Report to the Maui Electric Vehicle Alliance

Driving EVs Forward: A Case Study of the Market Introduction and Deployment of the EV in Hawaii

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This report focuses on changes being made in Hawaii's transportation sector, highlighting the steps towards greater adoption of EVs. More information on the Hawaii State Energy Office's programs and initiatives can be found at energy.hawaii.gov and electricvehicle.hawaii.gov. For questions or comments regarding this report, please contact:

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ACRONYMS

AARA	American Recovery and Reinvestment Act of 2009
AC	Alternative Current
BEVs	Battery Electric Vehicles
DBEDT	Department of Business, Economic Development & Tourism
DC	Direct Current
DOE	U.S. Department of Energy
EV TOU	EV Time of Use
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment or "Charging Station"
HADA	Hawaii Auto Dealers Alliance
HCATT	Hawaii Center for Advanced Transportation Technologies
HCEI	Hawaii Clean Energy Initiative
HECO	Hawaiian Electric Company, Inc.
HELCO	Hawaii Electric Light Company, Inc.
HMC	Hyundai Motor Company
HOV	High Occupancy Vehicle
HREDV	Hawaii Renewable Energy Development Venture
ICE	Internal Combustion Engine
KIUC	Kauai Island Utility Cooperative
kW	Kilowatt
kWh	Kilowatt-hour
LEED	Leadership in Energy and Environmental Design
Level 1	EV charging station providing charge at 120-volt AC outlets
Level 2	EV charging station providing charge at 208/240-volt AC connectors
Level 3	EV charging station providing charge at 480-volt AC input
MECO	Maui Electric Company, Ltd
MGY	Million Gallons per Year
MOU	Memorandum of Understanding
MUD	Multiple Unit Dwelling
NREL	National Renewable Energy Laboratory
PHEV	Plug-in Hybrid Electric Vehicles
PV	Photovoltaic
RB	Regenerative Braking
RPS	Renewable Portfolio Standard
SAE J1772™	The North American design standard for Level 2 charging connectors
SAE	Society of Automobile Engineers International
TOU	Time Of Use

1 INTRODUCTION

Hawaii is the most oil-dependent state in the Unites States, with more than 95% of its energy demand coming from imported fossil fuels, resulting in the highest gasoline and electricity prices in America[1]. Furthermore, Hawaii's dependence on petroleum, as its single source of energy, makes its economic security vulnerable to changes in world petroleum markets. Hawaii annually sends billions of dollars overseas and out of its local economy to support its petroleum needs.

As a strategy to relieve Hawaii's dependence on oil, the state has set a goal of achieving 70% clean energy by 2030, an undertaking that will require transforming how its energy is produced and consumed. To reduce consumption of petroleum within the transportation sector, Hawaii is looking at plug in electric vehicles (EV) as well as other alternative transportation solutions to address the challenges of modernizing its energy system and building a clean transportation future. Hawaii's leaders and stakeholders view the adoption and widespread deployment of EVs as a key approach in reducing Hawaii's fossil fuel dependency.

The State of Hawaii has exercised significant leadership in preparing for the deployment of EVs. The purpose of this report is to share Hawaii's experiences relating to EV deployment, identify challenges and opportunities, and highlighting best practices for creating a prosperous EV market in Hawaii. Lessons learned from the Hawaii State Energy Office and local stakeholders can provide a resource to local and national jurisdictions and offer insight on how to establish an EV market.

2 TECHNOLOGIES & TERMINOLOGY

Many of today's commercially available EVs can outperform many of their conventional internal combustion engine (ICE) vehicle counterparts in a number of different categories including; acceleration, torque, and cost to operate per mile. Furthermore, EVs are highly efficient and their fuel costs are lower compared with conventional ICE vehicles. EVs also offer a greater number of fueling options, including charging at home, work, commercial charging stations, public charging locations, and private fleet facilities. Lastly, EVs can be charged in part by regenerative braking, which generates electricity from some of the energy normally lost when braking. [2]

2.1 Types of EVs

EVs primarily exist in two configurations, battery electric vehicles (BEVs), completely dependent on electricity, and plug-in hybrid electric vehicles (PHEVs) by using a combination of electricity and gasoline to provide power and extended range. For the purposes of legislation and this report, the State of Hawaii defines EVs to include BEVs, PHEVs and Neighborhood Electric Vehicles (NEVs), an EV designed to operate at a maximum of 25 miles per hour on streets with lower speed limits.

[1] Hawaii relies on petroleum for more than 75% of its electrical generation and 96% fuel for its transportation sector.
[2] Department of Energy's Plug-In Electric Vehicle Handbooks for Consumers, Public Charging Station Hosts, Fleets and Electrical Contractors.

2.1.1 Battery Electric Vehicles

All BEVs use batteries to store electrical energy to power the motors. The batteries are charged by plugging the vehicle into the electric grid. BEVs do not use gasoline and can help Hawaii scale back on imported oil, even though in Hawaii oil is used in the production of electricity. In comparison to conventional ICEs, BEVs use less oil per mile traveled[3]. Furthermore, BEVs require less maintenance than conventional ICE vehicles and therefore have lower annual maintenance costs. This is due to the minimal scheduled maintenance of the EVs electrical system (battery, motor and associated electronics). Lastly, due to the mechanics of regenerative braking, brake systems used in BEVs typically last longer than those used in conventional ICE vehicles. An example of a BEV is the Nissan Leaf which is EPA-estimated to achieve 73 mile driving range.[4].

2.1.2 Plug-in hybrid Electric Vehicles

Plug-in hybrid electric vehicles (PHEV), sometimes called extended range EVs, use batteries to power an electric motor, plug into the electric grid to charge, and use a petroleum-based or alternative fuel to power an ICE or other propulsion source. PHEVs have small internal combustion engines and large, grid-chargeable batteries that enable all-electric driving ranges, typically 10 to 40 miles or more. Like BEVs, PHEVs can be plugged into the grid and charged, although the time required to charge depleted batteries is typically shorter for PHEVs, most have smaller battery packs. Since PHEVs also have an engine, they are suitable for longer trips without having to recharge the batteries. Charging the battery is augmented by a PHEV's internal combustion engine and regenerative braking. When running on gasoline, PHEVs consume less fuel and typically produce lower emissions than similar ICE vehicles. Powering the vehicle some of the time with electricity from the grid cuts petroleum consumption[5] and tailpipe emissions when compared with ICE vehicles. PHEV maintenance requirements are similar to those of conventional vehicles. An example of a range extended PHEV is the Chevy Volt which is EPA-estimated to achieve 38 miles range on electric. There is also an onboard gas generator that produces electricity resulting in a total of 380 miles on a full charge and full tank of gas.[6]

2.1.3 EV Battery Warranties and Recycling

Most manufacturers offer 8-year, 100,000 mile warranties for their EV batteries. Manufacturers have not published pricing for replacement batteries, but if the battery does need to be replaced outside the warranty, it is expected to be a significant expense. Nonetheless, battery prices are expected to decline as technology improves and production volumes increase. EVs are relatively new to the U.S. auto market, with only a small number of vehicles have approached the end of their useful lives. As a result, few post-consumer batteries from EVs are available, thus limiting the extent of battery-recycling infrastructure. The battery-recycling market is expected to expand as EVs become increasingly common. Wide scale battery recycling would keep hazardous materials from entering the waste stream, both at

[3] According to HECO a power plant generating electricity for thousands of EVs is more efficient and cleaner than thousands of IC vehicles burning oil.
[4] http://www.nissanusa.com/leaf-electric-car/range
[5] According to FuelEconomy.gov and goelectricdrive.com EVs convert about 59–62% of the electrical energy from the grid to power at the wheels, conventional gasoline vehicles only convert about 17–21% of the energy stored in gasoline to power at the wheels. No matter what the source of electricity, re-charging the battery of an EV from a 120 or 240-volt outlet produces less than half the greenhouse gases of the most efficient gasoline or diesel-powered engine – at 20-25% of the cost-per-mile.
[6] http://www.chevrolet.com/volt-electric

the end of a battery's useful life, as well as during its production.[7]

2.1.4 Types of Charging Stations

Onboard rechargeable batteries power EV's electric motors. Charging an EV requires plugging into an electrical appliance designed specifically to charge batteries within one or more EVs. Electric vehicle supply equipment (EVSE), also called charging stations, is the equipment used to deliver electrical energy from an electricity source[8] to charge an EV battery. A charging station helps to get AC power safely from the utility to the on-board charger of the EV. The EV's on-board charger then converts the AC power to DC energy and charges up the battery with the assistance of the charging station. The charging station communicates with the EV to ensure that an appropriate and safe flow of electricity is provided[9].

Charging stations come in a variety of shapes and sizes. EV charging stations vary based on EV battery type and size, charger configuration, and circuit capacity. There are several categories of charging levels, based on how quickly they charge an EV[10]. There are over three dozen companies in the United States marketing charging stations. There are over one dozen makes and models of charging stations available for public use in Hawaii[11]. The selling of electricity by non-utility organizations is prohibited in Hawaii[12], however charging station owners could charge a fee for utilizing the charging station if they so choose. There are various ways to collect revenue for providing the service, such as subscription-based, pay-per-charge session, and pay for-parking programs.[13]

2.1.4.1 Level 1 Charging Station

Level 1 charging stations provide charge through a 120-volt, AC plug (i.e. U.S. household electrical outlet) and requires a dedicated branch circuit. Based on the battery type of the EV, Level 1 charging adds about 2 to 5 miles of range to an EV per hour of charge time. Level 1 charging is commonly used with PHEVs or in long term parking scenarios.

2.1.4.2 Level 2 Charging Station

Level 2 charging stations provide charge through a 240-volt, AC plug and requires the installation of specialized charging equipment and a dedicated electrical circuit. A 240-volt, AC outlet is commonly used to power larger appliances, such as dryers, stoves, or air conditioners. It can provide faster

[7] US DOE Alternative Fuel Data Center,www.afdc.energy.gov/fuels/electricity_benefits.html

[8] such as electrical outlets

[9] For Levels 1 and 2, the conversion of the utility AC power to the DC power required for battery charging occurs in the vehicle's on-board charger. In DC Fast Charging, the conversion from AC to DC power typically occurs off-board, so that DC power is delivered directly to the vehicle.

[10] The time required to charge depleted batteries — which can range from less than 30 minutes to almost a full day — depends on the type of EV battery, its energy capacity, how depleted it is, the size of the vehicle's internal charger, and the type of charging equipment used. BEVs generally have more battery capacity than PHEVs, so charging a fully depleted EV takes longer than charging a fully depleted PHEV.

[11] Hawaii EV Charging Station Database

[12] Hawaii Revised Statutes, Section §269-1 "Public utility shall not include any person who owns, controls, operates, or manages plants or facilities primarily used to charge or discharge a vehicle battery that provides power for vehicle propulsion." http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0001.htm

charging of EVs than a Level 1 charge, utilizing both higher voltage and current. Based on the battery type of the EV, Level 2 charging adds about 10 to 20 miles of range to an EV per hour of charge time. Many EV drivers will charge their vehicles overnight at home using Level 1 or Level 2 charging stations.

The Society of Automobile Engineers (SAE) International, in cooperation with major automotive manufacturers, charging equipment manufacturers and organizations from North America, Europe and Asia, adopted the North American design standard for Level 2 charging connectors for EVs, called the J1772 standard. This standard makes Level 2 charging stations compatible with the vast majority of EVs in the US market today.

2.1.4.3 Level 3 and DC Fast Charging Stations

A Level 3 AC (480 V) charging protocol is planned but is not currently on the market and there are no vehicles ready to accept this protocol.

In addition to the three AC charging levels, DC Fast Charging is available. These charging stations are the fastest charging level currently in the market. DC Fast Chargers bypass a vehicle's on-board charger, converting grid AC power to DC power outside the car and enabling rapid charging at sites.[14] Unlike Level 2 charging stations that take 3 to 8 hours to fully recharge a depleted battery pack, DC Fast Chargers can charge an EV from 20% capacity to 80% in approximately 30 minutes.[15] The standards for DC fast chargers are evolving and not all EVs have fast-charging outlets[16]. Most BEVs on the market today have the option to use the CHAdeMO DC fast charging connector, which was developed by Japanese auto-manufactures in coordination with Tokyo Electric Power Company. CHAdeMO is the trade name of a quick charging method for BEVs that delivers up to 62.5kW of high-voltage direct current via a special connector. The Japanese CHAdeMO standard is not the agreed upon standard in the United States, but was the first DC Fast Charger port widely available in the United States. The Nissan and Mitusbishi, support DC fast charging using the CHAdeMO standard.

SAE International has approved a United States hybrid DC Fast Charging standard and has decided not to support CHAdeMO as the international standard. The SAE standard "hybrid connector" or "combo plug" adds high-voltage DC power contact pins to the J1772 connector, enabling use of the same receptacle for all charging levels. The SAE International DC connector is supported by United States and European auto manufacturers. These charging stations are expected to be commercially available by the end of 2012 and vehicles using the technology are expected to be available in 2013.[17]

[14] For Levels 1 and 2, the conversion of utility AC power to the DC power required for battery charging occurs in the vehicle's on-board charger. In DC Fast Charger, the conversion from AC to DC power typically occurs off-board, so that electricity DC is delivered directly to the vehicle battery at a higher rate than the on-board chargers would allow.

[15] Plug in America, Hawaii EV Ready Guidebook for Commercial Electric Vehicle Charging Station Installations. The charging capacity of DC fast chargers varies. Some only deliver 20 kilowatts, but some experimental chargers deliver well over 100 kilowatts (in comparison, most 240-volt outlets will deliver 3.3 kilowatts). A 50-kilowatt charger would be more than enough to charge a Nissan Leaf to 80 percent capacity within half an hour (it has a 24-kilowatt-hour battery pack and less than 100-mile range). MIT Technology Review, http://www.technologyreview.com/news/429283/will-fast-charging-make-electric-vehicles-practical/

[16] GM's Volt doesn't have a DC Fast Charger port, for example

[17] Alternative Fuel Data Center, http://www.afdc.energy.gov/fuels/electricity_infrastructure.html

3 BACKGROUND

3.1 Hawaii's Historical Involvement with EVs

Clean transportation experts chart three "waves" of modern interest in EVs across the United States. The first wave was in the 1970s in response to the U.S. Clean Air Act, which dealt with tailpipe emission reductions. The second wave began in 1990 as a response to emerging concerns over global warming, and to California's Zero Emissions Vehicle regulation. The third wave started in 2002 as a response to oil dependency and the escalating price of oil[18]. In Hawaii a 4th wave of interest began in 2008 with the Hawaii Clean Energy Initiative (HCEI). HCEI was instrumental in the State of Hawaii being able to invest millions of dollar of federal funding from the American Recovery and Reinvestment Act (ARRA) to incentivize the deployment of EVs and installation of EV charging equipment. In the last decade, a broad spectrum of issues have converged to stimulate the consideration of electricity as an alternative fuel in the transportation sector.[19] Energy security concerns are another factor of this renewed interest in transport electrification in Hawaii.

3.1.1 EV Demonstration Projects

The Hawaii Center for Advanced Transportation (HCATT) was first established in 1993 as the Hawaii Electric Vehicle Demonstration Project to represent the Hawaii Consortium in the Defense Advanced Research Projects Agency's Electric and Hybrid Vehicle Technology Program. Aimed at spearheading efforts to incorporate EVs into Hawaii's fleets, the Demonstration Project was one of seven state EV programs around the United States. The Project was launched with a Memorandum of Understanding (MOU) that was signed by the Governor of Hawaii and the President of Hyundai Motor Company (HMC) to demonstrate and evaluate a fleet of Hyundai Santa Fe EVs. HMC EV's introduction to Hawaii served as a safe harbor test site for four years. In 1998 the Project initiated a program to make Hawaii the first state to have rapid charging infrastructure.

Today HCATT facilitates public and private partnerships between the federal government and private industry to develop advanced low emission and zero emission vehicles centered on electric drive technologies. Thanks to the success of the EV Project and partnerships, EV demonstration and pilot projects continue being deployed around the state.

3.1.2 Hawaiian Electric Companies and Better Place Agreement

Hawaiian Electric Companies and Better Place, an international developer of EV infrastructure and networks, signed an MOU in 2009 to promote acceptance and adoption of EVs in Hawaii. Cooperation is ongoing and includes data collection and research, education and promotion, network development and more[20].

Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric Company, Ltd. (MECO), and Hawaii

[18]Electric Vehicle Waves of History: Lessons Learned about Market Deployment of Electric Vehicles D. J. Santini Argonne National Laboratory http://cdn.intechweb.org/pdfs/18663.pdf

[19] Plug-in Electric Vehicles: A Practical Plan for Progress School of Public and Environmental Affairs at Indiana University http://www.indiana.edu/~spea/pubs/TEP_combined.pdf

[20]http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=f8b10c9853afd110VgnVCM1000005c011bacRCRD&vgnextfmt=default&cpsextcurrchannel=1

Electric Light Company, Inc. (HELCO) serve 95% of the state's 1.2 million residents on the islands of Oahu, Maui, Hawaii Island, Lanai and Molokai. For the purpose of this report Hawaiian Electric Companies (HECO) includes its subsidiaries.

3.1.3 Hawaii Renewable Energy Development Venture

The Hawaii Renewable Energy Development Venture (HREDV) mission is designed to help Hawaii businesses commercialize renewable energy and efficiency innovations to solve Hawaii's energy challenges. HREDV has been a strategic partner in the launch of Hawaii's EV industry and in 2010 recognized that EV charge networks and services can play a catalyzing role in Hawaii's transition to a clean energy economy.[21] During this same year, HREDV selected the company Better Place to conduct a pre-commercial EV network demonstration. In the twelve-month demonstration, Better Place developed expertise for planning and deploying EV network infrastructure, conducted testing of the integration of smart EV network infrastructure with utilities, and collected vehicle, battery operation, and user behavior data[22], which will be used to help optimize EV network infrastructure for future commercial build out. The project included Better Place's EV network and services, PHEVs, and charging equipment sites with dedicated EV parking.

3.2 Why EVs in Hawaii

Growth in Hawaii's EV market has attracted emerging new technologies and projects, national and international business investments, federal funding, and smart grid projects. The arrival of mass market EVs presents an opportunity for Hawaii to reduce imported oil while boosting economic development and strengthening Hawaii's energy and economic security. Modernizing the electric grid, utilizing new energy supplies, and building EV supporting infrastructure will result in a cleaner environment, an improved quality of life and a stronger economy for Hawaii.

3.2.1 Hawaii Clean Energy Initiative

The EV movement in Hawaii was rejuvenated in 2008 with the signing of the HCEI, a partnership between the State of Hawaii and the U.S. Department of Energy. HCEI was launched with a goal to reduce Hawaii's dependence on imported fossil fuels and to move towards locally-produced renewable energy for Hawaii's electricity and transportation needs. HCEI seeks to achieve a 70% clean energy economy by 2030, with 40% of Hawaii's electricity from renewable resources and 30% from energy efficiency measures. Hawaii cannot achieve this ambitious clean energy goal without tremendous progress in reducing the amount of petroleum needed by Hawaii's ground transportation sector. Currently the HCEI ground transportation targets call for displacing 385 million gallons of petroleum per year (MGY) by 2030.

Each of the strategic pathways that follow represents a segment towards achieving the goal of reducing Hawaii's transportation sector petroleum demand by 2030. The HCEI goals are not projections but rather very aggressive targets. Unlike the more heavily regulated electricity and efficiency sectors, transportation does not have goals mandated by statute, therefore the pathways to achieving the HCEI transportation goals are recommended approaches and rely heavily on influencing personal behavior.

[21] Hawaii Renewable Energy Development Venture, http://www.hawaiirenewable.com/investments/better-place/
[22] driving and charging patterns

The potential petroleum displacement calculated for each of the following strategic pathways leads to the overall HCEI goal:

- Accelerate the deployment of EVs, 75 Million Gallons
- Expand the use of alternative/ biofuels for transportation, 150 Million Gallons
- Improve the efficiency of the standard vehicle fleet, 120 Million Gallons
- Reduce the overall number of vehicle miles traveled, 40 Million Gallons[23]

3.2.2 Ideal Conditions for EV Deployment

Hawaii's renewable energy resources[24] and high energy costs make it the ideal location in the US to implement renewable energy technologies and integrate them with EVs. Additionally, Hawaii's favorable warm climate and range (limited by geography and defined boundaries) enables a greater opportunity for efficient deployment and monitoring of EVs and their charging infrastructure.

3.2.2.1 Energy Resources

Hawaii currently generates about 12 percent of its energy from renewable resources such as wind, solar, geothermal and biofuels. Hawaii ranks third in the nation for cumulative installed photovoltaic capacity per capita.[25]

3.2.2.2 High Energy Costs

Hawaii has the highest electricity prices in the nation[26], more than three times higher than the U.S. average[27]. This is due to Hawaii's over-dependence on petroleum-based fuels and Hawaii's six separate electric grids, which are small and isolated. Hawaii's gasoline prices are consistently higher than the national average serving as a catalyst for consumers to consider fuel efficient vehicles. Hawaii's gasoline prices are. From 2006 to September 2012, the monthly state average regular gasoline prices ranged from $2.80 to $4.39 per gallon, whereas the national average ranged from $2.29 to $3.83 per gallon.

3.2.2.3 Climate

Hawaii's climate is ideal for optimum performance of an EV battery. Lithium ion batteries (most common EV batteries today) operate best in a climate with temperature ranges of 20-35°C[28], which is the average climate range of Hawaii. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy finds battery temperature affects vehicle performance, driving range, overall life, reliability, and safety. [29]

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[23] The HCEI Road Map 2011 Edition sets out the Steering Committee and working groups' long-term strategy toward energy independence. http://www.hawaiicleanenergyinitiative.org/storage/media/HCEI%20RoadMap_2011_40pgs.pdf

[24] including solar-power potential

[25] Clean Energy Update, 2012 HECO

[26] $0.32 vs. $0.10 per kWh.

[27] Hawaii is 77% dependent on oil for electricity; the U.S. average is 1%.

[28] 68°- 95°Fahrenheit

[29] US Department of Energy (2012) Automotive Li-ion Battery Cooling Requirements Energy Storage. Cunningham, Brian. R&D Hybrid and Electric Systems Team Vehicle Technologies Program
http://www1.eere.energy.gov/vehiclesandfuels/pdfs/thermoelectrics_app_2012/wednesday/cunningham.pdf

3.2.2.4 Range

Island driving with short commutes are ideal conditions for EV drivers.[30] Thus, assuming a full BEV charge at the start of a commute, typical driving patterns can be powered on a single charge. Although the limited land area of Hawaii makes the islands well-suited for BEVs, providing a charging network sufficient to overcome the fear of running out power is still a challenge.

3.2.3 Opportunities with Hawaii's Tourism Industry

EVs can provide an economic incentive and strategic synergy with the tourism industry, the largest economic sector and single source of private capital in Hawaii. As a world-class tourist destination and central hub for international business travel, Hawaii is uniquely positioned to be an international showcase and an ideal test bed for EV technology implementation.

Hawaii's tourism and hospitality industries have a significant opportunity to influence EV adoption rates by supporting the emerging "eco traveler" market and an undeveloped market: the "EV traveler". Integrating EVs with Hawaii's tourism industry creates opportunities for auto companies to showcase EVs to a new customer base, rental cars agencies and hotels to offer new experiences in transportation. By demonstrating the safety, reliability, real world performance and benefits of EVs, rental fleet operators could help to bring EVs to the marketplace in greater numbers by improving consumer perception and confidence. Some rental car agencies[31] in Hawaii have begun incorporating EVs into their fleets as part of their corporate social responsibility strategy, as a way to help lower operating costs, and to help reach the HCEI goals, demonstrating their commitment to energy security. In addition to the EV traveler, visitors may have EVs at home and may prefer to drive electric while on vacation.

3.2.4 Hawaii's Favorable EV Policies

Enacting policies supporting Hawaii's young EV market has been a key strategy by stakeholders and leaders, sending signals to businesses and the public that there is a value in improving energy infrastructure in Hawaii. As a result, there has been a local commitment to support a state regulatory structure favorable to EVs since the late 1990's. Consequently, Hawaii has become a national leader in establishing policies designed to promote the electrification of transportation.

The following list of policies adopted by Hawaii State Legislature were the first of their kind in the United States and have significantly contributed to the decision of EV manufacturers to target Hawaii as early launch market for EVs.[32]

- Free parking in State and County Government lots and facilities including parking meters (Act 168 of 2012 formerly Act 290 of 1997)
- Access to High Occupancy Vehicle (HOV) lanes (Act 168 of 2012)
- Public accommodations with at least one hundred parking spaces available for use by the general public shall have at least one (1) parking space exclusively for EVs and be equipped with an EV charging system. (Act 089 of 2012, formerly Act 156 of 2009)

[30] 9,020 Hawaii Annual vehicle miles of travel per vehicle, 2011 DBEDT Energy Data Book

[31] Enterprise Rent-A-Car and GreenCar see section 4.2.3, Hawaii Rental Car Agencies Integrate EVs into Fleet

[32] Reference Appendix B for Hawaii EV Laws

- EV definition to include electric and plug in hybrid EVs[33]
- EV charging station requirements in multi-family residential dwellings or townhouse (Act 186 of 2010)

3.2.5 Reduce Hawaii's Reliance on Fossil Fuels

The vast majority of Hawaii's fuel for electricity generation, as well as transportation, is imported into the State from outside sources. By encouraging Hawaii drivers to adopt EVs as an alternative to conventional ICE vehicles, Hawaii's dependence on imported petroleum can be greatly reduced. Analysis[34] shows that the energy value in a gallon of oil used to generate electricity results in further miles traveled in an EV than a gallon of gas used in a conventional ICE vehicle. Because energy is more efficiently used in *the power plant-battery-EV* sequence than energy provided directly to the ICE vehicles, Hawaii would use less oil generating electricity for EVs than would be used in refining gasoline for conventional ICE vehicles.

3.2.6 Integrating EV Battery Storage with Renewable Energy

The deployment of EVs in Hawaii is occurring concurrently with the expansion of renewable electricity on Hawaii's electrical grid. The State of Hawaii has established a 40% Renewable Portfolio Standard (RPS), by 2030[35]. It is expected that by 2015 there will be enough renewable energy sources connected to the electrical grid to provide approximately 15% of the state's electricity needs.

What makes EVs unique is their ability to charge from an off-board electric power source[36]; EVs can be plugged in and take advantage of local renewable energy by storing it in batteries. By facilitating the development of renewable energy sources and EV projects in parallel, as Hawaii's grid gets cleaner, so will the vehicles. EVs in Hawaii may initially be charged from petroleum generated electricity. As more renewable generation is added to the grid, EVs will help to displace petroleum as a transportation fuel.

3.2.6.1 Battery Storage

Hawaii's motivation to reduce dependency on imported oil and switch to local, renewable energy sources presents an opportunity to utilize EV's battery storage to take advantage of intermittent solar, wind, and other clean energy resources. EV batteries can charge from renewable energy most importantly that which is generated at night, which otherwise might be wasted. This is true to a certain extent today, with biomass on Oahu, wind on Maui, and geothermal on the Island of Hawaii, and is expected to be even more important in the future as more renewables are added to the grid. If EV battery charging is controlled so that the rate of charging, or the amount of energy per unit time that is being added to the battery, can be adjusted based on the grid's demand, it could help electric utilities to manage certain types of grid challenges caused by intermittent power sources[37]. This provides an

[33] As of July, 2012 County vehicle registration agencies in Hawaii are now required to define all types of EVs as Electric. For example, the plug-in Toyota Prius Hybrid qualifies as an EV.
[34] Reference Appendix A for performance and costs analysis of EVs vs. ICE vehicles
[35] The goal under HCEI, officially adopted into state law in 2009, is to achieve a 15% RPS by 2015, 25% RPS by 2025, and 40% RPS by 2030.
[36] generally the electricity grid
[37] An intermittent energy source is any source that is not continuously available. Solar energy is an example of an intermittent energy source since it is only available when the sun is shining. Wind is also an intermittent energy source.

example of how EV batteries have the ability to take *in* electricity in varying quantities and at varying times.

EV batteries could, theoretically, also put *out* varying quantities of electricity. For example, they could provide energy back to the grid to help firm it up. Or, the power could be provided to critical loads, to keep them running. This is currently under development. An example of this today is if the power is our at your house, and your cell phone is running low on battery power, you plug it in to your car's cigarette lighter port.

Most vehicles sit idle over the course of a given day, so they can become de facto energy storage devices if their batteries are plugged into the grid when they are not in use. With smart grid infrastructure in place, EVs can become an essential component to electricity load and clean energy resource balancing-in m addition to providing clean mobility solutions for Hawaii residents.[38]

3.3 Challenges to EV Adoption and Deployment in Hawaii

This section will explore the most formidable challenges and barriers to widespread adoption and deployment of EVs in Hawaii. Understanding these challenges can provide insight to potential solutions and opportunities.

3.3.1 Initial Vehicle Cost

The largest barrier to EV market growth is cost. Price point is the single most important factor consumers consider when deciding to purchase a vehicle. Consumers are generally more willing to purchase new vehicle technologies, such as hybrids or EVs, instead of conventional ICE vehicles if the economic benefit over a period of ownership is greater than the initial price of the vehicle. However, consumers may also be unwilling to spend more to purchase a vehicle, even if it accrues fuel cost savings beyond the initial cost over a relatively short period of time, if they are unfamiliar with the new technology or alternative fuel. Additional costs and benefits—such as refueling time or difficulty of refueling, increased or decreased maintenance, and resale value—also enters into vehicle choice decisions.[39]

EVs have a greater initial purchase price than the average consumer is willing to spend, ranging from mid-$30,000 to $40,000. The battery and advanced drivetrain system costs result in a higher purchase price as compared to conventional ICE vehicles. With vehicle purchases generally the second largest financial purchase most families make, behind housing, cost is considered carefully[40]. According to former General Motor's executive Bob Lutz, "price of fuel is a huge factor in making the EV viable, where 5% of Americans that will buy an EV for societal or environmental reasons the other 95% say, 'what's in it for me?" [41]

[38] Blue Planet Foundation
[39] Annual Energy Outlook 2012, U.S. Energy Information Administration
[40] US Department of Energy. One Million Electric Vehicles By 2015, February 2011 Status Report http://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf
[41] EVS26 GoElectric Plenary on May 9, 2912

3.3.2 Recharging time and Range Anxiety

EVs face significant battery-related challenges such as driving range and recharge time, consequently the same reasons consumers often choose not to purchase BEVs. Fully recharging a BEV battery pack can take 4 to 8 hours. Even a "quick charge" to 80% capacity can take 30 minutes. The majority of commercially available BEVs have a shorter driving range as compared to the mileage of conventional ICE vehicles.[42]

Most drivers rarely commute more than 25 to 50 miles a day, which is well within the range of a fully charged BEV.[43] Even with Hawaii's limited geographic boundaries, "range anxiety" serves as a major impediment to purchases and public acceptance of BEVs. Range anxiety in Hawaii means "non-typical trips" driving from town centers to major beaches and "hard-to-reach" popular destinations may be limited. While the majority of charging will be done at the lowest cost and where most convenient, most often at home and work, tourists and locals alike will require public charging stations to refuel their vehicles. Without easy access to charging stations Hawaii's drivers and visitors are restricted to destinations with charging availability.

3.3.3 Cost of Installing Charging Stations

Increasing the number and visibility of public charging stations can help to reduce range anxiety of EV drivers, market a "green" image of Hawaii, and assist companies in achieving Leadership in Energy and Environmental Design (LEED) credit. Despite the benefits mentioned, there are several obstacles to installing charging stations for public use.[44] Benefits can be outweighed by high installation costs and potential low utilization[45].

The cost of public EV charging equipment installation varies, depending on a parking lot site conditions, vehicle access, cost of product and cost of installation. Installation costs are influenced by site location and specific charging station placement, availability of electrical capacity and transformer, distance from the electrical panels to charging station and site specific installation issues such as trenching.

Based on data collected by the State Energy Office, charging station installations [46] in Hawaii can range from $4,000 to $25,000. A relatively simple project in Hawaii typically costs approximately $6,000-$8,000 per station, however prices vary considerably.

3.3.4 Installing Charging Stations at Condos and Apartments

A very important sector for the deployment of EV charging stations in Hawaii are multiple unit dwellings (MUDs), such as condominiums, apartments and townhomes. These housing segments make up a

[42] BEVs usually have a range of 80 to 120 miles before re-charging is required. PHEVs typically have an electric range of 10 to 40 miles, and an overall driving range of 300-400 miles. The range depends, in part, on driving conditions and habits in addition to manufacture specifications. http://goelectricdrive.com/index.php/faq-glossary

[43] The US Federal Highway Administration reports that average US drivers log 29 miles per day and the average vehicle trip length is 9.7 miles.http://www1.eere.energy.gov/vehiclesandfuels/facts/2012_fotw728.html

[44] Reference section 4.5 Developing Hawaii's Public Charging Network

[45] Data from General Motors, shows that USA vehicles spend more than 90% of their existence parked at home or at work. http://www.aprs.org/Energy/Charging/IEEEpaper.pdf

[46] Costs associated with installing a Level 2 charging station. Level 2 charging stations are widely installed across Hawaii.

significant percentage of Hawaii's housing market.[47] As of this report, few EV charging stations have been installed at MUDs.

Installing charging stations in shared parking scenarios is more complex than in a single-family residence garages because parking supply is generally low and the ownership or access of parking stalls can further complicate installation. The greatest challenges to installing charging stations in MUDs is in complexes where electric meters and electricity supply are spaced far from the preferred EV stall, parking spaces are deeded or allocated, and financing or billing mechanisms are not in place for residents or guests to charge their vehicle.

Stakeholders in Hawaii are working to solve the challenges of installing charging stations in MUDs. The Hawaii State Legislature helped to address this challenge by passing Act 186 in 2010[48]. This law permits a resident to install an EV charging station on or near the parking stall of any MUD owned by that person, and also permits private entities to adopt rules reasonably restricting the placement and use of stations provided that those restrictions do not prohibit charging stations altogether.

3.3.5 Grid Interconnection and Impact Due to EV Adoption

Research to understand the long-term impact of EV's on Hawaii's grid is being conducted with data from deployment projects and help from HECO. Early analysis[49] of potential EV impact found some variables affecting transformer life span are: transformer loading, EV adoption rate, vehicle mileage, and charging rate. Higher on-board charge rates[50], DC Fast Charging, and vehicles charging in concentrated locations (such as residential neighborhoods) could shorten the life expectancy of residential transformers. If the number of EVs increase faster than Hawaii's utilities can adapt to, it could stress the delivery capacity of the utility[51]. To help manage demand on the grid, favorable Time of Use Rates (TOU) can influence and manage the time of day when EV drivers choose to charge their vehicle[52]. However, even at the highest forecasted adoption rate, HECO does not predict issues in coming years. HECO is currently monitoring and studying the impacts of EV charging. Accurate models of EV adoption and charging infrastructure installations are essential to planning for future grid demand management.

3.3.6 Hawaii's Vehicle Turnover Rate

EV adoption in Hawaii is influenced by the price of oil, vehicle price and availability, convenient and affordable EV charging, financial and non-financial incentives, and consumer perception. Replacing low fuel economy vehicles with fuel efficient vehicles will accelerate ground transportation sector fuel savings. EVs represent a technology which will contribute significantly to the state clean energy goals.

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[47] According to the 2010 census, over 35% of occupied housing units in the State of Hawaii are not single-family homes.http://hawaii.gov/dbedt/info/census/acs/ACS2010/ACS2010_1_Year/subject_table/ACS_10_1YR_S2504.pdf

[48] Hawaii Revised Statues 196-7.5 http://capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0196/HRS_0196-0007_0005.htm

[49] The National Renewable Energy Laboratory

[50] The charging station is supplies energy—the actual device that regulates charging speed is on-board the car. The on-board charger determines the speed and rate of charge. Ford Focus has an onboard charger has a capacity of 6.6 kilowatts. All the other EVs, and the Chevrolet Volt, are limited to 3.3 kW. http://www.plugincars.com/how-fast-can-you-really-charge-your-plug-car-answer-more-complicated-you-think-64616.html

[51] Example: BEV owners coincidentally charge, only at Level 2 at the weekday priority peak (5:00p.m. to 9:00p.m.)

[52] http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=472f2b244c40a210VgnVCM1000005c011bacRCRD&vgnextfmt=default&cpsextcurrchannel=1

Understanding Hawaii's vehicle turnover rate and vehicle lifetime is critical to defining Hawaii's EV market penetration potential. In Hawaii roughly 50,000 vehicles are purchased or replaced per year, indicating average vehicle life is 20 years.[53]

Based on average vehicle life, it will take 20 years for a complete turnover of vehicles in operation today; vehicles purchased this year are counted towards projections for 2030, the HCEI target year. Based on information provided to the State, roughly half of the vehicles sold in Hawaii are passenger cars and the remainder is made by light duty trucks. [54] As of the writing of this report the majority of EVs available for sale in the United States are in the passenger car class. Vehicle turnover rate and sales trends will influence the long term adoption rate of EVs in Hawaii.

3.3.7 EV Adoption Rate in Hawaii

EVs currently represent 1% of new car purchases in Hawaii.[55] According to an October 31, 2012 Edmunds.com press release[56], Hawaii ranks 10th in the nation for EV registrations, with 2.9% of all EVs sold in the country in 2012 being in the islands. Today, there are approximately 1,098 licensed EVs in Hawaii (reference table below) and another 13,268 hybrid vehicles (no plug)[57].

Notable progress has been made in Hawaii's EV sales, installing charging infrastructure, attracting auto manufactures to launch EVs in Hawaii's small vehicle market, and generating national and international investment. However, this progress does not meet the growth levels needed to achieve market penetration to substantially impact the HCEI ground transportation goals. Purchase of EVs in Hawaii is still in the "early adopter" category. Moving beyond early adopters (hundreds of vehicles) to mass market penetration rates (thousands of vehicles) will require overcoming challenges, especially as government subsidies[58] expire.

Table 2: Number of Registered EVs in Hawaii per County as of November 2012[59]

County	Electric Vehicles (Passenger)
Oahu	845
Hawaii	79
Kauai	29
Maui	145
State of Hawaii	**1098**

3.3.8 Dealership Challenges

Hawaii's local vehicle dealers are essential partners in establishing a thriving EV market. One challenge dealers face selling EVs is educating the consumer on differences from conventional ICE vehicles. This

[53] Approximately one million vehicles in the state/50,000 vehicles replaced per year = 20 years for a complete turnover of the fleet. Reference Appendix C for new retail vehicle registrations by year
[54] Reference Appendix D Hawaii New Retail Car and Light Truck Registrations
[55] Department of Business, Economic Development and Tourism, Monthly Energy Trends Report
[56] http://www.edmunds.com/about/press/hawaii-buying-electric-cars-at-supercharged-rate-reports-edmundscom.html
[57] Hybrids have taken over ten years to reach their current figure in Hawaii and are in basic alignment with national hybrid adoption average of 2% of annual sales.
[58] The Hawaii EV Ready Rebate program expired May, 2012. The Federal tax credit for EVs currently ranges from between $2,500 to $7,500. For more information, reference IRS Plug-In EV Credit (IRC 30 and IRC 30D)
[59] Department of Business, Economic Development and Tourism, Monthly Energy Trends Report

requires additional time and knowledge base by the dealer than a typical ICE vehicle sale. Beyond the sale, local dealers will also encumber the cost of certification.

Auto dealers are required by the automakers to complete a certification process in order to sell and service EVs. Certification means the dealership has met the automaker's guidelines for selling EVs, including, but not limited to, purchasing specialty tools, installing on-site charging stations and participating in specialized EV training. The certification process can be a costly investment for local dealers.[60]

The lack of EV dealerships and trained technicians can influence the deployment and allocation of EVs in Hawaii and creates challenges for islands without certified EV dealers. For example, dealerships opting out of the certification process could leave EV owners without a local dealer or service station. Consumers may be wary of purchasing an EV without having a local service station on island. While shipping the vehicle to another island with a certified dealer is feasible, it would be a costly and time consuming option. Part of the challenge in expanding the EV market includes encouraging dealers on all islands to become EV certified.

Of the 66 dealerships in Hawaii, nearly 25 are EV certified or in the process of becoming EV certified. Today, at least four major EV models are available in Hawaii.

Table 3: Number of certified EV dealers by County and available EV models[61]

Hawaii EV Dealers by County					
County	Nissan Leaf	GM/Chevy Volt	Mitsubishi iMiEV	Toyota Plug-in Prius	Ford Focus EV (early 2013)
Oahu	3	3	1	3	3
Maui	1	1	0	1	1
Hawaii	0	1	0	2	0
Kauai	1	1	0	1	1

The following manufactures have announced launch markets which do not yet include Hawaii. These manufactures are considered a top priority to increase EV presence in the state.[62]

- Tesla (All models)
- BMW (Active E)
- Honda (Fit EV)

4 THE CASE STUDY: CREATION OF AN EV MARKET IN HAWAII

4.1 The Hawaii EV Ready Program

As the EV market re-emerged in the US, the State of Hawaii recognized a need to invest in EVs and related charging equipment. The American Recovery and Reinvestment Act of 2009 (ARRA), directed a significant amount of funding for energy activities to states across the nation. Nearly five million dollars of the ARRA project funds for the Hawaii State Energy Program were designated for use in the Hawaii

[60] One Hawaii Nissan LEAF dealer reported paying over $90,000 dollars for certification.
[61] Hawaii Auto Dealers Association
[62] Plugincars.com and pluginameria.com maintain up-to-date information on current and prospective EVs

Transportation Energy Diversification's EV Ready Program.

EV adoption in Hawaii faced a paradox: the installation of charging stations to encourage vehicle sales was dependent on vehicle sales to encourage charging station installations. The Hawaii State Energy Office worked to resolve this challenge by launching the EV Ready Program. This effort consisted of a Grant program and a Rebate program.[63] These programs were designed to stimulate Hawaii's EV market demand, support companies entering the market, alleviate initial costs for the purchase and installation of EV charging stations, and establish a charging network.

The Rebate program targeted individual sales by providing rebates for the purchase of EVs and charging stations. The Grant program provided funding for the deployment EVs and the installation of charging stations via multi-site, multi-partner projects.

4.2 Aligning EV Stakeholder Partnerships and Involvement

The Hawaii State Energy Office created a Vehicle Specialist position to manage the Hawaii EV Ready program and to facilitate the deployment of EVs in the Hawaii market via creating strategic partnerships with EV and transportation stakeholders.

4.2.1 State of Hawaii EV Stakeholders

Understanding stakeholder viewpoints was critical in assisting EV deployment and adoption, and beneficial in understanding the barriers and opportunities facing Hawaii's EV market. Due to Hawaii's size and small business community there exists a unique opportunity and strategic advantage for Hawaii's stakeholders to work together. The following is a list of key Hawaii EV stakeholders:

- Hawaii Clean Energy Initiative Transportation Working Group Members
- National Renewable Energy Lab
- Hawaii State and County Agencies: Department Commerce Consumer Affairs , State and County Motor Pool, Center for Appropriate Transportation Technologies, Department of Accounting General Services, Department of Transportation, Department of Planning, Permitting & Public Works, Mayor's office and related departments
- University of Hawaii: Hawaii Natural Energy Institute, Hawaii Energy Policy Forum, UH Economic Research Organization, and UH Maui College Maui EV Alliance
- Honolulu Clean Cities Coalition
- Hawaiian Electric Companies & Kauai Island Utility Cooperative
- Hawaii Auto Dealers Alliance
- Alliance of Automobile Manufactures
- Hawaii Renewable Energy Development Venture
- EV suppliers and manufactures with presence in Hawaii: Better Place, AeroVironment, Volta
- Oahu Metropolitan Planning Organization

[63] The EV Ready Program also allocated $475,500 to the State of Hawaii's Department of Accounting and General Services Automotive Management Division. The Division's State motor pool purchased a total of10 EVs (Chevrolet Volts and Nissan LEAFs) and installed over a dozen level two charging stations at the state motor pool and in state owned public parking lots.

- Hotel Associations
- Condominium Associations
- Parking Management Companies
- Commercial Property Owners and Home/Apartment Owners Associations
- Rental Car Agencies, including Enterprise Rent A Car and Green Car Hawaii
- Department of Defense: Hawaii military bases
- State Legislators: House Representatives and State Senators

4.2.2 Hawaiian Electric Company provides EV Time of Use Rates

To support Hawaii's EV readiness effort, the HECO began the EV Charging Rate Pilot Project offering residential and commercial EV TOU pilot rates in October 2010. The pilot EV TOU rates are designed to encourage the adoption of EVs and incentivize drivers to charge EVs during off-peak times that are beneficial to grid stability.

The commercial and residential EV TOU pilot rates are open to 1,000 customers on Oahu, 300 in Maui County, and 300 in Hawaii County. HECO offers a cost lower than the standard rate for charging EVs during periods of low energy demand on the grid (typically overnight while most people are sleeping). HECO's "off-peak" is during 9:00 p.m. to 7:00 a.m. every day and anytime on weekends for residential and commercial EV TOU rates. Charging during "peak hours" 7:00 a.m. to 9:00 p.m. on weekdays for all EV rates and weekends for rate EV TOU will be at higher than the standard rate. A residential customer has the option to charge their EV and use the TOU rate under a single house meter or under a separate meter used only for charging.

The EV TOU off peak rate is about six cents per kilowatt hour (kWh) *below* the standard residential rate on Oahu. Residential customers under the EV TOU may still charge EVs during peak hours at a higher rate, about two to five cents (for TOU EV priority peak) *above* the current residential rate. EV TOU rates have the ability to provide consumers with financial incentive to shift high-energy consuming appliances, such as flat screen TVs, dish washers, washing machines and dryers to off peak times in addition to EV charging.[64] HECO reports that roughly one fourth of known EV customers have enrolled in the EV TOU pilot rates. Of these approximately one third of the participants are charging at Level 1.

4.2.3 Hawaii Rental Car Agencies Integrate EVs into Fleet

Enterprise Rent-A-Car and Green Car Hawaii both began renting EVs to customers in 2011. Enterprise Rent-A-Car was the first agency in Hawaii to offer EVs for rent and introduced the Nissan Leaf to their Oahu fleet, and currently has approximately 30 EVs for rent. Green Car Hawaii, a newcomer to Hawaii's rental car industry, began renting EVs by the hour directly through Kauai and Oahu hotel and timeshare properties.

[64] goev.heco.com

4.3 Automakers Take Notice

The Hawaii State Energy Office and Hawaii Auto Dealers Association (HADA)[65] gained support from multiple EV manufactures through coordinated efforts, and convinced manufacturers to make Hawaii a priority early launch market. Requests for EV allocation in Hawaii were strengthened by educating manufacturers on Hawaii's favorable EV policies, ideal environment for EV use, government incentives (ARRA funded EV Ready Grant and Rebate Program) and State initiated HCEI goals. The State Energy Office was able to make the case to manufactures that Hawaii is well situated to showcase EV adoption and renewable energy integration. The State Energy Office was able to persuade the following manufacturers that Hawaii is ideally situated to showcase EV adoption and renewable energy grid integration, resulting Hawaii's selection as an early launch market.

4.3.1 Nissan North America

Nissan agreed to select Hawaii as an early launch market and deploy the BEV Nissan Leaf on the condition that the State would meet the following requirements:

- A regulatory framework that promoted the introduction and use of EVs
- Incentives for consumers and users of EVs
- Establish a comprehensive state-wide EV charging network
- Purchase or lease of EVs by State government and other public institutions
- Expedite the permitting and inspection process for Level 2 EV infrastructure installation in homes

In August 2010, the State announced a partnership with Nissan North America. The partnership involved a Definitive Agreement which committed Hawaii to prepare for the arrival of the Nissan Leaf and to promote the development of charging networks throughout the state. The partnership was Nissan's in the United States and helped pave the way for the deployment of the BEV Nissan Leaf in Hawaii. Nissan targeted a January 2011 deployment of the BEV Nissan Leaf. Shortly after the launch announcement in August, Nissan North America reported 1,400 Leaf "hand-raisers" and over 400 reservations[66].

4.3.2 Mitsubishi Motors North America

Mitsubishi Motors signed a MOU with the State of Hawaii in June 2011 formalizing cooperation on a statewide EV deployment and infrastructure development. In December 2011, Hawaii was the first location in the United States to receive Mitsubishi's EV made for North American consumers, the iMEV.

[65] HADA has played a critical role in Hawaii's deployment of EVs. HADA has developed a committee "to guide in the deployment of the new automotive technologies that use renewable fuels, or conserve fossil fuels and use them more efficiently," and has made energy a top priority. HADA has developed dealer EV readiness training and education, facilitated the installation of EV chargers at local dealerships, and coordinated "free shipping" of EVs from the West Coast to be featured at the annual First Hawaiian International Auto Show. On an annual basis the Auto Show showcases EVs and partners with HECO to provide information regarding the benefits of EV driving. HADA also awarded a Mitsubishi iMEV for the use of a year to the winner of Hawaii's 2012 State Teacher of the Year.

[66] According to Nissan North America, the top 7 states in order were: California, Washington, Texas, Oregon, Tennessee, Arizona and Hawaii. May 2012.

4.3.3 Ford

In April 2011, Ford named the City and County of Honolulu as a top 25 U.S. city paving the way for an influx of EVs.[67]

4.3.4 Chevrolet

Chevrolet began delivering Volts at participating Hawaii dealers in the third quarter of 2011. During the fourth quarter, Chevrolet began delivering Volts in all 50 states.

4.3.5 Toyota

As an initial launch state, the Prius Plug-in was made available at participating Hawaii dealers starting in the first quarter 2012, almost a full year before Toyota plans to open up availability to other states.

4.4 EV Ready Rebate Program

The Hawaii EV Ready Rebate Program was launched in August 2010. Designed to support local auto dealers; residents, businesses, government agencies and non-profit entities were eligible for rebates after purchase of EVs for use in Hawaii and after purchase and installation of EV charging equipment. EV Ready Rebate Program funding ran through April 2012.

EV Ready rebates were approved up to 20% of the EV purchase price, up to a maximum of $4500 per vehicle, and were restricted to one rebate per applicant. Rebates for charging equipment were approved up to 30% of the charging system cost, including installation, up to a maximum of $500. Residential applicants applying for charging station rebates were restricted to one charging station rebate per residence. Commercial applicants applying for charging station rebates were restricted to a one station per facility, or parking lot. Due to limited funding, the scope of the Program did not have the capacity to provide rebates for large fleet purchases. Eligibility for EV rebates was determined by the list of vehicles approved by the Internal Revenue Service for the Qualified Plug-in Electric Drive Motor Vehicle Credit. Charging equipment was required to be tested and certified by a nationally recognized testing laboratory, installed in compliance with Federal, State, and County laws, codes, and regulations, and in compliance with industry standards to receive a rebate. The State Rebates were subject to both Federal and State income taxes. Vehicles or charging stations funded under the Grant Program were not eligible for additional funding under the Rebate Program; similarly, vehicles and charging equipment funded under the Rebate Program were not eligible for additional funding under the Grant Program.

The Rebate Program helped to drive EV sales and dealer readiness while proving 455 rebates for EVs, and 279 charging station rebates across Hawaii.[68]

4.4.1 EV Allocation Lessons Learned

Initially manufacturers allocated a limited number of EVs to local auto dealerships resulting in a limited inventory of EVs to meet consumer demand. The greatest barrier dealers faced was the complex delivery process and extended delivery time. In some cases, consumers waited up to three months

[67] http://www.accenture.com/us-en/Pages/insight-changing-game-plug-in-electric-vehicle-pilots.aspx

[68] Reference Appendix F for a breakdown of EV Ready Rebates for Chargers and EVs by island.

before they could take possession of an EV shipped directly from the manufacturer. Without surveying, the State Energy Office cannot accurately estimate the impact of the "wait list effect" on consumer choices and decisions regarding the purchase of an EV or a conventional ICE vehicle. It is safe to say that most early EV adopters, fascinated by the technology, were more willing to put up with delays than the average consumer accustomed to driving their new car off the dealer's lot the same day they sign the purchase documents. The allocation problem seems to have subsided; today, most Hawaii dealers report available EV inventory.

4.4.2 EV Ready Grant Program

The Hawaii State Energy Office launched the EV Ready Grant Program to attract and partially fund the deployment of commercial EV charging stations and to accelerate the adoption of EVs. The EV Ready Grant Program helped to install over 230 Level 2 EV charging stations and six DC Fast Chargers at over 95 locations across Hawaii. Per the Grant Program, though a competitive solicitation process, six organizations were granted a total of $2.3 million dollars to promote, install, and deploy charging stations and EVs across the state. The grants were awarded to Better Place, AeroVironment, GreenCar, County of Kauai, City and County of Honolulu, and Plug In America. These organizations completed projects including the charging station installations, outreach and education, data collection, establishing an online permitting program, purchasing EVs.[69]

4.5 Developing Hawaii's Public Charging Network

Thanks largely to the success of the EV Ready Program, Hawaii has surged to the national forefront for the deployment of public charging stations and is currently the nation's leader for public EV charging stations on a per capita basis. In August 2012, Hawaii was recognized for its successful EV Ready Program, selected as one of the top 10 most EV-ready cities in the U.S.[70] by Plug Share, the community-driven EV mobile and web application to find and share public and private EV charging stations.

A locally managed EV charging station mapping tool is currently being developed and will launch early 2013 for smart phone application and web use. The new EV tool will provide EV drivers with mapping directions and location information to the growing network of charging stations across Hawaii.

Table 4: Publically Available Charging Stations per County[71]

Island	Charging Stations	Ports[72]
Oahu	170	182
Hawaii	23	37
Kauai	19	22
Maui	30	36
State of Hawaii	**242**	**277**

[69] Reference Appendix G for greater details on the EV Ready Grant Program awards and accomplishments
[70] by for public charging locations per 100,000 residents based on 2010 Census data
[71] Hawaii EV Charging Station Location Database, electricvehicle.hawaii.gov
[72] 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. Hawaii EV Charging Station Database, electricvehicle.hawaii.gov

4.5.1 Recruiting Level 2 Charging Station Host Site Locations

EV Ready Grant recipients identified and selected priority commercial charging station locations across Hawaii based on cost, location and access. EV Ready grantees, Better Place and AeroVironment, identified, pre-selected, and assessed top choice public charging station locations, yet later found that some priority sites were not interested in hosting charging stations and declined a contract. [73] Ultimately, many of the original proposed locations ended-up being very different from the final installed charging station's locations. The final locations were influenced by local businesses that were agreeable to the investment. The following bullet points describe the lessons industry representatives learned when *selecting* charging station site locations:

- Charging station representatives should not assume that preferred site owners will be willing to install charging equipment.
- Property owners may be reluctant to bear the installation cost.
- A significant investment in time and resources is required to secure a commitment to proceed with installation due to conducting customized site assessments, generating proposals, determining facility and utility requirements, and assisting property owners with technical, business and operational information including options and elements of owning and maintaining EV charging stations.
- Multiple layers of decision makers at a single property can create challenges and delays.

4.5.2 Challenges to Installing and Permitting Level 2 Public Charging Stations

The following bullet points describe the challenges which charging station representatives learned while deploying and installing charging stations.

- Be cautious of cost quotes.
- Charging station installation costs vary from one site location to the next.
- Contractors found some property owners take offense if additional charges to the quote are imposed onto them after the project has started, or if there is a substantial delay due to permitting reasons.
- Costs can accrue if unpermitted projects have previously been performed on the site. In this case often the contractor and even the current tenant or owner is unaware of the coding issues of the previously unpermitted jobs. The site host may be burdened to not only pay for the new EV charging station installation but also may need to bring the existing installations up to code.
- Costs can accrue at older code compliant project locations which are not able to be adapted to new electrical devices.
- The involvement of multiple decision makers can make installations time consuming and challenging. For MUDs, the decision makers generally include individual property owners, property manager(s), and association boards.

[73] AeroVironment found 15-20% of the sites surveyed or estimated turned into installations. This resistance should decrease as EVs become more main stream and property owners start to see and hear about stations on other properties.

- Given the right of an EV MUD owner to install an EV charging station at a MUD, it is important for MUD property associations to proactively adopt responsible and reasonable covenants, conditions and restrictions and bi-laws that address the installation and operation of EV charging stations at the MUD property.
- Initial agreements can change. Companies found properties that originally agreed to install charging stations later walked away due to:
    - Insufficient available electric capacity.
    - Electric panels located too far from parking stalls, creating high installation costs.
    - Old electric panels requiring upgrades for charging station installation.
    - Installation required significant trenching, resulting in high installation costs.
    - Sites not having as-built drawings from which new engineering/installation drawings can be created.

4.5.3 Best Practices and Suggestions for Installing and Permitting Charging Stations

The following bullet points describe the *solutions* and *best practices* charging station industry representatives found while *installing* and *permitting* charging stations in Hawaii:

- Within the City and County of Honolulu, obtaining residential building permits for EV charging station installations have been expedited by the availability of online permits. As long as an EV charging station has a City and County of Honolulu approved product code, the permit for residential installations is attainable online.
- Inconsistent National Electrical Code interpretations by City engineers and inspectors can create installation challenges. It is recommended that consistent guidelines be drafted, specifically regarding required protective bollards and placement of wheel stops.
- Neighbor Island municipalities should examine the best practices developed by the City and County of Honolulu in streamlining permitting processes for residential EV charging station permits. It is also recommended that all municipalities research how to extend the online benefits to commercial installations and inspections.
- Due to Hawaii's high salt, humidity and strong sun it is best practice to install charging stations in covered, shaded areas or inland.
- Commercial installations will benefit from having a permit runner, as well as having an organized, accurate stamped permit package.
- Due to flood zoning, in some locations charging stations cannot be installed at ground level. It is beneficial to understand flood zone location restrictions so that plans do not include flood zones. Within the City and County of Honolulu charging stations can be installed in a flood zone so long installations are designed in accordance to the flood ordinances, which requires installations to be above the regulator floor or flood-proofed to address the hazard. It is recommended that factoring zoning related issues surrounding tsunami inundation zones for the installation of charging station should be streamlined in the future.

- To encourage a quicker permitting and inspection process for commercial charging station installations, industry representatives should provide county inspectors with EV charging equipment information. Likewise, it is recommended that interpretations of the Electric Code are consistent to ensure conformity regarding design requirements and installation plan specifications.
- Property owners and managers are encouraged to research utility EV related benefits and challenges to installing EV charging stations, such as discounted electrical rates for EV charging (EV TOU) and the potential impact of utility "demand charges."[74] Site hosts should also research options for recouping the cost of electricity from charging station use.
- Planning discussions between home owner and MUD associations would help clarify potential demand for EV charging stations.

4.5.4 DC Fast Charging - Benefits and Opportunities in Hawaii

DC fast charging installations offer a number of benefits and opportunities primarily, charge time, additionally:

- Offer drivers an easier solution to driving BEVs, thereby encouraging the adoption of EVs in Hawaii.
- Provides a 'safety net' for BEV drivers who need to travel longer distances and do not want be inconvenienced by waiting for a slower Level 1 or 2 charge.
- Supports the rental car and tourism industry by increasing range availability to popular tourist destinations.
- Offers the ability for someone to own or operate an EV when they do not have access to slower charging at their home or workplace.

4.5.5 DC Fast Charging Challenges in Hawaii

DC Fast Charging installations may raise challenges for property owners and utilities, specifically:

- Cost of the technology is a major challenge. The equipment can cost tens of thousands of dollars, and installations costs can be triple the equipment costs, bringing the total to $100,000 or more in some cases.[75]
- The higher power requirements of a DC Fast Charger may require costly additional electrical upgrades.
- The power demand placed on the grid created by DC Fast Chargers may require utility upgrades to existing infrastructure serving the site.
- Higher electric demand can result in an increase in monthly demand charges. Demand chargers can raise electricity costs to the site host and discourage site hosts in installing a DC Fast Charger
- Local zoning may restrict siting of retail DC Fast Chargers[76]

[74] Maximum monthly demand is the highest average demand (kW) during any 15 minute interval that is measured in a billing period. www.heco.com, Business Services, Electric Rates, HECO Rates, Schedule J describes demand charges. Rate Schedule J specifies calculation of demand charge, based on 15-minute periods. That charge may not be less than 25 kW, but is the higher of: The highest maximum demand for the billing month or the average (mean) of the current billing month maximum demand and the greatest maximum from the preceding eleven (11) months.

[75] AeroVironment

- DC Fast Chargers ports are not standardized in the United States. Currently the only standard on the market is the Japanese CHAdeMO standard. The SAE Combo standard is expected to be the customary choice for US and European manufactures.

4.5.6 Installation of DC Fast Charger Lessons Learned

Despite challenges, Hawaii has facilitated the installation of six DC Fast Chargers through the Hawaii EV Ready Grant Program and is encouraging private companies to consider installing DC Fast Chargers. Following are the lessons learned:

- As with Level 2 charging stations, the DC Fast Charger's power requirements must be considered when siting the installation. Locating acceptable Fast Charger sites is hindered by the sites available power.
- Commercial site hosts facing a possible monthly demand charge can configure a DC Fast Charger to a limited, scaled back mode, for example offering a charge level at half power to avoid a peak demand charge. Lowering the charge may avoid the imposition of a demand charge but still offer a much faster recharge than provided by Level 2 charging stations.
- Site hosts may have a high electrical load and thus may already be paying a demand charge. In this case, the DC Fast Chargers may have little or no impact on the demand charge.
- Charging at 50 kW provides a complete charge faster than charging at 25 kW but the charge time is not doubled by reducing power from 50 kW to 25 kW[77]. A 50 kW charger may charge at a faster rate for the first 10 minutes of the charging cycle, after which it drops to a slower rate similar to the 25 kW charge rate. Therefore, the reduction in charging time is only about 10 minutes.
- Any single charge using a 50kW Fast-Charger will impact the location's demand charge if the charger station use raises the location's peak demand. Frequent fast charging sessions have little added impact on the demand charge, but may only add to energy consumption.

4.6 Hawaii's EV Policies

As the EV market grows in Hawaii the state gains insight on what early components of EV policies have been influential on industry, EV drivers, and government agencies and what aspects remain to be improved upon. The following section lists the lessons learned from enacting EV policies in Hawaii:

- Per Act 168 of 2012 (formerly Act 290 of 1997), the State Energy Office found that adding a time restriction on EV free parking is helpful in preventing potential abuse of privileges, and EV charging requirements and time restrictions at free parking stalls can be enforced via signage.
- Per Act 089 of 2012, (formerly Act 156 of 2009), the State Energy Office found that reserved EV only parking stalls *without* EV charging stations were effective in assisting the establishment of the EV market in Hawaii. However parking spaces *with* an installed charging station are the most effective incentive.

[76] Plug in America, Hawaii EV Ready Guidebook for Commercial EV Charging Station Installations
[77] Larry Butkovich, 2012, Charged Magazine, A case for 25 kW chargers, http://www.chargedevs.com/content/features-inside/case-25-kw-dc-quick-chargers

5 RECOMMENDATIONS & BEST PRACTICES

As innovative technologies and strategies emerge, Hawaii is well positioned to be a strategic test bed and EV leader. This section provides recommendations to facilitate continued growth of the Hawaii EV market, while attracting new business and further investment.

5.1 Strategic EV Charging Station Installations

Public charging continues to be needed as a convenience to EV drivers and to reduce range anxiety. As the EV market continues to develop, commercial properties are increasingly becoming EV ready and installing publically accessible charging stations across Hawaii. However gaps in key areas still remain. To maintain steady EV adoption charging installations are needed at public locations with an emphasis on "hard-to-reach" popular destinations. Public charging station installations, in particular DC Fast Chargers, will help to make longer or "non-typical trips" possible via installed charging stations at popular destinations and on major transportation corridors. It is recommended that stakeholder's research Hawaii's driving patterns and current EV charging station usage to identify optimal DC Fast Charging station and Level 2 charging station locations for future installations across Hawaii.

Education and outreach is recommended to ensure parking lot owners understand the EV policies and details associated with installing EV charging stations. As a first step, in partnership with Hawaii EV Grant Ready recipient Plug in America, the State Energy Office published the *Hawaii EV Ready Guidebook for Commercial Electric Vehicle Charging Station Installations*. The guidebook offers resources and information to help site hosts successfully tap into Hawaii's EV market including information on public charging equipment, signage, planning and installation considerations, station design, payment models, and operating EV charging stations.

5.2 Stakeholder Responsibility

According to US mainland studies of consumer behavior with respect to EVs, consumers will be more likely to purchase an EV if they understand the financial and environmental benefits of driving an EV. Educational campaigns with information such as how EVs can fit into a consumer's lifestyle including specific details regarding costs, range and technology are recommended to promote successful EV adoption.

5.2.1 Dealer Responsibility

Local dealers are ultimately in the best position to influence the EV market through direct customer education. Dealers can help potential customers consider EVs by discussing their driving habits and lifestyle to determine what type of EV would best fit their daily life. Recommended discussions should include the economics of EVs in Hawaii, the network of public charging stations in Hawaii and charging station installations based on housing type.

5.2.2 Tourism Responsibility

EVs can benefit tourism through national and international exposure, while attracting positive attention to Hawaii as a "clean" and "green" destination. Due to the limited range of BEVs, out-of-town travel may introduce a new stress to a traveler's experience. Rental car agencies have the responsibility of educating customers on EV range and charging station locations. Drivers should understand how far

they can drive on a single battery charge, how to find nearby charging stations and who to call for roadside assistance. Outreach to the tourism industry is recommended to encourage the installation of charging stations at hotels and destination points.

5.2.3 Government Responsibility

Further development of the EV market relies on government leader's support of funding opportunities, staying informed of new market standards and practices, engaging in the development of policies to drive EV adoption and working to coordinate test bed projects with international partners.

Today nearly every major auto manufacturer in the world is developing an EV and is selecting EV launch markets based on availability of public charging stations, incentives, and annual vehicle sales. Concurrently, Hawaii is seeking to create additional public-private partnerships with EV manufactures, automobile dealers, rental car agencies and charging network operators. The aim of these partnerships is to bring new products and allocation to the Hawaii market and to retain Hawaii's presence in the growing EV market.

5.2.4 EV Stakeholder Group Responsibility

The growth of Hawaii's EV market will depend on the support of EV stakeholder groups across Hawaii to advance public outreach, and education. For future EV working group development, the following were found as best practices:

- Meet frequently and arrange workshops to improve the industry's understanding of the EV market and consumer needs and behaviors.
- Gather in a group setting to ensure that EV market information is disseminated in a timely fashion and stakeholders have the opportunity to network, share challenges, solutions and best practices.
- Include multi-industry stakeholders with representation from tourism industry, financial and banking sector and educational institutions.
- Develop coordinated strategies to support EV deployment while utilizing public outreach events to involve and inform the public on emission reductions and oil savings that can occur from an integrated, comprehensive approach to electrifying Hawaii's vehicle markets.
- Include and educate State Legislators about the EV industry and the benefits of supporting incentives and EV policies in Hawaii.

5.3 EV Policy Recommendations

A well-designed, comprehensive strategy and commitment of resources is needed for growth of Hawaii's EV market. To date, the State of Hawaii has developed EV incentives through progressive policy. Going forward government agencies can impact EV adoption by taking an active role in both county and state legislative processes. The following policies, incentives and programs (financial and non-financial) could help to accelerate EV adoption and ease barriers to EV market development in Hawaii:

- Eliminating utility demand charges for DC Fast Chargers.

- Deeper discounts for night time electricity use for EVs (EV Time of Use rates).
- Streamlining/automating permitting procedures across all counties similar to City and County of Honolulu's online permitting system used to expedite residential charging installations.
- Requiring construction of new single family housing to accommodate the installation of charging stations.
- Waiving motor vehicle registration fees for EVs.
- Establishing an EV rebate program, similar to the past success of the federal "Cash for Clunkers" program which included dealers.

5.4 Market Research and Data Needs

Understanding Hawaii EV data and trends, in both the residential and commercial space, are critical to advancing the Hawaii EV market.

5.4.1 Charging Station Research Needed

Public charging stations installations are viewed as a means to resolve "range anxiety" among consumers and to encourage EV adoption. As more EV charging stations are installed at commercial sites, it will be important to research and evaluate the actual impact that the penetration of public charging stations had on EV adoption. Research would also help to understand costs associated with operating and maintaining charging stations, usage (frequency, duration, etc.) and grid demands.

Workplace charging is the second most frequent venue that drivers are expected to recharge, the first place being at home. For this reason alone it is recommended that the demand for charging station installations at Hawaii's workplaces is also researched.

Public EV charging stations in Hawaii either have a set fee or do not require users to pay for charging. To determine actual profitability, research is needed to understand how different potential pricing mechanisms influence the demand for charging stations. Researching EV drivers willingness to pay for public charging is essential to understand the potential profitability of a charging unit.

Although charging stations may not be a profit-generating project, there may be indirect revenues and value-add opportunities that arise from charging station installation. Research on how much revenue a charging station can bring to a property will be useful in defining the profitability of an EV charging station. [78]

5.4.2 EV Driver Data Needed

Research about EV driver habits will help identify current and potential barriers to EV adoption. Behavioral data would examine consumer intent to purchase EVs and assess the factors that increase or decrease interest. Research would also provide clarity regarding EV driver's interest in clean energy. Understanding the percentage of EV drivers participating in HECO's EV TOU pilot rate and EV drivers with installed residential photovoltaic would help to understand how EV drivers are integrating EV

[78] UCLA Luskin School of Public Affairs. Financial Viability Of Non-Residential Electric Vehicle Charging Stations

charging with renewable energy and home energy management.

5.5 EV Penetration in Hawaii Vehicle Market

Hawaii's residents and business community have a heightened awareness of the devastating impacts that oil price spikes can have on all aspects of the Hawaii economy. In Hawaii, oil prices not only affect the cost of fuel at the pump, but also the cost of electricity. The price of gas and electricity will impact the mass market adoption of EVs in Hawaii.

Most experts believe, including Hawaii's auto dealers, 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 ICE vehicles. As of the writing of this report, EVs represent less than one percent of all vehicles in Hawaii. The HCEI goal of 70% clean energy in Hawaii by 2030 requires transforming Hawaii energy production and consumption, and a key component to reducing fuel demand and utilizing locally produced renewable energy will be a vibrant EV market.

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7 APPENDIX A PERFORMANCE AND COST ANALYSIS: BEV VS. ICE VEHICLE

In order to analyze the performance and cost associated with Internal Combustion Engine (ICE) conventional vehicles versus Battery Electric Vehicles (BEV), a representative scenario will be utilized. The following analysis compares a 2012 Nissan Leaf BEV to a 2012 Nissan Versa, a 27 Mile per Gallon (MPG) ICE vehicle and a 2012 Honda Civic a 32mpg ICE vehicle[79]. The assumptions and calculations demonstrate that approximately 255 gallons of low-sulfur fuel oil (LSFO) are required to generate 3060 kWh, the amount of electricity consumed by a Nissan Leaf to deliver 9,020 miles[80].

Item	Assumptions for Nissan Leaf		
(a)	Electricity (kWh) to drive 9,020 miles	3,060.0	
(b)	Transmission efficiency**	90%	
(c)	Assumed heat rate for LSFO (MMBTU/kWh)***	0.011079	
(d)	Energy content of LSFO (MMBTU/barrel)****	6.2	
(e)	Number of gallons per barrel of fuel	42.0	
Item	**Calculations for Nissan Leaf**		**Method**
(f)	Required electrical generation (kWh)	3,400.0	(a)/(b)
(g)	Electricity/barrel of LSFO (kWh/barrel)	559.6	(d)/(c)
(h)	Electricity generated per gallon of LSFO (kWh/gal)	13.3	(g)/(e)
(i)	Number of gallons of LSFO required to drive 9,020 miles	255.2	(f)/(h)

Sources:
National Renewable Energy Laboratory (NREL)
** When calculating the amount of fuel needed to provide this electricity, it important to recognize an approximate transmission efficiency of 90% to account for the energy lost from the point of generation to the point of charging.
***HECO, see Target Heat Rates provided in link below:
http://www.heco.com/vcmcontent/FileScan/PDF/EnergyServices/Tarrifs/HECO/HECORatesECAC.pdf
**** HECO see provided link below:
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[79] Note: 7.1 Vehicle Specification Data
[80] 2011 Hawaii Annual vehicle miles of travel per vehicle, DBEDT Data Book Table 18.17
http://hawaii.gov/dbedt/info/economic/databook/db2011/section18.pdf

7.1 Vehicle Specification Assumptions

Vehicle	2012 Nissan Versa	2012 Honda Civic	2012 Nissan Leaf
Specifications[81]	1.8 L, 4 cyl, Automatic 4-spd	1.8 L, 4 cyl, Automatic 5-spd	Automatic (A1)
Fuel Type	Gasoline (ICE)	Gasoline (ICE)	Electric (BEV)
Miles Per Gallon (MPG)	27mpg Combined[82]	32mpg Combined	99 Combined MPGe[83]
Manufacturer's Suggested Retail Price	$10,990 - $18,590	$15,755 - $24,055	$35,200 - $37,250
Passenger Volume	90 ft^3	95 ft^3	90 ft^3
Luggage Volume	15 ft^3	12 ft^3	23 ft^3
EPA Size Class	Compact	Compact	Midsize

Assumptions	
Nissan Leaf Battery Type	24 KW
Nissan Leaf kWh per mile	.34
Cost of Electricity per KwH	$0.347[84]
Total Mileage for Year	9,020[85]
Cost per Gallon of Gas	$4.10[86]

[81] Fueleconomy.gov
[82] www.fueleconomy.gov, Based on 45% highway, 55% city driving
[83] Miles per Gallon Equivalent 1 gallon of gasoline=33.7 kW-hr
[84] Average cost of electricity in Hawaii, 2011 DBEDT Monthly Energy Databook. This does not represent HECO's EV TOU pilot rates. For more information about EV charging rates, goev.heco.com
[85] 2011 Hawaii Annual vehicle miles of travel per vehicle, DBEDT Data Book Table 18.17 http://hawaii.gov/dbedt/info/economic/databook/db2011/section18.pdf
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7.2 2012 Nissan Versa

The following assumptions and calculations demonstrate that 333 "at the pump" gallons are required for a ICE gasoline Nissan Versa[87] to deliver 9,020 miles assuming that the vehicle is able to achieve a combined mpg of 27 miles per gallon.

Item	Assumptions	
(a)	Nissan Versa MPG	27

Item	Calculations for Nissan Versa		Method
(c)	"At the pump" gallons required for 9,020 miles traveled	333	*9,020/(a)*

The following table shows the amount of LSFO required to generate 3060 kWh of electricity (with and without a renewable energy source contribution), which would be required by a Nissan Leaf in order to travel 9,020 miles. Ultimately, the below chart shows that in order to deliver 9,020 miles traveled, the Nisan Leaf consumes fewer gallons of LSFO than the Nissan Versa.

LSFO (gallons) Required by Nissan Leaf to Travel 9,020 Miles	Assumed Renewable Energy (%) Contribution	Number of Gallons Saved by Nissan Leaf	% of gallons saved by Nissan Leaf
230[88]	12%[89]	103	31%
220	15%	113	34%
200	25%	133	40%
160	40%	173	52%

[88] 230 gallons derived from 88% of approximately 260 gallons of LSFO required to drive 9,020 miles with 0% renewable energy contribution

[89] 12% of electricity needs supplied by renewable energy in 2011 HECO Clean Energy Update, 2012

7.3 2012 Honda Civic

The following assumptions and calculations demonstrate that 281 "at the pump" gallons are required for a Honda Civic[90] to deliver 9,020 miles assuming that the vehicle is able to achieve a combined mpg of 32 miles per gallon.

Item	Assumptions	
(a)	Honda Civic MPG	32

Item	Calculations for Nissan Versa		Method
(c)	"At the pump" gallons required for 9,020 miles traveled	281	*9,020/(a)*

The following table shows the amount of LSFO required to generate 3060 kWh of electricity[91] (with and without a renewable energy source contribution), which would be required by a Nissan Leaf in order to travel 9,020 miles. Ultimately, the below chart shows that in order to deliver 9,020 miles traveled, the Nisan Leaf consumes fewer gallons of LSFO than the Honda Civic.

LSFO (gallons) Required by Nissan Leaf to Travel 9,020 Miles	Assumed Renewable Energy (%) Contribution	Number of Gallons Saved by Nissan Leaf in comparison to Nissan Versa	% of gallons saved by Nissan Leaf in comparison to Nissan Versa
230	12%	51	18%
220	15%	61	22%
200	25%	81	29%
160	40%	121	43%

[90] Note: 7.1 Vehicle Specification Data

[91] 3,060 kWh are required to power a Nissan Leaf for 9,020 miles

7.4 Cost Comparison

Below is a vehicle cost comparison example showing the approximate[92] cost savings between internal combustion engine vehicles (ICE) with a Nissan Leaf. The analysis compares similar size 4-door sedans that compete in the market with the Nissan Leaf. The analysis shows the operating costs for the Nissan Leaf are lower than the ICE competitors.

Vehicle	2012 Nissan Versa	2012 Honda Civic	2012 Nissan Leaf
Fuel Type	Gasoline (ICE)	Gasoline (ICE)	Electric (BEV)
Miles Per Gallon (MPG)	27mpg Combined	32mpg Combined	99 Combined MPGe
Fuel Costs	$4.10 gallon	$4.10 gallon	Cost of Electricity per $0.347 Kwh
Car Fuel Costs			
Costs per mile	$0.1519	$0.1281	$0.11798
Fuel Cost for 9,020 Miles	$1,370	$1,156	$1,064
EV Savings 1 Mile	$0.0339	$0.0101	
EV Savings 9,020 Miles	$306	$92	

[92] Gasoline and electricity prices are subject to market conditions

8 APPENDIX B HAWAII EV LAWS

Listed here are the legislative acts and statues that have been enacted and are in effect at the time of publication of this report. To check for revisions or additions to existing policy and law, visit the Hawaii Electric Vehicle (EV) Ready Program webpage at: http://electricvehicle.hawaii.gov. Additionally, the Hawaii State Legislature website at http://capitol.hawaii.gov offers current and archived information about House and Senate procedures and members. The site also provides access to legislative information including Hawaii Revised Statutes (HRS), bill status, and current hearing information.

8.1 Relating to EVs

Act 168, 2012 supersedes Act 290 of 1997. The State of Hawaii Department of Transportation may adopt rules pursuant to chapter 91, Hawaii Revised Statutes, for the registration of, and issuance of special license plates for, EVs. An EV on which an EV license plate is affixed shall be exempt from payment of parking fees, including those collected through parking meters, charged by any state or county authority in this State, except that this exemption shall not apply:

- For more than two and one-half hours of metered parking, or the maximum amount of time the meter allows, whichever is longer; or to parking fees assessed in increments longer than one twenty-four-hour day, including weekly, monthly, or annual parking permits.
- An EV on which an electric vehicle license plate is affixed shall be exempt from high occupancy vehicle lane restrictions.

8.2 Designation of parking spaces for EVs

HRS 291-71 Act 089, 2012 supersedes Act 156, 2009. The purpose of this Act is to clarify requirements pertaining to parking spaces for EVs. Specifically, it declares that places of public accommodation with at least one hundred parking spaces available for use by the general public shall have at least one parking space exclusively for EVs and equipped with an EV charging system located anywhere in the parking structure or lot by July 1, 2012; provided that no parking space designated for electric vehicles shall displace or reduce accessible stalls required by the Americans with Disabilities Act Accessibility Guidelines.

8.3 Light-duty motor vehicle requirement

HRS 103D-412. This procurement policy applies to all state and county entities. Beginning January 1, 2010, when purchasing new vehicles, all state and county entities shall seek vehicles with reduced dependence on petroleum-based fuels that meet the needs of the agency. Priority for selecting vehicles shall be as follows:

(1) Electric or plug-in hybrid electric vehicles
(2) Hydrogen or fuel cell vehicles;
(3) Other alternative fuel vehicles;
(4) Hybrid electric vehicles; and
(5) Vehicles that are identified by the United States Environmental Protection Agency in its annual "Fuel Economy Leaders" report as being among the top performers for fuel economy in

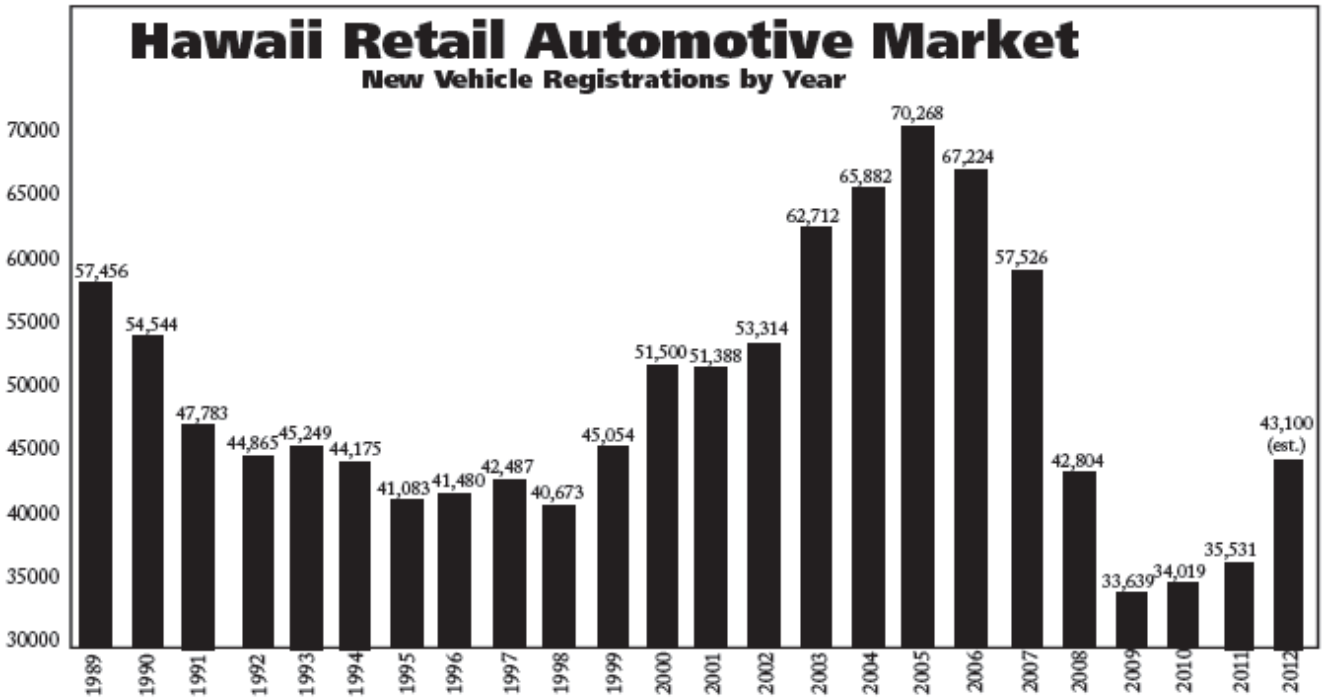
their class.

8.4 Placement of EV Charging System

HRS 196-7.5. Act 186, 2010. This act, codified into statute that:

- No person shall be prevented from installing an electric vehicle charging system on or near the parking stall of any multi-family residential dwelling or townhouse that the person owns.
- Every private entity may adopt rules that reasonably restrict the placement and use of electric vehicle charging systems for the purpose of charging electrical vehicles in the parking stalls of any multi-family residential dwelling or townhouse; provided that those restrictions shall not prohibit the placement or use of electric vehicle charging systems altogether. No private entity shall assess or charge any homeowner any fees for the placement of any electric vehicle charging system; provided that the private entity may require reimbursement for the cost of electricity used by such electric vehicle charging system.
- Under certain provisions, any person may place an electric vehicle charging system on or near the parking stall of any multi-family residential dwelling or townhouse unit owned by that person.
- If an electric vehicle charging system is placed on a common element or limited common element: (1) The owner and each successive owner of the parking stall on which or near where the system is placed shall be responsible for any costs for damages to the system, common elements, limited common elements, and any adjacent units, arising or resulting from the installation, maintenance, repair, removal, or replacement of the system. The repair, maintenance, removal, and replacement responsibilities shall be assumed by each successive owner until the electric vehicle charging system has been removed from the common elements or limited common elements. The owner and each successive owner shall at all times have and maintain a policy of insurance covering the obligations of the owner under this paragraph and shall name the private entity as an additional insured under the policy; and (2) The owner and any successive owner of the parking stall on which or near where the system is placed shall be responsible for removing the electric vehicle charging system if reasonably necessary or convenient for the repair maintenance, or replacement of the common elements or limited common elements.

9 APPENDIX C NEW RETAIL VEHICLE REGISTRATIONS BY YEAR



*Source: The Hawaii Auto Outlook, using AutoCount, an Experian Company, registration data on new, retail cars, and trucks in the Hawaii market. U-Drive/Fleet sales are excluded. 2002-2004 The Hawaii Auto Outlook, using RL Polk Co. 1989-2001 data provided by Nissan Motor Corp.

Average (years 1989-2012) = 48,942
Reference: Hawaii Auto Dealers Association

10 APPENDIX D HAWAII NEW RETAIL CAR AND LIGHT TRUCK REGISTRATIONS

Brand Registrations Report

Hawaii New Retail Car and Light Truck Registrations

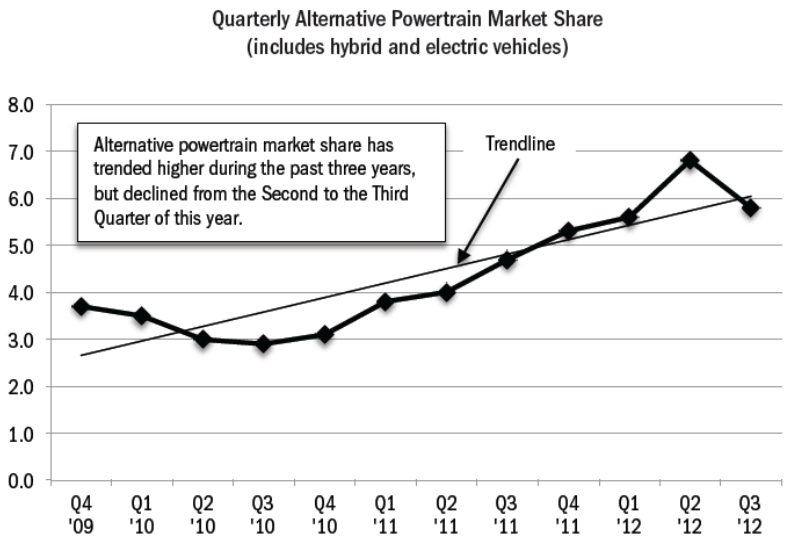
	Third Quarter						YTD thru September					
	Registrations			Market Share (%)			Registrations			Market Share (%)		
	3Q 2011	3Q 2012	% change	3Q 2011	3Q 2012	Change	YTD '11	YTD '12	% change	YTD '11	YTD '12	Change
TOTAL	9,198	11,774	28.0				27,708	33,884	22.3			
Cars	4,528	6,156	36.0	49.2	52.3	3.1	13,828	17,534	26.8	49.9	51.7	1.8
Light Trucks	4,670	5,618	20.3	50.8	47.7	-3.1	13,880	16,350	17.8	50.1	48.3	-1.8
Domestic Brands	1,981	2,361	19.2	21.5	20.1	-1.4	5,380	6,726	25.0	19.4	19.9	0.5
European Brands	1,181	1,432	21.3	12.8	12.2	-0.6	3,253	3,932	20.9	11.7	11.6	-0.1
Japanese Brands	5,305	7,095	33.7	57.7	60.3	2.6	16,881	20,639	22.3	60.9	60.9	0.0
Korean Brands	731	886	21.2	7.9	7.5	-0.4	2,194	2,587	17.9	7.9	7.6	-0.3
Acura	114	221	93.9	1.2	1.9	0.7	388	604	55.7	1.4	1.8	0.4
Audi	84	128	52.4	0.9	1.1	0.2	260	349	34.2	0.9	1.0	0.1
BMW	339	333	-1.8	3.7	2.8	-0.9	852	806	-5.4	3.1	2.4	-0.7
Buick	21	24	14.3	0.2	0.2	0.0	72	85	18.1	0.3	0.3	0.0
Cadillac	27	38	40.7	0.3	0.3	0.0	106	121	14.2	0.4	0.4	0.0
Chevrolet	461	538	16.7	5.0	4.6	-0.4	1,240	1,564	26.1	4.5	4.6	0.1
Chrysler	55	100	81.8	0.6	0.8	0.2	116	262	125.9	0.4	0.8	0.4
Dodge	170	217	27.6	1.8	1.8	0.0	457	645	41.1	1.6	1.9	0.3
Fiat	24	41		0.3	0.3	0.0	50	132		0.2	0.4	0.2
Ford	834	902	8.2	9.1	7.7	-1.4	2,303	2,557	11.0	8.3	7.5	-0.8
GMC	128	109	-14.8	1.4	0.9	-0.5	335	374	11.6	1.2	1.1	-0.1
Honda	908	1,515	66.9	9.9	12.9	3.0	3,693	4,406	19.3	13.3	13.0	-0.3
Hyundai	443	521	17.6	4.8	4.4	-0.4	1,238	1,474	19.1	4.5	4.4	-0.1
Infiniti	79	96	21.5	0.9	0.8	-0.1	252	260	3.2	0.9	0.8	-0.1
Jaguar	15	7	-53.3	0.2	0.1	-0.1	51	42	-17.6	0.2	0.1	-0.1
Jeep	206	315	52.9	2.2	2.7	0.5	480	786	63.8	1.7	2.3	0.6
Kia	288	365	26.7	3.1	3.1	0.0	956	1,113	16.4	3.5	3.3	-0.2
Land Rover	24	33	37.5	0.3	0.3	0.0	61	93	52.5	0.2	0.3	0.1
Lexus	271	365	34.7	2.9	3.1	0.2	873	1,088	24.6	3.2	3.2	0.0
Lincoln	11	19	72.7	0.1	0.2	0.1	44	48	9.1	0.2	0.1	-0.1
Mazda	364	418	14.8	4.0	3.6	-0.4	984	1,191	21.0	3.6	3.5	-0.1
Mercedes	261	249	-4.6	2.8	2.1	-0.7	699	803	14.9	2.5	2.4	-0.1
MINI	107	162	51.4	1.2	1.4	0.2	376	455	21.0	1.4	1.3	-0.1
Mitsubishi	72	36	-50.0	0.8	0.3	-0.5	145	149	2.8	0.5	0.4	-0.1
Nissan	1,089	1,099	0.9	11.8	9.3	-2.5	3,096	3,323	7.3	11.2	9.8	-1.4
Porsche	46	40	-13.0	0.5	0.3	-0.2	101	113	11.9	0.4	0.3	-0.1
Ram	68	98	44.1	0.7	0.8	0.1	225	281	24.9	0.8	0.8	0.0
smart	9	35	288.9	0.1	0.3	0.2	35	93	165.7	0.1	0.3	0.2
Subaru	127	217	70.9	1.4	1.8	0.4	397	531	33.8	1.4	1.6	0.2
Suzuki	57	49	-14.0	0.6	0.4	-0.2	184	122	-33.7	0.7	0.4	-0.3
Toyota/Scion	2,224	3,079	38.4	24.2	26.2	2.0	6,869	8,965	30.5	24.8	26.5	1.7
Volkswagen	201	315	56.7	2.2	2.7	0.5	552	840	52.2	2.0	2.5	0.5
Volvo	63	73	15.9	0.7	0.6	-0.1	182	166	-8.8	0.7	0.5	-0.2
Other	8	17	112.5	0.1	0.1	0.0	36	43	19.4	0.1	0.1	0.0

Source: AutoCount data from Experian Automotive

11 APPENDIX E HAWAII HYBRID AND EV NEW RETAIL REGISTRATIONS

MARKET TRACKER: HYBRID AND ELECTRIC VEHICLES

Hybrid & Electric Share Declines Slightly in Third Quarter



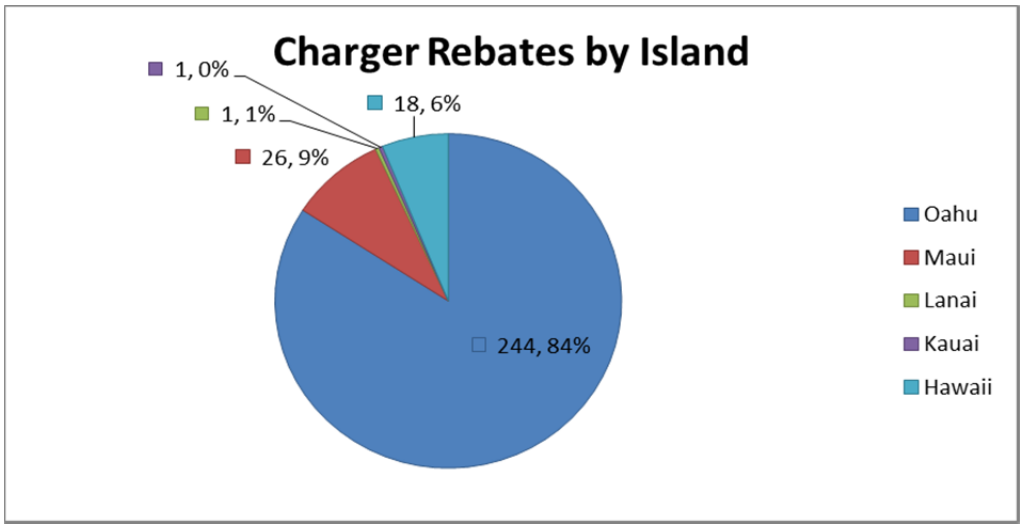
Hawaii Hybrid and Electric Vehicle New Retail Registrations 2005 thru 2011, and 2012 ytd thru Sept.

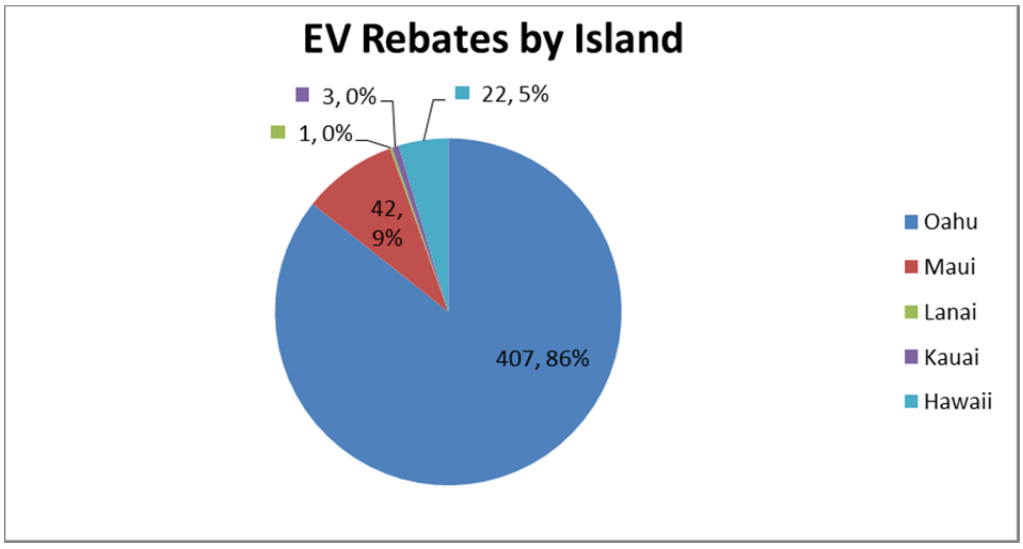
Year	Hybrids	Electrics	Total
2005	1388	0	1388
2006	1749	0	1749
2007	1495	0	1495
2008	1477	0	1477
2009	960	0	960
2010	1075	0	1075
2011	1342	307	1649
2012 ytd	1882	179	2061

New registrations of hybrid and electric vehicles have already exceeded the highest yearly total during the fist nine months of this year. A total of 2,061 hybrids and electrics were registered during the fist nine months of this year, above the record high of 1,749 in 2006.

Source: AutoCount data from Experian Automotive.

12 APPENDIX F EV READY REBATE PROGRAM REBATES BY ISLAND





13 APPENDIX G HAWAII EV READY GRANT PROGRAM DETAILS

Awardees by Organization	Funding Awarded	Project Description	Accomplishment
AeroVironment	$820,000	Install Level 2 Charging Stations on all islands and install DC Fast Charging Stations. Partner with Hawaii Auto Dealers Association to install charging stations at local EV dealerships.	After conducting over 250 individual site assessments at numerous locations across Hawaii, AeroVironment installed 71 Level 2 charging stations with one port per charging station at 36 different locations. AeroVironment also installed 6 DC fast charging stations with one port each at 6 different locations across Hawaii; 1 on Kauai, 4 on Oahu, and 1 on Maui. The DC fast-charging stations will allow owners of Nissan Leafs, Mitsubishi iMiEV and other BEVs with the CHAdeMO DC Fast Charger port to re-charge their vehicles in less than 30 minutes.
Better Place	$581,943	Install Level 2 Charging Stations on all islands, conduct grid integration analysis and partner with rental car companies to acquire EVs for their fleets.	After conducting over 150 individual site assessments at numerous locations across Hawaii, Better Place installed 65 Level 2 charging stations with 136 charging ports at 42 different locations.
City & County of Honolulu	$400,000	Install Charging Stations on Oahu, purchase EVs for City use and deploy an online Permitting System to expedite residential charging station installations.	City and County of Honolulu installed 8 Level 2 charging stations with one port each at 7 different locations across Honolulu and purchased 2 EVs for City agencies use. City and County of Honolulu made residential building permits available online for the installation of charging stations. The online feature helps to expedite residential charging station installations.
County of Kauai	$267,000	Install Level 2 Charging Stations on Kauai and purchase EVs for County fleets.	County of Kauai installed 10 Level 2 charging stations with one port each at 5 different locations across Kauai and purchased 5 EVs assigned to different County Agencies and Divisions.
GreenCar	$200,000	Purchase EVs for car sharing service (renting EVs by the hour) and install Level 2 Charging Stations accessible to GreenCar's fleet.	GreenCar purchased 4-Nissan Leafs, and 4-Mitsubishi iMiEV. GreenCar also installed 2 Level 2 ECOtality Blink charging stations with one port each at the Honolulu DoubleTree.
Plug In America	$50,000	Develop a Hawaii specific guidebook for the installation of EV Charging Stations at retail and commercial sites. Conduct public education and outreach.	Plug In America published EV Ready Guidebook for commercial charging station installations and participated in public forums that brought attention to opportunities and benefits of operating EVs across Hawaii.
Total	By the end of 2012, Hawaii will have more installed Level 2 EV charging stations (ports) per capita 1: 5,500 residents than any other state. Via the EV Ready Program EV drivers in Hawaii can charge up at over 230 charging sites, at more than 95 locations statewide. The new stations were made possible by private, Hawaii business investment and $2.3 million in federal ARRA stimulus funds through the EV Ready Grant Program.		

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