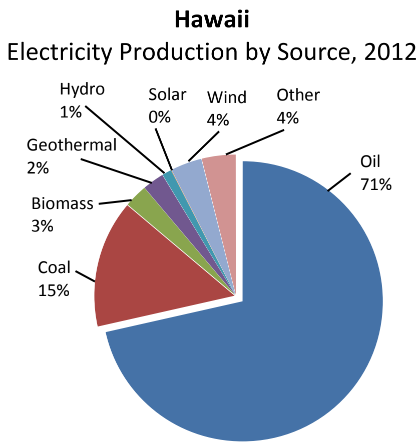
Hawaii Energy Facts & Figures
May 2014

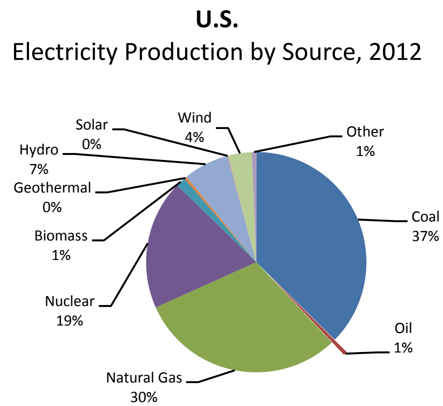
DBEDT
STATE OF HAWAII

State of Hawaii Department of Business, Economic Development and Tourism
Hawaii State Energy Office · energy.hawaii.gov
Follow us : @EnergyHawaiiGov on Twitter and www.facebook.com/HawaiiStateEnergyOffice on Facebook

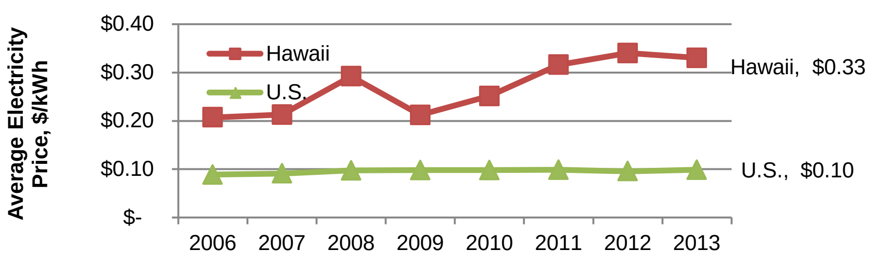
Hawaii Energy Overview

Hawaii is the only state that depends so heavily on petroleum for its energy needs. Whereas less than 1% of electricity in the nation is generated using oil, in 2012 Hawaii relied on oil for 71% and on coal for 15% of its electricity generation.[1]

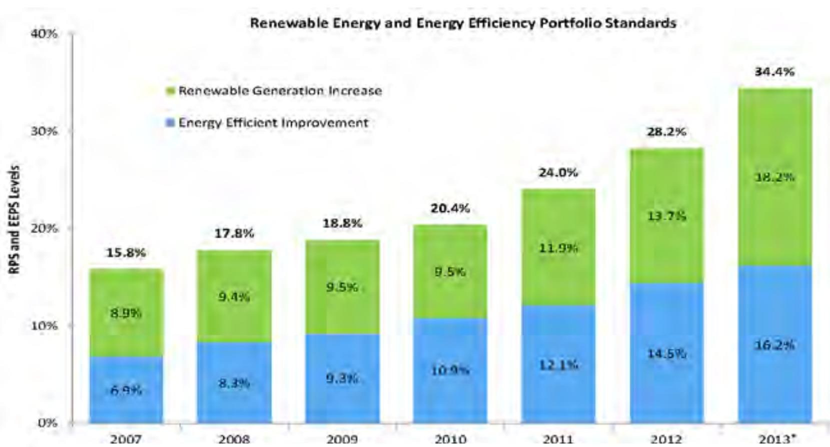




Hawaii's **electricity prices are three times higher** than the U.S. average.[2 3]

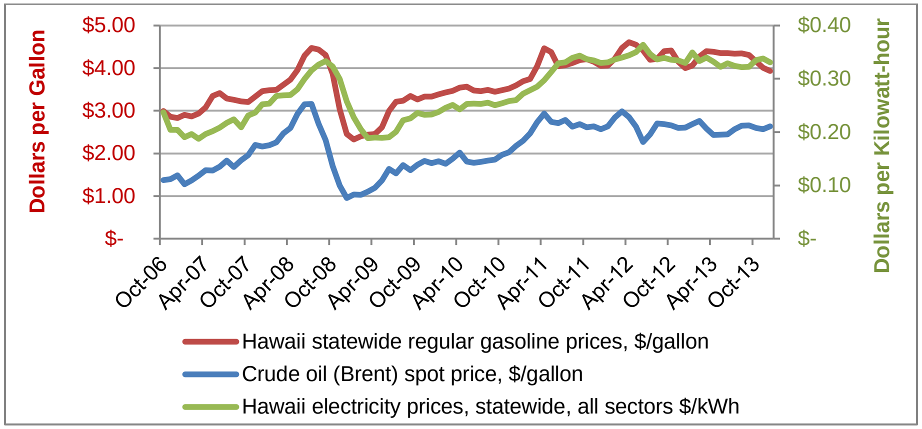


Although Hawaii's electricity production and costs are still heavily reliant on oil, **energy efficiency and renewable energy have been increasing**[4] in all counties.

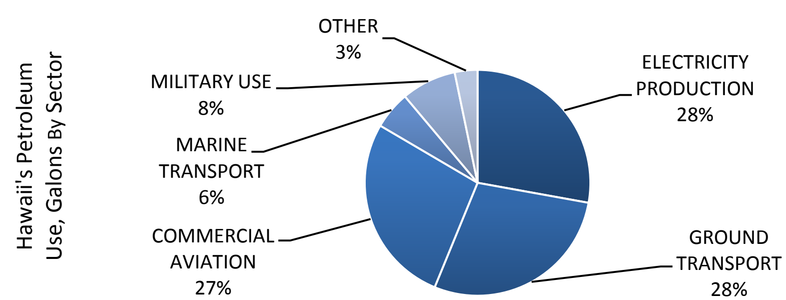


Source: *Renewable Portfolio Standards Status Reports*, 2007-2013 (Hawaii Public Utilities Commission)
* KIUC RPS and EEPS not included for 2013. These figures to be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

In Hawaii, both electricity and gasoline prices **follow the price of petroleum**. The graph below shows the prices of Brent crude oil, gasoline, and electricity.[5]



Electricity and gasoline are just part of Hawaii's energy picture. Large quantities of jet fuel are also used (this is different from the Mainland, where most petroleum is used for ground transportation). In Hawaii, roughly equal amounts of petroleum are used for electricity production, ground transportation, and commercial aviation, with the rest used for marine transport, military, and other uses.[6]

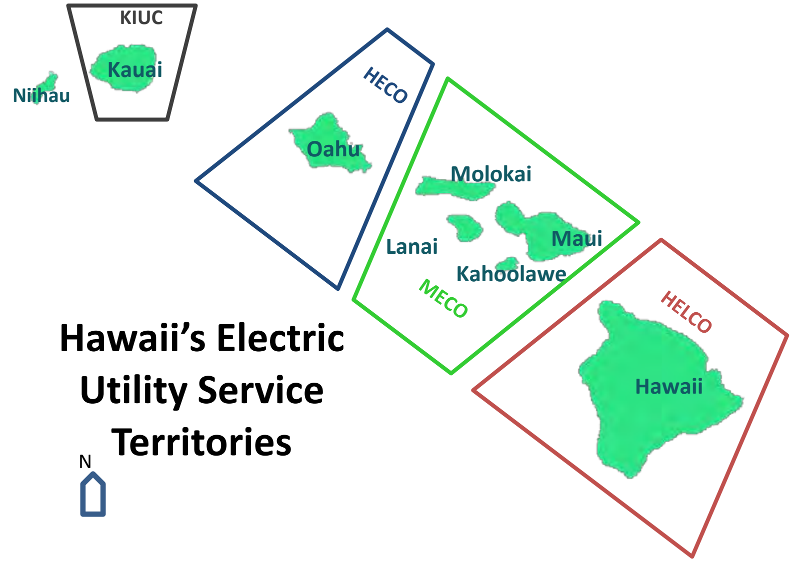


Total petroleum use 2013 (million barrels per year)[7]	**44.2**	Fuel for electricity production (million gallons per year)[8]	**409**
Total petroleum use 2013 (million gallons per year)[9]	**1856**	Fuel for air transportation (i.e. jet fuel) (million gallons per year)[10]	**476**
Hawaii's rank among 50 states for energy prices[11]	**1**	Fuel for ground transportation (million gallons per year)[12]	**446**

Electric Utilities

Each of Hawaii's six main islands has its own electrical grid, not connected to any other island. Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric (MECO) and Hawaii Electric Light Company (HELCO), serve about 95% of the State's population. The island of Kauai is served by Kauai Island Utility Cooperative (KIUC).

2013 except as noted	HECO	MECO			HELCO	HECO Companies Total	KIUC	STATE TOTAL
	Oahu	Maui	Lanai	Molokai	Hawaii		Kauai	
2011 Electricity Production (GWh)	7,797	1211	25	35	1,203	10,270	453	10,723
Firm capacity (MW)	1,783	262	10	12	292	2,359	125	2,484
Intermittent capacity (MW)	218	100	1	0	67	387	15	402
System Peak (MW)	1141	195	4.6	5.5	189	Not applicable	65	Not applicable[13]
Residential Customers	264,047	54,785	1,451	2,643	69,099	392025	28,215	420,240
Commercial Customers	33,482	9,262	226	555	12,693	56218	8,258	64,476
% of kWh used by Residential	25%	35%	29%	37%	38%	28%	36%	28%
% of kWh used by Commercial	75%	65%	71%	63%	62%	72%	64%	72%



COMPETITIVE BIDDING

Hawaii's electric utilities deliver electricity generated with their own units as well as power generated by Independent Power Producers (IPPs). If new or replacement generation is required, HECO, MECO, and HELCO are required to follow the "Competitive Bidding Framework" for new generation with capacities greater than 5 MW (Oahu) or 2.72 MW (MECO, HELCO), or receive a waiver of the competitive bidding requirements from the Hawaii Public Utilities Commission (PUC).[14] Current procurement activities include:[15]

HECO: A Request for Proposals (RFP) for 600-800 gigawatt-hours (or 200 MW) of as-available renewable electricity for use on Oahu is being redrafted per a July 2013 Order from the PUC. The redrafted RFP will remove references to the Lanai Wind Project and eliminate solicitations for an undersea transmission cable. Also in July 2013, the PUC opened a new docket to examine whether the cable may be in the public interest.

HECO: Hawaiian Electric is reviewing proposals received in March 2013, for renewable energy projects eligible for possible waivers from the PUC's Competitive Bidding Framework. Proposed projects were required to be larger than 5 MW, on Oahu, with levelized energy cost below 17 cents/kilowatt-hour without the use of Hawaii State tax incentives.[16]

HELCO: An RFP for up to 50 MW of geothermal capacity, for use on Hawaii Island, was released on 2-28-2013; 6 proposals were received and are under consideration. Generation is desired on-line 2018 to 2023, or earlier.

CONVERTING MW OF CAPACITY INTO MWh OF ELECTRICITY PRODUCTION

Generators do not always produce at full capacity, due to resource limits (sun not shining, wind not blowing), maintenance requirements, or power not needed.

The "capacity factor" is the percent of time a facility is expected to operate at full capacity (or its equivalent, in terms of energy production) over a one year period. For example, if a facility has a capacity of 1 MW and a capacity factor of 100%, it will generate 1MW x 24hours/day x 365 days/year = 8760 MWh per year.

CAPACITY FACTOR ASSUMPTIONS FOR RENEWABLE RESOURCES	Capacity Factors (assumed)*	MWh produced per MW capacity[17]
Biomass-Direct Firing	80%	7,000
Wind (Oahu, Hawaii, Kauai)**	35%	3,100
Wind (Lanai, Molokai)	40%	3,500
Wind (Maui)	45%	3,900
Geothermal	96%	8,400
Hydro	44%	3,900
Solar (rooftop)	19%	1,700
Solar (utility)	24%	2,100
Ocean	35%	3,100

Capacity factors presented in this table are assumptions used by Booz Allen, under contract to the National Renewable Energy Laboratory, in the *Hawaii Clean Energy Initiative Scenario Analysis*, Appendix C, Slide 26. March 2012.

*Actual capacity factors may vary from the assumptions presented here. **The Pakini Nui wind farm (on Hawaii island) generally has an annual capacity factor of over 60%.

Electric Utilities: Customers & Rates

Residential electricity use, rates, and average bills are shown below for 2013 and 2012. In general, rates were fairly stable and electricity use declined, so bills also declined.[18]

Residential Electricity Use, Rates, and Average Bill, 2013	Oahu	Hawaii	Kauai	Maui	Molokai	Lanai	State
Average use (kWh/month)	524	475	464	556	330	431	514
Average cost per kWh	$ 0.35	$ 0.42	$ 0.44	$ 0.37	$ 0.46	$ 0.46	$ 0.37
Average monthly bill	$ 181	$ 200	$ 205	$ 208	$ 151	$ 197	$ 189

Residential Electricity Use, Rates, and Average Bill, 2012	Oahu	Hawaii	Kauai	Maui	Molokai	Lanai	State
Average use (kWh/month)	561	498	465	578	348	425	545
Average cost per kWh	$ 0.35	$ 0.42	$ 0.45	$ 0.39	$ 0.46	$ 0.47	$ 0.37
Average monthly bill	$ 197	$ 211	$ 210	$ 224	$ 161	$ 198	$ 204

FEED - IN TARIFF (FIT)

Renewable electricity suppliers with generators smaller than 5 MW may be eligible to participate in the HECO Companies' Feed in Tariff,[19] supplying as-available power to the utility at constant, contracted rates over 20 years. The FIT queue, managed by the Accion Group, lists 124 active (60 MW) and 64 reserve (42 MW) projects as of May 2014.[20]

Feed-in Tariff (FIT) Rates, Hawaiian Electric Companies' Service Areas

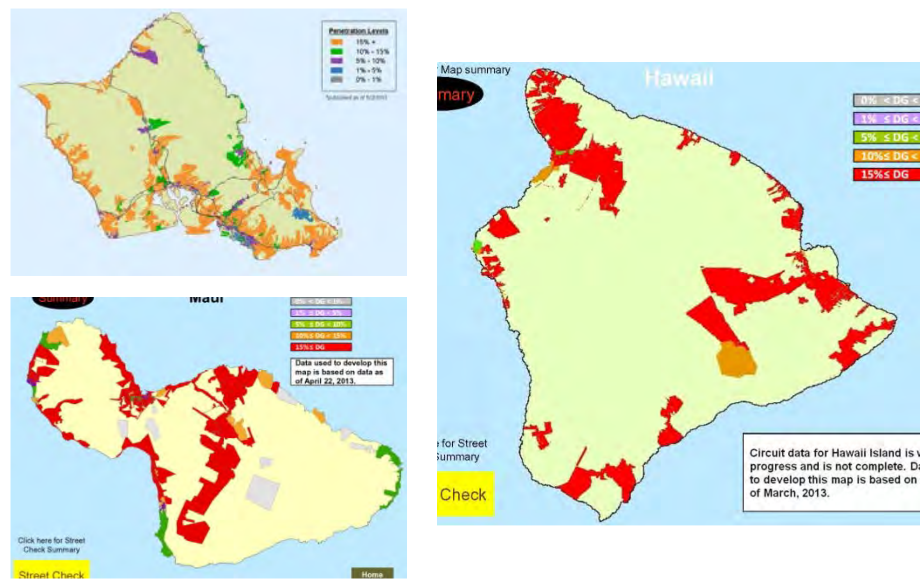
Tier	Island	Photovoltaics (PV)		Concentrating Solar Power (CSP)		On-Shore Wind		In-line Hydro	
		rate (¢/kWh)	size limit	rate (¢/kWh)	size limit	rate (¢/kWh)	size limit	rate (¢/kWh)	size limit
1	All Islands	21.8* 27.4**	20 kW	26.9* 33.1**	20 kW	16.1	20 kW	21.3	20 kW
2	Oahu	18.9* 23.8**	500 kW	25.4* 27.5**	500 kW	13.8	100 kW	18.9	100 kW
2	Maui & Hawaii	18.9* 23.8**	250 kW	25.4* 27.5**	500 kW	13.8	100 kW	18.9	100 kW
2	Lanai & Molokai	18.9* 23.8**	100 kW	25.4* 27.5**	100 kW	13.8	100 kW	18.9	100 kW
3	Oahu	19.7* 23.6**	5 MW	31.5* 33.5**	5 MW	12.0	5 MW	--	--
3	Maui & Hawaii	19.7* 23.6**	2.72 MW	31.5* 33.5**	2.72 MW	--	--	--	--

* With tax credit of 35%. ** With tax rebate of 24.5%.
HECO and the Independent Observer submitted a joint plan to the PUC for administering the FIT queues in September 2013.
Rates may be modified by the PUC if Federal or State tax laws change.
FIT aggregate limits: Oahu: 60 MW; Big Island: 10 MW; Maui, Lanai, Molokai (combined): 10 MW

NET ENERGY METERING[21]

Customers who generate renewable solar, wind, hydro, or biomass energy on their own property may be eligible for "net energy metering" (NEM) to offset their own use.

- If the customer uses more electricity than is produced, the customer pays for that net amount.
- If the customer produces more electricity than used, the customer pays a minimum bill (e.g. $17 for Oahu residential customers) or customer charge, and excess credits are carried forward to the next month, for up to 12 months.
- About 10% of Hawaii's residential electric utility customers had NEM agreements as of December 2013.[22]
- As of December 2013, there were more than 40,700 NEM systems, with a total capacity exceeding 312 MW, installed statewide.[23]
- In Order# 32052 on 4/28/14, PUC Docket 2012-0036, the PUC ordered the HECO companies to create a distributed generation interconnection plan (DGIP). The plan will be included in Docket #2011-0206 (Reliability Standards Working Group). The DGIP "will include actionable strategies and implementation plans for distribution system upgrades and utilization of advanced inverter technical functionality to enable distribution circuit solar PV penetrations to be increased over time in a safe and reliable manner."
- KIUC: New interconnections use Schedule Q[24] (100 kW or less) and "NEM Pilot"[25] (200 kW or less; 20¢/kWh for excess).



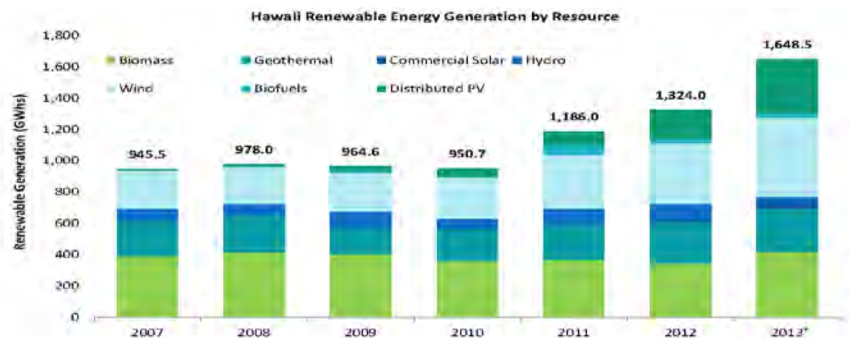
Sample Locational Value Maps for HECO, HELCO, and MECO Service Territories

Renewable Energy

"Renewable Energy"[26] is energy from:

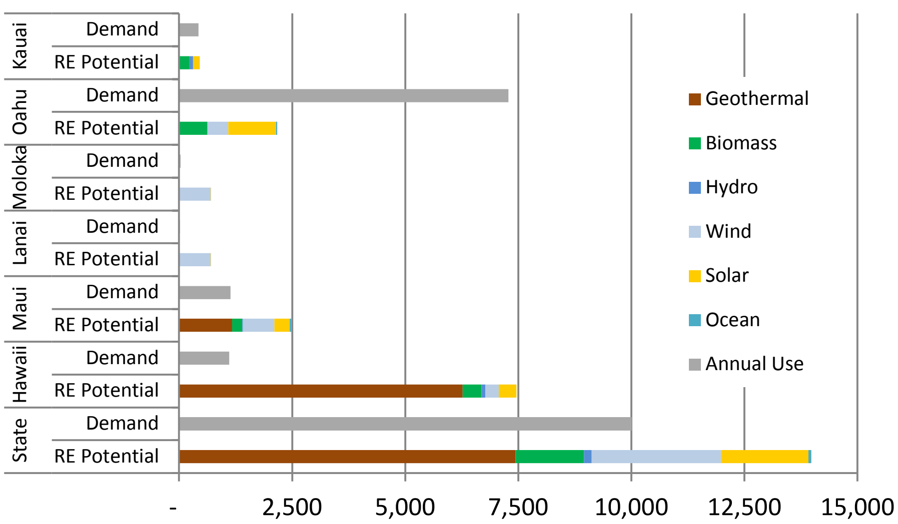
- Sun (i.e. solar)
- Wind
- Falling water (i.e. hydropower)
- Bioenergy, including biomass (e.g. crops, agricultural and animal residues, municipal and other solid waste); biofuels, and biogas
- Geothermal
- Ocean water, including ocean thermal energy conversion (OTEC) and wave energy
- Hydrogen produced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

In 2013, approximately 18% of Hawaii's electricity was generated from renewable sources. Renewable electricity production is primarily from bioenergy, wind, and geothermal, with solar increasing rapidly.[27]



Source: *Renewable Portfolio Standards Status Reports*, 2007-2013 (Hawaii Public Utilities Commission)
* KIUC RPS and EEPS not included for 2013. These figures to be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

Renewable resource potential, statewide, is greater than current electricity demand.[28]



Renewable Electricity Potential and Demand by Island, Gigawatt-hours

Electricity must be used, transmitted, or stored at the instant it is produced. If renewable energy is not used when it's produced, it is usually curtailed (i.e. not used).

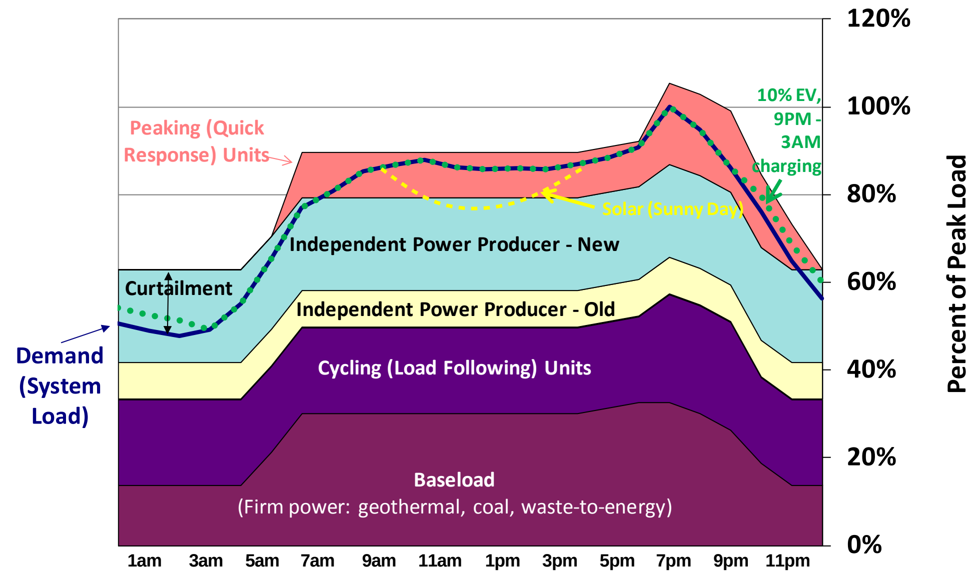
Baseload generation facilities produce energy at a constant rate. They generally do not react (ramp up or ramp down) quickly.

Dispatchable (cycling and peaking) units produce power when called upon by the utility, to fill gaps between production and load; they can ramp up and down quickly.

Independent power producer contracts may govern which units are brought on-line (dispatched) first when load is increasing, and which are taken off-line first, when load is decreasing. A new facility generally will not displace an older facility's place in the dispatch order, unless there is a technical reason for the utility to do so.

Intermittent (as-available) energy, such as from photovoltaic and wind independent power producers, may be curtailed at times of low load. The yellow line in the graph shows solar systems, on a sunny day, reducing mid-day demand for electricity from other sources.

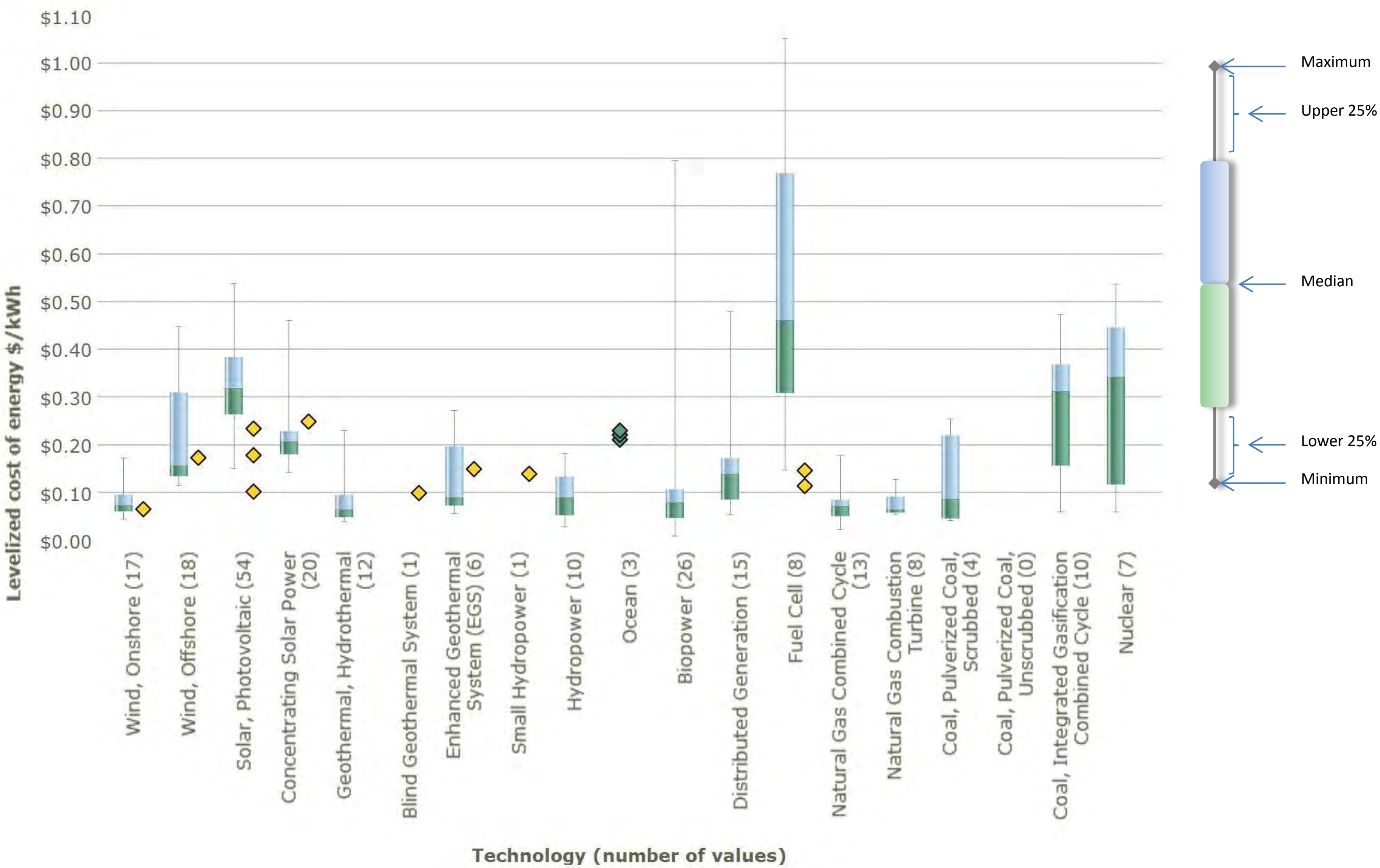
Electric vehicle charging, if managed so that it occurs at times of low load, can use energy that otherwise may have been curtailed.



Percent of Hawaii's electricity from renewable sources (2013)	~18%	Renewable generation required (i.e. Renewable Portfolio Standard, "RPS") by 12/31/2015[29]	15%
Renewable generation required (RPS) by 12/31/2020	25%	Renewable generation required (RPS) by 12/31/2030	40%

"Levelized Cost of Energy" is the price per kilowatt-hour in order for an energy project to break even; it does not include risk or return on investment. Costs (land, construction, labor) are different for every project.

The Transparent Cost Database[30] compiles cost information from studies and projects across the United States. The box & whisker chart below shows the data distribution using five numbers: The minimum (bottom of the whisker), lowest 25% (below green box), median, highest 25% (above blue box), and maximum point (top of the whisker). Where fewer than three data points are available, the individual data points (green diamonds) are shown. Yellow diamonds are US Department of Energy estimates.



Bioenergy

"Bioenergy" includes both electricity generation and fuel production from biomass.

Biomass is plant and animal matter, including energy crops, wood, grasses, algae, vegetable oils, and agricultural and municipal wastes. Bioenergy production potential in Hawaii depends on the availability of land and feedstock; CO_2 sources (for algae); markets and values for primary products (electricity, fuels) and by-products (animal feed); and overall revenues compared to costs.

Hawaii's demand for liquid fuels is shown below. Locally-produced biofuels could be blended with several petroleum-based fuels listed in the table.

Hawaii's Liquid Fuel Demand (approximate)

Use	Fuel	Petroleum-based fuels (million gallons per year)[31]	Biofuel (mgy)	Goal
ELECTRICITY PRODUCTION	Fuel Oil	390		
	Diesel	90	4	
	Naphtha	30		
GROUND TRANSPORTATION	Gasoline	400	40	
	Diesel	50	1	
COMMERCIAL AVIATION	Jet Fuel	450		
MARINE TRANSPORTATION	Bunker Fuel	70		
	Diesel	130		
MILITARY USE	JP8 Jet	80		25% (32 mgy) renewable by 2018
	JP5 Jet	10		
	Diesel	40		
OTHER USES	Methane, Propane	60		
TOTAL (Rounded)		**1800 mgy (1.8 billion gallons/yr)**		

Bioenergy facilities:

- Kauai: Green Energy is building a 6.7 megawatt biomass-fired generator that will produce 11% of Kauai's electricity once completed.
- Oahu: H-POWER[32] produces 7-8% of Oahu's electricity from trash.
- Maui:
  - Hawaiian Commercial and Sugar (HC&S) generates 10% of Maui's electricity from the fiber (bagasse) by-product of sugar production.
  - Maui County is planning a 15 MW waste to energy and a 1 MW landfill gas facility.
- Hawaii Island: Hu Honua is developing a 21.5 MW facility that will produce 10% of the Big Island's electricity when completed.

Waste materials (such as used cooking oil) and by-products from food, feed, or fiber production, although limited in quantity, are often the first bioenergy feedstocks due to their relatively low cost and the need for reduced waste management costs.

Since biodiesel fuel imports for electricity production began in 2010, the relative cost of the imported biodiesel fuel has been significantly higher than for the fossil-based fuels used for electricity generation in Hawaii.[33] In December 2013, fuel oil averaged $127.85/bbl, diesel fuel averaged $139.28/bbl, and biodiesel averaged $183.09/bbl.[34]

Crops may also be cultivated to produce biomass materials (oils, fiber, sugar) usable for electricity or fuel production.

Studies indicate that 136,000 suitable acres could be available without displacing current farming in Hawaii; with biomass production of 10 - 20 tons of fiber per acre per year, potential would be about 1.4 - 2.7 million tons of biomass per year.[35] As a reference, two million tons of biomass, if burned in conventional biomass combustion processes, would generate energy equivalent[36] to two million barrels (84 million gallons) of oil. Or, two million tons could be converted (at 80 gallons per ton,[37] via thermochemical processes) into 160 million gallons of fuel.

Algae has also been receiving attention, due to high yields per acre and potential use of CO_2. The 11 million tons of CO_2 produced by large energy facilities (power plants and refineries) in Hawaii could theoretically support the production of over 400 million gallons of oil per year.

Hawaii Biofuel Projects

Facility	Input (feedstocks)	Output (products)	Production Capacity
Aina Koa Pono	1. Remove invasive species. 2. Plant crops.	Renewable diesel, gasoline, biochar	24 million gallons per year (mgy) (planned)
Big Island Biodiesel	Used cooking oil, grease trap waste, crop oils	Biodiesel, glycerin, animal feed	5.5 mgy (built)
Cellana	Algae	Algae oil, animal feed	1.26 mgy (planned)
Hawaii BioEnergy, LLC Renewable Fuels Project	Eucalyptus, energy grasses, other	Renewable fuel oil, jet fuel, gasoline; feeds, fertilizers, electricity possible	Fuel oil replacement: 20 mgy (planned)
HawaiiGas Renewable Natural Gas (RNG) Plant	Animal and plant fats and oils	Renewable methane, hydrogen, propane	1 mgy (built)
Phycal	Algae	Fuel oil; renewable jet fuel; renewable diesel	100,000+ gallons per year pilot, followed by 3 mgy demonstration (planned)
UOP Honeywell Integrated Biorefinery	Woody materials, agricultural residues, algae	Renewable gasoline; diesel; jet fuel	62,000 gal/y, pilot (planned); 50 mgy facility (potential)

Biofuel, a renewable energy source that can be stored and transported in a manner similar to fossil fuels, can often be used in existing equipment and be blended with petroleum fuels. One ton of biomass replaces approximately one barrel of oil.

Hawaii's current use of petroleum-based fuels (million gallons/yr)	**1,800**	Algae oil yields demonstrated on Kauai[38]	**2000** gal/acre
Target cost per gallon, bio-based jet fuel[39]	**$3**	Pounds of animal feed per gallon of biodiesel from crop oil	**25**
Median Levelized Cost of Biomass Energy[40]	**8¢/kWh**	Animal feed used in Hawaii (million pounds/year)[41]	**100-200**

Electric Vehicles

An electric vehicle (EV) uses electricity in place of gasoline, reducing the need for petroleum-based fuel. Since EVs can use electricity produced from renewable resources available in Hawaii (i.e. sun, wind, hydropower, ocean energy, geothermal energy), the transition from gasoline fueled vehicles to electric vehicles supports Hawaii's energy independence goals.

Based on statewide averages, the amount of fossil fuel used to power an electric vehicle in Hawaii is 31% less than the fossil fuel required to power a similar gasoline-fueled vehicle.[42] This is expected to get even better as renewable energy increases in Hawaii.

Electricity is most commonly delivered to an electric vehicle's batteries at night, through a home vehicle charger. Electric vehicles can also use publically available charging stations.

Registered Electric Vehicles (EVs)
and Publically Available Charging Stations in Hawaii, May 2014

County	Electric Vehicles	Level 2 [43] Charging Stations	Ports[44]	Level 3 [45] Charging Stations
Oahu	1757	217	264	4
Maui	424	38	67	5
Hawaii	114	29	44	0
Kauai	80	32	26	1
State of Hawaii	**2375**	**316**	**401**	**10**

- Public charging, including fast charging, is needed as a convenience for EV drivers and to reduce range anxiety.
- The cost for a government or commercial property owner to install a Level 2 charging station is typically approximately $6,000-$8,000 per station. [46]

EVs have a greater initial purchase price[47] than comparable gasoline-fueled vehicles. Most experts, including Hawaii's auto dealers, believe that widespread acceptance of EVs will grow as a full battery charge provides greater driving range and the cost of EVs more closely matches the cost of conventional internal combustion engine (ICE) vehicles.

Hawaii EV Dealers by County

County	Nissan Leaf	GM/Chevy Volt	Mitsubishi iMiEV	Toyota plug-in Prius	Ford Focus EV
Oahu	3	3	1	3	3
Maui	1	1	0	1	1
Hawaii	0	1	0	2	0
Kauai	1	1	0	1	1
State of Hawaii	**5**	**6**	**1**	**7**	**5**

Fuel cost comparisons show approximate savings between internal combustion engine and electric vehicles. The example below shows that fuel costs are lower for the Nissan Leaf than for a comparable gasoline fueled vehicle.

Fuel Cost Comparison

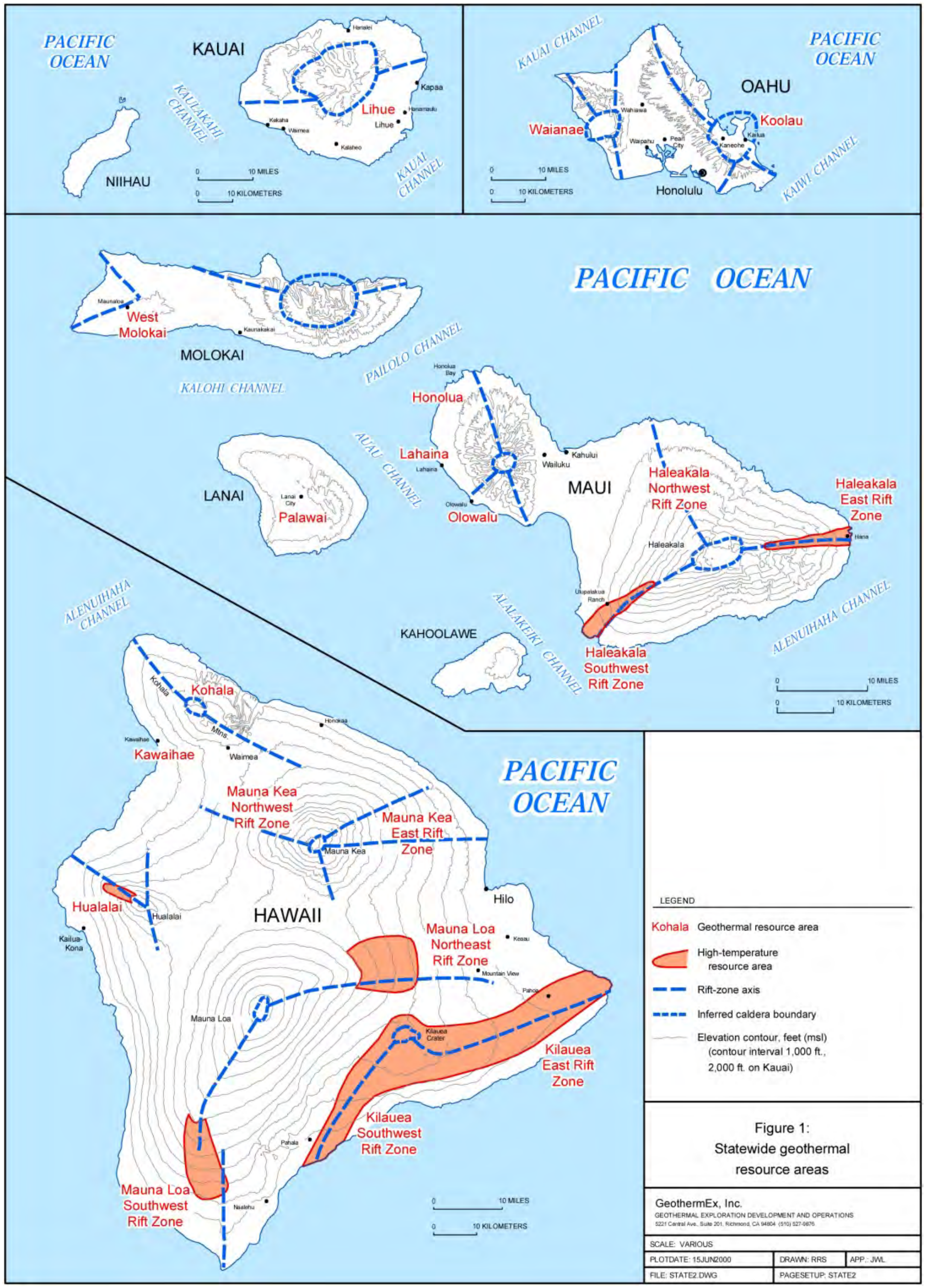
Vehicle	2012 Nissan Versa	2012 Honda Civic	2012 Nissan Leaf[48]
Fuel Type	Gasoline	Gasoline	Electricity
Miles Per Gallon (mpg)	27mpg Combined	32mpg Combined	99 Combined mpge
Fuel Costs	$ 4.10/gallon	$ 4.10/gallon	Electricity: $ 0.345/kWh
Fuel Cost per Mile	$ 0.1519 / mile	$ 0.1282 / mile	$ 0.1173 / mile
Fuel Cost per Year[49]	$ 1,370 / year	$ 1,156 / year	$ 1,058 / year

Hawaii's electric vehicle policies and incentives include:

- Free parking is provided in State and County Government lots, facilities, and at parking meters (Act 168 of 2012, formerly Act 290 of 1997).
- Vehicles with Electric Vehicle license plates are allowed access to High Occupancy Vehicle lanes (Act 168 of 2012).
- Parking lots with at least one hundred public parking spaces are required to have at least one parking space, equipped with an EV charging system, reserved exclusively for EVs (Act 089 of 2012, formerly Act 156 of 2009).
- Multi-family residential dwellings or townhouses cannot prohibit owners from installing EV chargers in their assigned parking spaces (Act 186 of 2010).

Electric Vehicle Land Speed Record	**303** miles per hour	Electric Vehicle Distance Record on a Single Charge	**423** miles[50]
Average distance driven by US driver in one day (easily accomplished by current EV technology).	**35** miles per day	Best temperature range to operate lithium ion batteries (most common EV batteries today).	**68°- 95°** Fahrenheit
EPA rating for 2013 Ford Fusion Energi plug in hybrid	**108** mpg city, **92** mpg hwy	Hawaii's rank in EV market share (1.6%)[51]	**1**

Geothermal



Map of Geothermal Resource Areas (Source: GeothermEx, 2005)

Hawaii's single geothermal power plant, the Puna Geothermal Venture (PGV) facility located on the Island of Hawaii, produced 281 gigawatt-hours (GWh) in 2013[52]. Geothermal provided approximately 23% of the total electricity consumed on Hawaii Island in 2012 as well as approximately **17% of the renewable electricity** generated statewide in 2013. The facility, which began operating in 1993, produces both baseload and dispatchable electricity.

The Hawaii Electric Light Company (HELCO) received six responses to its Request for Proposals for an additional 50 MW of dispatchable geothermal power for the island of Hawaii. This amount of geothermal capacity could allow HELCO to retire one of its fossil fuel power plants. HELCO has complied with the Independent Observer's recommendation to stay (suspend) the Geothermal RFP until the completion of the Hawaii Electric Light Power Supply Improvement Plan. If appropriate, HELCO may issue an addendum to the Geothermal RFP to gather further information from the bidders.[53]

Continued geothermal **exploration** will contribute to better understanding of Hawaii's geothermal resources. Ormat is exploring on Maui, focusing on the southwest rift zone of Haleakala, with partial funding from the U.S. Department of Energy. The University of Hawaii is also exploring rift zones on several islands using a non-invasive technique called magnetotellurics.

Geothermal resources are difficult to characterize without exploration and drilling since Hawaii's high-temperature resources are usually more than a mile beneath the surface. However, estimates from exploration efforts in the 1970s and '80s indicate that there may be more than 1,000 MW of geothermal reserves[54] (recoverable heat at drillable depths) on Maui and Hawaii islands, sufficient to provide more than 200% of the State's Renewable Portfolio Standards goal. Reaching that level of production would require interconnection of the islands' grids.

Geothermal electricity is cheaper than that produced from petroleum fuels in Hawaii, and also generally cheaper than other forms of renewable electricity.

Current geothermal production Capacity in Hawaii	**38** MW	Contracted price for first 25 MW of electricity from PGV[55]	**20.7¢** on peak **15.7¢** off peak per kilowatt-hour (kWh)
Estimated probable reserves, Maui & Hawaii	**1,000** MW	Contracted price for next 5 MW	**11.8¢ / kWh**
Median levelized cost of geothermal energy, U.S.[56]	**7¢** per kWh	Contracted price for next 8 MW	**9¢ / kWh**

Hydropower

Hydroelectricity was the **first renewable energy technology** used to generate electricity in Hawaii; plants date back to 1888.[57] Early hydroelectric facilities were located in Honolulu and Hilo. During the sugar era, additional hydroelectric plants were installed to help power sugar operations.

The technology is **fully commercial and reliable** but is limited by fluctuating water levels in Hawaii's streams and irrigation ditches. Due to our geology, run-of-the-river and run-of-the-ditch systems, which have no dams, are used. Both small, home-scale plants and utility-scale facilities are in operation.

1.1-MW Waiau Hydro Power Plant on the Wailuku River, Hilo

Hawaii currently has about 31 MW of hydroelectricity capacity statewide, or about 1% of the state's total power capacity. In 2012, approximately 104 gigawatt-hours were generated from hydroelectric resources, over 8% of the State's renewable generation.

Hydro is an important part of the energy portfolios on Kauai, where it represents 9% of the electricity generated in 2012, and on the island of Hawaii, where it generated 5% of the island's electricity in 2012.[58] Kauai Island Utility Cooperative is actively studying four[59] potential sites and hopes to increase hydro's contribution to 19% of electricity generated by 2020.[60]

As part of the Oak Ridge National Laboratory's National New Stream Development project, approximately 145 MW of undeveloped hydroelectric potential have been identified. That potential comes from 47 hydro sites identified in reconnaissance and feasibility reports. Most of the potential sites are small run-of-the-river projects.[61]

Pumped storage hydro is a related technology. A non-hydro source of electricity is used to pump water from one reservoir to a second, higher reservoir. This source of electricity could be low-cost baseload power or an intermittent resource such as wind. The water stored in the upper reservoir can be released as needed. Pumped storage has been proposed in Hawaii, but no commercial facilities have been constructed.

Another related technology is in-line hydro, which harvests energy within water pipelines. For instance, the Hawaii County Department of Water Supply (DWS) has three small in-line hydro power plants which each have capacities of 40 kW. These facilities capture the energy in pipes carrying water to DWS customers in West Hawaii.

Hawaii County Dept. of Water Supply's 45-kW in-line hydro plant in Kona

MW of hydroelectric capacity installed statewide	**31**[62]	Capacity of Wailuku River hydroelectric plant, the state's largest	**12.1**[63] MW
Year that Puueo hydro power plant, still in operation, began generating	**1910**[64]	Electricity generated by Wailuku Hydroelectric Plant in 2012[65]	**26,798,694** kWh

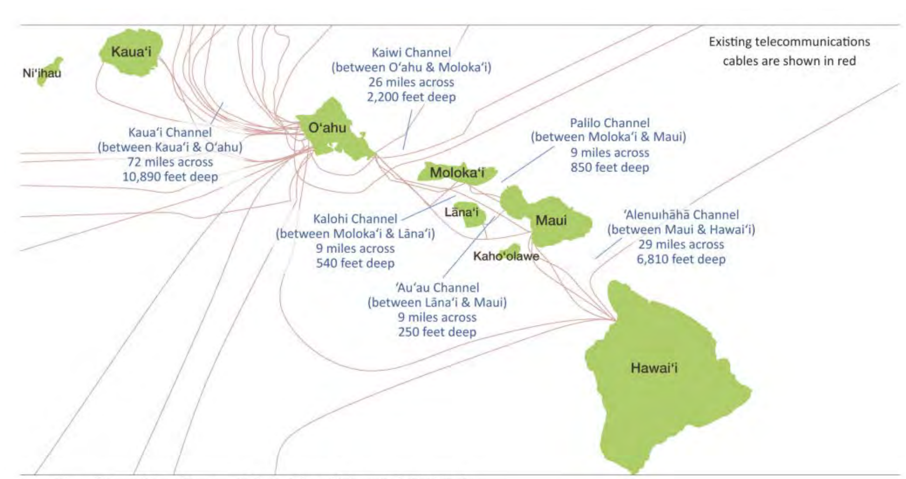
Inter-Island Cable Grid-Tie

The Interisland Cable Grid-Tie Project (a.k.a., the Oahu-Maui Interisland Transmission System) is an investigation by the Hawaii Public Utilities Commission (PUC) into the viability of connecting the electricity grids of Maui and Oahu with a 200 MW High Voltage Direct Current (HVDC) cable. DBEDT is strongly in favor of the project due to the significant economic, environmental and community benefits that it will bring to Hawaii ratepayers. Indeed, the Cable is a key enabler of achieving the State’s aggressive, and critical, Renewable Portfolio Standards (RPS).

The type of system being proposed is a two-way “grid-tie” (not the one-way “gen-tie” transmission cable, that was proposed earlier). This adds significant value to Hawaii’s pubilc and ratepayers because it will allow Oahu and Maui to coordinate operation of their respective electric grids, and provide flexibility to add significantly more clean, renewable energy generation in the most economical and equitable manner.

Eventually, the goal is to connect Maui to Hawaii Island to create an integrated system and take advantage of the Big Island’s abundant renewable resources.

Hawaii’s islands are already connected by several telecommunications cables, shown below.



Source: Bureau of Ocean & Energy Management & National Oceanic & Atmospheric Administration

The 200 MW HVDC cable bundle is no more than 10 inches in diameter.

The bundle shown in the picture is for transmission of 500 MW.

DBEDT estimates the overall savings on both islands at up to $423 million (2020-2050) before taking into consideration the social cost of carbon. Should the social cost of carbon be taken into consideration, the net benefit would rise to $551 million. These figures include fuels savings of approximately $1 billion. Other significant benefits include:[66]

Economic

- Lower and more uniform electricity prices for Maui and Oahu;
- Lower fuel costs and less exposure to price volatility;
- Increased capacity factors for wind generation;
- Greater utilization of lower cost generation resources;
- Reduced curtailment of intermittent renewable energy;
- Reduced environmental compliance costs; and
- Lower operating reserve requirements.

Environmental

- Lower nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), and carbon dioxide (CO_2) emissions;
- Higher penetration of renewable energy generation; and
- Increased flexibility in siting new renewable generation.

Public Policy

- Helps the State meet RPS requirements and the objectives of the Hawai’i Clean Energy Initiative (HCEI), i.e., 40% renewable energy by 2030;
- Reduced dependence on fossil fuels; and
- A model for potentially connecting with Hawaii Island in the future.

There have been at least 22 similar projects globally, including the following noteworthy ones:

- Trans Bay Cable (California), 53 miles: 660 MW installed in 2010.
- Cross Sound Cable (New York - Connecticut), 24 miles: 330 MW installed in 2002.
- Neptune (New York-New Jersey), 50 miles: 660 MW installed in 2007.
- NorNed (Netherlands – Norway) (**longest HVDC submarine cable**), **360 miles**: 700 MW installed in 2008.
- SAPEI (Italy) (**deepest** HVDC submarine cable, at **5,380 feet**), 261 miles: 1000 MW installed in 2011.

Longest undersea power cable	**360** miles	Deepest undersea power cable	**5,380** feet
Highest capacity undersea HVDC system	**2,000** MW	Estimated installed cost of Oahu to Maui grid tie[67]	**$ 626 million**
Year of installation, first HVDC undersea power cable	**1954**	Estimated net benefit of Oahu-Maui grid tie, (including social costs of carbon)[68]	**$ 551 million**
Expected undersea transmission cable life in years	**30-50**	2012 legislation: regulatory structure for inter-island power cables	**Act 165**

Ocean

Surrounded by the Pacific Ocean, Hawaii is rich in ocean renewable energy resources. Ocean energy includes both **hydrokinetic** and **thermal** resources.

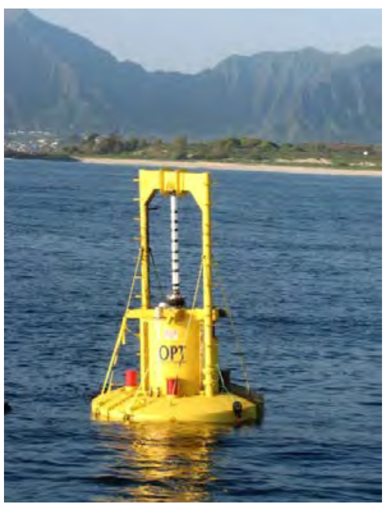
Hydrokinetic technologies tap the movement in the ocean—waves, currents and tides—to generate electricity. Ocean Thermal Energy Conversion (OTEC) makes use of the temperature differences between warm surface waters and cold, deep ocean waters.

Hawaii has **superior potential for wave energy and OTEC**. However, ocean current and tidal resources are not as promising with presently-envisioned technologies in Hawaii.

Ocean energy research, development and demonstration projects are taking place in Hawaii and elsewhere in the world.

The **Hawaii National Marine Renewable Energy Center** (HINMREC) at the University of Hawaii-Manoa is one of three federally-funded centers for marine energy research and development in the nation. HINMREC is working with the Department of Defense to establish a multiple-berth wave energy test center at Kaneohe Bay, Oahu. The first new tenant, NWEI, was selected to occupy the existing 30-meter-deep berth. An Environmental Assessment, resulting in a Finding of No Significant Impact, was completed on two new berths, at 60 m and 80 m depths, in February 2014. Construction is anticipated to begin in 2014.

The **first ocean wave-generated electricity** ever transmitted to the grid in the USA was generated by an Ocean Power Technologies (OPT) PowerBuoy at Kaneohe Bay in 2010. In a cooperative program with the U.S. Navy, three OPT buoys were deployed from 2004 to 2011.

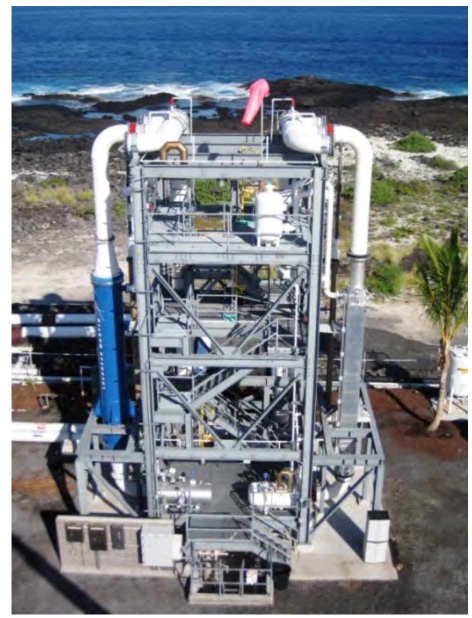


OPT's PB40 PowerBuoy in Kaneohe Bay, Oahu

The **Natural Energy Laboratory of Hawaii Authority** (NELHA) at Keahole Point, Kona, is among the world's premier OTEC research centers. Major milestones in OTEC were achieved at NELHA in the 1980s and '90s, including a 1-MW floating OTEC 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 OTEC.

NELHA's cold seawater supply pipes are the deepest large-diameter pipelines in the world's oceans, extending to 2,000-foot depths. The laboratory's location, with access to both warm surface water and cold deep ocean water, makes it a prime site for OTEC RD&D. Presently, a heat exchanger test facility is operating at NELHA, testing components and materials. A 100-kW generator is planned to be added to the test facility in 2014.

A one-megawatt OTEC demonstration facility at NELHA is in the planning stages and power plants up to 100 MW in capacity have been proposed for locations off Oahu.



OTEC heat exchanger test facility at NELHA

Number of berths expected at Kaneohe wave test center	**3**	Projected Levelized Cost of Electricity (LCOE) for commercial ocean energy[69]	**21¢-23¢/kWh**
Energy potential of trade wind waves in Hawaiian waters[70]	**15-25** kW/meter	Temperature of cold, deep seawater at NELHA[71]	**6°C (43°F)**
Number of operating hours achieved by OPT PowerBuoy PB40 at Kaneohe Bay[72]	**>5,600** hours	Temperature range of warm surface seawater at NELHA[73]	**24° – 28.5°C (75° – 83°F)**

Smart Grid

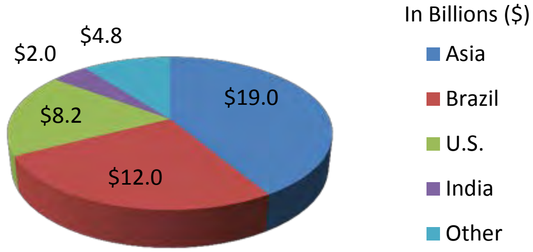
What is Smart Grid?[74]

The electric "grid" is a network of transmission lines, substations, transformers and more that deliver electricity from power plants to homes and businesses. It's what electric lights and appliances are plugged into. A "smart grid" is one that has more automatic sensors, controls, energy storage, and intelligent systems to better manage the complexity of constantly fluctuating demand and production of electricity efficiently and cost-effectively. Some common "smart grid" components are:

- Smart ("Advanced") Meters
  - Provide timely and detailed energy use information for customers
  - Allow for time of use rates
- Sensors, controls, and forecasting
  - Monitor conditions in real time
  - Allow higher penetration of renewables
- Energy Storage (batteries, capacitors, flywheels, pumped hydro, hydrogen)
  - Allow for increased renewable energy penetration
  - Stabilize the grid by conditioning power and smoothing fluctuations
- Demand Response (managing electricity use in response to available supply)

Smart Grid Market is Large

Worldwide Smart Grid Market:
$46 Billion in 2015[75]



*Asia and Brazil data are for 2016

- DOE gave $3.4 billion in grants for smart grid projects & grid upgrades in recent years.[76]

Potential Market in Hawaii

- Residential and commercial building energy management systems may become even more effective when connected to a utility-wide smart grid.
- Over 500,000 housing units and condos[77], and tens of thousands of commercial and government buildings statewide, can take advantage of smart grid technologies.
- Over $57 million has been invested in Smart Grid demonstration projects in Hawaii.[78]

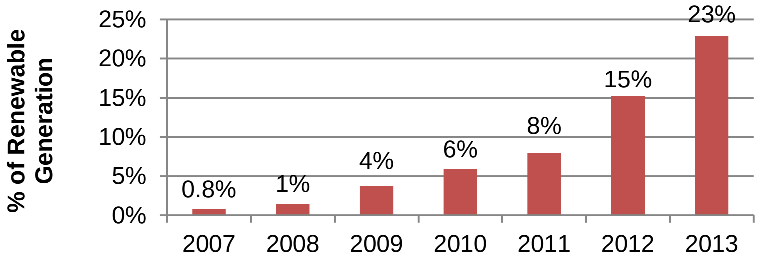
Existing Smart Grid Projects in Hawaii

Name	Description	Key Companies	Location
HECO Smart Grid and Smart Meter Initial Phase	First phase for an island wide rollout of smart grid technology and smart meters, pending approval by the Public Utilities Commission. During the initial phase, about 5,200 smart meters will be installed in homes and businesses.[79]	HECO, Silver Spring Networks, Blue Planet Foundation, Hawaii Energy	Moanalua Valley, parts of Pearl City, Kaimuki, Kahala, Diamond Head and Waikiki, Oahu
DOE Renewable and Distributed Systems Integration (RDSI) Maui Smart Grid Demonstration Project	Develop a distribution management system that aggregates distributed generation, energy storage, and demand response technologies with $7 million in DOE funds and $8 million in industry funds.[80]	HNEI, HECO/MECO, General Electric, First Wind	Maui Meadows and Wailea, Maui
JUMPSmart Maui Project	Develop advanced technologies that automate EV charging and demand response to allow more renewable energy on the grid. NEDO will invest $37 million in the project.[81]	NEDO, Hitachi, Mizuho, Cyber-Defense, US DOE, NREL, HECO/MECO, HNEI, MEDB, Maui County & DBEDT	Kihei, Maui
KIUC Smart Grid Demonstration	Installation of advanced metering infrastructure (AMI) and other smart grid technologies for grid management and energy efficiency information. Total cost of around $11 million for 33,000 meters in five years.[82]	KIUC, USDOE	Kauai
Honeywell Fast Demand Response	Industrial and Commercial programs available for designating non-essential facilities that can be turned off during critical energy situations with ten minutes' notice or less.[83]	HECO, Honeywell	Oahu

Solar

Due to Hawaii's extremely high energy prices, superior solar resource and progressive energy policies, the state has experienced unprecedented growth in solar generation. Solar energy in 2013 provided 23 percent of Hawaii's renewable energy generation.

Solar Energy as a % of Total Renewable Generation in Hawaii[84]

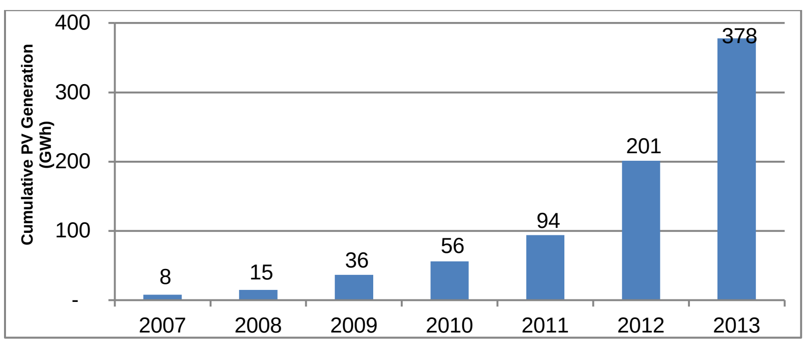


Most photovoltaic systems are installed under the utilities' net metering program. Both residential and commercial entities participate in the program. There are approximately 40,717 photovoltaic systems currently installed, providing a capacity of 312.3 MW.

	Number of PV systems	Capacity (MW)
HECO[85]	29,558	221
HELCO	5,355	41
MECO	5,255	38
KIUC[86]	1,875	12.3
TOTAL	**40,717**	**312.3**

Photovoltaic (PV) system installations on commercial and residential properties have been increasing rapidly; capacity has almost doubled every year since 2006. The graph below shows growth Hawaii's solar generation.

Total Photovoltaic (PV) Generation[87] **by Year (GWh)**



Progressive energy polices include:

- Net Energy Metering (NEM), which allows residential customers to receive full retail value for excess solar energy occasionally fed to the grid;
- Feed in Tariffs (FIT), which allow the owners of small renewable energy projects to receive fixed rates for renewable electricity provided to the grid; and
- State and Federal tax incentives.

Power Purchase Agreements (PPA) are contracts between independent power producers and the electric utility. Utility-scale PV systems have PPAs with utilities on several islands.

The integration of large amounts of solar generation can be challenging due to the intermittent nature of solar as well as Hawaii's small, individual, non-interconnected island grids. Potential solutions include battery storage as well as interconnecting the island grids.

Existing Utility Scale Solar Projects

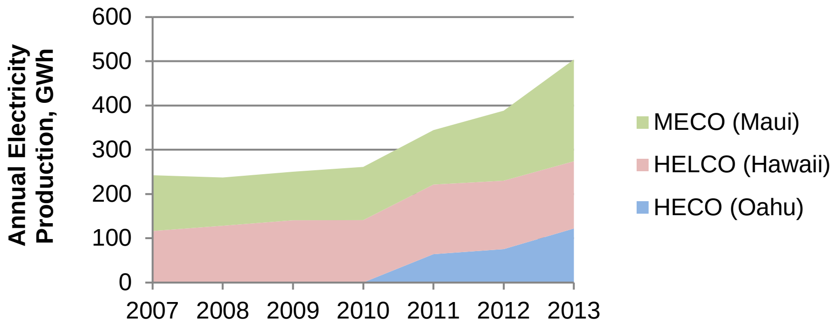
Project Name	Year Installed	Island	Developer	Capacity
La Ola Solar Farm	2006	Lanai	Castle & Cooke	1.1 MW
Kapolei Sustainable Energy Park	2011	Oahu	Forest City, Hoku	1.18 MW
Kapaa Solar Project	2011	Kauai	Kapaa Solar, KIUC	1.21 MW
Port Allen Solar Facility	2012	Kauai	A&B, McBryde, KIUC	6 MW
Kalaeloa Renewable Energy Park	2013	Oahu	Hanwha SolarEnergy, Swinerton, Scatec, Hunt Dev	5 MW
Kalaeloa Solar Power II	2013	Oahu	SunPower, Dept. of Hawaiian Homelands	5 MW
MP2 Solar Project	2013	Kauai	REC Solar, KIUC	300 kW
Pearl Harbor Peninsula	2013	Oahu	Forest City, NAVFAC, HECO, HOKU	1.23 MW

Percentage of electricity generated by solar, 2013 statewide[88]	**4.2%**	Nationwide rank of cumulative installed PV capacity per capita, 2013[89]	**3rd**
Penetration of rooftop PV, residential[90]	**~10%**	Levelized cost of PV, Hawaii utility scale[91]	**16.1¢** /kWh
Typical power density of PV array[92]	**10** watts per square foot	Watts per PV module (i.e. "panel")[93]	**60 - 445** watts/panel
Installed cost, U.S., residential[94]	~**$3.00** to **$7.00** / W	Installed cost, U.S., commercial.[95]	**$1.70 - $8.00** / W
Statewide 2013 construction expenditures attributed to solar [96]	**20.2%**	Acres per megawatt (Hawaii, utility-scale)[97]	**3.3 – 7.2** acres/MW

Wind

- Wind energy is Hawaii's second most utilized renewable energy resource, accounting for about 31% of the state's total renewable energy generation in 2013.[98]
- Hawaii has one of the most robust and consistent wind regimes in the world, with capacity factors exceeding those commonly found elsewhere. In 2011, the capacity factor of the Pakini Nui wind farm on the Big Island was 65%; Kaheawa I on Maui was 47%; and the Hawi wind farm on the Big Island was 45%.[99]
- Existing projects in Hawaii are located on the islands of Oahu, Maui, and Hawaii.

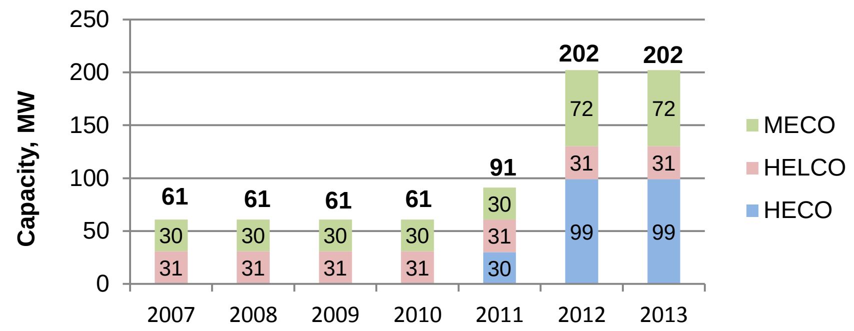
Electricity Produced from Wind Energy in Hawaii, by Island and Service Area[100]



Existing Utility Scale Projects

Project Name	Year Installed	Island	Developer	Capacity (MW)	Acres	Acres per MW
Hawi Renewable Development [101]	2006	Hawaii	Hawi Renewables	10.5	250	23.8
Kaheawa I Wind Farm[102]	2006	Maui	First Wind	30	200	6.7
Pakini Nui Wind Farm[103]	2007	Hawaii	Tawhiri Power	20.5	67	3.3
Kahuku Wind Farm[104]	2011	Oahu	First Wind	30	578	19.3
Kawailoa Wind Farm[105]	2012	Oahu	First Wind	69	650	9.4
Kaheawa II Wind Farm[106]	2012	Maui	First Wind	21	143	6.8
Auwahi Wind[107]	2012	Maui	Sempra Generation	21	68	3.2

Installed Wind Energy Production Capacity by Service Area[108]



Current installed wind capacity in Hawaii[109]	**202** MW	Average land area used per MW of wind	**9.7** acres
Height of 2.3 MW wind turbine[110]	**456** ft.	Levelized cost of wind energy[111]	**5¢** per kWh

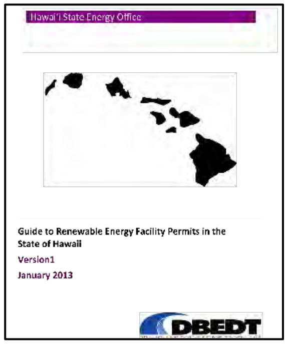
Challenges Facing Wind Energy Development in Hawaii

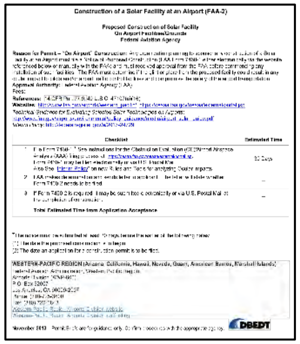
- Endangered avian and plant species can complicate the siting and development of wind projects in Hawaii's unique environments. Proactive measures, such as the development of area-wide habitat conservation plans, could be helpful for species protection as well as easier project siting in the future.
- Given the height of wind turbines and limited sites suitable for wind development in Hawaii, visual impacts may be of concern; they should be identified early and addressed carefully, working with local communities.

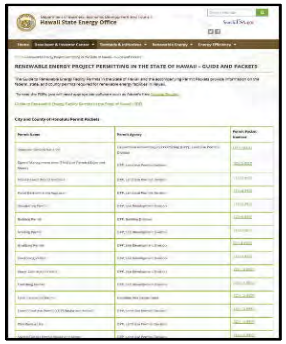
Permitting

The State of Hawaii and its four major counties have placed a priority on the permitting of renewable energy projects without compromising environmental protections and opportunity for meaningful public engagement. **Standardized checklists** and **electronic permitting** have been identified as two primary permit streamlining measures[112] that can help achieve this balance. Examples include:

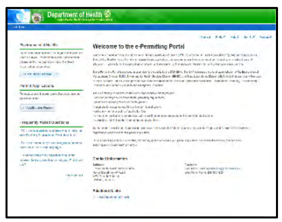
Developer & Investor Center (Hawaii State Energy Office)
http://energy.hawaii.gov/developer-investor/project-permitting-assistance-and-resources
The Guide to Renewable Energy Facility Permits in the State of Hawaii and attached Permit Packets provide information on approvals required for renewable energy facilities in Hawaii. These resources are currently being updated for republication in late 2014.



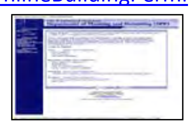




e-Permitting Portal (Hawaii Department of Health)
https://eha-cloud.doh.hawaii.gov/epermit/View/default.aspx
The DOH Environmental Health Administration (EHA) *e-Permitting Portal* is an Internet-based application that provides access to environmental permit applications, instructions and education. It allows for online application compilation and submission, online application fee payment and online submission tracking.



Online Building Permits (City and County of Honolulu)
http://dppweb.honolulu.gov/DPPWeb/Default.aspx?PossePresentation=OnlineBuildingPermit&PosseObjectDef=j_OnlineBP
This website provides for the electronic submission and processing of building permits required for residential solar heating, photovoltaic, and electric vehicle charger installations in the City and County of Honolulu.

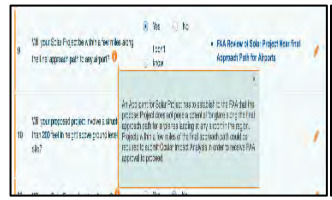


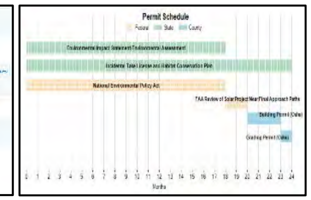
Facts about permitting renewable energy projects in Hawaii

- Permitting costs in Hawaii can range from **1% to 20% of overall project construction costs**.[113]
- Large energy projects in Hawaii **average 15 federal, state, and county permits**, with some facilities requiring over 40 such approvals.
- It can take **1-5 years to permit** a large renewable energy project in Hawaii.
- **Hawaii's Energy Policy** seeks to balance technical, economic, environmental, and cultural considerations. Not all renewable energy projects are created equal.

Renewable EnerGIS Mapping Tool (Hawaii State Energy Office, Office of Planning)
http://energy.hawaii.gov/resources/renewable-energis-map
Renewable EnerGIS provides renewable energy resource and site information for specific Hawaii locations selected by the user. This tool is intended to help landowners, developers, and policy makers understand the renewable energy potential of sites statewide. It also provides information to help determine site permitting requirements. DBEDT is now planning specified upgrades to EnerGIS.

Renewable Energy Permitting Wizard (Hawaii State Energy Office)
http://wizard.hawaiicleanenergyinitiative.org/
The Wizard was developed to help those proposing renewable energy projects understand the county, state, and federal permits that may be required for their individual project. The Wizard is currently being updated for rerelease in May 2014, with ongoing content edits.





Common permitting issues for renewable energy projects in Hawaii

- Hawaii's many protected cultural, historic, and ecologic resources
- Hawaii's many overlapping land use jurisdictions
- Hawaii's limited land and natural resources
- Renewable energy projects present new technological and permitting issues
- Time and effort spent going back and forth between applicant and permitting agency
- Heightened public interest in renewable energy projects
- Utility interconnection requirements/approvals and grid reliability issues
- Interplay with Hawaii Public Utilities Commission approvals
- Renewable energy facilities can have environmental impacts

Common solutions to renewable energy permitting issues in Hawaii

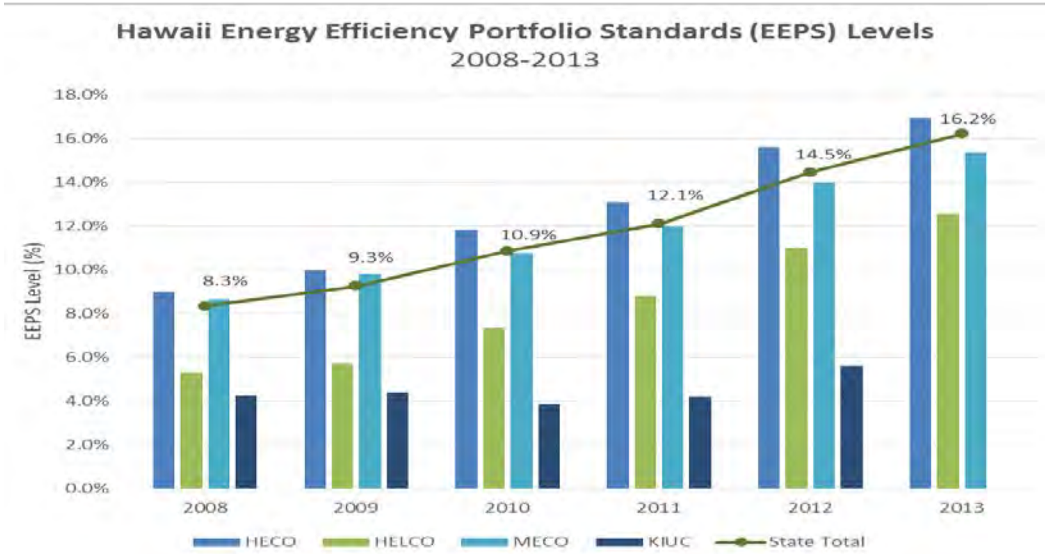
- Electronic permit processing – saves time, reduces back & forth, transparency, tracking
- Educate all stakeholders – permit guides/resources, various media, seminars, conferences
- Lawmaking – responsible allowances for renewables, clarity in permitting processes
- Gain community support – engage public early in the project development process
- Maximize gov't resources – provide agencies well-planned projects, complete applications
- Site projects appropriately – minimize environmental impacts, seek compatible areas
- Know the system – retain professionals with experience in Hawaii permit processes
- Be diligent – go slow in the beginning to go fast in the end

Energy Efficiency

Energy Efficiency Portfolio Standards (EEPS)

This graph shows Hawaii Energy Efficiency Portfolio Standard (EEPS) levels from 2008-2013. The EEPS requires that by 2030 annual energy savings amount to 30% of annual electricity sales statewide. In 2008 the statewide EEPS level was 8.35%. By December 2013 the EEPS level rose to 16.2%. The long-term EEPS goal (4,300 GW) remains achievable. An Energy Efficiency Potential Study, initiated by the Public Utilities Commission, indicates that there is the potential of exceeding this goal by 50% by 2030.

A major contributor to EEPS is Hawaii Energy (HE), a ratepayer-funded energy conservation and efficiency program that serves all islands except Kauai, which is handled by Kauai Island Utility Cooperative. HE is administered by Leidos Engineering, LLC, under contract with the Hawaii Public Utilities Commission. For HE's program year ending June 30, 2013, the estimated budget was $16.42 million for business programs, $13.44 million for residential programs and $2.37 million for transformational programs. HE delivered $21.8 million in incentives driving customer energy bill savings to $45 million for the first year. The lifetime energy savings totaled 1.317 GWh the equivalent to $404.9 million in energy costs.



Source: *Renewable Portfolio Standards Status Reports,* 2007-2013 (Hawaii Public Utilities Commission)
KIUC RPS and EEPS not included for 2013. These figures to be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

State and County Performance Contracting

Energy savings for these projects over 20 years (1.16 billion kWh) is equivalent to powering an estimated total of 156,995 households for one year.

Agency	Year(s)	Contract Amount ($)	Estimated Savings Over Life of Contract ($)
UH-Hilo	1996	$6,402,695	$14,630,066
County of Hawaii	1997-2006	$2,215,546	$8,157,880
County of Kauai	1998-2006	$525,965	$1,205,990
C&C Honolulu	2001-2005	$11,900,205	$36,066,761
HHSC	2001-2005	$22,542,969	$55,766,365
Judiciary	2003	$1,474,406	$9,785,036
DAGS Phase I	2009	$33,902,962	$56,149,562
PSD	2011	$25,511,264	$46,000,000
UHCC	2011	$32,802,838	$90,064,000
C&C Honolulu	2013	$16,000,000	$34,000,000
DAGS Phase II	2013	$17,400,000	$28,000,000
DOT	2013	$150,000,000	$518,025,760
	Total	**$320,678,850**	**$897,851,420**

Energy Efficiency

$150 Million Airports Energy Performance Contract

Largest Performance Contract in the Nation

Hawaii is the first in the nation per capita investment for energy performance contracting.

Over $338 million has been invested by both State and County agencies in EPCs with cost savings expected to grow to more than $887 million over the 20-year life of the contracts. DBEDT provides technical assistance to agencies.

12 airports statewide will be updated with the latest in energy efficient and green technology.

- Cut energy use by 49 percent
- Create more than 400 local jobs
- Save at least $518 million in energy costs over the next 20 years

Improvements will include:

- Replacing 74,500 light fixtures and 372 transformers
- Installing 9,100 solar photovoltaic panels
- Upgrading and replacing chilled water and air conditioning systems
- Installing smart controls
- Addressing deferred maintenance such as roof repairs to accommodate the upgrades

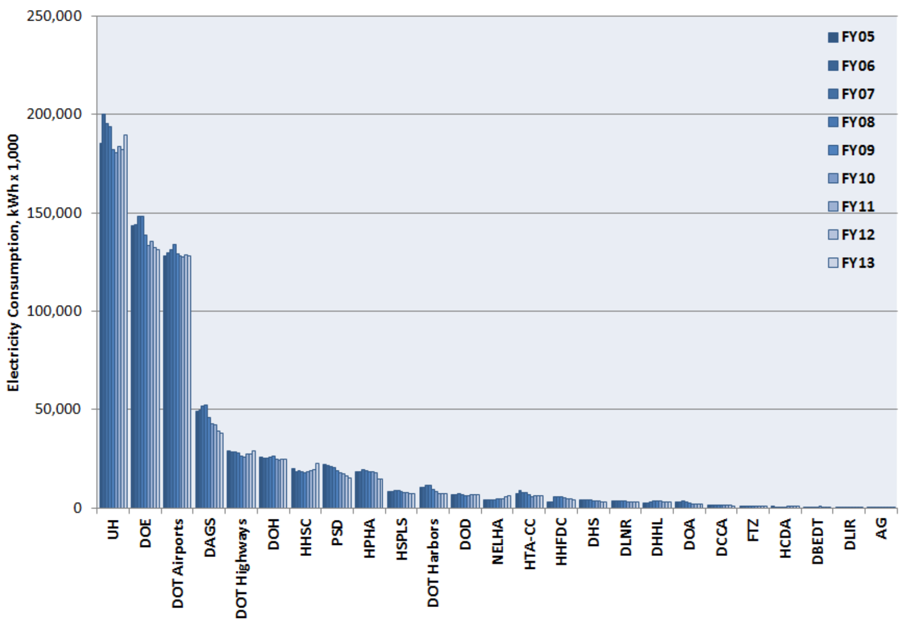
GreenSun HAWAII
Sustainability Made Affordable

GreenSun Hawaii is a public-private partnership with the ability to leverage $4.38 million in federal funds into $88 million in energy efficiency and renewable energy equipment loans statewide.
Impacts include:

- GreenSun Hawaii currently covers low-interest loans amounting to over $3 million
- The estimated energy savings for these installations is 13.3 million kWh of electricity over the life of the installations which will save participants' in excess of $6.5 million over the life of the installations
- Annual CO2 reduction of 980,000 lbs. (19.9 million lbs. over the life of the installations)
- Energy savings over the life of the equipment is equivalent to powering 1,796 households

State of Hawaii Agencies Lead By Example

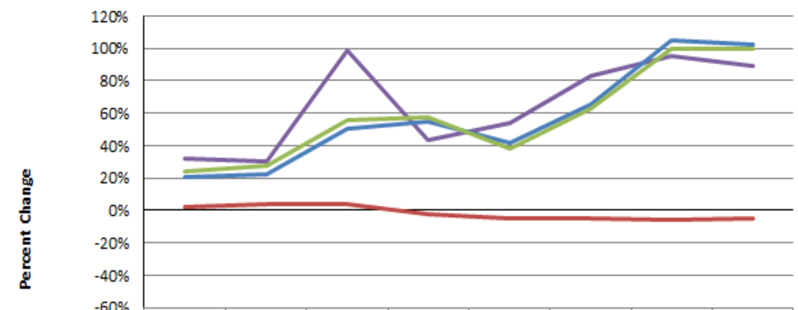
During FY13 state agencies' energy consumption increased by 1.4% from FY12 levels and the state paid 0.3 % more than FY12. When comparing FY13 figures against the 2005 baseline year, energy consumption dropped 4.8%, but due to the increasing cost for electricity, costs rose 99.9%. Consumption (kWh) by agency by year is shown in the chart below.



State of Hawaii Agencies Lead By Example

Percentage of Change from 2005

The following chart shows the percentage of change from the baseline year (2005) each year since the Lead By Example program began. Shown are the price of oil, the average retail price of electricity (based on EIA-826 reporting, dividing utility total revenues by total kWh sold and including fuel adjustment cost), total State of Hawaii electricity costs and the State of Hawaii electricity consumption (kWh).



	FY05-06	FY05-07	FY05-08	FY05-09	FY05-10	FY05-11	FY05-12	FY05-13
Price of Oil ($/bbl)	31.8%	30.0%	99.1%	43.0%	54.2%	83.1%	94.9%	89.1%
Total State Avg Retail Price (All Sectors; $/KWH)	20.9%	22.1%	50.5%	54.5%	41.8%	65.5%	104.5%	102.2%
Total SOH Building Electricity Cost ($)	24.0%	27.7%	55.6%	57.5%	38.5%	62.3%	99.2%	99.9%
KWH	2.4%	3.6%	3.5%	-2.5%	-5.1%	-4.6%	-6.1%	-4.8%

Sources: NYMEX WTI Future Price; EIA-826 ; Utilty (HECO, MECO, HELCO, & KIUC) Billing data

- State agencies have received more than $7.72 million in efficiency rebates since 1996 from the Hawaiian Electric Company (HECO) and its subsidiaries and from Hawaii Energy. These rebates combined have resulted in estimated cumulative dollar savings of over $130 million and electricity savings of over 799 million kilowatt-hours. Over the life of the equipment, the savings will be equivalent to approximately 108,000 households' annual electricity use. In FY13, state agencies received $397,124 in rebates.

- 21 State Buildings have been benchmarked and verified as Energy Star (upper 25% in energy efficiency for similar buildings in the U.S.).

State of Hawaii Agencies Lead By Example

Performance Contracting

First in the nation per capita investment for energy performance contracting: For the second consecutive year, the State of Hawaiʻi was nationally recognized and awarded the Energy Services Coalition's (ESC) Race to the Top in recognition for leading the nation in per capita performance contracting for state and county buildings. (Hawaii per capita investment is $235.74/person; national average is $36.36/person.) The ESC is a national nonprofit organization dedicated to supporting performance contracting.

Latest performance contract agreement:

Dept. of Transportation-Airports announcement as of December 2013

- Executed a $150M agreement for performance contracting for 12 airports statewide.
- Financed project by selling $167.7 million of certificates in the municipal bond market.
- Received an overwhelming response from market investors, receiving more than $1.1 billion in orders from local Hawaii and national investors.

This is the **largest EPC agreement by a single state agency in the nation**.

Using EPC, the state's 12 airports will be updated with the latest in energy efficient and green technology. The project will result in the following:

- **Cut energy use by 49 percent,**
- Create more than 400 local jobs, and
- **Save at least $518 million in energy costs over the next 20 years**.

Improvements will include the following:

- Replacing 74,500 light fixtures and 372 transformers,
- Installing 9,100 solar photovoltaic panels,
- Upgrading and replacing chilled water and air conditioning systems,
- Installing smart controls, and
- Addressing deferred maintenance such as roof repairs to accommodate the upgrades.

Leadership in Energy and Environmental Design (LEED)

- The U.S. Green Building Council (USGBC) released its ranking of the **Top 10 States for LEED**, on which the state of Hawaii placed ninth. The list highlights the regions around the country that are at the forefront of the movement for sustainable building design, construction and operation. Utilizing less energy and water, LEED-certified spaces save money for families, businesses and taxpayers; reduce carbon emissions; and contribute to a healthier environment for residents, workers and the larger community. The per-capita list is based on 2010 U.S. Census data and includes commercial and institutional green building projects that were certified throughout 2013. Hawaii certified 17 projects representing 2,323,379 square feet of real estate, or 1.71 square feet per resident, in 2013. The certified buildings included numerous private developments and included some state and county buildings.
- Twenty (20) state buildings are LEED certified or pending certification. An additional 54 LEED projects are in the process toward the goal of certification.
- **State Office Tower Certified Prestigious LEED Gold**.
  First large office building, public or private, in the state to be certified Gold under LEED for Existing Buildings: Operations & Maintenance. Water reduction: 39% and ENERGY STAR Rating: 96 (i.e., top 4% in energy efficiency among similar buildings nationally)
- Hawaii remains a member of the U.S. Green Buildings Council (USGBC), the non-profit entity which administers the LEED program. DAGS is developing LEED application guidelines to be used by state agencies.
- There are over 30 LEED Accredited Professionals on staff at six state agencies; DAGS, DBEDT, DOE, DOT, HPHA and UH. There are currently additional state personnel in training for this goal. The state requires all new construction and major renovation to meet LEED Silver standards, to the extent possible. DBEDT continues to offer LEED training opportunities for state agency staff. Six years ago, there was only one LEED Accredited Professional (AP) working for the state.
- A total of 20 workshops and other events relating to LBE topics were held in FY13, attracting at least 1500 participants, including many from state agencies. In some cases, DBEDT provided funds so that other executive agencies' staff members could attend the training.

State of Hawaii Agencies Lead By Example

Power Purchase Agreements

- DOT-Airports signed a 20-year power purchase agreement in 2009 for a total of seven (7) photovoltaic systems totaling 901 kW of capacity.
- Through a second round of power purchase agreements in 2011, DOT-Airports awarded development of photovoltaic renewable energy generation systems at 15 sites. Seven (7) power purchase agreements have been signed for a total capacity of 606 kW. The remaining eight (8) are pending, but are planned for an additional 2.69 MW.
- DOE has signed a power purchase agreement for 19 schools with anticipated completion by close of 2013.

State Building Code Update: The State Building Code Council voted to update the International Energy Conservation Code of 2009; Administrative Rules must be prepared.

	Utility kWh	Hoku kWh	Total		Utility $	Hoku $	Total $
FY2008	25,593,580	0	25,593,580	**FY2008**	$7,757,716	$0	$7,757,716
FY2009	25,319,886	217,682	25,537,568	**FY2009**	$7,859,866	$74,722	$7,934,588
FY2010	25,183,956	1,345,475	26,529,431	**FY2010**	$6,656,506	$466,998	$7,123,504
FY2011	24,881,079	1,432,550	26,313,629	**FY2011**	$7,631,471	$504,653	$8,136,123
FY2012	24,520,683	1,397,630	25,918,313	**FY2012**	$8,836,160	$508,313	$9,344,473

Performance Contracting for State and County Agencies

Performance contracting provides building owners with the opportunity to design, install, and maintain energy-efficient equipment without the significant upfront cost. Costs are paid over time from the energy savings. DBEDT provides technical assistance on performance contracting to state and county agencies.

Eight (8) projects initiated since 1996:

- University of Hawaii at Hilo
- Hawaii Health Services Corporation
- Judiciary
- Department of Accounting and General Services Phase I
- Department of Accounting and General Services Phase II
- Department of Public Safety (4 prisons)
- University of Hawaii Community Colleges
- Department of Transportation

Preliminary data show:

- The projects include over 242 buildings and over 4.5 million square feet
- Annual cost savings for all projects is $44.9M, representing an average of 39% savings
- Hawaii is ranked 1st in the nation for performance contracting (Energy Services Coalition)

Over 20 years, the projects will:

- Save over $897M in electricity costs
- Provided over $468M of direct (total investment) and indirect (repair/maintenance/taxes) impacts to the economy
- Claim over $1.5 million in utility rebate incentives

Performance Contracting for State and County Agencies

State & County Performance Contracting Projects 1990-2012

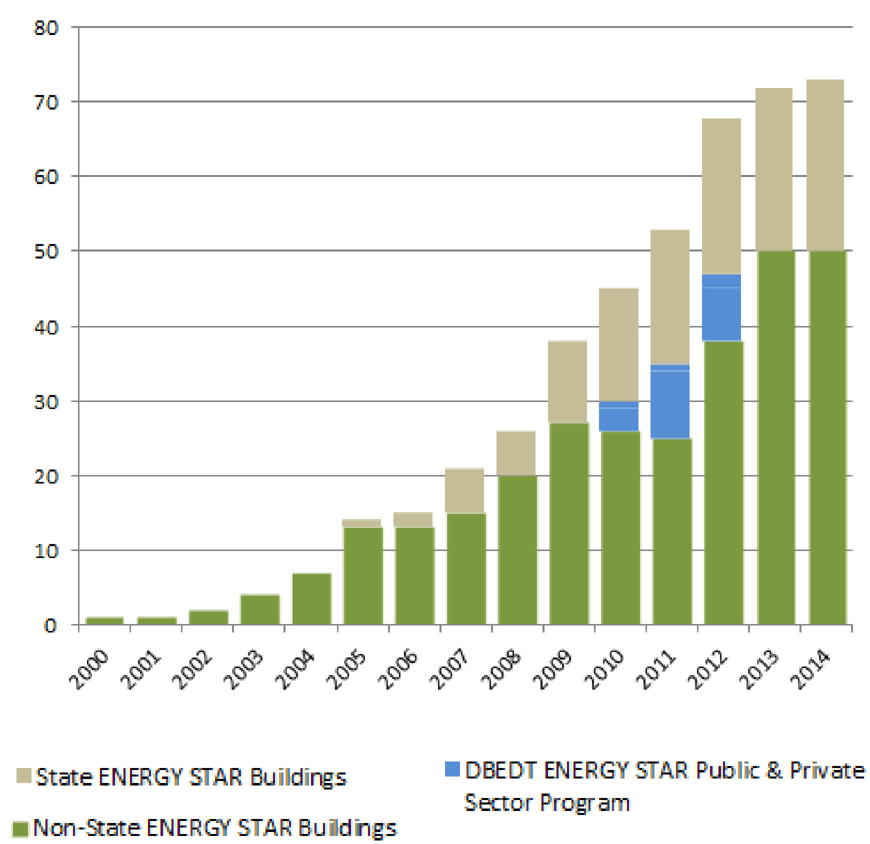
Agency	Year(s)	Contract Amount ($)	Estimated Savings Over Life of Contract ($)
UH-Hilo	1996	$6,402,695	$14,630,066
County of Hawaii	1997-2006	$2,215,546	$8,157,880
County of Kauai	1998-2006	$525,965	$1,205,990
C&C Honolulu	2001-2005	$11,900,205	$36,066,761
HHSC	2001-2005	$22,542,969	$55,766,365
Judiciary	2003	$1,474,406	$9,785,036
DAGS Phase I	2009	$33,902,962	$56,149,562
PSD	2011	$25,511,264	$46,000,000
UHCC	2011	$32,802,838	$90,064,000
C&C Honolulu	2013	$16,000,000	$34,000,000
DAGS Phase II	2013	$17,400,000	$28,000,000
DOT	2013	$150,000,000	$518,025,760
	Total	**$320,678,850**	**$897,851,420**

Energy savings for these projects over 20 years (1.1 billion kWh) is equivalent to powering an estimated total of 156,995 households for one year. Jobs maintained or created: 8,530
(Source: National Association of Energy Service Companies)

Additional projects not included below, but under development, include: City and County of Honolulu Board of Water Supply, City and County of Honolulu Honoulili and Sand Island Waste Water Treatment Plants, and the University of Hawaii at Hilo.

ENERGY STAR Buildings

Agencies and private sector building owners and managers can benchmark buildings to compare energy usage with other buildings in their portfolio or similar buildings nationally to identify investment priorities. If a building's performance, as reflected in its ENERGY STAR score, ranks in the top 25% of all buildings of its type, it can be certified as an ENERGY STAR building. Since 2000, 72 Hawaii buildings have received the ENERGY STAR certification. They include 27 public and 45 private buildings. During this time, DBEDT has assisted with the benchmarking and certification of 25 public and private (buildings should be certified annually). The chart below shows the rapidly increasing number of ENERGY STAR certified buildings in the state.



GreenSun Hawaii Loan Program (March 2014)

Program Objectives

- A state of Hawaii credit enhancement program funded by a grant from the U.S. Department of Energy
- Provides local financial institutions with access to a loan loss reserve (LLR) which may cover up to 100% of actual losses
- Enables participating lenders to:
  - Extend loan availability to a larger pool of borrowers
  - Offer more aggressive rates and terms than may otherwise be available without this credit enhancement
- Public-private partnership with the ability to leverage $4.38 million in federal funds into $88 million in energy efficiency and renewable energy equipment loans statewide

Program Purpose

Supports loans for all property owners

- Eligible Residential Loan Purposes:
  - ENERGY STAR refrigerators and air conditioners
  - Solar Thermal Hot Water System
  - Solar Electric (PV) System
- Eligible Non-Residential Loan Purposes:
  - Lighting Retrofits & Upgrades / Air Conditioning Retrofits & Upgrades
  - Solar Thermal Systems / Solar Electric (PV) Systems
  - Energy Efficiency Windows, Cool Roofs & all other installations eligible for Hawaii Energy / KIUC Rebates
  - Loan related fees
- Requires energy efficiency improvements before renewable improvements are funded

Participants

- 12 participating Lenders statewide
- 42 authorized Contractors statewide

Impacts

GreenSun Hawaii is a public-private partnership with the ability to leverage $4.38 million in federal funds into $88 million in energy efficiency and renewable energy equipment loans statewide

Impacts include:

- GreenSun Hawaii currently covers low-interest loans amounting to over $3 million
- The estimated energy savings for these installations is 13.3 million kWh of electricity over the life of the installations which will save participants' in excess of $6.5 million over the life of the installations
- Annual CO2 reduction of 980,000 lbs. (19.9 million lbs. over the life of the installations)
- Energy savings over the life of the equipment is equivalent to powering 1,796 households

End Notes / References and Links

[1] U.S. Energy Information Administration, http://www.eia.gov/electricity/data/state/annual_generation_state.xls
[2] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends/
[3] http://www.eia.gov/electricity/monthly/current_year/february2014.pdf
[4] Source: 2007-2013 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008. KIUC data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.
[5] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends/
[6] Volumes. Source: *Biofuels Study*; DBEDT; 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf
[7] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[8] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[9] 1 barrel = 42 U.S. gallons.
[10] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[11] Electricity: http://www.eia.gov/state/rankings/#/series/31 (last accessed 5/15/14); natural gas: http://www.eia.gov/state/rankings/#/series/28 (last accessed 5/15/14)
[12] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[13] Grids are separate.
[14] Hawaiian Electric Company, http:// www.heco.com/waiverprojects
[15] Hawaiian Electric Company, http://generationbidding.heco.com
[16] http://www.heco.com/ > clean energy > selling power to Hawaiian Electric
[17] The amount of electricity produced per year = facility capacity x 24 hours/day x 365 days/year x capacity factor.
[18] Electricity data are from DBEDT's *Monthly Energy Trends*, http://dbedt.hawaii.gov/economic/data_reports/energy-trends/
[19] HECO, http://www.heco.com/fit/
[20] Accion Group, https://www.hecofitio.com/_heco/accionhome.asp
[21] Database of State incentives for Renewable Energy, http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=HI04R&re=0&ee=0
[22] PUC Decision and Order No. 32053, "Exhibit A: Commission's Inclinations on the Future of Hawaii's Electric Utilities," April 18, 2014, p. 11.
[23] Source: 2007-2013 Annual NEM, FIT Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/
[24] Kauai Island Utility Cooperative (KIUC), http://kauai.coopwebbuilder.com/sites/kauai.coopwebbuilder.com/files/schedule_q_eff_092012.pdf
[25] http://kauai.coopwebbuilder.com/files/42_schedule_nem_effective_june_3_2011.pdf
[26] Hawaii Revised Statutes, Chapter 269-91.
[27] Source: 2007-2013 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008. KIUC data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission
[28] National Renewable Energy Laboratory, *Hawaii Clean Energy Initiative Scenario Analysis*, 2012; and DBEDT.
[29] Chapter 269-91 et.seq., Hawaii Revised Statutes. http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.htm
[30] National Renewable Energy Laboratory, http://en.openei.org/apps/TCDB/
[31] Naphtha data from facility-level data, USEPA (http://ghgdata.epa.gov/ghgp/main.do#/facility/) and USEIA (http://www.eia.gov/beta/api/qb.cfm?category=1017)
[32] The Honolulu Program of Waste Energy Recovery (HPOWER) is the waste-to-energy facility of the City and County of Honolulu.
[33] DBEDT, *Biofuels Report to the Legislature in Response to Act 203*, 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf
[34] DBEDT Research and Economic Analysis Division, *Monthly Energy Trend Highlights,* March 2014
[35] Hawaii Natural Energy Institute, Bioenergy Master Plan, 2010. http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications
[36] Sugar industry rule of thumb, for combustion process without pre-drying of biomass (Hawaiian Commercial and Sugar, http://www.hcsugar.com/energy_and_the_environment.shtml).
[37] Biofuels Digest, http://www.biofuelsdigest.com/bdigest/2012/11/12/everyday-low-fuel-prices-drop-in-advanced-biofuels-for-under-100-per-barrel, November, 2012.
[38] With CO_2 from power plant. General Atomics, DARPA-funded Kauai algae facility, Congressional Briefings, Washington, D.C. (March 2012).
[39] Defense Advanced Research Projects Agency.
[40] Transparent Cost Database, 26 values, last accessed May 6, 2014. Minimum: $0.01; Maximum: $0.80; Median $0.08. http://en.openei.org/apps/TCDB/

41 From work by Anthony Ostrowski, Oceanic Institute.

42 State of Hawaii, *Driving EVs Forward: A Case Study of the Market Introduction and Deployment of the EV in Hawaii*, 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/ReportMauiElectricVehicleAlliance_12_20_12.pdf

43 Level 2 charging is at 240 volts. All electric vehicles are equipped for this type of charging.

44 A "charger" can have one or more ports. The number of "ports" determines how many vehicles each charger can service at a time. One "port" can service one vehicle.

45 Level 3, also known as "fast charging," can provide an 80% charge for some vehicles in less than 30 minutes, depending on vehicle and charger specifications. Not all vehicles can use fast charging.

46 Based on data collected by the State Energy Office, a relatively simple project in Hawaii can range from $4,000 to $25,000; however, prices vary considerably.

47 Ranging from mid-$30,000 to $40,000.

48 Nissan Leaf: 24 kWh battery; 0.34 kWh per mile.

49 9,020 miles per year, from Hawaii State Data Book. http://dbedt.hawaii.gov/economic/databook/

50 The New York Times, "Father and Son Drive 423 miles on one charge," December 12, 2012.

51 Source: Edmunds.com: http://www.edmunds.com/industry-center/analysis/drive-by-numbers-tesla-in-all-50-states.html?SID=uf3gp4u01sml&kw=flexibletexttool&PID=6154448&AID=10364102&mktid=cj260233&mktcat=affiliates

52 From RPS reports to the Public Utilities Commission from Maui Electric Company (MECO), Hawaii Electric Light Company (HELCO), and Hawaiian Electric Company (HECO).

53 http://www.hawaiianelectric.com/heco/Clean-Energy/Clean-Energy-Generation/Geothermal-Request-for-Proposals, accessed 5/5/14.

54 GeothermEx, 2005*; Assessment of Energy Reserves and Costs of Geothermal Resources in Hawaii*.

55 Avoided cost as of October 1, 2013, http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=23d98435a651d110VgnVCM1000005c011bacRCRD&vgnextchannel=10629349798b4110VgnVCM1000005c011bacRCRD&vgnextfmt=default&vgnextrefresh=1&level=0&ct=article

56 Levelized Cost of Energy Calculator and Transparent Cost Database, 46 values, last accessed May 5, 2014. Minimum: $0.04; Maximum: $0.23; Median $0.07. http://en.openei.org/apps/TCDB/

57 Myatt, Carl; *Hawaii, The Electric Century*; 1991

58 Hawaii Electric Light Company, Inc.; "2012 Electricity Production & Purchased Power Summary."

59 http://website.kiuc.coop/content/hydro, accessed 5/5/14

60 Kauai Island Utility Cooperative, *"On the Road to Renewables; 2011 Annual Report*."

61 http://nhaap.ornl.gov/nsd/

62 Hawaii State Energy Office data.

63 Hawaii Electric Light Company, Inc.; "2012 Electricity Production & Purchased Power Summary."

64 http://www.hawaiianelectric.com/heco/Clean-Energy/Renewable-Energy-Basics/Hydroelectricity, accessed May 2014.

65 Hawaii Electric Light Company, Inc.; "2012 Electricity Production & Purchased Power Summary."

66 For the range of estimated net benefits, i.e., savings, in Net Present Value terms please see DBEDT's *Initial Public Comments in Response to Hawaii Public Utilities Commission Order No. 31356*, Table 1, p 22; NextEra Hawaii LLC's *Initial Public Comments Regarding the Public Interest Benefits of an Oahu-Maui Interisland Transmission System*, Table 1.2, p 8; and the HECO *IRP Action Plan* (Docket No. 2012-0036) Table 108, 109 and 110.

67 See DBEDT's *Initial Public Comments in Response to Hawaii Public Utilities Commission Order No. 31356* in PUC Docket No. 2013-0169.

68 See DBEDT's *Initial Public Comments in Response to Hawaii Public Utilities Commission Order No. 31356* in PUC Docket No. 2013-0169.

69 OpenEI Transparent Cost Database, last accessed October 10, 2013, http://en.openei.org/apps/TCDB/. Based on Intergovernmental Panel on Climate Change (IPCC) Annex 3.

70 Data from HINMREC.

71 NELHA website, http://nelha.org/about/facilities.html

72 Data from Ocean Power Technologies, Inc.

73 NELHA website, http://nelha.org/about/facilities.html

74 Smart Grid .gov: http://www.smartgrid.gov/the_smart_grid

75 Worldwide Smart Grid Spending to Hit $46 Billion in 2015: http://www.treehugger.com/clean-technology/worldwide-smart-grid-spending-hit-464-billion.html

76 Recovery Act- Smart Grid Investment Grants: http://energy.gov/oe/technology-development/smart-grid/recovery-act-smart-grid-investment-grants

77 Hawaii Data Book: http://hawaii.gov/dbedt/info/economic/databook/db2011/section01.pdf

78 Sum of stated investment in "Existing Smart Grid Projects in Hawaii"

[79] http://www.hawaiianelectric.com/heco/Clean-Energy/Smart-Grid-and-Smart-Meters

[80] University of Hawaii RDSI Demonstration Project: http://www.smartgrid.epri.com/doc/Hawaii%20RDSI%20Final.pdf

[81] DBEDT Press Release: http://energy.hawaii.gov/wp-content/uploads/2011/09/NR-MOU-Signing-NEDO-Hawaii.11.22.11.pdf

[82] KIUC Smart Meter FAQs: http://website.kiuc.coop/content/smart-meter-faqs

[83] Honeywell Press Release: http://honeywell.com/News/Pages/Honeywell-And-Hawaiian-Electric-To-Use-Demand-Response-To-Integrate-Renewables-And-Reduce-Fossil-Fuel-Dependence.aspx

[84] Source: 2007-2013 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008. KIUC data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

[85] From HECO website, http://www.heco.com/heco/_hidden_Hidden/CorpComm/Rooftop-PV-enjoys-another-strong-year-in-Hawaii?cpsextcurrchannel=1

[86] Source: 2007-2013 Annual NEM, FIT Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/

[87] Source: 2007 -2013 Annual RPS, NEM Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/ . KIUC RPS data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission. DBEDT calculation: solar generation (MWh) divided by HECO net sales (MWh).

[88] Source: 2007 -2013 Annual RPS Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/ . KIUC RPS data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

[89] http://energy.hawaii.gov/wp-content/uploads/2011/09/NR_EnvironAmerica_7.23.13.pdf

[90] PUC Decision and Order No. 32053, "Exhibit A: Commission's Inclinations on the Future of Hawaii's Electric Utilities" p. 11.

[91] Assumes 30 year life for a 15 MW project, Kahe Utility-Scale Photovoltaic ("PV") Generating System, Hawaiian Electric Application, Verification, Exhibits 1-11; Oct. 22, 2013. PUC Docket No. 2013-0360.

[92] Ranges from 6 – 15 watts per square foot, commercially available. Includes spacing. North American Board of Certified Energy Practitioners. *PV Installer Resource Guide*. http://www.nabcep.org/wp-content/uploads/2012/03/NABCEP-PV-Installer-Resource-Guide-March-2012-v.5.2.pdf.

[93] California Energy Commission. List of Eligible SB1 Guidelines Compliant Photovoltaic Modules, Updated as of March 1, 2013. http://www.gosolarcalifornia.org/equipment/pv_modules.php

[94] Solar Energy Industries Association, "U.S. Solar Market Insight Report 2013 Year-in-Review," http://www.seia.org/sites/default/files/TSF_SMI%202011%20YIR_survey%20incentive_0.pdf

[95] Solar Energy Industries Association, "U.S. Solar Market Insight Report 2013 Year-in-Review," http://www.seia.org/sites/default/files/TSF_SMI%202011%20YIR_survey%20incentive_0.pdf

[96] Source: DBEDT, March 2014.

[97] Maunalani, 0.3 MW, 1.5 acres; La Ola, 1.5 MW, 10 acres; Hoku/Forest City, 1.2 MW, 4 acres; Kapaa, 1.21 MW, 5 acres; Port Allen, 6 MW, 20 acres; Kalaeloa SunPower, 5 MW, 36 acres; Kaleloa Scatec Solar project, 5 MW, 20 acres; Kalaeloa Home Lands Solar, 5 MW, 29 acres.

[98] From RPS reports to the Public Utilities Commission from Maui Electric Company (MECO), Hawaii Electric Light Company (HELCO), and Hawaiian Electric Company (HECO). KIUC data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

[99] EIA 923 forms.

[100] Source: 2007 -2013 Annual RPS Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/ . KIUC RPS data not included for 2013. These figures will be included upon KIUC's Annual RPS Status Report to the Public Utilities Commission.

[101] http://www.edf-re.com/about/press/construction_of_hawi_wind_farm_to_begin_in_november_2005 ; http://www.nrel.gov/news/features/feature_detail.cfm/feature_id=1748

[102] http://www.businesswire.com/news/home/20120705005753/en/Wind-Announces-Completion-Kaheawa-Wind-II-Project

[103] Actual footprint is 26 acres. Personal communication, Steven Pace, 4/26/13. Parcel size is 67 acres. http://www.hawaiipropertytax.com. http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca

[104] http://hawaii.gov/dlnr/dofaw/hcp/Kahuku_HCP_Text.pdf

[105] http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Oahu/2010s/2010-09-23-OA-EISPN-Kawailoa-Wind-Farm.pdf

[106] http://www.businesswire.com/news/home/20120705005753/en/Wind-Announces-Completion-Kaheawa-Wind-II-Project

[107] http://www.semprausgp.com/_/downloads/pdfs/Final_EIS_for_Auwahi_Wind.pdf

[108] RPS reports. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008

[109] RPS reports and PUC fillings.

[110] Siemens turbines at Kawailoa, 90 m hub height.

[111] US Department of Energy program estimate, Transparent Cost Database, 110 values, last accessed October 10, 2013. Minimum: $0.03; Maximum: $0.09; Median $0.05. http://en.openei.org/apps/TCDB/

[112] *Renewable Energy Permitting Barriers in Hawaii: Experience from the Field*, National Renewable Energy Laboratory (2013). http://www.nrel.gov/docs/fy13osti/55630.pdf

[113] *Renewable Energy Permitting Barriers in Hawaii: Experience from the Field*, National Renewable Energy Laboratory (2013). http://www.nrel.gov/docs/fy13osti/55630.pdf