a geothermal power plant are listed in Section 2.3.3.2.3.

Detailed site planning, facility design, materials selection, landscaping programs, and adjustment to transmission line routing are key aspects of geothermal operations that can reduce impacts. Potential BMPs to reduce scenic and visual impacts and noise and vibration are discussed in Section 6.2.8 and Section 6.2.12. Additional BMPs to reduce impacts to recreation resources are provided in Section 3.9.5.

6.2.10 LAND AND MARINE TRANSPORTATION

6.2.10.1 Potential Impacts

6.2.10.1.1 Land Transportation

As identified in Table 6-3, other than temporary, localized traffic impacts due to construction, there would be no potential impacts to land transportation from the representative geothermal project.

6.2.10.1.2 Marine Transportation

As identified in Table 6-3, there would be no potential impacts to marine transportation from the representative geothermal project.

6.2.11 AIRSPACE MANAGEMENT

As identified in Table 6-3, there would be no potential impacts to airspace management from the representative geothermal project.

6.2.12 NOISE AND VIBRATION

6.2.12.1 Potential Impacts

Short-term noise and vibration impacts would result from exploration and construction of a representative utility-scale geothermal project. Potential impacts from noise and vibration would be wholly dependent on sound levels and the proximity of sensitive receptors to the source. Construction activities prior to drilling are estimated to generate noise levels that can reach approximately 89 dBA at a distance of 50 feet (DOE 2013). The well drilling, stimulation, and testing phases of exploration can last from one to five years. Drilling activities for the injection wells could generate 98 dBA at a distance of 50 feet based on typical noise levels for rock drilling (DOE 2013). Sound measurements of diesel-powered generators have shown that an individual generator produced sound levels at about 102 dBA at a distance of 10 feet and combined with drilling, at 200 feet from the rig, the average drilling sounds ranged from 71 to 79 dBA (Behrens and Associates 2006). Such noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. To evaluate the potential for impacts to sensitive receptors when selecting site locations, anticipated noise levels from the drilling activities with and without noise mitigation berms should be estimated. An evaluation of potential noise and vibration impacts would not only have to identify sound levels that would be produced by the specific project equipment, but it would also have to identify and characterize nearby receptors including sensitive receptors. Noise study data (measurements) from the drilling of a stratigraphic well indicates that at approximately 1,570 feet from the well, with the noise berms in place, the sound level during drilling activities would be reduced to approximately 36 dBA (DOE 2013). Local noise ordinances described in Section 3.12 would be temporarily exceeded during exploration and construction, which would require a permit variance, and short-term noise outside of permitted hours could occur.

Long-term noise and vibration impacts would result from operation of the representative geothermal project. Potential impacts from noise and vibration would be wholly dependent on sound levels and the proximity of sensitive receptors to the source. Noise and vibration generated by drilling operations would be similar to those produced during exploration, but over a longer duration. Normal operations of a geothermal power plant typically generate noise levels in the 71 to 83 decibel range at a distance of one-half mile (BLM 2008). Potential impacts to sensitive noise and vibration receptors (identified in Section

3.12) would be limited to specific areas on Maui and Hawai‘i where suitable geothermal resources are available. Long-term noise and vibration impacts would depend on the locations of the utility-scale geothermal plant and compatibility with the existing land uses.

Noise levels decrease, or attenuate, with distance from the source of noise (see Section 3.12.1). Noise levels from point sources typically attenuate at a rate of 6 to 7.5 dBA each time the distance from the noise source is doubled, and noise levels from line sources attenuate at a rate of 3 to 4.5 dBA each time the distance from the source is doubled (see Section 3.12.1).

6.2.12.2 Best Management Practices and Mitigation Measures

Noise permits would be required if noise levels exceed regulatory limits. A noise permit variance would be necessary when permitted noise limits would be exceeded. Noise avoidance and mitigation measures may be imposed directly as conditions of permit issuance.

The following recommended BMPs could further reduce noise levels:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project. Develop site-specific noise contours that include day and night noise and vibration levels, peak levels, and energy-averaged levels.
- Proposed drilling near residences and sensitive noise receptors may require mitigation measures to ensure compliance with all State and County laws, rules and ordinances regarding noise (County of Hawai‘i 2014). Locate stationary construction equipment such as compressors and generators as far as practicable from nearby residences.
- If blasting or other noisy activities are required during the construction period, notify nearby residents in advance.
- Only use explosives within specified times and at specified distances from sensitive wildlife or streams and lakes, as established by the Federal and State agencies (BLM 2008).
- Use equipment with sound-control devices, including use of noise-mitigating drilling technology. Equipment should be adequately muffled and maintained.
- Install physical barriers such as walls, earth berms, or vegetation and screening mechanisms between sources of noise and vibration, such as well drilling, and the offsite receptors.

6.2.13 UTILITIES AND INFRASTRUCTURE

6.2.13.1 Potential Impacts

Potential impacts on Maui or Hawai‘i’s electric utilities would range from small to moderate from the addition of 25-megawatt of power generation to either island’s overall power grid. For Maui and Hawai‘i, with island net capacity of 262 megawatt and 292 megawatt respectively, the change would be about 9.5 percent and 8.6 percent, respectively (see Section 3.13.1). The likelihood that the affected island utility would need to make a large adjustment to power management on the grid and overall power production for this change is moderate. Ten (10) miles of transmission lines would be installed to connect the geothermal facility to the power grid (see Section 8.1 for impacts related to new transmission lines). Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable.

6.2.13.2 Best Management Practices and Mitigation Measures

BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see Section 3.13.4).

6.2.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.2.14.1 Potential Impacts

6.2.14.1.1 Hazardous Materials

During the resource exploration and drilling phase, hazardous materials associated with the development (improvement or construction) of access roads and exploratory and flow testing wells may be utilized. These include hydraulic fluids, pipe dope, used oils and oil filters, rigwash, spilled fuel, drill cuttings, drums and containers, spent and unused solvents, paint and paint washes, sandblast media, and scrap metal associated with drilling that would produce hazardous waste. The wastes associated with drilling fluids include oil derivatives (e.g., such as polycyclic aromatic hydrocarbons [PAHs], spilled chemicals, suspended and dissolved solids, phenols, cadmium, chromium, copper, lead, mercury, nickel, and drilling mud additives, including potentially harmful contaminants such as chromate and barite). Adverse impacts could result if the hazardous materials were not properly handled or were released to the environment. However, standard industry practices would be implemented and disturbed areas would be restored with natural vegetation once drilling activities are completed. Produced geothermal fluids would be re-injected back into the geothermal reservoir. Therefore, no sludge would likely be generated. If any sludge were generated, it is anticipated that remaining sludge would be removed and transported to licensed offsite locations for disposal.

During construction of the geothermal facility, similar impacts as those addressed for the exploration and drilling phase may occur. Additional discussion regarding construction impacts can be found in Section 3.14.4.

Typical activities during the operations phase include operation and maintenance of production and injection wells and pipeline systems, operation and maintenance of the power plant, waste management, and maintenance and replacement of facility components. Project operations and maintenance may result in some amounts of hazardous materials (e.g., lubricating oils, hydraulic fluids, coolants, solvents, and cleaning agents). Impacts could result if these materials were not properly handled and were released to the environment. Environmental contamination could occur from accidental spills of herbicides or, more significantly, oil. As such, hazardous materials would be handled, stored, and transported properly by a licensed hauler to the appropriate permitted offsite disposal facility as a standard practice. See Section 3.14.4 for additional discussion.

During operations, hydrogen sulfide, which is naturally present (GEA 2007), may be released from geothermal fluids exposing workers and the offsite public to hazards. Section 6.2.2.1.1 addresses these air quality releases. In addition, it is anticipated that air monitoring for the presence and concentration of hydrogen sulfide by a qualified person using air monitoring equipment (such as hydrogen sulfide detector tubes or a multi-gas meter that detects the gas) shall occur. Those personnel working in areas containing hydrogen sulfide would also be required to wear appropriate respiratory protection and any other necessary personal protective equipment, rescue, and communication equipment, and be monitored for signs of overexposure.

6.2.14.1.2 Waste Management

Project construction of a 25-megawatt geothermal project may require land clearing, excavation, drilling, and other related construction activities. These activities would generate general construction waste and potential impacts to landfills accepting these wastes can be minimized through recycling efforts and resultant diversion of generated wastes. A general discussion of potential waste management impacts is provided in Section 3.14.4.

As discussed in Section 3.14, it is noted that some landfills in Hawaiʻi are currently at capacity. As such, depending on the proposed project location (either on the island of Maui or Hawaiʻi), the disposal of non-recyclable materials may add to existing landfill capacity constraints. The resolution of landfill siting and expansion in Hawaiʻi is pending or in process. Therefore, additional waste produced on Hawaiʻi may result in potential impacts, pending the resolution of existing landfill capacity constraints.

During the resource exploration and drilling phase, seismic and exploratory well crews may generate waste (plastic, paper, containers, fuel leaks/spills, food, and human waste). Wastes produced by drilling would include drilling fluid and muds, potential geothermal fluids/sludge, used oil and filters, spilled fuel, drill cuttings, spent and unused solvents, scrap metal, solid waste, and garbage.

During construction, impacts would be similar to but more extensive than those addressed for the exploration and drilling phase. Solid waste generated would mostly be nonhazardous, consisting of containers and packaging materials, miscellaneous wastes from equipment assembly and presence of construction crews (food wrappers and scraps), and woody vegetation. However some hazardous waste would be generated including minor amounts of paints, coatings, and spent solvents. Most of these materials would likely be transported offsite for disposal. In forested areas, commercial-grade timber could be sold, while slash may be spread or burned near the well site.

During project operations and maintenance, hazardous waste may be generated including lubricating oils, hydraulic fluids, coolants, solvents, and cleaning agents. However, these wastes would be handled, stored, and transported by a licensed hauler to the appropriate permitted offsite disposal facility as a standard practice. This would ensure that no environmental contamination could occur from accidental spills of herbicides or, more significantly, oil.

6.2.14.1.3 Wastewater

Wastewater impacts could result from geothermal waste fluid containing elevated levels of arsenic, mercury, lithium, and boron if released during exploration and drilling activities. These pollutants can damage aquatic life or drinking water supplies and water for irrigation. However, all geothermal liquids and condensable gases are expected to be closed loops (although minor leakage could occur). This means that the working fluid stays in the powerhouse and the geothermal fluids would be injected back into the subsurface reservoir. Since the working fluid is a pure material, the condenser's cooling system fluid, which can be either air or water, would not come into contact with the working fluid. In the event of leakage, produced geothermal fluids would be routed to sumps or pits and left to evaporate. The remaining sludge would then be removed, transported, and disposed of at the appropriate disposal facility.

6.2.14.2 Best Management Practices and Mitigation Measures

Prior to construction, the proposed project location would be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at the project site. In the event that the project location is sited at one of these sites, site remediation would be recommended prior to project development. Additional BMPs related to hazardous materials, waste management, and wastewater are discussed in Section 3.14.5.

6.2.15 SOCIOECONOMICS

6.2.15.1 Potential Impacts

Socioeconomic impacts in Hawaiʻi arising from the exploration, development, and operation of a 25-megawatt geothermal power plant would be small. The plant apparatus and appliances and the drilling equipment would likely be manufactured outside the State and, if so, economic benefits associated with the manufacturing would accrue elsewhere. The number of temporary jobs associated with the drilling operation, about 20 positions, and the numbers of jobs to monitor, operate, and maintain the plant, perhaps two dozen positions, would be small. Jobs directly associated the plant during both construction and operations would be likely filled by individuals residing within the area of influence (the State of Hawaiʻi) and not by workers migrating to the State to fill those positions. The geothermal power plant representative project would not create a large number of new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.2.15.2 Best Management Practices and Mitigation Measures

None noted.

6.2.16 ENVIRONMENTAL JUSTICE

6.2.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative geothermal project are expected to be small. Populations of special focus in an environmental justice analysis, i.e., racial and ethnical minorities and low-income residents, as well the general population, could benefit from job creation associated with the representative project.

6.2.16.2 Best Management Practices and Mitigation Measures

Any geothermal energy plant project site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.2.17 HEALTH AND SAFETY

6.2.17.1 Potential Impacts

Common potential health and safety impacts from typical construction and operations activities are identified in Section 3.17.3.

The development of geothermal resources has the same potential for health and safety impacts associated with oil and gas production and other technologies that involve drilling. The substantial experience gained over more than 100 years of drilling activities has resulted in techniques and the associated processes and procedures to monitor and mitigate the potential for health and safety impacts.

Physical hazards from geothermal project construction and operation would usually be associated with construction, exploration, drilling, flow testing, well venting, and power plant operation. Thermal hazards would be associated with heated fluids, and workers could be potentially burned by geothermal fluids. Chemical hazards would be associated with naturally occurring contaminants in the geothermal fluid. Health effects from chemical exposure may be acute or chronic, and exposure may be via inhalation of geothermal steam or ingestion of geothermal fluids (such as drinking contaminated water). Non-condensable gases form when geothermal fluids turn to steam, and the primary gas of concern is hydrogen sulfide (mercury, radon, and benzene may also be present, but are typically not at levels considered hazardous to human health) (BLM 2008). Steam would be produced during drilling, flow testing, well venting, and cooling of geothermal fluids during power plant operation. Binary geothermal power plants re-inject geothermal fluids, which reduces emissions; however, emissions do still occur during flow testing and well venting. Health impacts from high concentrations of hydrogen sulfide include nausea, headache, and eye irritation, while extremely high levels can result in death. However, as a result of standard abatement measures, geothermal plants typically produce only minimal hydrogen sulfide emissions (GEA 2007). While abatement systems may reduce levels of hydrogen sulfide, some abatement systems have their own suite of chemicals and wastes, exposure to which can also result in occupational illness (BLM 2008).

As noted above in Section 6.2.1, although today's sophisticated and fast-acting blowout preventers have practically eliminated their occurrence (MIT 2006), well blowouts can present an immediate risk to personnel and equipment at the rig from hot fluids and steam, and geothermal gases such as hydrogen sulfide, if present, could present toxicity concerns to a broader area around the rig.

During project development, the potential exists for the project to encounter lava. The few worldwide instances where lava has been encountered in, or entered drill holes, including the 2005 event when magma was encountered in a deep borehole on Hawai‘i and a similar occurrence in 2009 in Iceland, have not resulted in significant problems at or near the surface (Nature News 2008; UC Davis 2009). There was no indication that the drill hole might provide a route for the magma to reach the surface. Exploratory boreholes not developed into geothermal systems would be sealed in accordance with well establish methods and would not be expected to present any geologic concerns or weak spots.

Potential impacts on public safety services from construction and operation of this representative project would be the same as those as described in Section 3.13.3.2.

6.2.17.2 Best Management Practices and Mitigation Measures

Common BMPs for construction are identified in Section 3.17.4. Additionally, the following bullets identify BMPs that are specific to geothermal technologies (BLM 2008):

- Develop a health and safety program to protect both workers and the general public during exploration, construction, and operation of geothermal projects. The program should include health and safety training procedures.
- Prior to any geothermal resource development, prepare a health and safety plan that addresses worker and site safety, emergency response protocols, and procedures for managing hazardous

and toxic substances. The plan would identify requirements for notices to State and county emergency response authorities, include emergency response plans and procedures, and define health and safety performance standards.

- Air monitoring for the presence and concentration of hydrogen sulfide by a qualified person using air monitoring equipment (such as hydrogen sulfide detector tubes or a multi-gas meter that detects the gas).

- Personnel working in areas containing hydrogen sulfide would be required to wear appropriate respiratory protection and any other necessary personal protective equipment, rescue, and communication equipment, and be monitored for signs of overexposure.

6.3 Municipal Solid Waste (MSW)

The representative MSW-to-energy project would be a direct combustion facility designed to produce 5 megawatts of energy on 10 acres of land. It would require 165 tons of solid waste per day (see Section 2.3.3.4). Although the representative project assumes that the MSW facility would be co-located with the waste feedstock source, in some cases, the source of the municipal waste (which could be a dump or transfer station) could be miles away from the MSW facility. The feedstock source and the transportation of the waste would both have potential for additional environmental impacts.

If the scope of the representative project were increased by an order of magnitude (that is, increased from 5 megawatts to 50 megawatts), the land required and the daily feedstock requirements would increase linearly, by a factor of 10.

Table 6-4 presents a summary of the potential environmental impacts for the representative MSW-to-energy project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts. See Section 3.1.3. No operational impacts.	Same as those common across construction projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Increased criteria pollutant emissions (nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide, as well as carbon dioxide) from combustion.	Same as those common across construction projects. See Section 3.2.5. Design a boiler system to achieve high combustion and boiler efficiency. Apply maximum achievable control technologies to reduce emissions during project operations (i.e., dust collectors to reduce particulate matter emissions).

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential increase in pollutant emissions (including cadmium, carbon monoxide, dioxins/furans, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter, and sulfur dioxide) emissions during project operations	
Climate Change	Decreased greenhouse gas from electricity production.	Apply control technologies to reduce emissions during project operations.
Water Resources		
Surface Waters	General construction impacts. See Section 3.3.5. Potential water resource discharge impacts from blowdown chemicals. Potential stormwater contamination from solid waste activities, such as stockpiling, dumping, and moving.	Same as those common across construction projects. See Section 3.3.6 Implement precautionary measures during construction, such as response plans, cleanup equipment, and secondary containment. Incorporate water treatment measures to meet discharge permit limit requirements, as necessary. The project should be designed to eliminate the potential for precipitation or stormwater runoff to come into contact with waste materials (i.e., keep all waste storage areas covered and inside the facility).
Groundwater	General construction impacts. See Section 3.3.5. Potential for long-term increased runoff. Potential decrease in groundwater recharge. Potential increase in water demand.	Same as those common across construction projects. See Section 3.3.6. Evaluate projects on a site-specific basis, taking into consideration the groundwater sustainable yield for the applicable Aquifer System Area and the existing groundwater demand from that area. Conduct a heightened evaluation for a proposed action that involves any water demand on O‘ahu or Moloka‘i.
Floodplains and Wetlands	Potential for general construction impacts. See Section 3.3.5 (site-specific).	Same as those common across construction projects. See Section 3.3.5. To the extent feasible, the project shall avoid floodplains and wetlands areas during project siting.

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Biological Resources		
	General construction impacts. See Section 3.4.5. Potential for construction impacts including land disturbance to wildlife in adjacent habitats, particularly near important nesting and feeding areas, wetlands, or roost sites (site-specific). See Section 3.4.5.1. Potential for impacts to biological resources during operations (site-specific).	Same as those common across construction projects. See Section 3.4.6. As feasible, locate the project in the vicinity of the municipal waste used as fuel or near previously disturbed or heavily developed area in or near a municipal landfill.
Land and Submerged Land Use		
Land Use	Potential change in landownership patterns if the site is acquired by purchase or land use easement. Potential land use conversion impacts (i.e., the creation of transmission corridors).	Consider State designated land uses and county overlay zones.
Submerged Land Use	None; the MSW-to-energy facility would be entirely land-based.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to special management areas (CZMPs), shorefront access, and shoreline erosion (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General visual impacts during construction. See Section 3.8.3. Long-term visual impacts from the MSW combustion facility (site-specific). Long-term visual impacts from truck traffic delivery of MSW (site-specific).	Same as those common across construction projects. See Section 3.8.4 Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a MSW-to-energy facility.

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Consideration should be given to general land use plans and associated implementation tools such as zoning ordinances and development standards to protect and maintain open space and scenic resources, consistent with the State's land use designations. Detailed site planning, facility design, materials selection, landscaping programs, and adjustments to transmission line routing can reduce visual impacts caused by MSW combustion facilities.
Recreation Resources		
	General short-term construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts including from visual and noise impacts (site-specific). Potential recreational resource impacts from truck traffic. Potential impacts to recreation resources (i.e., nearby campgrounds or areas where a dark night sky is valued) from facility lighting.	Same as those common across construction projects. See Section 3.9.5. During site selection, consideration should be given to sensitive locations such as the recreation areas listed in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009). During site selection, additional consideration should also be given to each island's general land use plans and associated implementation tools such as zoning ordinances and development standards.
Land and Marine Transportation		
Land Transportation	Potential for localized transportation impacts from hauling or transporting MSW.	None.
Marine Transportation	None; the MSW-to-energy facility would be entirely land-based, Transfer of MSW between islands is not anticipated.	N/A
Airspace Management		
	Potential impacts if emission stacks are less than 200 feet.	Project locations near airports would require evaluation to ensure emissions stacks less than 200 feet would not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	General impacts during construction and operation. See Section 3.12.5.	Same as those common across construction projects. See Section 3.12.6. If sited near the MSW landfill, the potential noise impacts would likely be more suitable for the surrounding environment.
Utilities and Infrastructure		
Utilities	General construction and operational impacts. See Section 3.13.3.1. Varying impacts to utilities (site/island-specific i.e., small effects to O‘ahu, larger effects to Lāna‘i), requiring potential adjustment/management of power grids and overall power production.	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential hazardous material exposure impacts during project operations and maintenance. Potential exposure to hazardous materials from MSW delivered to the site. Potential impact from exposure to hazardous materials associated with the flammability of syngas production.	Same as those common across construction projects. See Section 3.14.5. Handled, store, and dispose of hazardous materials to the appropriate permitted facility. Manage the materials in accordance with standard industrial practices and in accordance with specific manufacturer’s recommendations and applicable regulatory requirements.
Waste Management	Potential exposure to hazardous waste (i.e., infectious waste, electronics, lead acid batteries, firearms, propane tanks, sludge, agricultural wastes, soil, and some noncombustible inorganic materials (such as concrete, stone).	Identified, separate, and dispose of hazardous waste received onsite at the appropriate permitted landfill. Ensure hazardous waste is picked up by a licensed contractor and disposed of appropriately.

Table 6-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – MSW-to-Energy Facility (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential waste management impacts from ash waste byproducts. Potentially beneficial impacts resulting from decreased MSW in landfills.	Upon completion of toxicity testing and deemed nonhazardous, use ash waste (to the extent feasible) for daily cover at lined landfills, roadbed construction, or concrete applications. If the ash waste could not be reused and is not deemed hazardous, dispose of the byproduct as an industrial waste at the appropriate landfill facility. If the ash way was determined to be hazardous, store and/or dispose of the byproducts at the appropriate hazardous waste facility.
Wastewater	Potential impacts to wastewater services from blowdown.	As necessary, incorporate water treatment measures to meet wastewater discharge permit requirements (including point source NPDES permit requirements) prior to wastewater discharge to any surface water or the municipal sewer network.
Socioeconomics		
	Very small population and economic benefits (i.e., few net new jobs) during construction and operation.	None.
Environmental Justice		
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3. No potential for accidents and intentional destructive acts effects. Construction and operation of an MSW-to-energy facility would not introduce any unique accident scenarios and therefore would not result in impacts from accidents and intentional destructive acts.	Same as those common across construction projects. See Section 3.17.5

6.3.1 GEOLOGY AND SOILS

6.3.1.1 Potential Impacts

Potential impacts on geology and soils from construction of a 5-megawatt MSW-to-energy facility would be the same as those expected for common construction actions as described in Section 3.1.3. Construction would involve disturbance of 10 acres of land, so the permitting requirements described in Section 3.1.3 would be fully applicable.

Construction of a MSW-to-energy facility larger than the representative project would involve disturbance of a greater area of land, but as described for a common construction project, the project would be required to obtain a storm water discharge permit, and to plan and implement measures to minimize erosion and discharge of pollutants. It is expected that the same type of BMPs would be implemented independent of the size of the disturbed area and that the measures would be equally protective. Because the primary concern with regard to pollutants would be spills or leaks of fuel and lubricants from the equipment, the longer construction period and the increased number of construction equipment may be associated with a higher probability for such an incident to occur. But the types of precautions normally implemented (i.e., response plans, cleanup equipment, secondary containment, etc.) would keep potential for on- or offsite soil contamination at a minimum.

Operation of the MSW-to-energy facility would not involve activities that would have the potential to affect geology and soils of the area.

6.3.1.2 Best Management Practices and Mitigation Measures

The BMPs for constructing and operating a MSW-to-energy facility would be the same as described for common construction projects in Section 3.1.3.

6.3.2 CLIMATE AND AIR QUALITY

6.3.2.1 Potential Impacts

Municipal solid waste systems convert municipal solid waste and other forms of waste into energy. A representative municipal solid waste project would include a 5-megawatt facility located near a municipal solid waste landfill that would burn about 165 tons of waste per day. The representative 5-megawatt project would have an assumed capacity factor of 75 percent (Gill 2013) and could theoretically replace electricity requirements from the existing baseline electrical grid by about 33,000 megawatt-hours per year. This could reduce oil consumption from electricity generation by about 2.2 million gallons per year.

6.3.2.1.1 Air Quality

The burning of municipal solid waste would emit carbon dioxide and the criteria pollutants of nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide. The total amount of emissions would vary depending on the amount of material burned and its heating value. Using emission factors defined in the EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) Section 2.1, "Refuse Combustion", the estimated annual emissions from a solid waste project that burns about 165 tons of waste per day (60,000 tons per year) would be about 54,000 metric tons of carbon dioxide, 110 tons of nitrogen oxide, 6.3 tons of particulate matter, 14 tons of carbon monoxide, and 100 tons of sulfur dioxide (EPA 2014). The burning of municipal solid waste could thus produce more carbon dioxide than is reduced by not burning oil in the baseline electrical grid.

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4. Municipal solid waste systems are subject to a number of air emissions regulations. A newly built small system is subject to 40 CFR Part 60 Subpart AAAA, "Standards of Performance for Small Municipal Waste Combustion Units for which Construction is Commenced after August 30, 1999, or for which Modification or Reconstruction is Commenced after June 6, 2001." In addition, Section 129 of the *Clean Air Act* requires EPA to set numerical emissions limitations on nine pollutants for both small and large municipal waste combustion units. The nine pollutants are cadmium, carbon monoxide, total mass basis dioxins/furans and toxic equivalency basis dioxins/furans, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter, and sulfur dioxide (http://www.combustionportal.org/mswi.html; Combustion Portal 2014). All standards established due to Section 129 must reflect maximum achievable control technology.

New Source Performance Standards are Federal standards adopted by the EPA to regulate air emissions by many types of industrial facilities. The standards are intended to promote use of the best air pollution control technologies. New Source Performance Standards exist for both small and large municipal waste combustors. The standards require the operator of the municipal waste combustor to meet certain general requirements, such as monitoring and recordkeeping. The complete New Source Performance Standards for a small waste combustor are located in 40 CFR Part 60 Subpart AAAA.

Title V of the Clean Air Act establishes a sulfur dioxide/nitrous oxide emissions program designed to reduce the formation of acid rain. County governments that operate municipal waste combustors may be subject to these requirements (http://www.combustionportal.org/mswi.html; Combustion Portal 2014).

Scaled versions of a MSW-to-energy facility would produce linearly scaled impacts to air quality. For instance, a 50-megawatt project would increase air emissions by ten times that of a 5-megawatt project. A 50-Megawatt facility would burn about 1,650 tons of waste per day and would thus be classified as a large combustor.

6.3.2.1.2 Climate Change

On O'ahu, the annual replacement of 33,000 megawatt-hours of electricity from the baseline electrical grid and the resulting reduction of 2.2 million gallons of fuel oil required to generate electricity would correspond to an annual reduction in greenhouse gas emissions of about 24,000 metric tons CO2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, the same annual replacement of 33,000 megawatt-hours of electricity usage would see an annual reduction in greenhouse gas emissions of about 20,000 metric tons CO2 equivalent due to a different mix of technologies used to produce electricity.

6.3.2.2 Best Management Practice and Mitigation Measures

BMPs that could minimize air impacts include designing a boiler system to achieve high combustion and boiler efficiency and applying control technology to reduce emissions during operation of the facility (such as dust collectors to reduce particulate matter emissions). Air quality permits would be required before construction and operation of a municipal solid waste facility to insure compliance with all county and Federal air quality regulations.

6.3.3 WATER RESOURCES

This section addresses potential environmental consequences to water resources from construction and operation of a MSW-to-energy direct combustion facility. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands. Potential impacts associated with the construction and operation of an onshore transmission line, as associated with the representative project, would be the same as addressed under the "On Island Electrical Transmission" technology in Section 8.1 and are not repeated here.

6.3.3.1 Potential Impacts

6.3.3.1.1 Surface Water

Effects on surface water from construction of a 5-megawatt MSW-to-energy facility would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations there would be process wastewater discharged from the facility and, depending on the design of the facility, stormwater runoff could continue to be a concern. At a minimum, process wastewater would consist of blowdown from the power plant's cooling system. Water in cooling systems typically consists of good quality water to which small concentrations of treatment chemicals are added to prohibit or reduce system corrosion and build-up of algae. Water in the system is cycled in the loop of the cooling system, but as water is lost to evaporation in the cooling tower, natural salt and mineral concentrations increase in what remains. The blowdown is water drained from the cooling system and replaced with fresh water, along with that added to replace evaporated water, in order to keep salts and minerals at acceptable levels. The blowdown may be relatively non-toxic (and depending on the treatment chemicals used in its formulation and the characteristics of the receiving water, would likely have no serious impacts), but could not be discharged to any surface water without a point source NPDES permit to ensure the water quality of the applicable receiving water was not degraded. As necessary, the MSW facility would have to incorporate water treatment measures to meet the discharge permit limits. If the MSW facility were connected to a municipal sewage treatment plant, another possibility for the disposition of the blowdown would be discharge to the sewage system. In this case, the discharge would still require a permit, but it would be one issued by the treatment plant. The offsite treatment plant would levy whatever discharge limits were needed to ensure that it could still meet its own discharge permit. Again, the MSW facility would have to incorporate water treatment measures if needed to meet the municipal sewage treatment plant's requirements. In either case, the applicable discharge requirements would ensure that the process wastewater from the MSW facility did not adversely impact surface waters.

The MSW energy recovery facility would not be one of the industrial activities identified in 40 CFR 122.26(b)(14)(i)-(xi) that automatically requires its stormwater discharge to be covered under a NPDES permit. However, there would be large amounts of solid waste dumped, moved, and stockpiled at the facility and, depending on the facility's design, it is easy to imagine that runoff from any areas where solid waste is managed could present stormwater contamination issues. It is assumed that the representative project would be designed to eliminate the potential for precipitation or stormwater runoff to come into contact with waste materials. This would require all waste handling and storage areas to be inside the facility, or at least under a cover. If this were not the case, it is reasonable to assume that the State would require a permit for the discharge of stormwater from the facility and the facility would be required to incorporate any treatment measures needed to meet the limits imposed by the permit. Again, with these requirements in place, it can be assumed that stormwater from the facility during its operation would not adversely impact surface waters of the area.

Outside of the concerns discussed above, it is likely that the operating MSW facility site would have a higher percentage of impermeable surfaces than the pre-construction site and, accordingly, would generate more storm water runoff. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

During construction of a larger scale MSW-to-energy project, potential impacts to surface waters would be similar to the representative project. The amount of land disturbed would increase, but the same requirements would be applicable and the same types of BMPs to control storm water discharge would be equally effective. The longer construction period and the increased number of construction equipment may be associated with a higher probability for spills or leaks of fuel and lubricants from equipment, but the types of precautions normally implemented (for example, response plans, cleanup equipment, and secondary containment) would minimize the potential for contaminants to reach surface water. During operations, the blowdown wastewater produced from a larger scaled facility would be proportionately larger, but the same requirements described for the smaller facility would still apply. Similarly, the potential for stormwater runoff from the facility to be contaminated would be the same as described previously, as would be the requirements, but because of an increased amount of impervious surfaces, the volume of runoff would be greater. If necessary, and because of the larger surface area, the facility could include onsite measures such as a stormwater detention pond to control the rate at which stormwater left the site.

6.3.3.1.2 Groundwater

Effects on groundwater from construction of a 5-megawatt MSW-to-energy facility would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the MSW-to-energy facility, impacts to groundwater would be limited primarily to the water needs to operate the facility. As described above, water going through the boiler and then steam to the turbine would be expected to be on a loop, but there would be continuous losses from evaporation and blowdown that would have to be replenished from the local water supply, which would likely involve groundwater. The representative project is described as requiring 4 million gallons of make-up water per month for this system. That equates to about 0.13 million gallons per day. Other water demands from the facility, including needs for the 14-person operations staff, facility cleanups, etc., would be minor in comparison, but it is assumed the facility's entire water demand would be about 0.14 million gallons per day. This amount of additional groundwater demand is very minor in comparison to the State's total groundwater sustainable yield, which is estimated at about 3.6 billion gallons per day. Accordingly, the water needed for the long-term operation of the system would not be expected to result in water availability issues, but would have to be evaluated on a site-specific basis taking into consideration the groundwater sustainable yield for the applicable Aquifer System Area and the existing groundwater demand from that area.

The long-term presence and operation of the MSW-to-energy facility would be associated with increased runoff and potentially an associated decrease in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility would go or how it was managed, the action may simply represent a change in where water would soak into the ground and possibly provide recharge.

Potential impacts to groundwater during construction of a larger scale MSW-to-energy project would be as described above for the representative project. The larger facility would be expected to require a proportional increase in the amount of water needed to support construction and operation. It is expected the higher groundwater demand would still be minor in comparison to the State's total groundwater sustainable yield, but again would have to be evaluated on a site-specific basis taking into consideration the groundwater sustainable yield for the applicable Aquifer System Area and the existing groundwater demand from that area.

6.3.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale, MSW-to-energy project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

6.3.3.2 Best Management Practices and Mitigation Measures

BMPs associated with water resources for typical construction projects are presented in Section 3.3.6. In addition to these BMPs, the following BMPs would also be applicable to the representative MSW project:

- Whether discharged to surface waters or a municipal sewer system, applicable discharge requirements would be needed to ensure that the process wastewater from the MSW facility would not adversely impact surface waters.

- Waste handling and storage areas should be inside the facility, or at least under a cover.

6.3.4 BIOLOGICAL RESOURCES

6.3.4.1 Potential Impacts

MSW power plants, such as a waste-to-energy direct combustion facility, are often co-located in the vicinity of the municipal waste which is used as fuel. Therefore, a MSW power plant would most likely be located in a previously disturbed or heavily developed area in or near a municipal landfill. Potential impacts to biological resources are expected to be minimal because of the existing disturbance and lack of habitat at the site of development. However, project siting is an important consideration and if located either on the edge of an industrial area or in a rural agricultural processing area, potential impacts to wildlife from land disturbance during construction (see Section 3.4.5.1) and disturbance to wildlife in adjacent habitats could occur, particularly if the site is near important nesting and feeding areas, wetlands, or roost sites.

6.3.4.2 Best Management Practices and Mitigation Measures

As noted above, project siting is an important consideration during siting of a MSW power plant to ensure that potential impacts to wildlife do not occur. As such, it is anticipated that a MSW power plant would be located in a previously disturbed or heavily developed area in or near a municipal landfill.

6.3.5 LAND AND SUBMERGED LAND USE

6.3.5.1 Potential Impacts

6.3.5.1.1 Land Use

The representative project is a 5-megawatt MSW-to-energy project. The site would require about 10 acres and would include refuse receiving, handling and storage facilities; a combustion and steam generation facility (boiler); flue gas cleaning system; power generation equipment (steam turbine and generator); condenser cooling water system; and residue hauling and storage system (fly and bottom ash). There would be site preparation and land disturbances during the construction phases of the project. The project assumes a 1-mile corridor for tie-in with the existing electrical grid. Operational activities would include maintenance and repair work.

Although there could be changes in land ownership patterns, those changes would not themselves have an impact on the environment. The potential environmental impacts would come from the conversion of land from one use to another, such as the creation of transmission corridors. The facility would most likely co-locate in or near a municipal landfill or industrial site. Therefore, the MSW facility would be compatible with existing uses. State land use designations and county overlay zones would still be considered.

6.3.5.1.2 Submerged Land Use

As identified in Table 6-4, there would be no potential impacts to submerged land use from the representative MSW-to-energy project.

6.3.5.2 Best Management Practices and Mitigation Measures

None noted.

6.3.6 CULTURAL AND HISTORIC RESOURCES

6.3.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, MSW power project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.3.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.3.7 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawai‘i Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.3.7.1 Potential Impacts

Because the whole State of Hawai‘i is considered as part of the coastal zone, a Federal consistency review could be required. MSW power plants are typically constructed in close vicinity to solid waste resources such as landfills or urban collection centers. A MSW power plant would likely be consistent with existing surrounding land uses. However, urban and industrial areas in Hawai‘i that generate MSW typically occur along coastal regions and each project location would require evaluation for potential impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion.

6.3.7.2 Best Management Practices and Mitigation Measures

As noted above, a Federal consistency review could be required for the project. In addition, each project location would be evaluated for potential impacts to special management areas designated under the Coastal Zone Management Program, shorefront access, and shoreline erosion.

6.3.8 SCENIC AND VISUAL RESOURCES

6.3.8.1 Potential Impacts

Land use requirements for a 5-megawatt facility are expected to be approximately 10 acres. Construction would last 18 months to two years. Potential impacts to visual resources from construction activities are discussed in Section 3.8.3.

Long-term visual impacts include the MSW combustion facilities and truck traffic to deliver the MSW. MSW combustion facilities would ideally co-locate with or be near a MSW landfill that would supply the facility with feedstock to minimize transportation distances of the waste to the fuel receiving area. Facilities would include various structures, such as refuse receiving, handling, and storage facilities; combustion and steam generation system (a boiler); flue gas cleaning system; power generation equipment (steam turbine and generator); condenser cooling water system; and residue hauling and storage system (fly and bottom ash). Exterior lighting would be installed on the facilities for safety and security purposes. It is assumed that 1 mile of transmission line would be needed to connect the plant to the power grid.

6.3.8.2 Best Management Practices and Mitigation Measures

Viewpoints from where the facilities would be seen should be taken into consideration when siting a MSW-to-energy facility to avoid visual impacts to scenic resources. Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the three designated scenic byways on Hawai‘i; State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a MSW-to-energy facility. Each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

Detailed site planning, facility design, materials selection, landscaping programs, and adjustments to transmission line routing can reduce visual impacts caused by MSW combustion facilities. Additional BMPs to minimize impacts to visual resources, including those from lighting, are provided in Section 3.8.4.

6.3.9 RECREATION RESOURCES

6.3.9.1 Potential Impacts

Land use requirements are expected to be approximately 10 acres. Construction would last 18 months to two years. Potential impacts to recreation resources from construction activities are provided in Section 3.9.4.

Long-term impacts to recreation resources would include the loss of recreational value if the existing land use of the proposed site is recreation. However, MSW combustion facilities would ideally co-locate with or be near a MSW landfill that would supply the facility with feedstock to minimize transportation distances of the waste to the fuel receiving area. In addition, potential visual and noise impacts from the new facility could affect nearby recreation areas. Truck traffic to deliver the MSW has the potential to impact some recreational activities, for example, bicycling. Lighting on the facility could affect resources, such as nearby campgrounds, that where a dark night sky is valued.

6.3.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as the recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when siting a MSW-to-energy facility. Viewpoints from where the facilities would be seen should be considered to avoid visual impacts that could affect recreation areas. Each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards.

BMPs to minimize impacts to recreation resources, including those from lighting, are provided in Section 3.9.5.

6.3.10 LAND AND MARINE TRANSPORTATION

Impacts to land transportation considered potential effects on traffic, alterations to existing roads, requirement for additional roads (excluding temporary or project specific access roads) infrastructure. Impacts to marine transportation considered potential effects on operation of the harbor systems, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations.

6.3.10.1 Potential Impacts

6.3.10.1.1 Land Transportation

Because MSW power plants are likely to be constructed in relatively close proximity to the MSW source, potential impacts to land transportation systems from hauling or transporting MSW are expected to be localized and minor.

6.3.10.1.2 Marine Transportation

As identified in Table 6-4, there would be no potential impacts to marine transportation systems from the representative MSW-to-energy project.

6.3.10.2 Best Management Practices and Mitigation Measures

None noted.

6.3.11 AIRSPACE MANAGEMENT

6.3.11.1 Potential Impacts

Construction and operation of a utility-scale MSW power plant is not likely to require an FAA obstruction to navigation evaluation because the height of the emission stack would likely be less than 200 feet. However, project locations near airports would require evaluation to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.

6.3.11.2 Best Management Practices and Mitigation Measures

As noted above, project locations near airports would require evaluation to ensure emissions stacks less than 200 feet do not interfere with regulated airspace or create thermal plume turbulence that would be a hazard to aircraft.

6.3.12 NOISE AND VIBRATIONS

6.3.12.1 Potential Impacts

Construction of the representative MSW project over 18-months to 2-years could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

The representative MSW project could potentially result in long-term impacts to existing noise and vibration levels. Impacts are expected to be minimal because MSW combustion facilities would ideally co-locate with or be near a MSW landfill that would supply the facility with feedstock and thus would be in a compatible setting. In addition, noise would be generated by truck traffic delivering feedstock to the plant. Impacts would depend on the location of facilities and compatibility with existing noise levels and land uses.

6.3.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

6.3.13 UTILITIES AND INFRASTRUCTURE

6.3.13.1 Potential Impacts

Effects on each island’s electric utilities would range from small to large from the addition of 5 megawatts of power generation to any island’s overall power grid. For O‘ahu, with the largest island net capacity of 1,756 megawatts, the change would be about 0.3 percent and for Lāna‘i with the smallest net capacity of 10-megawatt the change would be about 50 percent (see Section 3.13.1). With the higher percentage increase, Lāna‘i would need to adjust management of power on the grid and overall power production. On all islands, 1 mile of transmission lines would be installed to connect either biomass facility to the power grid (see Section 8.1 for impacts related to new transmission lines). Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable.

6.3.13.2 Best Management Practices and Mitigation Measures

BMPs to avoid conflicts with existing utilities would be the same as those common across projects for construction and operation. See Section 3.13.4.

6.3.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.3.14.1 Potential Impacts

6.3.14.1.1 Hazardous Materials

Hazardous materials may be used during project operations and maintenance that if released or spilled could result in environmental contamination or pollution. These could include the use of oils, greases or lubricants, or chemicals such as ethylene glycol, various metals and glass oxides, hydraulic fluids of various quantities as part of the generator and cooling systems and facility equipment. In addition to hazardous materials used onsite as part of project operations, hazardous materials from the MSW may be brought into the facility which would need to be separated and removed prior to processing. Such materials would be handled, stored, and disposed of to the appropriate permitted facility. However, these hazardous materials received would be expected to relatively minor in quantity and hazard. Management of these materials would occur in accordance with standard industrial practices and in accordance with specific manufacturer’s recommendations and applicable regulatory requirements.

Project operations would also result in a flammable syngas that would be generated, stored, and combusted which would require proper handling, storage, and use.

In addition, combustion of municipal solid waste could contain hazardous constituents (which would need to be handled as a hazardous waste) if the municipal waste stream included minor amounts of hazardous materials or hazardous waste. Proper handling, transport, and disposal of hazardous materials or substances would be required to comply with State and Federal OSHA, and county requirements. Additional discussion is provided in Section 3.14.4.

6.3.14.1.2 Waste Management

During construction, the proposed project would use common construction materials that may include concrete, concrete block, asphalt, metals, gypsum board, glass and ceramic items, and similar materials. Waste generated during facility construction would be stored properly onsite, and would likely be combusted during project operations. Those materials that can be recycled, such as construction demolition and debris would likely be transported offsite to the appropriate recycling facility. Similarly, hazardous waste would be separated and transported offsite by a licensed hauler to the appropriate permitted facility.

During project operations, personnel and activities supporting operation of the facility would produce small quantities of typical office waste which would be processed by the combustor onsite. Waste that the facility cannot process (such as hazardous materials used in operations) would be diverted to an appropriate storage facility or landfill through a contracted vendor.

Waste received onsite would likely vary and can include everyday items commonly used and thrown away, such as packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries and come from homes, schools, hospitals, and businesses. As feasible, those waste that can be recycled (primarily polyethylene terephthalate (#1 plastic) and high-density polyethylene (#2 plastic) plastic containers, and aluminum cans and other scrap metals, clean cardboard and paper, steel) would be separated out for transport to the appropriate recycling facility. Unacceptable waste such as hazardous waste, infectious waste, electronics, lead acid batteries, firearms, propane tanks, sludge, agricultural wastes, soil, and some noncombustible inorganic materials (such as concrete, stone) would be separated out and disposed of at the appropriate permitted landfill. Hazardous materials would be picked up by a contractor and disposed of appropriately.

Combustion of the waste would result in a solid waste byproduct or residue, which would likely be ash waste. To the extent feasible, this byproduct would be reused pending characterization of the byproducts and testing to ensure that no hazardous waste is present in the ash. The ash could be used for daily cover at lined landfills, roadbed construction, or concrete applications. However, changes to equipment operations and feedstock could alter composition and the reuse potential of the solid byproducts. As such, analytical testing would be required to determine reuse feasibility and to ensure that the byproducts (if to be reused) would not exceed thresholds of pollutants. Beneficial reuse would be subject to annual toxicity testing and certification/sampling pursuant to EPA SW-846, Sampling Methods, and other State laws and regulations. If the ash waste cannot be reused and is not deemed hazardous, the byproduct would be disposed of as an industrial waste at the appropriate landfill facility. If determined to be hazardous, the byproducts would be stored and disposed of at the appropriate hazardous waste facility in compliance with EPA pursuant to 40 CFR 261.

Potential impacts to landfills may occur as a result of the operation of a MSW combustion facility, as the amount of waste that would be processed by a MSW facility would reduce the amount of waste diverted to landfills (i.e., 165 tons per day for the representative project). This effect may be considered beneficial in those areas where landfill space is currently limited (i.e., Oʻahu, Hawaiʻi, Kauaʻi); but may not be considered beneficial in those areas where the amount of MSW generated is not currently considered sufficient to supply a MSW facility with adequate MSW feedstock to keep the facility in operation.

6.3.14.1.3 Wastewater

As discussed in Section 6.3.3, during operations there would be process wastewater discharged from the facility, consisting of (at minimum) wastewater blowdown from the power plant's cooling system. The blowdown is water drained from the cooling system and replaced with fresh water, along with that added to replace evaporated water, in order to keep salts and minerals at acceptable levels. The blowdown may be relatively non-toxic, but could not be discharged to any surface water without a point source NPDES permit to ensure the water quality of the applicable receiving water is not degraded. As necessary, the MSW facility would likely incorporate water treatment measures to meet wastewater discharge permit limits.

If the project were connected to a municipal sewage treatment plant, the blowdown would be discharged to the sewage system in compliance with wastewater discharge permit requirements by the wastewater treatment plant. Again, the project would likely be required to incorporate wastewater treatment measures to meet the municipal sewage treatment plant's requirements.

6.3.14.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.14.5.

6.3.15 SOCIOECONOMICS

6.3.15.1 Potential Impacts

Socioeconomic impacts in Hawaiʻi arising from the development and operation of a 5-megawatt MSW-to-energy direct combustion power plant would be very small. The plant apparatus and appliances including pollution control devices would likely be manufactured outside the State and, if so, economic benefit associated with that production accruing elsewhere. The number of temporary jobs associated with the construction would be approximately 25 for a period of about 18-24 months. The number of jobs to monitor, operate, and maintain the plant would be very small, perhaps 14 positions. Jobs directly associated the plant during both construction and operations would be likely filled by individuals residing within the area of influence (the State of Hawaiʻi) and not by workers migrating to the State to fill those positions. The MSW-to-energy direct combustion power plant representative project would create only a few new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.3.15.2 Best Management Practices and Mitigation Measures

None noted.

6.3.16 ENVIRONMENTAL JUSTICE

6.3.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative MSW-to-energy direct combustion power plant are expected to be small. The potential for environmental justice impacts also would be small.

6.3.16.2 Best Management Practices and Mitigation Measures

Any MSW plant project site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.3.17 HEALTH AND SAFETY

6.3.17.1 Potential Impacts

Common health and safety impacts for typical construction and operations activities are identified in Section 3.17.3. There are no additional potential health and safety risks that would be unique to MSW-to-energy projects.

6.3.17.2 Best Management Practices and Mitigation Measures

Common health and safety BMPs for typical construction and operations activities are identified in Section 3.17.5.

6.4 Marine Hydrokinetic Energy (MHK)

Due to the uncertainty of MHK technology readiness, it is difficult to describe with any accuracy what a representative project might look like and would ultimately depend on the type of wave or tidal technology selected. For the purposes of this PEIS, the potential environmental impacts of MHK technologies presented in this chapter consider the range of potential applications identified in Section 2.3.3.5.2 that address potential impacts to the shoreline, near-shore, and offshore environments. All three scenarios would involve electrical transmission lines from the onshore facility to the nearest grid connection; potential impacts associated with such an action are addressed under the “On-Island Electrical Transmission” technology in Section 8.1 and are not repeated here. The near-shore and offshore scenarios would include an undersea cable and associated land/sea transition site. The impacts of the cable and transition site are addressed in Section 8.2.Aspects of the representative project are discussed in more detail in the following sections.

Table 6-5 present a summary of the potential environmental impacts for a utility-scale MHK project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts including soil disturbance. See Section 3.1.3. Potential impacts associated with on-island electrical transmission lines are discussed in Section 8.1.1. Potential impacts to marine sediments and marine communities are discussed in Section 8.2.1 and Section 6.4.4, respectively. No operational impacts.	Same as those common across construction projects. See Section 3.1.3. During project siting, identify an area of good stability for installation of cables and pipes in the land-sea transition zones.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Potential land disturbance and associated fugitive dust at nearby onshore construction related areas. Potential short-term, minor increase in criteria pollutant emissions from construction equipment and marine vessels. Typically, no air quality impacts during operations	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Potential increase in greenhouse gas emissions from construction equipment and marine vessels. Potentially beneficial impacts from greenhouse gas reduction associated with less electricity production.	None.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Waters	**Onshore** General construction impacts. See Section 3.3.5. Potential for increased stormwater runoff from new building sites (site-specific). **Offshore** Potential ocean sediment disturbance. Potential increased turbidity to communities of concern (site-specific) in marine waters. See Section 8.2.3.	**Onshore** Same as those common across construction projects. See Section 3.3.6 **Offshore** Devices such as silt curtains should be deployed in locations (such as the breakout point) to reduce impacts to communities of concern. Schedule project activities during seasonal periods when wave, current, and wind will be expected to be at lows.
Groundwater	**Onshore** General construction impacts. See Section 3.3.5. Limited water supply impacts for facility operations. **Offshore** No groundwater impacts.	Same as those common across construction projects. See Section 3.3.6.
Floodplains and Wetlands	**Onshore** Potential for general construction impacts. See Section 3.3.5 (site-specific). **Offshore** Potential impacts offshore during placement of the MHK device, cables, or pipes.	Same as those common across construction projects. See Section 3.3.6. Activities involving discharges of dredged or fill materials into the waters of the U.S. (in this case territorial seas) require a Section 404 permit.
Biological Resources		
	Potential construction impacts include displacement of marine mammals, reptiles, and fish both from physical activity and noise transmission through ocean waters. Potential marine habitat impacts including to marine pools, beaches (both rocky and sand), and coral reefs. Potential loss of beach nesting habitat for sea turtles and marine birds; and resting sites for the Hawaiian monk seal.	Many of the marine-based BMPs to prevent or minimize potential impacts to biological resources are identified in Section 3.4.6.2. Additional technology-specific BMPs would be dependent on the MHK system selected for implementation.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential collision hazards to marine mammals and reptiles during anchor cabling. Potential localized noise (sound waves) impacts (potential auditory injury), avoidance, physical injury to marine mammals, fish, or other species, and alteration of water dynamics from submerged oscillating or rotating components. Potential electromagnetic field impacts from the undersea power cable.	
Land and Submerged Land Use		
Land Use	Potential land disturbance impacts during construction.	None.
Submerged Land Use	Potential localized impacts to the ocean floor from tethering and power cable installation, including obstruction of local marine habitats.	None.
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts including land disturbances, structural developments, lighting, and other impacts to special management areas (CZMPs), shorefront access. Potential alteration of shorefront access (site-specific) and alteration of ocean currents.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Scenic and Visual Resources		
	General visual impacts during construction. See Section 3.8.3. Long-term visual impacts (i.e., onshore/offshore—MHK technology and location specific). Long-term visual impacts from navigation lighting for devices.	Same as those common across construction projects. See Section 3.8.4. Sensitive locations such as coastal scenic resources from public viewing points, marine recreational areas; State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating devices in the shoreline, near-shore, and offshore environments. Consult with each island’s general land use plans and associated implementation tools such as zoning ordinances and development standards. Identify and consult key stakeholders early in the planning stage i.e., during project siting.
Recreation Resources		
	General short-term construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts from visual impacts (MHK technology and site specific). Potential effects to water-based recreation activities (i.e., swimming, surfing, boating, and fishing) resulting from access restrictions or use alterations to promote recreation user safety and prevent collisions or malfunctions to offshore technologies. Potential wave attenuation impacts at the shore (technology and site-specific; i.e., dependent on the array of devices and location)	Same as those common across construction projects. See Section 3.9.5. During site selection, consideration should be given to sensitive locations such as the recreation areas listed in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009). During site selection, areas where devices would attenuate waves at popular surfing beaches should be avoided. During site selection, consideration should be given to each island’s general land use plans and associated implementation tools such as zoning ordinances and development standards. Identify and consult key stakeholders early in the planning stage i.e., during project siting.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	None.	N/A
Marine Transportation	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.	Review and possible marking may be required under the U.S. Coast Guard's U.S. Aids to Navigation System.
Airspace Management		
	None; MHK would not include any tall structures and therefore would not impact airspace management.	N/A
Noise and Vibration		
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12). Temporal restrictions. Establishment of an exclusion zone and shutdown, soft-start, and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone). Visual monitoring. Use maintained equipment with sound-control devices. Place hydrodynamic foils on the upper half of the mooring line. Use video equipment and sonar imaging equipment to screen for species interactions and to monitor turbines during operation. Requests for Incidental Harassment Authorization must include monitoring and reporting plans.
Utilities and Infrastructure		
Utilities	General short-term construction impacts. See Section 3.13.3.1.	See Section 3.13.4.

Table 6-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Marine Hydrokinetic Energy (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Hazardous Materials and Waste Management		
Hazardous Materials	Common short-term construction impacts. See Section 3.14.4. Potential exposure to hazardous materials including fuels from boats, marine vessels, barges, lubricants and hydraulic fluids contained in the wave or tidal energy devices during operations and maintenance.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	Common short-term construction impacts. See Section 3.14.4. Potential landfill impacts to O‘ahu and Hawai‘i (pending the resolution of existing landfill capacity constraints) if non-recyclable materials add to existing landfill capacity constraints.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	Potential impacts to wastewater services from vessel effluent during construction. No operational impacts.	Vessels are subject to the EPA NPDES requirements, including EPA's Vessel General Permit requirements (for vessels greater than 79 feet).
Socioeconomics		
	None; MHK would result in few jobs and would not impact socioeconomics.	N/A
Environmental Justice		
	None; there would be no measurable impacts to the human environment, and there would be no environmental justice impacts.	N/A
Health and Safety		
	General construction and operation impacts. See Section 3.17.3. Potential for public health and safety effects including to boats, both civilian and military marine vessels, and to the public onshore in the event the device were destroyed, damaged or if the loss of mooring/spatial stabilization were to occur.	Same as those common across construction projects. See Section 3.17.5

6.4.1 GEOLOGY AND SOILS

6.4.1.1 Potential Impacts

The representative project to be evaluated for the MHK energy technology is a range of technologies consisting of those that would be deployed in the shoreline, near-shore, and offshore environments. For the purposes of evaluating potential impacts to geology and soils, the different deployment scenarios would have basically the same concerns. None of the scenarios would be expected to impact geology and the primary means by which soils could be affected would be through soil disturbing actions, such as during construction, which would occur under each of the scenarios. Under the shoreline scenario, the MHK device and power conversion equipment would likely all be included in a single facility, or joined facilities, at the shoreline. In the other two scenarios, the MHK device would be deployed offshore, but an associated electrical substation and possibly power conversion facility would have to be constructed onshore. The onshore facility would include power conversion equipment, for example, if the MHK device involved pumping water to the shore. It is also assumed that both of the offshore scenarios would involve horizontal directional drilling during construction to install connecting power cables (and possibly water lines) through the sea-to-land transition zone.

All three scenarios would involve electrical transmission lines from the onshore facility to the nearest grid connection, but potential impacts associated with such an action are addressed under the “On Island Electrical Transmission” technology in Section 8.1.1 and are not repeated here. The two offshore scenarios would also involve some means to anchor or moor the MHK devices to the ocean floor. Similarly, the deployment of an offshore MHK device would be expected to include some means of burying cables (and possibly water lines) in the ocean floor between the device location and the sea-to-land transition zone. These offshore elements of MHK projects would not involve potential soil-related impacts because of their marine location, but there would be corresponding effects on the marine sediments. For example, anchor devices would be expected to have impacts on the natural migration of sand. Potential impacts to marine sediments from offshore elements of MHK actions would basically be the same as described in Section 8.2.1 for placement of undersea cables and the associated land-sea transition zones for those cables. As a result, those potential impacts are also not repeated here. Potential impacts to marine communities associated with the affected ocean sediments are discussed in Section 6.4.4.

Potential impacts on geology and soils from onshore construction associated with MHK projects would be the same as those expected for common construction actions as described in Section 3.1.3. Based on the size of the shoreline facilities described in section 2.3.3.5 and the assumption that the near-shore and offshore scenarios would involve horizontal directional drilling, it is reasonable to assume that each MHK scenario would involve the disturbance of more than one acre, so the permitting requirements described in Section 3.1.3 would be fully applicable.

Operation of a MHK device would not involve activities that would have the potential to affect geology and soils of the area.

6.4.1.2 Best Management Practices and Mitigation Measures

BMPs include the consideration of sensitive locations or receptors with regard to onshore construction and operations of MHK facilities, which would be the same as described for common construction projects in Section 3.1.3. The horizontal directional drilling (HDD) operations that would likely be involved in installing cables or pipes in the land-sea transition zones require an area of good stability. However, a basic premise of the HDD technology (that is, tunneling under areas where surface actions are to be avoided) provides a mechanism to avoid areas that would present difficulties for drilling and subsequent construction.

6.4.2 CLIMATE AND AIR QUALITY

6.4.2.1 Potential Impacts

MHK technologies are devices that use the kinetic energy from moving water (e.g., waves, tides, and ocean currents) to generate electricity. Due to the uncertainty around MHK technology, a representative project could be either shore-based or offshore.

6.4.2.1.1 Air Quality

For shore-based installations, this technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

Off-shore construction of MHK devices would not generate fugitive dust at the site of installation, but the construction project could result in land disturbances and associated fugitive dust at nearby onshore construction-related areas. Construction equipment, including marine vessels, which are powered by fossil fuels such as diesel or gasoline would emit criteria pollutants, small amounts of hazardous air pollutants, and greenhouse gases during the duration of the construction project.

Operation of shore-based and off-shore MHK devices would not directly impact air quality.

The MHK devices should not produce emissions of criteria pollutants. Marine vessels servicing off-shore MHK devices would be powered by fossil fuel engines that would emit criteria pollutants during their time of operation. The frequency of trips by marine vessels should be low.

6.4.2.1.2 Climate Change

The MHK devices should not produce greenhouse gases. Marine vessels servicing off-shore MHK devices would be powered by fossil fuel engines that would emit air pollutants during their time of operation. The frequency of trips by marine vessels should be low. As an indirect impact, any reduction of electricity use from the baseline electrical grid would reduce oil consumption from electricity generation and thus reduce greenhouse gas emissions.

6.4.2.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.2.5.

6.4.3 WATER RESOURCES

6.4.3.1 Potential Impacts

The representative project to be evaluated for the MHK energy technology is actually a range of technologies consisting of those that would be deployed in the shoreline, near-shore, and offshore environments. For the purposes of evaluating potential impacts to water resources, each of these deployment scenarios is assumed to consist of a group of activities, and in many cases an action under one scenario is the same or very similar to that in another. Table 6-6 shows the different activities to be considered in the water resources evaluation and the MHK deployment scenario under which they are assumed to occur. As shown in the table, it is being assumed that horizontal directional drilling from a point set back from the shore would be used to install cables or other lines through the sea-to-land transition zone, and that beyond the drilling exit point, the cables would be buried into the ocean floor.

The near shore deployment scenario does not show cable burial as an activity because it is being assumed in this case that “near shore” is define by the practical limit of horizontal directional drilling.

Table 6-6. Activities Considered in the Water Resources Evaluation and the Applicable MHK Deployment Scenario

Activity Description	Range of MHK Deployment Scenarios		
	Shoreline	**Near Shore**	**Offshore**
At- or onshore construction and other land disturbing activities			
MHK device housing, power conversion facility, and electrical substation	✓		
Electrical substation and power conversion facility (would incorporate turbine if MHK device pumps water to shore)		✓	✓
Horizontal directional drilling for placing cable through sea-to-shore transition zone		✓	✓
Transmission line to grid	✓	✓	✓
Ocean floor disturbing activities			
MHK device anchoring		✓	✓
Bury cable on sea floor, from MHK device to sea-shore transition zone			✓
Break-out location of horizontal directional drilling for placing cable through sea-to-shore transition zone		✓	✓

In general, potential impacts to water resources would be very similar for each of the construction or soil disturbing activities that would occur onshore. Potential impacts from any of the ocean floor disturbing activities would also be similar to one another. Accordingly, potential impacts to water resources are addressed in terms of onshore and offshore activities and can be used as a guideline for which MHK deployment scenario is applicable. All three scenarios would involve electrical transmission lines from the onshore facility to the nearest grid connection, but potential impacts associated with such an action are addressed under the On Island Electrical Transmission technology in Section 8.1.3 and are not repeated here.

This section addresses potential environmental consequences to water resources from installation and operation of a MHK device. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

6.4.3.1.1 Surface Water

Onshore Activities

Effects on surface water from the onshore construction elements of a MHK project would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations there would be no activities that would have the potential to affect surface waters other than possibly increasing storm water runoff from the sites of new buildings. If the pre-construction project site was land with natural vegetation, the completed project site would have a higher percentage of impermeable surfaces and accordingly would generate more storm water runoff. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

Offshore Activities

At the locations where the HDD would breakout on the ocean floor, the MHK device would be anchored to the ocean floor, and electrical cables or other conduits were buried, ocean sediments would be disturbed and dispersed to some degree. Some of the drilling mud or slurries used in the HDD likely would be released at the breakout point. These dispersed sediments increase turbidity for at least some period of time and would settle out in different locations, possibly in areas of coral or other bottom communities of concern. Potential impacts to such communities would not only depend on whether they are present near MHK device deploy site and the cable installation path, but also whether they are periodically subjected to naturally occurring high turbidity. Devices such as silt curtains could be deployed in specific locations such as the breakout point to help reduce potential impacts. However, devices such as silt curtains often have limited effects, particularly if wave or current action is high at the site. Correspondingly, another mitigation measure normally considered would be to schedule such project activities during seasonal periods when wave, current, and wind would be expected to be at lows. These potential impacts to marine waters actions are very similar to those described in Section 8.2.3 for placement of undersea cables and the associated land-sea transition zones for those cables.

There would be no expected impacts to marine water quality during operation of the MHK device.

6.4.3.1.2 Groundwater

Onshore Activities

Effects on groundwater from the onshore construction elements of a MHK project would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the MHK system, impacts to groundwater would be limited to the water needs to operate the surface facilities, which would be very minor since there would be no constant demand for process water.

Offshore Activities

No groundwater impacts would be expected from the offshore activities associated with deployment or operation of a MHK system.

6.4.3.1.3 Floodplains and Wetlands

Onshore Activities

It is reasonable to assume that the proponent of a MHK project would avoid construction in a floodplain or wetland if at all possible, if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

Offshore Activities

A Section 404 permit from the Corps of Engineers would likely also be required for the placement of the MHK device and cables on the ocean side of the system. Activities involving discharges of dredged or fill materials into the waters of the U.S. (in this case, territorial seas) require a Section 404 permit. Although placement of pipes may not be a traditional dredge or fill action, the breakout point for the lines (from the HDD) could require placement of fill material to stabilize the location and areas along the ocean floor could require similar actions to ensure the MHK device was supported and stable. If there was any question about the applicability of a Section 404 permit, discussion with the Corps of Engineers would be the appropriate course of action.

6.4.3.2 Best Management Practices and Mitigation Measures

As discussed above, to avoid impacts to floodplains and wetlands, it is recommended that floodplains and wetlands be avoided during project siting. Devices such as silt curtains could be deployed in specific locations such as the breakout point to help reduce potential impacts due to sediment dispersal.

6.4.4 BIOLOGICAL RESOURCES

This section addresses environmental consequences to biological resources from the development of MHK energy technologies. Potential impacts are addressed in terms of terrestrial coastal habitats, marine habitats, threatened and endangered species, and other protected marine species considering the type, intensity, duration, and physical extent of potential impacts.

6.4.4.1 Potential Impacts

MHK energy projects would be developed in near onshore and offshore marine environments and would have potential impacts on land and in the ocean depending on the type of technology deployed. All technologies would require power cables that would cross the shoreline to transmit power to land-based transmission lines. Several technologies, such as overtopping and oscillating water column devices would require semi-submerged structures built into the shoreline or in shallow water. Depending on the project location, potential marine habitats that could be affected include marine pools, beaches (both rocky and sand), and coral reefs. Native coastal vegetation has been largely eliminated due to human development but remnant areas still exist and could be impacted by land clearing. Other potential impacts would include loss of beach nesting habitat for sea turtles and marine birds and resting sites for the Hawaiian monk seal.

Other MHK energy technologies require the deployment of various devices offshore that are anchored to the ocean floor. The anchoring points or foundations for the various types of devices would cause physical disturbances of shallow benthic communities and coral reefs or through deposition of suspended sediments that would affect growth and metabolism. The growth rate of some types of deep water corals (i.e., black, red, and gold) is slow and recovery from impacts can take a long time. Placement of structures (i.e., power generation devices, cabling, and anchors) in the ocean would provide surfaces for establishment of marine organisms (i.e., biofouling). Essential fish habitat could be impacted by placement of structures and alteration of the environment around the power generation devices. In some cases, the underwater structures could serve as fish aggregation devices that attract fish owing to the physical structure and habitat created by the biofouling organisms. Anchor cabling could be a potential collision hazard to marine mammals and reptiles although most species should be able to detect and avoid them.

Potential construction impacts include displacement of marine mammals, reptiles, and fish (i.e., avoidance of construction activity) both from physical activity and noise transmission through ocean waters. Several of the technologies involve placement of submerged oscillating (e.g., surge converters or hydrofoils) or rotating (turbines) components. These types of technologies have several types of potential operational impacts on marine environments including noise, avoidance, injury, and alteration of water dynamics. Rotating or oscillating devices would create sound waves that could cause marine mammals, reptiles, and fish to avoid an area surrounding the project. Sufficiently loud sounds can cause auditory injures but it is not known whether hydrokinetic energy devices produce sounds capable of causing auditory injury. Hydrokinetic energy devices with moving parts also could cause physical injury to marine mammals and fish or cause species to avoid the area creating loss of habitat. Depending on location or position in relation to the shoreline, hydrokinetic energy devices could alter water dynamics in the area surrounding the project. The dynamics of water affects movement of ocean nutrients, phyto- and zooplankton, and sediments. Water flow in marine environments is affected by the shape and slope of the ocean floor, position relative to the shoreline, surface winds, tidal flows, and local heating of the surface layers. Unless deployed in large arrays of generators, most of these impacts would be relatively localized and minor.

Marine hydrokinetic energy devices represent a range of technologies that could vary in size and operating environment. Therefore, the potential impacts to marine mammals by displacement from direct disturbance during facility construction or operation (e.g., from sound emissions or water column disturbance) could vary depending specific technologies and locations. Detailed evaluation of the potential displacement impacts on marine mammals would be performed prior to implementation of specific technologies and projects.

An undersea power cable transmitting power to land would introduce an electromagnetic field (EMF) into the marine environment along the cable. This is a potential impact associated with all marine energy projects (see Section 3.4.5.2). However, the EMF is attenuated fairly quickly with distance from the cable (15 feet) and the potential impact is likely to be negligible (Normandeau et al. 2011).

6.4.4.2 Best Management Practices and Mitigation Measures

Many of the marine-based BMPs to prevent or minimize potential impacts to biological resources are identified in Section 3.4.6.2. Additional technology-specific BMPs would be dependent on the MHK system selected for implementation.

6.4.5 LAND AND SUBMERGED LAND USE

6.4.5.1 Potential Impacts

6.4.5.1.1 Land Use

MHK devices can be located on the shoreline or offshore, depending on the technology. Because MHK technologies are in the early stages of development, there are a number of designs that vary in their current feasibility.

Under the shoreline scenario, the MHK device and power conversion equipment would be in a single or joint warehouse type facility. In two other scenarios, the device would be deployed offshore. The associated electrical substation and power conversion facility would be constructed onshore.

With regard to potential surface land use impacts, there would be land disturbance during the construction phase, followed by maintenance and the potential replacement or expansion of equipment. With regard to submerged land use impacts, any offshore technology would require tethering to the ocean floor; power cables would also be installed leading from the devices to the shoreline facilities. Attenuator technology designs would resemble semi-submerged train cars, a 750-kW device could be about 400 feet in length, and 11 feet wide.

6.4.5.1.2 Submerged Land Use

Some of these technologies can be semi-submerged, with some of the structure protruding above the water surface by about 10 to 30 feet.

Submerged land use impacts would result in localized changes to the sea bottom in terms of introducing obstructions to local marine habitats.

6.4.5.2 Best Management Practices and Mitigation Measures

None noted.

6.4.6 CULTURAL AND HISTORIC RESOURCES

6.4.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, semi-submersible, offshore MHK power project and associated onshore ancillary facilities if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.4.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.4.7 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawaiʻi Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.4.7.1 Potential Impacts

Development of MHK energy systems would include potential construction on the shoreline and in the near offshore depending on the type of technology deployed. All technologies would require installation of undersea power cables or a cable across the beach area to connect to onshore power grids. These types of developments would potentially create land disturbances, structural developments, lighting and other impacts which are inconsistent with the purpose for which the special management areas was designated by the counties under the Coastal Zone Management Program. The projects would include development within shore setback areas and have the potential to impact shorefront access in areas of project development. Development on the shoreline or in the offshore area could alter natural ocean currents and affect shoreline erosion processes.

6.4.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.4.8 SCENIC AND VISUAL RESOURCES

6.4.8.1 Potential Impacts

Each MHK technology category utilizes distinct designs to capture energy based on the kinetic properties of the water. MHK devices can be situated on the shoreline or offshore, depending on the technology. Because MHK technologies are in early stages of development, there is a large number of designs in various stages of viability for commercial deployment or even product testing. Therefore, the representative project is a range of technologies consisting of those that would be deployed in the shoreline, near-shore, and offshore environments.

Potential impacts to visual resources from construction activities are discussed in Section 3.8.3. Under the shoreline scenario, the MHK device and power conversion equipment would likely all be included in a single facility, or joined facilities, at the shoreline. In the other two scenarios, the MHK device would be deployed offshore, but an associated electrical substation and possibly power conversion facility would have to be constructed onshore. It is also assumed that both of the offshore scenarios would involve horizontal directional drilling during construction to install connecting power cables (and possibly water lines) through the sea-to-land transition zone.

Long-term visual impacts would depend upon the MHK technology. Each technology would cause some visual impact onshore from the new facilities as described above. In addition, for some near-shore and offshore technologies, some elements of the technology would be above the water line. The devices would be fitted with marine navigation lighting to indicate the presence of the structures. Attenuator technology designs resemble semi-submerged train cars; a 750-kW device may be about 400 feet in length and 11 feet in width and are composed of multiple segments, depending on technology design (NNMREC / OSU 2013).

Overtopping devices can be semi-submerged in the water and moored to the ocean floor, or be shore-based to capture waves on the shoreline. Currently, deployed prototype devices range in size, but commercially viable units will likely be between 5 to 10 megawatt per unit, and would be about 1,000 feet long by 600 feet wide and would rise approximately 10 to 30 feet out of the water.

Oscillating water column designs are partially submerged structures. These devices are large structures built into the shoreline or moored at sea. A 500-kilowatt shore-based facility can be roughly the size of a two-story house made of concrete, built half on the shore, half in the water. At-sea designs are still in the development phase; however, current designs range from 0.5 to 3 megawatts and about 100 feet long by 30 feet wide, with the surface floating about 8 feet above water level. At-sea devices would increase in size, depending on capacity (Oceanlinx 2013).

Visibility of the near-shore and offshore devices from the shoreline would depend upon the technology and the location of the devices.

6.4.8.2 Best Management Practices and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points, marine recreational areas; State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating devices in the shoreline, near-shore, and offshore environments.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

With the abundance of marine recreational and commercial activities in Hawaiʻi, project siting and stakeholder outreach are critical. Key stakeholders must be identified and consulted early in the planning stage. Additional BMPs to minimize impacts to visual resources are provided in Section 3.8.4.

6.4.9 RECREATION RESOURCES

6.4.9.1 Potential Impacts

Potential impacts to recreation resources from construction activities are discussed in Section 3.9.4. Under the shoreline scenario, the MHK device and power conversion equipment would likely all be included in a single facility, or joined facilities, at the shoreline. In the other two scenarios, the MHK device would be deployed offshore, but an associated electrical substation and possibly power conversion facility would have to be constructed onshore. It is also assumed that both of the offshore scenarios would involve horizontal directional drilling during construction to install connecting power cables (and possibly water lines) through the sea-to-land transition zone.

Long-term impacts to recreation resources would depend upon the MHK technology. Each technology would cause some visual impact onshore from the new facilities. In addition, for some near-shore and offshore technologies, some elements of the technology would be above the water line. The devices would be fitted with marine navigation lighting to indicate the presence of the structures. The devices range in size depending on the technology.

Offshore technologies would affect water-based recreation activities, such as swimming, surfing, boating, and fishing. Activities would be impacted by access restrictions or use alterations to prevent intentional or unintentional damage to the device and promote recreation user safety by preventing collisions or interactions with the device. Since MHK devices remove energy from waves, they have the potential to cause wave attenuation at the shore. Potential impacts to surfers would depend on the array of devices and their locations. One report modeled wave attenuation at the shore from a MHK device at 3 to 6 percent (ASR 2007). Visibility of the near-shore and offshore devices from the shoreline would depend upon the technology and the location of the devices.

6.4.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as the recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating devices in the shoreline, near-shore, and offshore environments. Particularly, areas where devices would attenuate waves at popular surfing beaches should be avoided. In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards.

With the abundance of marine recreational activities in Hawai‘i, project siting and stakeholder outreach are critical. Key stakeholders must be identified and consulted early in the planning stage. Additional BMPs to minimize impacts to recreation resources are provided in Section 3.9.5.

6.4.10 LAND AND MARINE TRANSPORTATION

Impacts to land transportation considered potential effects on traffic, alterations to existing roads, requirement for additional roads (excluding temporary or project specific access roads) infrastructure. Impacts to marine transportation considered potential effects on operation of the harbor systems, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations.

6.4.10.1 Potential Impacts from the Representative Project

6.4.10.1.1 Land Transportation

As identified in Table 6-5, there would be no potential impacts to land transportation from a utility-scale MHK project.

6.4.10.1.2 Marine Transportation

Several MHK energy systems would require deployment offshore and would either be floating or submerged and tethered to the ocean floor with cables or fixed on a seafloor foundation. Several of the technologies involve deployment of relative large devices (several hundred feet). Regardless of specific location, these projects are potential obstructions to marine navigation and would require review and possible marking under the U.S. Coast Guard's U.S. Aids to Navigation System. Depending on distance from shore, these projects could affect navigation by tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and possibly large commercial cargo ships. Military marine operations, surface and submarine navigation, could potentially be affected by both floating and submerged structures.

6.4.10.2 Best Management Practices and Mitigation Measures

The typical BMPs for marine transportation are presented in Section 3.10.4. Technology-specific BMPs for MHK projects would depend entirely on the type of project implemented. The selected practices would also depend on whether the project affected the near shore or offshore environments.

6.4.11 AIRSPACE MANAGEMENT

As identified in Table 6-5, there would be no potential impacts to airspace management resources from a utility-scale MHK project.

6.4.12 NOISE AND VIBRATION

6.4.12.1 Potential Impacts

Short-term noise and vibration impacts would result from the construction of MHK facilities. Local noise ordinances described in Section 3.12 could be temporarily exceeded during construction, which would require a permit variance, and construction noise outside of permitted hours could occur. Offshore construction noise from equipment and vessels, and vibration caused by potential pile-driving, could exceed regulatory levels. Potential acoustic sources from survey activity may include single beam echosounders, multi-beam echosounders, side-scan sonars, and shallow-penetration sub-bottom profilers. All MHK technologies would require installation of undersea power cables that would cross the shoreline using HDD drilling in order to transmit power to land-based transmission lines. Several technologies, such as overtopping and oscillating water column devices would require semi-submerged structures built into the shoreline or in shallow water. Other MHK technologies require the deployment of various devices offshore that are anchored to the ocean floor. Construction noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Further, according to the Incidental Harassment Authorization (77 FR 43259, July 24, 2012) exposure to elevated sound levels from vibratory and impact pile driving may result in temporary impacts to marine mammal hearing and behavior. However, in its Biological Opinion, the NMFS stated that it does not expect any takes of marine mammals by injury, serious injury, or mortality (NMFS 2012). Marine mammal prey species, such as fish, and sea turtles may also be temporarily impacted.

MHK could potentially result in long-term noise and vibration impacts. Several of the technologies operate using submerged oscillating (e.g., surge converters or hydrofoils) or rotating (turbines) components. Rotating or oscillating devices would create sound waves that could cause marine mammals, reptiles, and fish to avoid an area surrounding the project. Operational sound pressure levels and frequencies from turbines would be project-specific. Use of mooring lines creates what is called a “strum effect” from the current rushing past the mooring line and causing it to vibrate and hum (BOEM 2012). Sufficiently loud sounds can cause auditory injures to marine mammals and sea turtles, but it is not known whether hydrokinetic energy devices produce sounds capable of causing auditory injury.

6.4.12.2 Best Management Practices and Mitigation Measures

The following recommended BMPs could reduce the potential disturbances from noise and vibration (NMFS 2012):

- Temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i);
- Establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species or sea turtles);
- Shutdown and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone);
- Soft-start procedures (a technique that allows marine mammals or sea turtles to leave the immediate area before sound sources reach maximum noise levels);
- In-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving); and
- Visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during pile driving); and
- Per *Marine Mammal Protection Act* implementing regulations at 50 CFR 216.104 (a)(13), requests for Incidental Harassment Authorization must include monitoring and reporting plans.

Additional BMPs include the following:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Use equipment with sound-control devices. Equipment should be adequately muffled and maintained. In order to decrease the strum effect, place hydrodynamic foils on the upper half of the mooring line (BOEM 2012).
- Use video equipment and sonar imaging equipment to screen for species interactions and to monitor turbines during operation (BOEM 2012).

6.4.13 UTILITIES AND INFRASTRUCTURE

This section addresses potential environmental consequences to utilities and infrastructure from construction and operation of MKH energy projects. The MHK energy projects are actually a range of technologies consisting of those that could be deployed in the shoreline, near-shore, and offshore environments. For the purposes of evaluating potential impacts to utilities and infrastructure, the different deployment scenarios would have basically the same concerns. Under the shoreline scenario, the MHK device and power conversion equipment would likely all be included in a single facility, or joined facilities, at the shoreline. In the other two scenarios, the MHK device would be deployed offshore, but an associated electrical substation and possibly power conversion facility would have to be constructed onshore. The onshore facility would include power conversion equipment, for example, if the MHK device involved pumping water to the shore. It is also assumed that both of the offshore scenarios would involve horizontal directional drilling during construction to install connecting power cables (and possibly water lines) through the sea-to-land transition zone.

All three scenarios would involve electrical transmission lines from the onshore facility to the nearest grid connection, but potential impacts associated with such an action are addressed under the “On Island Electrical Transmission” technology in Section 8.1 and are not repeated here.

6.4.13.1 Potential Impacts

Effects on each island’s electric utilities would be small. The amount of potential electricity that could be generated from an MHK technology ranges widely from kilowatts to megawatts since several of these devices could be installed in arrays. The technology is still developing and is not yet ready for mature applications. The interface with utilities will depend somewhat on the type of MHK project selected and the projected capacity factor of that particular project. As the capacity factor increases, the power source becomes more reliable; which means that the project could replace other fossil-fueled base-load power sources. Common impacts from connection to utilities for construction and operation of these types of projects are described in Section 3.13.3.1.

6.4.13.2 Best Management Practices and Mitigation Measures

BMPs to avoid conflicts with existing utilities would be the same as those common across projects for construction and operation. See Section 3.13.4.

6.4.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.4.14.1 Potential Impacts

The representative project is the range of MHK technologies consisting of those that would be deployed in the shoreline, near-shore, and offshore environments. Potential hazardous material and waste management impacts on land and in the ocean depend on the type of technology deployed.

6.4.14.1.1 Hazardous Materials

Short-term hazardous material exposure impacts could result from the construction of MHK facilities. These are identified in Section 3.14.4.

Hazardous materials associated with the operation and maintenance of a utility scale MHK facility include the fuel for boats, vessels, and barges, and lubricants and hydraulic fluids contained in the wave or tidal energy devices. Adverse impacts could result if hazardous wastes are not properly handled and were released to the environment.

6.4.14.1.2 Waste Management

Short-term waste management impacts could result from the construction of MHK facilities. These are identified in Section 3.14.

Operation of an MHK facility is not anticipated to generate waste levels that would constrain existing landfill operations. Long-term waste impacts would not occur from the operation of an MHK facility.

6.4.14.1.3 Wastewater

Wastewater impacts would be minimal and may occur largely from vessel effluent during the construction of the proposed project. However, such vessels would be subject to the EPA NPDES requirements, including EPA's Vessel General Permit requirements (for vessels greater than 79 feet).

No adverse impacts to wastewater services are anticipated from the operation of the MHK facilities.

6.4.14.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater are discussed in Section 3.14.5.

6.4.15 SOCIOECONOMICS

As identified in Table 6-5, there would be no potential impacts to socioeconomics from the representative utility-scale MHK project.

6.4.16 ENVIRONMENTAL JUSTICE

As identified in Table 6-5, there would be no potential impacts to environmental justice from the representative utility-scale MHK project.

6.4.17 HEALTH AND SAFETY

6.4.17.1 Potential Impacts

The representative project may present public health and safety concerns to boats, both civilian and military marine vessels, and to the public onshore in the event the device were destroyed, damaged or if the loss of mooring/spatial stabilization were to occur. Such events are more likely occur as a result of rough seas and breaking waves associated with 50 and 100-year storms (particularly in shallow water) or in the event of natural disasters including a tsunami. While the possibility of such events is small, it may occur within the life expectancy of a future project. Therefore potential hazards and safety risks may occur as a result of accidents.

Effects on public safety services from construction and operation of this representative project would be the same as those as described in Section 3.13.3.2.

6.4.17.2 Best Management Practices and Mitigation Measures

None identified.

6.5 Ocean Thermal Energy Conversion (OTEC)

The representative OTEC project would consist of a 50-megawatt, closed-cycle system located in deep water 3.5 miles offshore from a land-sea cable transition site (see Section 2.3.3.6.4). A deep-water pipe 30 feet in diameter and 3,280 feet deep would draw deep cold seawater. Deep water would be retrieved at a temperature of 39º to 41ºF and surface water would be 75º to 82ºF. Warm sea water would be drawn through two 33-foot diameter pipes. Seawater flow rates would be 70,000 gallons per second of warm water and 36,300 gallons per second of cold water. The effluent sea water (both warm and cool waters combined) would be returned via two 40-foot-diameter pipes at a depth of 200 feet, in accordance with environmental standards and Zone of Mixing regulations to prevent alteration of natural ocean temperature profiles or disruption of thermohaline cycling.

The floating platform would be 650 feet long with a 128-foot beam, an operating draft of 53 feet, and be anchored to the ocean floor via mooring lines. The closed-cycle system would use pressurized anhydrous ammonia as the working fluid, which would pass through evaporating and condensing plate-fin heat exchangers. The facility would use the anhydrous ammonia at a rate of 6,063 pounds per second. The project would use chlorine to protect the heat exchangers from biofouling. It has been determined that there would be negligible bio-fouling from cold sea water and that evaporator fouling can be controlled effectively by intermittent chlorination (50 to 100 parts per billion of chlorine for 1 hour per day) (Vega 2010).

An undersea power cable no more than 5 inches in outside diameter would run approximately 6 miles to an onshore land-sea cable transition site, which would connect to the power grid to power the pumps and to deliver electricity to the entire facility. The floating platform would keep auxiliary diesel-powered generators to provide backup power to maintain operation of the OTEC system.

If this ocean thermal energy conversion facility was scaled down to produce 5 megawatts of energy the diameter of the pipes and seawater flow rates would decrease, but depths would remain the same. The size of the floating platform would decrease, as would the power transmission requirements and diameter of the undersea cable. The scaled project would use less ammonia and chorine and at a lower rate.

Table 6-7 present a summary of the potential environmental impacts for the representative OTEC project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; the only potential impacts to geology and soils would be the interface of the undersea cable to connect the OTEC facilities with the grid. These impacts are addressed in Section 8.1.	N/A

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4 Limited, intermittent, and short-term air quality impacts during construction. Potential land disturbance and related fugitive dust at nearby onshore construction related areas, including areas where offshore electrical lines connect with the onshore regional electric grid. Potential increase in criteria pollutant emissions during construction from equipment or marine vessels powered by fossil fuels. Potential operational emissions from auxiliary diesel generators on the platform.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Potential increase in greenhouse gas emissions from construction equipment and operation of diesel generators on the platform. Potential greenhouse gas emissions reduction from a mix of technologies used to produce electricity.	None.
Water Resources		
Surface Waters (Marine Water)	Potential ocean sediment disturbance resulting in increased turbidity and impacts to coral or other bottom communities of concern. Potential water quality impacts from discharge not meeting water quality criteria for marine waters (i.e., nutrient levels such as nitrite plus nitrate, phosphate, phosphorous, etc.). Potential increased algal bloom impacts from increased nutrient levels. Potential impacts from temperature variation and elevated chlorine levels of discharge. See Section 6.5.4 for impacts to biological resources.	To the extent feasible, deploy devices such as silt curtains in locations to reduce impacts to communities of concern. Schedule project activities during seasonal periods when wave, current, and wind is expected to be at lows. A Section 404 permit from the Army Corps of Engineers as well as a certification from the State is required pursuant to Section 401 and Section 404 of the *Clean Water Act* for seafloor disturbing activities. Establish a zone of mixing (per HAR 11-54-9) and obtain approval under the permitting process for the system's water discharge in order for the discharge to meet the State's water quality regulations (not applicable in designated class AA waters).

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Ensure the project design includes a diffuser system for the discharge outfall in order to minimize the size of the zone of mixing and perform modeling to demonstrate compliance is achievable (with the specific diffuser design and proposed zone of mixing) under all reasonable conditions.
Groundwater	Minimal groundwater impacts during construction and operations.	The facility could include in its design, water treatment (desalination) capabilities.
Floodplains and Wetlands	None.	N/A
Biological Resources		
	Potential for short-term and small disturbances during placement of the cabling lines, moors, and anchors. Potential disturbance to deep and shallow marine habitats and shorelines (including marine pools, sandy and rocky beaches, seagrass habitat, shallow benthic communities, and coral reefs at multiple depths) during construction (site-specific). Potential impacts to the marine environment from introduction of an electromagnetic field along the undersea cable. Potential attraction of marine fish, mammals, and seabirds to structures and for biofouling organisms. Potential impacts to marine communities from nutrient rich discharge waters. Potential impacts to marine organisms due to intake pipes. Potential collision hazards to marine mammals from mooring lines.	Deepwater corals should be avoided to minimize impacts as these corals have slow growth rates and would take a long time to recover from either physical disturbance or impacts from sediment deposition caused by seafloor disturbances. Screening could be considered in the large intake pipes during project design to reduce the potential hazard to all but the smallest of organisms. Any night safety lighting should be minimized and designed to not attract seabirds to minimize potential collisions with the above water structure.

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	See Section 8.2.5 for typical land use impacts associated with the interface of an undersea cable and the electrical grid.	None.
Submerged Land Use	Potential for large obstructions in the ocean floor from structures.	See Section 8.2.5.2
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas from the cable crossing the shoreline (site-specific). Potential shorefront access impacts from the cable crossing the shoreline (site-specific). Potential shoreline erosion impacts from the cable crossing the shoreline (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General visual impacts during construction. See Section 3.8.3 See Section 8.2.8 for potential visual impacts from land/sea cable transition sites. Potential long-term visual impacts onshore from the introduction of a transition site.	Same as those common across construction projects. See Section 3.8.4. During project siting for the onshore transition site, consider sensitive locations identified in Section 3.8.
Recreation Resources		
	General short-term construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts in the vicinity of onshore and offshore facilities from access restrictions and potential visual impacts from the facilities.	Same as those common across construction projects. See Section 3.9.5.

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	None.	N/A
Marine Transportation	Potential obstruction impacts to marine navigation including to tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Potential impacts to military marine operations, surface and subsurface navigation from both floating and submerged structures.	Review and possible marking may be required under the U.S. Coast Guard’s U.S. Aids to Navigation System.
Airspace Management		
	Potential impacts to military transportation operations (marine surface and aviation operations). Potential impacts on approach paths to airports.	Consider military airspace transportation operations. Project siting should include coordination with FAA and military organizations and avoidance of airport flight paths, if possible.
Noise and Vibration		
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12). Adhere to temporal restrictions. Establish an exclusion zone and shutdown, soft-start, and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone). Conduct visual monitoring. Use maintained equipment with sound-control devices. Place hydrodynamic foils on the upper half of the mooring line. Requests for Incidental Harassment Authorization must include monitoring and reporting plans.
Utilities and Infrastructure		
Utilities	General construction impacts. See Section 3.13.3.1. Potentially moderate effects to electric utilities (site-specific).	Same as those common across construction projects. See Section 3.13.4. If feasible, an alternative smaller project should be considered for those smaller grids on Lānaʻi or Molokaʻi.

Table 6-7. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Ocean Thermal Energy Conversion (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Hazardous Materials and Waste Management		
Hazardous Materials	General construction impacts. See Section 3.14.4. Potential exposure to hazardous materials during operations from large quantities of ammonia and/or chlorine gas/liquid, including through accidental releases or leaks. Potential for fires or explosions from chorine and gaseous ammonia combinations.	Same as those common across construction projects. See Section 3.14.5. Monitor the OTEC facility for leaks during operation and maintenance. Develop, approve, and implement a risk management program and emergency management plan prior to delivery of ammonia.
Waste Management	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	Potential impacts to wastewater effluent from added chlorine. See Section 6.5.3 for additional discussion on impacts to water resources.	None.
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.
Environmental Justice		
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3. Potential worker exposure to chlorine and ammonia gases.	Same as those common across construction projects. See Section 3.17.5 Safe handling, use, and storage of hazardous materials.

6.5.2 GEOLOGY AND SOILS

As identified in Table 6-7, there would be no potential impacts to geology and soils from the representative OTEC project.

6.5.3 CLIMATE AND AIR QUALITY

6.5.3.1 Potential Impacts

OTEC systems rely on temperature gradients in the oceans to generate electricity. A representative utility-scale project would consist of the construction and operation of a 50-megawatt offshore system. A representative 50-megawatt project could theoretically replace electricity requirements from the existing baseline electrical grid by 440,000 megawatt-hours per year if electricity was produced at full capacity every day for an entire year. Although a 100 percent capacity factor would not be achievable, it provides a theoretical maximum number that can be used for air quality impact analysis and comparison.

6.5.3.1.1 Air Quality

Air quality impacts associated with construction of a utility-scale offshore project would be short term, intermittent, and limited to the duration of the construction project. Off-shore installation of a floating platform would not generate fugitive dust at the site of installation, but the construction project could result in land disturbances and related fugitive dust at nearby onshore construction-related areas, including locations where the offshore electrical lines connect with the onshore regional electric grid. Construction equipment, including marine vessels, which are powered by fossil fuels such as diesel or gasoline, would emit criteria pollutants, small amounts of hazardous air pollutants, and greenhouse gases during the duration of the construction project. Refer to Section 3.2.4 for common construction-related impacts to air quality from onshore construction.

Operation of an OTEC project would not be a large source of criteria pollutant emissions, although auxiliary diesel generators on the platform would be a source of emissions.

6.5.3.1.2 Climate Change

Operation of an OTEC project would not be a large source of greenhouse gas emissions, although auxiliary diesel generators on the platform would be a source of emissions. A replacement of about 440,000 megawatt-hours of electricity per year from the existing baseline electrical grid would reduce oil consumption from electricity generation by about 29 million gallons. On O‘ahu, the annual replacement of 440,000 megawatt-hours of electricity would correspond to an annual reduction in greenhouse gas emissions of about 320,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, the same annual replacement of 440,000 megawatt-hours of electricity usage would correspond to an annual reduction in greenhouse gas emissions of about 270,000 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity.

Scaled versions of a utility-scale project would produce linearly scaled impacts to air quality. For instance, a 5-megawatt project would replace electricity usage from the existing baseline grid by 10 percent of that of a 50-megawatt project. The corresponding reduction in greenhouse gases also would be 10 percent that of a 50-megawatt project. Air emissions during construction would also be proportional due to the decreased size and power transmission requirements of the system.

6.5.3.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures for general air quality and climate change impacts are discussed in Section 3.2.5.

6.5.4 WATER RESOURCES

This section addresses potential environmental consequences to water resources from construction and operation of an OTEC facility. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

6.5.4.1 Potential Impacts

The representative project is described as a 50-megawatt offshore OTEC facility and the project includes bringing the undersea power cable towards shore as far as the onshore land/sea cable transition site. Evaluations of potential impacts associated with an onshore land-sea cable transition project are addressed separately in Section 8.2.3. As a result of this project definition, there would be no onshore land actions or disturbances associated with the action and, accordingly, the discussion of impacts to surface water deals solely with marine waters.

6.5.4.1.1 Surface Water (Marine Water)

At the locations where the floating OTEC platforms would be anchored to the sea floor and along the route where the power cable would be buried, ocean sediments would be disturbed and dispersed to some degree. These dispersed sediments increase turbidity for at least some period of time and will settle out in different locations, possibly in areas of coral or other bottom communities of concern. Potential impacts to such communities would not only depend on whether they are present near the pipe installation path, but also whether they are periodically subjected to naturally occurring high turbidity. Devices such as silt curtains could be deployed in specific locations, but such devices often have limited effects, particularly if wave or current action is high at the site. Correspondingly, another mitigation measure normally considered would be to schedule such project activities during seasonal periods when wave, current, and wind would be expected to be low.

Activities in the navigable waters of the U.S. are regulated by the U.S. Army Corps of Engineers under Section 404 of the *Clean Water Act*. Accordingly, a Section 404 permit from the Corps of Engineers would likely be required for the seafloor disturbing activities. Any action that requires a Section 404 permit from the Corps of Engineers must also obtain certification from the State pursuant to Section 401 of the *Clean Water Act*. The certification dictates BMPs and monitoring and assessment plans to ensure project actions comply with State water quality standards. If there was any question about the applicability of a Section 404 permit, discussion with the Corps of Engineers would be the appropriate course of action.

During operation, the OTEC system would pull cold water from a depth of almost 3,300 feet below the surface, use it for cooling (via a heat exchanger), combine it with water taken from near the ocean surface, and return the combined water flow to a depth of about 200 feet below the surface. The combined flow back to the ocean is characterized as consisting of roughly 2 parts of near surface water to 1 part deep water. Although the process would return ocean water back to the ocean with no additives other than chlorine, there could still be issues with the discharge meeting water quality criteria for marine waters because the ocean water at 3,300 feet below the surface does not meet the criteria. A primary example would be nutrient levels as indicated by nitrite plus nitrate (NO_2 + NO_3) values. As shown in Figure 3-36, nitrite plus nitrate values at a depth of 3,300 feet would be about 40 micromoles per kilogram, which converts to about 560 micrograms per liter (as nitrogen). The water quality standard set by State regulation (HAR 11-54) for nitrite plus nitrate is 1.5 micrograms per liter (as nitrogen) in oceanic waters. (The standards also set higher concentrations not to be exceeded for specific percentages of the time.) The discharge from the OTEC system would be well over the standard even when combined with the near surface water, which has essentially none of the nutrients, and would be expected to be over the standard on a continuous basis. As indicted in Section 3.3.4.2, other parameters such as phosphate (PO_4) would be expected to have vertical distributions similar to that of nitrite plus nitrate nutrients; that is, there would be depleted or very low concentrations in the upper layers where photosynthesis takes place. The State water quality standards include criteria for total phosphorus (P), so it could also be an issue. Increased nutrient levels at depths where photosynthesis occurs could result in changes such as unusual algal blooms. Although algae is a normal component of marine life, increased density in an area has the potential to affect the existing balance of the area's ecosystem as well as recreational and other uses of the area. Changes in temperature and chlorine levels, as described below, could also affect existing conditions by other mechanisms (see Section 6.5.4 for potential impacts to biological resources).

The representative project describes chlorine applications being required only one hour per day at concentrations of 50 to 100 micrograms per liter, and only for the warm surface water. The State's standard for chlorine in any saltwater is 13 micrograms per liter as a maximum, acute level at any time and 7.5 micrograms per liter as chronic, long-term level not to be exceeded as an average over any 24-hour period. During the hour in which chlorine was applied, the discharges would exceed the acute standard even after being combined with the non-chlorinated deep water, but over a 24-hour period the average chronic level would be met. Other parameters would have to be similarly evaluated.

Temperature would also be an expected problem for the discharge because the ocean's surface mixing layer can vary from less than 100 to nearly 400 feet in thickness depending on the season (see Section 3.3.4.2). The temperature of the mixing layer is in the mid to upper 70s ºF, or higher, and as the thickness of that layer changes (by roughly 300 feet over the course of the year) the underlying thermocline position and gradient changes accordingly. The temperature of the water discharged from the OTEC facility would remain relatively constant, but at a depth of about 200 feet, it would be expected to be in and out of the mixing layer over the course of the year. As a result, it could not match the ocean temperature year-around. The State's water quality standard for oceanic waters is that temperature should not vary by more than one degree Celsius (or about two degrees Fahrenheit) from ambient conditions.

Were the OTEC discharge in State-regulated waters, a zone of mixing (per HAR 11-54-9) would have to be established and approved under the permitting process for the system's water discharge in order for the discharge to meet the State's water quality standards. The zone of mixing is a limited area around the discharge outfall where dilution would be allowed. The permit would then stipulate that applicable standards be met at the boundary of the zone of mixing. As part of the permitting process, the action proponent would likely have to design a diffuser system for the discharge outfall in order to minimize the size of the zone of mixing and perform modeling to demonstrate compliance could be achieved (with the specific diffuser design and proposed zone of mixing) under all reasonable conditions. At a distance of about 6 miles from shore, the primary permitting requirements for the OTEC facility would be a Federal responsibility. However, stipulations of the *Coastal Zone Management Act* and State certification requirements under Section 401 of the *Clean Water Act* would require that Federal permitting actions comply with State standards, including in this instance, State water quality standards. So it is reasonable to assume that the State's water quality limits and need for establishment of a zone of mixing would be part of the OTEC project requirements, whether as a direct State permit or as part of the Federal permit. Practical means of meeting water quality standards would likely be limited to actions such as designing a diffuser system as part of establishing a zone of mixing. Alternatives such as treating the water (for example, nutrient removal or temperature adjustment) before discharge would normally be a consideration, but at the scale (about 106,000 gallons per second) and location of water discharge required for the representative project, any treatment other than mixing would likely be impractical.

6.5.4.1.2 Groundwater

Construction of the representative project would not impact groundwater. The defined project in this instance would include no onshore actions.

During long-term operations of the OTEC, potential impacts to groundwater would be limited to the water needs to operate the offshore facilities. Since the fresh water would have to be transported by boat to the facilities, it is reasonable to assume these demands would be minor. Alternatively, the facility could include its own treatment (desalination) capabilities. In either case, the project would not be expected to have adverse impacts on water availability.

6.5.4.1.3 Floodplains and Wetlands

Since there would be no land activities associated with the representative project, there would be no potential for impacts to floodplains or wetlands

6.5.4.2 Best Management Practices and Mitigation Measures

As described above, discharges back to the ocean from the OTEC project would be expected to require a discharge permit with a zone of mixing stipulation because the discharge would not meet all water quality standards set for coastal waters. According to State Water Quality Standards (HAR 11-54), marine waters designated as class AA waters are not permitted to have zones of mixing under certain conditions. However, these conditions do not extend beyond depths of 59 feet where there is a defined reef or beyond 1,000 feet offshore if there is no defined reef area. The ocean depth requirements associated with the representative project would not allow it to be sited in the restricted areas. Other than offshore areas not meeting the physical requirements for an OTEC, there would be no sensitive locations or receptors with respect to impacts to water resources.

6.5.5 BIOLOGICAL RESOURCES

6.5.5.1 Potential Impacts

The floating OTEC system would be tethered to the seafloor with cable mooring lines and anchors. The anchors would create small disturbances during placement but the impacts are expected to be small and short term. The power plant would be anchored 3.5 miles offshore in deep water (at or greater than 3,500 feet deep) and would avoid more productive shallow marine habitats near shore. However, deepwater corals should be avoided to minimize impacts as these corals have slow growth rates and would take a long time to recover from either physical disturbance or impacts from sediment deposition caused by seafloor disturbances. An approximately 5-inch undersea power cable would be installed from the platform to an onshore land/sea cable transition site to deliver power and obtain power for the water pumps. The cable would cross deep and shallow marine habitats and the shoreline and would cause disturbances during construction. The specific habitats that would be impacted would depend on the specific installation location but could include marine pools, sandy and rocky beaches, seagrass habitat, shallow benthic communities, and coral reefs at multiple depths.

An undersea power cable could introduce an electromagnetic field (EMF) into the marine environment along the cable. This is a potential impact associated with all marine energy projects as power cables are needed to transmit power to land (see Section 3.4.5.2). However, the EMF is attenuated fairly quickly with distance from the cable (15 feet) and the potential impact is likely to be negligible (Normandeau et al. 2011).

The floating platform is a large structure (650 feet long). The structure could serve as an attractant to fish and potentially a surface for biofouling organisms. Large volumes of cold deep water (from about 3,200 feet) would be extracted and returned at a depth of 200 feet with a comparable temperature of the surrounding water. Even though the nutrient rich (i.e., nitrogen and phosphorus) deepwater would be mixed with the nutrient-poor surface water at a ratio of 2 to 1, the discharge water at 200 feet would still be relatively nutrient rich compared to the surrounding water. The surface mixing zone for the ocean can vary from 100 to 400 feet and the water temperature at the discharge point would not match the surrounding water throughout year. An influx of nutrient rich discharge water could create an area of increased marine productivity. How large of an effect nutrient enrichment could have on the marine ecosystem would depend on the surrounding marine communities, the volume of discharge water, and the rate of dilution and dispersal of nutrients in the larger volume of ocean water. How ocean microbes, and in turn other higher trophic levels, would respond to an influx of nutrients is an area of active research (http://cmore.soest.hawaii.edu/microbes.htm). With potential biofouling of the floating platform, influx of nutrient rich water, and possible attraction of marine fish and mammals to the in-ocean structures, a localized area of enhanced marine biological activity and productivity could develop. The increase in marine productivity would have a positive effect on the marine community. However, the attraction of marine organisms, including larger marine mammals, sea birds, and fish, to the area surrounding the floating platform and could expose them to hazards such as collisions with the mooring cables and above and below water platform structures or entrainment in the water intake pipes. The amount of chlorine used periodically to control biofouling on the heat exchangers would have negligible impact on water quality and would be effectively diluted.

The project would have large intake pipes (approximately 30-33 feet in diameter) for both cold deepwater and shallow warm water. These pipes could be an entrainment hazard for marine organisms depending on the volume and rate of water intake. Screening could be considered as a method to reduce the potential hazard to all but the smallest of organisms. The smaller life stages of various fish, invertebrates, and corals that float and disperse in ocean currents before settling on or in protective cover of sea floor substrates would be most susceptible to impact through entrainment in the intake flow. Although entrainment is a recognized potential hazard, more detailed analysis of the potential effects on populations of marine organisms cannot be meaningfully conducted until specific project locations are known.

The mooring lines represent a potential collision hazard to marine mammals. The probability that a whale or other marine mammal would strike a cable is very low. The cable mooring lines would remain taut and would not be an entanglement hazard to whales. No impacts would occur to the Hawaiian Islands Humpback Whale National Marine Sanctuary because the floating power system platform would be anchored in water depths much greater than those found in the sanctuary. Cable mooring lines could impact marine mammal migration corridors and habitats used for breeding, feeding, resting, and raising young. However, the potential impacts would depend on specific project locations in relation to migration corridors and habitats used for specific life history functions which should be considered during project site selection and evaluated in more detail during project development.

The above water structure of the floating platform could be an attractant to seabirds, particularly if there is an increase in marine fish and other marine life in the waters surrounding the platform. Any night safety lighting should be minimized and designed to not attract seabirds to minimize potential collisions with the above water structure.

6.5.5.2 Best Management Practices and Mitigation Measures

As noted above, deepwater corals should be avoided to minimize impacts to corals as corals have slow growth rates and a long recovery time.

In addition, night safety lighting should be minimized and designed to not attract seabirds and minimize potential collisions with the above water structure.

Other BMPs for marine ecosystems are identified in Section 3.4.6.2.

6.5.6 LAND AND SUBMERGED LAND USE

6.5.6.1 Potential Impacts

6.5.6.1.1 Land Use

The representative OTEC project would be a 50-megawatt, closed-cycle system located in deep water 3.5 miles offshore. A 650-foot-long floating platform with a 128-beam would be constructed. Onshore, a land/sea cable transition site would be required to connect to the electrical grid to power the pumps as well as to deliver the electricity produced.

6.5.6.1.2 Submerged Land Use

The installation of mooring lines and the electrical cable to the shoreline would have impacts to the sea floor and local marine habitat. A submerged lands lease would be required.

6.5.6.2 Best Management Practices and Mitigation Measures

Section 8.2.5 describes BMPs associated with the undersea power cable connecting the OTEC facility with the onshore power grid.

6.5.7 CULTURAL AND HISTORIC RESOURCES

6.5.7.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, floating, OTEC power project and associated onshore ancillary facilities if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.5.7.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.5.8 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawaiʻi Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.5.8.1 Potential Impacts

Development of the OTEC project could require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. The project would require a power cable from the floating platform to land. Depending on the location where the cable crosses the shoreline, the project could impact designated special management areas, restrict shorefront access, and affect shoreline erosion. However, these potential impacts would be evaluated and reviewed during the Federal consistency review.

6.5.8.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.5.9 SCENIC AND VISUAL RESOURCES

6.5.9.1 Potential Impacts

Significant visual impacts to viewers on the shoreline from the representative OTEC project are unlikely due to the distance from shore. A 1982 study found that if a platform was moored between 3 and 5 miles offshore and had a superstructure or components that extended 150 feet above the water, the facility would be visible from shore. However, the plant would appear much smaller than actual size and would probably be perceived as a ship coming over the horizon. The closer to shore the plant is moored, the more discernible the plant components would be and the plant would appear more visually intrusive (Hawai‘i 1982). It is likely that any safety or navigation lighting on the platform could be seen from shore at night.

Onshore, a land/sea cable transition site would be required to connect to the grid to power the pumps as well as to deliver the electricity produced. Section 8.2 analyzes potential impacts from land/sea cable transition sites. Construction of the transition site would take 24 months. Potential impacts to visual resources from construction activities are described in Section 3.8.3.

Long-term visual impacts onshore from the transition site would occur in the vicinity of the site. The representative transition site project analyzed in Section 8.2 is a converter station that would have a footprint of 6 acres and would be located 0.5 mile from the beach. The tallest structure would extend up to 40 feet above ground level.

6.5.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating an onshore transition site.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

BMPs to minimize impacts to visual resources, including those from lighting, are provided in Section 3.8.4.

6.5.10 RECREATION RESOURCES

6.5.10.1 Potential Impacts

Construction of the transition site would take 24 months. Potential impacts to recreation resources from construction activities are described in Section 3.9.4.

Long-term impacts to recreation would occur in the vicinity of the onshore and offshore facilities from access restrictions and potential visual impacts of the facilities.

6.5.10.2 Best Management Practices and Mitigation Measures

Sensitive locations such as recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating an OTEC project. In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards.

BMPs to minimize impacts to recreation resources, including those from lighting, are provided in Section 3.9.5.

6.5.11 LAND AND MARINE TRANSPORTATION

Impacts to land transportation considered potential effects on traffic, alterations to existing roads, requirement for additional roads (excluding temporary or project specific access roads) infrastructure. Impacts to marine transportation considered potential effects on operation of the harbor systems, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations.

6.5.11.1 Potential Impacts

6.5.11.1.1 Land Transportation

As identified in Table 6-7, there would be no potential impacts to land transportation from the representative OTEC project.

6.5.11.1.2 Marine Transportation

The representative OTEC project would require deployment of a large floating platform in deep water approximately 3.5 miles offshore that is tethered to the ocean floor with cables. Regardless of specific location, these projects are potential obstructions to marine navigation and would require review and possible marking under the U.S. Coast Guard’s Aids to Navigation System. Depending on distance from shore, these projects could affect navigation by tourist cruises, passenger ferries, fishing vessels (recreational and commercial), and large commercial cargo ships. Military marine operations, surface and submarine navigation, could potentially be affected by both floating and submerged structures.

6.5.11.2 Best Management Practices and Mitigation Measures

OTEC projects may require review and possible marking under the U.S. Coast Guard's Aids to Navigation System to minimize potential obstructions to marine navigation.

6.5.12 AIRSPACE MANAGEMENT

6.5.12.1 Potential Impacts

The above water structure of the OTEC project would extend about 150 feet above the ocean surface. Although this is below the 200 foot level for an aviation obstruction evaluation, the Departments of Defense and Homeland Security conduct many marine operations in the waters surrounding Hawai‘i including low elevation operations with helicopters. Many military operations may have linked marine surface and aviation operations. Because the OTEC could have impacts on marine transportation, potential impacts to airspace should be considered. Depending on the location of the project off of the coast, it could have potential impact on approach paths to airports.

6.5.12.2 Best Management Practices and Mitigation Measures

Potential impacts to airspace should be considered to minimize potential impacts on marine transportation. Typical construction and operations-related BMPs for airspace management are identified in Section 3.11.4.

6.5.13 NOISE AND VIBRATION

6.5.13.1 Potential Impacts

Short-term noise and vibration impacts would result from the construction of OTEC facilities. Noise sources from construction would include installation of an undersea power cable that would cross the shoreline using HDD drilling, a floating platform tethered to the seafloor with cable mooring lines and anchors, and installation of intake and effluent pipes. Offshore construction noise from equipment and vessels, and vibration caused by pile-driving, could exceed regulatory levels. Construction noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Further, according to the Incidental Harassment Authorization (77 FR 43259, July 24, 2012) exposure to elevated sound levels from vibratory and impact pile driving may result in temporary impacts to marine mammal hearing and behavior. However, in its Biological Opinion, the NMFS stated that it does not expect any takes of marine mammals by injury, serious injury, or mortality (NMFS 2012). Marine mammal prey species, such as fish, and sea turtles may also be temporarily impacted.

OTEC could potentially result in long-term noise and vibration impacts. Noise and vibration would result from operation of the pumps, turbine, heat exchanger, piping, and undersea cables. Mooring lines create what is called a “strum effect” from the current rushing past the mooring line and causing it to vibrate and hum (BOEM 2012). Sufficiently loud sounds can cause auditory injures to marine mammals and sea turtles, but it is not known whether hydrokinetic energy devices produce sounds capable of causing auditory injury.

6.5.13.2 Best Management Practices and Mitigation Measures

The following recommended BMPs could reduce the potential disturbances from noise and vibration (NMFS 2012):

- temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i);

- establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species or sea turtles);

- shutdown and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone);

- soft-start procedures (a technique that allows marine mammals or sea turtles to leave the immediate area before sound sources reach maximum noise levels);

- in-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving);

- visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during construction); and

- per Marine Mammal Protection Act implementing regulations at 50 CFR § 216.104 (a)(13), requests for Incidental Harassment Authorization must include monitoring and reporting plans.

Additional BMPs include the following:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Use equipment with sound-control devices. Equipment should be adequately muffled and maintained.
- In order to decrease the strum effect, place hydrodynamic foils on the upper half of the mooring line.

6.5.14 UTILITIES AND INFRASTRUCTURE

6.5.14.1 Potential Impacts

Effects on each island’s electric utilities would range from medium to large from the addition of 50 megawatts of power generation to any island’s overall power grid. For O‘ahu, with largest island net capacity of 1,756 megawatts, the change would be about 3 percent and for Kaua‘i with capacity of 125-megawatt the change would be about 40 percent (see section 3.13.1). A 50-megawatt facility for O‘ahu would be a small addition but may require some adjustment to the utility’s management of power on the grid and overall power production. The 40 percent increase for Kaua‘i would represent a large change, and it would require adjustment to grid power management and rescheduling of other current power generation capability on Kaua‘i. For the smaller grids, such as Lāna‘i or Moloka‘i, a 50 megawatt project would be too large and, if feasible, an alternative smaller project would need to be considered. Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable.

6.5.14.2 Best Management Practices and Mitigation Measures

For the smaller grids, such as Lāna‘i or Moloka‘i, a 50 megawatt project would be too large and, if feasible, an alternative smaller project would need to be considered. BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see 3.13.4).

6.5.15 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.5.15.1 Potential Impacts

6.5.15.1.1 Hazardous Materials

The OTEC facility would use and store both ammonia, the working fluid for thermal energy conversion, and chlorine gas or liquid to prevent biofouling and maintain the efficiency of the heat exchangers in the OTEC. In addition, a large amount of polyester resin will be used during construction. All of these compounds are considered hazardous materials in industrial quantities (NELHA 2012).

Prior to construction, it is recommended that the proposed project locations be investigated to identify possible hazardous materials that may be present at the proposed development locations. In the event that the project location is sited in a contaminated site (including MEC sites), abatement and remediation activities would be required before construction can occur by trained and certified professionals or a new site location should be selected.

Short-term hazardous material exposure impacts could result from the construction of a 50-megawatt utility-scale closed-cycle offshore OTEC facility. Construction activities would involve the use of hazardous materials such as fuels, oils, solvents, and glues as well as polyester resins (similar to surfboard resin) for bonding. In addition, inadvertent spills could occur during onsite fueling of equipment or by accident (for example, a puncture of a fuel tank through operator error or slope instability). Therefore, the use of hazardous materials would be required to comply with developed site-specific BMPs related to fueling, use, and storage of chemicals to minimize any risk to workers or the public. Transport, use, and disposal of these materials are regulated along with maximum permissible exposure to workers. The concentrations of vapors are likely to be noticeable depending on wind speed and direction during the construction period. Additional discussion of general hazardous material exposure impacts during construction are discussed in Section 3.14.4.

Long-term hazardous material exposure impacts could occur from the operation of a 50-megawatt offshore OTEC facility. Ammonia would alternate between a liquid and gas state inside the power block of the facility and would be stored in a storage tank. No perceptible releases of ammonia to the water or atmosphere are expected under normal operating conditions. If a leak were to occur in the heat exchangers, the ammonia would dissolve in seawater but it is unlikely that significant concentrations of ammonia would be released into the atmosphere. An ammonia leak in other machinery outside of the heat exchangers is less likely because of design safety standards; however, pressurized ammonia leaking into air spaces would result in an airborne plume that may be hazardous (NELHA 2012). The OTEC facility would be monitored for ammonia leaks during operation. Toxic levels for ammonia exposure are 200 ppm according to the U.S. EPA. A Risk Management Program and Emergency Management Plan would be developed, approved and implemented prior to delivery of ammonia.

Because of the intermittence and reactivity of chlorine in seawater, residual chlorine is expected to be negligible at the time of discharge from the system and effluent seawater is not anticipated to result in adverse effects. Biofouling tests at NELHA demonstrated that microbial film production on heat exchanger surfaces is controlled by chlorination at levels roughly one order of magnitude lower than is required in temperate waters and that free and combined chlorine-produced oxidants are significantly more persistent in subtropical than in temperate waters, thus requiring a lower dosage to achieve the desired effects (NELHA 2012). Chlorine would be stored in pressurized cylinders located in an enclosed facility away from workers. Spills or leaks of chlorine are most likely to occur during delivery or cylinder change. Unlike ammonia, chlorine gas is 2.5 times heavier than air and in a worst case scenario, chlorine gas is not likely to represent a hazard due to the limited quantities stored and characteristically slow dispersal. Although chlorine is not flammable, it can combine with other substances, particularly gaseous ammonia, to cause fires or explosions (NELHA 2012).

Operation of a utility-scale OTEC facility would involve the use of hazardous materials such as fuels, oils, solvents, and glues. In addition, inadvertent spills could occur during onsite fueling of equipment or by accident (for example, a puncture of a fuel tank through operator error or slope instability). Therefore, the use of hazardous materials onsite would be required to comply with developed site-specific BMPs related to fueling, vehicle washing and handling, use, and storage of chemicals to minimize any risk to workers or the public.

6.5.15.1.2 Waste Management

Common waste management impacts are identified Section 3.14. Long-term waste management impacts would not be expected from the operation of an OTEC facility.

6.5.15.1.3 Wastewater

Minimal to no wastewater impacts would likely result from construction personnel and during project operations. The project would require no additives other than minimal amounts of chlorine. However, there may still be issues meeting wastewater quality discharge requirements. As such, the project would likely incorporate BMPs to meet water quality standard limits and OTEC project requirements such as a zone of mixing, whether required by the State or as part of the Federal permit requirements. Additional discussion is provided in Section 6.5.3 Water Resources of this Section.

6.5.15.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater are discussed in Section 3.14.5.

6.5.16 SOCIOECONOMICS

6.5.16.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from a 50-megawatt OTEC operation would be very small. The deep water pipe, heat exchangers, floating platform and the related apparatus would likely be manufactured outside the State and, if so, economic benefits associated with the manufacturing would accrue elsewhere. The number of temporary construction jobs would be relatively small. Jobs directly associated the project would be likely filled by individuals residing within the area of influence (the State of Hawai‘i) and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.5.16.2 Best Management Practices and Mitigation Measures

None noted.

6.5.17 ENVIRONMENTAL JUSTICE

6.5.17.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative OTEC project are expected to be small. The potential for environmental justice impacts also would be small.

6.5.17.2 Best Management Practices and Mitigation Measures

Any OTEC project site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.5.18 HEALTH AND SAFETY

6.5.18.1 Potential Impacts

There would be the potential for exposure to chlorine and ammonia gases on the operating platform of the OTEC facility. BMPs would be implemented to ensure the safe handling, use, and storage of these hazardous materials. Other standard industrial hazards are identified in Section 3.17.3

6.5.18.2 Best Management Practices and Mitigation Measures

BMPs would be implemented to ensure the safe handling, use, and storage of hazardous materials. Common BMPs for protection of workers and the public from standard industrial hazards are identified in Section 3.17.5

6.6 Photovoltaic (PV) Systems

The representative utility-scale PV project involves a facility with 5 megawatts of generating capacity that ties directly into the electrical distribution grid and has a footprint of approximately 25 acres with about 20,000 solar modules (see Section 2.3.3.7.4).

Table 6-8 present a summary of the potential environmental impacts for the representative utility-scale PV project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts from land disturbance/soil erosion. See Section 3.1.3. No operational impacts.	Same as those common across construction projects. See Section 3.1.4.

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4 No operational impacts.	Same as those common across construction projects. See Section 3.2.4.
Climate Change	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	None.
Water Resources		
Surface Waters	General construction impacts. See Section 3.3.5. Potential stormwater runoff from the site (dependent on the amount of impermeable surface/nature of the pre-construction site).	Same as those common across construction projects. See Section 3.3.6. Management of stormwater runoff may be included in project design as needed, including but not limited to collection ditches or stormwater detention ponds to control the rate of flows from the site.
Groundwater	General construction impacts. See Section 3.3.5 Potential changes in runoff to the site and potential associated change in groundwater recharge.	Same as those common across construction projects. See section 3.3.6
Floodplains and Wetlands	Potential impacts during construction (site-specific). See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6. To the extent feasible, the project shall avoid floodplains and wetlands areas during project siting.
Biological Resources		
	General construction impacts. See Section 3.4.5 Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	Same as those common across construction projects. See Section 3.4.6 Site selection that avoids known locations of sensitive biological resources or high value habitats should be considered to reduce potential impacts.

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	Potential land use impacts including land disturbance and possible conversion of undeveloped land and land in other current use to an energy generating facility. Potential change in land ownership patterns and/or easements required for the project (i.e., project site, access roads, corridors to the nearest electrical grid). Potential impacts to adjacent land uses (roads, residential/commercial areas, historic sites, scenic locations, and airports) from the glint and glare of the solar panels.	Consider State land use designations and county overlay zones in locating the project site.
Submerged Land Use	None; PV projects would be land-based and not impact submerged land uses.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General visual impacts during construction. See Section 3.8.3. Potential long-term visual impacts from solar panels, including in association with new facilities and associated buildings. Potential glinting, glare, and visual effects depending on the panel orientation, sun angle, viewing angle, viewer distance, and other visibility factors; may also be dependent on individual viewer sensitivity. Potential long term visual effects from routine maintenance activities.	Same as those common across construction projects. See Section 3.8.4. Solar facilities should be sited and designed to ensure that glint and glare do not have significant effects on roadway users, nearby residences, commercial areas, or other highly sensitive viewing locations. Sensitive viewing locations include areas with historic significance where aesthetics play and important role in an area’s long-established character and areas valued for their lack of man-made intrusions, such as National and State parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves.

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		The Bureau of Land Management has outlined the following measures as BMPs to minimize the visual impacts from utility-scale PV systems (BLM 2013): • Site and operate the modules to avoid offsite glare • Screen solar modules to avoid offsite glare with fencing, berms, or vegetation • Use and maintain non-reflective or color-treated backs and support structures to decrease visual contrast • Avoid complete removal of vegetation beneath the modules or consider re-vegetation consistent with facility operations and safety considerations • Prohibit commercial messages and symbols on the modules. • The Federal Aviation Administration and the Hawaiʻi Department of Transportation, Airports Division requires review of all PV projects sited near active airports to ensure panel glare does not interfere with nearby aircraft.
Recreation Resources		
	General construction impacts. See Section 3.9.4. Potential long-term recreation resource impacts such as land cover required for the arrays and associated facilities required for the project resulting in access restrictions to area as well as visual impacts created by the presence of the facilities and maintenance activities. Potential impacts to nearby recreation areas from panels and other components that reflect and result in glinting, glare, and other visual effects.	Same as those common across construction projects. See Section 3.9.5. Solar facilities should be sited and designed to ensure that glint and glare do not have significant effects on nearby recreational users. Popular recreation areas are listed in Appendix A of the State Comprehensive Outdoor Recreation Plan.
Land and Marine Transportation		
	None; installation and operation of a utility-scale PV system would not impact land or marine transportation.	N/A

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Airspace Management		
	Potential hazards to aircraft and pilots from sunlight reflection; dependent on the magnitude of reflection (glint and glare) from solar power systems.	The Federal Aviation Administration and the Hawaiʻi Department of Transportation, Airports Division requires review of all PV projects sited near active airports to ensure panel glare does not interfere with nearby aircraft.
Noise and Vibration		
	General impacts during construction and operation. See Section 3.12.5.	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
	General construction impacts. See Section 3.13.3.1. Potential minimal impacts to electric utilities (site-specific).	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General impacts during construction and operation. See Section 3.14.4. Potential exposure to trace amounts of hazardous materials (i.e., cadmium, selenium, arsenic) if panels were broken.	Same as those common across construction projects. See Section 3.14.5. Hazardous materials must be stored, handled, and disposed of at the appropriate hazardous waste facility.
Waste Management	General impacts during construction and operation. See Section 3.14.4. Potential hazardous waste impacts resulting from trace amounts of cadmium, selenium, or arsenic if solar panels are broken and/or during solar panel decommissioning/disposal.	Same as those common across construction projects. See Section 3.14.5. To the extent feasible, recover and reuse components of PV modules, such as glass, aluminum, and semiconductor materials, either for new PV modules or other products.
Wastewater	Potential impacts from wastewater discharge resulting from disposal of PV modules at their end-life, particularly from potential leaching or contamination from cadmium containing materials.	Solar modules would require proper handling and transport for disposal at the appropriate hazardous waste facility to ensure that no hazardous wastes are disposed of at landfills nor enter the waste stream.
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.

Table 6-8. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – PV Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Environmental Justice		
	Small potential impacts to the general population. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3	Same as those common across construction projects. See Section 3.17.5

6.6.1 GEOLOGY AND SOILS

6.6.1.1 Potential Impacts

Effects on geology and soils from construction of a 5-megawatt solar photovoltaic (PV) would be the same as those expected for common construction actions as described in Section 3.1.3. Since the amount of land disturbed would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable.

Operation of the PV facility would not involve activities that would have the potential to affect geology and soils of the area.

6.6.1.2 Best Management Practices and Mitigation Measures

During construction, precautionary measures should be implemented (for example, response plans, cleanup equipment, secondary containment, etc.) to minimize the potential for on- or offsite soil contamination.

6.6.2 CLIMATE AND AIR QUALITY

6.6.2.1 Potential Impacts

6.6.2.1.1 Air Quality

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

Operation of a photovoltaic project would not be a source of criteria pollutant emissions.

6.6.2.1.2 Climate Change

Operation of a photovoltaic project would not be a source of greenhouse gas emissions. Assuming a 20 percent capacity factor, the project would generate about 8,800 megawatt-hours per year and could replace electricity requirements from the existing baseline electrical grid by that same amount. A replacement of 8,800 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 580,000 gallons. On Oʻahu, the annual replacement of 8,800 megawatt-hours of electricity would correspond with an annual reduction in greenhouse gas emissions of about 6,400 metric tons CO2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, an annual replacement of 8,800 megawatt-hours of electricity usage would see an annual reduction in greenhouse gas emissions of about 5,400 metric tons CO2 equivalent due to a cleaner mix of technologies used to produce electricity on the other islands.

6.6.2.2 Best Management Practices and Mitigation Measures

The common BMPs for air quality are identified in Section 3.2.5.

6.6.3 WATER RESOURCES

6.6.3.1 Potential Impacts

This section addresses potential environmental consequences to water resources from construction and operation of a utility-scale PV project. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

6.6.3.1.1 Surface Water

Effects on surface water during construction of the PV project would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations of the PV facility there would be no activities that would have the potential to affect surface waters other than possibly changing the quantities of stormwater runoff from the site as a result of changes in the characteristics of the surface areas. Whether the constructed site would include more or less impermeable surfaces would depend on the nature of the pre-construction site. If the runoff volume were increased, its management would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

6.6.3.1.2 Groundwater

Effects on groundwater during construction of the PV project would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations of the PV facility there would be no activities that would have the potential to affect groundwater other than possible changes in runoff from the site (as described previously) and potentially an associated change in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility goes or how it is managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge.

6.6.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale, PV project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

6.6.3.2 Best Management Practices and Mitigation Measures

Consideration of sensitive locations or receptors with regard to construction and operations of a PV facility would be the same as described for common construction projects in Section 3.3.5. Common BMPs for the protection of water resources are identified in Section 3.3.6.

6.6.4 BIOLOGICAL RESOURCES

This section addresses environmental consequences to biological resources. Potential impacts are addressed in terms of terrestrial vegetation and wildlife habitat, threatened and endangered plant and animal species, designated critical habitat, and high value biological resources such as wetlands and protected land areas considering the type, intensity, duration and physical extent of potential impacts.

6.6.4.1 Potential Impacts

Installation of a solar PV power plant would require clearing approximately 5 acres for each megawatt of capacity. A representative 5-megawatt capacity plant would require clearing approximately 25 acres to install the panels of PV cells and associated infrastructure. The amount of land required for larger capacity plants would increase proportionally. The primary impact to biological resources would be from clearing of vegetation and loss of wildlife and their habitat. Photovoltaic projects are best installed in areas with relatively flat terrain and abundant solar radiation. Those conditions are generally found at lower elevations, and particularly on the leeward side of the islands. Therefore, most of the native vegetation, threatened and endangered species, and protected land areas, including critical habitat that are found at mid- to upper elevation areas where topography is generally steeper and solar radiation is lower would be avoided. However, important biological resources occur at lower elevations and depending on specific project locations, impacts from habitat loss could occur to migratory birds, threatened and endangered plant and animals, critical habitat, protected land areas, and wetlands from site development. Project locations near the ocean may also include marine anchialine pools that may occur several hundred meters inland.

6.6.4.2 Best Management Practices and Mitigation Measures

During project siting, known locations of sensitive biological areas or high value habitats should be avoided to reduce potential impacts to biological resources. Common BMPs for biological resources are identified in Section 3.4.6.1.

6.6.5 LAND AND SUBMERGED LAND USE

This section discusses the potential environmental consequences to land use from a utility-scale photovoltaic system.

6.6.5.1 Potential Impacts

6.6.5.1.1 Land Use

The 5-megawatt representative project would require approximately 25 acres to be cleared and prepared for the installation of the solar panels. A utility-scale PV facility may include the following: an administration building, maintenance building, component assembly building, guardhouse, and other small structures. In some cases, some of the buildings could be located offsite. The site could also need road access, if not existing. There would also be a need for a corridor to tie-in the solar farm to the existing transmission grid. This representative project assumes no energy storage technologies are required.

Land use impacts would include the amount of land disturbed, and the possible conversion of undeveloped land and land in other current use to an energy generating facility. Land ownership patterns could also change or land use easements could be required for the solar site, access roads, and corridors to the nearest electrical grid.

State land use designations and county overlay zones would be considered in locating the facility.

6.6.5.1.2 Submerged Land Use

There would be no impacts to submerged land use.

6.6.5.2 Best Management Practices and Mitigation Measures

None noted.

6.6.6 CULTURAL AND HISTORIC RESOURCES

6.6.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, PV power project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.6.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.6.7 COASTAL ZONE MANAGEMENT

6.6.7.1 Potential Impacts

Development of a solar PV energy project could require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. Impacts to special management areas, shorefront access, and shoreline erosion would depend on the location of the solar photovoltaic project. However, these potential impacts would be evaluated and reviewed during the Federal consistency review.

6.6.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.6.8 SCENIC AND VISUAL RESOURCES

6.6.8.1 Potential Impacts

For the 5-megawatt representative project, approximately 25 acres would be cleared and prepared. Potential impacts to visual resources from construction activities are discussed in Section 3.8.3.

Long-term visual impacts would result from the solar arrays covering approximately 25 acres of land. PV facilities do not require infrastructure associated with heating, transporting, boiling, and cooling water and other heat transfer fluids. However, a utility-scale PV facility may include one or more of the following: administration building, maintenance building, component assembly building, guardhouse, and other small structures. In some cases, these buildings may be located offsite. PV modules are not designed to reflect light and therefore have less potential for glint and glare than the mirrored surfaces of parabolic troughs (see Section 6.7.7). However, the arrays and other components would reflect light that may result in glinting, glare, and other visual effects that would vary depending on module orientation, sun angle, viewing angle, viewer distance, and other visibility factors.

Geometric patterns of reflected light can be caused by simultaneous reflection of sunlight from regularly spaced metal surfaces in the gaps between the PV modules. These reflections would not be bright enough to cause discomfort; however they may cause visual contrast and change as the observer moves (Sullivan et al. 2012). The degree of contrast would be dependent on viewer position with respect to the facility, lighting, and sun angle. The arrays of PV facilities have appeared black, through a range of blues, to white. These color shifts can cause increases in visual contrast (Sullivan et al. 2012). The degree of contrast has also been found to be much greater from elevated viewpoints. Because the arrays generally have very low vertical profiles, when viewed from the valley floor or other low-elevation viewpoints, the arrays may blend in with the typically strong horizon line (Sullivan et al. 2012). In general, PV projects have lower visual impacts than other solar technologies because of the low profile of the arrays and the lower reflectivity of the PV panels compared to the highly reflective mirrors used by other technologies, for example, parabolic troughs (see Section 6.7.7).

Long-term visual impacts would also occur from routine maintenance activities, such as washing the solar module surfaces, road and building maintenance, and repairs. Washing the surfaces could occur at night and may require vehicle-mounted lights.

Viewer sensitivity to the solar panels would likely depend on the individual. Individuals that view solar power and renewable energy favorably would be less likely to view the impacts of the project in a negative manner.

Short-term and long-term visual impacts for a project larger than the representative project would be as described above for but would be in a larger area in proportion to the increase in size of the project. The visual impacts of glinting, glare, geometric patterns, color shifts, and visual contrast would be of greater magnitude with the larger area of solar panels.

6.6.8.2 Best Management Practices and Mitigation Measures

Solar facilities should be sited and designed to ensure that glint and glare do not have significant effects on roadway users, nearby residences, commercial areas, or other highly sensitive viewing locations. Sensitive viewing locations include areas with historic significance where aesthetics play and important role in an area’s long-established character and areas valued for their lack of man-made intrusions, such as National and State parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves.

BMPs to minimize impacts to visual resources are addressed in Section 3.8.4. The Bureau of Land Management has outlined the following measures as BMPs to minimize the visual impacts from utility-scale PV systems (BLM 2013):

- Site and operate the modules to avoid offsite glare
- Screen solar modules to avoid offsite glare with fencing, berms, or vegetation
- Use and maintain non-reflective or color-treated backs and support structures to decrease visual contrast
- Avoid complete removal of vegetation beneath the modules or consider revegetation consistent with facility operations and safety considerations
- Prohibit commercial messages and symbols on the modules

In addition, the Federal Aviation Administration and the Hawaiʻi Department of Transportation, Airports Division requires review of all PV projects sited near active airports to ensure panel glare does not interfere with nearby aircraft.

6.6.9 RECREATION RESOURCES

6.6.9.1 Potential Impacts

For the 5-megawatt representative project, approximately 25 acres would be cleared and prepared. Potential impacts to recreation resources from construction activities are discussed in Section 3.9.4.

Long-term impacts to recreation resources could result from the arrays covering approximately 25 acres of land, from access restrictions to the area, and as visual impacts created by the presence of the facilities and maintenance activities. PV panels are not designed to reflect light and therefore have less potential for glint and glare than the mirrored surfaces of parabolic troughs (Section 6.7.7). However, the panels and other components would reflect light that may result in glinting, glare, and other visual effects that could affect nearby recreation areas. Impacts would vary depending on panel orientation, sun angle, viewing angle, viewer distance, and other visibility factors. Visual impacts of PV solar facilities are described in more detail in Section 6.6.7.

6.6.9.2 Best Management Practices and Mitigation Measures

Solar facilities should be sited and designed to ensure that glint and glare do not have significant effects on nearby recreational users. Popular recreation areas are listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan*.

BMPs to minimize impacts to recreation resources are addressed in Section 3.9.5.

6.6.10 LAND AND MARINE TRANSPORTATION

As identified in Table 6-8, there would be no potential impacts to land or marine transportation from the representative utility-scale PV project.

6.6.11 AIRSPACE MANAGEMENT

6.6.11.1 Potential Impacts

Solar PV power systems are low in profile and do not pose an obstruction hazard to airspace. Sunlight reflection (glint and glare) from solar power systems is a potential hazard to aircraft and their pilots. The potential impact is related to the magnitude of the reflection. Solar photovoltaic panels typically have a low reflection because they are designed to absorb as much sunlight as possible for conversion into electricity. Therefore, impacts to airspace from the development of solar photovoltaic power plants are expected to be minor.

6.6.11.2 Best Management Practices and Mitigation Measures

Proponents should coordinate with the FAA during the siting process to ensure that any potential impacts to nearby airports or flight paths are minimized.

6.6.12 NOISE AND VIBRATION

6.6.12.1 Potential Impacts

Construction of the representative PV project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

Long-term noise and vibration impacts from operation of photovoltaic would be minimal and limited to maintenance activities.

6.6.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

6.6.13 UTILITIES AND INFRASTRUCTURE

6.6.13.1 Potential Impacts

Potential impacts on each island’s electric utilities would typically be small from the addition of 5 megawatts of power generation to any island’s overall power grid. For O‘ahu, with largest island net capacity of 1,756 megawatts, the change would be about 0.3 percent and for Kaua‘i with a net capacity of 125 megawatts the change would be about 4 percent (see section 3.13.1). Higher percentage change increases the likelihood that the affected island utility would need to adjust management of power on the grid and overall power production. For the smaller grids, such has Lāna‘i or Moloka‘i, a 5 megawatt project would be large and a smaller project should be considered. Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable. Because of the lower capacity factors for solar power (approximately 20%), utilities would need to also implement energy storage technologies or arrange for other base load power sources in times when solar power is not being generated (e.g., night).

6.6.13.2 Best Management Practices and Mitigation Measures

BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see 3.13.4).

6.6.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.6.14.1 Potential Impacts

6.6.14.1.1 Hazardous Materials

General hazardous material impacts that could occur prior to and during the installation of a PV system are discussed in Section 3.14.4.

Project operations are not anticipated to require hazardous materials that could be spilled or released to the environment. Some solar panels may contain trace amounts of cadmium, selenium, and arsenic which could be hazardous if broken. As such, these hazardous materials must be stored, handled, and disposed of at the appropriate hazardous waste facility. Hazardous materials exposure impacts may result at the end-of-life of the photovoltaic system during disposal. However, these would be secondary waste management impacts.

6.6.14.1.2 Waste Management

General waste management impacts that could occur prior to and during the installation of a PV system are discussed in Section 3.14.4.

Project operations are not anticipated to result in waste management impacts. Some solar panels may contain trace amounts of cadmium, selenium, and arsenic which could be hazardous if broken. Such panels would be deemed hazardous and would need to be handled and disposed of at the appropriately permitted hazardous waste facility.

Potential impacts would result from the disposal of the photovoltaic system at its end-life. As discussed in Section 4.3, Solar Water Heating, it is anticipated that most components of PV modules such as glass, aluminum, and semiconductor materials would be successfully recovered and reused either for new PV modules or other products. However, some PV systems may need to be managed and disposed of as hazardous waste resulting in potential impacts. In particular, the manufacturing, decommissioning and disposal of some PV modules (some thin film PV products) may involve cadmium. Cadmium is a heavy metal that is considered a probable carcinogen in humans and animals and can accumulate in plant and animal tissues. While cadmium does not pose health risks when a PV module is in operation, the production of some PV modules can result in waste sludge[1] and cadmium contaminated wastewater which would need to be properly disposed of at the appropriate hazardous waste facility. Although PV modules are not anticipated to be manufactured in the State, proper disposal of some PV modules at the appropriate hazardous waste facility would be required at its end-life, to ensure no leaching or contamination from cadmium occurs.[2]

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[1] Sludge is defined by the EPA as a semisolid residue from air or water treatment processes (Source: Risk Assessment Glossary, Available online at: http://www.epa.gov/oswer/riskassessment/glossary.htm; EPA 2012b). During the production of PVs, toxic sludge can be created when metals and other toxins are removed from the water used during the manufacturing process, and is classified as hazardous waste.

[2] In order to be deemed ‘hazardous’ by regulators, decommissioned or defective solar panels must fail to meet the US Environmental Protection Agency (EPA) Toxicity Characteristic Leaching Procedures (TCLP) standards in accordance with the RCRA.

6.6.14.1.3 Wastewater

Minimal to no wastewater impacts would be expected from the installation and operation of a solar farm. Some wastewater may be produced during maintenance from personnel and machinery operations. However these would be minor and limited. Industrial wastewater discharge would be regulated by NPDES wastewater discharge permit requirements.

Potential impacts may result during the production of the PV modules as the production of some PV modules can result in cadmium contaminated wastewater which would need to be properly disposed of at the appropriate hazardous waste facility. Although PV modules are not anticipated to be manufactured in the State, proper disposal of some PV modules at the appropriate hazardous waste facility would be required at its end-life, to ensure no leaching or contamination from cadmium occurs. As such, solar modules would require proper handling and transport for disposal at the appropriate hazardous waste facility to ensure that no hazardous wastes are disposed of at landfills and that hazardous wastes do not enter the waste stream.

6.6.14.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater are discussed in Section 3.14.5.

6.6.15 SOCIOECONOMICS

6.6.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from the installation of PV modules to generate 5 megawatts of utility-scale electricity would be very small. Jobs directly associated the installation of the PV modules and the maintenance of the system would be very small. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.6.15.2 Best Management Practices and Mitigation Measures

None noted.

6.6.16 ENVIRONMENTAL JUSTICE

6.6.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the PV system are expected to be small. The potential for environmental justice impacts also would be small.

6.6.16.2 Best Management Practices and Mitigation Measures

Any utility-scale PV project site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.6.17 HEALTH AND SAFETY

6.6.17.1 Potential Impacts

Common health and safety impacts for typical construction and operations activities are identified in Section 3.17.3. There are no additional potential health and safety risks that would be unique to PV projects.

6.6.17.2 Best Management Practices and Mitigation Measures

Common health and safety BMPs for typical construction and operations activities are identified in Section 3.17.5.

6.7 Solar Thermal Systems

The representative solar thermal project would be a parabolic trough facility with 5-megawatt capacity on 20 to 45 acres of land (see Section 2.3.3.8.4). The construction and operation of solar modules and support structures would be confined to that acreage and spaced to avoid shading the panels.

Table 6-9 present a summary of the potential environmental impacts for the representative solar thermal project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts;. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts from land disturbance. See Section 3.1.3. Potential for soil contamination in the event of a leak or accidental release of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	Same as those common across construction projects. See Section 3.1.4. Monitor during operations to quickly identify and respond to any leaks or accidental releases of heat transfer fluids, including stopping the spill or release and cleaning up any soil contamination.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. No operational impacts.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Potential greenhouse gas emissions reduction from a mix of different technologies used to produce electricity.	None.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Waters	General construction impacts. See Section 3.3.5. Potential stormwater runoff contamination in the event of leaks or accidental releases of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system.	Same as those common across construction projects. See Section 3.3.6. Management of stormwater runoff may be included in project design as needed, including but not limited to collection ditches or stormwater detention ponds to control the rate of flows from the site. Monitor during operations to quickly identify and respond to any leaks or accidental releases of heat transfer fluids, including stopping the spill or release and cleaning up any soil contamination.
Groundwater	Minor groundwater impacts during construction. See Section 3.3.5. Potential changes in runoff to the site and potential associated change in groundwater recharge.	Same as those common across construction projects. See Section 3.3.6. If necessary, the project should include onsite measures such as a stormwater detention pond to control the rate at which stormwater leaves the site.
Floodplains and Wetlands	Potential impacts during construction (site-specific). See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6. To the extent feasible, the project shall avoid floodplains and wetlands areas during project siting.
Biological Resources		
	General construction impacts. See Section 3.4.5. Potential impacts to biological resources including migratory birds, threatened and endangered plants and animals, critical habitat, protected land areas, and wetlands) from habitat loss during site development (site-specific). For locations near the ocean, potential impacts may occur to marine anchialine pools.	Same as those common across construction projects. See Section 3.4.6. Site selection that avoids known locations of sensitive biological resources or high value habitats should be considered to reduce potential impacts.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	Potential change in land ownership patterns through purchase and or land use leases for both the solar thermal project site and any linear corridors required to tie in to the existing electrical grid. Potential impacts to undeveloped land or land currently used for other uses could be converted to energy uses.	Consider State land use designations and county overlay zones in locating the project site.
Submerged Land Use	None; solar thermal projects would be land-based and not impact submerged land uses.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific); Potential for adverse impacts to those locations near the shoreline. Potential for increase in runoff and sedimentation and impacts to coastal water habitats from land clearing.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General visual impacts during construction. See Section 3.8.3. Potential long-term dynamic visual impacts from parabolic troughs/mirrors (glare/ reflected light), thermal storage tanks, steam condenser, cooling towers (plumes) and generator as well as road access, parking, maintenance facilities, and transmission line tie-in. Potential for individual discomfort from glare effects, depending on viewer sensitivity, viewer location, viewer movement, and time of day.	Same as those common across construction projects. See Section 3.8.4. During project siting, the project shall consider sensitive locations. The facility should be sited away from roads and trails to avoid causing offsite glare that may cause annoyance and visual discomfort. The project shall consider effects on views from nearby mountains, where elevated observation points would afford open views of solar module fields, as well as potential impacts on the dark night skies that are valued scenic and tourist resources.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential increase in light pollution impacts (skyglow, light trespass, and glare) from security lighting and other exterior lighting around buildings, parking areas, work areas and during maintenance activities (vehicle-mounted lights).	The Bureau of Land Management has outlined the following measures as BMPs to minimize the visual impacts from utility-scale solar projects (BLM 2013): • Use dry cooling technology to avoid water vapor plumes • Site and operate the modules to avoid offsite glare. • Screen solar modules to avoid offsite glare with fencing, berms, or vegetation. • Use and maintain non-reflective or color-treated backs and support structures to decrease visual contrast. • Avoid complete removal of vegetation beneath the modules or consider revegetation consistent with facility operations and safety considerations. • Prohibit commercial messages and symbols on the modules. Give consideration to each of the six islands general land use plans and associated implementation tools such as zoning ordinances and development standards related to protecting and maintaining open space and scenic resources. The Federal Aviation Administration and the Hawai‘i Department of Transportation, Airports Division requires review of all solar projects sited near active airports to ensure glare does not interfere with nearby aircraft.
Recreation Resources		
	General construction impacts. See Section 3.9.4. Potential long-term impacts to recreation resources from access restrictions to the site and visual impacts associated with the new facilities. See Section 6.7.8 regarding visual effects of solar thermal facilities.	Same as those common across construction projects. See Section 3.9.5. Sensitive locations such as recreation areas listed in Appendix A of the State Comprehensive Outdoor Recreation Plan should be considered when locating a utility-scale solar thermal system.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential impacts to recreation resources from light pollution, particularly those areas where a dark night sky is valued (i.e., campgrounds).	The project shall consider effects on views from nearby mountains, where elevated observation points afford open views of solar module fields, as well as potential impacts on the dark night skies that are valued recreation resources (for example, camping) during project development.
Land and Marine Transportation		
Land Transportation	Potential short-term transportation impacts associated with construction traffic.	None.
Marine Transportation	None; installation and operation of a solar thermal system would not have any marine transportation impacts as it would be totally land-based.	N/A
Airspace Management		
	Potential hazards to both military and civilian aircraft from reflections of the concentrated solar power (CSP) facility. Potential air turbulence hazards to both military and civilian aircraft (likely limited to low altitude aircraft i.e., helicopters or during take-offs and landings) from CSP plants employing a dry cooling system.	Project locations should be evaluated in relation to surrounding airspace to minimize potential hazards to both military and civilian aircraft.
Noise and Vibration		
	General impacts during construction and operation. See Section 3.12.5.	Same as those common across construction projects. See Section 3.12.6.
Utilities and Infrastructure		
	General construction impacts. See Section 3.13.3.1. Potential minimal impacts to electric utilities (site-specific).	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.

Table 6-9. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Solar Thermal Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.
Environmental Justice		
	Minimal potential for environmental justice impacts due to small environmental impacts to general population.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3	Same as those common across construction projects. See Section 3.17.5

6.7.1 GEOLOGY AND SOILS

6.7.1.1 Potential Impacts

The representative project would require approximately 1 mile of onshore transmission lines to reach the nearest grid connection, but potential impacts associated with such an action are addressed under the On Island Electrical Transmission technology in Section 8.1 and are not repeated here.

Potential effects on geology and soils from construction of a 5-megawatt solar thermal facility would be the same as those expected for common construction actions as described in Section 3.1.3. Since the amount of land disturbed would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable.

Operation of the solar thermal facility would not normally involve activities that would have the potential to affect geology and soils of the area. However, the heat transfer fluids (such as synthetic oil or even molten salt) used in the system could cause soil contamination were there to be leaks or accidental releases. Normal operational monitoring would be expected to quickly identify and respond to any such incidents, including stopping the spill or release and cleaning up any soil contamination.

6.7.1.2 Best Management Practices and Mitigation Measures

Sensitive geology and soil related locations or receptors should be considered during the siting of a solar thermal facility. The common BMPs for construction are identified in Section 3.1.4.

6.7.2 CLIMATE AND AIR QUALITY

6.7.2.1 Potential Impacts

Solar thermal energy technology converts solar energy into heat energy that can be used to generate electricity. A representative utility-scale 5-megawatt facility would consist of the required hardware (which varies depending on the technology chosen) operating on 20 to 45 acres. Capacity factors range from 25 percent to 73 percent depending on the technology. The parabolic trough facility used in the representative project has a capacity factor of 25 percent, so the project could provide base load electricity of 11,000 megawatt-hours per year and could replace electricity requirements from the existing baseline electrical grid by that same amount.

6.7.2.1.1 Air Quality

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

Operation of a solar thermal project would not be a large source of criteria pollutant emissions.

6.7.2.1.2 Climate Change

Operation of a solar thermal project would not be a large source of greenhouse gas emissions. A replacement of 11,000 megawatt-hours of electricity per year from the existing baseline electrical grid would reduce oil consumption from electricity generation by about 730,000 gallons per year. On O‘ahu, the annual replacement of 11,000 megawatt-hours of electricity would correspond with an annual reduction in greenhouse gas emissions of about 8,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, an annual replacement of 11,000 megawatt-hours of electricity usage would see an annual reduction in greenhouse gas emissions of about 6,700 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity on the other islands.

6.7.2.2 Best Management Practices and Mitigation Measures

Common BMPs for construction activities are identified in Section 3.2.5.

6.7.3 WATER RESOURCES

6.7.3.1 Potential Impacts

This section addresses potential environmental consequences to water resources from construction and operation of a solar thermal energy facility. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands. The representative project is assumed to require approximately 1 mile of onshore transmission lines to reach the nearest grid connection, but potential impacts associated with such an action are addressed under the On Island Electrical Transmission technology in Section 8.1.3 and are not repeated here.

6.7.3.1.1 Surface Water

Effects on surface water from construction of a 5-megawatt solar thermal facility would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations of the solar thermal facility there would be no activities that would have the potential to affect surface waters other than possibly changing the quantities of stormwater runoff from the site as a result of changes in the characteristics of the surface areas. Whether the constructed site would include more or less impermeable surfaces would depend on the nature of the pre-construction site. If the runoff volume were increased, its management would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns. As noted in Section 6.7.1.1, there could be leaks or accidental releases of the heat transfer fluids (such as synthetic oil or even molten salt) used in the system, which could contaminate stormwater runoff and possibly reach surface waters. Normal operational monitoring would be expected to quickly identify and respond to any such incidents, including stopping the spill or release and cleaning up any soil contamination before stormwater could be affected.

6.7.3.1.2 Groundwater

Effects on groundwater from construction of a 5-megawatt solar thermal facility would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the solar thermal facility, impacts to groundwater would be limited primarily to the water needs to operate the facility. Water demand for the facility is estimated at about 230,000 gallons per year, which is only about 630 gallons per day. This water demand is assumed to include that necessary to support routine washing of the concentrators in order to maintain their efficiency as well as other facility and personnel needs. This amount of additional groundwater demand is very minor in comparison to the State’s total groundwater sustainable yield, which is estimated at about 3.6 billion gallons per day. Accordingly, the water needed for the long-term operation of the system would not be expected to result in water availability issues, but would have to be evaluated on a site-specific basis taking into consideration the groundwater sustainable yield for the applicable Aquifer System Area and the existing groundwater demand from that area.

The operations could be associated with changes in runoff from the site and potentially an associated change in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility goes or how it is managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge.

6.7.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale, solar thermal energy project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

6.7.3.2 Best Management Practices and Mitigation Measures

As discussed above, the facility could include onsite measures such as a stormwater detention pond to control stormwater runoff rates as part of the project design to reduce impacts to surface waters. In addition, it is anticipated that the project would implement normal operational monitoring to quickly identify and respond to any such incidents, including stopping the spill or release and cleaning up of any soil contamination from heat transfer fluids during project operations.

To avoid impacts to floodplains and wetlands, it is recommended that floodplains and wetlands be avoided during project siting.

6.7.4 BIOLOGICAL RESOURCES

This section addresses environmental consequences to biological resources from the development of a utility-scale solar thermal power plant. Potential impacts are addressed in terms of terrestrial vegetation and wildlife habitat, threatened and endangered plant and animal species, designated critical habitat, and high value biological resources such as wetlands and protected land areas considering the type, intensity, duration and physical extent of potential impacts.

6.7.4.1 Potential Impacts

Installation of a solar thermal power plant would require clearing 4 to 9 acres for each megawatt of capacity. A representative 5-megawatt capacity plant would require clearing approximately 20 to 45 acres to install the solar heat collectors and associated infrastructure. The amount of land required for larger capacity plants would increase proportionally. The primary impact to biological resources would be clearing and removal of vegetation and loss of wildlife and their habitat. Solar thermal projects are best installed in areas with relatively flat terrain and abundant solar radiation. Those conditions are generally found at lower elevations, particularly the leeward side of the islands. Therefore, native vegetation, threatened and endangered species, and protected land areas, including critical habitat that are found at mid- to upper elevation areas where topography is generally steeper and solar radiation is lower would be avoided. However, important biological resources also occur at lower elevations and depending on specific project locations, impacts from habitat loss could occur to migratory birds, threatened and endangered plant and animals, critical habitat, protected land areas, and wetlands from site development. Project locations near the ocean may also have marine anchialine pools that may occur several hundred meters inland. Site selection that avoids known locations of threatened and species, critical habitat, wetlands, and sensitive biological areas would reduce potential impacts.

6.7.4.2 Best Management Practices and Mitigation Measures

As noted above, during project siting, locations of threatened and species, critical habitat, wetlands, and sensitive biological areas should be avoided to reduce potential impacts to biological resources. Common BMPs for terrestrial environments are identified in Section 3.4.6.

6.7.5 LAND AND SUBMERGED LAND USE

This section describes the potential environmental impacts to land use from solar thermal projects.

6.7.5.1 Potential Impacts

6.7.5.1.1 Land Use

A 5-megawatt solar thermal facility could require approximately 25 to 45 acres of land as well as road access, parking, maintenance facilities, and a potential 1-mile transmission line. The installation of a solar thermal project could result in changed ownership patterns through purchase or land use leases for both the solar thermal project site and any linear corridors required to tie-in to the existing electrical grid. Undeveloped land or land currently used for other uses could be converted to energy uses.

The State land use designations and county overlay zoning criteria would be considered.

6.7.5.1.2 Submerged Land Use

As identified in Table 6-9, there would be no potential impacts to submerged land use from the representative solar thermal project.

6.7.5.2 Best Management Practices and Mitigation Measures

None identified.

6.7.6 CULTURAL AND HISTORIC RESOURCES

6.7.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, solar thermal power project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6.

6.7.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.7.7 COASTAL ZONE MANAGEMENT

6.7.7.1 Potential Impacts

Development of a solar thermal energy project could require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. Impacts to special management areas, shorefront access, and affect shoreline erosion would depend on location of the project. Locations near the shoreline would potentially have the most impact. Land clearing could potentially increase runoff and sedimentation with potential impacts on coastal water and habitats.

6.7.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.7.8 SCENIC AND VISUAL RESOURCES

6.7.8.1 Potential Impacts

Any proposed project site would experience land clearance activities and require lay-down yards. Depending on efficiency and tracking requirements, a solar thermal facility would require 5 to 10 acres to generate one megawatt of power (NREL 2013). Therefore, for a 5-megawatt facility, 25 to 50 acres of land would be required. Construction would take approximately 1 year. Potential impacts to visual resources from construction activities are described in Section 3.8.3.

Long-term visual impacts would result from the new facilities that would include parabolic troughs, thermal storage tanks, steam condenser, and a generator as depicted on Figure 2-32. In addition, road access, parking, maintenance facilities, and a transmission tie-in of a least 1 mile would be required. Visual impacts from parabolic trough facilities include glare from heat transfer fluid tubes or related components, geometric patterns of reflected light that create strong scintillations, plumes associated with cooling towers, and reflections from mirror supports and ancillary facilities. A study performed by Argonne National Laboratory’s Environmental Science Division found that parabolic trough facilities were found to be easily visible at long distances in both daytime and nighttime observations. In some cases, glare was bright enough to cause strong visual discomfort and temporary after images when observed at distances as far as several miles (Sullivan et al. 2012). Some observers experienced discomfort from glare at distances of up to 4 miles from an elevated viewpoint. The study concluded that it is likely that glare may have been observable at even longer distances, but it could not be verified because of road access limitations (Sullivan et al. 2012).

Other visual effects observed included dramatic and rapid changes in the apparent colors and/or reflectivity of the solar collector arrays, depending on the time of day, viewer location, and viewer movement. The parabolic trough facilities exhibited a range of colors from black to silvery white and included blues, grays, browns, and greens. These large color shifts can cause dramatic increase in the visual contrast from the facility. In some cases the color shifts may make the facility blend in with the background more effectively, or make it appear to mimic a natural feature, such as a lake (Sullivan et al. 2012).

The study found that because of their large size, reflective surfaces, and regular geometry --- under favorable viewing conditions --- even relatively small solar facilities may be visible for long distances, in excess of 20 miles; however, they generally cannot be recognized as solar facilities at these distances and may sometimes blend in with the surrounding landscape. A major conclusion of the study was that the visual experience of the facilities is very dynamic, primarily because of the large number of reflective surfaces. The appearance varies substantially, depending on the horizontal and vertical viewing angle and distance, as well as the time of day, and it may change dramatically as the observer moves, e.g., driving by in a vehicle, or as even short stretches of time elapse (Sullivan et al. 2012).

Security and other exterior lighting around buildings, parking areas, and other work areas could contribute to light pollution. Maintenance activities conducted at night, such as mirror washing, might require vehicle-mounted lights, which could also contribute to light pollution. Light pollution impacts associated with utility-scale solar facilities include skyglow, light trespass, and glare (BLM 2013).

6.7.8.2 Best Management Practices and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a utility-scale solar thermal system. The facility should be sited away from roads and trails to avoid causing offsite glare that may cause annoyance and visual discomfort. Effects on views from nearby mountains, where elevated observation points would afford open views of solar collector fields, as well as potential impacts on the dark night skies that are valued scenic and tourist resources should also be considered.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

BMPs to minimize impacts to visual resources during construction are addressed in Section 3.8.4. The Bureau of Land Management has outlined the following measures as BMPs to minimize the visual impacts from utility-scale solar projects (BLM 2013):

- Use dry cooling technology to avoid water vapor plumes
- Site and operate the collectors to avoid offsite glare

- Screen solar collectors to avoid offsite glare with fencing, berms, or vegetation
- Use and maintain non-reflective or color-treated backs and support structures to decrease visual contrast
- Avoid complete removal of vegetation beneath the collectors or consider revegetation consistent with facility operations and safety considerations
- Prohibit commercial messages and symbols on the collectors

In addition, the Federal Aviation Administration and the Hawai‘i Department of Transportation, Airports Division requires review of projects sited near active airports to ensure glare does not interfere with nearby aircraft.

6.7.9 RECREATION RESOURCES

6.7.9.1 Potential Impacts

As mentioned above, any proposed site would undergo land clearing. Potential impacts to recreation resources from construction activities are described in Section 3.9.4.

Long-term impacts to recreation resources would result from access restrictions to the site and potential visual impacts of the new facilities as depicted on Figure 2-32. In addition, road access, parking, maintenance facilities, and a transmission tie-in of a least 1 mile would be required. Visual impacts of solar thermal facilities are described in more detail in Section 6.7.8.

Security and other exterior lighting around buildings, parking areas, and other work areas could contribute to light pollution. Maintenance activities conducted at night, such as mirror washing, might require vehicle-mounted lights, which could also contribute to light pollution. Light pollution impacts could affect nearby recreation areas where a dark night sky is valued, such as campgrounds. This could impact or remove land from current recreational uses.

6.7.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* should be considered when locating a utility-scale solar thermal system. The facility should be sited away from roads and trails to avoid causing offsite glare that may cause annoyance and visual discomfort. Effects on views from nearby mountains, where elevated observation points would afford open views of solar collector fields, as well as potential impacts on the dark night skies that are valued recreation resources (for example, camping) should also be considered.

BMPs to minimize impacts to recreation resources are addressed in Section 3.9.5. BMPs to minimize impacts to visual resources from utility-scale solar thermal systems are addressed in Section 6.7.8.2 and can minimize impacts to recreation resources where scenic quality is important.

6.7.10 LAND AND MARINE TRANSPORTATION

6.7.10.1.1 Land Transportation

As identified in Table 6-9, there would be no impacts to land transportation from the representative solar thermal project.

6.7.10.1.2 Marine Transportation

As identified in Table 6-9, there would be no potential impacts to marine transportation from the representative solar thermal project.

6.7.11 AIRSPACE MANAGEMENT

6.7.11.1 Potential Impacts

Parabolic trough technology uses relatively low profile equipment that would not create an obstruction to airspace. Contrary to solar PV panels, mirrors and reflectors in concentrated solar power (CSP) facilities are designed for maximum reflection. Reflection from a CSP system could be a potential hazard to both military and civilian aircraft. Project locations would have to be evaluated in relation to surrounding airspace.

CSP plants that employ a dry cooling system (i.e., air cooled condenser) with large fans that blow air up across the condensers to enhance cooling could produce air turbulence that could be hazardous to aircraft. The potential impact depends on the size of the cooling system and location relative to air traffic. Impacts would likely be limited to low altitude aircraft such as helicopters or take-offs and landings and could be mitigated by appropriately locating facilities.

6.7.11.2 Best Management Practices and Mitigation Measures

As noted above, as part of BMPs, project locations should be evaluated in relation to surrounding airspace to minimize potential hazards to both military and civilian aircraft.

6.7.12 NOISE AND VIBRATION

6.7.12.1 Potential Impacts

Construction of the representative solar thermal project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

It is not expected that operation of the representative solar thermal project would generate noise that exceeds the acceptable noise levels beyond the site boundaries (State of Hawaiʻi 2011). Long-term noise and vibration impacts from operation of solar thermal systems would be minimal.

6.7.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

6.7.13 UTILITIES AND INFRASTRUCTURE

6.7.13.1 Potential Impacts

Effects on each island's electric utilities typically be small from the addition of 5 megawatts of power generation to any island's overall power grid. For Oʻahu, with largest island net capacity of 1,756 megawatt, the change would be about 0.3 percent and for Kauaʻi with a net capacity of 125 megawatts the change would be about 4 percent (see Section 3.13.1). Higher percentage change increases the likelihood that the affected island utility would need to adjust management of power on the grid and overall power production. For the smaller grids, such has Lāna‘i or Moloka‘i, a 5 megawatt project would be large and a smaller project should be considered. Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1. Because of the lower capacity factors for solar power (approximately 20 percent), utilities would need to also implement energy storage technologies or arrange for other base load power sources in times when solar power is not being generated (e.g., night).

6.7.13.2 Best Management Practices and Mitigation Measures

As noted above, for the smaller grids, such as Moloka‘i or Lāna‘i, a 5-megawatt project would be a 40 percent to 50 percent addition and would require the utility to adjust or consider a smaller project. BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see 3.13.4).

6.7.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.7.14.1 Potential Impacts

6.7.14.1.1 Hazardous Materials

General hazardous material exposure impacts that could occur prior to and during the installation of a solar thermal system are discussed in Section 3.14.4.

During project operations and maintenance, small quantities of hazardous materials may be periodically used, transported, and disposed of. These hazardous materials would mostly consist of small amounts of fuels, oils, coolants and various other chemicals. In the event of a spill or an accident, minor releases may occur.

6.7.14.1.2 Waste Management

General waste management impacts that could occur prior to and during the installation of a solar thermal system are discussed in Section 3.14.4.

Project operations from concentrated solar power (CSP) technologies such as the parabolic trough may generate substantial amounts of heat transfer fluids (HTFs) and some industrial wastes, such as lubricating oils, compressor oils, dielectric fluids, and hydraulic fluids. As such, proper handling, transport and disposal waste at the appropriately permitted hazardous waste facility would be required for such waste to ensure that no hazardous materials are disposed of at landfills and that hazardous materials do not enter the waste stream.

6.7.14.1.3 Wastewater

Wastewater impacts resulting from the construction and operation of solar thermal collectors would be minimal as most water utilized by the project would be converted into steam to power engine/turbines and generate electricity. Minimal wastewater would be generated from personnel and machinery operations and maintenance. In addition, the project would be required to comply with NPDES wastewater discharge permit requirements during construction and facility operations to regulate facility wastewater discharges.

6.7.14.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater services are discussed in Section 3.14.5.

6.7.15 SOCIOECONOMICS

6.7.15.1 Potential Impacts

Socioeconomic impacts in Hawaiʻi arising from construction and operating a 5-megawatt solar thermal facility would be very small. The solar collectors and associated apparatus could be manufactured in Hawaiʻi and hence, the economic benefits associated with the manufacturing would accrue within the State. The number of jobs associated with the manufacture of the solar collectors, the construction of the facility, and the number of jobs to operate and maintain the plant would be very small. Approximately 10 temporary construction workers would be needed for a period up to twelve months and 10-15 positions would be created to operate the facility. Jobs directly associated with the manufacture of the solar collectors, construction of the solar thermal facility, and operation of the facility would be likely filled by individuals residing within the area of influence (the State of Hawaiʻi) and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.7.15.2 Best Management Practices and Mitigation Measures

None noted.

6.7.16 ENVIRONMENTAL JUSTICE

6.7.16.1 Potential Impacts

The potential environmental impacts to the general population associated with a 5-megawatt solar thermal facility are expected to be small. The potential for environmental justice impacts also would be small.

6.7.16.2 Best Management Practices and Mitigation Measures

Any solar thermal facility site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.7.17 HEALTH AND SAFETY

6.7.17.1 Potential Impacts

Common health and safety impacts for typical construction and operations activities are identified in Section 3.17.3. There would not be any unique hazards or accident scenarios associated with solar thermal energy projects.

6.7.17.2 Best Management Practices and Mitigation Measures

Common health and safety BMPs for typical construction and operations activities are identified in Section 3.17.3.

6.8 Wind (Land-Based)

The representative utility-scale, onshore wind project is the construction and operation of a 25-megawatt facility consisting of ten 2.5-megawatt wind turbines (see Section 2.3.3.9.4). If the scope of the representative project were scaled smaller or larger, the number of wind turbines would decrease or increase by the same factor.

Table 6-10 present a summary of the potential environmental impacts for the representative utility-scale, onshore wind project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology; and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts from land disturbance/soil erosion. See Section 3.1.3. No operational impacts.	Same as those common across construction projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4 No operational impacts.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	None.
Water Resources		
Surface Waters	General construction impacts. See Section 3.3.5. Potential impacts from power pole installation to the nearest electrical grid are discussed in Section 8.1.3, On Island Electrical Transmission. Potential for increased stormwater runoff as a result of increased impermeable surfaces (wind turbine foundations, electrical support buildings, and paved roads or parking areas) – (site-specific).	Same as those common across construction projects. See Section 3.3.6.

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Groundwater	General construction impacts. See Section 3.3.5	Same as those common across construction projects. See Section 3.3.6.
Floodplains and Wetlands	General construction impacts (site-specific). See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6.
Biological Resources		
	General construction and operation impacts. See Section 3.4.5. Potential impacts to biological resources including loss of vegetation and wildlife (migratory birds, threatened and endangered plants and animals, critical habitat, and other high value areas such as wetlands and native plant communities) from site development (site-specific). Potential for mortality of avian species and bats (site-specific). Potential impacts to seabirds by attracting/disorienting them from onsite lighting.	General construction and operation BMPs. See Section 3.4.6. Minimize lighting during construction and operations. Avoidance of sites with threatened and endangered species and critical habitat, areas of high bird or bat concentrations such as nesting sites or roost trees, and landscape positions along flight paths would reduce additional mitigation actions. Re-vegetation of construction disturbances and controlling invasive species as necessary. Adjust the cut-in speed to reduce blade rotation at low wind speeds and reduce the probability of mortalities. Develop a Bird and Bat Conservation Strategies (BBCS) or alternatively a HCP if required under the applicable regulations.
Land and Submerged Land Use		
Land Use	Potential land use impacts including land disturbance during site preparation and turbine installation, as well as access road construction and support structures. Potential conversion of undeveloped land or land with other current land uses for energy use. Potential landownership changes and obtainment of land use easements.	Turbines would be sited in locations that do not have obstructions to the blades. Nearby homes, commercial property; and other land uses would located outside the fall zone.
Submerged Land Use	None; land-based wind turbines would have no potential effects to submerged land use.	N/A

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	General construction and operation BMPs. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General short-term visual impacts during construction including site preparation activities such as clearing, construction of access and onsite roads, equipment laydown areas, installation of turbine foundations, erection of turbines, and connection to the grid. See Section 3.8.3. Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, movement of the rotor blades, shadow flicker, blade glinting, flashing aviation warning lights, roads, vehicles, and workers conducting maintenance activities. Depending on viewer sensitivity, potential for long-term impacts to viewers nearby due to the strong vertical lines/large sweep of turbines/moving blades that can dominate views or command visual attention. Depending on viewer sensitivity, potential for long-term shadow flicker impacts for viewers close enough to fall within the shadows cast by the turbines.	Same as those common across construction projects. See Section 3.8.4. Aviation warning lights (usually red flashing lights) are required for towers taller than 200 feet tall. Sensitive locations should be considered when locating a wind turbine project. Each of the islands’ general land use plans and associated implementation tools such as zoning ordinances and development standards should be taken into consideration during project siting. The Bureau of Land Management has outlined the following measures as BMPs to minimize visual impacts of wind energy facilities (BLM 2013): • Consider topography when siting turbines • Cluster or group turbines to break up overly long lines of turbines • Create visual order and unity among clusters • Site turbines to minimize shadow flicker • Use audio visual warning system technology to reduce night sky impacts from red warning lights

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		• Create visual uniformity in shape, color, and size • Use fewer, larger turbines • Use non-reflective coatings on turbines and other facility components • Prohibit commercial messages and symbols on wind turbines • Keep wind turbines in good repair • Clean nacelles and towers • Consult with any National Park System units within the viewshed of the proposed project. • Complete a thorough viewshed analysis to minimize potential impacts to scenic resources. • Conduct local community outreach for wind turbines given Hawai‘i’s scenic beauty and limited landscapes that increase wind farm visibility. • Consider the appropriate color for the wind turbines based on the specific project location. • Consider placing aviation lighting on the ends of a series of towers, as opposed to every individual tower. Slower pulsing or constant marker lighting should be avoided. • New technology that triggers beacons by radar when aircraft is in the vicinity should be considered.
Recreation Resources		
	General recreation resource impacts during construction. See Section 3.9.4. Potential long-term recreational resource impacts such as access restrictions due to the presence of wind-turbines, movement of the rotor blades, shadow flicker, blade glinting, aviation warning lights, roads, vehicles, and workers conducting maintenance activities. Potential impacts to nearby recreation areas from strong vertical lines of the turbines dominating views and large sweep of moving blades commanding visual attention.	Same as those common across construction projects. See Section 3.9.5. Sensitive locations such as recreation areas in Appendix A of the State Comprehensive Outdoor Recreation Plan (DLNR 2009) should be considered when locating a wind turbine project. Recreation areas that value a dark night sky should also be considered. Each of the six islands general land use plans and associated implementation tools such as zoning ordinances and development standards should be considered during project siting.

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential intrusion to the natural scenery and viewshed depending on the viewer sensitivity. Potential impacts to the night sky for nearby recreation areas (i.e., campgrounds) from aviating warning lights.	The proponent should complete a thorough viewshed analysis to minimize potential impacts to recreation resources.
Land and Marine Transportation		
Land Transportation	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the construction site).	Coordinate transportation of large equipment with local authorities.
Marine Transportation	Minor impacts on marine transportation from shipment via marine cargo ship.	None.
Airspace Management		
	Potential hazards to airspace navigation, both military (training and operations) and civilian (including tourist industry helicopters/fix-winged). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor-induced turbulence.	During project siting, evaluate project locations relative to defined airspace and relative to radar and other communication systems to identify and mitigate potential impacts. Maintain separation distances and obstacle avoidance to reduce potential hazards to aircraft.
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Operational noise and vibration impacts from land-based wind turbines would occur when wind conditions are favorable, day or night.	General noise BMPs during construction. See Section 3.12.6. Noise avoidance and mitigation measures may be imposed directly as conditions of noise permit issuance. Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project. Manufacturers may also mitigate noise levels through the use of noise reduction materials and soundproofing techniques when designing wind turbines.

Table 6-10. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Land-Based) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Utilities and Infrastructure		
	General construction impacts. See Section 3.13.3.1. Potential minor impacts to electric utilities (site-specific). See Section 3.13.1	Same as those common across construction projects. See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General construction impacts. See Section 3.14.4. See Section 8.5.14 regarding potential hazardous material exposure impacts resulting from use of batteries for energy storage.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	General construction impacts. See Section 3.14.4. See Section 8.5.14 regarding potential hazardous waste impacts resulting from use of batteries for energy storage.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	General construction impacts. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.
Environmental Justice		
	Small environmental justice impacts. Potentially adverse impacts to minority populations or to low-income population associated with potential visual and scenic, noise and vibration, or other resource impacts in the adjunct and nearby areas from development of a utility-scale wind turbine project.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction and operation impacts. See Section 3.17.3	Same as those common across construction projects. See Section 3.17.5

6.8.1 GEOLOGY AND SOILS

6.8.1.1 Potential Impacts

Effects on geology and soils from construction/installation of 10 utility-scale wind turbines would be the same as those expected for common construction actions as described in Section 3.1.3. Since the amount of land disturbed would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable.

Construction of a scaled, smaller or larger, wind farm would involve disturbance of a proportionally smaller or greater area of land. The project would be required to obtain a storm water discharge permit, and the same type of BMPs would be implemented independent of the size of the disturbed area and the measures would be equally protective. For a larger project, the longer construction period and the increased number of construction equipment may be associated with a higher probability for spills or leaks of fuel and lubricants from equipment, but the types of precautions normally implemented (for example, response plans, cleanup equipment, secondary containment, etc.) would keep potential for on- or offsite soil contamination at a minimum.

Operation of 10 wind turbines or a greater number of wind turbines would not involve activities that would have the potential to affect geology and soils of the area.

6.8.1.2 Best Management Practices and Mitigation Measures

Consideration of sensitive geology and soil related locations or receptors for construction and operations of a wind farm would be the same as described for common construction projects in Section 3.1.3.

6.8.2 CLIMATE AND AIR QUALITY

6.8.2.1 Potential Impacts

Wind turbines convert the kinetic energy of the wind to mechanical power. A representative utility-scale 25-megawatt facility would consist of ten 2.5-megawatt wind turbines. Capacity factors for several Hawaiʻi wind farms range from 45 to 65 percent (DBEDT 2013). Assuming a 50 percent capacity factor, the project would provide base load electricity of about 110,000 megawatt-hours per year and could replace electricity requirements from the baseline electrical grid by that same amount.

6.8.2.1.1 Air Quality

This technology could result in impacts commonly associated with general construction activities, which are addressed in Section 3.2.4.

6.8.2.1.2 Climate Change

A replacement of 110,000 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 7.3 million gallons. On Oʻahu, the annual replacement of 110,000 megawatt-hours of electricity would correspond with an annual reduction in greenhouse gas emissions of about 80,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, the same annual replacement of electricity usage would see an annual reduction in greenhouse gas emissions of about 67,000 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity on the other islands (EPA 2012a).

Scaled versions of a utility-scale wind turbine project would produce linearly scaled impacts to air quality. For instance, a 50-megawatt wind turbine project would replace electricity usage from the baseline grid by two times that of a 25-megawatt project. The corresponding reduction in greenhouse gases also would be two times that of a 25-megawatt project. Air emissions during construction would also be proportional.

6.8.2.2 Best Management Practices and Mitigation Measures

None noted.

6.8.3 WATER RESOURCES

6.8.3.1 Potential Impacts

6.8.3.1.1 Surface Water

Effects on surface water from construction/installation of ten utility-scale wind turbines would be the same as those expected for common construction actions as described in Section 3.3.5. Effects of installing power poles over a mile distance to the nearest connection to the existing electrical grid would be the same as addressed under the On Island Electrical Transmission technology in Section 8.1.3.

During operations there would be no activities that would have the potential to affect surface waters other than possibly increasing storm water runoff from the site as a result of the new impermeable surfaces (wind turbine foundations, electrical support buildings, and paved roads or parking areas if applicable) that would be at the site. If the pre-construction project site was agricultural land or land with natural vegetation, the completed project site (with concrete pads for the turbine bases and new access roads) could have a higher percentage of impermeable surfaces and accordingly could generate more storm water runoff. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

Potential impacts to surface waters during construction of a smaller or larger scaled project, would be similar to that of the representative project. The amount of land disturbed would decrease or increase, but the same requirements would be applicable and the same types of BMPs to control storm water discharge would be equally effective. For a larger project, the longer construction period and the increased number of construction equipment may be associated with a higher probability for spills or leaks of fuel and lubricants from equipment, but the types of precautions normally implemented (for example, response plans, cleanup equipment, secondary containment, etc.) would minimize the potential for contaminants to reach surface water. During operations a greater amount of impermeable surfaces associated with a larger wind farm would tend to generate more runoff, but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns. Also, with the amount of open space required between wind turbines, the area would still be largely unchanged from its preconstruction condition.

6.8.3.1.2 Groundwater

Effects on groundwater from construction/installation of ten utility-scale wind turbines would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the wind turbines there would be no, or negligible demands for water. The operations would be associated with increased runoff (as described previously) and potentially an associated decrease in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility goes or how it is managed, the action may simply represent a change in where water soaks into the ground and possibly provides recharge.

Potential impacts to groundwater during construction would be as described above for the representative project. More water would be required to support a larger construction effort, but the demand would still be limited primarily to dust suppression and soil compaction uses, so it would be minor.

6.8.3.1.3 Floodplains and Wetlands

The proponent of a utility-scale, wind turbine project would be expected to avoid floodplains and wetlands areas if only to reduce costs and minimize regulatory requirements. This is particularly true of wetland areas since there would likely be an increased occurrence of birds in such areas. However, if they could not be avoided, construction considerations would be the same as described for common construction actions discussed in Section 3.3.5. This is independent of project size and would apply equally to a scaled project.

6.8.3.2 Best Management Practices and Mitigation Measures

As noted above and as part of BMPs, during project siting, it is recommended that floodplains and wetlands be avoided.

6.8.4 BIOLOGICAL RESOURCES

This section addresses environmental consequences to biological resources from the development of utility-scale wind energy. Potential impacts are addressed in terms of terrestrial vegetation and wildlife habitat, threatened and endangered plant and animal species, designated critical habitat, and high value biological resources such as wetlands and protected land areas considering the type, intensity, duration and physical extent of potential impacts.

6.8.4.1 Potential Impacts

Common potential impacts from typical construction and operations activities are identified in Section 3.4.5. The primary impacts to biological resources from developing utility-scale wind energy would be clearing of vegetation for construction of wind turbines and access roads and potential mortality of wildlife species from collisions with the turbine blades. The amount of land required is about 10 acres per megawatt of installed capacity. The actual vegetation temporarily disturbed during construction is approximately 1.7 acres per megawatt and 0.7 acre of permanently disturbed vegetation. A representative project of ten 2.5-megawatt wind turbines (25-megawatt project) would require approximately 250 acres but disturb approximately 43 acres during construction with permanent loss of about 18 acres from project development. These estimates are approximate values and the amount land disturbed will depend specific site conditions. For example, some locations may have steeper topography between towers and require longer or separate access routes. Some additional clearing of vegetation may occur around the turbine towers to assist in impact monitoring (i.e., surveying for bird or bat mortalities). Potential impacts from the land disturbances on vegetation, wildlife, threatened and endangered plant and animal species, critical habitat, and other high value areas such as wetlands and native plant communities would be a function of the specific project location and the biological resources located on and near the project site. Appropriate evaluations and mitigation would have to be developed on a site specific basis as each potential project site may have different resources.

Mortality of avian species and bats is a primary concern for large utility-scale wind projects. The fauna of Hawaiʻi is rich in bird diversity. Different groups of birds have different risks of collision with turbine blades based on individual behavior such as flight height, time of flight (day versus night), and frequency of flight. Project location is an important factor and must be considered from two perspectives. First, the vegetation or habitat surrounding the wind turbines would influence species at risk of mortality. Secondly, the landscape in the region surrounding the project may include habitats (e.g., wetlands, native vegetation communities, critical habitat, seabird nesting colonies) and landscape features (e.g., ridges, cliffs, beaches) that may increase the likelihood that a particular species or group of birds would cross the project site. For example, seabirds frequently fly between nesting colonies and ocean foraging sites. Water birds may fly between ponds and wetlands. The Hawaiian hoary bat moves between roosting trees and foraging areas. Migratory birds may arrive from northern breeding ranges along the northern coasts of the islands.

The USFWS has prepared onshore wind energy guidelines to assist with developing wind projects and minimizing potential impacts to birds and bats (USFWS 2012). The guidelines use a tiered approach for assessing potential adverse effects to species of concern and their habitats. The tiered approach is an iterative decision-making process for collecting information in increasing detail; quantifying the possible risks of proposed wind energy projects to species of concern and their habitats; and evaluating those risks to make siting, construction, and operation decisions.

6.8.4.2 Best Management Practices and Mitigation Measures

Common BMPs for typical construction and operations activities are identified in Section 3.4.6. Potential impacts from the land disturbances on vegetation, wildlife, threatened and endangered plant and animal species, critical habitat, and other high value areas such as wetlands and native plant communities would be function of the specific project location and the biological resources located on and near the project site. Avoidance of sites with threatened and endangered species and critical habitat, areas of high bird or bat concentrations such as nesting sites or roost trees, and landscape positions along flight paths would reduce potential mitigation actions.

Re-vegetation of construction disturbances and controlling invasive species are additional mitigation actions that reduce potential impacts. The location of the project in relation to these regional habitats and landscape feature may influence the potential risk of turbine collisions. Adjusting the cut-in speed to reduce blade rotation at low wind speeds may reduce the probability of mortalities. Onsite lighting could attract and disorient seabirds. Minimizing operational lighting and night-time lighting during construction would mitigate these potential impacts. The project could develop a Bird and Bat Conservation Strategies (BBCS) or alternatively a HCP if required under the applicable regulations. A wind energy project-specific BBCS is an example of a document or compilation of documents that describes the steps a developer could or has taken to apply the wind energy guidelines to mitigate for adverse impacts and address the post-construction monitoring efforts the developer intends to undertake. A developer may prepare a BBCS in stages, over time, as analysis and studies are undertaken and more information is obtained (USFWS 2012).

6.8.5 LAND AND SUBMERGED LAND USE

6.8.5.1 Potential Impacts

6.8.5.1.1 Land Use

The representative project would be to construct and operate a 25-megawatt facility comprised of ten 2.5-megawatt wind turbines. Each turbine would be on a horizontal axis unit, with a 390-foot rotor (the blade lengths are about 190 feet). The rotors would be mounted on a 360-foot monopole.

The land required for the entire project would be about 250 acres. Within the 250 acres, the land that would be permanently disturbed (under turbine areas, roads, and other structure footprints) is about 17.5 acres. The site would be disturbed during site preparation and turbine installation, as well as access road construction, and support structures. The turbines would need to be sited in locations that do not have obstructions to the blades.

Undeveloped land or land with other current land uses would be converted to energy uses. A tie-in to the existing transmission grid is assumed to be 1 mile. Landownership changes could be possible as well as obtaining land use easements.

6.8.5.1.2 Submerged Land Use

As identified in Table 6-10, there would be no potential impacts to submerged land use from the representative utility-scale, onshore wind project.

6.8.5.2 Best Management Practices and Mitigation Measures

Common BMPs for typical construction activities are identified in Section 3.5.3. Nearby homes, commercial property; and other land uses would be required to be outside the fall zone. The fall zone is an area in which a turbine could conceivably land if it were to topple.

6.8.6 CULTURAL AND HISTORIC RESOURCES

6.8.6.1 Potential Impacts

Adverse impacts could potentially occur to cultural, historic, and related natural resources during construction and operation of the representative utility-scale, onshore wind power project if effective conservation and BMPs are not implemented. This technology could result in cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6. Of particular importance in Hawaiʻi is the potential visual impact of wind turbines that might be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.

6.8.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.8.7 COASTAL ZONE MANAGEMENT

6.8.7.1 Potential Impacts

Development of a utility-scale wind energy project could require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. Impacts to special management areas, shorefront access, and affect shoreline erosion would depend on project location.

6.8.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.8.8 SCENIC AND VISUAL RESOURCES

6.8.8.1 Potential Impacts

Approximately 250 acres of land would be required for the 25-megawatt facility consisting of ten 2.5-megawatt wind turbines. Short-term visual impacts during construction would include site preparation activities such as clearing; construction of access and onsite roads; equipment laydown areas; installation of turbine foundations; erection of the turbines; and connection to the grid at a distance of 1 mile from the edge of the 50-acre property. Potential impacts to visual resources from construction activities are addressed in Section 3.8.3.

Long-term visual impacts associated with operations include the presence of the wind turbines, movement of the rotor blades, shadow flicker, blade glinting, aviation warning lights, roads, vehicles, and workers conducting maintenance activities. The ten turbines would be horizontal axis units, with a 390-foot rotor diameter (the blade lengths are about 190 feet), and would be mounted on monopoles, 360 feet tall. Aviation warning lights would be required because the towers are more than 200 feet tall. Normally these are red flashing lights and are not required on every turbine.

For nearby viewers, the strong vertical lines of the turbines could dominate views and the large sweep of the moving blades may command visual attention. Shadow flicker could occur for viewers close enough to fall within the shadows cast by the turbines. The visual impact of a wind turbine depends, to some extent, on the sensitivity of the viewer. Some individuals consider the aerodynamic design of the turbines graceful and modernistic, while others feel they are an unnatural intrusion to the natural scenery and viewshed.

Short- and long-term impacts for a larger project would be similar to those above but greater in magnitude. If the scope were increased by some factor, the number of wind turbines, the land required for the entire project, the land permanently disturbed, and the land temporarily disturbed would all increase by about the same order of magnitude. The strong vertical lines of the towers and the movement of the blades of more turbines would be more likely to command visual attention. In addition, the red warning lights on a greater number of turbines would cause greater visual impacts as compared to fewer blinking lights for a smaller project. However, typically lights are not required on every turbine in a wind farm or installation. The number of lighted turbines would depend on the arrangement of the turbines.

6.8.8.2 Best Management Practices and Mitigation Measures

As part of BMPs, sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a wind turbine project.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties’ plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State’s land use designations.

The Bureau of Land Management has outlined the following measures as BMPs to minimize visual impacts of wind energy facilities (BLM 2013):

- Consider topography when siting wind turbines
- Cluster or group turbines to break up overly long lines of turbines

- Create visual order and unity among turbine clusters
- Site wind turbines to minimize shadow flicker
- Relocate turbines to avoid visual impacts
- Use audio visual warning system technology to reduce night sky impacts from red warning lights
- Create visual uniformity in shape, color, and size
- Use fewer, larger turbines
- Use non-reflective coatings on turbines and other facility components
- Prohibit commercial messages and symbols on wind turbines
- Keep wind turbines in good repair
- Clean nacelles and towers

Other BMPs specific to wind energy facilities include:

- Consult with any National Park System units within the viewshed of the proposed project.

- Complete a thorough viewshed analysis to minimize potential impacts to scenic resources. Local community outreach is also a priority for wind turbines, given Hawai‘i’s scenic beauty and limited landscapes that increase wind farm visibility. Proper outreach includes providing accurate visual simulations of the project to local community groups, leaders, and neighborhood boards. Developers may need to adjust their project. This could include visuals for night and day operations, as the required aviation safety (red) lighting has been described as an environmental impact. Thorough viewshed analysis may also include additional simulations and mapping at distances farther than the standard 5-mile and 10-mile potential impact radius. A 20-mile radius or larger may be required for visual simulations and visibility mapping for areas visible from NPS units. Mapping radii and visual simulation distances should be decided in consultation with NPS and other Federal agencies.

- Consider the appropriate color for the wind turbines based on the specific project location. White can be visually intrusive in some locations; a muted gray or other color may be better to help blend the turbines into the sky or surroundings.

- Consider placing aviation lighting on the ends of a series of towers, as opposed to every individual tower. Lower intensity or density lighting on the intervening towers may also be an option in lieu of the highest intensity lighting on each tower. Slower pulsing or constant marker lighting should be avoided. New technology that triggers beacons by radar when aircraft is in the vicinity should be considered.

6.8.9 RECREATION RESOURCES

6.8.9.1 Potential Impacts

Approximately 250 acres of land would be required for a 25-megawatt facility consisting of ten 2.5-megawatt wind turbines. Potential impacts to recreation resources from construction activities are addressed in Section 3.9.4.

Long-term impacts to recreation resources associated with operations include access restrictions due to the presence of the two wind turbines, movement of the rotor blades, shadow flicker, blade glinting, aviation warning lights, roads, vehicles, and workers conducting maintenance activities. For nearby recreation users, the strong vertical lines of the turbines could dominate views and the large sweep of the moving blades may command visual attention. Shadow flicker could occur for those individuals close enough to fall within the shadows cast by the turbines. Some recreation users may feel that the wind turbines are an unnatural intrusion to the natural scenery and viewshed. Aviation warning lights would impact the night sky for nearby recreation areas, such as campgrounds.

Short- and long-term impacts for scaled larger project would be similar to those above but greater in magnitude. If the scope were increased by some factor,, the number of wind turbines, the land required for the entire project, the land permanently disturbed, and the land temporarily disturbed would all increase by about the same order of magnitude. The strong vertical lines of the towers and the movement of the blades of more turbines would be more likely to command visual attention. In addition, a greater number of red warning lights would be required for more turbines. However, not all wind turbines within an installation or farm need to be lighted. The number of lighted turbines would depend on the arrangement of the turbines. These blinking lights would cause impacts to the night sky for nearby recreation areas, such as campgrounds.

6.8.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as recreation areas in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating a wind turbine project. Recreation areas that value a dark night sky should also be considered. In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards.

BMPs to minimize impacts to recreation resources are addressed in Section 3.9.5. In addition the BMPs for visual impacts in Section 6.8.8.2 should be implemented. The proponent should complete a thorough viewshed analysis to minimize potential impacts to recreation resources. Local community outreach is also a priority for wind turbines, given Hawai‘i’s scenic beauty and limited landscapes that increase wind farm visibility. Proper outreach includes providing accurate visual simulations of the project to local community groups, leaders, and neighborhood boards. Developers may need to adjust their project. This could include visuals for night and day operations, as the required aviation safety (red) lighting has been described as an environmental impact. Thorough viewshed analysis may also include additional simulations and mapping at distances farther than the standard 5-mile and 10-mile potential impact radius. A 20-mile radius or larger may be required for visual simulations and visibility mapping for areas visible from NPS units. Mapping radii and visual simulation distances should be decided in consultation with NPS and other Federal agencies. In addition, consultation should be conducted for site-specific wind energy development with any National Park System units within the viewshed of the proposed site.

6.8.10 LAND AND MARINE TRANSPORTATION

6.8.10.1 Potential Impacts

6.8.10.1.1 Land Transportation

Development of utility-scale wind energy on the islands would have minimal impact on land transportation. Transportation of wind turbine components such as the blades and turbines to the construction site would have short-term impacts on road traffic.

6.8.10.1.2 Marine Transportation

Development of utility-scale wind energy on the islands would have minimal impact on marine transportation. Wind turbine components would likely be shipped via marine cargo ship. The amount of added cargo handling created by wind turbine components would not substantially impact the marine transportation system or harbor operations.

6.8.10.2 Best Management Practices and Mitigation Measures

None noted.

6.8.11 AIRSPACE MANAGEMENT

6.8.11.1 Potential Impacts

Utility-scale wind turbines, towers, and rotor blades often exceed 200 feet and would require an FAA obstruction to navigation determination. Because of their height, wind turbines are a potential hazard to airspace navigation, both military and civilian. Hawai‘i also has an abundance of lower altitude aviation associated with the tourist industry (both helicopter and fix-winged) and military training and operations (helicopters) that could be impacted by wind turbines. Project locations relative to defined airspace will be important in mitigating potential impacts.

Wind turbines could also impact aviation navigation and communication systems such as radar. This impact is a concern for both civilian and military aviation operations. Location of wind turbines relative to radar and other communication systems may require evaluation to identify and mitigate any potential impacts.

Rotor-induced turbulence downwind from a wind turbine could pose a hazard to aircraft. However, the turbulence would likely not be any different than from other large structures such as buildings and could be mitigated by maintaining separation distances and obstacle avoidance.

6.8.11.2 Best Management Practices and Mitigation Measures

As noted above, the project’s location relative to defined airspace will be important in mitigating potential impacts. In addition, as part of BMPs, the project would require an FAA obstruction to navigation determination to minimize potential hazards to both military and civilian airspace navigation.

6.8.12 NOISE AND VIBRATION

6.8.12.1 Potential Impacts

Short-term noise and vibration impacts would result from construction of ten 2.5-megawatt utility-scale wind turbines. Construction would last about one year.

Wind turbines operate when wind conditions are favorable, day or night. Wind turbines generate both aerodynamic sounds (generated by the blades passing through the air) and mechanical noise (generated from the turbine’s internal gears). Depending on the wind turbine design and wind speed, the aerodynamic noise produces a repetitive sound that may seem like a buzzing, whooshing, or pulsing. Wind turbine noise is present at all frequencies, which includes infrasound (low frequency sound inaudible to the human ear), frequencies in the audible range for humans, and high frequencies. Infrasound is inaudible to the human ear and its effects on humans are not well understood (NRC 2007). This unheard sound may cause human annoyance, sensitivity, disturbance, and disorientation, and the effects on birds, bats, and other wildlife may be more profound (USFWS 2011). Frequency varies with wind speed, blade pitch, and blade speed, and wind turbines can have different acoustics on different days even at the same wind speed (NREL 2012). Additionally, the noise the human ear can detect from a wind turbine is dependent on background noise levels. Noise would be more audible at lower levels in rural areas compared to urban areas. As wind speed increases, the wind itself masks the increasing turbine noise (BLM 2005).

Operational noise levels produced by each 2.5-megawatt utility-scale wind turbine would be 106 dBA at the source at standard power. Combined noise levels from multiple turbines should be estimated. Different arrangements of multiple wind turbines (for example, in a line or in clusters) would result in different noise levels; however, the resultant noise levels would not vary by more than 10 dB (BLM 2005). Continuous and long-term noise levels in excess of 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals (see section 3.12). Long-term noise and vibration impacts would depend on the location of the wind turbine and compatibility with the existing land uses.

6.8.12.2 Best Management Practices and Mitigation Measures

Nearby sensitive receptors for noise and vibration near proposed sites for a new utility-scale wind farm should be considered to avoid potential impacts to these locations.

Noise and vibration impacts should be considered when siting a utility-scale wind farm. Developers must comply with Federal, State, and county noise regulations and ordinances. Available noise and vibration data should be referenced and noise studies are recommended to develop expectations regarding operational noise levels before installation. Conduct wind study to determine if predicted noise levels would be masked by wind noise.

Manufacturers may also mitigate noise levels through the use of noise reduction materials and soundproofing techniques when designing and retrofitting wind turbines and wind farms. Mitigation through design for mechanical sounds can include special finishing of gear teeth, using low-speed cooling fans and mounting components in the nacelle instead of at ground level, adding baffles and acoustic insulation to the nacelle, using vibration isolators and soft mounts for major components, and designing the turbine to prevent sounds from being transmitted into the overall structure. Efforts to reduce aerodynamic sounds include the use of lower tip speed ratios, lower blade angles of attack, upwind rotor designs, variable speed operation and most recently, the use of specially modified blade trailing edges.

6.8.13 UTILITIES AND INFRASTRUCTURE

6.8.13.1 Potential Impacts

Effects on each island’s electric utilities would typically be small from the addition of 25 megawatt of power generation to any island’s overall power grid. For O‘ahu, with largest island net capacity of 1,756 megawatt, the change would be about 1.4 percent (see Section 3.13.1). For islands with a smaller net capacity, the project would need to be sized to match the particular needs. Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable.

6.8.13.2 Best Management Practices and Mitigation Measures

BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see 3.13.4).

6.8.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.8.14.1 Potential Impacts

6.8.14.1.1 Hazardous Materials

As indicated in Table 6-10, the representative onshore wind project would not result in hazardous material exposure impacts other than those associated with general construction activities. Additional discussion is provided in Section 3.14.4.

Potential hazardous material exposure impacts may occur from the use of batteries for energy storage, which is discussed in Section 8.5.14.

6.8.14.1.2 Waste Management

As indicated in Table 6-10, the representative onshore wind project would result in minimal impacts to waste management as a result of general construction activities. Additional discussion is provided in Section 3.14.4.

Potential waste management impacts may occur from the decommissioning of the wind turbines and during the disposal of the batteries used for energy storage. Consideration should be given to those landfills currently at capacity or are pending expansion—particularly on the islands of O‘ahu and Hawai‘i. Additional discussion is provided in Section 3.14.4.

Waste management impacts from the disposal of the batteries used for energy storage are provided in Section 8.5.14.

6.8.14.1.3 Wastewater

As indicated in Table 6-10, the representative onshore wind energy project would not result in impacts to wastewater services. Water use would be relatively minor (for dust control measures and that used in the formulation of concrete for footings).

6.8.14.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater are discussed in Section 3.14.5.

6.8.15 SOCIOECONOMICS

6.8.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from ten 2.5-megawatt land based wind turbines on a scale utilized by an electric utility company would be very small. The turbines, rotor and blades, and mounting poles would likely be manufactured outside the State and, if so, economic benefits associated with the manufacturing would accrue elsewhere. The number of temporary jobs associated with the installation of the units and the numbers of jobs to monitor, operate, and maintain the units would be very small. Jobs directly associated the project likely would be filled by individuals residing within the area of influence (the State of Hawai‘i) and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

Possible changes to electrical rates for residential, commercial, and industrial users and changes in the consumption of electricity that could occur from changes in rates associated with utility land based wind turbines were not evaluated.

Similar to the representative project, a scaled project would also result in relatively few new jobs and therefore would not result in any noticeable socioeconomic impacts.

6.8.15.2 Best Management Practices and Mitigation Measures

None noted.

6.8.16 ENVIRONMENTAL JUSTICE

6.8.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative utility-scale land-based wind turbines are expected to be small to the human population.

Similar to the representative project, the scaled project would result in relatively small environmental impacts to the human population.

6.8.16.2 Best Management Practice and Mitigation Measures

Any utility-scale, onshore wind project site selection process would include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.8.17 HEALTH AND SAFETY

6.8.17.1 Potential Impacts

Workers have the potential to be injured or killed during construction, operation, and decommissioning of wind turbines through industrial accidents such as falls, fires, and dropping or collapsing equipment. Such accidents are uncommon in the wind industry and are avoidable through implementation of proper safety practices and equipment maintenance.

Collapse of a turbine or breakage (and throwing) of one or more turbine blades is possible, but both are very unlikely occurrences. Debris falling from these occurrences would likely be limited to a calculated fall zone, which is defined to approximate the area around the base of the turbine that would likely receive the tower and turbine if it were to fall.

Effects on public safety services from construction and operation of the representative project would be the same as those as described in Section 3.13.3.2.

6.8.17.2 Best Management Practices and Mitigation Measures

Employ safety BMPs to avoid impacts from standard industrial hazards. Consider the fall zone of the individual turbines when siting the facilities and attendant structures.

6.9 Wind (Offshore)

The representative utility-scale, offshore wind project is the construction and operation of a 50-megawatt facility consisting of ten 5-megawatt wind turbines (see Section 2.3.3.10.4). The wind turbines would be deployed over an area of about 3.9 square miles, about 4.3 nautical miles (5 miles) from the shoreline and away from the nearshore environment in water with a depth greater than 200 feet on a floating platform with a semi-submersible design. If the scope of the representative project were increased, the number of wind turbines and the area required for the entire project would all increase by roughly the same factor.

Table 6-11 present a summary of the potential environmental impacts for the representative utility-scale, offshore wind project, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General onshore construction impacts from land disturbance/soil erosion. See Section 3.1.3. Potential impacts to marine sediments (i.e., natural migration of sand, etc.) from anchor/mooring devices, undersea cables, and land/sea transition zones. See Section 8.2.1. No operational impacts.	General onshore construction BMPs. See Section 3.1.3. Conduct horizontal directional drilling in areas of good stability.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Potential increased criteria pollutants from construction equipment including marine vessels (powered by fossil fuels i.e., diesel, or gasoline) during construction. Potential for fugitive dust at nearby onshore construction related areas.	Same as those common across construction projects. See Section 3.2.4.
Climate Change	Potential greenhouse gas emissions reduction from a mix of cleaner technologies used to produce electricity.	None.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Waters	General construction impacts including horizontal directional drilling for electrical cables and for the construction of a substation. See Section 3.3.5. No potential onshore effects during operations. Potential for increased turbidity at breakout point from drilling mud or slurries used during horizontal directional drilling. Potential impacts to coral or other bottom communities of concern from high turbidity (site-specific).	Same as those common across construction projects. See Section 3.3.6. Devices such as silt curtains could be deployed in specific locations such as the HDD breakout point to help reduce potential impacts. Schedule project activities during seasonal periods when wave, current, and wind are expected to be at lows.
Groundwater	General onshore construction impacts. See Section 3.3.5. No operational impacts.	Same as those common across construction projects. See Section 3.3.6.
Floodplains and Wetlands	General construction impacts (site-specific). See Section 3.3.5.	Same as those common across construction projects. See Section 3.3.6. To the extent feasible, avoid siting the project location in a floodplain or wetland. Activities involving discharges of dredged or fill materials into the waters of the U.S. require a Section 404 permit (for the placement of the wind turbine anchoring devices and cables on the ocean side of the system and those actions which are conducted within the territorial seas—area within 3 nautical miles of the shore).
Biological Resources		
	General construction impacts (site-specific). See Section 3.4.5. Potential disturbance impacts to the ocean floor and marine communities/ habitats (i.e., coral reefs, shallow benthic communities, seagrasses, beaches, and possibly marine pools) during installation of anchors, undersea cables (site-specific). Potential impacts to marine animals from temporary construction noise impacts.	Same as those common across construction projects. See Section 3.4.6. The project shall install anchor points in locations that avoid high value habitats such as coral reef. Use dedicated observers to minimize potential for marine mammal collision during construction.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Potential for increase in marine mammal collisions from ships and boats during construction. Potential increase for hazards to marine mammals congregating in marine subsurface structures. Potential for increased collision hazard for large marine mammals (i.e., whales) from mooring cables. Potential hazards (increased risk for mortalities by rotor blade collision) to seabirds in areas surrounding wind turbines due to potential aggregation of forage fish near submarine structures, tower safety lighting, and potential use of aboveground platform structures as resting areas. Potential introduction of an electromagnetic field into the marine environment along the cable resulting in potential impacts to marine mammals with electrosensory systems.	Use HDD in the land/sea transition zone to minimize potential impacts to near shore coral reefs, beaches, and marine pools.
Land and Submerged Land Use		
Land Use	Potential change in local landownership patterns. Potential land disturbance during construction of the tie-in to the existing transmission grid.	Use erosion control and sedimentation guidelines to minimize potential surface land use impacts. Consider State land use designations and county overlay zones during project siting.
Submerged Land Use	Potential impacts to sea floor requiring a submerged lands lease. See Section 8.2.5.	Incorporate BMPs associated with undersea cable. Se Section 8.2.5.
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Potential adverse impacts to cultural, historic, and related natural resources during construction and operation. The visual impact of wind turbines may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	General construction and operation BMPs. See Section 3.6.7.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Coastal Zone Management		
	Potential impacts to designated special management areas, shorefront access, and shoreline erosion (site-specific).	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	Potential long-term visual impacts from wind turbine operations including the presence of the wind turbines, the sweeping movement of the blades, lighting for the marine and aviation navigation, and the land/sea transition site. Depending on viewer sensitivity, potential for long-term impacts to viewers due to the strong vertical lines/large sweep of turbines/moving blades that can dominate views or command visual attention.	Same as those common across construction projects. See Section 3.8.4. Conduct local community outreach for wind turbines, given Hawaiʻi's scenic beauty and limited landscapes that increase wind farm visibility. Proper outreach includes providing accurate visual simulations of the project to local community groups, leaders, and neighborhood boards. Developers may need to adjust their project. This could include visuals for night and day operations, as the required aviation safety (red) lighting has been described as an environmental impact. Consider placing aviation lighting on the ends of a series of towers, as opposed to every individual tower. Lower intensity or density lighting on the intervening towers may also be an option in lieu of the highest intensity lighting on each tower. Slower pulsing or constant marker lighting should be avoided. Consider new technology that triggers beacons by radar when aircraft is in the vicinity.
Recreation Resources		
	General recreation resource impacts during construction. See Section 3.9.4. Potential long-term recreational resource impacts including access restrictions due to the presence of the wind turbines, the sweeping movement of the rotor blades, lighting for marine and aviation navigation, and the land/sea transition site.	Same as those common across construction projects. See Section 3.9.5. The proponent should complete a thorough viewshed analysis to minimize potential impacts to recreation resources. To reduce seascape impacts, the project facilities must be sited away from recreation resource areas and viewing locations. Consultation should be conducted for site-specific wind energy development with any National Park System units within the viewshed of the proposed offshore location.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	Potential short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine components such as the blades and turbines to the harbor for transport to the construction site).	Coordinate transfer of larger pieces of equipment with local authorities.
Marine Transportation	Potential navigation hazards to domestic and military marine transportation including to military submarine operations from undersea structures (mooring cables and power lines extending down to the ocean floor)	Review and mark offshore wind platforms under the U.S. Coast Guards Aids to Navigation program. During project siting, locate structures and cables away from major marine shipping routes to minimize potential navigational hazards.
Airspace Management		
	Potential hazards to airspace navigation, both military (military training and operations) and civilian (including tourist industry helicopters/fix-winged aircraft). Potential impacts to aviation navigation and communication systems such as radar. Potential hazards to aircrafts downwind of rotor-induced turbulence.	During project siting, evaluate project locations relative to defined airspace and relative to radar and other communication systems to identify and mitigate potential impacts. Maintain separation distances and obstacle avoidance to reduce potential hazards to aircraft.
Noise and Vibration		
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12). Noise avoidance and mitigation measures may be imposed directly as conditions of noise permit issuance. Establish an exclusion zone and soft-start, shutdown, and delay procedures during construction (if a marine mammal or sea turtle approaches or enters an exclusion zone). Conduct visual monitoring during construction. Adhere to temporal restrictions. Use maintained equipment with sound-control devices. Place hydrodynamic foils on the upper half of the mooring line.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
		Requests for Incidental Harassment Authorization must include monitoring and reporting plans. In order to decrease the strum effect, place hydrodynamic foils on the upper half of mooring lines. Manufacturers may also mitigate noise levels through the use of noise reduction materials and soundproofing techniques when designing wind turbines.
Utilities and Infrastructure		
	General construction impacts. See Section 3.13.3.1. Potential impacts to electric utilities (site-specific). See Section 3.13.3.1.	See Section 3.13.4.
Hazardous Materials and Waste Management		
Hazardous Materials	General construction impacts. See Section 3.14.4. Potential hazardous materials exposure impacts associated with construction from MRS sites. See Section 8.2.14.	Same as those common across construction projects. See Section 3.14.5.
Waste Management	General construction impacts. See Section 3.14.4. Minimal construction and demolition waste. Potential impacts during the decommissioning and dismantling of the wind turbine as result of turbine removal, and etc.	Same as those common across construction projects. See Section 3.14.5.
Wastewater	Minor and limited wastewater impacts from construction and during operations/maintenance activities from personnel and machinery operations.	None.
Socioeconomics		
	Very small socioeconomic impacts; minimal job and population effects.	None.

Table 6-11. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Wind (Offshore) Systems (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Environmental Justice		
	Small potential for environmental justice impacts. Potentially adverse impacts to minority populations or to low-income population associated general environmental impacts in the adjunct and nearby areas from development of a utility-scale offshore wind turbine project.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	General construction impacts. See Section 3.17.3. Potential for public health and safety impacts including to boats, both civilian and military marine vessels, and to the public onshore in the unlikely event the device were destroyed, damaged or if the loss of mooring/spatial stabilization were to occur.	Same as those common across construction projects. See Section 3.17.5.

6.9.1 GEOLOGY AND SOILS

The representative utility-scale, offshore wind project would require approximately 1 mile of onshore transmission lines to reach the nearest grid connection, but potential impacts associated with such an action are addressed under the On Island Electrical Transmission technology in Section 8.1.1 and are not repeated here.

6.9.1.1 Potential Impacts

Onshore Activities

Onshore activities for construction of the representative project would consist of horizontal directional drilling to bring the electrical cable from the offshore wind farm in through the sea-to-land transition area. It would also involve construction of a small substation at or near the HDD setup site to condition the power for relay to the electrical grid. Alternatively, the substation could be included on one of the wind turbine platforms. Effects on geology and soils from these actions would be the same as those expected for common construction actions as described in Section 3.1.3.

There would be no impacts to onshore geology or soils during operation of the offshore wind turbine.

Offshore Activities

The ocean-side elements of the offshore wind power project would not involve potential soil-related impacts because of their marine location, but there would be corresponding effects on the marine sediments. For example, anchor devices would be expected to have impacts on the natural migration of sand. Potential impacts to marine sediments from an offshore wind power project would basically be the same as described in Section 8.2.1 for placement of undersea cables and the associated land-sea transition zones for those cables.

Operation of the offshore wind turbines would not be expected to have further impacts on marine sediments beyond those initiated during construction.

6.9.1.2 Best Management Practices and Mitigation Measures

HDD operations that would be involved in installing cables in the land-sea transition zones require an area of good stability. However, a basic premise of the HDD technology (that is, tunneling under areas where surface actions are to be avoided) provides a mechanism to avoid areas that would present difficulties for drilling and subsequent construction.

6.9.2 CLIMATE AND AIR QUALITY

6.9.2.1 Potential Impacts

Wind turbines convert the kinetic energy of the wind to mechanical power. Offshore wind turbines tend to have larger capacities then onshore turbines. A representative utility-scale 50-megawatt facility would consist of ten 5-megawatt wind turbines deployed 4.3 nautical miles from shore and mounted on a 280-foot-long monopole. Assuming a 40 percent capacity factor (Chapter 2), the project would provide base load electricity of about 180,000 megawatt-hours per year and would replace electricity requirements from the baseline electrical grid by that same amount.

6.9.2.1.1 Air Quality

Air quality impacts associated with construction of an offshore utility-scale wind turbine project would be short term, intermittent, and limited to the duration of the construction project. Off-shore installation of wind turbines would not generate fugitive dust at the site of installation, but the construction project could result in land disturbances and related fugitive dust at nearby onshore construction-related areas, including locations where the offshore electrical lines connect with the onshore regional electric grid. Construction equipment, including marine vessels, which are powered by fossil fuels, such as diesel or gasoline, would emit criteria pollutants, small amounts of hazardous air pollutants, and greenhouse gases during the duration of the construction project. These common construction-related impacts to air quality are discussed in Section 3.2.4.

6.9.2.1.2 Climate Change

It is projected that a 50-megawatt offshore wind project would not produce as much electricity per year as a 50-megawatt onshore wind project due to a capacity factor of 40 percent for offshore turbines compared with a capacity factor of between 45 and 65 percent for onshore projects. Consequently, the replacement of electricity from the baseline electrical grid would be less for offshore wind turbines.

A replacement of 180,000 megawatt-hours of electricity per year from the baseline electrical grid would reduce oil consumption from electricity generation by about 12 million gallons per year. On O‘ahu, the annual replacement of 180,000 megawatt-hours of electricity would correspond with an annual reduction in greenhouse gas emissions of about 130,000 metric tons CO_2 equivalent based on EPA eGrid2012 emission factors for estimating greenhouse gas emissions from electricity generation (http://www.epa.gov/egrid; EPA 2012a). On other islands by comparison, a similar annual replacement of electricity usage would see an annual reduction in greenhouse gas emissions of about 110,000 metric tons CO_2 equivalent due to a different mix of technologies used to produce electricity on the other islands.

6.9.2.2 Best Management Practices and Mitigation Measures

BMPs for climate and air quality would be the same as those for common construction and operations projects. See Section 3.2.5.

6.9.3 WATER RESOURCES

This section addresses potential environmental consequences to water resources from installation and operation of offshore wind turbines. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands. The representative project is assumed to require approximately 1 mile of onshore transmission lines to reach the nearest grid connection, but potential impacts associated with such an action are addressed under the On Island Electrical Transmission technology in Section 8.1.3 and are not repeated here.

6.9.3.1 Potential Impacts

6.9.3.1.1 Surface Water

Onshore Activities

Onshore activities for construction of the representative project would consist of horizontal directional drilling to bring the electrical cable from the wind turbine in through the sea-to-land transition area. It would also involve construction of a small substation at or near the HDD setup site to condition the power for relay to the electrical grid. Alternatively, the substation could be included on one of the wind turbine platforms. Effects on (non-marine) surface water from these actions would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations there would be no activities that would have the potential to affect surface waters. Areas disturbed during construction would be restored to pre-disturbance condition so any long-term changes in runoff quantities would not be expected.

Offshore Activities

At the locations where the HDD would breakout on the ocean floor, the wind turbines would be anchored to the ocean floor, and electrical cables or other conduits were buried between the wind turbines and into the shore, ocean sediments would be disturbed and dispersed to some degree. The drilling mud or slurries used in the HDD could also be released at the breakout point. These dispersed sediments increase turbidity for at least some period of time and, depending on the currents or wave actions at the site, would settle out in different locations, possibly in areas of coral or other bottom communities of concern. Potential impacts to such communities would not only depend on whether they are present near wind turbine deployment sites and the cable installation paths, but also whether they are periodically subjected to naturally occurring high turbidity. Devices such as silt curtains could be deployed in specific locations such as the HDD breakout point to help reduce potential impacts. However, devices such as silt curtains often have limited effects, particularly if wave or current action is high at the site. Correspondingly, another mitigation measure normally considered would be to schedule such project activities during seasonal periods when wave, current, and wind would be expected to be at lows. These potential impacts to marine waters actions are very similar to those described in Section 8.2.3 for placement of undersea cables and the associated land-sea transition zones for those cables.

There would be no expected impacts to marine water quality during operation of the wind turbines.

6.9.3.1.1 Groundwater

Onshore Activities
Effects on groundwater from onshore construction activities would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of the offshore wind turbines, no impacts to groundwater would be expected.

Offshore Activities
No groundwater impacts would be expected from the offshore activities associated with deployment or operation of the wind turbines.

6.9.3.1.2 Floodplains and Wetlands

Onshore Activities
It is reasonable to assume that the proponent of an offshore wind turbine project would avoid onshore construction in a floodplain or wetland if at all possible, if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

Offshore Activities
A Section 404 permit from the Corps of Engineers would likely be required for the placement of the wind turbine anchoring devices and cables on the ocean side of the system; that is, to the extent such actions are done within the territorial seas (the area within about 3 nautical miles of the shore). Activities involving discharges of dredged or fill materials into the Waters of the U.S. require a Section 404 permit. The breakout point for the lines (from the HDD) could require placement of fill material to stabilize the location and be subject to a Section 404 permit. Depending on how it was to be performed, the action of burying cables along the ocean floor might be considered excavation and filling all in a single action rather than a discharge of dredged or fill materials, so the Corps may not consider it to be subject to 404 permitting (Sharples 2011). If there was any question about the applicability of a Section 404 permit, discussion with the Corps of Engineers would be the appropriate course of action.

6.9.3.2 Best Management Practices and Mitigation Measures

BMPs to prevent or minimize impacts to water resources from construction activities are described in Section 3.3.6.

6.9.4 BIOLOGICAL RESOURCES

6.9.4.1 Potential Impacts

Common potential impacts from typical construction and operations activities are identified in Section 3.4.5. Installation of ten large-scale (280 foot tower, 205 foot turbine blades) floating 5-megawatt wind turbines approximately five miles offshore could impact seabirds and the marine environment. The floating platforms would be tethered to the ocean floor with mooring cables and anchors. Installation of anchors would create a small disturbance on the ocean floor during installation. If the three anchor points avoid high value habitats such as coral reefs and are anchored in mud sediments, the potential disturbance impact would be small and localized. Potential construction impacts from noise could cause temporary avoidance behavior by marine animals. Many marine species have well developed acoustical communication and may be sensitive to introduced sound. Ships and boats used during construction could temporarily increase potential collisions with marine mammals but could be effectively mitigated using dedicated observers.

The semi-submersible turbine platform structure, cabling, and seafloor anchors would serve as potential surfaces for biofouling organisms, effectively acting as artificial reefs. The subsurface wind turbine structures could serve as fish aggregation devices that attract marine animals. The mooring cables are a potential collision hazard for large marine mammals such as whales. However, the probability of a collision would be low but could increase if marine mammals congregate in the vicinity of the subsurface structures. Tension on the mooring lines would be sufficient to prevent looping and creating an entanglement hazard. The ten turbines would be distributed over approximately four square miles (about one turbine per 250 acres). Collectively as a group the turbine structures could create an area of increased marine activity; increased production of substructures (biofouling), attraction of fish, and then possibly marine mammals. Cable mooring lines could impact marine mammal migration corridors and habitats used for breeding, feeding, resting, and raising young. However, the potential impacts would depend on specific project locations in relation to migration corridors and habitats used for specific life history functions which should be considered during project site selection and evaluated in more detail during project development.

Above water, little is known about the flight patterns and behavior of seabirds at sea and therefore, the probability of mortality by collision with turbine blades is not known. Of concern would be the potential of seabirds to be attracted to the region surrounding the wind turbines because of possible aggregation of forage fish near the turbine submarine structures. Tower safety lighting could be an attractant to seabirds. Following lighting guidelines similar to those for onshore wind turbines could help minimize potential effects. Seabirds are well adapted to life at sea, and it is not known whether seabirds would use aboveground platform structures as resting areas. Any change in the marine environment that would increase the probability of seabirds flying in the vicinity of the wind turbines could potentially increase the risk of mortalities by rotor blade collisions.

An offshore wind turbine would require an undersea power cable to transmit electricity to shore. Installation of the power cable would disturb marine habitats including coral reefs, shallow benthic communities, seagrasses, beaches, and possibly marine pools. The potential impacts would depend on specific project location and the cable route selected. An HDD would be used in the land/sea transition zone and would minimize potential impacts to near shore coral reefs, beaches, and marine pools. An undersea power cable could introduce an electromagnetic field (EMF) into the marine environment along the cable. Although potential impacts to and responses of marine organisms to EMFs are not fully understood, many marine species such as sharks, marine mammals, sea turtles, and some bony fishes have well developed electrosensory systems that may be involved in orientation, homing, and navigation or life functions such as detection of prey and predators (Normandeau et al., 2011). The potential strength of the EMF surrounding the cable is a function of the voltage, cable shielding, and whether the cable is buried or laid along the ocean floor. However, the EMF is attenuated fairly quickly with distance from the cable (5 meters) and the potential impact is likely to be negligible (Normandeau et al., 2011).

6.9.4.2 Best Management Practices and Mitigation Measures

Common BMPs from typical construction and operations activities are identified in Section 3.4.5. BMPs associated with the undersea cable connecting the offshore wind farm to the electrical grid are discussed in Section 8.2.4. BMPs and mitigation measures identified for the off-shore wind include:

- Use dedicated observers during construction to reduce potential collisions between ships and boats and marine mammals

- Follow lighting guidelines similar to those for onshore wind turbines to minimize potential effects to seabirds.
- Use HDD in the land/sea transition zone to minimize potential impacts to near shore coral reefs, beaches, and marine pools.
- During project siting, select an undersea cable route to minimize potential disturbance to marine habitats including coral reefs, shallow benthic communities, seagrasses, beaches, and possible marine pools.

6.9.5 LAND AND SUBMERGED LAND USE

6.9.5.1 Potential Impacts

6.9.5.1.1 Land Use

Onshore land would be acquired through purchase or easement for the tie-in to the existing transmission grid; this could result in a change in local landownership patterns. There would be land disturbance during construction of the tie-in to the grid.

6.9.5.1.2 Submerged Land Use

The installation of mooring lines and the electrical cable to the shoreline would have impacts to the sea floor and local marine habitat.

Regarding the shoreline interface, State land use designations and county overlay zoning would be considered, along with Coastal Zone Management guidelines. A submerged lands lease would be required.

Section 8.2.5 Undersea Cable Corridors, provides additional information on the potential environmental impacts to land and submerged land use.

6.9.5.2 Best Management Practices and Mitigation Measures

Routing of any undersea power cable to connect to the offshore wind facility should avoid or minimize the crossing of existing or planned telecommunication cables. The waters around the islands, especially O‘ahu, also have dumps of subsurface munitions and chemical weapons, which should be avoided. Additional bathymetry studies can assist in defining environmentally sensitive and important areas.

With regard to the potential temporary surface land use impacts, land disturbances would be minimized through the use of erosion control and sedimentation guidelines and the use of HDD. Siting of the sea/land transition sites would also consider State land use designations and county overlay zones.

If there is a need for undersea cables to cross seabed obstructions, especially in areas that are congested with pipelines and/or telecommunication cables, two methods are available for mitigation: 1) concrete mattresses to support the cable above obstructions, and 2) use of protective sleeves over the obstructions.

6.9.6 CULTURAL AND HISTORIC RESOURCES

6.9.6.1 Potential Impacts

Potential adverse impacts could occur to cultural, historic, and related natural resources during construction and operational phases of a utility scale, floating platform, semi-submersible designed, offshore wind turbine and associated onshore ancillary facilities if effective conservation and BMPs are not implemented. This technology could result in potential cultural and historic resource impacts commonly associated with general construction and operational activities, which are addressed in Sections 3.6.6. Of particular importance in Hawai‘i is the potential visual impact of wind turbines that might be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.

6.9.6.2 Best Management Practices and Mitigation Measures

Associated BMPs to reduce potential impacts to cultural, historic, and related natural resources during construction and operation are discussed in Section 3.6.7.

6.9.7 COASTAL ZONE MANAGEMENT

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawai‘i Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion.

6.9.7.1 Potential Impacts

Development of the utility-scale offshore wind energy project could require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. The project would require a power cable from the floating turbine platform to land. Depending on the location where the cable crosses the shoreline, the project could impact designated special management areas, restrict shorefront access, and affect shoreline erosion.

6.9.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

6.9.8 SCENIC AND VISUAL RESOURCES

6.9.8.1 Potential Impacts

Ten 5-megawatt wind turbines, with 420-foot rotor diameter (the blade lengths are about 205 feet), would be mounted on 280-foot-long monopoles. The wind turbines would be about 5 miles from the shoreline on floating platforms with a semi-submersible design. The area required for the entire project is assumed to be 3.9 square miles. Connection to the electrical grid would be approximately 1 mile from the nearest shoreline. A land/sea transition zone would be required. Section 8.2 analyzes the potential impacts of land/sea cable transition sites and the undersea cable.

Long-term visual impacts include the turbines themselves, the sweeping movement of the blades, lighting for marine and aviation navigation, and the land/sea transition site. Argonne National Laboratory's Environmental Science Division (EVS) and the University of Arkansas Center for Advanced Spatial

Technology (CAST) conducted a preliminary assessment of the visibility of offshore wind facilities in the United Kingdom. The facilities studied ranged in size from 25 to 140 turbines (Sullivan et al. 2012).

Results showed that under favorable viewing conditions, small to moderately sized facilities were visible to the unaided eye at distances greater than 26 mi (42 km), with turbine blade movement visible up to 24 mi (39 km). At night, aviation navigation lighting was visible at distances greater than 24 mi (39 km). The observed wind facilities were judged to be a major focus of visual attention at distances up to 10 mi (16 km); were noticeable to casual observers at distances of almost 18 mi (29 km); and were visible with extended or concentrated viewing at distances beyond 25 mi (40 km) (Sullivan et al. 2012).

Sullivan et al. (2012) also reported that the synchronized sweeping movement of the massive blades during the day and the synchronized flashing of the lighting at night contribute to the facilities' visibility over very long distances. The study showed that even small offshore wind facilities of a few dozen turbines can be seen easily at distances exceeding 15 mi (25 km) and that moderately sized facilities of 100 turbines are seen easily at distances of 22 mi (35 km) or even farther, in a variety of weather and lighting conditions. At distances of 9 mi (14 km) or less, even isolated, small facilities will likely be a major focus of visual attention in seaward views, again in a variety of weather and lighting conditions. Based on this study, it is likely that 10 wind turbines located 4 miles offshore would be a focus of visual attention. As with onshore wind systems, some individuals would view the turbines in a positive manner, while others would feel they are an unnatural intrusion into the seascape.

Short- and long-term visual impacts of a larger offshore wind facility would be of greater magnitude. The number of wind turbines and the area required for the entire project would all increase by the same order of magnitude. A larger array of wind turbines would provide power that would be collected at one of the platforms where a substation would be located, allowing the run of a single cable (or group of cables placed together) to shore.

6.9.8.2 Best Management Practices and Mitigation Measures

Sensitive locations such as designated scenic byways; State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating an offshore wind facility.

Consultation should be conducted for site-specific wind energy development with any National Park System units within the viewshed of the proposed siting location. In addition, a thorough viewshed analysis should be completed to minimize the impacts to scenic resources. Thorough viewshed analysis may include additional simulations and mapping at distances farther than the standard 5-mile and 10-mile potential impact radius. A 20-mile radius or larger may be required for visual simulations and visibility mapping for areas visible from NPS units. Mapping radii and visual simulation distances should be decided in consultation with NPS and other Federal agencies.

Visual impacts of offshore wind turbines would be extremely difficult to mitigate; therefore, to reduce the impacts in a seascape, the facilities must be sited away from sensitive visual resource areas and viewing locations. To minimize impacts from aviation lighting, consider placing lighting on the ends of a series of towers, as opposed to every individual tower. Lower intensity or density lighting on the intervening towers may also be an option in lieu of the highest intensity lighting on each tower. Slower pulsing or constant marker lighting should be avoided. New technology that triggers beacons by radar when aircraft are in the vicinity could be considered.

6.9.9 RECREATION RESOURCES

6.9.9.1 Potential Impacts

The 10 5-megawatt wind turbines would be about 5 miles from the shoreline on floating platforms with a semi-submersible design. Section 8.2 analyzes the potential impacts of land/sea cable transition sites.

Long-term impacts to recreation resources include potential access restrictions to the site of the facility and potential visual impacts of the turbines themselves, the sweeping movement of the blades, lighting for marine and aviation navigation, and the land/sea transition site. Some foundations act as artificial reefs which could enhance recreational fishing.

The synchronized sweeping movement of the massive blades during the day and the synchronized flashing of the lighting at night contribute to the facilities' visibility over very long distances. Potential visual impacts of offshore wind facilities that could impact recreation resources are described in more detail in Section 6.9.8.

6.9.9.2 Best Management Practices and Mitigation Measures

Sensitive locations such as recreation areas listed in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009) should be considered when locating an offshore wind facility. In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Visual impacts of offshore wind turbines would be extremely difficult to mitigate, therefore to reduce the impacts in a seascape, the facilities must be sited away from recreation resource areas and viewing locations.

Consultation should be conducted for site-specific wind energy development with any National Park System units within the viewshed of the proposed siting location. In addition, a thorough viewshed analysis should be completed to minimize the impacts to recreation resources. Thorough viewshed analysis may include additional simulations and mapping at distances farther than the standard 5-mile and 10-mile potential impact radius. A 20-mile radius or larger may be required for visual simulations and visibility mapping for areas visible from NPS units. Mapping radii and visual simulation distances should be decided in consultation with NPS and other Federal agencies.

6.9.10 LAND AND MARINE TRANSPORTATION

6.9.10.1 Potential Impacts

6.9.10.1.1 Land Transportation

During project construction, the project would likely result in short-term impacts on roadway traffic during project development (i.e., transportation of wind turbine and transmission line components such as the blades and turbines to the harbor for transport to the construction site.

6.9.10.1.2 Marine Transportation

Development of offshore utility-scale wind energy would create a potential navigation hazard to domestic and military marine transportation. Offshore wind platforms would require review and marking under the U.S. Coast Guards Aids to Navigation program. The undersea structures including the mooring cables and power line extending down to the ocean floor are potential obstacles and hazards to military submarine operations. Locations away from major marine shipping routes would minimize potential navigational hazards.

6.9.10.2 Best Management Practices and Mitigation Measures

Any movement or transport of the large pieces of equipment associated with the offshore wind turbines (either on land or by sea) should be coordinated with the proper authorities to ensure that any traffic issues are minimized.

6.9.11 AIRSPACE MANAGEMENT

6.9.11.1 Potential Impacts

The types of potential impacts to airspace for offshore wind turbines would be similar to those for onshore turbines (Section 6.8.11). An FAA obstruction to navigation evaluation would be required. However, depending on offshore locations, offshore airspace may require evaluation to determine if any airspace classification would be affected. The wind turbines could be a hazard to low elevation aviation such as civilian and non-civilian helicopters and small fixed-wing aircraft. An evaluation also may be required to evaluate potential impacts to radar and communication systems.

6.9.11.2 Best Management Practices and Mitigation Measures

As noted above, as part of BMPs, an FAA obstruction to navigation evaluation would be required as well as an evaluation of potential impacts to radar and communication systems.

6.9.12 NOISE AND VIBRATION

6.9.12.1 Potential Impacts

Short-term noise and vibration impacts would result from construction of ten 5-megawatt offshore wind turbines. Undersea cables would connect the offshore wind facility to a land/sea cable transition site (see Section 8.2.12). Construction noise from equipment and vessels, and vibration caused by pile-driving, could exceed regulatory levels. The large majority of the noise would be attributable to on-shore development including the HDD for the cable and the land/sea transition site. Construction noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Further, according to the Incidental Harassment Authorization (77 FR 43259, July 24, 2012) exposure to elevated sound levels from vibratory and impact pile driving may result in temporary impacts to marine mammal hearing and behavior. However, in its Biological Opinion, the NMFS stated that it does not expect any takes of marine mammals by injury, serious injury, or mortality (NMFS 2012). Marine mammal prey species, such as fish, and sea turtles may also be temporarily impacted.

Wind turbines operate when wind conditions are favorable, day or night. Wind turbines generate both aerodynamic sounds (generated by the blades passing through the air) and mechanical noise (generated from the turbine’s internal gears). Depending on the wind turbine design and wind speed, the aerodynamic noise produces a repetitive sound that may seem like a buzzing, whooshing, or pulsing. Wind turbine noise is present at all frequencies, which includes infrasound (low frequency sound inaudible to the human ear), frequencies in the audible range for humans, and high frequencies. Infrasound is inaudible to the human ear and its effects on humans are not well understood (NRC 2007). This unheard sound can cause human annoyance, sensitivity, disturbance, and disorientation, and the effects on seabirds and other wildlife may be more profound (USFWS 2011). Frequency varies with wind speed, blade pitch, and blade speed, and wind turbines can have different acoustics on different days even at the same wind speed (NREL 2012). Additionally, the noise the human ear can detect from a wind turbine is dependent on background noise levels. Noise would be more audible at lower levels in rural areas compared to urban areas. As wind speed increases, the wind itself masks the increasing turbine noise (BLM 2005).

Operation of a utility-scale offshore wind project could potentially result in long-term noise and vibration impacts. Each of the ten representative 5-MW floating wind turbines would produce a noise level of 108 dBA at the source at standard power. Combined noise levels from multiple turbines should be estimated. Different arrangements of multiple wind turbines (for example, in a line or in clusters) would result in different noise levels. At a distance of 5 miles from shore, noise from operation of the wind turbine would decrease to a level that would likely not be detectable or would be barely audible to people on shore. In addition, the turbine noise would be masked by ambient noise (such as wind and waves) and during calm periods, the turbine would spin less or not all, resulting in less or no noise. Each of the ten floating platforms for the wind turbines would be held in place by three freely hanging mooring lines. Mooring lines create what is called a “strum effect” from the current rushing past the mooring line and causing it to vibrate and hum (BOEM 2012).

6.9.12.2 Best Management Practices and Mitigation Measures

Noise and vibration impacts should be considered when siting a utility-scale offshore wind project. These BMPs take into account the potential noise associated with the land-sea transition site. The following recommended BMPs could reduce the potential disturbances from noise and vibration (NMFS 2012):

- temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i);
- establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species or sea turtles) during construction and shutdown and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone);
- soft-start procedures during construction (a technique that allows marine mammals or sea turtles to leave the immediate area before sound sources reach maximum noise levels);
- in-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving);
- visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during construction); and
- per Marine Mammal Protection Act implementing regulations at 50 CFR § 216.104 (a)(13), requests for Incidental Harassment Authorization must include monitoring and reporting plans.

Additional BMPs include the following:

- Developers must comply with Federal, State, and county noise regulations and ordinances. Noise permits would be required if noise levels exceed regulatory limits. A noise permit variance would be necessary when permitted noise limits would be exceeded. Noise avoidance and mitigation measures may be imposed directly as conditions of permit issuance.
- In order to decrease the strum effect, place hydrodynamic foils on the upper half of mooring lines.
- Manufacturers may also mitigate noise levels through the use of noise reduction materials and soundproofing techniques when designing wind turbines.

6.9.13 UTILITIES AND INFRASTRUCTURE

This section addresses potential environmental consequences to utilities and infrastructure from construction and operation of a 50-megawatt offshore wind project located 5 miles offshore.

6.9.13.1 Potential Impacts

Effects on each island's electric utilities would typically be small from the addition of 50 megawatt of power generation to any island's overall power grid. For O‘ahu, with largest island net capacity of 1,756 megawatts, the change would be about 3 percent (see Section 3.13.1). For islands with a smaller net capacity, the project would need to be sized to match the particular needs. Impacts from connection to utilities for construction and operation of this representative project would be the same as those described in Section 3.13.3.1, as applicable.

6.9.13.2 Best Management Practices and Mitigation Measures

BMPs for construction would be expected to be implemented to avoid conflicts with existing utilities (see 3.13.4).

6.9.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

6.9.14.1 Potential Impacts

6.9.14.1.1 Hazardous Materials

During construction activities, the potential exists for the project to encounter hazardous materials including Munition Response Sites (MRSs) offshore. MRS sites pose safety and hazardous risks as MRS sites include munitions and explosives of concern, unexploded ordnance and discarded military munitions. Additional information regarding the locations/ or potential locations of these sites can be found in Section 3.14. While DoD is currently in the process of citing and cleaning up these sites, not all sites have currently been identified. As such, the project would be required to implement BMPs during project siting to minimize potential safety and hazardous materials risks associated with MRS sites. Additional discussion is also provided in Section 8.2.14.

Construction activities may involve the use of hazardous materials such as fuels, oils, solvents, and glues. In addition, inadvertent spills could occur during onsite fueling of equipment or by accident (e.g., puncture of a fuel tank through operator error or slope instability). Therefore, the use of hazardous materials would be required to comply with developed site-specific BMPs related to fueling, vessel washing and handling, use, and storage of chemicals to minimize any risk to workers or the public. In addition, to minimize the potential for release of oil and other contaminants into surface water or groundwater, the project would be required to provide a Safety Response Plan, which would contain a spill prevention control and countermeasures plan (SPCCP detailing procedures to minimize and mitigate any spills of hazardous materials. All hazardous materials would be disposed of appropriately at an offsite permitted facility. Additional discussion is provided in Section 6.9.14.1.2 Waste Management.

The operation and maintenance of the wind turbines may require the use of chemicals such as lubricating oils, hydraulic fluids, battery electrolytes, dielectric fluids, coolants, solvents, purging solutions, and cleaning agents. Most of these fluids would be contained within the equipment. However, during maintenance, the potential for a spill or accidental release into the marine environment could occur. As such, these hazardous materials or substances would be handled, stored, transported and disposed of at the appropriate permitted facility, in accordance with Federal, State, and county laws and regulations to ensure that hazards are not released into the environment. Additional discussion regarding disposal of this waste is discussed in the section that immediately follows, in Waste Management. In the event of a spill or if an accidental release occurs, appropriate safety precautionary measures and rapid response would be taken including following procedures outlined in spill and safety response plans, EPA materials safety data sheets, BOEM requirements, OSHA requirements, and notifying the appropriate authorities including the State DOH and first responders (as necessary). Spills offshore are also subject to the Clean Water Act. For potential impacts regarding water resources please refer to Section 6.9.3, Water Resources. For potential impacts regarding toxicity to marine life please refer to Section 6.9.4, Biological Resources.

6.9.14.1.2 Waste Management

The representative project would install ten 5-megawatt wind turbines approximately five miles offshore and would require the construction and development of floating platforms and substations. Most of the materials used for the facility would arrive pre-fabricated, rather than built onsite. Therefore, the amount of construction and demolition waste generated would likely be minimal. For example, the large structural components such as the turbine rotors, generators, floating semi-submersible platform, and electric cables are already pre-built. In addition it is anticipated that the nominal amount of waste generated onsite would be minimized through recycling efforts and resultant diversion of generated wastes. During design and construction phases, consideration should be given to development and implementation of a recycling plan. In addition, a recycling program would effectively recover building materials that could contain potentially hazardous substances (e.g., liquid wastes, paints, oil, or solvents).

Typically, whenever machinery is used and equipment using hydraulic power is used on construction projects, there is the potential for generation of waste oil and fluids resulting from maintenance and repair activities on the machinery and equipment. Proper handling, transport, and disposal of hazardous materials or substances would be required to comply with State and Federal OSHA, and county requirements. This includes proper handling and transport for disposal at the appropriate hazardous material facility to ensure that no hazardous materials are disposed of at landfills and that no hazardous materials enter the waste stream.

The operation and maintenance of the wind turbines may require the use of industrial wastes such as lubricating oils, hydraulic fluids, battery electrolytes, dielectric fluids, coolants, solvents, purging solutions, and cleaning agents. These would be handled, stored, in accordance with Federal, State, and county laws and disposed of at the appropriate permitted offsite disposal facility to ensure that no hazardous materials are disposed of at landfills and that hazardous materials do not enter the waste stream.

Potential impacts could also occur during the decommissioning and dismantling of the wind turbine as result of turbine removal, and etc. However, much of the solid material could be recycled and sold as scrap or used in road building or bank re-stabilization projects. The remaining nonhazardous waste would be sent to permitted disposal facilities.

Potential impacts may result to the existing landfills pending resolution of new landfills siting, particularly in the island of Oʻahu and Hawaiʻi. Additional discussion is provided in Section 3.14.4.

6.9.14.1.3 Wastewater

As indicated in Table 6-11, the representative offshore wind project would not result in impacts to wastewater services. Water use would be minor.

6.9.14.2 Best Management Practices and Mitigation Measures

BMPs for hazardous materials, waste management, and wastewater would be the same as those for common construction and operations projects. See Section 3.14.5.

6.9.15 SOCIOECONOMICS

6.9.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from a 50-megawatt offshore wind energy project would be very small. The turbine, rotor and blades, and mounting pole would likely be manufactured outside the State and, if so, economic benefits associated with the manufacturing would accrue elsewhere. The number of temporary jobs associated with the installation of the units, perhaps several dozen, and the numbers of jobs to monitor, operate, and maintain the turbines, about 3 positions, would be very small. Jobs directly associated the project would be likely filled by individuals residing within the area of influence (the State of Hawai‘i) and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

6.9.15.2 Best Management Practices and Mitigation Measures

None noted.

6.9.16 ENVIRONMENTAL JUSTICE

6.9.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative offshore wind farm are expected to be small. The potential for environmental justice impacts also would be small.

6.9.16.2 Best Management Practices and Mitigation Measures

A utility-scale offshore wind turbine project site selection process should include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

6.9.17 HEALTH AND SAFETY

6.9.17.1 Potential Impacts

Common health and safety impacts from typical construction and operations activities are identified in Section 3.17.3. As discussed in Section 6.4.17, the representative project may present public health and safety concerns to boats, both civilian and military marine vessels, and to the public onshore in the event a device were destroyed, damaged or if the loss of mooring/spatial stabilization were to occur. Such events likely occur as a result of rough seas and breaking waves associated with 50 and 100-year storms (particularly in shallow water) or in the event of natural disasters including a tsunami. Potential hazards and safety risks may occur as a result of accidents.

6.9.17.2 Best Management Practices and Mitigation Measures

Common health and safety BMPs from typical construction and operations activities are identified in Section 3.17.5.

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CHAPTER 7

Environmental Impacts from Alternative Transportation Fuels and Modes

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LIST OF TABLES

7 ENVIRONMENTAL IMPACTS FROM ALTERNATIVE TRANSPORTATION FUELS AND MODES

This chapter presents the potential environmental impacts that could be expected for activities and technologies from alternative transportation fuels and modes. These activities and technologies were presented in Chapter 2, Section 2.3.4. For each activity/technology evaluated in this chapter, there is a representative project that aids the PEIS in presenting and characterizing the potential environmental impacts. These representative projects are described in detail in Section 2.3.4 and are summarized again here for each activity/technology. The potential impacts are presented for each environmental resource area. As was described in Chapter 3, many of the activities and technologies could result in environmental impacts that would be common of typical construction projects and may not be unique to the specific activity or technology. In these cases, the presentation of potential impacts in this chapter refers the reader to the appropriate section in Chapter 3 that presents these common impacts for that resource area. Therefore, the details in this chapter deal primarily with those impacts that would be unique to the specific activity or technology being evaluated.

Where feasible, common representative projects were developed to assess the potential impacts (positive and negative) of the alternative transportation fuels and modes technology options. For the representative projects, the objective was to reduce annual petroleum production by 20 million gallons of gasoline or diesel by2030, consistent with the HCEI goal. Some of the technologies and activities could easily scale up to commercial production thereby reducing annual petroleum by more than 20 million gallons; however, the lower volume represents a more realistic project for comparison in the State of Hawaiʻi.

Each of the sections below includes a summary table of the potential environmental impacts and best management practices (BMPs) for that activity or technology. Not all technologies have the potential to impact all environmental resource areas analyzed in this document. Therefore, the summary table also identifies and screens those resource areas that are not expected to be impacted by the technology. This approach is consistent with DOE's sliding scale approach to the preparation of NEPA analyses.

7.1 Biofuels

As discussed in Section 2.3.4.1, due to the uncertainty of biofuel technology readiness, it is difficult to describe with any accuracy what a representative project might look like, which would ultimately depend on the type of biofuel technology selected. For purposes of this PEIS, this section considers the range of potential biofuel feedstocks identified in Section 2.3.4.1.2 that addresses potential impacts from development and utilization of biofuels in Hawaiʻi. Aspects of the representative project are discussed in more detail in the sections that follow.

Table 7-1 presents a summary of the potential environmental impacts for biofuels, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	Construction impacts would be similar for any of the biofuel technologies and would be consistent with those expected for common construction actions as described in Section 3.1.3. During operation, potential impacts on geology and soils could vary greatly depending on the biofuel technology and feedstock: potential impacts include soil nutrient depletion; contamination from over-application of pesticides; and increased risk of erosion following crop harvest.	Employ standard best agricultural practices to keep soil contamination and erosion to a minimum.
Climate and Air Quality		
Air Quality	General construction and operation impacts. See Section 3.2.4. The production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit criteria pollutants during the production process. These emissions are addressed in Section 6.1.2 for utility-scale biomass projects.	Same as those common across construction and operation projects. See Section 3.2.5.
Climate Change	The production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit greenhouse gases during the production process. These emissions are addressed in Section 6.1.2 for utility-scale biomass projects. Gasoline replacement would result in annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	None.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Water	General construction impacts to surface water. See Section 3.3.5. Minimal operational impacts of a biofuel processing plant other than possibly increasing storm water runoff from the site. Potential water use impacts associated with feedstock crops. See Section 6.1. Potential impacts from runoff contamination during feedstock/agricultural production as a result of fertilizer or pesticide applications. No impacts to surface water resources from use of biofuel as a supplement to, or replacement for gasoline.	Evaluate water needs for a dedicated biofuel crop on a site-specific basis. Ensure agricultural materials used are appropriately approved or licensed for the intended use and handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.
Groundwater	General construction impacts on groundwater during construction. See Section 3.3.5. Long-term operational impacts of biofuel processing plant to groundwater would be limited primarily to the water needs to operate the facilities. Potential operational impact of biofuel agricultural activities due to contamination from fertilizer or pesticide applications reaching groundwater either via runoff or local recharge. Use of biofuel as a supplement to, or replacement for gasoline would not be expected to have any impact on groundwater resources.	Evaluate water needs for a biofuel production plant on a site-specific basis. Ensure agricultural materials used are appropriately approved or licensed for the intended use and handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.
Floodplains and Wetlands	Potential effects to floodplain and wetland areas during construction if floodplains and wetlands were not avoided.	Same as those common across construction and operation projects. See Section 3.3.5.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Biological Resources		
	Impacts common to construction and operations activities are identified in Section 3.4.5. Impacts to terrestrial wildlife and protected plants and animals from construction of the biofuel production plant and local infrastructure (i.e., access roads, water lines, electrical lines) are expected to be relatively minor. Potential impacts associated with agricultural production of some feedstocks posing invasive risk. Minimal potential impacts associated with conversion of land to feedstock production as there is readily available surplus of arable land previously used in agricultural production.	BMPs common to construction and operations activities are identified in Section 3.4.6. Site selection for the biofuel plant important in reducing potential impacts. Evaluate biomass production lands in proximity to areas with critical habitat and other high value habitats such as wetlands, areas of native vegetation, and protected land areas to ensure that potential impacts to wildlife or protected plant species are minimized or avoided.
Land and Submerged Land Use		
Land Use	Impacts common to construction and operations activities are identified in Section 3.5.4 Land use impacts could occur from the construction and operation of new production facilities required to generate the biofuels and the infrastructure required to distribute it as an alternative transportation fuel source.	BMPs common to construction and operations activities are identified in Section 3.5.5.
Submerged Land Use	Potential submerged land use impacts if feedstock used to produce the biofuels were harvested offshore (i.e., algae).	None.
Cultural and Historic Resources		
	General construction and operation impacts. See Sections 3.6.6.	Same as those common across construction and operational projects. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts if development of harbor facilities for handling and distributing biofuels between islands is required. The harbor facilities could impact designated special management areas and affect shorefront access; development likely to occur in areas of similar existing facilities and compatible uses.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Scenic and Visual Resources		
	Potential visual impacts from constructing and operating biofuel processing plant described in Section 6.1.8. Minimal long-term visual impacts typical of agricultural activity, including presence of workers and equipment; lands zoned for agricultural use. Minimal visual impacts associated with truck traffic delivering biomass to processing plant.	General construction BMPs. See Section 3.8.4. Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the four designated scenic byways (three on Hawai‘i and one on Kaua‘i); State, National, and National Historical Parks; National Historic Trails and Landmarks; National Natural Landmarks; and reserves protected by the Natural Area Reserves System should be considered and avoided when locating a power generating plant. Consideration should be given to general land use plans and associated implementation tools such as zoning ordinances and development standards to protect and maintain open space and scenic resources, consistent with the State’s land use designations.
Recreation Resources		
	General construction impacts. See Section 3.9.4. Minimal long-term impacts of feedstock production due to existing agricultural character of the area potentially included in the growing of feedstock and likelihood of growing feedstock in land zoned for agricultural uses as opposed to recreation uses.	Consider distance to popular recreation areas identified in Appendix A of the *State Comprehensive Outdoor Recreation Plan*. Same as those common across construction and operation projects. See Section 3.9.5.
Land and Marine Transportation		
Land Transportation	Increased truck and employee traffic around processing facilities. Minor increase in truck traffic near biomass collection points. Repeated truck traffic could increase wear and tear on road pavement and increase the frequency of road maintenance.	Same as those common across construction and operation projects. See Section 3.10.4.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Marine Transportation	Potential impacts on operation of the harbor systems, harbor infrastructure, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations. Potential impact to harbor system if new liquid bulk handling facilities are required.	None.
Airspace Management		
	None; interference with safe air traffic would not occur as a result of the development or use of biofuels.	N/A
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses.	Same as those common across construction and operation projects. See Section 3.12.6.
Utilities and Infrastructure		
	Potential impact to local energy utilities by bringing large production facilities online which could affect their load capacity.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impacts from exposure to hazardous materials could result from chemical application (herbicides, pesticides, soil amendments) related to feedstock production. Potential impacts from exposure to hazardous materials associated with biofuel processing. See Section 6.1.14. Potential impacts from exposure to hazardous materials from accidents and spills during handling, storage, and transport of biofuels to fuel stations.	Handling, storage, and transport of biofuels may require more stringent safety measures due to the potential corrosive properties of other fuels such as E85. Compliance with EPA, OSHA, USDOT, and the State's DOH and DOT requirements during the handling, storage, and transport of the biofuel to ensure compliance with Federal, State, and local safety procedures.
Waste Management	Minimal waste management impacts from feedstock production and processing. Potential impacts would occur during the construction and operation of the processing facilities to produce biofuels. See Section 6.1.14.	None.

Table 7-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Biofuels (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Wastewater	Refer to surface water impacts.	None.
Socioeconomics		
	The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.	None.
Environmental Justice		
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	None; the development or use of biofuels would not introduce any unique health hazard beyond that already addressed as a function of air quality or standard industrial hazards.	N/A

7.1.1 GEOLOGY AND SOILS

7.1.1.1 Potential Impacts

The representative project to be considered in this case is a range of potential applications of biofuel technologies. Implementation of any of the biofuel technologies would be expected to involve construction actions for processing plants, distribution infrastructure, and other support facilities. Potential impacts to geology and soils from such construction actions primarily would be associated with controlling soil erosion and preventing soil contamination. These impacts would be similar for any of the biofuel technologies and would be consistent with those expected for common construction actions as described in Section 3.1.3. Construction actions would be expected to involve disturbance of more than one acre of land, so the permitting requirements described in Section 3.1.3 would be fully applicable.

During operations, potential effects on geology and soils could vary greatly depending on the biofuel technology. For example, some technologies may involve a greater number of hazardous materials than others, but the same type of precautions would be implemented to prevent spills or leaks to soils. Possibly the technologies with the greatest potential to affect soils would be those requiring large agricultural operations to generate feedstocks. Large-scale agricultural actions would pull nutrients from the soils that would likely have to be replenished over time through addition of soil supplements and fertilizers consistent with standard agricultural practices. Pesticides would likely be used as necessary to maintain the crop value. Supplements, fertilizers, and pesticides might all be considered soil contaminants if misused, including overuse such that the materials could be carried off the site in runoff. Also, as crops were harvested, there would be periods when soils would be more susceptible to erosion. These periods would be dependent on the type of biomass used; crops such as sugarcane are harvested every 1 to 2 years, whereas trees might be harvested every 7 to 12 years.

Use of the biofuel as a supplement to, or replacement for gasoline would not be expected to have any impact on geology or soils.

7.1.1.1 Best Management Practices and Mitigation Measures

Standard best management agricultural practices would keep soil contamination and erosion to a minimum. Additional BMPs can be found in Section 3.1.3.

7.1.2 CLIMATE AND AIR QUALITY

7.1.2.1 Potential Impacts

7.1.2.1.1 Air Quality

Impacts on air quality from the representative project would be the same as those expected for common construction actions described in Section 3.2.4. The production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit criteria pollutants during the production process. See in Section 6.1.2 for utility-scale biomass projects.

Depending on the type of biofuel technology chosen, the biofuel would likely be slowly integrated into the State’s alternative fuel mix. Some of these fuels may be incorporated as a blend or provided at fueling stations on their own if the infrastructure were built to support it. As these fuels would initially be blended with gasoline, air emissions from vehicles would still occur, albeit reduced.

7.1.2.1.2 Climate Change

Biofuels are fuels derived from biomass or waste feedstocks. If biofuel technology can replace 20 million gallons of gasoline and diesel from being burned in vehicles, that would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent. The greenhouse gas reduction occurs because of the concept that burning biofuels would be carbon neutral. Refer to Section 5.1.2.1 for a brief discussion of carbon neutrality and how it is an unsettled issue that is under litigation. The premise of carbon neutrality is that as long as biomass resources are managed sustainably (that is, the annual amount of biomass resources grown are greater or equal to the annual amount used), the combustion of harvested materials presents no net increase of carbon to the ongoing carbon cycle. Therefore, the burning of biofuels should not be considered an increase in greenhouse gas emissions. By comparison, the combustion of fossil fuels such as oil emits carbon that has been out of the current carbon cycle for millennia and therefore does contribute to an increase in greenhouse gas emissions.

As noted above, the production of the biomass required to produce the biofuels and the operation of facilities to produce biofuels would emit criteria pollutants and subsequently greenhouse gases during the production process. These emissions are addressed in Section 6.1.2 for utility-scale biomass projects.

7.1.2.2 Best Management Practices and Mitigation Measures

None noted.

7.1.3 WATER RESOURCES

7.1.3.1 Potential Impacts

7.1.3.1.1 Surface Water

Potential impacts to surface water would primarily concern controlling construction materials and storm water runoff such that sediments or other contaminants were not carried offsite to receiving waters. These impacts would be similar for any of the biofuel technologies and would be consistent with those expected for common construction actions as described in Section 3.3.5.

During operation of a biofuel processing plant, there likely would be no routine activities that would have the potential to affect surface waters other than possibly increasing storm water runoff from the site. Management of this increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns. The potential for spills or leaks of hazardous substances is always a concern for industrial facilities, but normal procedures, structures, and equipment for preventing such incidences and for response actions should they ever occur, would minimize the potential for contaminants to reach surface waters. Depending on the nature of the processing plant, there could be wastewaters generated that would have to be disposed of. Such wastewaters might be appropriate for discharge to a sanitary sewer or even as use for crop irrigation. They would not, however, be authorized for discharge to any surface water without a permit, which would require that the water quality of the receiving water not be adversely impacted.

Possibly the greatest potential effect during biofuel operations would be the water demand to support large agricultural operations needed to generate feedstocks for some of the technologies. It is likely such a demand would have to come from surface water sources. The biomass projects evaluated in Section 6.1 include a direct combustion project with a dedicated crop that required 12 to 17 million gallons per day and another dedicated crop to support a biodiesel plant that would require 21 to 40 million gallons per day even after accounting for contribution from precipitation (Section 6.1.3.1.1). It is reasonable to assume that agricultural activities to support a large biofuel project would have water demands of a similar order of magnitude. Although 800 million gallons of surface water was used each day by the sugar industry in 1920, the amount of surface water used in irrigation over the entire State was down to about 74 million gallons per day in 2005 (see Section 3.3.1.1.4). Accordingly, a water demand in the region of 10 to 40 million gallons per day that might be needed to support a biofuel project would be a large increase in demand for irrigation water, particularly if it would be in a localized area. The water need is small in comparison to the average amount of runoff from rain created from the islands each day, which is estimated at 10 to 40 percent of 21 billion gallons per day (see Section 3.3.2.1.2), but there would be existing competing water uses on every island, even if it were only to maintain stream habitat. On a Statewide basis, the water need may appear to be well within the carrying capacity of the resource, but water needs for a dedicated biofuel crop would have to be evaluated further on a site-specific basis. Water in Hawaiʻi is a precious and limited public resource owned by the people of Hawaiʻi. Its use for private commercial enterprises is regulated by the Commission on Water Resource Management, which dictates the amount of water allocated to private entities.

Operation of the dedicated biofuel crop would also represent potential for runoff contamination from the fields as a result of fertilizer or pesticide applications. This runoff could then reach surface water resources. Depending on their characteristics and concentrations, fertilizer and pesticide chemicals can produce adverse environmental impacts if they reach surface waters. The potential for such impacts is minimized if the materials used are appropriately approved or licensed for the intended use and they are handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

Use of the biofuel as a supplement to, or replacement for gasoline would not be expected to have any impact on surface water resources.

7.1.3.1.2 Groundwater

Effects on groundwater during construction associated with any of the biofuel technologies would be the same as those expected for common construction actions as described in Section 3.3.5.

During long-term operations of a biofuel processing plant, impacts to groundwater would be limited primarily to the water needs to operate the facilities. These water demands would not be expected to be prohibitive, but as described for surface water, groundwater is a valuable resource and the needs to support a biofuel plant would have to be evaluated further on a site-specific basis.

Operation of biofuel agricultural activities would also represent potential for contamination from fertilizer or pesticide applications to reach groundwater either via runoff or local recharge. Fertilizer and pesticide chemicals potentially can be carried down by infiltrating water and result in groundwater areas where drinking water standards are threatened or even exceeded. The potential for such impacts is minimized if the materials used are appropriately approved or licensed for the intended use and they are handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

Use of the biofuel as a supplement to, or replacement for gasoline would not be expected to have any impact on groundwater resources.

7.1.3.1.3 Floodplains and Wetlands

The proponent of a large-scale, biofuel project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

7.1.3.2 Best Management Practices and Mitigation Measures

If it is assumed the biofuel processing plant would have access to a sewer system, there would be no sanitary or process wastewater issues associated with facilities' operation and there would be no sensitive water resource locations or receptors that should be given special consideration. With regard to water resources to support the operation's water needs, most of O‘ahu and all of Moloka‘i have been designated Groundwater Management Areas (Sections 3.3.2.3 and 3.3.2.4) because of concerns over the long-term availability of groundwater. This designation authorizes the State to manage groundwater through a permitting process. This does not mean the project could not be implemented on either island due to lack of water, but it does identify a heightened level of concern that would have to be evaluated for a proposed action that involved any water demand. Also, Lāna‘i has no surface water resources that could be used to support irrigation of a dedicated biomass crop and groundwater resources are very limited.

Standard BMPs to protect water resources are identified in Section 3.3.6.

7.1.4 BIOLOGICAL RESOURCES

7.1.4.1 Potential Impacts

Common impacts to biological resources from typical construction and operation activities are identified in Section 3.4.5.

Potential impacts to biological resources from the development of a biofuel industry would occur primarily during the biomass production and harvesting process and construction and operation of the biofuel production plant. The amount of land area disturbed (i.e., cleared of vegetation) for construction of the biofuel plant would depend on the production capacity of the plant. Some of the land disturbed during construction would be landscaped after construction. It is assumed that the production facility would be located in elevations and terrain suitable for growing the type of feedstock selected. Impacts to terrestrial wildlife and protected plants and animals from construction of the biofuel production plant and local infrastructure (i.e., access roads, water lines, electrical lines) are expected to be relatively minor. Site selection for the biofuel production plant would be important in reducing potential impacts. Locations in areas with native vegetation, near wetland habitats, or protected land areas, including critical habitat, would potentially have the most impact. Use of previously disturbed areas or lands with highly modified vegetation such as existing arable agriculture would minimize impacts. Facility lighting during operation of the biofuel plant could have potential impacts on flights of marine birds, such as shearwaters and petrels, depending on the project location. Lighting designs and operation routines to minimize lighting needs could be used to avoid or reduce this potential impact.

The biomass production process would require the most land area, approximately 15,000 acres. Biomass feedstock would be produced from either existing agricultural cropland or former cropland. Because of recent declines in agriculture production throughout the islands, existing fallow arable land is available for the production of biomass crops. However, some former crop land may now contain vegetation that has sufficiently recovered to provide some value as wildlife habitat. Impacts to threatened and endangered species could occur as some species use both native and non-native vegetation. Biomass production lands in proximity to areas with critical habitat and other high value habitats such as wetlands, areas of native vegetation, and protected land areas would require evaluation to ensure that potential impacts to wildlife or protected plant species are minimized or avoided. Some biomass crop species, such as banagrass, are potential risks as invasive species, particularly in areas close to protected areas and high value habitats.

7.1.4.2 Best Management Practices and Mitigation Measures

As discussed above, site selection for the biofuel production plant is important in reducing potential impacts to biological resources. Biomass production lands in proximity to areas with critical habitat and other high value habitats such as wetlands, areas of native vegetation, and protected land areas would require evaluation. BMPs would be the same as those common across projects for construction and operation. See Section 3.4.6.

7.1.5 LAND AND SUBMERGED LAND USE

7.1.5.1 Potential Impacts

7.1.5.1.1 Land Use

Land use impacts could occur from the construction and operation of new production facilities required to generate the biofuels and the infrastructure required to distribute it as an alternative transportation fuel source. Common impacts to land use from typical construction and operation activities are identified in Section 3.5.4.

7.1.5.1.2 Submerged Land Use

Submerged land use impacts could occur from the feedstock required to generate the biofuels (i.e., if algae were to be used) as some feedstock may need to be harvested offshore.

7.1.5.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.5.5.

7.1.6 CULTURAL AND HISTORIC RESOURCES

7.1.6.1 Potential Impacts

Impacts to cultural and historic resources from the representative biofuels project would be consistent with those expected for common construction and operation actions as described in Section 3.6.6.

7.1.6.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures associated with the development and utilization of biofuels are discussed in Section 3.6.7.

7.1.7 COASTAL ZONE MANAGEMENT

7.1.7.1 Potential Impacts

Development of biofuels production could eventually require development of harbor facilities for handling and distributing biofuels between islands. The harbor facilities could impact designated special management areas and affect shorefront access. However, these facilities would likely be developed in an area with similar existing facilities and would most likely be consistent with current uses. These potential impacts could require evaluation through a Federal consistency review under the Coastal Zone Management Program.

Operation of the biofuel vehicles supported by the representative project would not be expected to have any impact on coastal zone management areas.

7.1.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

7.1.8 SCENIC AND VISUAL RESOURCES

7.1.8.1 Potential Impacts

The biofuel for the representative project would be produced in a utility-scale biomass processing plant. Potential visual impacts from constructing and operating a biomass processing plant are described in

Section 6.1.8. This section evaluates potential visual impacts of the production of the crops to support biofuels production and those fuel-specific vehicles that use the new fuel source.

The amount of land required would depend on the particular crop. Long-term visual impacts would be typical of agricultural activity, including the presence of workers and equipment. Because these lands are zoned for agricultural use, planting and harvesting these crops would be compatible uses of the land and therefore, visual impacts would not be significant. Visual impacts would also be caused by truck traffic to deliver the feedstock to the processing plant.

Operation of fuel-specific vehicles would not cause visual impacts. The transition to biofuels would require integration into the existing petroleum and fuel distribution infrastructure already present in the State to reduce costs and efficiently utilize the existing built-in infrastructure or may require the construction of new infrastructure and distribution systems. Short and long-term visual impacts could occur from construction and operation of new infrastructure and distribution systems. Short-term visual impacts would be typical of construction activities described in Section 3.8.3. Long-term visual impacts would depend on the locations of new infrastructure and their compatibility with the existing environment.

7.1.8.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.8.4. Additionally, the BMPs identified for biomass projects in Section 6.1.8 would also be applicable.

7.1.9 RECREATION RESOURCES

7.1.9.1 Potential Impacts

Potential recreation resource impacts from constructing and operating a biomass processing plant are described in Section 6.1.9. This section evaluates potential recreation impacts of the production of the crops to support biofuels production and those vehicles that may be used for the new fuel source.

Long-term recreation resource impacts would be minimal because of the existing agricultural character of the area potentially included in the biofuels effort.

Operation of flex fuel vehicles would not cause recreation resource impacts. The transition to biofuels would require integration into the existing petroleum and fuel distribution infrastructure already present in the State to reduce costs and efficiently utilize the existing built-in infrastructure, or may require the construction of new infrastructure and distribution systems. Short and long-term recreation resource impacts could occur from construction and operation of new infrastructure and distribution systems. Short-term visual impacts would be typical of construction activities described in Section 3.9.4. Long-term recreation resource impacts would depend on the locations of new infrastructure and their compatibility with the existing land uses.

7.1.9.2 Best Management Practices and Mitigation Measures

Consider distance to popular recreation areas identified in Appendix A of the *State Comprehensive Outdoor Recreation Plan* (DLNR 2009).

BMPs to minimize potential impacts to recreation resources are provided in Section 3.9.5.

7.1.10 LAND AND MARINE TRANSPORTATION

7.1.10.1 Potential Impacts

7.1.10.1.1 Land Transportation

Minor impacts would be expected around the biofuel processing facilities as a result of truck and employee traffic. Other, more distributed, truck traffic would occur near the various agricultural lands from which the biomass would be collected. Increased heavy truck traffic could increase wear on road pavement and increase the frequency of road maintenance. The use of biofuels as a transportation fuel would have no impact on land transportation (i.e., traffic).

7.1.10.1.2 Marine Transportation

Impacts to marine transportation would include potential effects on operation of the harbor systems, harbor infrastructure, primary shipping routes between islands, general marine transportation around the islands (tourism, fishing), and military marine surface and subsurface operations. These impacts would be applicable if biofuels were generated on one island and transported to other islands, or even the mainland. If biofuels were shipped through the harbor systems, new liquid bulk handling facilities that are separate from those that now handle petroleum-based fuels may be needed because of different fuel characteristics.

7.1.10.2 Best Management Practices and Mitigation Measures

None identified.

7.1.11 AIRSPACE MANAGEMENT

As identified in Table 7-1, there would be no potential impacts to airspace management from the representative biofuels project.

7.1.12 NOISE AND VIBRATION

7.1.12.1 Potential Impacts

The representative biofuels project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

The representative biofuels project could potentially result in long-term impacts to existing noise and vibration levels. Industrial noise would be produced from feedstock production, operation of biofuel processing facilities, and truck deliveries. If a biofuel production facility and the power plant are not co-located, tanker truck transportation would be required to transport the biofuel from the production facility to the power plant. Such noise could indirectly impact scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. Impacts would depend on the location of facilities and compatibility with existing noise levels and land uses. Long-term noise and vibration impacts from operation of fueling infrastructure and biofuel vehicle use would be negligible.

7.1.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

7.1.13 UTILITIES AND INFRASTRUCTURE

7.1.13.1 Potential Impacts

The representative biofuels project could impact local energy utilities by bringing large production facilities online which could affect their load capacity. These production facilities would be new, potentially large users of electricity. Since these would be facilities used to produce biofuels for transportation use, the electricity use would not be offset by electricity generation using the biofuels (as in Section 6.1.17).

Considering that these facilities would be planned and coordinated with the local utilities well in advance of full operations, impacts to the ability of the utility to handle the load would be minimal.

7.1.13.2 Best Management Practices and Mitigation Measures

None noted.

7.1.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

7.1.14.1 Potential Impacts

7.1.14.1.1 Hazardous Materials

The production of biofuels for the representative project likely would result from various feedstocks that could require the use of chemicals such as herbicides, pesticides, and fertilizers to propagate higher yields. Application of these must occur be in accordance with EPA Materials Safety Data Sheets, USDA, USDOT, and State DOA and DOH regulations to ensure the proper handling, transport, and disposal of these chemicals. Certain feedstock, such as sugar cane, already has an established history of commercial production in Hawai‘i. As such, the pesticides and herbicides anticipated for use in the representative project could be of similar type and would require similar handling, transport, and disposal. Other feedstock, such as banagrass and algae, has not been grown in the State for commercial scale production. As such, the representative project would be required to ensure adequate precautions are taken to prevent chemical spills or release from occurring.

After harvesting, the biofuel feedstock would be transported to a biomass conversion facility. For details regarding the potential impacts of a biomass plants, refer to Section 6.1.14.

Upon processing, the biofuel would be distributed to various fueling stations for retail sale. Depending on the biofuel being distributed, the handling, storage, and transport of the biofuel produced by the representative project may require more stringent safety measures due to potentially corrosive properties (i.e., E85). As such, the representative project would require compliance with EPA, OSHA, USDOT, and the State’s DOH and DOT requirements during the handling, storage, and transport of the fuel to ensure compliance with Federal, State, and local safety procedures.

7.1.14.1.2 Waste Management

The feedstock production for biofuels is anticipated to result in minimal generation of waste, as production would likely occur in areas zoned for agricultural production similar to existing practices. This may involve the use of herbicides and pesticides, which would be considered hazardous waste and would need to be stored, handled, and transported offsite for disposal at the appropriate hazardous waste facility.

The processing of feedstock for biofuel conversion would result in some waste generation. These other impacts would occur during the construction and operation of the processing facilities to produce the biofuel. Those impacts would be similar to those that would occur from the representative project discussed in Section 6.1.14.

The distribution of the biofuel is not anticipated to result in waste generation. However, there would be impacts from the import and use of fuel-specific vehicles depending on the type of biofuel used (i.e., E85 would require the use of flex-fuel vehicles). These fuel-specific vehicles may need to be imported into the State. As existing internal combustion engine vehicles would need to be replaced, this would result in an increase in the amount of waste from vehicles that would be disposed of in Hawaiʻi. It is anticipated that the majority of the vehicles would be disposed of at recycling facilities in the State; however, it is noted that not all car parts or materials may be reused or recycled. Therefore, those non-recyclable car parts or materials may require disposal at one of the various landfills serving the State.

7.1.14.1.3 Wastewater

Primary wastewater impacts resulting from the use of biofuel in vehicles would be minimal to none. Biofuels would likely be integrated into the existing infrastructure, to the extent feasible. However, additional refueling stations or infrastructure may be required, the construction of which may generate minimal wastewater. However, such projects would likely incorporate BMPs including compliance with NPDES wastewater discharge permit requirements.

Secondary impacts could result during the manufacture and processing of biofuels. This is further discussed in Section 5.1.14 and 6.5.14.

7.1.14.2 Best Management Practices and Mitigation Measures

Prior to planting biomass crops or siting a biofuels facility, parcels would be investigated via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at development or agricultural locations. In the event that the project location is sited at one of these sites, site remediation would be recommended prior to project development.

Consider current landfill constraints when siting a biofuels processing facility.

7.1.15 SOCIOECONOMICS

7.1.15.1 Potential Impacts

Socioeconomic impacts associated with the development of biofuels to replace gasoline or diesel fuels could necessitate the construction and operation of new infrastructure and distribution systems. New net jobs could be created. Additional jobs in the agriculture sector could also be generated as acreage is devoted to harvesting feedstock. The number of jobs associated with the new infrastructure and/or new agriculture ventures would be very small, perhaps several dozen positions. Jobs directly associated with the project likely would be filled by individuals residing within the State of Hawaiʻi and not by in-migrating workers. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal would be very small.

7.1.15.2 Best Management Practices and Mitigation Measures

None identified.

7.1.16 ENVIRONMENTAL JUSTICE

7.1.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the development of biofuels are expected to be small. Impacts to minority and low-income populations also would be small.

7.1.16.2 Best Management Practices and Mitigation Measures

Any site selection process would need to include a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

7.1.17 HEALTH AND SAFETY

7.1.17.1 Potential Impacts

Because the representative project for development of biofuels would use dedicated crops as feedstock for the process, the project would include the application of chemicals such as herbicides, fertilizers, and pesticides (see Section 7.1.14). In the event of an accidental spill or release, the project would be required to comply with a spill and response plan including notifying the proper authorities such as the local fire department and the DOH to minimize risks to workers and to the public. With incorporation of precautionary safety measures and compliance with Federal, State, and local regulations, it is not anticipated that chemicals spills or release would occur and project impacts would be minimal.

Effects on island public safety services would be small since the workers to construct and to operate the biofuels facility and to work the agricultural positions would be expected to come from the island's existing work force. Police, fire, and medical services would not be adversely affected with this small change.

7.1.17.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across construction and operation projects. See Section 3.17.5.

7.2 Plug-In Electric Vehicles (PEVs)

The representative PEV project would increase the light-duty (i.e., passenger car) electric vehicle population to avoid the use of 20 million gallons of gasoline fuel by 2030 (see Section 2.3.4.2.5). The representative project assumes that the Statewide vehicle mix remains 50 percent passenger cars and 50 percent light trucks, and that only passenger cars will transition to electric vehicles (i.e., no light trucks). The representative project assumes a mixture of battery electric vehicles and different levels of plug-in hybrid-electric vehicles (e.g., PHEV-10, PHEV-20, and PHEV-40) to mimic a potential future fleet mix. Details on these vehicles can be found in Chapter 2.

Table 7-2 presents a summary of the potential environmental impacts for plug-in electric vehicles, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Plug-in Electric Vehicles

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	Soil disturbances would be limited to instances where minor trenching was required to install chargers at commercial or residential locations.	None.
Climate and Air Quality		
Air Quality	Reduction in air emissions from lowering gasoline usage in passenger vehicles would be partially offset by the amount of air emissions produced from generating electricity.	None.
Climate Change	Reduction in greenhouse gas emissions from lowering gasoline usage in passenger vehicles would be partially offset by the amount of greenhouse gas emissions produced from generating electricity.	None.
Water Resources		
	None; increasing the number of electric vehicles I Hawaiʻi would not impact water resources.	N/A
Biological Resources		
	None; increasing the number of electric vehicles in Hawaiʻi would not impact surface water.	N/A
Land and Submerged Land Use		
Land Use	Reduced gasoline demand could result in decreased number of conventional fueling stations; small parcels of land could be converted to other uses and ownership.	None.
Submerged Land Use	None; increasing the number of electric vehicles in Hawaiʻi would not impact submerged land use.	N/A
Cultural and Historic Resources		
	None; increasing the number of electric vehicles in Hawaiʻi would not impact cultural or historical resources.	N/A
Coastal Zone Management		
	None; increasing the number of electric vehicles in Hawaiʻi would not impact coastal zone management.	N/A
Scenic and Visual Resources		
	None; increasing the number of electric vehicles in Hawaiʻi would not impact scenic or visual resources.	N/A

Table 7-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Plug-in Electric Vehicles (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Recreation Resources		
	None; increasing the number of electric vehicles in Hawai‘i would not impact recreation resources.	N/A
Land and Marine Transportation		
Land Transportation	Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of plug-in electric vehicles increased.	None.
Marine Transportation	None; increasing the number of electric vehicles in Hawai‘i would not impact marine transportation.	N/A
Airspace Management		
	None; increasing the number of electric vehicles in Hawai‘i would not impact airspace management.	N/A
Noise and Vibration		
	General impacts during construction and operation. See Section 3.12.5.	Same as those common across construction and operation projects. See Section 3.12.6.
Utilities and Infrastructure		
	Potential impacts on the islands’ electric utilities would primarily be an increased power demand of 292 gigawatt-hours per year (equivalent to about 33 megawatts if operated continuously) to operate charging stations for the required number of vehicles to support the reduction of 20 million gallons of gasoline. This increase would need to be met either by offsetting renewable power generators or continued use of existing power facilities. This additional load would ramp up slowly as the penetration of PEVs increased on the islands.	Same as those common across construction and operation projects. See Section 3.13.3. Developers of PEV charging stations and should stay in communication with local utilities to allow accurate forecasting of future power needs.
Hazardous Materials and Waste Management		
Hazardous Materials	Minimal hazardous material exposure impacts from plug-in electric vehicles during operations. Hazardous material exposure impacts may result at the end-life of the vehicle use from batteries. See Section 7.2.14.1.2.	Special treatment is recommended during the disposal of the vehicle battery packs that cannot be recycled, including setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous material facility.

Table 7-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Plug-in Electric Vehicles (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Waste Management	Potential waste management impacts at the end-life of electric vehicles or during its disposal. Potential impacts would result from the import and use of plug-in electric vehicles; replacement of existing internal combustion engine vehicles result in an increase in the amount of waste vehicles.	Special treatment is recommended during the disposal of the vehicle battery packs that cannot be recycled, including setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous material facility
Wastewater	None; transitioning to a fleet of electric and hybrid electric vehicles would not impact wastewater.	N/A
Socioeconomics		
	The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.	None.
Environmental Justice		
	None; transitioning to a fleet of electric and hybrid electric vehicles would not have environmental justice impacts.	N/A
Health and Safety		
	None; transitioning to a fleet of electric and hybrid electric vehicles in Hawai‘i would not introduce any new significant hazards compared with gasoline- or diesel-powered vehicles.	N/A

7.2.1 GEOLOGY AND SOILS

7.2.1.1 Potential Impacts

Increasing the number of electric and hybrid electric vehicles in Hawai‘i would be expected to have no substantive impacts on geology or soils. Soil disturbances would be limited to instances where minor trenching was required to install chargers at commercial or residential locations. Where necessary, the amount of trenching required is estimated at 10 to 150 feet per charger. Since the trenching would simply be for the installation of electric cable or conduit, the trenches would not be expected to be very deep or require a wide disturbance. Land disturbance at any single location would not be expected to even approach an acre, so the work would not be performed under a stormwater discharge permit. However, it is reasonable to assume this work would be performed by businesses with trained workers, working under procedures to minimize the potential for any loose soil to be carried away from the site by wind or stormwater. The small size of the trenching action at any site would be expected to translate into a very quick project, with the site being returned to a stable condition in a short time, so there would be a lower probability of encountering runoff or erosion issues than if it were a longer duration project.

During operation of the vehicles or charging stations there would be no activities that would have the potential to affect geology or soils.

7.2.1.2 Best Management Practices and Mitigation Measures

None identified.

7.2.2 CLIMATE AND AIR QUALITY

7.2.2.1 Potential Impacts

7.2.2.1.1 Air Quality

The representative project involves the use of approximately 88,000 electric vehicles being powered by a battery pack. Vehicle charging occurs via plugging into an electrical power source increasing energy demand on the grid. While project operations would result in an annual reduction of 20 million gallons of gasoline, this would be offset by increased energy usage required from existing power plants that are likely generating electricity from oil products. As such, air emissions reduced by the use of plug-in electric vehicles would be partially offset by the increased load required from electrical generating plant. A full reduction in air emissions could be realized if electricity were generated from renewable sources rather than from petroleum.

7.2.2.1.2 Climate Change

The representative project would require approximately 88,000 electric vehicles in the State. An annual reduction of 20 million gallons of gasoline would correspond to an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent. The reduction in greenhouse gas emissions from lowering gasoline usage in passenger vehicles would be partially offset by the amount of greenhouse gas emissions produced from generating the electricity from oil products that would be required to charge the vehicles. The greater the amount of electricity produced by renewable sources in 2030, the greater the greenhouse gas reductions. A full reduction in greenhouse gases could be realized if electricity were generated from renewable sources rather than from petroleum.

The electric capacity required to charge the 2030 fleet is estimated to be 800,000 kilowatt-hours daily and would require a generation capacity of about 133 megawatts. This demand equates to 5.2 percent of the firm generation power capacity in Hawai‘i for each avoided 20 million gallons of gasoline (Chapter 2).

7.2.2.2 Best Management Practices and Mitigation Measures

None identified.

7.2.3 WATER RESOURCES

7.2.3.1 Potential Impacts

7.2.3.1.1 Surface Water

As identified in Table 7-2, there would be no potential impacts to surface water from the representative PEV project.

7.2.3.1.2 Groundwater

As identified in Table 7-2, there would be no potential impacts to groundwater from the representative PEV project.

7.2.3.1.3 Floodplains and Wetlands

The only construction-related or soil disturbing actions associated with the representative project would be the minor trenching required to install charging stations at some locations. In order for such actions to impact floodplains or wetlands, the applicable commercial or residential facility would have to be located within or immediately adjacent to a floodplain or wetland. Although such a situation could occur, it is reasonable to assume that it would be not be the norm. It is also reasonable to assume that in such a location, and deciding where a charging station might be placed, care would be taken to avoid conflicts with floodplains or wetlands if at all possible, if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

7.2.3.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce potential impacts to water resources are discussed in Section 3.3.6.

7.2.4 BIOLOGICAL RESOURCES

As identified in Table 7-2, there would be no potential impacts to biological resources from the representative PEV project.

7.2.5 LAND AND SUBMERGED LAND USE

7.2.5.1 Potential Impacts

7.2.5.1.1 Land Use

Increasing the number of electric vehicles in Hawai‘i would have a minimal impact on land use. In limited instances, minor trenching (10 to 150 feet) may be required to install charging stations at residential, commercial, and tourist areas. However, such disturbances would small and temporary.

As electric vehicles increase in popularity, the number of gasoline driven vehicles could decrease, reducing the demand for gasoline and diesel fuel. As a result, there could be decreases in the number of conventional fueling stations and small parcels of land could be converted to other uses and ownership.

7.2.5.1.2 Submerged Land Use

As identified in Table 7-2, there would be no potential impacts to submerged land use from the representative PEV project.

7.2.5.2 Best Management Practices and Mitigation Measures

None identified.

7.2.6 CULTURAL AND HISTORIC RESOURCES

7.2.6.1 Potential Impacts

Increasing the number of electric vehicles in Hawai‘i would be expected to have no impacts on cultural or historical resources. However, potential adverse impacts could occur to cultural, historical, and related natural resources during trenching if effective conservation and BMPs are not implemented. The potential cultural and historic impacts associated with constructing and operating ancillary support facilities for electric vehicles is discussed in Sections 3.6.6.

During operation of the vehicles or charging stations there would be no activities that would have the potential to affect cultural or historical resources.

7.2.6.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce potential impacts to cultural and historic resources are discussed in Section 3.6.7.

7.2.7 COASTAL ZONE MANAGEMENT

As identified in Table 7-2, there would be no potential impacts to coastal zone management from the representative PEV project.

7.2.8 SCENIC AND VISUAL RESOURCES

As identified in Table 7-2, there would be no potential impacts to scenic or visual resources from the representative PEV project.

7.2.9 RECREATION RESOURCES

As identified in Table 7-2, there would be no potential impacts to recreation resources from the representative PEV project.

7.2.10 LAND AND MARINE TRANSPORTATION

7.2.10.1 Potential Impacts

7.2.10.1.1 Land Transportation

To support the increase in electrical vehicles, additional charging stations may have to be constructed. Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of electric vehicles increases, which support maintenance of the State road systems. However, this impact would be expected to occur over several years as the number of plug-in electric vehicles increases, allowing opportunity to address this potential impact.

7.2.10.1.2 Marine Transportation

As identified in Table 7-2, there would be no potential impacts to marine transportation from the representative PEV project.

7.2.10.2 Best Management Practices and Mitigation Measures

None identified.

7.2.11 AIRSPACE MANAGEMENT

As identified in Table 7-2, there would be no potential impacts to airspace management from the representative PEV project.

7.2.12 NOISE AND VIBRATION

7.2.12.1 Potential Impacts

There are no PEVs manufactured in Hawai‘i, nor are any State-based vendors likely to manufacture home charger stations. Therefore noise and vibration impacts associated with manufacturing would occur elsewhere. Recharging stations and appliances would be constructed and installed. The representative plug-in EV project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

Noise and vibration levels for operation of plug-in EVs vehicles would be similar to or less than existing levels resulting from operation of traditionally fueled vehicles. The noise that would be expected from operating charging station would be negligible.

7.2.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

7.2.13 UTILITIES AND INFRASTRUCTURE

7.2.13.1 Potential Impacts

Potential impacts on the islands electric utilities would primarily be an increased power demand of 292 gigawatt-hours per year (equivalent to about 33 megawatts if operated continuously) to operate charging stations for the required number of vehicles to support the reduction of 20 million gallons of gasoline. This increase would need to be met either by offsetting renewable power generators or continued use of existing power facilities. This additional load would ramp up slowly as the penetration of PEVs increased on the islands. Island utilities are aware of this type of increase and have both renewable energy and continued use plans under consideration to meet this type of increased demand source (HECO 2013).

7.2.13.2 Best Management Practices and Mitigation Measures

In addition to the common BMPs for utilities and infrastructure identified in Section 3.13.3, developers of PEV charging stations and should stay in communication with local utilities to allow accurate forecasting of future power needs.

7.2.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

7.2.14.1 Potential Impacts

7.2.14.1.1 Hazardous Materials

The representative project assumes the use of 88,000 plug-in electric or hybrid electric vehicles which utilize battery packs, such as lithium-ion batteries to fuel and power an electric powertrain to propel a vehicle. Unlike the lead-acid batteries in traditional motor vehicles, lithium-ion batteries are classified as non-hazardous except in California. As such, the operation of plug-in electric vehicles is not anticipated to result in hazardous material impacts. Hazardous material exposure impacts may result at the end-life of the vehicle use. A detailed discussion of battery disposal impacts is included in 7.2.14.1.2.

Prior to charging station installation, proposed project sites are recommended for investigation via the review of public records and the performance of site inspections to identify possible hazardous materials that may be present at development locations.

7.2.14.1.2 Waste Management

Primary waste management impacts resulting from the use of plug-in electrical vehicles would occur at the end-life of electric vehicles or during its disposal. As discussed in 2.3.4.2, PEVs have more components than conventional vehicles (e.g., batteries, electric motors, power electronics, and cabling). Most of these materials are of high value so it is anticipated that these components would be reused and recycled to the extent feasible. Recycling practices and protocols for lithium-ion batteries have been in place for decades and are being further developed to handle the various types of lithium-ion batteries used in hybrid electric vehicles and plug-in electric vehicles. Batteries in electric vehicles are considered to have reached their end-of-life when the battery charge is 80 percent of the new battery capacity. At this point, batteries still have a lot of potential for other “second use” applications, such as providing an energy buffer for solar or wind generation and utility grid support. The likely path for healthy batteries will be to recondition them and redeploy them in service in a non-vehicle application. This approach avoids all of the costs and energy use to produce new batteries and improves batteries’ life cycle emissions and costs because the batteries are kept out of the recycling stream for many years past when they are not fit for use in hybrid electric vehicles and plug-in electric vehicles. Batteries that cannot be repurposed would likely be recycled and would have the raw materials recaptured to produce new batteries.

As lithium-ion batteries are made out of many materials that can be toxic to humans and animals in chemical reactions (such as water), special treatment is recommended during the disposal of the vehicle battery packs that cannot be recycled. This includes setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous material facility. This would ensure that no hazardous materials are disposed of at landfills and that hazardous materials do not enter the waste stream.

Additional impacts may result from the import and use of plug-in electric vehicles. As discussed in Section 2.3.4.2, the representative project would result in the import of approximately 88,000 plug-in electric vehicles in the State. As existing internal combustion engine vehicles would need to be replaced, this would result in an increase in the amount of waste vehicles that would be disposed of in Hawaiʻi. It is anticipated that the majority of the vehicles would be disposed of at recycling facilities in the State; however, it is noted that not all car parts or materials may be reused or recycled. Therefore those non-recyclable car parts or materials may require disposal at one of the various landfills serving the State.

7.2.14.1.3 Wastewater

As identified in Table 7-2, there would be no potential impacts to wastewater from the representative PEV project.

7.2.14.2 Best Management Practices and Mitigation Measures

As discussed in Section 3.14, several landfills in the islands of Oʻahu and Hawaiʻi are currently at capacity. As such, depending on the proposed project location, the disposal of non-recyclable car parts/materials may add to existing landfill capacity constraints. The resolution of landfill siting and expansion on several islands are pending or are in the process. Therefore, additional waste produced in the islands of Oʻahu and Hawaiʻi may result in potential impacts, pending the resolution of existing landfill capacity constraints.

7.2.15 SOCIOECONOMICS

7.2.15.1 Potential Impacts

Socioeconomic impacts associated with transition of conventional, gasoline-powered vehicles to more plug-in electric vehicles would be very small. Some new net jobs could be created, but most new jobs would replace soon-to-be obsolete positions. There are no plug-in electric vehicles manufactured in Hawaiʻi, nor are any State-based vendors likely to manufacture home charger stations. Therefore, economic benefits associated with manufacturing would accrue elsewhere. Existing vehicle dealerships, mechanics, and support personnel would likely transform their offerings to meet the emerging plug-in electric vehicle market, but create few new net jobs.

While the need for traditional gasoline service stations would diminish, recharging stations and appliances would be constructed and installed. The number of jobs associated with the construction and installation of new charging infrastructure would be very small. Jobs directly associated with the recomposed vehicle fleet would be likely filled by individuals residing within the area of influence (the State of Hawaiʻi), who now perform similar services for conventional vehicles, and not by in-migrating workers. The conversion to a plug-in electric vehicle fleet would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.

7.2.15.2 Best Management Practices and Mitigation Measures

None identified.

7.2.16 ENVIRONMENTAL JUSTICE

As identified in Table 7-2, there would be no environmental justice impacts from the representative PEV project.

7.2.17 HEALTH AND SAFETY

As identified in Table 7-2, there would be no health and safety impacts from the representative PEV project.

7.3 Hybrid Electric Vehicles (HEVs)

The representative HEV project would increase the light-duty (i.e., passenger car) hybrid-electric vehicle population to avoid the use of 20 million gallons of gasoline fuel by 2030 (see Section 2.3.4.3.5). As with the PEV project, the HEV representative project assumes that the Statewide vehicle mix remains at 50-percent passenger car and 50-percent light truck and that only passenger cars and light trucks will transition to hybrid-electric vehicles. Further, the representative project assumes 60 percent of the hybrids will be micro-hybrids and 25 percent will be full hybrids. Reaching the 20-million-gallon petroleum reduction goal would require roughly 383,000 hybrid-electric vehicles (or roughly 30 percent of all passenger vehicles in 2030). Specific comparisons of miles traveled to fuel consumption are presented in Chapter 2.

Table 7-3 presents a summary of the potential environmental impacts for hybrid electric vehicles, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-3 Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hybrid Electric Vehicles

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; increasing the number of HEVs would not impact geology and soils.	N/A
Climate and Air Quality		
Air Quality	Potential reduction in criteria pollutants emitted by internal combustion engine vehicles.	None.
Climate Change	A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	None.

Table 7-3 Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hybrid Electric Vehicles (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
	None; increasing the number of HEVs would not impact water resources.	N/A
Biological Resources		
	None; increasing the number of HEVs would not impact biological resources.	N/A
Land and Submerged Land Use		
	None; increasing the number of HEVs would not impact land or submerged land use.	N/A
Cultural and Historic Resources		
	None; increasing the number of HEVs would not impact cultural or historical resources.	N/A
Coastal Zone Management		
	None; increasing the number of HEVs would not impact coastal zone management.	N/A
Scenic and Visual Resources		
	None; increasing the number of HEVs would not impact scenic or visual resources.	N/A
Recreation Resources		
	None; increasing the number of HEVs would not impact recreation resources.	N/A
Land and Marine Transportation		
Land Transportation	Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of hybrid electric vehicles increases.	None.
Marine Transportation	None; increasing the number of HEVs would not impact marine transportation.	N/A
Airspace Management		
	None; increasing the number of HEVs would not impact airspace management.	N/A
Noise and Vibration		
	None; there are no HEVs manufactured in Hawai‘i. Therefore, noise and vibration impacts associated with construction would occur elsewhere.	N/A
Utilities and Infrastructure		
	None; increasing the number of HEVs would not impact utilities and infrastructure.	N/A

Table 7-3 Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hybrid Electric Vehicles (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Hazardous Materials and Waste Management		
Hazardous Materials	Potential hazardous material exposure impacts resulting from hybrid electric vehicles at its end-life or during its disposal.	Special treatment recommended for disposal of vehicle battery packs that cannot be recycled, including setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous waste facility.
Waste Management	Potential waste management impacts resulting from the use of hybrid electric vehicles would occur at the end-life of the vehicles or during their disposal.	Special treatment recommended for disposal of vehicle battery packs that cannot be recycled, including setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous waste facility.
Wastewater	None; increasing the number of HEVs would not impact wastewater.	N/A
Socioeconomics		
	None; increasing the number of HEVs would not impact socioeconomics.	N/A
Environmental Justice		
	None; increasing the number of HEVs would not have environmental justice impacts.	N/A
Health and Safety		
	None; increasing the number of HEVs in Hawai‘i would not introduce any new significant hazards as compared to gasoline- or diesel-powered vehicles	N/A

7.3.1 GEOLOGY AND SOILS

As identified in Table 7-3, there would be no potential impacts to geology and soils from the representative HEV project.

7.3.2 CLIMATE AND AIR QUALITY

7.3.2.1 Potential Impacts

7.3.2.1.1 Air Quality

Hybrid electric vehicles combine an internal combustion engine and an energy storage system to propel the vehicle. Fuel savings is achieved by recovering braking energy and thus decreasing fuel consumption. As the vehicles would result in fuel savings, hybrid electric vehicles would reduce the amount of criteria pollutant emissions emitted by regular vehicles.

7.3.2.1.2 Climate Change

A proposed representative project would increase the light-duty hybrid-electric vehicle population to avoid 20 million gallons of gasoline fuel use by 2030. This would require about 380,000 hybrid-electric vehicles. A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.

7.3.2.2 Best Management Practices and Mitigation Measures

None identified.

7.3.3 WATER RESOURCES

As identified in Table 7-3, there would be no potential impacts to water resources, including surface water, groundwater, wetlands, and floodplains, from the representative HEV project.

7.3.4 BIOLOGICAL RESOURCES

As identified in Table 7-3, there would be no potential impacts to biological resources from the representative HEV project.

7.3.5 LAND AND SUBMERGED LAND USE

As identified in Table 7-3, there would be no potential impacts to land or submerged land use from the representative HEV project.

7.3.6 CULTURAL AND HISTORIC RESOURCES

As identified in Table 7-3, there would be no potential impacts to cultural or historical resources from the representative HEV project.

7.3.7 COASTAL ZONE MANAGEMENT

As identified in Table 7-3, there would be no potential impacts to coastal zone management from the representative HEV project.

7.3.8 SCENIC AND VISUAL RESOURCES

As identified in Table 7-3, there would be no potential impacts to scenic and visual resources from the representative HEV project.

7.3.9 RECREATION RESOURCES

As identified in Table 7-3, there would be no potential impacts to recreation resources from the representative HEV project.

7.3.10 LAND AND MARINE TRANSPORTATION

7.3.10.1 Potential Impacts

7.3.10.1.1 Land Transportation

Land transportation infrastructure could be affected through decreases in HDOT revenue from reductions in petroleum fuel taxes as the number of hybrid electric vehicles increases, which support maintenance of the State road systems. However, this impact would be expected to occur over several years as the number hybrid electric vehicles increases, allowing opportunity to address this impact.

7.3.10.1.2 Marine Transportation

As identified in Table 7-3, there would be no potential impacts to marine transportation from the representative HEV project.

7.3.10.2 Best Management Practices and Mitigation Measures

None identified.

7.3.11 AIRSPACE MANAGEMENT

As identified in Table 7-3, there would be no potential impacts to airspace management from the representative HEV project.

7.3.12 NOISE AND VIBRATION

As identified in Table 7-3, there would be no potential impacts to noise and vibration from the representative HEV project.

7.3.13 UTILITIES AND INFRASTRUCTURE

As identified in Table 7-3, there would be no potential impacts to utilities and infrastructure from the representative HEV project.

7.3.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

7.3.14.1 Potential Impacts

7.3.14.1.1 Hazardous Materials

The representative project assumes the use of about 383,000 hybrid electric vehicles which uses gasoline and battery packs (such as nickel metal hydride or lithium-ion batteries) to fuel and power a vehicle. These vehicles operate similar to conventional vehicles. As mentioned in Section 2.3.4.3, Hybrid Electric Vehicles, all current HEVs in the U.S. are gasoline-fuelled; as such, HEVs are fueled in exactly the same way at the same fueling stations that conventional internal combustion engine vehicles are. The servicing of electric vehicles that occur at dealerships would occur in the same manner as conventional vehicles, except that new and unique services are required for hybrid system components. Many vehicle manufacturers already have hybrids on the market and vehicle maintenance and repair would remain similar to existing practices. As such, the operation and maintenance of hybrid electric vehicles are not anticipated to result in hazardous material exposure impacts. Hazardous material exposure impacts may result at the end-life of the vehicle use due to the hazardous material contents in battery packs. A detailed discussion of battery disposal impacts is discussed in Section 7.3.14.1.2, Waste Management, below.

Additional impacts may occur during the construction and development of gasoline fueling stations. However, it is not anticipated that additional gasoline fueling stations would be required to accommodate the use of hybrid electric vehicles. The increased usage of hybrid electric vehicles in the State would likely utilize existing gasoline fueling stations.

7.3.14.1.2 Waste Management

Potential waste management impacts resulting from the use of hybrid electric vehicles would occur at the end-life of the vehicles or during their disposal. As discussed in Section 2.3.4.3, hybrid electric vehicles have more components than conventional vehicles (e.g., batteries, electric motors, power electronics, and cabling). Most of these materials are of high value so it is anticipated that these components would be reused and recycled to the extent feasible. Recycling practices and protocols for lithium-ion batteries have been in place for decades and are being further developed to handle the various types of lithium-ion batteries used in hybrid electric vehicles and plug-in electric vehicles. Batteries in hybrid electric vehicles are considered to have reached their end-of-life when the battery charge is 80 percent of the new battery capacity. At this point, batteries still have a lot of potential for other “second use” applications, such as providing an energy buffer for solar or wind generation and utility grid support. The likely path for healthy batteries will be to recondition them and redeploy them in service in a non-vehicle application. This approach avoids all of the costs and energy use to produce new batteries and improves batteries’ life cycle emissions and costs because the batteries are kept out of the recycling stream for many years past when they are not fit for use in hybrid electric vehicles. Batteries that cannot be repurposed would likely be recycled and would have the raw materials recaptured to produce new batteries.

As lithium-ion batteries are made out of many materials that can be toxic to humans and animals in chemical reactions (such as water), special treatment is recommended during the disposal of the vehicle battery packs that cannot be recycled. This includes setting aside these battery packs, and proper handling and transport for disposal at the appropriate hazardous material facility. This would ensure that no hazardous materials are disposed of at landfills and that hazardous materials do not enter the waste stream.

Secondary impacts would result from the import and use of hybrid electric vehicles. As discussed in Section 2.3.4.3, the representative project would result in the import of approximately 383,000 hybrid electric vehicles in the State. As existing, conventional, internal combustion engine vehicles would need to be replaced, this would result in an increase in the amount of waste vehicles that would be disposed of in Hawaiʻi. It is anticipated that the majority of the vehicles would be disposed of at recycling facilities in the State; however, it is noted that not all car parts or materials may be reused or recycled. Therefore, those non-recyclable car parts or materials may require disposal at one of the various landfills serving the State.

7.3.14.1.3 Wastewater

As identified in Table 7-2, there would be no potential impacts to wastewater from the representative HEV project.

7.3.14.2 Best Management Practices and Mitigation Measures

As discussed in Section 3.14, several landfills in the islands of Oʻahu and Hawaiʻi are currently at capacity. As such, depending on the proposed project location, the disposal of non-recyclable car parts/materials may add to existing landfill capacity constraints. The resolution of landfill siting and expansion on several islands are pending or are in the process. Therefore, additional waste produced in the islands of Oʻahu and Hawaiʻi may result in potential secondary impacts, pending the resolution of existing landfill capacity constraints.

7.3.15 SOCIOECONOMICS

As identified in Table 7-3, there would be no potential impacts to socioeconomics from the representative HEV project.

7.3.16 ENVIRONMENTAL JUSTICE

As identified in Table 7-3, there would be no environmental justice impacts from the representative HEV project.

7.3.17 HEALTH AND SAFETY

As identified in Table 7-3, there would be no health and safety impacts from the representative HEV project.

7.4 Hydrogen

The representative project involves the production and distribution of hydrogen as an alternative transportation fuel source to replace approximately 20 million gallons per year of gasoline (see Section 2.3.4.5.5). This would require the production of approximately 44 million pounds, or 20 million kilograms, per year of hydrogen. The representative project assumes production of hydrogen from water via a combination of two sources: (1) the 38-megawatt Puna Geothermal Venture Plant on Hawaiʻi Island; and (2) 50 megawatts of solar energy on Oʻahu. This would require the installation and development of distribution infrastructure including pipelines, storage tanks, and fueling stations on Hawaiʻi and Oʻahu. The representative project would have the option of using tanker trucks instead of distribution pipelines, or a combination of both.

Table 7-4 presents a summary of the potential environmental impacts for hydrogen, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction and operation impacts. See Section 3.1.3.	Same as those common across construction and operation projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Potential air emissions associated with distribution of hydrogen.	Same as those common across construction and operation projects. See Section 3.2.5.

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate Change	Potential beneficial impact; A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.	
Water Resources		
	General construction and operation impacts. See Section 3.3.5. Groundwater likely would be required for the generation of hydrogen.	Same as those common across construction and operation projects. See Section 3.3.6.
Biological Resources		
	None; the generation of hydrogen and use of hydrogen as a vehicle fuel would not result in impacts to biological resources.	N/A
Land and Submerged Land Use		
Land Use	Potential change in land use from the expansion of the existing geothermal facility on Hawai‘i and a future PV complex on O‘ahu. Depending on the actual siting of the facility there could be change in landownership patterns. Potential change in land use in locations where distribution pipeline and storage tanks would be installed and fueling stations constructed. Operation impacts to land use would be limited to facility maintenance activities.	During site selection, consider Hawai‘i land use designations and county overlay zoning. Avoid sensitive features, such as scenic and historic properties, and important designated areas, such as Hawai‘i Volcanoes National Park on Hawai‘i and multiple scenic and historical areas of O‘ahu.
Submerged Land Use	None.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6. Additional cultural perspectives and impacts regarding geothermal energy development are described in Section 6.2.6.	Same as those common across construction and operation projects. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts to designated special management areas and affect shorefront access.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Scenic and Visual Resources		
	General construction impacts. See Section 3.8.3. Long-term visual impacts would occur from the presence of the new production facilities and distribution infrastructure, including pipelines, storage tanks, and fueling stations, and exterior lighting. Visual impacts would be highly dependent on the location and compatibility with the existing viewshed and land uses.	During site selection, avoid: • Coastal scenic resources from public viewing points and coastal highways; • Designated scenic byways on Hawai‘i and Kaua‘i; • State, National, and National Historical Parks; • Reserves protected by the Natural Area Reserves System; and • Residential and recreational areas. Consult with the county general land use plans and associated implementation tools such as zoning ordinances and development standards regarding protecting and maintaining open space and scenic resources.
Recreation Resources		
	General construction and operation impacts. See Section 3.9.4.	Same as those common across construction and operation projects. See Section 3.9.5.
Land and Marine Transportation		
Land Transportation	General construction impacts. See Section 3.10.3. Potential long-term land transportation impacts from tanker trucks transporting the produced hydrogen if tankers are used with or in place of pipelines.	None.
Marine Transportation	Potential long-term marine transportation impacts if produced hydrogen is transported to other islands; would require additional handling facilities at harbors as well as ships with the appropriate storage capability.	Consider potential hazards of hydrogen fuel when locating and designing harbor facilities for handling hydrogen; consider compatibility with existing harbor infrastructure and operations.
Airspace Management		
	None; the generation of hydrogen or the use of hydrogen as a vehicle fuel would not result in any tall structures or other impacts to regional airspace.	N/A
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses.	Same as those common across construction and operation projects. See Section 3.12.6.

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Increase in marine vessel transport operations would increase noise levels at the harbors.	
Utilities and Infrastructure		
	Impacts from increased hydrogen production would similar to those in Section 6.2.3 for the geothermal technology and Section 6.7.3 for PV technology. No impacts from hydrogen-operated vehicles because it would not result in a change to electricity demand.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Minimal hazardous material exposure impacts anticipated from increased hydrogen production at the Puna Geothermal Plant. No hazardous material exposure impacts anticipated from hydrogen production via a 50-megawatt utility-scale solar PV system. Minimal hazardous waste exposure impacts during distribution of fuel via tankers or pipelines. Minimal impacts from exposure to hazardous materials during construction and development of hydrogen pipelines and fueling stations. Minimal hazardous material exposure impacts during operation of hydrogen fuel-celled vehicles.	If hydrogen were to be distributed via pipelines, proper siting procedures and BMPs would be implemented.
Waste Management	No new solid waste to be generated by the Puna Geothermal Plant for hydrogen production. Minimal waste management impacts would occur during construction of utility-scale PV system for hydrogen production and associated distribution pipelines and fueling stations; See Section 3.14.4. Minimal impacts would occur during the end life of the PV system; discarded solar panels may need to be managed and disposed of as hazardous waste; it is anticipated that primary waste management impacts resulting from the project would be minimal.	Displaced vehicle wastes would be disposed of at recycling facilities in the State; non-recyclable car parts or materials may require disposal at one of the landfills serving the State.

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Other potential impacts may result from displacement of existing internal combustion vehicles, potentially increasing vehicle waste disposal--potential impacts pending resolution of existing landfill capacity constraints.	
Wastewater	Potential wastewater impacts associated with hydrogen production from the representative geothermal project would be similar to those impacts discussed in Section 6.2, Geothermal. Potential beneficial impacts to water resources and wastewater services if the project produced hydrogen using wastewater. Wastewater impacts resulting from solar energy produced hydrogen would likely occur during the manufacturing process. These impacts are discussed in Section 5.4.14.1.2.	None.
Socioeconomics		
	The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be small.	None.
Environmental Justice		
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians

Table 7-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Hydrogen (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Health and Safety		
	No significant accident consequences are anticipated as a result of increased use of hydrogen as a vehicle fuel. Effects on island public safety services would be small; workers needed to construct and operate facilities expected to come from the State's existing workforce. Police, fire, and medical services would not be adversely affected with this small change.	As production methods are studied, the application of the existing safe infrastructure and associated processes and procedures will be tailored to the specific safety risks of each. First responder training for any unique features of this technology as it is introduced to Hawai'i may be needed to improve emergency response safety and effectiveness. Training such as the National Alternative Fuels Consortium's First Responder Safety Training may be used to become trained.

7.4.1 GEOLOGY AND SOILS

7.4.1.1 Potential Impacts

Potential impacts to geology and soils from the construction and operation of the representative project facilities would be the same as those expected for common construction actions as described in Section 3.1.3. Since the amount of land disturbed would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable. Any ground disturbance from installation of pipelines, storage tanks, and fueling stations also would result in the types of potential impacts expected for common construction activities.

Operation of the hydrogen production facilities would not involve activities that would have the potential to affect geology and soils of the area. Likewise, operation of the hydrogen fuel cell vehicles supported by the representative project would not be expected to have any impact on geology or soils.

7.4.1.2 Best Management Practices and Mitigation Measures

BMPs for geology and soils would be the same as those common across construction and operation projects. See Section 3.1.4.

7.4.2 CLIMATE AND AIR QUALITY

7.4.2.1 Potential Impacts

7.4.2.1.1 Air Quality

The representative project would require the construction of facilities to produce hydrogen and the infrastructure to distribute it. Impacts on air quality from the representative project would be the same as those expected for common construction actions described in Section 3.2.4.

The facilities used to produce hydrogen would use either geothermal or solar energy. Using these energy sources would reduce air emissions compared with processes that burn fossil fuels to produce electricity. However, these reduced air emissions may be partially offset during the distribution of hydrogen. Suppliers can transport hydrogen via pipeline or over roadways using tube trailer or cryogenic liquid hydrogen tankers. If hydrogen were transported via pipeline, reduction in air emissions would be realized. However, if hydrogen were transported over roadways, air emissions may be partially offset dependent on the fuel used by the trailer/tanker.

Operation of hydrogen fuel cell vehicles would result in reduced air emissions when compared with vehicles operating using existing internal combustion engines.

7.4.2.1.2 Climate Change

A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent.

7.4.2.2 Best Management Practices and Mitigation Measures

BMPs for climate and air quality would be the same as those common across construction and operation projects. See Section 3.2.5.

7.4.3 WATER RESOURCES

7.4.3.1 Potential Impacts

The representative project assumes hydrogen would be generated using electricity from a combination of geothermal technology and solar photovoltaic technology. Potential impacts to water resources from these technologies were described in Sections 6.2.3 and 6.7.3, respectively, and are not repeated here.

7.4.3.1.1 Surface Water

Effects on surface water during construction of hydrogen production plants would be the same as those expected for common construction actions as described in Section 3.3.5.

Runoff from the hydrogen production facilities likely would be different than conditions prior to construction, and if the amount of impermeable surfaces were greater, higher runoff rates would be expected. Management of an increased volume of runoff would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

Operation of hydrogen fuel cell vehicles supported by the representative project would not be expected to have any impact on surface water resources.

7.4.3.1.2 Groundwater

Impacts to groundwater during construction of hydrogen production plants would be the same as those expected for common construction actions as described in Section 3.3.5.

During operations, water from groundwater would likely be the source of the hydrogen produced from the facilities, so both the geothermal and solar energy facilities would have an additional water demand not considered in either Section 6.2.3 or 6.7.3. Based solely on its molecular structure, the minimum amount of water that would be required to produce 44 million pounds of hydrogen on an annual basis would be 396 million pounds, or about 48 million gallons per year. (Ideally, the hydrogen produced would be two-eighteenths, or one-ninth, of the water processed.) Split between the two facilities, the water demand at each would be about 24 million gallons per year, or 0.066 million gallons per day. These water demands would not be expected to be prohibitive. The groundwater resources on O‘ahu’s and Hawai‘i’s are characterized as having sustainable yields of 407 and 2,410 million gallons per day, respectively, compared to a groundwater usage of only about 190 and 92 million gallons per day (Tables 3-19 and 3-27), so on an island-wide basis, groundwater availability would not appear to be a problem. In addition, other sources of water (e.g., surface water, seawater, or treated wastewater) may be appropriate for hydrogen production.

Operation of hydrogen fuel cell vehicles supported by the representative project would not be expected to have any impact on groundwater resources.

7.4.3.1.3 Floodplains and Wetlands

The proponent of the representative hydrogen project would be expected to avoid floodplains and wetlands areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as those described for common construction actions in Section 3.3.5.

7.4.3.2 Best Management Practices and Mitigation Measures

BMPs for water resources would be the same as those common across construction and operation projects. See Section 3.3.6.

7.4.4 BIOLOGICAL RESOURCES

Beyond those identified for geothermal and solar PV projects, as identified in Table 7-4, there would be no potential impacts to biological resources from the representative hydrogen project.

7.4.5 LAND AND SUBMERGED LAND USE

7.4.5.1 Potential Impacts

7.4.5.1.1 Land Use

The representative project involves the production of hydrogen at an existing geothermal facility and/or solar energy facility. Surface land use impacts could occur from the expansion of the geothermal facility on Hawaiʻi island and a future solar energy complex on Oʻahu. Both projects could result in removing land from its current uses for the development of hydrogen. Depending upon the actual siting of the solar facility there could be some change in landownership patterns. Operational impacts to land use would be limited to facility maintenance activities.

7.4.5.1.2 Submerged Land Use

As identified in Table 7-4, there would be no potential impacts to submerged land use from the representative hydrogen project.

7.4.5.2 Best Management Practices and Mitigation Measures

- During site selection, consider Hawaiʻi land use designations and county overlay zoning.
- Avoid sensitive features, such as scenic and historic properties, and important designated areas, such as Hawaiʻi Volcanoes National Park on Hawaiʻi and multiple scenic and historical areas of Oʻahu.

7.4.6 CULTURAL AND HISTORIC RESOURCES

7.4.6.1 Potential Impacts

Potential impacts to cultural and historic resources from the construction and operation of the representative project facilities would be the same as those expected for common construction and operation actions as described in Section 3.6.6. Cultural perspectives and impacts regarding geothermal energy development are described in Section 6.2.6.

Operation of the hydrogen fuel cell vehicles supported by the representative project would not be expected to have any impact on cultural and historic resources.

7.4.6.2 Best Management Practices and Mitigation Measures

BMPs for cultural and historic resources would be the same as those common across construction and operational projects. See Section 3.6.7.

7.4.7 COASTAL ZONE MANAGEMENT

7.4.7.1 Potential Impacts

Development of hydrogen fuel production could eventually require development of harbor facilities for handling and distributing produced hydrogen between the islands. The harbor facilities could impact designated special management areas and affect shorefront access. However, these facilities likely would be developed in areas with similar, existing facilities and would most likely be consistent with current uses. Nevertheless, potential impacts could require evaluation through a Federal consistency review under the Coastal Zone Management Program.

7.4.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

7.4.8 SCENIC AND VISUAL RESOURCES

7.4.8.1 Potential Impacts

Potential impacts to scenic and visual resources from the construction of the representative project facilities would be the same as those expected for common construction actions as described in Section 3.8.3.

Long-term visual impacts would occur from the presence of the new production facilities and distribution infrastructure. In addition to the pipelines, storage tanks, and fueling stations on the islands, exterior lighting would be necessary for safety and security purposes. Visual impacts would be highly dependent on the location and compatibility with the existing viewshed and land uses. If tanker trucks were used along with or instead of distribution pipelines, the visual impacts from the added infrastructure would be reduced or avoided.

7.4.8.2 Best Management Practices and Mitigation Measures

During site selection, avoid sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the three designated scenic byways; State, National, and National Historical Parks; reserves protected by the Natural Area Reserves System; and residential and recreational areas.

Consult with the county general land use plans and associated implementation tools such as zoning ordinances and development standards regarding protecting and maintaining open space and scenic resources.

7.4.9 RECREATION RESOURCES

7.4.9.1 Potential Impacts

Potential impacts to recreation resources from the construction and operation of the representative project would be the same as those expected for common construction and operation actions as described in Section 3.9.4.

7.4.9.2 Best Management Practices and Mitigation Measures

BMPs for recreation resources would be the same as those common across construction and operation projects. See Section 3.9.5.

7.4.10 LAND AND MARINE TRANSPORTATION

7.4.10.1 Potential Impacts

7.4.10.1.1 Land Transportation

Potential impacts to land transportation from the construction of the representative project would be the same as those expected for common construction actions as described in Section 3.10.3.

Long-term impacts would occur if tanker trucks were used to augment or replace the pipeline distribution system for transporting produced hydrogen from the point of production to the point of use (i.e., fueling stations). The use of hydrogen fuel cells in vehicles should not have any adverse impacts to the transportation system.

7.4.10.1.2 Marine Transportation

The representative project could involve marine transport to distribute the produced hydrogen to the other Hawaiian Islands, such as Maui and Kaua‘i, which would require additional handling facilities at harbors and ships with the appropriate storage capability.

7.4.10.2 Best Management Practices and Mitigation Measures

Consider the potential hazards of hydrogen fuel when locating and designing harbor facilities for handling hydrogen as well as compatibility with existing harbor infrastructure and operations.

7.4.11 AIRSPACE MANAGEMENT

As identified in Table 7-4, there would be no potential impacts to airspace management from the representative hydrogen project.

7.4.12 NOISE AND VIBRATION

7.4.12.1 Potential Impacts

Short-term noise and vibration impacts would result during construction of facilities required to produce hydrogen and the infrastructure required to distribute it as an alternative transportation fuel source. It is assumed that the hydrogen would be produced via energy from the existing Puna Geothermal Venture Plant on Hawai‘i and also via solar energy on O‘ahu. The representative hydrogen project could result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

The representative hydrogen project could potentially result in long-term impacts to existing noise and vibration levels. Noise and vibration would result from operation of production and distribution facilities, including fueling stations. Tanker trucks may be utilized in place of distribution pipelines. Hydrogen would also then be distributed via marine transport to the other islands such as Maui and Kaua‘i. The increase in vessel operations could increase noise levels at the harbors, potentially affecting nearby noise and vibration-sensitive receptors identified. Noise and vibration impacts would be dependent on the location and compatibility with the existing noise levels and land uses.

7.4.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

7.4.13 UTILITIES AND INFRASTRUCTURE

7.4.13.1 Potential Impacts

Potential impacts to utilities and infrastructure from the construction and operation of the representative project facilities would be very similar to those described in Section 6.2.3 for the geothermal technology and Section 6.7.3 for PV technology.

As identified in Table 7-4, there would be no potential impacts to utilities and infrastructure from the operation of hydrogen-powered vehicles since no electrical demand change is expected for this initiative. However, the construction and operation of new hydrogen fueling stations would be required.

7.4.13.2 Best Management Practices and Mitigation Measures

None noted.

7.4.14 HAZARDOUS MATERIAL AND WASTE MANAGEMENT

7.4.14.1 Potential Impacts

7.4.14.1.1 Hazardous Materials

The Hawai‘i Natural Energy Institute prepared a draft environmental assessment to analyze potential impacts of producing hydrogen at the Puna Geothermal Venture Plant (HNEI 2012). That document reported that there are no known spills or other incidents involving hazardous or toxic substances that would require precautions during placement of equipment at the sites beyond those that would normally occur in an industrial setting, where flammable and hazardous substances are stored and used as part of various operations. As with any fuel, there are hazards involved in hydrogen production, storage, and transportation. However, these can be minimized by adhering to standard industry practices.

It is anticipated that the representative hydrogen production and storage facility would adhere to Federal, State, and local laws and codes and regulations. In the event of an emergency or spill, the project would comply with existing spill and response plans, including compliance with manufacturers’ material safety data sheets, OSHA, USDOT, and HDOT requirements. In addition, project personnel would notify first responders and HDOH. As such, hazardous material exposure impacts resulting from increased hydrogen production at the Puna Geothermal Plant would be minimal.

Potential impacts from the production of hydrogen via a PV system would be the same as those expected for common construction actions as described in Section 3.14.4.

Once produced, hydrogen would be distributed to fueling stations either via tankers or via pipelines. The distribution of hydrogen via tankers would occur in accordance with Federal, State, and county laws and regulations for the storage, handling, and transport of fuels. Hydrogen distributed via pipelines would require construction of a pipeline distribution system, and proper siting procedures and BMPs would be implemented.

The representative project also includes use of hydrogen-fueled vehicles, the operation of which would not result in impacts to hazardous material. Hazardous material exposure impacts would be related to the vehicles' end-of-life, in that the vehicles' battery pack to fuel and power the vehicle would require long-term disposal. A detailed discussion of battery disposal impacts follows.

7.4.14.1.2 Waste Management

No new solid waste is anticipated to be generated by producing hydrogen at the Puna Geothermal Plant; therefore, there would be no impacts to waste management.

Minimal impacts would occur during the construction of a utility-scale PV system for hydrogen production. Impacts associated with PV systems are discussed in Section 6.6.14.

The primary waste management impacts resulting from the use of hydrogen as a fuel would occur at the end-of-life of the hydrogen fuel cell vehicles (see Section 7.3.14.1.2). Special treatment is recommended during the disposal of the vehicle battery packs that cannot be recycled, as most batteries are made out of many materials that can be toxic to humans and animals. Special treatment could include setting aside the battery pack, and employing proper handling and transport for disposal at the appropriate hazardous material facility. This would ensure that no hazardous materials were disposed of at landfills and that hazardous materials did not enter the waste stream. Additional discussion regarding batteries and fuel cell disposal can be found in Sections 5.3.14 and 8.5.14.

As discussed in Section 3.14, several landfills on the islands of O‘ahu and Hawai‘i are currently at capacity. As such, depending on the proposed project location, the disposal of non-recyclable car parts/materials may add to existing landfill capacity constraints. The resolution of landfill siting and expansion on several islands are pending. Therefore, additional waste produced on the islands of O‘ahu and Hawai‘i may result in potential impacts.

7.4.14.1.3 Wastewater

Potential impacts to wastewater from the construction and operation of the representative project would be the same as those expected for common construction and operation actions as described in Section 3.14.4.

Wastewater impacts related to using a PV system to produce hydrogen are discussed in Section 5.4.14.1.2.

7.4.14.2 Best Management Practices and Mitigation Measures

7.4.14.2.1 Hazardous Materials

Ensure the hydrogen system meets all appropriate hydrogen codes and standard requirements, is thoroughly tested by the manufacturers, and undergoes third-party acceptance testing.

Site infrastructure designs would also be expected to meet applicable hydrogen safety codes and standards, and installation be conducted by experienced and reputable contractors. These include Federal, State, and county regulations as well as codes of the International Code Council and those developed by the National Fire Protection Association affecting or related to the storage, dispensing, use, and handling of gaseous and liquefied hydrogen.

7.4.14.2.2 Waste Management

- Separate the used battery packs to ensure non-recyclable packs are not batched for recycling.
- Employ proper handling and transport for disposal at the appropriate hazardous material facility.
- During site selection, consider existing landfill capacity constraints.

7.4.14.2.3 Wastewater

BMPs for wastewater would be the same as those common across construction and operation projects. See Section 3.14.5.

7.4.15 SOCIOECONOMICS

7.4.15.1 Potential Impacts

Socioeconomic impacts in Hawai‘i arising from the representative hydrogen project would be very small. The plant apparatus and appliances pipelines, storage tanks, and fuel station apparatus likely would be manufactured outside of the State. Therefore, economic benefits associated with manufacturing would accrue elsewhere. If the pipeline distribution infrastructure was installed, there would be additional, but still very small, socioeconomic impacts. The few jobs directly associated with the production of hydrogen and the temporary jobs associated with the installation of a distribution system would likely be filled by individuals residing within the area of influence (the State of Hawai‘i) and not by in-migrating workers. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and county government sector; to rental housing; and to personal income would be very small.

7.4.15.2 Best Management Practices and Mitigation Measures

None identified.

7.4.16 ENVIRONMENTAL JUSTICE

7.4.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative hydrogen project are expected to be small. Impacts to minority and low-income populations also would be small.

7.4.16.2 Best Management Practices and Mitigation Measures

During site selection of the PV facility on O‘ahu, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

7.4.17 HEALTH AND SAFETY

7.4.17.1 Potential Impacts

Effects on public safety services would be small since the workers needed to construct and operate the hydrogen production facilities would be expected to come from the island's existing work force. Police, fire, and medical services would not be adversely affected with this small change. First responder training for any unique features of this technology as it is introduced to Hawai‘i may be needed to improve emergency response safety and effectiveness. Training such as the National Alternative Fuels Consortium's First Responder Safety Training may be used to become properly trained.

Potential health and safety impacts associated with the production of hydrogen are addressed in Sections 6.2.17 and 6.6.17. Common construction impacts could occur from standard industrial hazards.

7.4.17.2 Best Management Practices and Mitigation Measures

The BMPs associated with the production of hydrogen are addressed in Sections 6.2.17 and 6.6.17.

7.5 Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas

The representative natural gas project would offset a total of 20 million gallons per year of gasoline by importing approximately 10 million gallons per year gasoline gallon equivalency of natural gas and increasing local production of liquefied petroleum gas (LPG) to approximately 10 million gallons per year gasoline gallon equivalency (see Section 2.3.4.5). The imported natural gas would be used to produce approximately 15 million gallons (10 million gallons per year × 1.5362) of liquefied natural gas (LNG).

The representative project assumes LNG would replace synthetic natural gas use. As the distribution system for synthetic natural gas is currently set up in the State, the liquefied natural gas would use the existing infrastructure, with modifications and/or expansions to the existing distribution system occurring to the extent necessary. Likewise, the current liquefied petroleum gas distribution network would be modified and/or expanded as necessary.

The import of natural gas to the State for transportation use would require increased capital for upfront investments to develop a liquefied natural gas import station, the fueling infrastructure on O‘ahu, and for smaller import terminals on the other islands. The representative project assumes natural gas vehicles would not be imported, as car conversions would occur, albeit costly. Passenger vehicles would mostly be converted to compressed natural gas- and propane powered vehicles, while heavy-duty vehicles, including transit buses, waste collection and transfer vehicles, airport shuttles and vehicles, and City and State vehicles would be converted to run on liquefied natural gas.

Table 7-5 presents a summary of the potential environmental impacts for compressed and liquefied natural gas, and liquefied petroleum gas, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of compressed and liquefied natural gas, and liquefied petroleum gas and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction and operation impacts. See Section 3.1.3.	Same as those common across construction and operation projects. See Section 3.1.4.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Operational impacts could occur due to marine vehicles importing natural gas generating criteria pollutants, as would trucks used for on-island transport. Leaks and air emissions from the liquid natural gas import station would be possible. Potentially beneficial operational air quality and climate change impacts due to replacement of 20 million gallons of gasoline.	Same as those common across construction and operation projects. See Section 3.2.5.
Climate Change	General construction impacts. See Section 3.2.4. Operational impacts could occur due to marine vehicles importing natural gas generating greenhouse gasses, as would trucks used for on-island transport. Leaks and air emissions from the liquid natural gas import station would be possible. Potential beneficial operational benefits due to replacement of 20 million gallons of gasoline.	Same as those common across construction and operation projects. See Section 3.2.5.
Water Resources		
	General construction and operation impacts. See Section 3.3.5.	Same as those common across construction and operation projects. See Section 3.3.6.

Table 7-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Biological Resources		
	Potential localized impacts from disturbance to marine communities during construction and anchoring of offshore facilities (if such facilities are required). No biological resources impacts anticipated during upgrade and expansion of existing onshore infrastructure as these activities are expected to occur in existing developed areas.	Same as those common across construction and operation projects. See Section 3.4.6.
Land and Submerged Land Use		
Land Use	General construction and operation impacts. See Section 3.5.4.	Consider State land use designations, county overlay zones, and other recognized scenic and historic features and areas. Locate new import facilities at existing industrial and harbor locations. Construct natural gas/LPG fueling stations along existing highways.
Submerged Land Use	None; the import of natural gas and subsequent installation of LNG and LPG infrastructure would not impact submerged land use.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6.	Same as those common across construction and operation projects. See Section 3.6.7.
Coastal Zone Management		
	Potential impacts due to development of harbor facilities for handling and distributing natural gas between islands.	Federal consistency review could be required to ensure consistency with the policies and goals of the Coastal Zone Management Program.
Scenic and Visual Resources		
	General construction impacts. See Section 3.8.3. Potential long-term impacts due to new import terminal (onshore or offshore); new industrial facility with one or more aboveground storage tanks; exterior lighting; cargo ship traffic (site-specific).	Same as those common across construction and operation projects. See Section 3.8.4.
Recreation Resources		
	General construction and operation impacts. See Section 3.9.4.	Same as those common across construction and operation projects. See Section 3.9.5.

Table 7-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	Land transportation would be required to distribute gas to local fueling stations. Natural gas would likely replace other petroleum-based products; therefore the amount of truck transportation would not increase but change to a different type of vehicle.	Safety issues would have to be addressed in the development of land-based natural gas infrastructure and operations.
Marine Transportation	The import of natural gas would require development of fueling infrastructure at island harbors, either onshore or offshore. Shipping transportation would require specialized tankers or natural gas carriers to maintain natural gas temperature.	Shipment of natural gas would raise issues of safety and potential accidents that would have to be addressed in the development of infrastructure and operations.
Airspace Management		
	None; the import of natural gas and subsequent installation of LNG and LPG infrastructure would not impact airspace management.	N/A
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Potential long-term impacts to existing noise and vibration levels, depending on the location of facilities and compatibility with existing noise levels and land uses. Increase in marine vessel transport operations would increase noise levels at the harbors.	Same as those common across construction and operation projects. See Section 3.12.6.
Utilities and Infrastructure		
	Small net change in expected power demand to electric utilities. Infrastructure of LNG/LPG fueling stations would need to be expanded to support demand.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential exposure to hazardous material impacts during import and distribution of natural gas if accidental spills or releases occur. Potential short-term construction impacts from exposure to hazardous materials during modifications and/or expansions of natural gas distribution system. See Section 3.14.	Safety guidelines should be considered during the design and installation of compressed natural gas refueling facilities including the National Fire Prevention Association's NFPA 52 Vehicular Gaseous Fuel Systems Code as well as compliance with Federal, State, and local laws and regulations for the storage, handling, and transport of fuels.

Table 7-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
	Minimal impacts from exposure to hazardous materials from increased propane production, distribution and use on O‘ahu. The operation of compressed natural gas vehicles and propane-powered vehicles is not anticipated to result in hazardous material exposure impacts.	Safety guidelines would apply similar to those required for natural gas during the handling, transport, and distribution of propane gas, and in the event of accidental releases or spills. Compliance with Federal, State, and local laws and regulations for the storage, handling, and transport of fuels. Vehicle conversions shall occur via licensed technicians associated with vehicle manufacturers and would be certified to meet EPA requirements and to ensure that equipment is properly installed, safe and durable, and meets the associated standards of the vehicle model year.
Waste Management	No potential impacts associated with import and use of natural gas. Potential waste management impacts during construction and development of additional natural gas infrastructure/modification and expansions. See Section 3.14 Minimal impacts associated with modification and expansion of LPG infrastructure. Minimal impacts associated with retrofitting existing vehicle fleet for natural gas/LPG use.	None.
Wastewater	None.	N/A
Socioeconomics		
	The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.	None.
Environmental Justice		
	Small environmental justice impacts.	None.

Table 7-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Compressed and Liquefied Natural Gas, and Liquefied Petroleum Gas (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Health and Safety		
	General construction and operation impacts. See Section 3.17.3.	Follow State reporting requirements for releases above regulatory limits. Follow National Fire Prevention Association's NFPA 52 Vehicular Gaseous Fuel Systems Code.

7.5.1 GEOLOGY AND SOILS

7.5.1.1 Potential Impacts

Impacts on geology and soils during actions to import natural gas and upgrade natural gas and LPG infrastructure and distribution systems would be the same as those expected for common construction actions as described in Section 3.1.3. It is assume the amount of land disturbed the project, or individual elements of the project would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable.

7.5.1.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce impacts to geology and soils are discussed in Section 3.1.4.

7.5.2 CLIMATE AND AIR QUALITY

7.5.2.1 Potential Impacts

7.5.2.1.1 Air Quality

Impacts on air quality from the representative project would be the same as those expected for common construction actions described in Section 3.2.4. The representative project would require the construction of facilities to distribute natural gas and liquefied petroleum gas. The construction would include a natural gas import station, regasification facilities, facilities required to increase liquid petroleum gas production on the islands, and the fueling infrastructures for both types of fuel.

The marine vessels required to import natural gas would generate criteria pollutants from their engines as would the trucks required to transport the fuel on the islands. Leaks and air emissions from the natural gas import station would be possible.

7.5.2.1.2 Climate Change

The proposed representative project would replace 20 million gallons of gasoline usage in transportation vehicles in the State. A reduction of 20 million gallons of gasoline would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent. However, although natural gas vehicles generate fewer criteria pollutants and greenhouse gases than gasoline-powered vehicles, they still generate emissions. Consequently, the reduction in greenhouse gas emissions from lowering gasoline usage in passenger vehicles would be partially offset by the emissions from the natural gas vehicles. Typically, the greenhouse gas emissions from natural gas-fueled vehicles are 25 percent lower than conventional gas or diesel powered vehicles (EPA 2014).

As noted above, the marine vessels required to import natural gas would generate criteria pollutants and subsequently greenhouse gas from their engines as would the trucks required to transport the fuel on the islands. Leaks and air emissions from the natural gas import station would be possible.

7.5.2.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce air quality and greenhouse gas emission impacts are discussed in Section 3.2.5.

7.5.3 WATER RESOURCES

7.5.3.1 Potential Impacts

Impacts on water resources during actions to upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction actions as described in Section 3.3.5.

7.5.3.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to minimize potential water resource impacts are discussed in Section 3.3.6.

7.5.4 BIOLOGICAL RESOURCES

7.5.4.1 Potential Impacts

Some offshore import infrastructure may be developed to handle natural gas in addition to modification of existing on shore facilities. Some localized disturbance to the marine communities would occur during the construction and anchoring of offshore facilities. Upgrading and expanding existing onshore natural gas infrastructure is not expected to impact biological resources as they would be expected to occur in existing developed areas. If new land was disturbed, common construction impacts from vegetation clearing could occur as discussed in Section 3.4.5.

7.5.4.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to minimize construction impacts from vegetation clearing are discussed in Section 3.4.6.

7.5.5 LAND AND SUBMERGED LAND USE

7.5.5.1 Potential Impacts

7.5.5.1.1 Land Use

From a land use perceptive, increased use of natural gas would require modifications and/or expansions to existing distribution systems. LPG distribution networks could also require modifications or expansions.

A natural gas import station and fueling infrastructure would be required on O‘ahu, and smaller import terminals would be required on the other islands. The location and construction of terminals and associated support facilities would result in land disturbance. There would be no operational impacts on land use.

7.5.5.1.2 Submerged Land Use

As identified in Table 7-5, there would be no potential impacts to submerged land use from the representative project.

7.5.5.2 Best Management Practices and Mitigation Measures

The installation of distribution systems and the siting of import terminals would consider State land use designations, county overlay zones, and other recognized scenic and historic features and areas. The facilities would be located at existing industrial and harbor locations. The natural gas/LPG fueling stations would be constructed along existing highways to be convenient to the driving population.

7.5.6 CULTURAL AND HISTORIC RESOURCES

7.5.6.1 Potential Impacts

Impacts on cultural and historic resources during actions to import natural gas and upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction and operation actions as described in Sections 3.6.6.

7.5.6.2 Best Management Practices and Mitigation Measures

The project would be required to apply construction and operations BMPs to minimize impacts to cultural and historic resources, as discussed in Section 3.6.7.

7.5.7 COASTAL ZONE MANAGEMENT

7.5.7.1 Potential Impacts

Importation of natural gas would require development of harbor facilities for handling and distributing LNG between islands. The harbor facilities, either onshore or offshore, could impact designated special management areas and affect shorefront access. However, these facilities would likely be developed in an area with similar existing facilities and would most likely be consistent with current uses. These potential impacts could require evaluation through a Federal consistency review under the Coastal Zone Management Program.

7.5.7.2 Best Management Practices and Mitigation Measures

As part of BMPs, a Federal consistency review could be required to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program.

7.5.8 SCENIC AND VISUAL RESOURCES

7.5.8.1 Potential Impacts

Impacts on scenic and visual resources during actions to import natural gas and upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction actions as described in Section 3.8.3.

Long-term visual impacts would occur from importing natural gas on a large-scale via cargo ships from the West Coast of the United States. In addition, an import terminal would be required. The import terminal could be located onshore or offshore. Either location would cause visual impacts from a new industrial facility with one or more aboveground storage tanks. Exterior lighting on the facility would be visible at night. During operations, visual impacts would occur from the arrival, unloading, and departure of cargo ships. Visual impacts would be highly dependent on the location and compatibility with the existing viewshed and land uses. Local and existing suppliers of LPG would increase LPG production and thus visual impacts would not occur from increased use of LPG.

7.5.8.2 Best Management Practices and Mitigation Measures

Sensitive locations such as coastal scenic resources from public viewing points and coastal highways; State, National, and National Historical Parks; and reserves protected by the Natural Area Reserves System, and residential and recreational areas should be considered when locating a natural gas import facility.

In addition, each of the six islands have general land use plans and associated implementation tools such as zoning ordinances and development standards. Some of the counties' plans include more detail than others, but all include objectives related to protecting and maintaining open space and scenic resources consistent with the State's land use designations. For example, Honolulu County's plan includes policies protecting scenic views, especially those seen from highly developed and heavily traveled areas and locating public facilities and utilities in areas where they will least obstruct important views of the mountains and the sea (City and County of Honolulu 2002).

Visual impacts should be considered when siting a natural gas import facility. Due to the size of the facility, especially natural gas storage tanks, using measures such as vegetative screening to reduce visual impacts would not be possible. BMPs to minimize impacts to visual resources are described in Section 3.8.4.

7.5.9 RECREATION RESOURCES

7.5.9.1 Potential Impacts

Impacts on recreation resources during actions to import natural gas and upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction and operation actions as described in Section 3.9.4.

7.5.9.2 Best Management Practices and Mitigation Measures

Recreation resource impacts should be considered when siting a natural gas import facility. Due to the size of the facility, including natural gas storage tanks, high use recreation areas could be avoided and steps taken through design work to minimize obstructions to recreation activities. Tables 3-47 and 3-48 identify the popular land and sea-based recreation activities.

BMPs and mitigation measures to minimize impacts to recreation resources are described in Section 3.9.5.

7.5.10 LAND AND MARINE TRANSPORTATION

7.5.10.1 Potential Impacts

7.5.10.1.1 Land Transportation

The import of natural gas would require the development of fueling infrastructure at island harbors. These facilities could be either onshore or offshore. The shipping transportation would require specialized tankers or natural gas carriers to keep the LNG at cold temperatures.

Land transportation would be required to distribute the gas to local fueling stations. Because the natural gas would likely replace other petroleum-based products, the amount of truck transportation would not increase but change to a different type of vehicle. Safety issues would have to be addressed in the development of land-based natural gas infrastructure and operations.

7.5.10.1.2 Marine Transportation

Similar to land transportation, the marine shipment of natural gas would raise issues of safety and potential accidents that would have to be addressed in the development of infrastructure and operations.

7.5.10.2 Best Management Practices and Mitigation Measures

None identified.

7.5.11 AIRSPACE MANAGEMENT

As identified in Table 7-5, there would be no potential impacts to airspace management from the representative project.

7.5.12 NOISE AND VIBRATION

7.5.12.1 Potential Impacts

Modifications and/or expansions of the existing CNG, LNG, and LPG distribution systems, as well as construction of an LNG import facility on O‘ahu and smaller import terminals on the other islands, would result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

Importing LNG on a large-scale via cargo ships from the U.S. West Coast and operation of a new import terminal located onshore or offshore, could potentially result in long-term impacts to existing noise and vibration levels. The increase in vessel operations could increase noise levels at the harbors, potentially affecting nearby noise and vibration-sensitive receptors identified. Noise and vibration impacts would be dependent on the location and compatibility with the existing noise levels and land uses.

7.5.12.2 Best Management Practices and Mitigation Measures

BMPs would be the same as those common across projects for construction and operation. See Section 3.12.6.

7.5.13 UTILITIES AND INFRASTRUCTURE

7.5.13.1 Potential Impacts

Potential impacts on island electric utilities would include the addition of the natural gas production and handling facilities including fueling stations for vehicles. The net change in the expected power demand from these facilities to electric utilities is expected to be small. HECO utilities have reported that they could retrofit existing oil fired generators with LNG fuel if sources on the islands are built, although this evolution is not evaluated in this PEIS (see HECO 2013).

7.5.13.2 Best Management Practices and Mitigation Measures

None identified.

7.5.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

7.5.14.1 Potential Impacts

7.5.14.1.1 Hazardous Materials

Natural and synthetic gases, or mixtures of natural and synthetic gases, are not considered hazardous materials (pursuant to CERCLA Section 101(14); therefore, if a release of one of these substances occurs, CERCLA notification is not required. However, the State of Hawaiʻi has mandates in place should such a release occur (see Section 7.5.17).

Impacts from exposure to hazardous materials during actions to upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction and operation actions as described in Section 3.14.4.

7.5.14.1.2 Waste Management

Waste management impacts during actions to upgrade natural gas and LPG infrastructure and distributions systems would be the same as those expected for common construction and operation actions as described in Section 3.14.4.

7.5.14.1.3 Wastewater

No wastewater impacts would occur from the import and use of natural gas. Some amount of wastewater would be produced from the additional propane that would be produced locally. However, as propane is currently being produced in the State, production of additional propane would occur in accordance with existing regulations and would operate similar to existing conditions. As such, minimal effects would occur to existing wastewater services.

7.5.14.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce hazardous material and waste management impacts are discussed in Section 3.14.5.

7.5.15 SOCIOECONOMICS

7.5.15.1 Potential Impacts

Socioeconomic impacts associated with the transition to a fleet of transit buses, waste collection and transfer vehicles, airport shuttles and vehicles, and municipal- and State-owned to run on natural gas instead of petroleum products vehicles would necessitate the construction and operation of new infrastructure and distribution systems. New net jobs could be created. The number of jobs associated with importation of natural gas and operation of port terminals; the construction of new fueling infrastructure; and related improvements could be moderate. Most of socioeconomic benefit would accrue in the county in which the primary import terminal was located. Jobs directly associated with the effort would likely be filled by individuals residing within the area of influence (the State of Hawaiʻi), and most likely residing in the county in which the primary import terminal was located, and not by workers migrating to the State to fill those positions. The representative project would create new net jobs during construction. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.

7.5.15.2 Best Management Practices and Mitigation Measures

None identified.

7.5.16 ENVIRONMENTAL JUSTICE

7.5.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative project are expected to be small. Impacts to minority and low-income populations also would be small.

7.5.16.2 Best Management Practices and Mitigation Measures

None noted.

7.5.17 HEALTH AND SAFETY

7.5.17.1 Potential Impacts

Imported natural gas would be stored, handled, and distributed in accordance with Federal, State and county guidelines for combustible materials. This includes compliance with the USDOT’s Pipeline and Hazardous Material Safety Administration’s (PHMSA) regulatory program to assure safe distribution of natural gas and the State DOH.

As propane is currently processed and distributed in the State, an increase in the amount of LPG available for use would not result in additional health and safety impacts.

7.5.17.2 Best Management Practices and Mitigation Measures

In the event an emergency were to occur during the import of natural gas to the State, owners or operators of facilities or vessels that release the substance into the environment above the reportable limit would be required to notify the State pursuant to the HEER Office legal authorities including the Hawaiʻi Environmental Response Law (HRS 128D), the Hawaiʻi State Contingency Plan (HAR 11-451), and the

Hawai‘i Emergency Planning and Community Right-to-Know Act (HEPCRA) (HRS 128E and HAR 11-453), as well as USDOT Spill Response Plans and noticing requirements (http://www.hazmat.dot.gov).

Additional safety guidelines that need to be considered during the design and installation of natural gas refueling facilities include the National Fire Prevention Association’s NFPA 52 Vehicular Gaseous Fuel Systems Code.

7.6 Multi-Modal Transportation

The representative multi-modal transportation project would increase mass transit ridership (bus and rail) to avoid personal car travel to eliminate 20 million gallons of gasoline fuel use in 2030 (see Section 2.3.4.6). Increasing mass transit use and the sustainability of the operations is important on all islands, but the representative project is assumed to be located on O‘ahu. The representative multi-modal transportation project would increase ridership on the existing conventional diesel bus fixed-route service and rapid rail system.

Table 7-6 presents a summary of the potential environmental impacts for multi-model transportation, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 7-6. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Multi-Modal Transportation

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction and operation impacts. See Section 3.1.3.	Any new structures would be constructed in accordance with applicable building codes,
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Using electricity to operate the rail transit would result in criteria pollutants from producing electricity from oil products, unless the generation used renewable sources. Although total transportation energy demand would decrease by 14.1 million gallons per year and reduce passenger vehicle emissions, criteria pollutant emissions still would occur from the operation and usage of diesel buses.	Same as those common across construction and operation projects. See Section 3.2.5.

Table 7-6. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Multi-modal Transportation (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Climate Change	General construction impacts. See Section 3.2.4. Using electricity to operate the rail transit would result in greenhouse gas emissions from producing electricity from oil products, unless the generation used renewable sources. Although total transportation energy demand would decrease by 14.1 million gallons per year and reduce passenger vehicle emissions, greenhouse gas emissions still would occur from the operation and usage of diesel buses.	Same as those common across construction and operation projects. See Section 3.2.5.
Water Resources		
Surface Water	General construction impacts. See Section 3.3.5. Potential improvement to storm water runoff quality from fewer cars on the road (i.e., less contamination).	None.
Groundwater	General construction impacts. See Section 3.3.5. Potential improvement to groundwater quality from cleaner runoff.	None.
Floodplains and Wetlands	General construction impacts. See Section 3.3.5	None.
Biological Resources		
	General construction and operation impacts. See Section 3.4.5.	Locate new rail line or extensions of existing rail lines in areas that are pre-disturbed when possible.
Land and Submerged Land Use		
Land Use	Potential change in land use designation and/or ownership in areas of railway. Reduced demand for gasoline and diesel fuel leading to a decrease in the number of conventional fueling stations, and small parcels of land could be converted to other uses and ownership.	Consider Hawai‘i land use designations, county overlay zones, and other recognized scenic and historic features and areas.
Submerged Land Use	None.	N/A
Cultural and Historic Resources		
	General construction and operation impacts. See Section 3.6.6.	None.

Table 7-6. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Multi-modal Transportation (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Coastal Zone Management		
	None; the representative project does not include locations near the coast.	N/A
Scenic and Visual Resources		
	General construction impacts. See Section 3.8.3. Long-term scenic and visual resource impacts from new infrastructure (site-specific).	Locate new rail infrastructure near existing facilities.
Recreation Resources		
	Potential long-term impacts if new infrastructure intersected an area currently used or with potential for future use for recreational purposes.	Locate new rail infrastructure near existing facilities.
Land and Marine Transportation		
Land Transportation	Beneficial impacts to traffic congestion by reducing number of cars on the road. Potential for an expanded and/or new maintenance and heavy maintenance facility for increased fleet of diesel buses. Potential local traffic impacts during construction of infrastructure to support increased fleet of diesel buses and to expand light rail service.	None.
Marine Transportation	None; while an increase in multi-model transportation could affect inter- and intra-island ferry use, the representative project addresses bus and rail transportation only.	N/A
Airspace Management		
	None; no impacts to airspace management would be expected from the increased use of multi-modal transportation.	N/A

Table 7-6. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Multi-modal Transportation (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Operation of expanded bus and rail systems could potentially result in long-term impacts compared to existing noise and vibration levels, depending on the location of transit corridors and compatibility with the existing noise levels and land uses.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12). Noise avoidance and mitigation measures may be imposed directly as conditions of permit issuance. Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project. Use wheel skirts, sound-absorptive materials under tracks, and automatic track lubrication devices capable of eliminating wheel squeal. Insulate affected buildings. Install sound barriers or other screening mechanisms between the source and the offsite receptors, such as earth berms or vegetation. Monitor operational noise levels for regulatory compliance, and install further mitigation as needed. Noisy activities during construction should be limited to the least noise-sensitive times of day (see Section 3.12). Use equipment with sound-control devices. Equipment should be adequately muffled and maintained.
Utilities and Infrastructure		
	None; no impacts to utilities and infrastructure would be expected from increased use of multi-modal transportation.	N/A
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impact from exposure. Increased fleet size leads to an increased potential for leaks and spills of lubricating oils, hydraulic fluids, coolants, solvents, and cleaning agents	Same as those common across construction and operation projects. See Section 3.14.5.

Table 7-6. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations – Multi-modal Transportation (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Waste Management	General construction and operation impacts. See Section 3.14.4.	
Wastewater	General construction and operation impacts. See Section 3.14.4.	Same as those common across construction and operation projects. See Section 3.14.5.
Socioeconomics		
	The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.	None.
Environmental Justice		
	Small environmental justice impacts.	None.
Health and Safety		
	None; no impacts to health and safety would be expected from increased use of multi-modal transportation.	N/A

7.6.1 GEOLOGY AND SOILS

7.6.1.1 Potential Impacts

Construction may include building additional railways, rail stations, or expanding maintenance facilities for multi-modal transportation systems. Potential impacts on geology and soils would be the same as those expected for common construction actions as described in Section 3.1.3. Construction may involve land disturbance, so the permitting requirements described in Section 3.1.3 would be fully applicable.

During operation, the increased use of multi-modal transportation would not involve activities that would have the potential to affect geology and soils of the area. The potential risk of the representative project being adversely impacted from earthquakes would be at an acceptably low level.

7.6.1.2 Best Management Practices and Mitigation Measures

In accordance with applicable building codes, any new facilities constructed as a result of the representative project would require incorporation of seismic provisions appropriate for the project locations.

7.6.2 CLIMATE AND AIR QUALITY

7.6.2.1 Potential Impacts

7.6.2.1.1 Air Quality

Potential impacts on air quality would be the same as those expected for common construction actions as described in Section 3.2.4.

Operation of the rapid rail system would require electricity to power the trains. Although the rail transit system would reduce total transportation energy demand by 5.9 million gallons of fuel resulting in reduced air emissions, criteria pollutants still would be created from producing electricity from oil products. A greater reduction in air emissions would be realized if all electricity were generated from renewable sources rather than from petroleum.

Operation of additional fleets of diesel buses would also generate criteria pollutants. A 55-percent increase in bus ridership would be required to offset this increase with a corresponding decrease in passenger vehicle emissions. The 55-percent increase corresponds to 40.9 million additional transit bus trips per year. Although total transportation energy demand would decrease by 14.1 million gallons per year and reduce passenger vehicle emissions, criteria pollutant emissions still would occur from the operation and usage of diesel buses.

7.6.2.1.2 Climate Change

A reduction of 20 million gallons of petroleum fuel would correspond with an annual reduction in greenhouse gas emissions of about 190,000 metric tons carbon dioxide equivalent. A rail transit system would reduce transportation energy demand by the equivalent of 5.9 million gallons of fuel in 2030. Both the reduction in fuel usage from personal vehicles and the increase in fuel usage required to generate electricity to operate the trains are included in the 5.9 million gallons calculations. Therefore, 5.9 million gallons is the net fuel savings (Chapter 2).The remaining 14.1 million gallons of avoided fuel use would come from increased transit bus ridership (Chapter 2).

As noted above, the operation of the rapid rail system would still require electricity to power the trains, resulting in greenhouse gas emissions from the electricity generated by oil products. A greater reduction in greenhouse gases could be realized if all electricity would be generated from renewable sources rather than from petroleum.

Similarly, the operation of a fleet of diesel buses would still generate greenhouse gas emissions.

7.6.2.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce potential air quality and greenhouse gas emission impacts are discussed in Section 3.2.5.

7.6.3 WATER RESOURCES

7.6.3.1 Potential Impacts

This section addresses potential environmental consequences to water resources from use of the Honolulu rapid rail system and increasing the O‘ahu bus system’s number of buses, number of trips, and ridership. Potential impacts are addressed in terms of surface water, groundwater, and floodplains and wetlands.

7.6.3.1.1 Surface Water

Use of the Honolulu rail system and increasing use of the O‘ahu bus system would not be expected to result in adverse impacts to surface water. Construction may include building additional railways, rail stations, and maintenance facilities for the rapid rail system and/or building or expanding maintenance facilities for multi-modal transportation systems. Potential impacts on surface water from construction would be the same as those expected for common construction actions as described in Section 3.3.5. In addition, land disturbance activities would be required to comply with permitting requirements. Therefore, permitting requirements described in Section 3.3.5 would be fully applicable.

During operations, there would be no increases in the potential for stormwater runoff to carry sediments or other contaminants to receiving waters.

The representative project would involve reductions in personal vehicle miles traveled and, therefore, could result in beneficial impacts to surface waters. Runoff from roads and highways typically includes small amounts of anti-freeze/coolant and petroleum products that have been dripped or leaked from vehicles onto the roadway and then washed off with the storm water. It is reasonable to conclude, all other things being equal, that fewer vehicles on the road would be associated with less contamination of this nature on the roadway and less in runoff. Also, it is reasonable to assume that buses in a public fleet would be on a regular inspection and maintenance schedule and, as a result, less apt to experience drips or leaks of contaminants or improperly disposed of engine oil than vehicles not regularly inspected.

7.6.3.1.2 Groundwater

Potential impacts on groundwater from construction of additional railways, rail stations, and maintenance facilities for the rapid rail system and/or building or expanding maintenance facilities for multi-modal transportation systems would be the same as those expected for common construction actions as described in Section 3.3.5.

Similar to the rationale described above, during operation, the representative project would result in no adverse impacts to groundwater. Further, the “cleaner” runoff would eventually make its way into the groundwater adjacent to roadways, thereby improving the quality of the groundwater in those locations. Rail usage and the increased usage of buses would be not expected to have any effects on water usage or demand.

7.6.3.1.3 Floodplains and Wetlands

The proponent of additional multi-modal transportation systems would be expected to avoid floodplains and wetland areas if only to reduce costs and minimize regulatory requirements. However, if unavoidable, construction considerations would be the same as described for common construction actions in Section 3.3.5.

If additional infrastructure were built, no operational impacts would be expected to floodplains or wetlands from increased use of multi-modal transportation systems.

7.6.3.2 Best Management Practices and Mitigation Measures

None identified.

7.6.4 BIOLOGICAL RESOURCES

7.6.4.1 Potential Impacts

Potential impacts to biological resources may occur from land clearing and disturbance to construct additional infrastructure for the representative multi-modal transportation project. Short-term impacts could occur from human disturbance during construction and the potential spread of invasive species by creating disturbed areas. However, it is anticipated that additional infrastructure associated with the representative project would occur in areas currently built out and developed to service areas with higher populations, reducing the likelihood of impacts to biological resources.

Similarly, there would be no potential impacts to biological resources from the operation or increased use of multi-modal transportation.

7.6.4.2 Best Management Practices and Mitigation Measures

Locate new rail line or extensions of existing rail lines in areas that are pre-disturbed, when possible.

7.6.5 LAND AND SUBMERGED LAND USE

7.6.5.1 Potential Impacts

7.6.5.1.1 Land Use

Construction of additional railways, rail stations, and maintenance facilities associated with the representative project may require additional land for development and/or clearing, grading, and leveling of areas, which could result in a change of land use or ownership.

Areas of railway expansion could require a change in land use designation and/or ownership. As bus and rail service increase in popularity, the number of personally driven vehicles could decrease, reducing the demand for gasoline and diesel fuel. As a result, there could be decreases in the number of conventional fueling stations, and small parcels of land could be converted to other uses and ownership.

7.6.5.1.2 Submerged Land Use

As identified in Table 7-6, there would be no potential impacts to submerged land use from the representative multi-modal transportation project.

7.6.5.2 Best Management Practices and Mitigation Measures

Consider Hawai‘i land use designations, county overlay zones, and scenic and historic areas during site selection.

7.6.6 CULTURAL AND HISTORIC RESOURCES

As identified in Table 7-6, there would be no potential impacts to cultural or historical resources from the representative multi-modal transportation project beyond those that could occur during the construction of rail facilities.

7.6.7 COASTAL ZONE MANAGEMENT

As identified in Table 7-6, there would be no potential impacts to coastal zone management from the representative multi-modal transportation project.

7.6.8 SCENIC AND VISUAL RESOURCES

7.6.8.1 Potential Impacts

Potential impacts to scenic and visual resources would be the same as those expected for common construction actions as described in Section 3.8.4.

Long-term visual impacts may occur; however, it is anticipated that additional infrastructure built as part of the multi-modal transportation system would occur in areas currently built out and developed to service areas with higher populations. Therefore impacts to scenic and visual resources would be minimal from increased use of multi-modal transportation.

7.6.8.2 Best Management Practices and Mitigation Measures

Locate new rail infrastructure near existing facilities.

7.6.9 RECREATION RESOURCES

As identified in Table 7-6, there would be no potential impacts to recreation resources from representative multi-modal transportation project.

7.6.10 LAND AND MARINE TRANSPORTATION

7.6.10.1 Potential Impacts

7.6.10.1.1 Land Transportation

The goal of the multi-modal transportation project is to increase mass transit use and reduce use of personal cars to save on gasoline use. A beneficial impact of this effort is a reduced amount of traffic congestion by removing cars from the roads. Increased use of transit service diesel buses would require expanding the fleet of buses and likely create a need for both an expanded or new maintenance and heavy maintenance facility. The overall effect to the land transportation system would be to make it more efficient.

Development of multi-modal transportation projects such as light rail systems, reconfiguring road systems for dedicated bus lanes, or turn out lanes for bus stops could have significant impacts on local traffic during the construction phase. For example, the Honolulu Rail Transit Project will require extensive roadwork during installation of various elements of the project. Additionally, centralized parking facilities may be required in and around major rail and bus stop locations. This not only could have a negative, localized traffic impact during construction, it could also have a lasting, albeit smaller, impact during operations.

7.6.10.1.2 Marine Transportation

As identified in Table 7-6, there would be no potential impacts to marine transportation from the representative multi-modal transportation project.

7.6.10.2 Best Management Practices and Mitigation Measures

None identified.

7.6.11 AIRSPACE MANAGEMENT

As identified in Table 7-6, there would be no potential impacts to airspace management from the representative multi-modal transportation project.

7.6.12 NOISE AND VIBRATION

7.6.12.1 Potential Impacts

Development of the representative multi-modal transportation project would result in noise and vibration impacts typical of general construction activities, which are addressed in Section 3.12.5.

Operation of expanded bus and rail systems could potentially result in long-term impacts compared to existing noise and vibration levels. Noise and vibration impacts would be dependent on the location of transit corridors and compatibility with the existing noise levels and land uses.

7.6.12.2 Best Management Practices and Mitigation Measures

Noise and vibration impacts should be considered when siting multi-modal transportation projects. The following recommended BMPs would further reduce noise levels:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Comply with Federal, State, and local noise regulations and ordinances. Noise permits would be required if noise levels exceed regulatory limits. Noise avoidance and mitigation measures may be imposed directly as conditions of permit issuance.
- Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project.
- Use wheel skirts, sound-absorptive materials under tracks, and automatic track lubrication devices capable of eliminating wheel squeal.
- Insulate affected buildings.
- Install screening mechanisms or sound barriers between the source and the offsite receptors, such as earth berms or vegetation.
- Monitor operational noise levels for regulatory compliance, and install further mitigation as needed.
- Noisy activities during construction should be limited to the least noise-sensitive times of day (see Section 3.12).
- Use equipment with sound-control devices. Equipment should be adequately muffled and maintained.

7.6.13 UTILITIES AND INFRASTRUCTURE

As identified in Table 7-6, there would be no potential impacts to utilities or infrastructure from the representative project.

7.6.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

7.6.14.1 Potential Impacts

7.6.14.1.1 Hazardous Materials

Operation of additional diesel buses and extended rail systems would increase the potential for leaks and spills of lubricating oils, hydraulic fluids, coolants, solvents, and cleaning agents.

7.6.14.1.2 Waste Management

Waste management impacts resulting from the representative multi-modal transportation project likely would result during construction and would be similar to those commonly associated with general construction action discussed in Section 3.14.4.

During project operation, hazardous waste may be generated and would be handled, stored, and transported by a licensed hauler to the appropriate permitted disposal facility.

7.6.14.1.3 Wastewater

Potential impacts on wastewater from construction and operation would be the same as those expected for common construction and operation actions as described in Section 3.14.4.

7.6.14.2 Best Management Practices and Mitigation Measures

- Ensure regulated materials are properly handled to avoid release to the environment.
- Ensure compliance with NPDES wastewater discharge permit requirements.

7.6.15 SOCIOECONOMICS

7.6.15.1 Potential Impacts

Socioeconomic impacts associated with an increase in transit ridership and the resulting avoidance of personal car travel would be very small. Some new jobs (for drivers, mechanics, and support personnel) could be created as additional buses are added to the current fleet. There are no buses manufactured in Hawai‘i, so the economic benefit of vehicle manufacturing would accrue elsewhere. The number of jobs associated with the larger fleet of buses, regardless of the fuel options exercised and described Section 2.3.4.6, would be very small. Jobs directly associated with the expanded fleet would be likely filled by individuals residing within the area of influence (the State of Hawai‘i), and not by workers migrating to the State to fill those positions. The representative project would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.

7.6.15.2 Best Management Practices and Mitigation Measures

None identified.

7.6.16 ENVIRONMENTAL JUSTICE

7.6.16.1 Potential Impacts

The potential environmental impacts to the general population associated with an increase in mass transit ridership are expected to be small.

Mass transit initiatives would likely occur in the City and County of Honolulu. Approximately 78 percent of the area's residents are minority and about 9.3 percent of the area's residents are low-income. Adverse impacts to environmental resources expected from the effort to increase transit ridership are negligible. Therefore, no disproportionately high and adverse impacts to minority populations or to low-income population from an increase in mass transit ridership would be expected.

7.6.16.2 Best Management Practices and Mitigation Measures

None identified.

7.6.17 HEALTH AND SAFETY

As identified in Table 7-6, there would be no potential impacts to health and safety from the representative multi-modal transportation project.

7.7 References

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2012-10-08-DEA-hawaii-Natural-Energy-Institute-Electrolyzer-Based-Hydrogen-Production-System.pdf.

CHAPTER 8

Environmental Impacts from Electrical Transmission and Distribution

CONTENTS

LIST OF TABLES

8 ENVIRONMENTAL IMPACTS FROM ELECTRICAL TRANSMISSION AND DISTRIBUTION

This chapter presents the potential environmental impacts that could be expected from electrical transmission and distribution systems (see Section 2.3.5). The electrical transmission and distribution technologies would be required to fully implement the distributed and utility-scale renewables presented in earlier chapters. For each technology evaluated in this chapter, there is a representative project that aids the PEIS in presenting and characterizing the potential environmental impacts. These representative projects are described in detail in Section 2.3.5 and are summarized again here for each technology. The potential impacts are presented for each environmental resource area. As was described in Chapter 3, many of the activities and technologies could result in environmental impacts that would be common of typical construction projects and may not be unique to the specific activity or technology. In these cases, the presentation of potential impacts in this chapter refers the reader to the appropriate section in Chapter 3 that presents these common impacts for that resource area. Therefore, the details in this chapter deal primarily with those impacts that would be unique to the specific activity or technology being evaluated.

Each of the sections below includes a summary table of the potential environmental impacts and best management practices (BMPs) for that technology. Not all technologies have the potential to impact all environmental resource areas analyzed in this document. Therefore, the summary tables also identify and screen those resource areas that are not expected to be impacted by the technology. This approach is consistent with DOE's sliding scale approach to the preparation of NEPA analyses.

8.1 On-Island Transmission

The representative project for on-island transmission of electricity is a new electrical connection to a large, renewable energy generation plant. The project assumes that the generation source is 20 miles from the nearest transmission line and the transmission line operates at 69 kilovolts. The transmission line would be assumed to have a 100-foot-wide, 20-mile-long, 0.38-square-mile disturbed area for right-of-way easement, and a 70-foot pole or structure height. The representative project allows for use of an underground transmission line when feasible.

Table 8-1 presents a summary of the potential environmental impacts for on-island transmission, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology; and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 8-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – On-Island Transmission

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General impacts during construction. See Section 3.1.3.	Same as those common across construction projects. See Section 3.1.4.
Climate and Air Quality		
	General impacts during construction See Section 3.2.4	Same as those common across construction projects. See Section 3.2.5
Water Resources		
Surface Water	General impacts during construction. See Section 3.3.5. Operational impacts include possible alteration of stormwater runoff along transmission corridor as vegetation is reestablished. Any single drainage path expected to experience minimal alteration. Potential application of herbicides to maintain transmission corridor could produce negative environmental impacts if they reach surface waters.	Same as those common across construction projects. See Section 3.3.6. If herbicides are applied, use appropriate handling, storage, and application guidelines according to manufacturer guidance and chemical-specific material safety data sheets.
Groundwater	General impacts during construction. See Section 3.3.5. No adverse operational impacts unless herbicides applied to maintain transmission corridor.	
Floodplains and Wetlands	Potential impacts during construction. See Section 3.3.5.	

Table 8-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – On-Island Transmission (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Biological Resources		
	General impacts to terrestrial ecosystems during construction, including potential access roads. See Section 3.4.5. Operational maintenance of cleared areas around towers and vegetation height along transmission corridor. Potential bird and bat collisions with towers and lines, especially nocturnal flying species.	Same as those common for construction projects. See Section 3.4.6. Use helicopters in remote and rugged terrain without vehicular access. Apply landscape and habitat perspectives to transmission line route planning to avoid high-risk areas and configurations. Use shorter towers to place lines below bird flight paths. Apply horizontal line arrays rather than vertical arrays, when possible. Orient lines parallel to typical flight paths where possible. Install bird flight diverters appropriate to species of concern and landscape characteristics. Use underground transmission lines in extremely high-risk areas.
Land and Submerged Land Use		
Land Use	Transmission line corridors and location of substations and switching yards could result in changes of land ownership patterns and land use.	If feasible and cost effective, install transmission lines underground to minimize visual effects to adjacent land uses. Early coordination with landowners to identify potential issues associated with easements and rights of way.
Submerged Land Use	None; the on-island transmission project would not extend offshore.	N/A
Cultural and Historic Resources		
	General impacts during construction and operation. See Section 3.6.6. The visual impact of on-island transmission projects may be unacceptable near cultural and historic areas where the historic integrity (setting, feeling, association, viewsheds) plays an important role in the value of the resource.	Same as those common across construction and operation projects. See Section 3.6.7.

Table 8-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – On-Island Transmission (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Coastal Zone Management		
	General impacts during construction and operation. See Section 3.7.8. Potential impacts to coastal zone resources (site-specific).	During site selection, avoid the beach and near offshore areas. Evaluate through a Federal consistency review under the Coastal Zone Management Program.
Scenic and Visual Resources		
	General impacts during construction. See Section 3.8.3. Long-term visual impacts associated with towers, transmission lines, cleared transmission corridors, substations, and switching yards.	Same as those common across construction projects. See Section 3.8.4. Consider sensitive locations and route adjustments when locating transmission lines. Apply right-of-way management to reduce adverse impacts. Use structure design and materials with the least adverse impacts to scenic and visual resources.
Recreation Resources		
	General impacts during construction. See Section 3.9.4. Long-term obstruction to some recreational activities; conversely, some activities could be enhanced by improved access (e.g., from access roads for installed transmission infrastructure).	Same as those common across construction projects. See Section 3.9.5.
Land and Marine Transportation		
Land Transportation	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., towers and tower foundations). Short-term impacts during line stringing. Impacts during construction and operation if transmission line installation required road crossings.	Same as those common across construction and operation projects. See Section 3.10.4.
Marine Transportation	None; the on-island transmission project would not extend offshore.	N/A

Table 8-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – On-Island Transmission (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Airspace Management		
	Potential air traffic impacts during construction if helicopters are used to transport supplies or for line stringing. Potential construction and operation impacts and hazards to civilian and military aviation due to topography and high presence of low-altitude aviation. Potential long-term impacts from radio frequency interference.	Same as those common across construction and operation projects. See Section 3.11.4. Coordinate with FAA and other entities if transmission line installation is near an airport. Redefine airspace if necessary and practicable. Depending on the location of the transmission lines relative to airports or agricultural land that could use aircraft for crop dusting, line marker balls may be required or recommended to ensure visibility of the transmission line from nearby aircraft.
Noise and Vibration		
	Short-term noise and vibration impacts during construction. Potential vibration and humming noise during operation from loose hardware. Sizzles, crackles, hissing noises possible, especially during periods of higher humidity.	Same as those common across construction projects. See Section 3.12.6. Apply routine maintenance to mounting hardware and insulators. Use polymer insulators instead of ceramic or glass.
Utilities and Infrastructure		
	Potential impacts related to adding electricity capacity to the grid.	Same as those common across construction and operation projects. See Section 3.13.4. The utility may need to consider grid-balancing measures, as follows: • Projects requiring 5 to 50 megawatt grid connections are discussed in Chapter 6. • Projects requiring 51 to 99 megawatts scale in a manner similar to the 5- to 50-megawatt projects discussed in Chapter 6. • Projects requiring 100-megawatt or larger grid connections are required to comply with the Public Utilities Commission requirements for Transmission Line Approval and Power Purchase Agreements.

Table 8-1. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – On-Island Transmission (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Hazardous Materials and Waste Management		
Hazardous Materials	General impacts from exposure to hazardous materials during construction. See Section 3.14.4. Potential impacts from exposure to hazardous materials during operation and maintenance from use of herbicides to maintain transmission corridor	Same as those common across construction and operation projects. See Section 3.14.5.
Waste Management	None; any vegetation cleared likely would be composted or reused.	N/A None
Wastewater	General impacts during construction. See Section 3.14.4.	Same as those common across construction projects. See Section 3.14.5.
Socioeconomics		
	Minimal beneficial impacts during construction and operation.	None
Environmental Justice		
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	During site selection, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.
Health and Safety		
	Potential health and safety impacts to workers during installation, maintenance, and repairs of the transmission lines. Typical industrial hazards. Additional health and safety risks specific to electrical generation, transmission, and distribution industry. Potential health and safety impacts to the public during operation of the transmission lines as a result of electromagnetic fields generated. Limited to areas immediately adjacent to transmission lines. Police, fire, and medical services would not be adversely affected.	During the installation, maintenance, and repair of transmission lines, ensure activities are conducted and personnel trained in accordance with OSHA guidance related to power generation: https://www.osha.gov/SLTC/powergeneration/ Read available literature about electromagnetic fields and radio frequency health.

8.1.1 GEOLOGY AND SOILS

8.1.1.1 Potential Impacts

Potential impacts on geology and soils would be the same as those expected for common construction actions as described in Section 3.1.3. Since the amount of land disturbed would be well over one acre, the permitting requirements described in Section 3.1.3 would be fully applicable.

The construction of a 20-mile-long transmission line could cross multiple types of terrain as well as encounter many differing land uses and owners. General means of protecting against soil erosion or contamination would be expected to be similar all along the route, but specific approaches may have to be employed to accommodate different land use needs and expectations of landowners. For example, actions going across roads or along road rights of way, particularly State roads, would have to incorporate control measures consistent with roadway operations.

Operation of the installed transmission line would not involve activities that would have the potential to affect geology and soils of the area.

8.1.1.2 Best Management Practices and Mitigation Measures

BMPs for geology and soils would be the same as those common across construction projects. See Section 3.1.4.

8.1.2 CLIMATE AND AIR QUALITY

8.1.2.1 Potential Impacts

8.1.2.1.1 Air Quality

The representative on-island transmission project could result in air quality impacts typical of general construction activities as described in Section 3.2.4.

Operation of an electrical transmission system would not produce criteria pollutants. Minimal emissions from vehicles may result during required maintenance of the transmission line.

8.1.2.1.2 Climate Change

The representative on-island transmission project could produce greenhouse gases typical of general construction activities as described in Section 3.2.4.

Operation of an electrical transmission system would not produce greenhouse gases. Emissions from vehicles required to maintain the transmission line would be minimal.

8.1.2.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction projects. See Section 3.2.5.

8.1.3 WATER RESOURCES

8.1.3.1 Potential Impacts

8.1.3.1.1 Surface Water

Potential impacts on surface water would be dependent on the location of the transmission line structures and potential crossings of surface waters; but in general, would be the same as those expected for common construction actions as described in Section 3.3.5.

During operation there would be no activities that would have the potential to affect surface waters other than possible changes in storm water runoff from along the transmission line while vegetation was re-established. Because the disturbed ground would be spread out over such a large area (i.e., along the 20-mile-long transmission line), any single drainage path would be expected to experience very minor changes, if any.

Operation and maintenance of the transmission line could involve occasional applications of herbicides to keep vegetation at reasonable levels and access roads open. Depending on their characteristics and concentrations, herbicide chemicals can produce adverse environmental impacts if they reach surface waters.

8.1.3.1.2 Groundwater

Construction of the representative project would not be expected to impact groundwater. However, during construction actions, loosened soil conditions result in decreased storm water runoff and would result in more water soaking into the ground and potentially reaching the groundwater. Any impacts would be temporary, as once construction was complete, the ground surface would be returned to preconstruction condition.

Water needs during construction would be expected to come from groundwater resources, either via municipal water systems or private wells, but they would be minor, involving such uses as for dust suppression and soil compaction.

During long-term operation of the transmission line, there would be no impacts to groundwater. However, herbicide use to maintain vertical clearance for rights-of-way could cause adverse impacts to groundwater if not used appropriately.

8.1.3.1.3 Floodplains and Wetlands

The proponent for the electrical transmission line project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

8.1.3.2 Best Management Practices and Mitigation Measures

If used, ensure herbicides are licensed for intended use and they are handled, stored, and applied in accordance with the manufacturer guidelines and material safety data sheets.

8.1.4 BIOLOGICAL RESOURCES

8.1.4.1 Potential Impacts

Potential impacts to biological resources from construction and operation of electrical transmission lines would include vegetation clearing for the installation of transmission line structures, maintenance of vegetation underneath transmission lines, and bird collisions with transmission lines and towers.

Installation of the representative project would require clearing of vegetation to install foundations and subsequent maintenance of a cleared area around the tower. Vegetation underneath the transmission lines would need to be trimmed and maintained to a height that would not interfere with the lines and create a fire hazard. Construction may also require access roads. In more remote and rugged terrain, use of helicopters could reduce the amount of surface disturbance; any related disturbance to biological resources would be limited to helicopter landings and take-offs.

Long-term impacts on vegetation, wildlife, and protected species would largely depend on the routing of the transmission lines. Because transmission lines can be constructed through areas without existing access and across steeper topography, they have the potential to encroach on more remote landscapes that may have high conservation value. Although the individual land disturbances for the towers are relatively small, they could provide opportunity for establishment of invasive or nonnative plant species.

The towers and transmission lines are potential collision hazards to birds, especially nocturnal flying seabirds and bats. Also of concern would be water birds and colonial nesting species that concentrate in smaller areas (i.e., wetlands and nesting colonies) and create areas with high numbers of bird flights as well as wider ranging species such as the Hawaiian hawk and Hawaiian goose.

8.1.4.2 Best Management Practices and Mitigation Measures

In addition to the standard BMPs for typical construction activities (see Section 3.4.6), a variety of approaches could be taken to minimize potential bird and bat collisions. These include the following:

- Use shorter tower heights so that the transmission lines would hang below the typical flight height.
- Use vegetation and topography as a means to shield power lines from flight paths.
- Use power line configuration with fewer layers of lines (i.e., horizontal versus vertical arrays).
- Consider underground installations in high-risk areas (KIUC 2010).
- Locate transmission lines away from lighted sources. Although transmission towers are not lighted, transmission lines located in proximity to light sources that attract and disorient night flying seabirds could increase the probability of collisions.
- Locate transmission lines away from wetlands, ridgelines, and protected refuge areas that attract concentrations of birds and bat roost trees and thus could increase the potential impacts to avian species and the Hawaiian hoary bat.
- Use landscape perspective in route planning. Bird flight patterns follow landscape features. Consider these flight patterns during transmission line route planning.

- Install one of the numerous bird flight diverters on the transmission lines to reduce avian impacts. The different designs can be reviewed and selected based on the particular species being protected and the characteristics of the surrounding landscape.

8.1.5 LAND AND SUBMERGED LAND USE

8.1.5.1 Potential Impacts

8.1.5.1.1 Land Use

The representative on-island transmission line project would require a 20-mile-long corridor in addition to substations and switching yards, all of which could result in changes to land ownership patterns and land uses.

Long, linear projects could affect numerous landowners. The proponent or utility would coordinate with each individual landowner to obtain a right-of-way easement to allow the use of the property for the transmission line.

8.1.5.1.2 Submerged Land Use

As identified in Table 8-1, there would be no potential impacts to submerged land use from the representative project.

8.1.5.2 Best Management Practices and Mitigation Measures

A BMP to reduce potential impacts to land use includes installing new transmission lines underground to minimize potential visual or other impacts to adjacent properties.

Early coordination with landowners to identify potential issues associated with easements and rights of way.

8.1.6 CULTURAL AND HISTORIC RESOURCES

8.1.6.1 Potential Impacts

The representative on-island transmission project could result in cultural and historic resource impacts typical of general construction and operational activities described in Sections 3.6.6. Additionally, the visual impact of on-island transmission projects may be unacceptable near cultural and historic areas where the historic integrity (e.g., setting, feeling, association, viewsheds) plays an important role in the value of the resource.

8.1.6.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.6.7.

8.1.7 COASTAL ZONE MANAGEMENT

8.1.7.1 Potential Impacts

Impacts to coastal zones were evaluated based on the extent to which a project would conflict with the policies of the Hawaiʻi Coastal Zone Management Program and potentially affect special management areas, shorefront access, and shoreline erosion. The representative on-island transmission project could affect coastal zone resources but would largely depend on the specific project location. Projects near the shoreline would have the most potential to impact shore setbacks areas, shorefront access, and special management areas.

8.1.7.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures to reduce the above impacts include the following:

- Avoid the beach and near offshore areas, and
- Evaluate the project through a Federal consistency review under the Coastal Zone Management Program.

8.1.8 SCENIC AND VISUAL RESOURCES

8.1.8.1 Potential Impacts

The representative on-island transmission project would result in scenic and visual resource impacts typical of general construction activities described in Section 3.8.3.

Long-term visual impacts would result from placement of the 70-foot-tall structures that support the transmission line, the transmission line itself, the permanent right-of-way where vegetation would be controlled (as opposed to natural growth) to avoid interference with the transmission line, and from a substation or switching yard. The visual impacts of the new transmission line would depend on the topography, land cover, and existing land uses. For example, tall-growing trees must be permanently removed from the right-of-way to allow line maintenance; whereas, in agricultural areas, the right-of-way could still be used for agriculture and pasture land after construction ends and the fields are restored. The magnitude of potential visual impacts would be related to the transmission line’s potential to change the visual character of the area.

8.1.8.2 Best Management Practices and Mitigation Measures

In addition to the standard BMPs for typical construction activities (see Section 3.8.4), projects should also avoid sensitive locations such as coastal scenic resources from public viewing points and coastal highways; the three designated scenic byways; State, National, and National Historical Parks; reserves protected by the Natural Area Reserves System; and residential and recreational areas.

Consult with the county general land use plans and associated implementation tools such as zoning ordinances and development standards regarding protecting and maintaining open space and scenic resources.

Choose the structure design and material that would best avoid conflicts with scenic and visual resources. For examples, structures constructed of wood or of rust-brown oxidized steel may blend better with wooded landscapes.

8.1.9 RECREATION RESOURCES

8.1.9.1 Potential Impacts

The representative on-island transmission project could result in recreation resource impacts typical of general construction and operational activities described in Sections 3.8.3.

Long-term recreation resource impacts could result in obstructions to some recreational activities. Conversely, some recreation activities could be compatible with new transmission lines and increased access from the right-of-ways created for transmission line maintenance. Such activities include hiking, hunting, backcountry camping, and birding.

8.1.9.2 Best Management Practices and Mitigation Measures

Recreation resource impacts should be considered when siting the on-island transmission line. Tables 3-47 and 3-48 identify the popular land- and sea-based recreation activities in Hawaiʻi. The *State Comprehensive Outdoor Recreation Plan* (SCORP) provides detailed matrixes of all recreation areas on each island and the recreational activities that take place at each area (DLNR 2009).

8.1.10 LAND AND MARINE TRANSPORTATION

8.1.10.1 Potential Impacts

8.1.10.1.1 Land Transportation

Some local impacts could occur to land transportation in the vicinity of the transmission line construction. These impacts could include increased truck traffic for delivering construction materials (e.g., towers, cabling, and tower foundations). These impacts are expected to be short-term in specific locations as construction proceeds along the 20-mile route.

In areas where transmission lines are installed along existing road rights-of way, impacts may be greater because the construction would occur near existing traffic. Some short-term road closures (e.g., less than one day) may occur during cable stringing across roads.

8.1.10.1.2 Marine Transportation

As identified in Table 8-1, there would be no potential impacts to marine transportation from the representative project.

8.1.10.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.10.4.

8.1.11 AIRSPACE MANAGEMENT

8.1.11.1 Potential Impacts

Construction of the representative on-island transmission project could cause short-term impacts to airports if any part of the 20-mile-long line occurred nearby. During construction, some project locations could require use of helicopters to install towers and string power cabling. Construction air traffic could temporarily impact other aviation operations in the vicinity and would have to be coordinated with the FAA and other potentially affected organizations.

Although the representative on-island transmission project would be only about 70 feet tall, well below the criteria (200 feet) for evaluation as an obstruction to airspace, long-term use of the transmission line could impact airspace and present a hazard to civilian and non-civilian aviation. The transmission line could cross mountainous terrain and, depending on routing, towers could be located on or along ridges and across valleys. Hawaiʻi has an abundance of low-elevation aviation including military helicopter training, U.S. Coast Guard operations, and civilian tour operators, and transmission towers and lines could pose a hazard to these activities.

As outlined in Section 3.11, there is a variety of airspaces defined within the Hawaiian Islands. Some airspace designations may require redefinition if a transmission line is located through or near a specific area. Also, construction sites in the vicinity of airports would require evaluation to ensure that the transmission line would not be an obstruction to air traffic and pose a safety hazard.

Depending on the location of the transmission line, marker balls may be required on the catenary lines (transmission lines between support structures). These guidelines regarding installation and lighting of these catenary markers are found in FAA Advisory Circular AC 70/7460-1K, *Obstruction Marking and Lighting* (FAA 2007).

8.1.11.2 Best Management Practices and Mitigation Measures

Coordinate with the appropriate authorities as appropriate regarding airspace designations.

If the transmission line goes near or through an airport, coordinate with the FAA and potentially affected organizations to ensure the transmission line would not be an obstruction to air traffic and pose a safety hazard. This could include the installation of catenary markers on the transmission lines.

8.1.12 NOISE AND VIBRATION

8.1.12.1 Potential Impacts

The representative on-island transmission project could result in noise and vibration impacts typical of general construction activities described in Section 3.12.5.

Corona noise is the most common type of sound association with on-island transmission line operation. Often described as hissing, sizzles, or crackles, corona noise is caused by ionization of electricity in moist air near the wires; noise levels increase with humidity. Though corona noise is audible near the transmission line, it quickly dissipates with distance and is masked by typical background noises. Long-term noise and vibration impacts from operation of a 69-kilovolt transmission line would be negligible.

8.1.12.2 Best Management Practices and Mitigation Measures

Perform routine maintenance and repair dirty or cracked insulators on mounting equipment to minimize vibration and humming noise. When possible, use longer-lasting polymer insulators instead of ceramic or glass insulators.

8.1.13 UTILITIES AND INFRASTRUCTURE

8.1.13.1 Potential Impacts

The representative on-island transmission project would add electricity to the power grid and, as such, would be required to comply with the Public Utilities Commission (PUC) requirements for Transmission Line Approval and Power Purchase Agreements. Those requirements include interfacing with the appropriate island utility (see Section 3.13.1).

The addition of a large generation source or many small generations sources (e.g. residential solar or wind) either individually or in combination would require the affected utility, the PUC, DBEDT, and the reliability administrator (if this position, under consideration by the PUC, is created) to consider grid-balancing measures such as smart grid (see Section 2.3.5.3) and energy storage (see Section 2.3.5.4).

8.1.13.2 Best Management Practices and Mitigation Measures

The utility may need to consider grid-balancing measures, as follows:

- Projects requiring 5 to 50 megawatt grid connections are discussed in Chapter 6.
- Projects requiring 51 to 99 megawatts scale in a manner similar to the 5- to 50-megawatt projects discussed in Chapter 6.
- Projects requiring 100-megawatt or larger grid connections are required to comply with the Public Utilities Commission requirements for Transmission Line Approval and Power Purchase Agreements.

8.1.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

8.1.14.1 Potential Impacts

8.1.14.1.1 Hazardous Materials

The representative on-island transmission project could result in impacts from exposure to hazardous materials typical of general construction activities described in Section 3.14.4.

Potential impacts from exposure to hazardous materials would be related to occasional applications of herbicides to maintain vegetation and to keep access paths clear. The use of large quantities of herbicides or chemicals can produce adverse environmental impacts in the event of an emergency, spill, or accident.

8.1.14.1.2 Waste Management

As identified in Table 8-1, there would be no waste management impacts from the representative on-island transmission project.

8.1.14.1.3 Wastewater

The representative on-island transmission project would result in wastewater impacts typical of general construction and operation activities described in Section 3.14.4.

8.1.14.2 Best Management Practices and Mitigation Measures

Ensure herbicides are appropriately approved or licensed for the intended use and handled, stored, and applied in accordance with the manufacturer guidelines and the chemical-specific material safety data sheets.

8.1.15 SOCIOECONOMICS

8.1.15.1 Potential Impacts

Socioeconomic impacts from the representative on-island transmission project would involve a temporary construction and installation workforce of about 20 workers for about 6 months (MacDonald and Martinez 2013). The number of jobs associated with the operations and maintenance of the transmission lines would be very small, about three full-time positions. Jobs directly associated with the installation of the lines and maintenance of those lines likely would be filled by individuals residing within the State of Hawaiʻi and not by in-migrating workers.

8.1.15.2 Best Management Practices and Mitigation Measures

None identified.

8.1.16 ENVIRONMENTAL JUSTICE

8.1.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative on-island transmission project are expected to be small. The potential for environmental justice impacts also would be small.

8.1.16.2 Best Management Practices and Mitigation Measures

During site selection of the transmission line, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

8.1.17 HEALTH AND SAFETY

8.1.17.1 Potential Impacts

The representative on-island transmission project would cause potential health and safety impacts to workers during all phases of the project; i.e., installation, maintenance, and repair. These impacts would be typical of standard industrial hazards.

There would be potential health and safety impacts to the public during operations of the transmission lines as a result of electromagnetic field (EMF) and/or radio frequency concerns. Since the mid-twentieth century, electricity has been an essential part of our lives. Electricity powers our appliances, office equipment, and countless other devices that we use to make life safer, easier, and more interesting. Use of electric power is something we take for granted. However, some have wondered whether the EMFs produced through the generation, transmission, and use of electric power might adversely affect our health. Numerous research studies and scientific reviews have been conducted to address this question.

One of the largest evaluations to date was led by two U.S. government institutions – the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health and DOE – with input from a wide range of public and private agencies. This evaluation, known as the Electric and Magnetic Fields Research and Public Information Dissemination (EMF RAPID) Program, was a six-year project with the goal of providing scientific evidence to determine whether exposure to power-frequency EMF involves a potential risk to human health.

In 1999, at the conclusion of the EMF RAPID Program, the NIEHS reported to Congress that the overall scientific evidence for human health risk from EMF exposure is weak. No consistent pattern of biological effects from exposure to EMF had emerged from laboratory studies with animals or with cells. However, epidemiological studies (studies of disease incidence in human populations) had shown a fairly consistent pattern that associated potential EMF exposure with a small increased risk for leukemia in children and chronic lymphocytic leukemia in adults. Since 1999, several other assessments have been completed that support an association between childhood leukemia and exposure to power-frequency EMF. These more recent reviews, however, do not support a link between EMF exposures and adult leukemias. For both childhood and adult leukemias, interpretation of the epidemiological findings has been difficult due to the absence of supporting laboratory evidence or a scientific explanation linking EMF exposures with leukemia. Additional information and commonly asked questions and answers regarding EMF and potential health effects can be found online in the NIEHS report (NIEHS 2002).

Specifically for transmission lines, the report provides the following (NIEHS 2002):

- At a distance of 300 feet and at times of average electricity demand, the magnetic fields from many transmission lines can be similar to typical background levels found in most homes. The distance at which the magnetic field from the line becomes indistinguishable from typical background levels differs for different types of lines.

- In the United States, there are no Federal standards limiting occupational or residential exposure to 60-Hz EMF. At least six states have set standards for transmission line electric fields; two of these also have standards for magnetic fields. In most cases, the maximum fields permitted by each state are the maximum fields that existing lines produce at maximum load-carrying conditions. Some states further limit electric field strength at road crossings to ensure that electric current induced into large metal objects such as trucks and buses does not represent an electric shock hazard. Hawai‘i does not have specific standards for transmission line electric or magnetic fields.

Effects on each island’s public safety services would be small since the workers to construct and to operate the transmission line and associated substation and switching yard are expected to come from the island’s existing workforce (see above). Police, fire, and medical services would not be adversely affected with this small change in employment.

8.1.17.2 Best Management Practices and Mitigation Measures

Ensure all activities are conducted and personnel trained in accordance with OSHA guidance related to power generation (OSHA 2014a).

Read literature by the following organizations to learn about EMFs and radiofrequency health: The World Health Organization, Institute of Electrical and Electronics Engineers, The National Institutes of Health, OSHA, the Federal Communications Commission, and the Centers for Disease Control and Prevention (CDC).

8.2 Undersea Cables

The representative undersea cable project would transfer power between two islands via a 10-inch high-voltage direct current (HVDC) undersea cable. The undersea cable would be bounded by two land-sea cable transition sites with a converter station at each end. The stations each would have a total footprint of 6 acres (3 acres plus an additional 3 acres for laydown and future expansion). They would each be located within 0.5 mile from the shoreline and within 10,000 feet of the endpoints of the cable. The undersea cable would have two-way transmission capability and could transmit 200 megawatts of renewable energy without grid instability (i.e., transmitted at a constant rate). The cable package would operate at 150 kilovolts. The undersea cable would connect to the land-sea transition sites within 10,000 feet from the shoreline. The land-sea transition sites would serve as substations for the cable; connecting one island's grid to the other.

Table 8-2 presents a summary of the potential environmental impacts for undersea cables, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cable

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	Onshore General impacts during construction. See Section 3.1.3. **Offshore** Potential disturbance of marine sediments during construction (short-term) with minor impacts: • Sediment disturbance at horizontal directional drilling (HDD) breakout point • Drilling mud/slurry release at HDD breakout point • Sediment disturbance at trenching locations. No impacts to geology and soils during operation.	**Onshore** Same as common across construction projects. See Section 3.1.4. **Offshore** Apply silt curtains or other silt-control devices to sensitive areas and/or schedule construction during periods of low wave, wind, and current activity. Consult with the U.S. Army Corps of Engineers and relevant State agencies regarding Section 404 and Section 401 permits, if applicable. These certifications will include BMPs. Avoid sensitive terrain when siting cable route.
Climate and Air Quality		
	General impacts during construction. See Section 3.2.4. Beneficial impacts resulting from higher penetration of renewable generation on each connected island grid.	Same as common across construction projects. See Section 3.2.5

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cables (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Water Resources		
Surface Water	**<u>Onshore</u>** General impacts during construction (short-term). See Section 3.3.5. Potential impacts if increase in impermeable surfaces at built up land-sea transition sites. **<u>Offshore</u>** Sediment disturbance/dispersal and increased turbidity during HDD. Potential site-specific impacts may occur to habitats or communities of concern. No operational impacts.	**<u>Onshore</u>** Same as common across construction projects. See Section 3.3.6. Develop land-sea transition sites in a manner that does not add to runoff volumes, velocities, and sediment loads. **<u>Offshore</u>** Apply silt curtains or other silt-control devices to sensitive areas. Schedule project activities (sea floor disturbance) during seasonal periods when wave, current, and wind are expected to be at a low. Consider habitats and communities of concern when siting cable and transition area.
Groundwater	General impacts during construction. See Section 3.3.5.	Develop land-sea transition site in a manner that allows no net loss of groundwater recharge.
Floodplains and Wetlands	Potential short-term impacts during construction. See Section 3.3.5.	Consideration of permitting requirements and building restrictions.
Biological Resources		
	General impacts to terrestrial and marine ecosystems during construction (short-term impacts to benthic communities and marine mammals if construction occurred in the Hawaiian Islands Humpback Whale National Marine Sanctuary). Potential localized disturbance impacts to benthic communities at HDD breakout point and along cable route during construction due to direct displacement or indirect sedimentation. Potential operational impacts on sensitive species by EMF fields along undersea cable route.	Same as those common for construction projects. See Section 3.4.6. Locate onshore transition sites within or near existing developed areas if possible to avoid disturbing animals and habitat. Manage nighttime light at transition sites to minimize attraction and disorientation of sensitive species. Site HDD breakout point and undersea cable away from sensitive biological resources. Consider EMF shielding through cable burial or encasement in areas of sensitive species.

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cables (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Submerged Land Use		
Land Use	General impacts during construction and operation. See Section 3.5.4	Same as common across construction and operation projects. See Section 3.5.5
Submerged Land Use	Short-term submerged land disturbance impacts along the undersea cable corridor during construction; Potential temporary impacts during maintenance/expansion activities. Potential land use impacts along undersea cable corridor.	Avoid or minimize the crossing of areas of high use, including existing or planned telecommunications cables. Conduct bathymetry studies to help define and locate existing pipe and cable corridors and munitions dumps. If there is a need for undersea cables to cross seabed obstructions, especially in areas that are congested with subsea pipelines and/or telecommunication cables, use mattresses to support the cable above obstructions or use protective sleeves over the obstructions.
Cultural and Historic Resources		
	General impacts during construction and operation. See Section 3.6.6.	Same as common across construction and operation projects. See Section 3.6.7.
Coastal Zone Management		
	Potential effects to special management areas established to protect specific coastline resources and limit shorefront access (project/site-specific).	Evaluate through a Federal consistency review under the Coastal Zone Management Program.
Scenic and Visual Resources		
	Short-term impacts to visual resources during construction. See Section 3.8.3. Short-term visibility of cable-laying ships. Long-term visual impacts associated with the new transition sites.	Same as common across construction and operation projects. See Section 3.8.4.
Recreation Resources		
	General impacts during construction. See Section 3.9.5. Short-term impacts during construction; limited to no impacts during operations	Review the SCORP when siting the land-sea transition site.

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cables (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Land and Marine Transportation		
Land Transportation	Potential traffic congestion during construction from wide-load hauling of transmission line components (e.g., cables and installation equipment). General impacts during construction and operation of the land-sea transition sites.	Same as those common across construction and operation projects. See Section 3.10.4.
Marine Transportation	Potential short-term impacts on harbor operations, local marine transportation, and military marine (including submarine) operations.	Coordinate construction activity with U.S. Coast Guard to ensure civilian and military surface marine and submarine operations as well as harbor operations are managed to minimize or avoid impacts.
Airspace Management		
	None; construction and operation of undersea cable and land-sea transition sites would not require any tall structures and therefore would not impact airspace management.	N/A
Noise and Vibration		
	Short-term noise and vibration impacts to sensitive noise receptors, including potential impacts to marine mammals and sea turtles. Long-term noise and vibration impacts from operation of undersea cables would be negligible. Noise and vibration impacts from land-based converter stations would be dependent on the location and compatibility with the existing noise levels and land uses.	Avoid sensitive receptors for noise and vibration (identified in Section 3.12). Temporal restrictions. Establishment of an exclusion zone, pile driving shutdown and delay procedures, and soft-start procedures. Visual monitoring and in-situ underwater sound monitoring. Incidental Harassment Authorization requests must include monitoring and reporting plans. Restrict noisy land-based or near-shore construction activities to daytime hours. Use maintained construction equipment with sound control devices. Operational noise and vibration mitigation may be incorporated into the design of undersea cables through the use of insulation. Monitor and maintain project components.

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cables (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Utilities and Infrastructure		
	Potential impacts related to adding electricity capacity to the local power grid. Connecting the electrical grids of two or more islands would have the beneficial impacts of: • Enabling the transmission of power and ancillary services in both directions and allow the two networks to operate in a coordinated fashion • Improving the power system economics and reliability on each island • Reducing renewable energy curtailments • A full list of benefits can be found at http://energy.hawaii.gov/renewable-energy/O‘ahu-maui-gridtie	Same as those common across construction and operation projects. See Section 3.13.4. The local utility may need to consider grid-balancing measures, as follows: • Projects requiring 5 to 50 megawatt grid connections are discussed in Chapter 6. • Projects requiring 51 to 99 megawatts scale in a manner similar to the 5- to 50-megawatt projects discussed in Chapter 6. • Projects requiring 100-megawatt or larger grid connections are required to comply with the Public Utilities Commission requirements for Transmission Line Approval and Power Purchase Agreements.
Hazardous Materials and Waste Management		
	General impacts during construction and operation, particularly during development of converter stations. See Section 3.14.4. Any waste generated onboard the construction vessels and barges would be disposed of at the appropriate landfill.	Same as those common across construction projects. See Section 3.14.5.
Socioeconomics		
	Minimal beneficial impacts during construction and operation.	None
Environmental Justice		
	Small environmental justice impacts. Site-specific evaluation of impacted populations required.	During site selection for the transition sites, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

Table 8-2. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Undersea Cables (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Health and Safety		
	Potential health and safety impacts to workers during installation, maintenance, and repairs of the undersea cables and transition sites, including increased safety risks associated with the marine environment. Additional health and safety risks specific to electrical generation, transmission, and distribution industry. Police, fire, and medical services would not be adversely affected.	During the installation, maintenance, and repair of transmission lines and converter stations, ensure activities are conducted and personnel trained in accordance with OSHA guidance related to power generation: https://www.osha.gov/SLTC/powergeneration/

8.2.1 GEOLOGY AND SOILS

8.2.1.1 Potential Impacts

Onshore Activities

Potential impacts on soils from the representative undersea cable project would be associated with construction or other soil-disturbing actions associated with the land-sea transition, and would be the same as those expected for common construction actions as described in Section 3.1.3. It is estimated that a minimum of 1 acre of land at each end of the undersea cable would be disturbed with the HDD setup and the subsequent converter station construction, so the permitting requirements described in Section 3.1.3 would be fully applicable.

No impacts to surface geology or soils would be expected from the operation of an undersea cable and land/sea transition sites.

Offshore Activities

At the locations where the HDD would break out on the ocean floor, ocean sediments would be disturbed and dispersed to some degree. The drilling mud or slurries used in the HDD would also be released at the breakout point. These dispersed sediments would increase turbidity for at least some period of time and, depending on the currents or wave actions at the site, would settle out in different locations, possibly in areas of coral or other bottom communities of concern. Potential impacts to such communities would not only depend on whether they are present near the site, but also whether they are periodically subjected to naturally occurring high turbidity.

HVDC cable installation may occur in two primary ways: laying on the surface of the ocean floor or burial through shallow trenches on the ocean floor. Multilayer sheathing is a common feature in extruded cable for submarine power transmission and provides environmental benefits, such as neutral EMFs (DC cable magnetic field is lower than the earth's natural magnetic field), oil-free cables, and low electricity losses. HVDC submarine cables are not limited by distance nor grid constraints and deliver electricity with minimal electrical losses (ABB 2013).

In those instances where the cable may be buried, it typically would be done in areas with muddy sediments by using a plow-like device at the time the cable was deployed or by using a remotely controlled installing device after the cable was laying on the sea floor. In both cases, sea floor sediments would be disturbed and suspended in the water for some time. In shallow areas, this could even cause turbidity that was visible to people at the surface, but in the majority of areas, these suspended solids would not be expected to move far or present any visible evidence. Over time, the trenches would be filled in completely as a result of natural currents and associated movements of sediments. Although dependent on site-specific ocean currents, experience with the trenching devices is that much of the disturbed sediments settle back down in the same location to provide at least some backfill for the cable. Impacts to soils or sediments of the disturbed areas would be minor. Installation of the undersea cables would be expected to have no effects on geology, but the sea floor geology could have adverse impacts on the cable. In rocky areas, particularly in sloped areas where it may be difficult to secure the cables to the floor, over time even minor movement could abrade the cable exterior and eventually cause damage.

Activities involving discharges of dredged or fill materials into the waters of the U.S. are regulated by the U.S. Army Corps of Engineers under Section 404 of the *Clean Water Act*. Accordingly, a USACE Section 404 permit likely would be required for the HDD action because the breakout point for the cables could require fill material to stabilize the location. Any action that requires a USACE Section 404 permit must also obtain certification from the State pursuant to Section 401 of the *Clean Water Act*. The certification dictates BMPs and monitoring and assessment plans to ensure project actions comply with

State water quality standards. A Section 404 permit and Section 401 certification may also be required for the placement of the undersea cable; that is, to the extent such actions are done within the territorial seas (the area within about 3 nautical miles of the shore). Depending on how it was to be performed, the action of burying cables along the ocean floor might be considered excavation and filling all in a single action rather than a discharge of dredged or fill materials, so USACE may not consider it applicable to 404 permitting (Sharples 2011). If there was any question about the applicability of a Section 404 permit, discussion with USACE would be the appropriate course of action.

Operation of the undersea power cable would not affect undersea geology or sediment.

8.2.1.2 Best Management Practices and Mitigation Measures

Onshore Activities

Avoid areas with highly erodible soils and high slopes for converter station sites. The HDD operation would also require an area of good stability. Standard construction BMPs are identified in Section 3.1.4.

Offshore Activities

Deploy devices such as silt curtains in specific locations, such as the HDD breakout point, to help reduce potential impacts. However, devices such as silt curtains often have limited effects, particularly if wave or current action is high at the site.

Schedule such project activities during seasonal periods when wave, current, and wind would be expected to be at lows.

Route cables to avoid steep slopes, sharp changes in slopes, and suspended spans. Coral reefs fringe all the islands and living coral reefs, along with extremely rugged seafloors, dominate between east Lāna‘i and west Maui. The submarine canyons and landslides west of Molokai would prove challenging due to steep slopes. Cable installation technologies include various means of dealing with problematic sea floor conditions that include rock cutting, burying the cable under ballast or cement, or placing support devices across areas where the cable would be installed. It is expected that any of these potential technologies would become more difficult with increased depths.

8.2.2 CLIMATE AND AIR QUALITY

8.2.2.1 Potential Impacts

The representative undersea cable project would result in impacts to air quality typical of general construction activities described in Section 3.2.4.

Section 8.2.13.1 addresses the positive benefits of an interconnection of island electrical grids via an undersea cable. One of those benefits would be the increased ability of each respective grid to accommodate additional renewable energy. That benefit would have a direct and applicable benefit to air quality since the air emissions of criteria pollutants and greenhouse gas emissions would be reduced with an increased deployment of renewable energy electricity generation.

8.2.2.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction projects. See Section 3.2.5.

8.2.3 WATER RESOURCES

8.2.3.1 Potential Impacts

8.2.3.1.1 Surface Water

Onshore Activities

Onshore activities associated with the representative undersea cable project at both islands would use HDD to bring the power cable through the land-sea transition site and construction of a converter station at or near the HDD setup site to condition the power for relay to the electrical grid. Impacts on surface water from construction of onshore activities would be the same as those expected for common construction actions as described in Section 3.3.5.

Operation of the converter station and power cable would not affect surface waters other than possibly changing the quantities of storm water runoff from the site as a result of changes in the characteristics of the surface areas (e.g., cement foundations). Whether the constructed site would include more or less impermeable surfaces would depend on the nature of the preconstruction site. If the runoff volume were increased, its management would depend on the nature of the specific site (for example, whether there were collection ditches or detention ponds already available), but the amount of land and impermeable surfaces involved would not be expected to present unusual or difficult runoff management concerns.

Offshore Activities

At the locations where the HDD would break out on the ocean floor, ocean sediments would be disturbed and dispersed to some degree. The drilling mud or slurries used in the HDD could also be released at the breakout point. Drilling mud, which is primary bentonite clay, and drill cuttings would be circulated back to the shore work site during drilling operations, and actions would be taken to minimize any loss of drilling mud when the breakout point is reached. However, it is difficult to control all of the drilling mud when one end of the hole is underwater, and it is assumed some would be released. Depending on the currents at breakout point, these disturbed sediments could cause increased turbidity at the site for some period of time and could settle out in different locations. As indicated in Section 8.2.4, the HDD of the representative project would avoid disturbing the more productive marine environment, such as coral reefs, by extending to about 10,000 feet from the shoreline; therefore, it is unlikely that coral communities would be impacted by the dispersed sediments. The presence of other habitats of concern would be a site-specific issue. With regard to the installation of the other portions of the undersea cable, sea floor sediments would be disturbed and dispersed to some degree at the locations where the cable was buried or anchored. These dispersed sediments would increase turbidity for at least some period of time and would settle out in different locations.

There would be no expected impacts to land-based surface water or marine water quality during operation of the power cable.

8.2.3.1.2 Groundwater

Onshore Activities

Effects on groundwater from construction and operation of the representative undersea cable project would be the same as those expected for common construction actions as described in Section 3.3.5.

If there was an increase in runoff (as described above) there could be an associated change in groundwater recharge. However, the area involved is relatively small and, depending on where runoff from the facility would go or how it would be managed, the action may simply represent a change in where water soaks into the ground.

Offshore Activities

No groundwater impacts would be expected from the offshore activities associated with deployment or operation of the power cable.

8.2.3.1.3 Floodplains and Wetlands

Onshore Activities

It is reasonable to assume that the proponent of an undersea power cable project would avoid onshore construction in a floodplain or wetland if at all possible, if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

Offshore Activities

As noted above, a USACE Section 404 permit likely would be required for the placement of the cables on the ocean side of the system. The HDD breakout points would be expected to require placement of fill material to stabilize the location, and potential burial of the undersea cable at other locations, depending on the method used, may also require fill. Any action that requires a USACE Section 404 permit must also obtain certification from the State pursuant to Section 401 of the *Clean Water Act*, which would ensure the actions complied with State water quality standards. If there was any question about the applicability of a Section 404 permit, discussion with USACE would be the appropriate course of action.

8.2.3.2 Best Management Practices and Mitigation Measures

Devices such a silt curtains could be deployed at the HDD breakout point to help reduce potential impacts. However, devices such as silt curtains often have limited effects, particularly if wave or current action is high at the site. Correspondingly, another mitigation measure normally considered would be to schedule such project activities during seasonal periods when wave, current, and wind would be expected to be at lows.

Schedule sea floor disturbing activities during seasonal periods when wave, current, and wind would be expected to be at lows.

Develop land-sea transition sites in a manner that would not add to runoff volumes, speeds, and sediment loads.

8.2.4 BIOLOGICAL RESOURCES

8.2.4.1 Potential Impacts

Impacts to the marine environment from the representative undersea cable project would be mostly confined to construction disturbances during installation. The extent of impacts to marine habitats would depend on whether the cable was buried or placed on the ocean floor and on the type of marine habitats along the selected route. Although the physical disturbance (i.e., displacement or mortality of marine organisms) during installation of the cable would be relatively short term for many marine communities, the duration of the effect would likely vary for particular habitats and organisms. For example, a disturbance in an area of mud sediment would be relatively short-term, although suspension of sediments could cause longer-term impacts to corals if reefs are located nearby; a disturbance in a coral reef would require much longer time to recover, particularly deepwater corals, which are slower growing, and could potentially impact a larger number of marine species.

The Humpback Whale National Marine Sanctuary covers a large area surrounding the Hawaiian Islands, particularly between O‘ahu and the islands that comprise Maui County. Potential impacts during construction in that area could involve collisions with the marine mammals because of additional boat activity.

During operation, an undersea power cable could introduce an EMF into the marine environment along the cable. Although potential impacts to and responses of marine organisms to EMFs are not fully understood, many marine species such as sharks, marine mammals, sea turtles, and some bony fishes have well developed electrosensory systems that may be involved in orientation, homing, and navigation or in life functions such as detection of prey and predators (Normandeau et al. 2011). The potential strength of the EMF surrounding the cable is a function of the voltage, cable shielding, and whether the cable is buried or laid along the ocean floor. However, the EMF attenuates relatively quickly with distance from the cable (15 and 30 feet for AC and DC cables, respectively) along and above the seafloor, and the potential impacts to those species most sensitive to EMFs is likely to be relatively small (Normandeau and Exponent 2011).

In the near shore environment, there could be potential impacts (i.e., disturbance) to productive shallow marine habitat such as fringing and barrier reefs, fishponds, sea grass habitats, sandy and rocky beaches, and marine pools during cable laying. HDD under the shoreline would minimize potential impacts to marine habitats along the shoreline. However, marine habitats could be disturbed at the HDD breakout point. Furthermore, suspension and then deposition of sediments during HDD could extend the construction impact beyond the immediate vicinity of cable. Of particular concern would be corals and other photosynthetic organisms that could be covered in sediment. The potential impacts would depend on the specific location and the marine habitats in the area. Shallower, near-shore marine areas contain some of the more productive marine environments because the photosynthetic zone reaches to the ocean floor. However, there also are prolific deepwater corals that are slow growing, highly valued (e.g., black corals), and support a precious coral fishery.

Potential impacts of the converter stations would be typical of general construction and operation activities described in Section 3.4.5.

8.2.4.2 Best Management Practices and Mitigation Measures

In addition to the standard BMPs for typical construction activities (see Section 3.4.6), the following BMPs and mitigation measures could reduce or help avoid the above-identified impacts:

- Project sites within or near existing developed areas should minimize disturbance of sea turtle habitats (e.g., nesting beaches), resting areas for monk seals (i.e., beaches), seabird nesting sites, and remnants of native coastal vegetation that likely would occur in less developed coastal areas.
- Minimize nighttime light management to avoid attraction and disorientation in seabirds and nesting sea turtles if present in the project area.
- Avoid sensitive or high value marine habitats by collocating undersea cables of the representative project with existing cables.
- Mitigate potential impacts to humpback whales and other marine mammals by using dedicated observers to detect their presence in the impact area.

- Coordinate with the National Marine Sanctuary and the NMFS to develop an undersea cable route plan to help protect threatened and endangered species and identify high-value marine habitats and resources

8.2.5 LAND AND SUBMERGED LAND USE

8.2.5.1 Potential Impacts

8.2.5.1.1 Land Use

The representative undersea cable project would result in impacts typical of general construction and operation activities described in Section 3.5.4.

8.2.5.1.2 Submerged Land Use

Installation of a cable on the ocean floor would introduce a new submerged land use and consequent obstruction along the undersea corridor that could require coordination with owners/operators of existing undersea cables.

The waters around the islands have dumps of subsurface munitions and chemical weapons, especially around O‘ahu, which could impact the route along which the representative undersea cable project would travel.

8.2.5.2 Best Management Practices and Mitigation Measures

The following BMPs and mitigation measures could reduce or help avoid the above identified impacts:

- Avoid or minimize the crossing of areas of high use, including existing or planned telecommunications cables.

- Conduct bathymetry studies to help define and locate existing pipe and cable corridors and munitions dumps.

- If there is a need for undersea cables to cross seabed obstructions, especially in areas that are congested with subsea pipelines and/or telecommunication cables, use mattresses to support the cable above obstructions or use protective sleeves over the obstructions.

8.2.6 CULTURAL AND HISTORIC RESOURCES

8.2.6.1 Potential Impacts

The representative undersea cable project would result in impacts typical of general construction and operation activities described in Section 3.6.6.

8.2.6.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.6.7.

8.2.7 COASTAL ZONE MANAGEMENT

8.2.7.1 Potential Impacts

Construction of the representative undersea cable project would require a Federal consistency review to ensure the project is consistent with the policies and goals of the Coastal Zone Management Program. The project would require a power cable connection between the onshore converter station and the undersea cable offshore. Depending on the location of where the cable would cross under the shoreline, the project could impact designated special management areas, restrict shorefront access, and/or affect shoreline erosion. The converter station, which would be built 0.5 mile from the shoreline, also could potentially affect designated special management areas.

8.2.7.2 Best Management Practices and Mitigation Measures

Evaluate the project through a Federal consistency review under the Coastal Zone Management Program.

8.2.8 SCENIC AND VISUAL RESOURCES

8.2.8.1 Potential Impacts

The representative undersea cable project would result in impacts typical of general construction and operation activities described in Section 3.8.3.

8.2.8.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.8.4.

8.2.9 RECREATION RESOURCES

8.2.9.1 Potential Impacts

The representative undersea cable project would result in impacts typical of general construction activities described in Section 3.9.4.

Generally speaking, short-term impacts would be related to construction activities (e.g., HDD, cable lay, converter station construction); long-term impacts would be those associated with the operations of a project (e.g., energy transmission via cables and converter station operation).

The representative project would have a significant impact on recreation resources if it impedes access to or displaces recreation resources or users.

Almost all recreation resources discussed in Section 3.9 are under the stewardship of a government (county, State, or Federal) for the public; access to these resources is already provided and would likely be on public property. During construction, it is possible that related equipment could be staged in an area that could cause users to take detours to a recreation resource. It is possible that construction activities could block access to the resource; during the operational period, no impact would occur to access of recreation resources.

Neither construction nor operation associated with laying undersea cables and the converter stations would have an adverse impact on land-based nature recreation, sports activities, or interpretive recreation (nature parks, botanical gardens, scenic lookout, historic/cultural sites, and educational/interpretive displays). Non-stationary activities, such as walking/jogging, may need to be rerouted (displacement) if construction activities affect public rights-of-way. Impacts would cease once construction was completed.

Impacts to water-based recreation from HDD activities may occur during undersea cable installation. For instance, an area set up to accommodate HDD activities may be on or near a popular surfing spot. At least during the duration of the construction activities, recreation users would be displaced. Depending on the location of the drilling activity, one or more activities may be affected. Activities along the cable route would also be impacted during the temporary presence of the cable laying ships. Impacts would cease once construction was completed.

8.2.9.2 Best Management Practices and Mitigation Measures

Install cable in locations that already accommodate undersea cables (e.g., communications cables).

Recreation resource impacts should be considered when siting the land-sea transition site. Tables 3-47 and 3-48 identify the popular land- and sea-based recreation activities in Hawaiʻi. Review the SCORP prior to siting the land-sea transition site.

8.2.10 LAND AND MARINE TRANSPORTATION

8.2.10.1 Potential Impacts

8.2.10.1.1 Land Transportation

The representative undersea cable project could potentially increase truck traffic during delivery of construction materials (e.g., cables and installation equipment). Any impacts would be short-term, during construction activities.

8.2.10.1.2 Marine Transportation

Construction of the representative undersea cable project would have minimal short-term impacts (i.e., less than a month) on civilian and military marine and submarine transportation. A buffer area around and below the cable laying ship would have to remain clear of all surface and submarine transportation. The buffer area would be a moving area as the cable laying ship travels the installation pathway. The length of the construction would vary depending upon the submarine topography, the length of the cable route, and whether the cable is being buried or laid on the surface of the ocean floor but is expected to be less than a month.

Construction of an undersea power cable and land-sea transition facilities may have short-term impacts on local marine traffic. Assuming the cable from the onshore converter station to the offshore main undersea cable is installed via a horizontal direction drill under the shoreline, offshore construction ships during construction of the HDD and the installation of the power cable in the HDD would have to remain free of marine transportation traffic. A buffer zone around the connection site with the undersea cable also would have to remain free of surface and submarine marine transportation while the power cable connection is completed. Construction activity would be coordinated with the U.S. Coast Guard to ensure that civilian and military mariners are aware of the activity.

8.2.10.2 Best Management Practices and Mitigation Measures

Construction activity would be coordinated with the U.S. Coast Guard to ensure that civilian and military mariners are aware of the activity.

Location of the undersea cable would need to be marked under water and digitally recorded to avoid future disturbance to the cable and for the safety of future work that could be conducted in the vicinity. Coordination with the HDOT Harbors Division should be done during project planning to avoid underwater locations that could be impacted by future harbor expansion (e.g., dredging).

8.2.11 AIRSPACE MANAGEMENT

As described in Table 8-2, there would be no potential impacts to airspace management from the representative undersea cable project.

8.2.12 NOISE AND VIBRATION

8.2.12.1 Potential Impacts

During construction of the representative undersea cable project local noise ordinances described in Section 3.12 could be temporarily exceeded, and the project would require a permit variance. In addition, construction noise outside of permitted hours could occur. Offshore construction noise from equipment and vessels, and vibration caused by potential pile-driving, could exceed regulatory levels. Sources of noise or vibration from survey activity may include single-beam echosounders, multi-beam echosounders, side-scan sonars, and shallow-penetration sub-bottom profilers.

Construction noise in general can impact biological resources, scenic and visual resources, recreation resources, cultural resources, worker health and safety, and possibly public health. According to the "Incidental Harassment Authorization" (77 FR 43259; July 24, 2012), exposure to elevated sound levels from vibratory and impact pile driving may result in temporary impacts to marine mammal hearing and behavior. However, the NMFS stated in its Biological Opinion of the Authorization that it does not expect any takes of marine mammals by injury, serious injury, or mortality (NMFS 2012). Marine mammal prey species, such as fish, and sea turtles may also be temporarily impacted. Noise and vibration impacts would be dependent on the location and compatibility with the existing noise levels and land uses.

Long-term noise and vibration impacts from operation of the representative undersea cable project would be negligible. Noise and vibration impacts from land-based converter stations would be the typical of general construction activities described in Section 3.12.5.

8.2.12.2 Best Management Practices and Mitigation Measures

When required, requests for Incidental Harassment Authorization must include monitoring and reporting plans.

The following BMPs and mitigation measures could reduce or help avoid the above-identified impacts (NMFS 2012):

- Temporal restrictions (such as not conducting vibratory pile driving during peak humpback whale season in Hawai‘i)

- Establishment of an exclusion zone (a buffer to prevent harassment [injury] of any marine mammal species).
- Pile-driving shutdown and delay procedures (if a marine mammal or sea turtle approaches or enters an exclusion zone);
- Soft-start procedures (a technique that allows marine mammals and sea turtles to leave the immediate area before sound sources reach maximum noise levels);
- In-situ underwater sound monitoring (sound monitoring during sheet pile and test pile driving); and
- Visual monitoring (an onsite, biologically trained individual approved in advance to monitor sound during pile driving).

Additional BMPs include the following:

- Avoid sensitive receptors for noise and vibration (identified in Section 3.12).
- Restrict noisy land-based or near-shore construction activities to daytime hours.
- Use maintained construction equipment with sound control devices.

8.2.13 UTILITIES AND INFRASTRUCTURE

8.2.13.1 Potential Impacts

The representative undersea cable project would add electricity to the local power grid and, as such, would be required to comply with the Public Utilities Commission (PUC) requirements for Transmission Line Approval and Power Purchase Agreements. Those requirements include interfacing with the appropriate island utility (see Section 3.13.1).

The addition of a large generation source or many small generations sources (e.g. residential solar or wind) either individually or in combination would require the affected utility, the PUC, DBEDT, and the reliability administrator (if this position, under consideration by the PUC, is created) to consider grid-balancing measures such as smart grid (see Section 2.3.5.3) and energy storage (see Section 2.3.5.4).

Connecting the electrical grids of two or more islands would have several beneficial impacts as identified in DBEDT's initial public comments in response to the Hawai‘i Public Utilities Commission Order 31356 (DBEDT 2013). DBEDT was asked to opine on whether an interisland cable would be in the public's interest. DBEDT provided details on the following benefits of an interisland cable:

- Benefits would outweigh the costs;
- It would enable the transmission of power and ancillary services in both directions and allow the two networks to operate in a coordinated fashion;
- It would improve the power system economics and reliability on each island;
- It would reduce renewable energy curtailments, thereby reducing the reliance on fossil fuel use for electricity generation;
- It would increase the flexibility in siting renewable energy generation; and

- It would advance the State’s efforts to meet its Renewable Portfolio Standards.

8.2.13.2 Best Management Practices and Mitigation Measures

- The local utility may need to consider grid-balancing measures.
- Projects requiring 100-megawatt or larger grid connections are required to comply with the Public Utilities Commission requirements for Transmission Line Approval and Power Purchase Agreements.

8.2.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

8.2.14.1 Potential Impacts

8.2.14.1.1 Hazardous Materials

Impacts from hazardous material exposure from the representative undersea cable project would be typical of those for construction projects described in Section 3.14.4.

8.2.14.1.2 Waste Management

General construction and operational waste management impacts are discussed in Section 3.14 and would be applicable to the project construction. In addition, waste specific to the representative project likely would be generated onboard the construction vessels and barges. Such waste would be returned to shore for disposal at the appropriate landfill.

8.2.14.1.3 Wastewater

Minimal to no wastewater is anticipated from construction and operation of the cable and the converter stations.

8.2.14.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.14.5.

8.2.15 SOCIOECONOMICS

8.2.15.1 Potential Impacts

Direct socioeconomic impacts in Hawai‘i from the representative undersea cable project would be very small. In July 2013, the Hawai‘i PUC initiated in a proceeding (Docket No. 2013-0169, Order No. 31356) the solicitation of information to establish whether an interisland transmission system connecting the O‘ahu and Maui island electrical grids would be in the public interest (PUC 2013). The proceeding outcome is pending. DBEDT supports an interisland transmission cable connecting O‘ahu and Maui grids. As the State’s Energy Resources Coordinator, DBEDT believes an O‘ahu-Maui grid tie is in the public interest.

Jobs directly associated with the laying of an undersea cable likely would be filled by individuals currently residing outside the State of Hawai‘i. The undersea cable project would not create many new net jobs, and hence, the impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.

Socioeconomic impacts associated with the land-sea transition site would be very small. Construction of the converter stations would take approximately 24 months. The grading and foundation work would require 20 construction workers, and building erection would require 10 to 15 construction workers. Electrical installation would require 20 additional construction workers. The positions would not overlap. These jobs likely would be filled by individuals residing in the State of Hawaiʻi and not by in-migrating workers. The construction of a land-sea transition site would not create many new net jobs. The impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and personal income would be very small.

8.2.15.2 Best Management Practices and Mitigation Measures

None identified.

8.2.16 ENVIRONMENTAL JUSTICE

8.2.16.1 Potential Impacts

The potential environmental impacts to the general population associated with the representative undersea cable project are expected to be small. The potential for environmental justice impacts also would be small.

8.2.16.2 Best Management Practices and Mitigation Measures

During site selection for the land-sea transition site and converter stations, conduct a detailed environmental impact study to determine the specific location of low-income populations and minority populations, specifically Native Hawaiians.

8.2.17 HEALTH AND SAFETY

8.2.17.1 Potential Impacts

The representative undersea cable project would cause potential health and safety impacts to workers during all phases of the project; i.e., installation, maintenance, and repair. The workers would be subject to standard industrial hazards. Health and safety impacts also include risk from electricity generation, transmission, and distribution, as outlined by OSHA at https://www.osha.gov/SLTC/powergeneration/index.html.

Potential health and safety impacts to the public during operation of the undersea cable and converter stations could involve EMFs. The potential for health and safety impacts from EMF is described briefly in Section 8.1.17.

Impacts on public safety from construction and operation of the representative undersea cable project would be the same as those as described in Section 3.17.3.

8.2.17.2 Best Management Practices and Mitigation Measures

Ensure all activities are conducted and personnel trained in accordance with OSHA guidance for construction, including marine construction: (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10772; OSHA 2014b).

Effects from EMF dissipate rapidly as a function of distance. Typically, facilities such as converter stations would be constructed with the converter equipment inside a fenced area to protect both the equipment and the nearby public.

8.3 Smart Grid

The representative smart grid project would consist of a comprehensive, robust, secure communications infrastructure capable of near real-time communication to more than 100,000 remote devices (see Section 2.3.5.3.4).

Table 8-3 presents a summary of the potential environmental impacts for smart grid, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and BMPs and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 8-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Smart Grid

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; installing electronic equipment and upgrading software for the representative smart grid project would not involve land disturbance and therefore would not impact geology and soils.	N/A
Climate and Air Quality		
	None; installing electronic equipment and upgrading software for the representative smart grid project would not involve land disturbance and therefore would not impact climate or air quality.	N/A
Water Resources		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact water resources.	N/A

Table 8-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Smart Grid (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Biological Resources		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact biological resources.	N/A
Land and Submerged Land Use		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and would not impact land and submerged land use.	N/A
Cultural and Historic Resources		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact cultural or historical resources.	N/A
Coastal Zone Management		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact coastal zone management.	N/A
Scenic and Visual Resources		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact scenic or visual resources.	N/A
Recreation Resources		
	None; installing electronic equipment and upgrading software for the representative project would not involve land disturbance and therefore would not impact recreation resources.	N/A
Land and Marine Transportation		
	None; installing electronic equipment and upgrading software for the representative project would not involve land or marine transportation.	N/A
Airspace Management		
	None; installing electronic equipment and upgrading software for the representative project would not involve installation of towers and therefore would not impact airspace management.	N/A

Table 8-3. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Smart Grid (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Noise and Vibration		
	None; installing electronic equipment and upgrading software for the representative project would not construction activities or result in any operational noise.	N/A
Utilities and Infrastructure		
	Power transmission using smart grid technologies assumes that other measures such as energy storage and renewables are also implemented. Potential benefits and concerns are discussed in Section 2.3.5.3.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential impact from exposure to hazardous materials that may be present in old utility meters that are replaced by smart meters.	Handle any hazardous materials according to applicable county, State, and Federal regulations, including OSHA requirements.
Waste Management	Potential impacts from exposure related to disposal of old utility meters.	Implement recycling program to process old meters to the extent practicable.
Wastewater	None; installing electronic equipment and upgrading software for the representative project would not involve wastewater services.	N/A
Socioeconomics		
	As technologies advance, the requirements of existing jobs will change.	Utility companies and other smart grid stakeholders will need to retrain current employees and recruit new ones as the growing industry creates more jobs.
Environmental Justice		
	None; installing electronic equipment and upgrading software for the representative project would not result in environmental justice impacts.	N/A
Health and Safety		
	Standard industrial hazards to workers installing electrical equipment. Minimal potential for health and safety impacts to the public associated with electromagnetic fields and radiofrequency.	During the installation, maintenance, and repair of transmission lines, ensure activities are conducted and personnel trained in accordance with OSHA guidance related to power generation: https://www.osha.gov/SLTC/powergeneration/ Read available literature about electromagnetic fields and radiofrequency health.

8.3.1 GEOLOGY AND SOILS

As identified in Table 8-3, there would be no impacts to geology and soils from the representative smart grid project.

8.3.2 CLIMATE AND AIR QUALITY

As identified in Table 8-3, there would be no impacts to climate and air quality from the representative smart grid project.

8.3.3 WATER RESOURCES

As identified in Table 8-3, there would be no impacts to water resources, including surface water, groundwater, floodplains, and wetlands from the representative smart grid project.

8.3.4 BIOLOGICAL RESOURCES

As identified in Table 8-3, there would be no impacts to biological resources from the representative smart grid project.

8.3.5 LAND AND SUBMERGED LAND USE

As identified in Table 8-3, there would be no impacts to land and submerged land use from the representative smart grid project.

8.3.6 CULTURAL AND HISTORIC RESOURCES

As identified in Table 8-3, there would be no impacts to cultural or historical resources from the representative smart grid project.

8.3.7 COASTAL ZONE MANAGEMENT

As identified in Table 8-3, there would be no impacts to coastal zone management from the representative smart grid project.

8.3.8 SCENIC AND VISUAL RESOURCES

As identified in Table 8-3, there would be no impacts to scenic or visual resources from the representative smart grid project.

8.3.9 RECREATION RESOURCES

As identified in Table 8-3, there would be no impacts to recreation resources from the representative smart grid project.

8.3.10 LAND AND MARINE TRANSPORTATION

As identified in Table 8-3, there would be no impacts to land or marine transportation from the representative smart grid project.

8.3.11 AIRSPACE MANAGEMENT

As identified in Table 8-3, there would be no impacts to airspace management from the representative smart grid project. The representative project assumes the use of existing radio towers.

8.3.12 NOISE AND VIBRATION

As identified in Table 8-3, there would be no impacts to noise and vibration from the representative smart grid project.

8.3.13 UTILITIES AND INFRASTRUCTURE

8.3.13.1 Potential Impacts

Adding smart grid capability is one tool that each island utility could implement (some in Hawai‘i are currently doing so; see Section 2.3.5.4) to manage transmission of power from diverse sources. The effects to the utilities and the islands’ power customers would be more reliable and less fossil-dependent power. Power transmission using smart grid techniques assumes that other measures such as energy storage and renewable sources are also implemented. See Section 2.3.5.4 for more details regarding implementation benefits and concerns.

8.3.13.2 Best Management Practices and Mitigation Measures

None identified.

8.3.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

8.3.14.1 Potential Impacts

8.3.14.1.1 Hazardous Materials

Implementation of the representative smart grid project would be largely software- and telecommunications-based. Project installation would occur in existing homes where old analog meters are currently in operation. There could be some hazardous materials within the older utility meters.

8.3.14.1.2 Waste Management

Impacts related to waste management could occur, as removed analog meters would need to be disposed of. Similarly, impacts may result when the smart meters reach their end-of-life and need to be disposed of. To the extent feasible, these wastes could be minimized through electronic recycling efforts and repurposing of these materials. As such, consideration should be given to development and implementation of an electronic recycling plan or potential repurposing of these meters which could also effectively recover materials that could contain potentially hazardous substances.

8.3.14.1.3 Wastewater

As identified in Table 8-3, there would be no impacts to wastewater from the representative smart grid project.

8.3.14.2 Best Management Practices and Mitigation Measures

Handle any hazardous materials according to applicable county, State, and Federal regulations, including OSHA requirements.

Employ proper handling and transport for disposal of old analog meters as well as smart meters at their end-of-life at the appropriate hazardous material facilities to ensure no hazardous materials are disposed of at landfills and that no hazardous materials enter the waste stream.

8.3.15 SOCIOECONOMICS

8.3.15.1 Potential Impacts

The representative smart grid project would introduce a requirement for utility workers to develop new skillsets. The number of employees necessary to support a smart grid project would not be significantly different that that currently in place. Therefore, any socioeconomic impacts from the representative project would be very minor.

8.3.15.2 Best Management Practices and Mitigation Measures

Utility companies and other smart grid stakeholders will need to retrain current employees and recruit new ones as the growing industry creates more jobs.

8.3.16 ENVIRONMENTAL JUSTICE

As identified in Table 8-3, there would be no environmental justice impacts from the representative smart grid project.

8.3.17 HEALTH AND SAFETY

8.3.17.1 Potential Impacts

Concerns have been raised about the safety of smart meters, mainly because they give off the same kinds of radiofrequency (RF) waves as cell phones and Wi-Fi devices. The following information on the potential safety of smart meters was obtained from the American Cancer Society (http://www.cancer.org/cancer/cancercauses/othercarcinogens/athome/smart-meters; American Cancer Society 2012).

Smart meters are typically installed outside the home, either in place of or as part of existing analog meters. The level of exposure to RF energy depends on the distance from the smart meter antenna and the communications protocol used in the smart meter. The frequency and power of the RF waves given off by a smart meter are similar to that of a typical cell phone, cordless phone, or residential Wi-Fi router. However, smart meters are typically only in operation a small portion of the time because they only send and receive short messages at set intervals throughout the day (often several times an hour).

Because smart meter antennas typically are located outside the home, people are much farther away from the source of RF waves than with personal cell phones, cordless phones, or Wi-Fi routers. In addition, walls between the person and the smart meter’s antenna further reduce the amount of RF energy exposure. For these reasons, the exposure to RF energy from smart meters is estimated to be much less than the typical exposure people receive through cell phones, cordless phones, and/or home Wi-Fi routers. Smart meters emit RF waves, which are a type of electromagnetic radiation, so there is the “potential” for them to cause harm. The “actual” risk of harm, if it exists, is likely to be extremely low, for a number of reasons.

The RF waves that smart meters give off are a form of electromagnetic energy that falls between frequency modulation (FM) radio waves and microwaves. Like FM radio waves, microwaves, visible light, and heat, RF waves are a form of non-ionizing radiation. They do not have enough energy to cause cancer by directly damaging the DNA inside cells. RF waves are different from stronger (ionizing) types of radiation such as x-rays, gamma rays, and ultraviolet (UV) light, which can break the chemical bonds in DNA. Long-term exposure to ionizing radiation is a known cause of cancer.

At very high levels, RF waves can heat up body tissues. But the levels of energy given off by smart meters are much lower, and are not enough to raise temperatures in the body. The low levels of energy that smart meters give off at their source are further diluted by the distance they typically need to travel to reach people (unlike cell phones, for instance) and by any walls they have to pass through.

Smart meters are still fairly new, so there has been very little direct research on the possible health effects of exposure to RF from smart meters. Research has been done, however, on the possible health effects of RF waves in general and from other sources. For example, a good deal of research has focused on the possible link between cell phone use and cancer in recent years. Some research has suggested that the RF waves from cell phones might produce biological effects in human cells (in lab dishes), but it’s not clear if these effects could possibly cause tumors or help them grow in people.

Several dozen studies have looked at the possible link between cell phone use and cancer (mainly brain tumors) in people. Most of these studies have not found a link, but a few studies have found a possible link. All of these studies have suffered from limitations that prevent researchers from being able to draw firm conclusions, so this continues to be an area of active research. Several agencies (national and international) study different environmental exposures to determine if they can cause cancer. The American Cancer Society looks to these organizations to evaluate the risks based on evidence from laboratory, animal, and human research studies.

For example, the major goal of the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, is to identify causes of cancer. IARC has not assessed smart meters specifically, but it has recently classified RF radiation as “possibly carcinogenic to humans.” This is based on the finding of a possible link in at least one study between cell phone use and a specific type of brain tumor. IARC considers the evidence overall to be “limited” because of the conflicting findings and generally low quality of the studies that have been done. In general, most experts agree at this time that the evidence of a possible link between RF waves and cancer is limited. This is based on the generally poor quality of studies done so far and the fact that it’s not clear how the low levels of energy in RF waves might cause cancer. But experts also agree that more research is needed to assess this risk.

Many researchers continue to examine the possibility of other health effects from exposure to extremely low levels of RF energy. For example, researchers are studying the possible link between cell phone use and problems such as headaches, dizziness, vision problems, disturbed sleep, loss of memory, and the development of benign tumors of the nerve connecting the ear and the brain. So far, there is no conclusive evidence of such links.

One concern with cell phones has been whether the RF waves they give off might interfere with electronic medical devices such as heart pacemakers. According to the U.S. Food and Drug Administration (FDA), cell phones should not pose a major risk for most pacemaker wearers, especially if the phone is kept more than 6 inches from the device as normally occurs in typical cell phone use.

Because smart meters would generally be much farther away, they are not expected to pose such problems.

Other organizations have concerns and opposing views on the potential safety risks associated with smart meters. While they acknowledge that there is no scientific literature that specifically evaluates the health risks of smart meters because they are a relatively new technology, they have extrapolated the results from studies on effects of EMF and cell phones. Some of the opposing views on the health risks of smart meters have been published in 2012 by the Santa Cruz County, California Health Services Agency (http://emfsafetynetwork.org/wp-content/uploads/2009/11/Health-Risks-Associated-With-SmartMeters.pdf; CSC-HSA 2012) and the American Academy of Environmental Medicine (http://emfsafetynetwork.org/wp-content/uploads/2009/11/AAEM-Resolution.pdf; AAEM 2012).

8.3.17.2 Best Management Practices and Mitigation Measures

According to the American Cancer Society, there is no clear evidence at this time that RF waves from smart meters (or other devices) can cause harmful health effects. The low levels of energy from RF waves have not been clearly shown to cause problems even at close range, and the energy decreases the farther a person is from the transmission source.

If there is any increased risk, it is likely to be extremely small – even smaller than any possible increased risk from cell phones. Although it's not clear if cell phones cause any health problems, some experts recommend that people concerned about possible health effects keep the device at least 3 to 4 inches from the head to lower exposure to RF waves, just to be safe. In the case of smart meters, people are already much farther from these devices, and an added degree of safety is provided by the one or more walls between the person and the smart meter antenna.

Some people may still have health or other concerns (such as privacy) related to the use of smart meters on their homes. In some places where smart meters are being installed, people have the choice to opt in or opt out of having them.

8.4 Energy Storage

There are many forms of energy storage; therefore this PEIS identifies two representative projects to provide a better perspective of potential impacts (see Section 2.3.5.4.4). Both projects consider separate facilities and different capacity energy systems. The first project is an energy storage system for a 400-room hotel or resort facility intended to maintain critical systems. This distributed utility system uses flywheel energy storage because of its small footprint, fast response time, and life cycle. The second energy storage project is for a renewable energy generation plant where the energy storage system serves as a bridging power function. The project assumes that one-third of the generation capacity is needed in storage and that the energy storage is co-located with the generation source that is already connected to the power grid. This utility-scale system uses sodium-sulfur battery storage because of response time, discharge duration, and modularity to allow for more or less power depending on the generation capability.

Tables 8-4 and 8-5 present a summary of the potential environmental impacts for energy storage technologies for a distributed flywheel system and a utility-scale battery system, respectively, whether such impacts are resource-specific, regardless of the technology employed, or occur solely because of the technology and B and/or measures to mitigate such impacts. Those resource areas with no impacts are shaded and were not carried forward for analysis.

Table 8-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Flywheel

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. No long-term impacts from operation; the flywheel energy storage system would not produce criteria pollutants from fossil fuels. No fossil fuel would be burned and no fugitive dust would be generated.	Same as those common across construction and operation projects. See Section 3.2.5.
Climate Change	General construction impacts. See Section 3.2.4. Negligible increase in greenhouse gas emissions during operation of the flywheel energy storage system.	Same as those common across construction and operation projects. See Section 3.2.5
Water Resources		
Surface Water	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Groundwater	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Floodplains and Wetlands	General construction and operation impacts. See Section 3.2.5. .	Same as those common across construction projects. See Section 3.3.5
Biological Resources		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Land and Submerged Land Use		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A

Table 8-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Flywheel

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Cultural and Historic Resources		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Coastal Zone Management		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Scenic and Visual Resources		
	None; the flywheel energy storage system would not cause adverse visual impacts as it would be installed in the utility room and would be compatible with the existing setting.	N/A
Recreation Resources		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Land and Marine Transportation		
	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Airspace Management		
	None; installation of energy storage technologies would not involve any tall facilities; therefore, no impacts to airspace management would be expected.	N/A
Noise and Vibration		
	General construction impacts. See Section 3.12.5. Operational noise levels for the representative flywheel energy storage system would be less than 70 dBA at a distance of 3 feet.	Same as those common across construction and operation projects. See Section 3.12.6. The flywheel equipment could be installed inside a sound-insulated room to further dampen any noise from being noticed by hotel guests.
Utilities and Infrastructure		
	Beneficial impacts to the utilities and the distributed generator by helping to manage power demand.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	None; no hazardous materials would be required for the construction or installation of a flywheel energy storage system.	N/A

Table 8-4. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Flywheel

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Waste Management	General construction and operation impacts. See Section 3.14.4.	Reuse or recycle flywheel system components to the extent feasible.
Wastewater	None; the flywheel energy storage system would involve minor land disturbance in a previously developed location and then be installed inside the hotel.	N/A
Socioeconomics		
	Very small impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income.	None.
Environmental Justice		
	None; installation of a flywheel for energy storage would not result in environmental justice impacts.	N/A
Health and Safety		
	General construction and operation impacts. See Section 3.17.3. No added impacts to each island's public safety services since the workers to construct and to operate the facility are expected to already reside on the island.	None.

Table 8-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Sodium-Sulfur Battery

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Geology and Soils		
	General construction impacts. See Section 3.1.3. No operational effects to geology and soils.	Same as those common across construction projects. See Section 3.1.3.
Climate and Air Quality		
Air Quality	General construction impacts. See Section 3.2.4. Negligible increase in criteria pollutants during operations. No fugitive dust generated during operation.	Same as those common across construction projects. See Section 3.2.5.
Climate Change	Negligible increase in greenhouse gas emissions during operation, since fossil fuels would not be burned.	None.
Water Resources		
Surface Water	General construction impacts. See Section 3.3.5. Potential increase in storm water runoff during operation.	None.
Groundwater	Minimal groundwater impacts during construction of the sodium-sulfur battery facility. Potential for increased runoff in the long-term and decrease in groundwater recharge.	None.
Floodplains and Wetlands	General construction and operation impacts. See Section 3.2.5.	Same as those across construction and operation projects. See Section 3.3.5.
Biological Resources		
	None; the battery energy storage system would involve minor land disturbance in previously developed locations.	N/A
Land and Submerged Land Use		
	None; the battery energy storage system would involve minor land disturbance in previously developed locations.	N/A
Cultural and Historic Resources		
	General impacts during construction and operation. See Section 3.6.6.	Same as those common across construction and operation projects. See Section 3.6.7.

Table 8-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Sodium-Sulfur Battery (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Coastal Zone Management		
	General impacts during construction and operation. See Section 3.7.8.	Evaluate through a Federal consistency review under the Coastal Zone Management Program.
Scenic and Visual Resources		
	General impacts during construction and operation activities. See Section 3.8.3.	Same as those common across construction projects. See Section 3.8.4.
Recreation Resources		
	None; the battery energy storage system would involve minor land disturbance in previously developed locations.	N/A
Land and Marine Transportation		
	None; the battery energy storage system would involve minor land disturbance in previously developed locations	N/A
Airspace Management		
	None; the battery energy storage system would not involve tall facilities and not impact airspace.	N/A
Noise and Vibration		
	General impacts during construction. See Section 3.12.5. Negligible long-term noise and vibration impacts during operation.	Same as those common across construction and operation projects. See Section 3.12.6.
Utilities and Infrastructure		
	Potentially beneficial impacts to utilities by helping to manage power generation.	None.
Hazardous Materials and Waste Management		
Hazardous Materials	Potential hazardous material exposure impacts during construction and operation due to presence of hazardous chemicals inside the battery.	Handle, package, store, and transport battery according to all applicable county, State, Federal regulations, including USDOT and ICAO regulation, both during setup and decommissioning. Dispose of batteries and/or battery components in a manner that minimizes hazardous material exposure impacts.
Waste Management	General construction and operation impacts. See Section 3.14.4. Potential impacts may occur during disposal of battery at its end of life.	Dispose of battery and battery components in a manner that minimizes hazardous waste impacts.

Table 8-5. Summary of the Potential Environmental Impacts and Best Management Practices/Mitigations, including Resource Areas with No Potential for Impacts – Energy Storage: Sodium-Sulfur Battery (continued)

Resource Area	Potential Impacts	Best Management Practices/ Mitigation Measures
Wastewater	None; the battery energy storage system would involve minor land disturbance in previously developed locations.	N/A
Socioeconomics		
	Very small impacts to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income.	None.
Environmental Justice		
	None; installation of a sodium-sulfur battery for energy storage would not result in environmental justice impacts.	N/A
Health and Safety		
	General impacts during construction and operation. See Section 3.17.4. Small potential for impacts to public safety services.	Install and implement safety measures and procedures to isolate batteries from fire threats and to enable fire suppression and emergency response.

8.4.1 GEOLOGY AND SOILS

8.4.1.1 Potential Impacts

8.4.1.1.1 Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to geology and soils from the representative flywheel energy storage project.

8.4.1.1.2 Sodium-Sulfur Batteries – Utility-Scale Energy Source

Effects on geology and soils from installation of the battery system would be the same as those expected for common construction actions as described in Section 3.1.3. The group of batteries that would be installed under the representative project represents a large grouping of equipment with a footprint of 26,000 square feet, or 0.6 acre. With footing excavations, equipment laydown areas, electrical connections to the adjacent renewable energy facility, and the need for a heavy load access road, it is reasonable to assume that the total amount of soil disturbed by the project could be over 1 acre, so the permitting requirements described in Section 3.1.3 could be fully applicable.

Operation of the battery energy storage facility would not involve activities that would have the potential to affect geology or soils of the area.

8.4.1.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction projects. See Section 3.1.4.

8.4.2 CLIMATE AND AIR QUALITY

8.4.2.1 Potential Impacts

8.4.2.1.1 Air Quality

Flywheel – Distributed Energy Source
The representative flywheel energy storage project would result in air quality impacts typical of general construction activities described in Section 3.2.4. Most units of the system would be manufactured offsite and moved into position at the site.

Operation of the representative flywheel energy storage system would not produce criteria pollutants from fossil fuels. No fossil fuels would be burned and no fugitive dust would be generated during operation. Beneficial impacts to air quality would result from the use of energy storage devices since the technology would increase the usefulness of variable renewable energy electrical generation sources, which could offset generation using diesel fuel.

Sodium-Sulfur Batteries – Utility-Scale Energy Source
The representative battery energy storage project would result in air quality impacts typical of general construction activities described in Section 3.2.4. As with the flywheel project, most units of the battery system would be manufactured offsite and moved into position at the site.

Operation of the representative battery energy storage system would not produce criteria pollutants from fossil fuels. No fossil fuels would be burned and no fugitive dust would be generated during operation.

8.4.2.1.2 Climate Change

Flywheel - Distributed Energy Source
This technology could result in impacts typical of general onsite construction activities, which are addressed in Section 3.2.4. Most units of the system would be manufactured off-site and moved into position at the site.

Operation of an energy storage system would not produce measureable amounts of greenhouse gases. No fossil fuels would be burned during operation.

Sodium-Sulfur Batteries – Utility-Scale Energy Source
This technology could result in impacts typical of general on-site construction activities, which are addressed in Section 3.2.4. Most units of the system would be manufactured off-site and moved into position at the site.

Operation of an energy storage system would not produce measureable amounts of greenhouse gases. No fossil fuels would be burned during operation.

8.4.2.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction projects. See Section 3.2.5.

8.4.3 WATER RESOURCES

8.4.3.1 Potential Impacts

8.4.3.1.1 Surface Water

Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to surface water from the representative flywheel energy storage project.

Sodium-Sulfur Batteries – Utility-Scale Energy Source

Impacts on surface water from installation of the representative battery energy storage system would be the same as those expected for common construction actions as described in Section 3.3.5.

During operation there would be no activities that would have the potential to affect surface waters other than possibly increased storm water runoff from the site. If the pre-construction project site had natural vegetation, the completed project site would have a higher percentage of impermeable surfaces and, accordingly, would generate more storm water runoff. The amount of land involved is minor and would not be expected to present unusual or difficult runoff management concerns.

8.4.3.1.2 Groundwater

Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to groundwater from the representative flywheel energy storage project.

Sodium-Sulfur Batteries – Utility-Scale Energy Source

Construction of the representative battery energy storage facility would not be expected to impact groundwater nor would they be expected to involve any unusual sources of contamination.

Periods during construction when large amounts of loosened soil might result in decreased storm water runoff, as described above, would also represent periods when there would be more storm water soaking into the ground and potentially providing recharge to groundwater. As noted previously, these would be temporary conditions with little potential to have any notable effect on groundwater.

Water needs during construction would be expected to come from groundwater resources, either via municipal water systems or private wells, but they would be minor, involving such uses as for dust suppression and in soil compaction.

The long-term presence and operation of the energy storage facility would be associated with increased runoff (as described previously) and potentially an associated decrease in groundwater recharge. However, the area involved would be small and, depending on where runoff from the facility would go or how it would be managed, the action may simply represent a change in where water soaks into the ground.

8.4.3.1.3 Floodplains and Wetlands

The proponents of either energy storage project would be expected to avoid floodplain and wetland areas if only to reduce costs and minimize regulatory requirements. However, if they could not be avoided, construction considerations would be the same as described for common construction actions in Section 3.3.5.

8.4.3.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.3.6.

8.4.4 BIOLOGICAL RESOURCES

As identified in Tables 8-4 and 8-5, there would be no impacts to biological resources from either representative energy storage project.

8.4.5 LAND AND SUBMERGED LAND USE

As identified in Tables 8-4 and 8-5, there would be no impacts to land and submerged land use from either representative energy storage project.

8.4.6 CULTURAL AND HISTORIC RESOURCES

8.4.6.1 Potential Impacts

8.4.6.1.1 Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to cultural or historical resources from the representative flywheel energy storage project.

8.4.6.1.2 Sodium Sulfur Batteries – Utility-Scale Energy Source

Impacts on cultural and historic resources from the representative battery energy storage system would be the same as those expected for common construction and operation actions as described in Section 3.6.6.

8.4.6.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.6.7.

8.4.7 COASTAL ZONE MANAGEMENT

8.4.7.1 Potential Impacts

8.4.7.1.1 Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to coastal zone management from the representative flywheel energy storage project.

8.4.7.1.2 Sodium-Sulfur Batteries – Utility-Scale Energy Source

Impacts on coastal zone management from the representative battery energy storage system would be the same as those expected for common construction and operation actions as described in Section 3.7.8.

8.4.7.2 Best Management Practices and Mitigation Measures

Evaluate the project through a Federal consistency review under the Coastal Zone Management Program.

8.4.8 SCENIC AND VISUAL RESOURCES

8.4.8.1 Potential Impacts

8.4.8.1.1 Flywheel – Distributed Energy Source

As identified in Table 8-4, there would be no impacts to scenic or visual resources from the representative flywheel energy storage project.

8.4.8.1.2 Sodium-Sulfur Batteries – Utility-Scale Energy Source

Impacts on scenic and visual resources from the representative battery energy storage system would be the same as those expected for common construction and operation actions as described in Section 3.8.3.

Long-term visual impacts are not expected since the storage system would be co-located with an existing renewable energy generation source that is already connected to the transmission line.

8.4.8.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.8.4.

8.4.9 RECREATION RESOURCES

As identified in Tables 8-4 and 8-5, there would be no impacts to recreation resources from either representative energy storage project.

8.4.10 LAND AND MARINE TRANSPORTATION

As identified in Tables 8-4 and 8-5, there would be no impacts to land or marine transportation from either representative energy storage project.

8.4.11 AIRSPACE MANAGEMENT

As identified in Tables 8-4 and 8-5, there would be no impacts to airspace management from either representative energy storage project.

8.4.12 NOISE AND VIBRATION

8.4.12.1 Potential Impacts

8.4.12.1.1 Flywheel – Distributed Energy Source

The representative flywheel energy storage project could result in noise and vibration impacts typical of general construction activities described in Section 3.12.5.

Operational noise levels would be less than 70 dBA at 3 feet from the source of the flywheel energy storage facility. The sound would dissipate to around 58 dBA at 50 feet with no other sound absorption or mitigation measures. If inside an insulated room, the sound would be much less.

8.4.12.1.2 Sodium-Sulfur Batteries – Utility-Scale Energy Source

As with the flywheel project, the representative battery energy storage project could result in noise and vibration impacts typical of general construction activities described in Section 3.12.5.

Operational noise levels for the battery technology are low as well. Operational noise and vibration levels would be similar to existing noise levels. Long-term noise and vibration impacts from operation of the representative energy storage project would be negligible.

8.4.12.2 Best Management Practices and Mitigation Measures

BMPs and mitigation measures would be the same as those common across construction and operation projects. See Section 3.12.6.

For operational noise associated with the flywheel equipment, the equipment could be installed inside a sound-insulated room to further dampen any noise from being noticed by hotel guests.

8.4.13 UTILITIES AND INFRASTRUCTURE

8.4.13.1 Potential Impacts

Both representative energy storage projects would result in beneficial impacts by helping to manage power demand and generation. In addition, energy storage, in general, provides more reliable and less fossil-fuel-dependent power to the islands' power customers. Most successful energy storage projects connected to a power grid assume that other measures such as smart grid technology and renewable sources are also implemented.

8.4.13.2 Best Management Practices and Mitigation Measures

None identified.

8.4.14 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

8.4.14.1 Potential Impacts

8.4.14.1.1 Hazardous Materials

Flywheel – Distributed Energy Source
As identified in Table 8-4, there would be no impacts from exposure to hazardous materials from the representative flywheel energy storage project.

Sodium-Sulfur Batteries – Utility-Scale Energy Source
Sodium-sulfur batteries contain sodium, sulfur, beta-alumina ceramic electrolyte, and sulfur polysulfide components, which are considered hazardous materials and would be subject to USDOT and International Civil Aviation Organization regulations.

8.4.14.1.2 Waste Management

Flywheel – Distributed Energy Source
The representative flywheel energy storage project could result in waste management impacts typical of general construction activities, which are addressed in Section 3.14.4.

Sodium-Sulfur Batteries – Utility-Scale Energy Source
Sodium-sulfur batteries contain sodium, sulfur, alumina, and sodium polysulfide components that could be recycled or disposed of at the end of their life by routine industrial processes. As most of these materials are of high value, it is anticipated that most battery materials would be captured through reuse and recycling processes. Recycling practices and protocols for batteries are being further developed to handle various types. Batteries are considered to have reached their end-of-life when the battery charge is 80 percent of the new battery capacity. At this point, batteries still have a lot of potential for other “second use” applications, such as providing an energy buffer for solar or wind generation and utility grid support. The likely path for healthy batteries would be reconditioning and redeploying in other applications. This approach would avoid all of the costs and energy used to produce new batteries and would improve battery lifecycle emissions and costs by keeping them out of the recycling stream for many years past their use.

8.4.14.1.3 Wastewater

As identified in Tables 8-4 and 8-5, there would be no impacts to wastewater from the either representative energy storage project.

8.4.14.2 Best Management Practices and Mitigation Measures

Sodium-sulfur batteries contain components that may be toxic to humans and animals such as chromium compounds, particularly hexavalent chromium, if not disposed of properly. Therefore, special treatment is recommended during the disposal of the battery parts that cannot be repurposed or recycled. This includes testing for chromium using EPA’s Toxic Characteristic Leachate Procedure test methods. Those battery wastes exceeding maximum concentration levels of 5.0 milligrams per liter would be required to be set aside as hazardous waste, and proper handling and transport for disposal at the appropriate hazardous material facility would be required.

The following BMPs could reduce the above-identified impacts for both representative projects:

- Reuse or recycle batteries at their end of life to the extent practicable.
- Handle, package, store, and transport battery according to all applicable county, State, and Federal regulations, including USDOT and ICAO regulation, both during setup and decommissioning.
- Dispose of batteries and/or battery components in a manner that minimizes hazardous material exposure impacts.

8.4.15 SOCIOECONOMICS

8.4.15.1 Potential Impacts

Direct socioeconomic impacts in Hawai‘i from the representative energy storage projects would be very small. Construction jobs directly associated with the project likely would be filled by individuals residing within the State of Hawai‘i. Operation jobs likely would be filled by current workers. The overall impact to population; to employment variables such as the size of the labor force, unemployment rates, and employment in the State and local government sector; to rental housing; and to personal income would be very small.

8.4.15.2 Best Management Practices and Mitigation Measures

None identified.

8.4.16 ENVIRONMENTAL JUSTICE

As identified in Tables 8-4 and 8-5, there would be no environmental justice impacts from either representative energy storage project.

8.4.17 HEALTH AND SAFETY

8.4.17.1 Potential Impacts

8.4.17.1.1 Flywheel Technology

Potential health and safety impacts from construction and operation would be the same at the typical impacts describes in Section 3.17.3

Effects on each island public safety services would be small since the workers to construct and to operate the facility are expected to come from the island’s existing work force (see Section 8.4.15). Police, fire, and medical services would not be adversely affected with this small change.

8.4.17.1.2 Sodium-Sulfur Batteries – Utility-Scale Energy Source

Sodium-sulfur batteries contain sodium, sulfur, beta-alumina ceramic electrolyte, and sulfur polysulfide components. Batteries have the potential to short-circuit, which can lead to fires. Some batteries contain corrosive liquid, which can injure people or damage property. Sodium-sulfur batteries contain sodium, which presents a safety hazard, as pure sodium can spontaneously burn when in contact with air and moisture.

Effects on each island public safety services would be small since the workers to construct and to operate the facility are expected to come from the island's existing workforce (see Section 8.4.15). Police, fire, and medical services would not be adversely affected with this small change.

8.4.17.2 Best Management Practices and Mitigation Measures

Review and update first responder training, as necessary, for any unique features of these technologies as they are introduced to Hawai'i.

The battery system must be protected, including employing safety enhancement measures to prevent the potential for fires and the spread of fires from occurring. This includes the use of insulation boards between blocks in the battery module to prevent leaking molten materials from causing a short circuit, the use of anti-fire boards between battery modules to prevent fires from spreading, the implementation of a monitoring system, the installation of fire-prevention equipment, and a fire-fighting structure for fire preparedness and safety, as well as a fire evacuation and guidance plan.

8.5 References

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APPENDIX A

Public Notices

The following Notice of Intent appeared in the *Federal Register* on December 14, 2010.

Federal Register / Vol. 75, No. 239 / Tuesday, December 14, 2010 / Notices **77859**

DEPARTMENT OF ENERGY

Notice of Intent To Prepare a Programmatic Environmental Impact Statement for the Hawai'i Interisland Renewable Energy Program: Wind (DOE/EIS–0459)

AGENCY: Department of Energy (DOE).

ACTION: Notice of intent to prepare a Programmatic Environmental Impact Statement (EIS).

SUMMARY: DOE announces its intention to prepare a Programmatic EIS with the State of Hawai'i as joint lead agencies pursuant to the National Environmental Policy Act (NEPA) of 1969 and the Hawai'i Environmental Policy Act. The Hawai'i Interisland Renewable Energy Program: Wind Programmatic Environmental Impact Statement (hereinafter referred to as the Hawai'i Wind EIS or the EIS) will assess the foreseeable environmental impacts which may arise from wind energy development under the Hawai'i Interisland Renewable Energy Program (HIREP). Hawai'i proposes to facilitate the development of wind-generated electric energy and the required improvements to the existing electric transmission infrastructure in Hawai'i. This EIS is the first phase of a programmatic environmental review of developing and increasing renewable energy technologies in Hawai'i.

DATES: The public scoping period starts with the publication of this Notice in the **Federal Register**. Comments on the scope of the EIS should be submitted by March 1, 2011. Comments e-mailed or postmarked after that date will be considered to the extent practicable. DOE and Hawai'i will hold public scoping meetings in the first quarter of 2011. Dates will be announced in the **Federal Register**, on the DOE NEPA Web site at *http://www.nepa.energy.gov,* on the EIS Web site at *http://www.hirep-wind.com,* and in local media at least 15 days before each meeting.

ADDRESSES: DOE and Hawai'i will announce locations of scoping meetings as indicated in **DATES**. Send comments on the scope of the Hawai'i Wind EIS or a request to be added to the EIS distribution list:

- By e-mail to *comments@hirep-wind.com.*
- By submitting electronic comments on the EIS Web page at *http://www.hirep-wind.com.*
- By facsimile (fax) to 808–586–2536, Attention Allen G. Kam.
- By mail to Allen G. Kam, Esq., AICP, HIREP EIS Manager, State of Hawai'i, Department of Business, Economic Development and Tourism, Renewable Energy Branch, State Energy Office, P.O. Box 2359, Honolulu, HI 96804.

Information on the HIREP: Wind Phase is available at the EIS Web site at *http://www.hirep-wind.com.* This Notice of Intent, and the draft and final EIS when issued, also will be posted on the DOE NEPA Web site at *http://www.nepa.energy.gov.* These documents and additional materials relating to this EIS will be available at:

- Hawai'i State Library, 478 South King Street, Honolulu HI 96813.
- Lāna'i Public and School Library, 555 Fraser Ave, Lāna'i City, HI 96763.
- Wailuku Public Library, 251 High Street, Wailuku, HI 96793.
- Moloka'i Public Library, 15 Alamalama, Kaunakakai, HI 96748.
- Edwin H. Mo'okini Library, University of Hawai'i–Hilo, 200 West Kāwili Street, Hilo, HI 96720–4091.
- Kailua-Kona Public Library, 75–138 Hualālai Road, Kailua-Kona, HI 96740–1704.
- Līhu'e Public Library, 4344 Hardy Street, Līhu'e, HI 96766.
- DOE Freedom of Information Act Public Reading Room, 1000 Independence Avenue, SW., Washington, DC 20585.

FOR FURTHER INFORMATION CONTACT: For information on DOE's proposed action, contact Anthony J. Como, DOE NEPA Document Manager, Office of Electricity Delivery and Energy Reliability (OE–20), U.S. Department of Energy, 1000 Independence Avenue, SW.,

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Washington, DC 20585; or at *anthony.como@hq.doe.gov.* For general information about the DOE NEPA process, contact Carol Borgstrom, Director, Office of NEPA Policy and Compliance (GC–54), U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585; or at 800–472–2756 or *askNEPA@hq.doe.gov.*

For information on the Hawai'i Interisland Renewable Energy Program, contact Mr. Allen G. Kam, Esq., AICP, HIREP EIS Manager, State of Hawai'i, Department of Business, Economic Development and Tourism, Renewable Energy Branch, State Energy Office, P.O. Box 2359, Honolulu, HI 96804; or at 808–587–9023 or *hirep@dbedt.hawaii.gov.*

SUPPLEMENTARY INFORMATION:

1. Background

Section 355 of the Energy Policy Act of 2005 (EPAct) requires the Secretary of Energy to assess the economic implications of the dependence of the State of Hawai'i on oil as a principal source of energy, including the technical and economic feasibility of increasing the contribution of renewable energy resources for the generation of electricity on an island by island basis. Such an assessment is to include, among other factors, siting and facility configuration, the effects on utility system reliability, and environmental considerations. In furtherance of the provisions of section 355 of EPAct, DOE and Hawai'i executed a Memorandum of Understanding (MOU) in January 2008 that established the Hawai'i Clean Energy Initiative (HCEI) and a long-term partnership between DOE and Hawai'i to implement the initiative. HCEI has a goal of providing 70 percent of the state's primary energy from clean energy sources by 2030 by replacing 40 percent of fossil fuel use with renewable energy and reducing energy consumption by 30 percent through energy efficiency measures. Of the alternative renewable energy sources available in Hawai'i—including wind, geothermal, solar, biomass, ocean thermal energy conversion, and wave—wind power has been identified as the most commercially available and economically viable option at the present time. The island of O'ahu, with 80 percent of the state's population, is the island with the greatest energy demand; however, the island does not contain sufficient renewable energy potential to meet the HCEI's goals. The islands of Maui, Lāna'i, and Moloka'i have the most abundant and viable wind resources of those islands closest to O'ahu. The analysis provided in the O'ahu Wind Integration and Transmission Study (November 2010) (additional information at *http://www.nrel.gov/wind/systemsintegration/owits.html*), prepared by DOE's National Renewable Energy Laboratory, concluded that bringing 400 megawatts (MW) of wind-generated power to O'ahu via undersea cable (*i.e.*, the Hawai'i Interisland Wind Program) is technically feasible and should be considered an important part in reaching the HCEI's goals. Subsequent environmental reviews may address non-wind renewable technologies.

2. Environmental Review Process

The Hawai'i Wind EIS will be prepared pursuant to NEPA, as amended, the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR parts 1500–1508), the DOE NEPA implementing procedures (10 CFR part 1021), and the Hawai'i Environmental Policy Act (Hawai'i Revised Statutes (HRS) chapter 343). The EIS will assess the potential environmental impacts from the development of wind generation facilities, the transmission required to deliver the wind-generated energy to O'ahu, and the required improvements to the existing electric transmission infrastructure on O'ahu. Because the proposed actions and alternatives may involve activities in floodplains and wetlands, the draft EIS may include a floodplain and wetland assessment prepared in accordance with 10 CFR part 1022, Compliance with Floodplain and Wetland Environmental Review Requirements. The proposed actions and alternatives will involve undersea transmission cables that will transect federal Outer Continental Shelf waters, where the Department of the Interior's Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) has exclusive authority over right-of-way grants for undersea renewable energy transmission cables.

DOE and Hawai'i invite agencies, Native Hawaiian and other organizations, and members of the public to participate in developing the scope of the EIS—that is, the proposed actions, the range of reasonable alternatives and environmental impacts and other issues to be considered—by submitting written comments and by participating in public scoping meetings that DOE and Hawai'i will conduct jointly. DOE and Hawai'i also invite those agencies with jurisdiction by law or special expertise to be cooperating agencies in EIS preparation.

3. DOE Purpose and Need for Agency Action and Proposed Action

DOE's purpose and need for agency action is to meet its obligations under section 355 of EPAct and the 2008 MOU with Hawai'i to transform the way in which renewable energy and efficiency resources are planned and used in the State. DOE's proposed action is to work with and support Hawai'i in the implementation of the HCEI.

4. Hawai'i's Purpose and Need for State Action and Proposed Action

Hawai'i's purpose and need for action is to determine how to use its wind energy resources to meet the 2030 goals set forth in the HCEI. Hawai'i's proposed action is to facilitate renewable energy development that will be required for the State of Hawai'i to meet the HCEI renewable energy goals, including the development of wind resources on the islands of Maui, Lāna'i, and/or Moloka'i and the required improvements to the existing electric transmission infrastructure, including undersea cables to transmit renewable energy generation to O'ahu.

5. Alternatives

Alternatives to be analyzed in this EIS include the proposed action, which would provide for the implementation of an oversight program to develop up to 400 MW of wind energy on the Maui County islands of Maui, Lāna'i, and/or Moloka'i and transmission of that energy to O'ahu. A range of wind development projects could be pursued under the proposed action, and include varying power capacities and configurations among the islands, undersea cable corridors and routes, and locational criteria for landing sites (see *www.hirep-wind.com* for additional information including conceptual maps). The EIS will address scenarios under the proposed action that consider a programmatic approach to all wind energy deriving from a single island in Maui County (i.e., Maui, Lāna'i, or Moloka'i) and all wind energy deriving from a combination of generation on two or more islands in Maui County, along with associated programmatic approaches to cable corridors and routes and landing site locations. The EIS will also analyze a no-action alternative.

6. Preliminary Identification of Environmental Issues

The EIS will evaluate the full range of potential environmental, social, cultural, and economic impacts associated with a proposed wind energy program encompassing the islands of Maui, Lāna'i and Moloka'i and use areas on O'ahu. The EIS also will include a cultural impact assessment prepared in accordance with Hawai'i law, specifically Act 50, SLH 2000.

Impacts will be analyzed across a number of resource areas, including:

- Air quality (including climate change and greenhouse gas emissions).
- Water resources and drainage.
- Coastal zone resources.
- Geography, geology, and soils.
- Land and submerged land use.
- Threatened and endangered species, special status species, and related sensitive resources such as the Hawaiian Islands Humpback Whale National Marine Sanctuary.
- Land transportation.
- Marine transportation and commerce.
- Airspace utilization.
- Public health and safety.
- Noise.
- Natural hazards.
- Hazardous materials.
- Accidents and intentional destructive acts.
- Cultural and historical resources.
- Recreational resources.
- Visual resources.
- Socioeconomic impacts, community services and infrastructure.
- Environmental justice considerations (disproportionately high and adverse impacts to minority and low income populations).
- Cumulative impacts (past, present, and reasonably foreseeable future actions).
- Irreversible and irretrievable commitments of resources.

The programmatic analysis will identify best management practices, outline regulatory procedures, address mitigation of environmental impacts and support the development of general guidance for major components of an interisland undersea cable energy grid for the transmission of wind energy.

7. Public Participation: Scoping, EIS Distribution, Schedule

As indicated in the DATES section, public scoping meetings will be conducted in early 2011. Each scoping meeting will be structured in two parts: first an informal "workshop" discussion period that will not be recorded, then a formal commenting session, which will be transcribed by a court stenographer. The meetings will provide interested parties the opportunity to view exhibits on the HIREP: Wind, ask questions, and submit comments orally or in writing. Representatives from DOE, Hawai'i, and any cooperating agencies will be available to answer questions and provide additional information to participants. Individuals who submit comments during the scoping process will receive paper or electronic copies of the draft EIS, according to their preference. Persons who do not wish to submit comments or suggestions at this time, but would like to receive a copy of the draft EIS when it is issued should submit a request as provided in the ADDRESSES section and include their preference for a paper or electronic copy.

In preparing the draft EIS, DOE and Hawai'i will consider comments received during the scoping period. The agencies plan to issue the draft EIS by October 2011. After the agencies issue the draft EIS, the U.S. Environmental Protection Agency will publish a notice of availability of the draft EIS in the **Federal Register**, which will begin a minimum 45-day public comment period. In addition to and concurrent with this NOI publication in the **Federal Register**, the State of Hawai'i is preparing a state-level environmental review notice. That notice along with this NOI will be published in the State of Hawai'i Environmental Notice consistent with all state requirements.

The agencies will announce how to comment on the draft EIS and will hold public hearings during the public comment period, but no sooner than 15 days after the notice of availability is published. In preparing the final EIS, the agencies will respond to comments received on the draft EIS. The agencies plan to issue the final EIS by April 2012. No sooner than 60 days after the Environmental Protection Agency publishes a Notice of Availability of the final EIS, DOE and Hawai'i will each issue its Record of Decision regarding their actions considered in the EIS.

Issued in Washington, DC, on December 8, 2010.

Patricia A. Hoffman,

Assistant Secretary, Office of Electricity Delivery and Energy Reliability.

[FR Doc. 2010–31310 Filed 12–13–10; 8:45 am]

BILLING CODE 6450–01–P

The following Amended Notice of Intent appeared in the *Federal Register* on August 10, 2012.

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DEPARTMENT OF ENERGY

Amended Notice of Intent To Prepare the Hawai'i Clean Energy Programmatic Environmental Impact Statement

AGENCY: Department of Energy (DOE).

ACTION: Amended Notice of Intent (NOI) to prepare a Programmatic Environmental Impact Statement (PEIS).

SUMMARY: In 2010, DOE announced its intent to prepare a *PEIS for the Hawai'i Interisland Renewable Energy Program (HIREP): Wind* (DOE/EIS–0459) (HIREP: Wind PEIS). In response to public scoping comments on the HIREP: Wind PEIS, as well as regulatory and policy developments since the scoping meetings, DOE proposes to broaden the range of energy efficiency and renewable energy activities and technologies to be analyzed in the PEIS and, accordingly, has renamed it the *Hawai'i Clean Energy PEIS.* DOE's proposal will involve the development of guidance to use in future funding decisions and other actions to support Hawai'i in achieving the goal established in the Hawai'i Clean Energy Initiative (HCEI) to meet 70% of the State's energy needs by 2030 through energy efficiency and renewable energy. Achieving the HCEI goal could involve a diverse range of activities. Accordingly, this PEIS will analyze the potential environmental impacts of activities in the following clean energy categories: (1) Energy Efficiency, (2) Distributed Renewables, (3) Utility-Scale Renewables, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution. The State of Hawai'i and the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) are cooperating agencies in preparing this PEIS.

DATES: DOE invites public comment on the scope of the PEIS during a 60-day public scoping period ending on October 9, 2012. See *Public Participation: Scoping, EIS Distribution, Schedule* in the **SUPPLEMENTARY INFORMATION** section below for public scoping meeting dates and locations. DOE will consider all comments received or postmarked by the end of the scoping period, and will consider comments received or postmarked after the ending date to the extent practicable.

ADDRESSES: Written comments on the scope of the PEIS or a request to be added to the PEIS distribution list may be submitted as follows:

- Email to *hawaiicleanenergypeis@ee.doe.gov.*
- Electronic comments via the PEIS Web site at *http://www.hawaiicleanenergypeis.com.*
- Facsimile (fax) to (808) 541–2253. Attention: Hawai'i Clean Energy PEIS.
- U.S. mail to Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850–0247.

FOR FURTHER INFORMATION CONTACT: For information on DOE's proposed action, contact Jane Summerson, Ph.D., DOE National Environmental Policy Act (NEPA) Document Manager, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, 1000 Independence Avenue SW., Washington, DC 20585, or Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850–0247, or send an email to *hawaiicleanenergypeis@ee.doe.gov.* Information on the Hawai'i Clean Energy PEIS is available on the PEIS Web site at *http://www.hawaiicleanenergypeis.com* and at the public libraries listed under *Public Participation: Scoping, EIS Distribution, Schedule* in the **SUPPLEMENTARY INFORMATION** section below.

For general information about the DOE NEPA process, contact Carol Borgstrom, Director, Office of NEPA Policy and Compliance (GC–54), U.S. Department of Energy, 1000 Independence Avenue SW, Washington, DC 20585, or (800) 472–2756 or *askNEPA@hq.doe.gov.*

SUPPLEMENTARY INFORMATION:

1. Background

DOE and the State of Hawai'i Coordination and Collaboration

DOE and Hawai'i entered into a Memorandum of Understanding (MOU) in January 2008 that established a long-term partnership to transform the way in which energy efficiency and renewable energy resources are planned and used in the State. The MOU established working groups to address key sectors of the energy economy (e.g., electricity, end-use efficiency, transportation, and fuels), which led to the establishment of the HCEI. The goal of the HCEI is to meet 70% of Hawai'i's energy needs by 2030 through energy efficiency and renewable energy (collectively "clean energy").

To support this goal, in 2009, Hawai'i's legislature established a Renewable Portfolio Standard of 15% by 2015, 25% by 2020, and 40% by 2030. [See Haw. Rev. Stat. Sections 269–91 to 296–95 (2012) and Haw. Rev. Stat. Section 196 (2012).] Hawai'i also has established an Energy Efficiency Portfolio Standard that calls for the

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statewide reduction in electricity use of 4,300 gigawatt hours via efficiency measures by 2030. [Haw. Rev. Stat. Section 269–96 (2012).]

Meanwhile, DOE has helped advance Hawai'i's clean energy goals by providing technical research and analysis, direct staff involvement, competitive solicitations, and funding. For example, DOE has provided funding for distributed photovoltaics on O'ahu and Maui; a wind farm on O'ahu; smart grid projects on Maui and Kaua'i; electric vehicle public charging networks; efficient appliance rebates; solar water heating rebates; and low-interest loans. Also, in accordance with Section 355 of the Energy Policy Act of 2005, DOE assessed the economic implications of Hawai'i's dependence on oil as a principal source of energy, including the technical and economic feasibility of increasing the use of renewable energy resources for the generation of electricity on an island-by-island basis. The report concluded that Hawai'i has many opportunities to diversify energy use through greater utilization of renewable energy for electricity and transportation applications.[1]

2010 Notice of Intent for the HIREP: Wind PEIS

On December 14, 2010, DOE issued a NOI to prepare a PEIS, with the State of Hawai'i as a joint lead, on the wind phase of the Hawai'i Interisland Renewable Energy Program (75 FR 77859). That NOI referred to the PEIS as the HIREP: Wind PEIS. Scoping meetings were held in Honolulu, Kahului, Kaunakakai, and Lāna'i City in February 2011. Commenters expressed concern that DOE and the State would not analyze energy efficiency measures, distributed renewable energy, or the full range of potential renewable energy technologies. Commenters also expressed concern about the construction of interisland electricity transmission connection(s) and cable(s), the potential disparity of impacts on islands that could host wind development projects versus those that would use the electricity, and potential impacts to cultural resources, among other issues. In light of these comments, as well as regulatory and policy developments since the scoping meetings, DOE consulted with the State and decided to broaden the range of energy efficiency and renewable energy activities and technologies to be analyzed in the PEIS. In preparing the PEIS, DOE will consider scoping comments already received on the initial NOI, along with comments received in response to this amended NOI.

[1] U.S. Department of Energy. *Assessment of Dependence of State of Hawaii on Oil.* (December 2008); available at *http://hawaiicleanenergypeis.com/wp-content/uploads/2012/07/Hawaii_Oil_Dependency.pdf.*

2. Environmental Review Process

The Hawai'i Clean Energy PEIS will be prepared pursuant to the National Environmental Policy Act (NEPA), as amended, the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500 through 1508), and the DOE NEPA implementing procedures (10 CFR Part 1021). The PEIS also will consider, among other regulatory items, the requirements of the Hawai'i Environmental Policy Act (Hawai'i Revised Statutes [HRS] chapter 343).

DOE invites Federal, State, and local government agencies, Native Hawaiian and other organizations, and members of the public to submit comments and participate in public meetings on the scope of the PEIS—that is, the proposed action, the range of reasonable alternatives, and potential environmental impacts and other issues to be considered. DOE also invites government agencies with jurisdiction by law or special expertise to be cooperating agencies in EIS preparation. The State of Hawai'i and BOEM have agreed to be cooperating agencies.

The PEIS will not eliminate the need for project-specific environmental review of individual projects or activities that may be eligible for funding or other support by DOE. To the extent that DOE proposes to fund or undertake particular projects or activities that may fall within the scope of the PEIS, project-specific NEPA review for such projects and activities is expected to be tiered from the PEIS and to be more effective and efficient because of the PEIS. Moreover, such projects and activities will be subject to compliance with obligations under other environmental laws such as the Endangered Species Act and National Historic Preservation Act.

3. DOE Purpose and Need for Agency Action

DOE's purpose and need for agency action is based on the 2008 MOU with Hawai'i that established a long-term partnership to transform the way in which energy efficiency and renewable energy resources are planned and used in the State. Consistent with this MOU, DOE's purpose and need is to support the State in its efforts to meet 70% of the State's energy needs by 2030 through clean energy.

4. DOE's Proposed Action

DOE's proposed action is to develop guidance that it can use in making decisions about future funding or other actions to support Hawai'i in achieving the goal established in the HCEI to meet 70% of the State's energy needs by 2030 through energy efficiency and renewable energy. For purposes of this PEIS, DOE has divided these potential future actions into five clean energy categories and will analyze, at a programmatic level, the potential environmental impacts of future DOE actions that would fall within these categories and be subject to DOE's proposed guidance.

Energy Efficiency

Buildings (new construction and retrofits)
Energy Conservation
Ground Source Heat Pumps
Initiatives and Programs (e.g., tax incentives and rebates)
Sea Water Cooling
Solar Water Heating

Distributed Renewables

Biomass (small systems)
Hydroelectric (small systems)
Hydrogen Fuel Cells
Solar Photovoltaic Panels
Wind (small systems)

Utility-Scale Renewables

Biomass Geothermal
Hydroelectric
Municipal Solid Waste (including landfill gas)
Ocean Energy (wave and tidal)
Ocean Thermal Energy Conversion
Solar Photovoltaic Arrays
Solar Thermal Systems
Wind (land-based)
Wind (offshore)

Alternative Transportation Fuels and Modes

Biofuels
Electric Vehicles
Hybrid Electric Vehicles
Hydrogen
Liquefied Natural Gas
Mass Transportation

Electrical Transmission and Distribution

On Island Transmission
Land/Sea Cable Transition Sites
Undersea Cable Corridors
Smart Grid
Energy Storage

The PEIS will analyze the potential environmental impacts of only those clean energy activities and technologies that are eligible under Hawai'i's Renewable Portfolio Standard or Energy Efficiency Portfolio Standard. It will analyze these potential impacts, as

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appropriate, on an island-by-island basis for the islands of Hawai'i, Kaua'i, Lāna'i, Maui, Moloka'i, and O'ahu. The PEIS will build upon the environmental and technical studies and public comments and outreach conducted to date.

The energy efficiency activities and renewable energy technologies and resources available in Hawai'i, including distributed and utility-scale renewable energy, vary by island and in commercial availability and economic viability. Furthermore, as in all utility systems, Hawai'i's ability to incorporate clean energy into individual island grids can be limited by the capacity of the power transmission system. Thus, DOE will consider several factors in determining the appropriate level of detail for analyzing the potential environmental impacts of each form of clean energy in the PEIS. These factors may include the potential to make a timely contribution to the HCEI goal; stage of technical development; commercial availability; and potential for significant environmental impacts. Similarly, DOE will consider the conditions on an individual island to help determine the appropriate level of detail for analysis of potential impacts on that island. In other words, the PEIS will not assume that each energy efficiency activity or renewable energy technology has the same potential for use on each island or that it would result in the same potential environmental impacts on each island.

The PEIS may identify (a) general geographical areas suitable for development of renewable energy resources, (b) combinations of energy efficiency activities and renewable energy technologies that may be both feasible and efficient in helping Hawai'i meet its HCEI goal, and (c) selection criteria and priorities that DOE could consider when reviewing project-specific proposals. In addition, the PEIS will provide information needed to consider the potential environmental impacts from clean energy activities and technologies. As a result, DOE will have information relevant to prioritizing future funding or other decisions. This could help DOE avoid redundancies and inefficiencies in future project development and decision-making.

The PEIS also will analyze, as connected actions or for cumulative impacts, on-going and reasonably foreseeable actions by other entities that could contribute to meeting Hawai'i's clean energy goals. Such energy efficiency and renewable energy actions could be proposed or undertaken by other federal agencies, state or local government agencies, or private parties.

No-Action Alternative

Under the no-action alternative, DOE would continue to support, through funding and other actions, Hawai'i in meeting the HCEI goal on a case-by-case basis, but without guidance to integrate and prioritize funding decisions and other actions.

5. Preliminary Identification of Environmental Issues

The PEIS will evaluate the full range of potential environmental, including cultural and socioeconomic, impacts associated with implementing clean energy activities and technologies on the islands of Hawai'i, Kaua'i, Lāna'i, Maui, Moloka'i, and O'ahu.

The following environmental resource areas have been tentatively identified for consideration in the EIS:

- Cultural and historical resources.
- Air quality (including climate change and greenhouse gas emissions).
- Water resources.
- Floodplains and wetlands.
- Coastal zone management.
- Geology and soils.
- Land and submerged land use.
- Biological resources (including threatened and endangered species, special status species, and related sensitive resources).
- Land and marine transportation.
- Airspace management.
- Public health and safety.
- Noise.
- Natural hazards.
- Hazardous materials and waste management.
- Accidents and intentional destructive acts.
- Recreational resources.
- Visual resources.
- Socioeconomics.
- Environmental justice (disproportionately high and adverse impacts to minority and low-income populations).
- Utilities and infrastructure.
- Cumulative impacts (past, present, and reasonably foreseeable future actions).
- Irreversible and irretrievable commitments of resources.

6. Public Participation: Scoping, EIS Distribution, Schedule

Public scoping meetings will be conducted at the following times and locations:

- September 11, 2012, 5:00–8:30 p.m. at O'ahu, McKinley High School, 1039 South King Street, Honolulu, HI 96814
- September 12, 2012, 5:30–9:00 p.m. at Kaua'i, Kaua'i War Memorial Convention Hall, 4191 Hardy Street, Lihue, HI 96766
- September 13, 2012, 5–8:30 p.m. at Hawai'i, Kealakehe High School, 74–5000 Puohulihuli Street, Kailua-Kona, HI 96740
- September 14, 2012, 5–8:30 p.m. at Hawai'i, Hilo High School, 556 Waianuenue Avenue, Hilo, HI 96720
- September 17, 2012, 5:30–9 p.m. at Maui, Pomaika'i Elementary School, 4650 South Kamehameha Avenue, Kahului, HI 96732
- September 18, 2012, 5–8:30 p.m. at Lāna'i, Lāna'i High & Elementary School, 555 Fraser Avenue, Lanai City, HI 96763
- September 19, 2012, 5:30–9 p.m. at Molokai, Mitchell Pau'ole Community Center, 90 Ainoa Street, Kaunakakai, Molokai, HI 96748
- September 20, 2012, 5–8:30 p.m. at O'ahu, James B. Castle High School, 45–386 Kaneohe Bay Drive, Kaneohe, HI 96744

Each scoping meeting will involve: a presentation that describes the NEPA process and the concept of a Programmatic EIS; a question and answer session; and a formal commenting session, which will be transcribed by a court reporter to ensure that all comments are available to DOE for consideration during preparation of the draft PEIS. The meetings will provide opportunities to view exhibits on potential clean energy approaches, ask questions, and submit comments orally or in writing. Representatives from DOE, Hawai'i, BOEM, and any other involved agencies will be available to answer questions and provide additional information to participants. Individuals who submit comments during the scoping process and provide their contact information will receive copies of the draft PEIS. The format of the draft PEIS provided could be a printed summary and CD of the complete document, a CD of the document, Web site access to the document, or a complete printed document, according to the commenter's format preference. Persons who do not submit comments during scoping, but would like to receive a copy of the draft PEIS when it is issued, should submit a request as provided in the **ADDRESSES** section and specify their format preference.

Information on the Hawai'i Clean Energy PEIS is available on the PEIS Web site at *http://www.hawaiicleanenergypeis.com.* Materials relating to this PEIS also will be available at the public libraries listed below and several additional public libraries across the State of Hawai'i (for a complete list, see the PEIS Web site):

- Hawai'i State Library, 478 South King Street, Honolulu, HI 96813.

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• Lāna'i Public and School Library, 555 Fraser Ave, Lāna'i City, HI 96763.
• Wailuku Public Library, 251 High Street, Wailuku, HI 96793.
• Moloka'i Public Library, 15 Ala Malama, Kaunakakai, HI 96748.
• Hilo Public Library, 300 Waianuenue Ave, Hilo, HI 96720.
• Kailua-Kona Public Library, 75–138 Hualalai Road, Kailua-Kona, HI 96740.
• Lihu'e Public Library, 4344 Hardy Street, Lihu'e, HI 96766.

In preparing the draft PEIS, DOE will consider comments received during the scoping period and will consider late comments to the extent practicable. DOE plans to issue the draft PEIS in 2013. The U.S. Environmental Protection Agency (EPA) will publish a Notice of Availability (NOA) of the draft PEIS in the **Federal Register**, which will begin a minimum 45-day public comment period. DOE will announce how to comment on the draft PEIS and will hold public hearings during the public comment period, but no sooner than 15 days after the NOA of the draft PEIS is published.

In preparing the final PEIS, DOE will respond to comments received on the draft PEIS. DOE plans to issue the final PEIS in 2014. No sooner than 30 days after EPA publishes a NOA of the final PEIS, DOE may issue its Record of Decision regarding its actions considered in the PEIS.

Issued in Washington, DC, on August 3, 2012.

Patricia Hoffman,

Assistant Secretary for Electricity Delivery and Energy Reliability.

[FR Doc. 2012–19647 Filed 8–9–12; 8:45 am]

BILLING CODE 6450–01–P

DOE-Hawai‘i placed the following advertisement in the *Star-Advertiser* on September 4 and 10, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Tuesday, September 11, 2012
McKinley High School • 1039 South King Street, Honolulu
5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held in Kaneohe and on Kaua‘i, Moloka‘i, Lāna‘i, Maui, and Hawai‘i Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Garden Island* on September 5, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Wednesday, September 12, 2012

Kaua‘i War Memorial Convention Hall • 4191 Hardy Street, Lihue

5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Garden Island* on September 10, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Wednesday, September 12, 2012

Kaua‘i War Memorial Convention Hall • 4191 Hardy Street, Lihue

5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on Moloka‘i, Lāna‘i, Maui, and Hawai‘i Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawaiʻi placed the following advertisement in *West Hawaiʻi Today* on September 6 and 11, 2012.

U.S. Department of Energy

HAWAIʻI CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Thursday, September 13, 2012

Kealakehe High School • 74-5000 Puohulihuli Street, Kailua-Kona

5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawaiʻi Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawaiʻi in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held in Hilo and on Oʻahu, Kauaʻi, Molokaʻi, Lānaʻi, and Maui; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawaiʻi Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawaiʻi Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawaiʻi placed the following advertisement in *Hawaiʻi Tribune Herald* on September 7 and 12, 2012.

U.S. Department of Energy

HAWAIʻI CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Friday, September 14, 2012
Hilo High School • 556 Waianuenue Avenue, Hilo
5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawaiʻi Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawaiʻi in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held in Kailua-Kona and on Oʻahu, Kauaʻi, Molokaʻi, Lānaʻi, and Maui; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawaiʻi Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawaiʻi Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Maui News* on September 10, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETINGS

Monday, September 17, 2012
Pomaika‘i Elementary School • 4650 South Kamehameha Ave, Kahului
5:30 pm – 9:00 pm

Tuesday, September 18, 2012
Lāna‘i High & Elementary School • 555 Fraser Ave, Lāna‘i City
5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on O‘ahu, Kaua‘i, Moloka‘i, and Hawai‘i Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered
Hawai‘i clean energy initiative

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Maui News* on September 14, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETINGS

Monday, September 17, 2012
Pomaika‘i Elementary School • 4650 South Kamehameha Ave, Kahului
5:30 pm – 9:00 pm

Tuesday, September 18, 2012
Lāna‘i High & Elementary School • 555 Fraser Ave, Lāna‘i City
5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on Molokai and in Kaneohe; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Moloka‘i Dispatch* on September 12, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Wednesday, September 19, 2012

Mitchell Pau‘ole Community Center • 90 Ainoa Street, Kaunakakai

5:30 pm – 9:00 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on O‘ahu, Lāna‘i, Maui, and Hawaii Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in *The Moloka‘i Dispatch* on September 19, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Wednesday, September 19, 2012

Mitchell Pau‘ole Community Center • 90 Ainoa Street, Kaunakakai

5:30 pm – 9:00 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on O‘ahu and Lāna‘i ; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in the *Star Advertiser* on September 13, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Thursday, September 20, 2012

James B. Castle High School • 45-386 Kaneohe Bay Drive, Kaneohe

5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Meetings will be held on Maui, Lāna‘i , Moloka‘i, and Hawai‘i Island; please check the website for the specific schedule.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i placed the following advertisement in the *Star Advertiser* on September 18, 2012.

U.S. Department of Energy

HAWAI‘I CLEAN ENERGY

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS)

PUBLIC SCOPING MEETING

Thursday, September 20, 2012

James B. Castle High School • 45-386 Kaneohe Bay Drive, Kaneohe

5:00 pm – 8:30 pm

The U.S. Department of Energy (DOE) invites public comment on the scope of the Hawai‘i Clean Energy PEIS, in which DOE proposes to develop guidance to use in future funding decisions and other actions to support Hawai‘i in achieving its goal of 70% clean energy by 2030. The PEIS will analyze, at a programmatic level, the potential environmental impacts of activities in the categories of energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

Comments can be submitted through October 9, 2012 via:

- Internet - http://www.hawaiicleanenergypeis.com
- Email - hawaiicleanenergypeis@ee.doe.gov
- Fax - (808) 541-2253, Attention: Hawai‘i Clean Energy PEIS
- U.S. mail addressed to: Jim Spaeth, U.S. Department of Energy, 300 Ala Moana Blvd., P.O. Box 50247, Honolulu, HI 96850-0247

Hawai‘i Powered

The Amended Notice of Intent and information about the 60-day public scoping period can be found at http://www.hawaiicleanenergypeis.com

DOE-Hawai‘i mailed the following postcard to the Hawai‘i mailing list on August 10, 2012.

NOTICE OF PUBLIC SCOPING

The U.S. Department of Energy (DOE) and the State of Hawai‘i have established a long-term partnership to transform the way in which renewable energy and energy efficiency resources are planned and used in the state. In 2010, DOE announced its intent to prepare a programmatic environmental impact statement (PEIS) with the State as a joint lead for wind energy development under the Hawai‘i Interisland Renewable Energy Program (HIREP). In response to public comments, as well as regulatory and policy developments, DOE has broadened the scope of the PEIS to now include energy efficiency, distributed renewables, utility-scale renewables, alternative transportation fuels and modes, and electrical transmission and distribution.

DOE invites public comments on the revised scope of the PEIS, now called the Hawai‘i Clean Energy PEIS. The State of Hawai‘i and the U.S. Department of the Interior’s Bureau of Ocean Energy Management (BOEM) are cooperating agencies in preparing this PEIS. DOE will hold eight public scoping meetings on six islands from September 11–20, 2012. The public is invited to attend and participate in these meetings. Meeting details, information about the PEIS, the Amended Notice of Intent, and instructions for commenting on the PEIS can be found on the following website:

http://www.hawaiicleanenergypeis.com

APPENDIX B

Distribution List

DISTRIBUTION LIST

DOE provided electronic copy (CD-ROM) of this Hawai‘i Clean Energy PEIS to Federal, State, and county elected and appointed government officials and agencies as well as libraries throughout the State of Hawai‘i and the DOE Freedom of Information Act Reading Room. To defer costs and expedite release of the Draft PEIS, DOE sent an email notice of availability with the Internet address of the Draft PEIS and information about the public comment process to individuals who had previously signed up to receive a copy of the Draft PEIS. This was preceded by a notice emailed to the individuals that copies would not be mailed (for the above reasons) unless specifically requested. About a dozen individuals requested a CD of the Draft PEIS and two individuals requested printed copies of the document. DOE complied with these requests.

In addition, DOE sent the same email notice of availability to all individuals who had provided an email address at a public scoping meeting, through the Hawai‘i Clean Energy PEIS mailing list application, via direct email to the PEIS email address, or through personal communication with a project representative. For those individuals who requested notification of the Draft PEIS but who provided only a postal mailing address, DOE sent the same notice of available through the U.S. postal service.

DOE will provide copies of the Draft PEIS upon request and has made it available online at the Hawai‘i Clean Energy PEIS Website (www.hawaiicleanenergyPEIS.com) and on the DOE NEPA Website (http://energy.gov/nepa/eis-0459-hawaii-clean-energy-programmatic-environmental-impact-statement).

U.S. Senate for the State of Hawai‘i

Mazie Hirono
Brian Schatz

U.S. Senate Committees

Barbara Mikulski, Chairman, Committee on Appropriations
Richard Shelby, Ranking Member, Committee on Appropriations
Mary Landrieu, Chairman, Committee on Energy and Natural Resources
Lisa Murkowski, Ranking Member, Committee on Energy and Natural Resources
Barbara Boxer, Chairman, Committee on Environment and Public Works
David Vitter, Ranking Member, Committee on Environment and Public Works
Jeff Merkley, Chairman, Subcommittee on Green Jobs and the New Economy, Committee on Environment and Public Works
Roger F. Wicker, Ranking Member, Subcommittee on Green Jobs and the New Economy, Committee on Environment and Public Works
Thomas R. Carper, Chairman, Subcommittee on Transportation and Infrastructure, Committee on Environment and Public Works
John Barrasso, Ranking Member, Subcommittee on Subcommittee on Transportation and Infrastructure, Committee on Environment and Public Works
Benjamin L. Cardin, Chairman, Subcommittee on Water and Wildlife, Committee on Environment and Public Works
John Boozman, Ranking Member, Subcommittee on Water and Wildlife, Committee on Environment and Public Works

U.S. House of Representatives for the State of Hawai‘i

Colleen Hanabusa
Tulsi Gabbard

U.S. House of Representatives Committees

Frank D. Lucas, Chairman, Committee on Agriculture
Collin C. Peterson, Ranking Member, Committee on Agriculture
Glenn Thompson, Chairman, Subcommittee on Conservation, Energy, and Forestry, Committee on Agriculture
Timothy J. Walz, Ranking Member, Subcommittee on Conservation, Energy, and Forestry, Committee on Agriculture
Hal Rogers, Chairman, Committee on Appropriations
Nita Lowey, Ranking Member, Committee on Appropriations
Fred Upton, Chairman, Energy and Commerce Committee
Henry Waxman, Ranking Member, Energy and Commerce Committee
John Shimkus, Chairman, Subcommittee on Environment and the Economy, Energy and Commerce Committee
Paul Tonko, Ranking Member, Subcommittee on Environment and the Economy, Energy and Commerce Committee
Doc Hastings, Chairman, Committee on Natural Resources
Peter DeFazio, Ranking Member, Committee on Natural Resources
Doug Lamborn, Chairman, Subcommittee on Energy and Mineral Resources, Committee on Natural Resources
Rush Holt, Ranking Member, Subcommittee on Energy and Mineral Resources, Committee on Natural Resources
Josh Fleming, Chairman, Subcommittee on Fisheries, Wildlife, Oceans and Insular Affairs, Committee on Natural Resources
Gregorio Kilili Camacho Sablan, Ranking Member, Subcommittee on Fisheries, Wildlife, Oceans and Insular Affairs, Committee on Natural Resources
Rob Bishop, Chairman, Subcommittee on Public Lands and Environmental Regulation, Committee on Natural Resources
Raúl M. Grijalva, Ranking Member, Subcommittee on Public Lands and Environmental Regulation, Committee on Natural Resources
Tom McClintock, Chairman, Subcommittee on Water and Power, Committee on Natural Resources
Grace Napolitano, Ranking Member, Subcommittee on Water and Power, Committee on Natural Resources
Bill Shuster, Chairman, Committee on Transportation and Infrastructure
Nick J. Rahall, Ranking Member, Committee on Transportation and Infrastructure
Bob Gibbs, Chairman, Subcommittee on Water Resources and Environment, Committee on Transportation and Infrastructure
Timothy H. Bishop, Ranking Member, Subcommittee on Water Resources and Environment, Committee on Transportation and Infrastructure

Federal Agencies

Zach Church, National Park Service, Department of the Interior

M. Melia Lane-Kamahele, National Park Service, Department of the Interior

Dr. Cynthia Stiles, Natural Resources Conservation Service, U.S. Department of Agriculture

Dr. Gregory Koob, Natural Resources Conservation Service, U.S. Department of Agriculture

Ann McPherson, U.S. Environmental Protection Agency Region 9

Scott Sysum, U.S. Environmental Protection Agency Region 9

Colin F. Williams, Ph.D., U.S. Geological Survey, Department of the Interior

Dr. Richard Ferrera, U.S. Geological Survey, Department of the Interior

Mark Eckenrode, Bureau of Ocean Energy Management, Department of the Interior

Dr. Sue Goodfellow, U.S. Marine Corps, Department of Defense

Nicole Griffin, U.S. Marine Corps, Department of Defense

Mr. John Muraoka, Department of the Navy, Department of Defense

Ms. Karen Foskey, Department of the Navy, Department of Defense

David Suomi, Federal Aviation Administration

Dan Clark, U.S. Fish and Wildlife Service, Department of the Interior

Domingo Cravalho, U.S. Fish and Wildlife Service, Department of the Interior

Patrice Ashfield, U.S. Fish and Wildlife Service, Department of the Interior

Dawn Greenlee, U.S. Fish and Wildlife Service, Department of the Interior

Dan Polhemus, U.S. Fish and Wildlife Service, Department of the Interior

Kevin Foster, U.S. Fish and Wildlife Service, Department of the Interior

Lee Webb, Advisory Council on Historic Preservation

Charlene Vaughn, Advisory Council on Historic Preservation

Mr. Mark Plank, Rural Utilities Service, U.S. Department of Agriculture

Mr. Steve Kokkinakis, National Oceanic and Atmospheric Administration, Department of Commerce

Hawai‘i Governor
Neil Abercrombie

Hawai‘i State Senators
Gilbert Kahele, District 1
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Josh Green, District 3
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Other Organizations

Western Interstate Energy Board
American Bird Conservancy
Gas Technology Institute
Institute for Energy and Environmental Research
The Minnesota Project
Renewable Fuels Association
Union of Concerned Scientists
Western Resource Advocates
I Aloha Molokai (IAM)
Hawaiʻi Natural Energy Institute
Aha Kiole
American Academy of Environmental Medicine
American Bird Conservancy
Apex Wind Energy
Babes Against Biotech
Castle & Cooke Hawaiʻi
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Island Naturals Markets
IslandBreath.org
Ke Nani Kai Home Owners Assoc.
Kūpaʻa no Lānaʻi
Lānaʻi Aina
Life of the Land
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Maui Electric
Maui Nui Seabird Recovery Program
Maui Tomorrow Foundation, Inc.
Molokaʻi Sustainable Farm Project
Native Hawaiian Legal Corp
NextEra Energy Resources, LLC
Pacific Light & Power, Inc.
Pele Defense Fund
Polestar Gardens
Puna Pono Alliance
Sierra Club Hawaiʻi chapter
The Environmental Caucus of the Democratic Party of Hawaiʻi
The Permaculture Foundation of Hawaiʻi
The WisdomWay Center
ThinkTech Hawaiʻi
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APPENDIX C

List of Preparers

LIST OF PREPARERS

This appendix lists the individuals and organizations that filled primary roles in the preparation of this *Hawai‘i Clean Energy Programmatic Environmental Impact Statement* (DOE/EIS-0459; Hawai‘i Clean Energy PEIS). Dr. Jane Summerson of the U.S. Department of Energy (DOE) was the federal National Environmental Policy Act (NEPA) Document Manager and directed the preparation of this document. The Hawai‘i Clean Energy PEIS contractor team was led by New West Technologies LLC through contracts with DOE and the State of Hawai‘i. New West was assisted by JAD Environmental LLC, which provided project management, public participation, and technical assistance support. The PEIS contractor team was led by Joe Rivers of JAD Environmental.

DOE provided direction to the PEIS contractor team, which was responsible for developing the analytical methodology and alternatives, coordinating the work tasks, collecting the required data, performing the impact analyses, and producing the document. DOE was responsible for data quality, the scope and content of the PEIS, and issue resolution.

Pursuant to the Council on Environmental Quality (CEQ) regulations that implement NEPA, DOE invited agencies that could have jurisdiction by law or special expertise with respect to any environmental issue to be addressed in the PEIS (40 CFR 1501.6) to be involved with its preparation as cooperating agencies. Eight of those agencies agreed to participate as cooperating agencies: State of Hawai‘i, Department of Business, Economic Development, and Tourism; two bureaus within the Department of the Interior (Bureau of Ocean Energy Management and National Park Service); U.S. Department of Agriculture, Natural Resources Conservation Service; U.S. Department of Transportation, Federal Aviation Administration, Western-Pacific Region; two bureaus within the Department of Defense (U.S. Marine Corps and Navy); and U.S. Environment Protection Agency, Region 9.

As the lead agency, DOE used the analyses and proposals of the cooperating agencies to the maximum extent possible consistent with its responsibility. Accordingly, cooperating agencies accepted obligations to contribute staff to the PEIS team, developed and reviewed analyses for which they have particular expertise, and funded their own participation. Ultimately, DOE retained the responsibility for determining the appropriateness and adequacy of incorporating any data, analyses, and results of other work by these organizations for this PEIS. The PEIS contractor team was responsible for integrating such work in the document.

As required by Federal regulations [40 CFR 1506.5(c)], New West and JAD Environmental have signed NEPA Disclosure Statements in relation to the work they performed on this PEIS. These statements are included at the end of the table.

Name	Education	Experience	Project Responsibilities
Jane Summerson DOE	• PhD., Geology • M.S., Geobiology • M.A., Anthropology • B.A, Anthropology	• 14 years of experience as a DOE NEPA Compliance Office and NEPA Document Manager • 20 years of DOE project management experience	NEPA Document Manager
Faith Klareich New West	• Graduate Studies, Energy and Technology Management • B.A., International Affairs	• Over 25 years of experience in the management of environmental and clean energy programs.	New West Contract Executive

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Laura Fabeny New West	• PMP Certification, 2010 • M.B.A., Business Administration, 2007 • B.B.A., Marketing, 1998	• 14 years of project management experience including NEPA environmental assessments and impact statements	New West Project Manager
Joe Rivers JAD Environmental	• B.S., Mechanical Engineering, 1982 • Engineering Science and Mechanics post-graduate work	• 30 years of experience in commercial and DOE nuclear projects, NEPA and regulatory compliance, systems engineering, and safety analysis	JAD Project Manager
Ernie Harr JAD Environmental	• B.S., Zoology, 1977	• 30 years of experience successfully managing DOE NEPA evaluations • Successfully managed numerous large multi-corporate teams using the virtual office concept	JAD Deputy Project Manager Energy Conservation Photovoltaic Health and Safety
Joanne Stover JAD Environmental	• B.S., Business Administration, 1997	• 23 years of experience in the cradle-to-grave production of technical reports • 8 years of experience editing and producing NEPA documents, including preparing administrative records	Technical Editor Document Production/ Records Management
Amanda Tyrrell New West	• M.S. Environmental Sciences and Policy, 2008 • B.S. Integrated Science and Technology, Environment Concentration, 2000	• 14 years of NEPA experience • Supported environmental planning decisions on behalf of DOE, NOAA, FAA, NSF, and DoD	Technical Coordinator Ground Source Heat Pumps Ocean Thermal Energy Conversion Undersea Cables Noise and Vibration
Tonya Bartels JAD Environmental	• M.S., Analytical Chemistry, 1994 • B.S., Chemistry, 1991	• More than 15 years of NEPA experience for DOE, U.S. Department of Defense, and U.S. Army Corps of Engineers projects	Recreational Resources Scenic and Visual

Name	Education	Experience	Project Responsibilities
Ailene Batoon New West	• M.S., Environmental Sciences and Policy, 2013 • B.A., Geography, Specialization in Environmental Studies, 2005	• More than 9 years of experience of Federal (NEPA), State (CEQA, etc.), and local environmental planning and impact assessment • More than 4 years of combined experience supporting the DOE Federal Energy Management Program, the DOE State and Alternative Fuel Provider Transportation Program, and the DOE Vehicle Technologies Office	Energy Efficient Buildings Biofuels Hydrogen CNG, LNG, and LPG Hazardous Materials and Waste Management
Pixie Baxter JAD Environmental	• M.B.A., Management and Economics • B.A., Art History	• More than 25 years of professional experience in multidisciplinary economic and business area applications in planning and research capacities and regulatory analysis	Socioeconomics Environmental Justice
Dawn Chang Ku‘iwalu	• J.D., Richardson School of Law • Masters, Social Work • B.A. Sociology	• Expert on land issues and regulatory requirements. • 14 years as the Deputy Attorney General in Hawaii and counsel to various state boards and Commissions.	Facilitator at Public Scoping Meetings
Bill Craig JAD Environmental	• BS in Forestry and Natural Resource Management, University of Tennessee • MS in Planning, University of Tennessee	• More than 30 years' experience with utility management and NEPA compliance • Experience in federal TVA utility management in power plant siting ,NEPA compliance, and nuclear fuel planning and analysis • Project manager for 5 DOE EISs and 25 EAs • Senior consultant to DOE's Office of NEPA Compliance	Municipal Solid Waste Solar Thermal Land and Submerged Land Use
Keith Davis JAD Environmental	• M.S., Civil and Environmental Engineering, 1976 • B.S., Civil Engineering, 1973	• More than 30 years of diverse environmental experience • Extensive experience with Federal and numerous state environmental regulations • Registered Professional Engineer (Civil) in Idaho, Arizona, and Utah	Wind Geothermal Water Resources Geology and Soils

Name	Education	Experience	Project Responsibilities
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Ron Green JAD Environmental	• Ph.D., Zoology, Colorado State University • M.S., Wildlife Biology, Colorado State University • B.S., Wildlife Biology, Colorado State University	• Experienced wildlife biologist with over 20 years of DOE experience • NEPA consultation experience for Endangered Species Act	Biomass Coastal Zone Management Biological Resources Land and Marine Transportation Airspace Management
Michelle Hank New West	• Ph.D., Business Administration • M.S., General Administration • B.S., Legal Studies	• over 20 years of experience organizational administration including a comprehensive background in social, legal, and business environments	Document Production
Steve Hauser New West	• M.S., Chemical Engineering • B.S., Engineering Physics	• A leader in clean energy and smart grid technology development for more than 30 years. • Recognized expert on transforming the power sector to meet future needs.	Smart Grid
Ben Henderson New West	• Post-graduate Research in Geography, 2010 • Master of Urban and Regional Planning, 2005 • B.S., Biology, 2001	• 10 years of environmental planning experience, including NEPA	Research Analyst
Richard Holder JAD Environmental	• M.B.A., Business Administration, 1986 • M.S., Electrical Engineering, 1970 • B.S., Electrical Engineering, 1966	• 40 years of experience in team and line management for nuclear, utility, industrial, and overseas projects	On Island Electrical Transmission Utilities and Infrastructure
Annmarie Mulholland New West	• M.Ed., Curriculum and Instruction • B.A., English	• Experienced technical writer who has contributed to multiple DOE, and other federal agency reports.	Technical Editing Support

Name	Education	Experience	Project Responsibilities
Russ Owens, P.E. New West	• M.S., Mechanical Engineering, 2002 • B.S., Mechanical Engineering, 1996	• 6 years of research and development experience with electric- and hybrid-electric vehicle testing and development • Over 10 years of experience of technical and field evaluations for transportation propulsion system, fuels, vehicle emissions, cost/performance evaluations, and fleet transition analysis	Electric Vehicles Hybrid-Electric Vehicles Multi-modal Transportation
Julie Perez New West	• M.B.A., Business Administration, 2010 • M.S., Mechanical Engineering, 1999 • B.S., Aerospace Engineering, 1996	• More than 18 years of diverse engineering experience • Extensive experience with power plant development, R&D energy and materials programs • Project Management Professional	Energy Storage
Kristina Rivenbark JAD Environmental	• BA in Anthropology (Candidate), University of North Carolina at Wilmington • Print and Broadcast Journalism graduate, Defense Information School, 1992	• 17 years of experience in creating print and web projects from conceptual development to finished product. • Proficient with Adobe Photoshop, Adobe Illustrator, Adobe InDesign, Adobe Dreamweaver, Microsoft Office, Adobe Acrobat, Mac OS	Document Production/Graphics
Robert Schaller New West	• B.A., Sociology	• Technical Writer and Opposition Researcher	Research Analyst
Leroy Shaser JAD Environmental	• M.S., Geology, 1978 • B.S., Geology, 1976	• 16 years of experience in NEPA analysis, including air quality, health and safety, and utilities and infrastructure • GIS and computer mapping proficiency	Hydrogen Fuel Cells Climate and Air Quality
Natan Simhai New West	• B.S., Bioengineering, 2011	• 2 years of experience as DOE contractor, including NEPA writing and environmental review	Research Analyst

Name	Education	Experience	Project Responsibilities
Raphael Tisch New West	• M.P.A. Environmental Science and Policy, 2008 • B.A. Environmental Studies (Earth Systems Dynamics), 2005	• 5 years supporting environmental impact and technical project management for the DOE's Wind and Water Power Technologies Office • 3+ years renewable energy consulting	Solar Water Heating Sea Water Air Conditioning Hydroelectric Marine Hydrokinetic Energy
Richard M. Todaro New West	• M.P.P., Public Policy 2009 • M.A. Journalism, 2001 • M.S. Meteorology, 1997 • B.S. Physical Science (mathematics and physics), 1994	• 10 years of experience as technical writer and editor in earth, atmospheric, and space sciences • Over 4 years of experience providing cross-programmatic technical and analytical support to DOE EERE	Document Production References Glossary Introduction

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE HAWAII CLEAN ENERGY PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMEMT

The Council on Environmental Quality regulations (CEQ) at Title 40 of the *Code of Federal Regulations* (CFR) Section 1506.5(c), which have been adopted by the U.S. Department of Energy (10 CFR Part 1021), require contractors and subcontractors who will prepare an environmental impact statement to execute a disclosure statement specifying that they have no financial or other interest in the outcome of the project.

"Financial or other interest in the outcome of the project" is defined as any direct financial benefit such as a promise of future construction or design work in the project, as well as indirect financial benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients).

In accordance with these requirements, Spike Bighorn, on behalf of the company and its employees, hereby certifies as follows, to the best of its knowledge as of the date set forth below:

(a) New West Technologies has no financial or other interest in the outcome of the project.

(b) ______________________ has the following financial or other interest in the outcome of the project and hereby agrees to divest itself of such interest prior to aware of this contract, or agrees to the attached plan to mitigate, neutralize or avoid any such conflict of interest.

Financial or Other Interests

1.
2.
3.

Certified by:

[signature], COO (Spike Bighorn)

Name, Title

New West Technologies LLC

Company

March 15, 2012

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE HAWAII CLEAN ENERGY PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMEMT

The Council on Environmental Quality regulations (CEQ) at Title 40 of the *Code of Federal Regulations* (CFR) Section 1506.5(c), which have been adopted by the U.S. Department of Energy (10 CFR Part 1021), require contractors and subcontractors who will prepare an environmental impact statement to execute a disclosure statement specifying that they have no financial or other interest in the outcome of the project.

"Financial or other interest in the outcome of the project" is defined as any direct financial benefit such as a promise of future construction or design work in the project, as well as indirect financial benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients).

In accordance with these requirements, **David Hoberg**, on behalf of the company and its employees, hereby certifies as follows, to the best of its knowledge as of the date set forth below:

(a) **JAD Environmental, LLC** has no financial or other interest in the outcome of the project.

(b) ______________________ has the following financial or other interest in the outcome of the project and hereby agrees to divest itself of such interest prior to aware of this contract, or agrees to the attached plan to mitigate, neutralize or avoid any such conflict of interest.

Financial or Other Interests
1.
2.
3.

Certified by:

David Hoberg
____
David Hoberg, Contracts Lead

JAD Environmental, LLC
Company

March 21, 2012
Date