Hawaii Energy Facts & Figures

HAWAII STATE Energy Office

ENERGY.HAWAII.GOV

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Prepared by

Hawaii State Energy Office

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Hawaii Energy Facts & Figures

The decisions necessary for Hawaii to meet its goal of becoming carbon neutral economy by 2045 can be complex and costly, so it is important that they are based on the best available information and data. Providing easily accessible and understandable information also helps energy stakeholders and others stay informed about the latest development in Hawaii's clean energy transformation. The Hawaii State Energy Office (HSEO) contributes to this effort through its publication of Hawaii Energy Facts & Figures report, which combines in one place key information and data about Hawaii's energy ecosystem.

Hawaii's embrace of clean energy is rooted in a commitment to end its historical dependence on fossil fuels, which negatively impacts the state's economy, the environment and energy security. Passage of a 2015 law requires 100 percent of Hawaii's electricity sales to come from renewable resources by 2045. That was followed by passage of a law in 2018 to make Hawaii carbon neutral by 2045. Hawaii Energy Facts & Figures provides an overview of Hawaii's energy sector and highlights progress in the areas of energy efficiency, renewable energy, energy systems and planning, and clean transportation.

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Hawaii Energy Overview

Hawaii depends more on petroleum for its energy needs than any other state. Less than 1 percent of electricity in the United States is generated using oil. By contrast, Hawaii relied on oil for 68 percent and on coal for 13.2 percent of its electricity generation in 2018.[1]

Fig. 1: **Hawaii Electricity Production by Source (2018)**

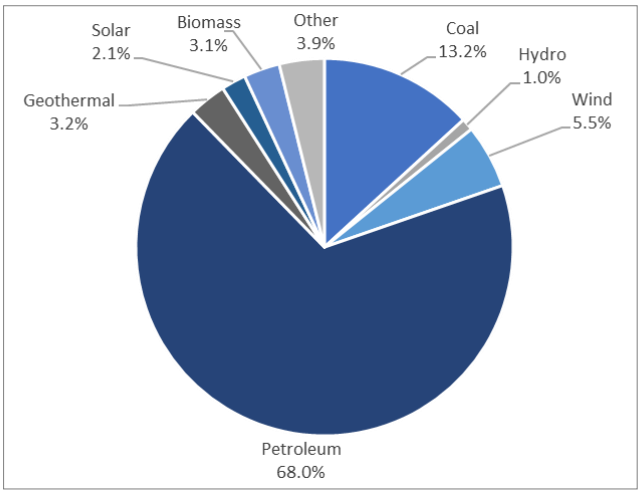
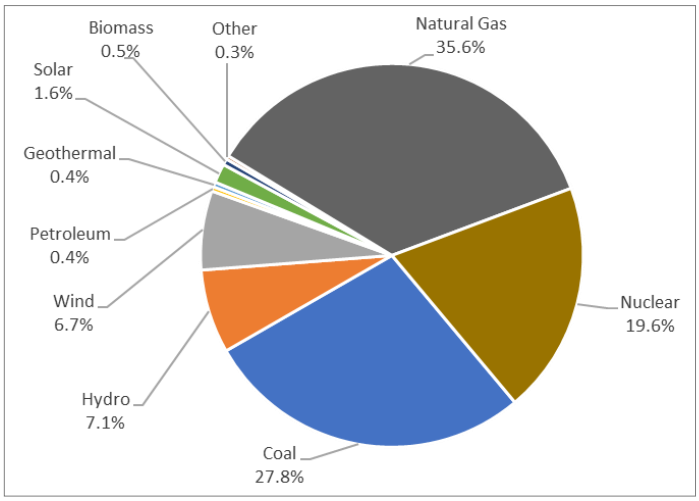
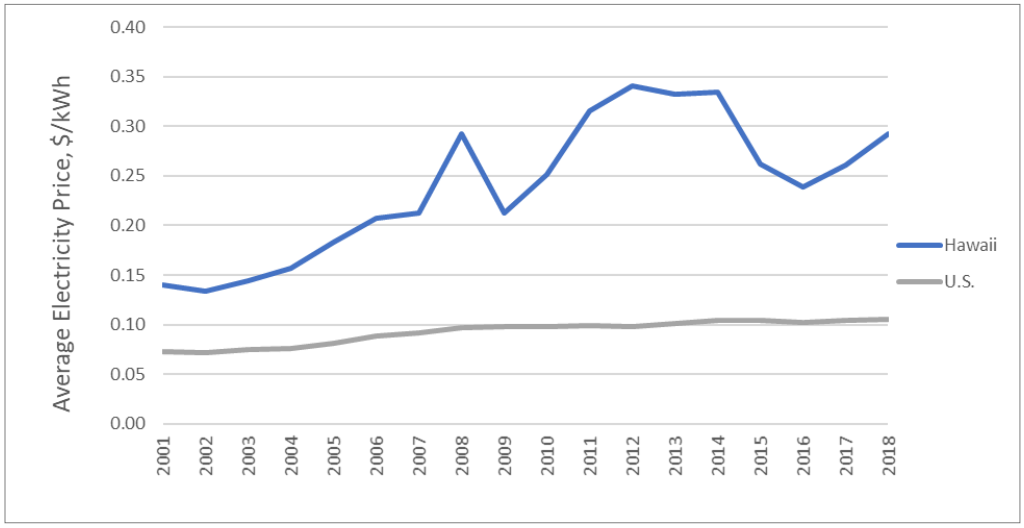


Fig 2: **U.S. Electricity Production by Source (2018)**



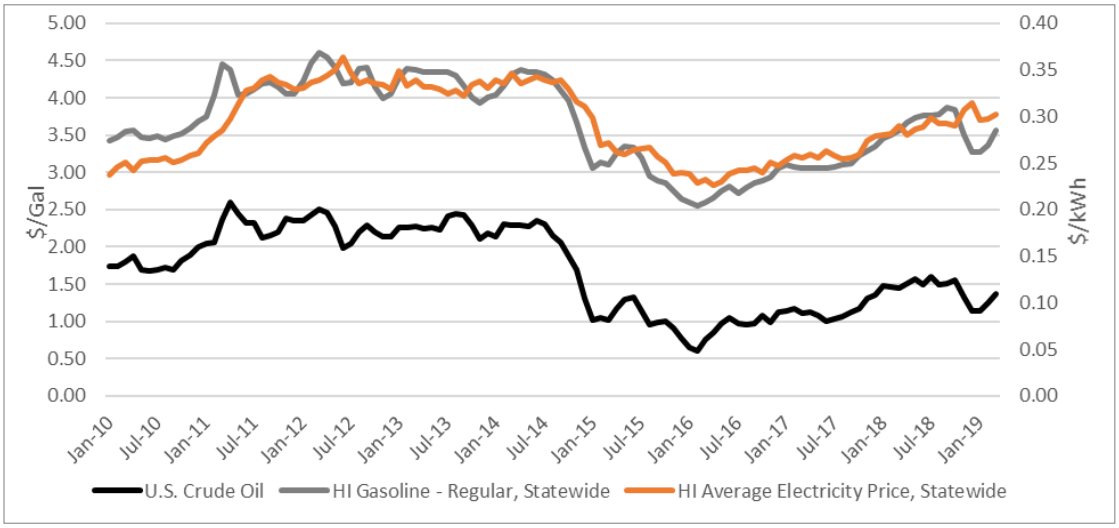
ELECTRIC UTILITES

Fig. 3: **Hawaii's electricity prices are more than double the U.S. average.**



In Hawaii, both electricity and gasoline prices correlate closely with the price of petroleum.

Fig. 4: **Prices of crude oil, gasoline, and electricity.**[2]



Hawaii Energy Overview

Electricity production and motor gasoline are just part of Hawaii's fossil fuel usage. Large quantities of jet fuel are also used in the state. In Hawaii, the air transportation sector accounts for the highest percentage of petroleum use, followed by ground transportation and electricity production, with the remainder used for marine transportation, commercial, industrial and residential uses.[3] The chart below represents 2017 petroleum use, as reported by the U.S. Energy Information Administration (EIA).

Fig. 5: **Hawaii's Petroleum Use by Sector 2017.**

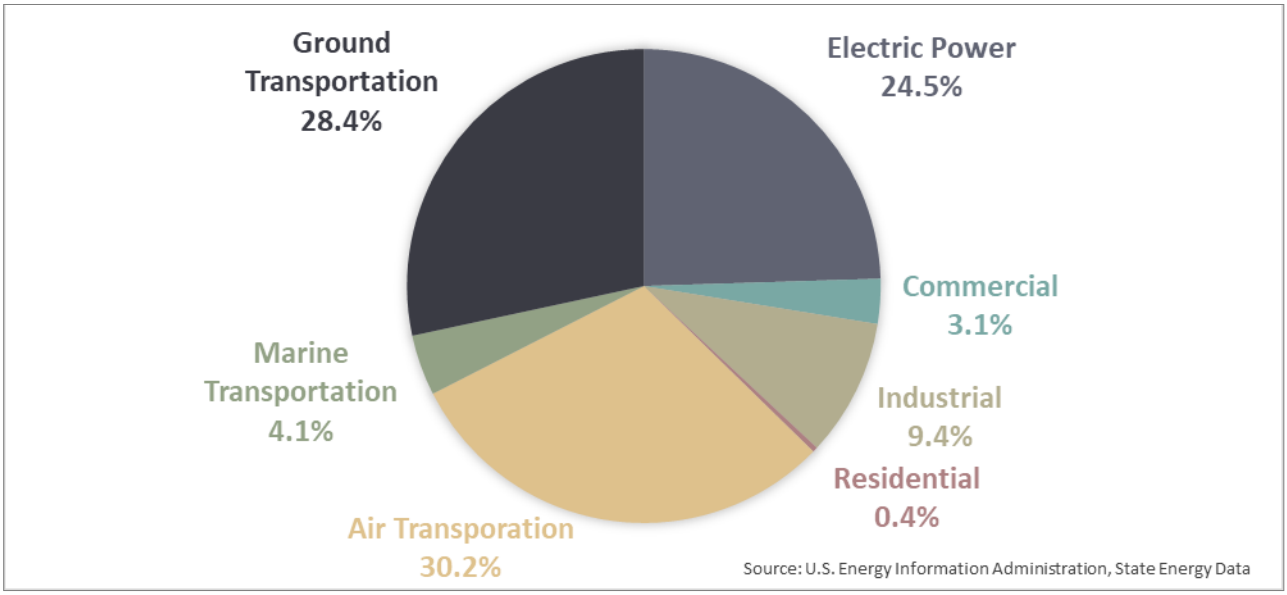


Table 1: **Imports, production, transportation.**

2018 total foreign crude oil imports (million barrels)[4]	34.9	2018 fuel for electricity production (million gallons)[5]	385
2018 total foreign petroleum imports (million gallons)[6]	1,845	2018 impacted foreign fuel for air transportation (i.e. jet fuel) (million gallons)[7]	336
2018 Hawaii's rank among 50 states for energy prices[8]	1	2018 fuel for ground transportation (million gallons)[9]	511

Hawaii Energy Overview

The two primary electric utilities that service the power needs of the state are Hawaiian Electric Industries Inc. (HEI) and Kauai Island Utility Cooperative (KIUC).

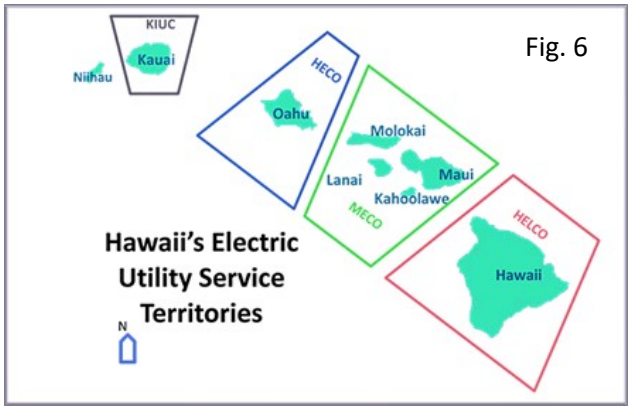


Fig. 6

HEI is the largest supplier of electricity in the state and serves the majority of Hawaii's population. Under HEI are three electric utilities: Hawaiian Electric Company, Inc. (HECO) serves Oahu; Maui Electric Company, Limited (MECO) serves Maui, Molokai, and Lanai; and Hawaii Electric Light Company, Inc. (HELCO) serves Hawaii Island.

KIUC operates as a cooperative and is not structured in the same manner as HEI. Both companies; however, are committed to the adoption and integration of renewable sources of energy in the effort to reduce the state's dependency on oil and both are regulated by Hawaii Public Utilities Commission.

RESIDENTIAL ELECTRICITY USE, RATES, AND MONTHLY BILLS

In general, the residential electricity use, rates, and bills have declined since 2011.

Table 2: **RESIDENTIAL, AVERAGE MONTHLY USE (KWH)**

Year	State Total	Oahu	Hawaii	Kauai	Lanai	Maui	Molokai
2011	**584**	609	520	473	435	612	373
2012	**543**	561	494	465	413	574	345
2013	**514**	523	473	464	430	557	329
2014	**496**	501	458	464	443	545	312
2015	**497**	504	454	474	424	541	306
2016	**484**	488	450	478	425	517	312
2017	**482**	486	451	491	417	510	324
2018	**494**	493	471	503	447	533	325

Source: State of Hawaii Data Book

Table 3: **RESIDENTIAL, AVERAGE RATE ($/KWH)**

Year	State Total	Oahu	Hawaii	Kauai	Lanai	Maui	Molokai
2011	**$0.35**	$0.32	$0.42	$0.43	$0.44	$0.36	$0.43
2012	**$0.37**	$0.35	$0.42	$0.45	$0.47	$0.39	$0.46
2013	**$0.37**	$0.35	$0.42	$0.44	$0.46	$0.38	$0.46
2014	**$0.37**	$0.35	$0.42	$0.43	$0.46	$0.38	$0.47
2015	**$0.30**	$0.28	$0.35	$0.34	$0.38	$0.31	$0.38
2016	**$0.28**	$0.26	$0.32	$0.34	$0.34	$0.29	$0.33
2017	**$0.30**	$0.28	$0.34	$0.35	$0.36	$0.31	$0.36
2018	**$0.33**	$0.31	$0.37	$0.37	$0.40	$0.34	$0.37

Source: State of Hawaii Data Book

Hawaii Energy Overview

Table 4: **RESIDENTIAL, AVERAGE MONTHLY BILL**

Year	State Total	Oahu	Hawaii	Kauai	Lanai	Maui	Molokai
2011	**$202**	$195	$218	$205	$192	$219	$161
2012	**$203**	$197	$210	$209	$192	$222	$159
2013	**$189**	$181	$199	$205	$199	$211	$153
2014	**$185**	$178	$192	$199	$203	$206	$147
2015	**$149**	$141	$157	$163	$159	$168	$115
2016	**$135**	$127	$142	$163	$142	$147	$102
2017	**$145**	$137	$154	$170	$150	$157	$115
2018	**$163**	$155	$175	$187	$179	$180	$121

Source: State of Hawaii Data Book

Energy Efficiency

ENERGY EFFICIENCY PORTFOLIO STANDARDS (EEPS)

Under HRS 269-96 (EEPS statute), the Hawaii Public Utilities Commission is responsible for establishing standards that will maximize cost-effective energy-efficiency programs and technologies. The goal for EEPS is a reduction of electricity consumption by 4,300 gigawatt-hours by 2030.

Hawaii Energy (HE) continues to be a major contributor to the state's EEPS goals. Hawaii Energy encourages and rewards smart energy decisions which will allow our state to reach 100 percent clean energy faster and cheaper through energy efficiency and conservation. As the Public Benefits Fee Administrator*, HE serves all of the islands except for Kauai. From July 1, 2018 through March 31, 2019, the program invested over $18 million to deliver more than 1.1 billion kWh in estimated lifetime customer-level energy savings at a rough cost of one-cent per kWh. This is the equivalent to building a 56 MW solar farm, or the equivalent saved energy to power 173,000 homes for a year. In addition, this will reduce greenhouse gas emissions by nearly 1 million tons.

Energy Performance Contracts

Energy performance contracts (EPC) finance improvements that reduce energy and water use with the future savings from the energy conservation measures (ECM) that are installed. ECM also include photovoltaic installations.

Under an EPC, the energy service company contracted to install the ECM will guarantee the savings or pay for the shortfall. EPC allow government agencies to maximize their energy investments because they can include deferred maintenance and performance period maintenance services under a single contract with guaranteed savings measures. The economic impacts of performance contracts are significant, providing great value to the state.

Performance contracts allows agencies to install ECM in a timely manner. ECM can take less than one year to up to three years to install. Therefore, energy savings occur sooner than later. Capital improvement projects can take from six to 10 years, resulting in missed opportunities for annual energy and water use savings. State and county agencies face increasing energy and water costs and the need to upgrade aging, inefficient, and obsolete energy- and water-consuming equipment. Capital improvement and operating budgets have been unable to keep up with the needed upgrades for ECM.

Hawaii surpassed the half-billion-dollar mark for investment in EPC in 2017. With $507.1 million in signed EPC to date, Hawaii is just one of nine states nationally to eclipse the half-billion-dollar threshold for EPC investment.

* Hawaii Energy is the Public Benefits Fee Administrator that is contracted by the Hawaii Public Utilities Commission to manage and deliver energy-efficiency and demand-side management programs and services using the surcharge called the "Public Benefits Fee" that is collected by the Hawaiian Electric Companies.

Energy Performance Contracts

RACE TO THE TOP AWARD

For seven consecutive years Hawaii has garnered further national recognition with the *Race to the Top* award from the Energy Services Coalition (ESC)*. The award is given to the national leader with the highest per capita investment in performance contracting projects. With the Department of Transportation, Airports Division, performance contract for nearly $209.8 million, ESC recognizes Hawaii with the distinction of signing the single largest performance contract by a state agency. Since 2012 through 2018 the ESC has awarded Hawaii the *Race to the Top* award for being the all-time per-capita investment leader. Hawaii also received a second *Race to the Top* award from the ESC in 2018 for having the most EPC investment per capita in 2017.

Table 5: **Energy Services Coalition Ranking**

State	**Population**	**Performance Contracting**	**Dollars per Capita**
1. Hawaii	1,360,301	$507,133,904	$372.81
2. Washington	6,724,540	$1,356,449,930	$201.72
3. Delaware	897,934	$177,776,651	$197.98
4. Kentucky	4,339,367	$750,000,000	$172.84
5. Massachusetts	6,547,629	$1,008,848,634	$154.08

Since HSEO started the performance contracting program in 1996, state and local government agencies have signed a total of over $507 million in performance contracts that are estimated to save in excess of $1.1 billion over the life of the contracts. These savings are the equivalent of powering 396,586 homes for one year. The projects comprise over 112 million square feet in 295 existing buildings or facilities.

* *ESC is a national nonprofit organization of experts working together to increase energy efficiency and building upgrades through energy performance contracting.*

State of Hawaii Agencies Lead By Example

STATE AND COUNTY ENERGY PERFORMANCE CONTRACTS

The chart below illustrates the number of EPC projects conducted by state and county agencies from 1996 through 2018. In addition, over $8 million in rebate incentives have been claimed from Hawaii Energy, reducing the cost of the energy efficiency improvements through performance contracting projects. Looking ahead, the state anticipates more EPC investments.

Table 6:

Agency	Year(s)	Contract Amount ($)	Estimated Savings Over Life of Contract ($)
U.H. Hilo	1996-2012	$6,402,695	$14,630,066
County of Hawaii	1997-2026	$2,215,546	$8,157,880
County of Kauai	1998-2012	$525,965	$1,205,990
C&C of Honolulu	2001-2025	$11,900,205	$36,066,761
Hawaii Health Systems Corporation	2002-2022	$21,936,997	$55,766,364
Judiciary	2003-2012	$1,474,406	$9,785,036
Dept. of Accounting & General Services Phase I	2009-2029	$36,873,266	$72,580,767
Department of Public Safety	2010-2030	$25,511,264	$57,211,112
University of Hawaii Community Colleges	2012-2032	$34,207,392	$37,000,000
C&C Honolulu Kailua Wastewater Treatment Plant	2013-2033	$6,054,178	$13,693,910
Dept. of Accounting and General Services Phase II	2013-2033	$17,400,000	$28,000,000
Department of Transportation	2013-2034	$309,506,592	$795,560,746
Honolulu Board of Water Supply	2016-2036	$33,125,398	$56,846,668
Total		**$507,133,904**	**$1,186,505,300**

For nearly 20 years HSEO has been leading the state's award-winning EPC efforts with a policy offering technical assistance to state agencies contemplating performance contracting. We've assisted the following entities:

- University of Hawaii at Hilo
- Hawaii Health Systems Corporation
- City and County of Honolulu's four city buildings and Kailua Wastewater Treatment Facility
- County of Hawaii
- County of Kauai
- The Judiciary
- Department of Accounting and General Services (DAGS)-Phase I-10 large office buildings
- University of Hawaii Community Colleges
- Department of Public Safety's four large facilities
- Department of Transportation: Airports, Highways and Harbors
- DAGS Phase II - 33 buildings
- Honolulu Board of Water Supply

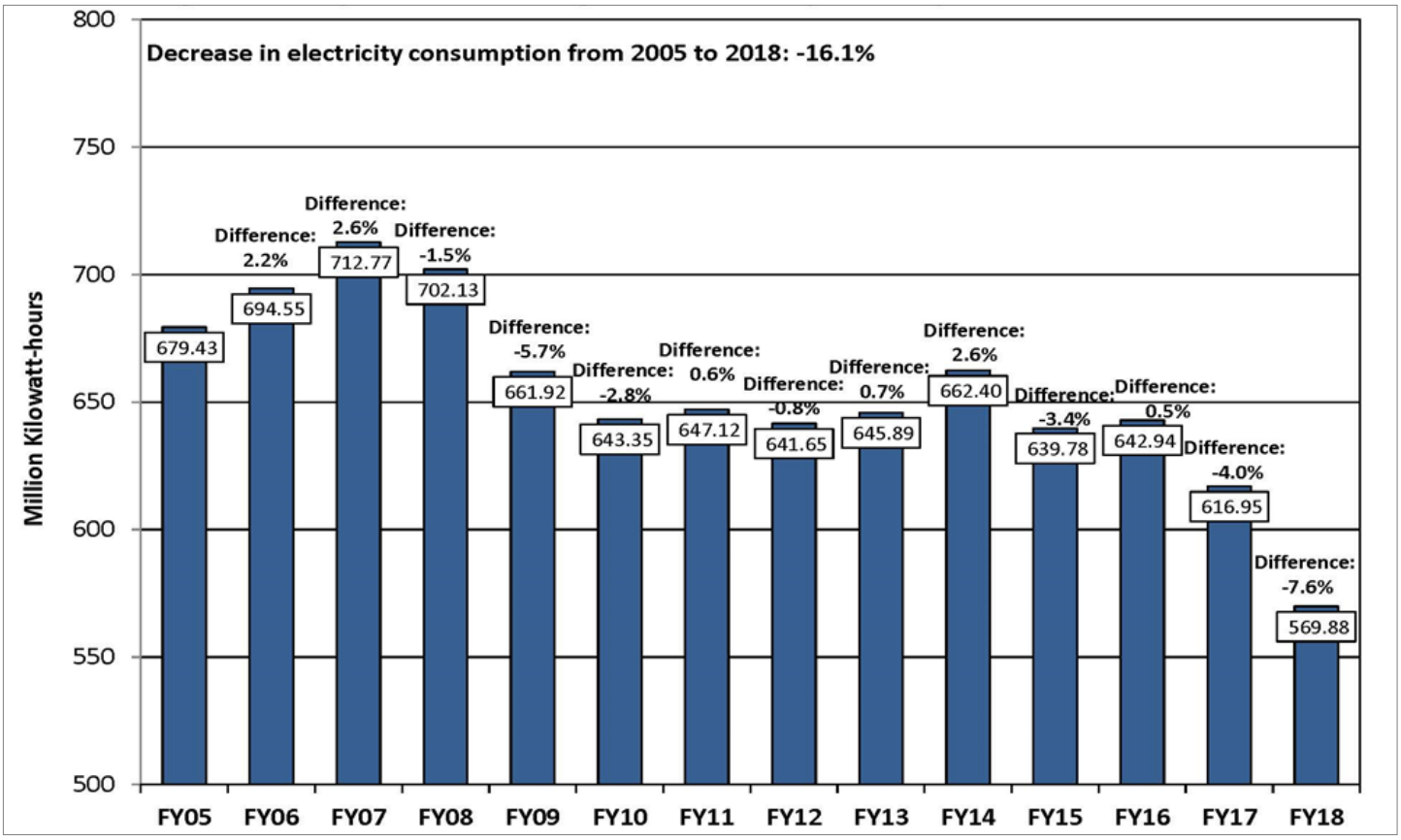
State of Hawaii Agencies Lead By Example

The types of technical assistance offered, pending funding, include:

1. Assisting an agency in compiling building plans and other information to use in solicitations
2. Reviewing draft solicitations
3. Evaluating proposed energy conservation measures, including renewable and water efficiency measures
4. Setting energy performance baselines
5. Reviewing methods for estimating energy savings (including formulas and simulation models); measurement and verification
6. Reviewing investment grade energy audits
7. Reviewing draft contract documents
8. Advising on commissioning
9. Advising on how project risks can be allocated and minimized for the state agency

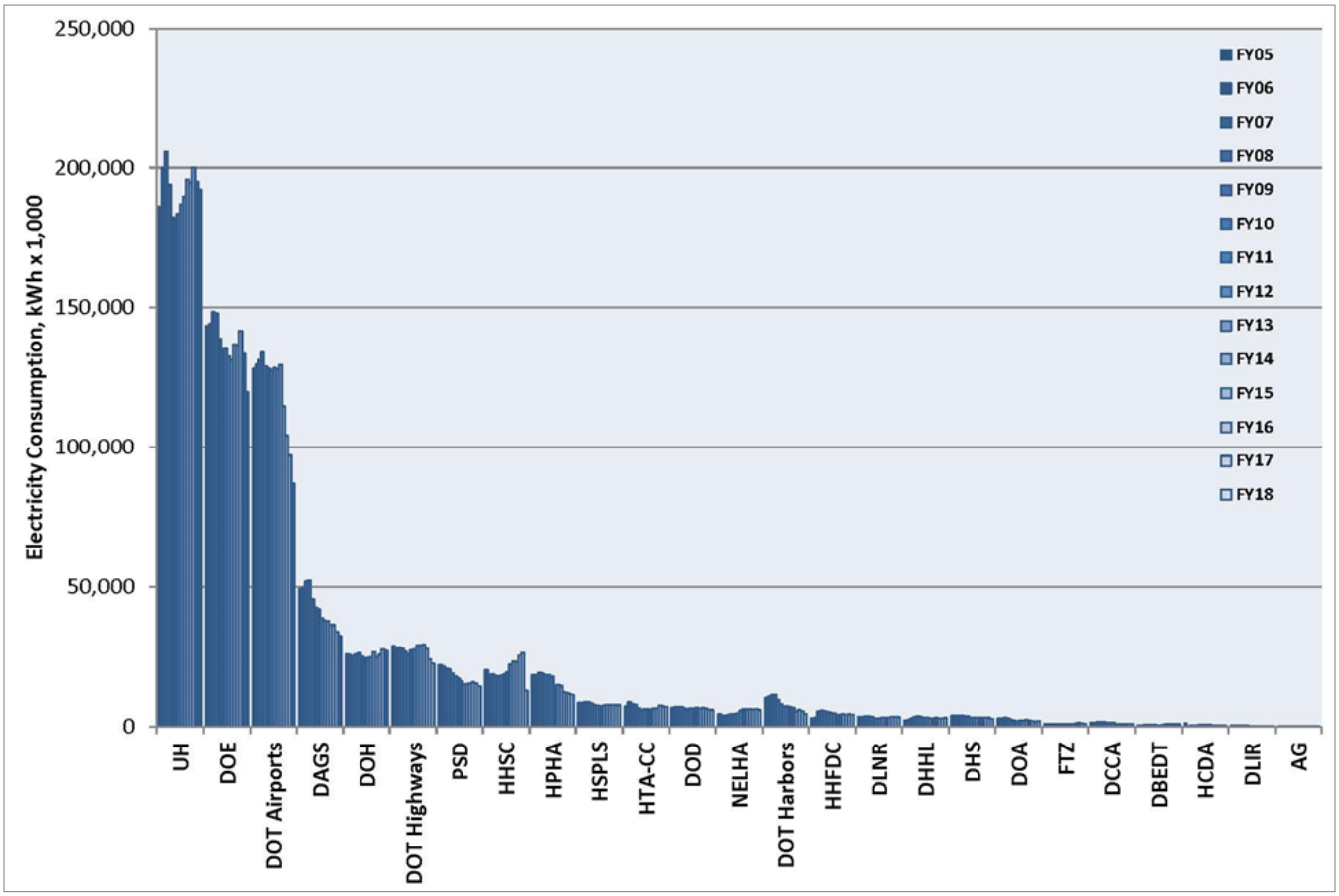
In 2006 legislative and executive mandates to incorporate energy and resource efficiency and conservation in government facilities, fleets, and personnel practices gave impetus to the state's Lead by Example (LBE) initiative to put state agencies at the forefront of energy independence efforts. As shown in the graph below, Hawaii state agencies' electricity purchased through 2018 has declined 16.1 percent from 2005 (the baseline year). HSEO tracks and reports on electricity purchased by state agencies as part of the LBE initiative.

Fig. 7: **Comparison of State Agencies' Electricity Consumption in kWh: FY05 to FY18**



State of Hawaii Agencies Lead By Example

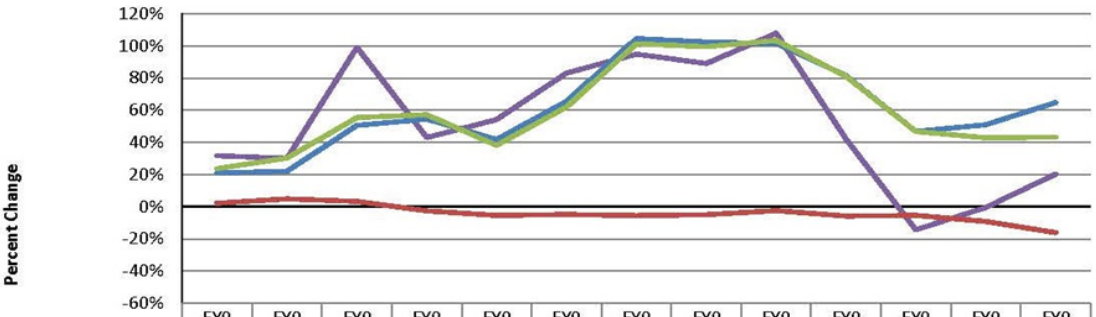
Fig. 8: **Comparison of kWh Purchased by Agency by Year**



AG	Department of the Attorney General
DAGS	Department of Accounting and General Services
DBEDT	Department of Business, Economic Development & Tourism
DCCA	Department of Commerce and Consumer Affairs
DHHL	Department of Hawaiian Home Lands
DHS	Department of Human Services
DLIR	Department of Labor and Industrial Relations
DLNR	Department of Land and Natural Resources
DOA	Department of Agriculture
DOD	Department of Defense
DOE	Department of Education
DOH	Department of Health
DOT Airports	Department of Transportation/Airports Division
DOT Harbors	Department of Transportation/Harbors Division
DOT Highways	Department of Transportation/Highways Division
FTZ	Foreign-Trade Zone Division
HCDA	Hawaii Community Development Authority
HHFDC	Hawaii Housing Finance & Development Corporation
HHSC	Hawaii Health Systems Corporation
HPHA	Hawaii Public Housing Authority
HSPLS	Hawaii State Public Library System
HTA-CC	Hawaii Tourism Authority – Convention Center
NELHA	Natural Energy Laboratory of Hawaii Authority
PSD	Department of Public Safety
UH	University of Hawaii

State of Hawaii Agencies Lead By Example

Fig. 9: **Statewide Electricity Purchased Since 2005**



	FY05-06	FY05-07	FY05-08	FY05-09	FY05-10	FY05-11	FY05-12	FY05-13	FY05-14	FY05-15	FY05-16	FY05-17	FY05-18
Price of Oil ($/bbl)	31.8%	30.0%	99.1%	43.0%	54.2%	83.1%	94.9%	89.1%	107.9%	42.3%	-14.4%	-0.5%	20.3%
Total State Avg Retail Price (All Sectors; $/KWH)	20.9%	22.1%	50.5%	54.5%	41.8%	65.5%	104.6%	102.5%	101.5%	81.5%	46.7%	51.0%	64.8%
Total SOH Building Electricity Cost ($)	23.7%	30.3%	55.4%	57.3%	38.2%	62.0%	101.3%	99.5%	103.4%	81.1%	46.8%	42.9%	43.3%
KWH	2.2%	4.9%	3.3%	-2.6%	-5.3%	-4.8%	-5.6%	-4.9%	-2.5%	-5.8%	-5.4%	-9.2%	-16.1%

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

Percentage change in electricity purchased, from baseline (2005) and each following year. Shown are the price of oil, the average retail price of electricity*, total statewide electricity costs and electricity purchased (kWh).

Since 1996, state agencies have received nearly $12.2 million in efficiency rebates from Hawaii Energy, the Hawaiian Electric Company and its subsidiaries. Combined, these rebates have resulted in more than $274 million estimated cumulative dollar savings and 1.5 billion kWh electricity savings. Over the life of the equipment, these savings would be enough to power about 180,000** households for a year. From June 2018 through March 2019, state agencies received $322,000 in rebates.

**Based on U.S. Energy Information Administration-816m reporting, dividing utility total revenues by total MWh sold, including fuel adjustment cost.*

**Starting in 2019, the number of households is calculated using an average equipment useful life (EUL) of 13 years. Thus, the total household figure is decreased from the 2018 reported 208,000 households.

State Energy Building Code Update

On July 14, 2015, the State Building Code Council (SBCC) unanimously voted to adopt the International Energy Conservation Code (IECC) 2015, with the Tropical Climate Zone Code for residential dwellings and other energy-saving amendments. Gov. David Ige signed and approved IECC 2015 on March 20, 2017 as Hawaii Administrative Rule. All counties adopted the 2015 IECC as amended as of April 1, 2019, either by adoption or by default.

HSEO staff chairs the SBCC which was established by statute to update building codes. HSEO provided IECC 2015 technical assistance and staff training for 310 private and public-sector design professionals and county building officials. HSEO testified in support of adopting the IECC 2015 and will promulgate the prompt adoption of the 2018 IECC as required by state law. The 2018 iteration does not include any major changes from the 2015 IECC. HSEO staff attended public hearings on the 2021 IECC, successfully advocating for inclusion of electric vehicle-ready and renewable energy provisions.

The estimated net savings from the 2015 IECC with Hawaii amendments is 12,962 MWh in 2019, 1,083,590 MWh in 2029 (year 10), 1,991,059 MWh in 2032 and 4,702,738 MWh in 2038 (year 20). These savings could power 732,514 homes in 2038.

Commercial Code Savings: Commercial buildings are expected to save about 33 percent compared to the 2006 IECC. The savings estimates will rise as a result of additional amendments adopted by the counties.

Residential Code Savings: Fully conditioned 2015 IECC residences may achieve a 6 to 9 percent improvement in energy efficiency. Those following the Tropical Climate Zone compliance path could realize a savings of up to 48 percent compared to the model code by opting to utilize natural ventilation and choosing the highest-efficiency options.

Visit HSEO's website, Hawaii Energy Building Code, for more information on the updated energy code including a report on the analysis of the code amendments, FAQs gathered from the various training sessions statewide, presentation webinars, fact sheets and a report forecasting the energy savings for the updated code.

Leadership in Energy and Environment Design (LEED)

The U.S. Green Building Council (USGBC) released its State Market Briefs. The brief highlights the number of LEED certified and registered projects in the state, as well as the gross square footage. As of May 2019, Hawaii has 206 LEED certified projects and 231 registered projects. This totals 437 total projects for a gross square footage of over 50.5 million gross square feet. Utilizing less energy and water, LEED-certified spaces save money for families, businesses and taxpayers; reduce carbon emissions; and contribute to a healthier environment for residents, workers and the larger community. The certified buildings included numerous private developments, as well as federal, state, and county public buildings. There are 946 LEED Credentialed professionals based in Hawaii.

HSEO remains a member of USGBC, the non-profit entity which administers the LEED program. In 2018, Hawaii was back among the top 10 states for LEED certified project square footage per capita. With 4.5 million LEED-certified gross square footage, Hawaii rated 4th highest state in the U.S. this year.

The state requires all new construction and major renovation to meet LEED Silver standards, to the extent possible. HSEO continues to promote LEED training opportunities for state agency staff. Hookele Elementary School, Moana Surfrider, Sheraton Waikiki, and The Royal Hawaiian Hotels were recently LEED-certified.

ENERGY STAR® Buildings

To help identify energy efficiency investment priorities, agencies and private sector building owners and managers can benchmark buildings to compare energy usage with other buildings in their portfolio or similar buildings nationally. If a building's performance, as reflected in its ENERGY STAR score, ranks in the top 25 percent of all buildings of its type, it can be certified as an ENERGY STAR building.

To qualify for certification, a building must meet ENERGY STAR requirements as verified by a licensed professional engineer or architect. The U.S. Environmental Protection Agency (EPA) then evaluates the verification submitted and, if approved, will officially certify the applicant as an ENERGY STAR building. Since 2000, 173 Hawaii buildings have received the ENERGY STAR certification, including over 100 public buildings. During this time, HSEO has helped benchmark 83 state facilities. Since energy use is dynamic, buildings should be verified and certified as ENERGY STAR annually to ensure optimum efficiency.

Hawaii Green Business Program

Hawaii's businesses are also contributing to the clean energy movement by improving their operations in an environmentally, culturally and socially responsible manner. To help businesses implement energy and resource efficiency practices, the state set up the Hawaii Green Business Program as a partnership between HSEO, the Department of Health, the Board of Water Supply and the Chamber of Commerce of Hawaii. When businesses embrace green business practices, they don't just enjoy utility cost savings – they also contribute to Hawaii's collective energy independence goals and, ultimately, a more sustainable environment.

From 2009-2017, over 100 business and government entities have benefited from the program, including sectors such as hospitality, commercial office, retail, restaurant, food services, grocery, venue and green events. Their savings amounts to:

- 22.7 million kWh of energy (equivalent to powering 3,531 homes for one year in Hawaii)
- 203.2 million gallons of water
- $6.4 million in energy costs

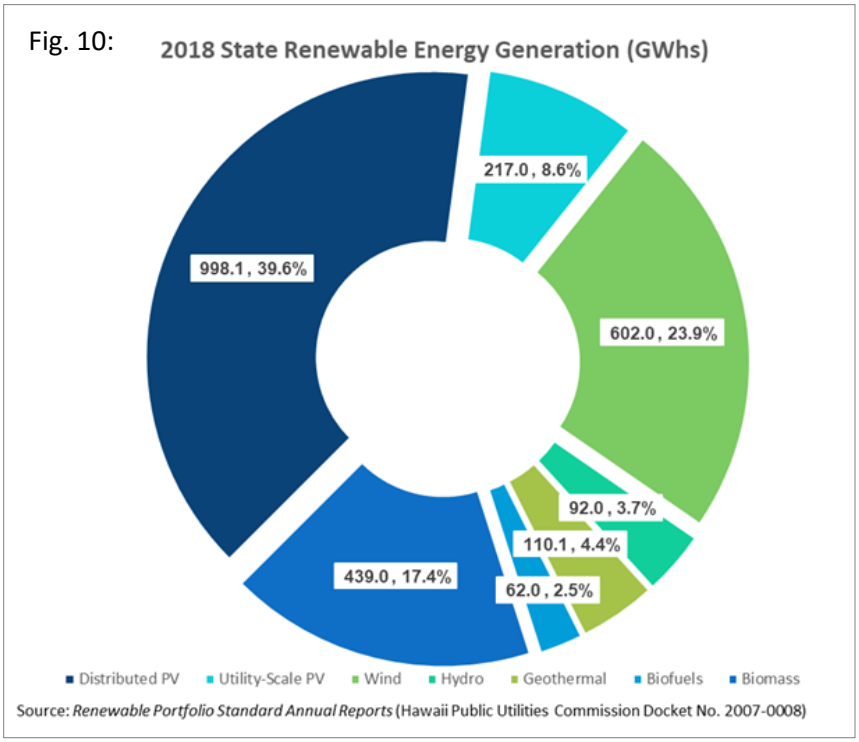
For more information go to Hawaii Green Business Program.

Renewable Energy

Under Section 269-91, Hawaii Revised Statutes (HRS), "renewable energy" is defined as energy generated or produced using the following sources:

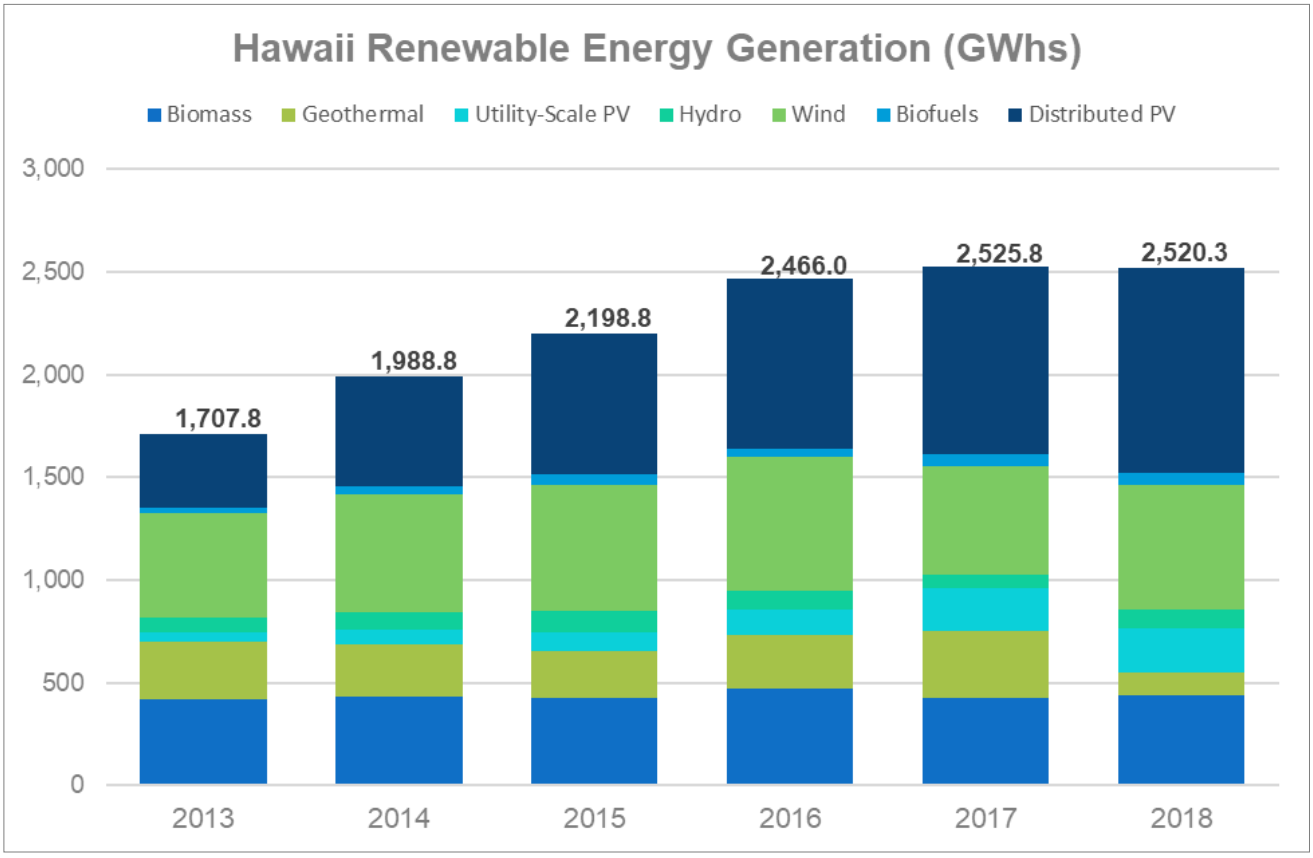
- Biofuels;
- Biogas, including landfill and sewage-based digester gas;
- Biomass, including biomass crops, agricultural and animal residues and wastes, and municipal solid waste and other solid waste;
- Falling water;
- Geothermal;
- Hydrogen produced from renewable energy sources;
- Ocean water, currents, and waves, including ocean thermal energy conversion;
- the sun; and
- Wind.

Fig. 10:



Source: *Renewable Portfolio Standard Annual Reports* (Hawaii Public Utilities Commission Docket No. 2007-0008)

Fig. 11: **Hawaii's diverse renewable energy resources comprise its present renewable energy portfolio**



Source: *Renewable Portfolio Standard Annual Reports* (Hawaii Public Utilities Commission Docket No. 2007-0008)

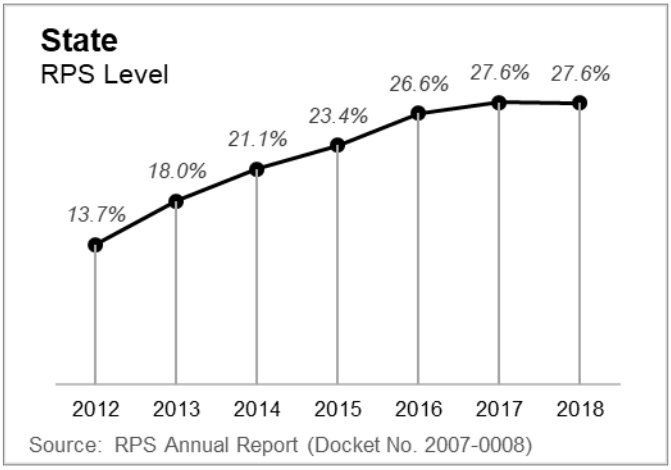
Renewable Portfolio Standards (RPS)

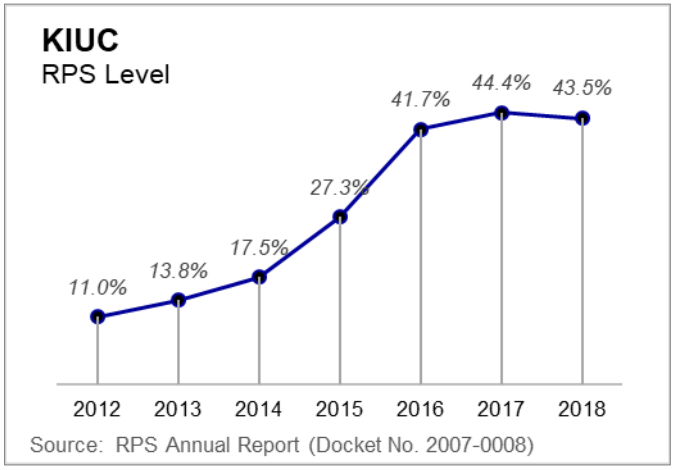
"Renewable portfolio standard" means the percentage of electrical energy sales that is represented by renewable electrical energy (HRS 269-91). Renewable electrical energy generated by each utility, independent power producers, and customer-sited, grid-connected sources (e.g., rooftop photovoltaic systems) are counted towards the utilities' RPS. As required by HRS 269-92, each electric utility company that sells electricity for consumption in Hawaii shall establish a renewable portfolio standard of:

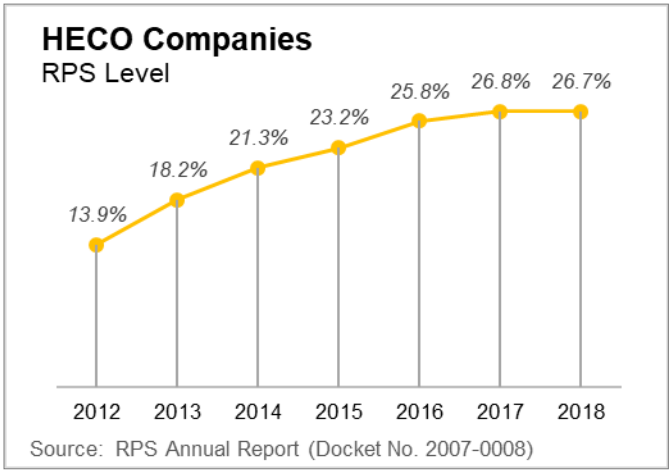
- 10 percent of net electricity sales by Dec. 31, 2010
- 15 percent of net electricity sales by Dec. 31, 2015
- 30 percent of net electricity sales by Dec. 31, 2020
- 40 percent of net electricity sales by Dec. 31, 2030
- 70 percent of net electricity sales by Dec. 31, 2040
- 100 percent of net electricity sales by Dec. 31, 2045

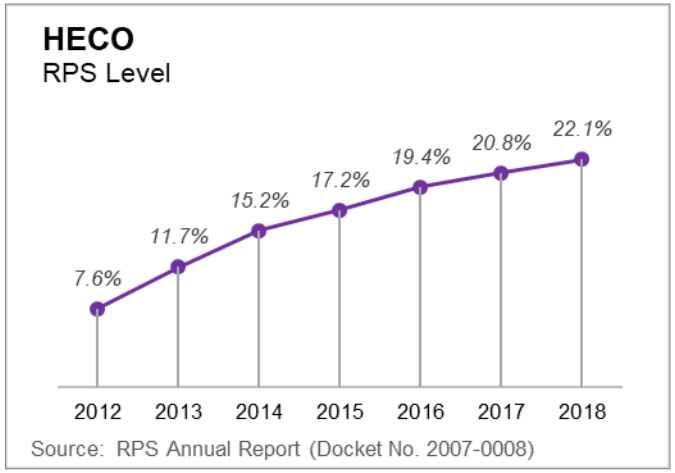
All four of Hawaii's electric utilities (KIUC, HECO, MECO, HELCO) must file an annual RPS status report to the Hawaii Public Utilities Commission (Docket 2007-0008). Hawaii's statewide RPS is determined by combining the four RPS reports.

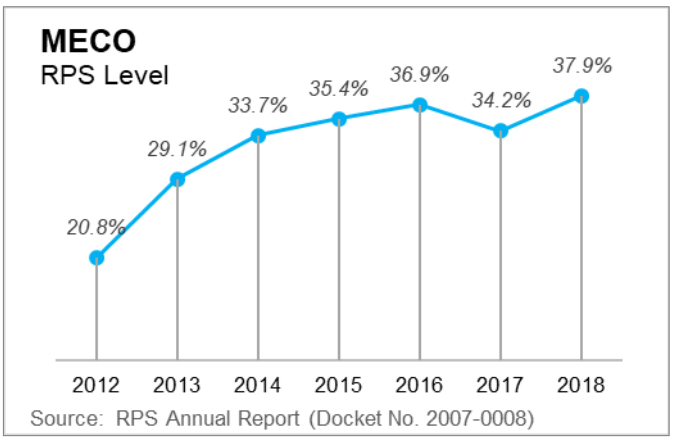
Fig. 12: **Hawaii's statewide RPS.**

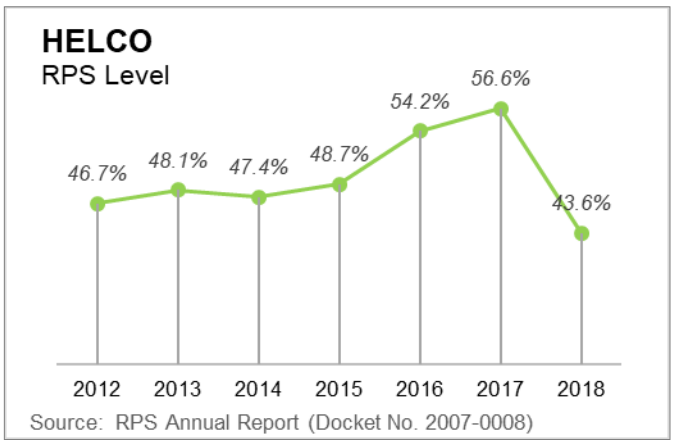












Bioenergy and Waste-To-Energy

"Bioenergy" is a broadly used term that includes energy produced by biomass and biofuels. Bioenergy production potential in Hawaii depends largely on the availability of land and feedstock, input expenses (fertilizer, water, CO_2 for algae, seeds), development expenses (permitting, equipment, construction), operating expenses (labor, processing, transportation), markets and values for primary products (electricity, fuels) and by-products (animal feed, pharmaceuticals), and overall revenues compared to costs. For the purposes of this document, bioenergy projects include facilities that produce feedstock or biofuel and facilities that generate power through the consumption of biomass or biofuel.

BIOMASS AND WASTE-TO-ENERGY

Under Hawaii law (HRS 269-91), "biomass" includes agricultural and animal residues and wastes, municipal solid waste and other solid waste (waste-to-energy), and biomass crops grown primarily or secondarily for energy conversion (energy crops). There are significant differences between organic plant matter and anthropogenic (made by humans) or agricultural waste materials, however, all are considered "biomass" for RPS purposes in Hawaii. Biomass including waste-to-energy contributed approximately 17.4 percent towards Hawaii's RPS in 2018.

BIOMASS AND WASTE-TO-ENERGY PRICING

Pricing for Hawaii's two operating utility-scale biomass and waste-to-energy projects is based on numerous factors and may be adjusted annually (average FY18 price, Hawaii Public Utilities Commission Annual Report FY 2018):

- **Green Energy Biomass-to-Energy Facility**: $0.2466/kWh
- **H-POWER**: $0.1703/kWh (on-peak), $0.1238/kWh (off-peak)

Table 7: **BIOMASS PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
Green Energy Biomass-to-Energy Facility	Kauai	Koloa	6.7 MWac	Existing/Operational
Honua Ola Bioenergy Facility	Hawaii	Pepeekeo	21.5 MW	Proposed/Under Development
Keaau Zero Waste Facility	Hawaii	Keeau	Feedstock	Proposed/Under Development

Table 8: **WASTE-TO-ENERGY PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
H-POWER	Oahu	Kapolei (Campbell Industrial Park)	88 MW (68.5 MW)	Existing/Operational
Hawaii Air National Guard Waste-to-Energy Microgrid System Demo	Oahu	Joint Base Pearl Harbor-Hickam	Demonstration	Existing/Operational
PVT Bioconversion Feedstock Facility	Oahu	Nanakuli	Feedstock Production	Existing/Operational
Hawaii Integrated Resource Recovery Facility	Hawaii	Waikoloa	15 MMBTU/hr	Proposed/Under Development
Maui County Integrated Waste Conversion and Energy Project	Maui	Puunene	15 MW	Proposed/Under Development

Bioenergy and Waste-To-Energy

BIOFUELS

Under Hawaii law (HRS 269-91), "biofuels" includes liquid or gaseous fuels produced from organic sources such as biomass crops, agricultural residues and oil crops, such as palm oil, canola oil, soybean oil, waste cooking oil, grease, and food wastes, animal residues and wastes, and sewage and landfill wastes. Materials (feedstocks) that could be used for biofuel production include sugars (from plants such as sugarcane or sweet sorghum), starch (such as from corn or cassava), fiber (from grasses, trees, husks, stalks, fibers from oilseeds, and from waste materials such as paper, sawdust, or other organic materials), and oil (such as jatropha, kukui, microalgae, soybean, peanut, sunflower, oil palm, or waste cooking oil). Biofuels are a renewable energy source that can be stored and transported in a manner similar to fossil fuels, can often be used in existing equipment and be blended with petroleum fuels. According to the U.S. Department of Energy estimate, and as an illustrative example, one ton of cellulosic biomass can yield about two barrels of biofuels.

Table 9: **BIOFUELS PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
Big Island Biodiesel	Hawaii	Keaau	5 MGY	Existing/Operational
Campbell Industrial Park Generating Station	Oahu	Kapolei	120 MW	Existing/Operational
Cellana Algae Kona Demonstration Facility	Hawaii	Kailua-Kona	Demonstration	Existing/Operational
Daniel K. Inouye International Airport Dispatchable Standby Generation Project	Oahu	Honolulu	10 MW	Existing/Operational
Hawaii Pure Plant Oil	Hawaii	Keaau	Demonstration	Existing/Operational
Honouliuli Wastewater Treatment Plant Biogas Project	Oahu	Ewa Beach	800,000 Therms / Year	Existing/Operational
Kauai Algae Farm	Kauai	Lihue	Demonstration	Existing/Operational
Pacific Biodiesel Biofuel Crop Demonstration Project	Maui	Central Valley	Feedstock Demon-stration	Existing/Operational
Pacific Biodiesel Honolulu Plant	Oahu	Honolulu	1 MGY	Existing/Operational
Schofield Generating Station	Oahu	Wahiawa	50 MW	Existing/Operational
TerViva Pongamia Feedstock Demonstration	Oahu	Haleiwa	Demonstration	Existing/Operational
Maui Energy Park (Mahinahina Energy Park)	Maui	Lahaina	4.5 - 6 MW	Proposed/Under Development
TerViva Pongamia Feedstock Demonstration	Maui	Maalaea-Kihei	Demonstration	Proposed/Under Development

BIOFUELS PRODUCTION AND CONSUMPTION IN HAWAII

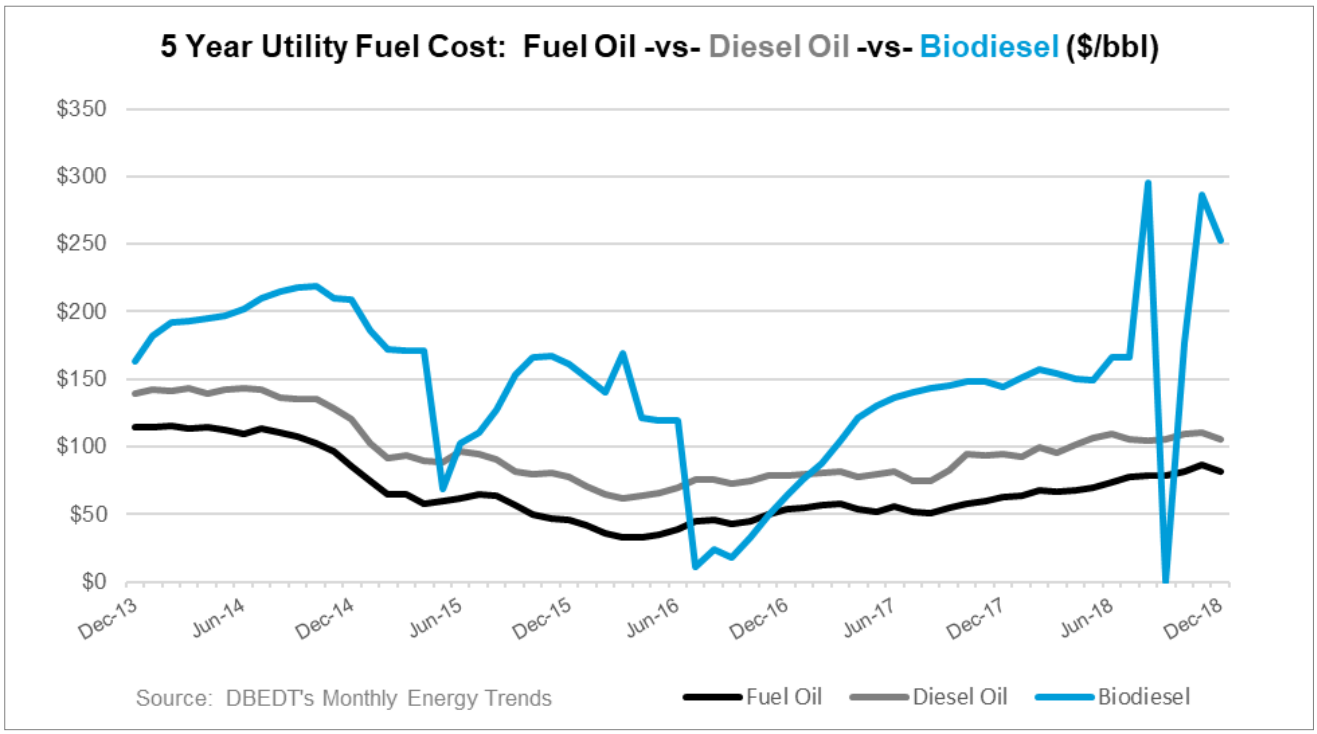
Currently, biofuel and biogas in Hawaii is produced primarily through the conversion of waste feedstocks – waste greases (Pacific Biodiesel Technologies plants) and wastewater treatment (HAWAII GAS biogas plant). Biofuels contributed approximately 2.5 percent towards Hawaii's RPS in 2018; however, the annual RPS reports do not indicate what percentage of this contribution can be attributed to locally produced biofuels.

Bioenergy and Waste-To-Energy

BIOFUELS PRICING

Since biodiesel fuel imports into Hawaii for electricity production began in 2010, the relative cost of the imported biodiesel fuel has been significantly higher than for the fossil-based fuels used for electricity generation in Hawaii.

Fig. 13:



ENVIRONMENTAL CONSIDERATIONS

The cultivation, production, transportation, and consumption of bioenergy has potential for significant environmental impacts throughout the product chain, particularly given Hawaii's protected environments and native ecosystems. Close consideration of the potential impacts and risks from each phase is necessary to fully appreciate and regulate the environmental impacts from bioenergy projects in Hawaii.

Geothermal

According to the University of Hawaii School of Ocean and Earth Science and Technology, the State of Hawaii has three active volcanoes and three potentially active (dormant) volcanoes throughout the island chain: Loihi (submerged south of Hawaii), Kilauea (Hawaii), Mauna Loa (Hawaii), Mauna Kea (Hawaii), Hualalai (Hawaii), and Haleakala (Maui).

CURRENT PRODUCTION

Prior to its closure in May 2018 due to the Kilauea eruption, the State of Hawaii had one operating geothermal power plant: the 38 megawatt (MW) Puna Geothermal Venture (PGV) facility owned and operated by Ormat Technologies and located in Pahoa on the eastside of Hawaii island. From January 2018 to May 2018, PGV generated 110,089 megawatt-hours (MWh), which was 10 percent of energy sales on Hawaii island that year. This is a 212,520 MWh reduction from 2017, when PGV produced 30.8 percent of Hawaii island energy sales for the entire year (322,609 MWh). At time of this print, PGV's future status remains unknown, however, PGV has announced its intention to repower this facility, has carved a new road to the facility, and has started the regulatory processes.

Fig. 14. Puna Geothermal Venture Power Plant, Ormat Technologies (February 2019)

PGV began operating in 1993 at 25 MW and was expanded in 2011 to its current capacity of 38 MW. With the 2011 expansion, PGV became the world's first integrated combined cycle power plant capable of providing both baseload power to the grid and dispatchable power that supports the integration of other intermittent (fluctuating) renewable energy sources on Hawaii island (wind, solar, hydropower). PGV extracts steam and hot fluids from production wells a mile or more beneath the earth's surface and converts the steam into energy through heat exchangers and steam turbine generators. Reuse of the steam in a closed loop system maximizes the energy output of the extracted steam and fluids and minimizes plant emissions under normal operating conditions. After use, the exhaust steam and fluids are re-injected into the ground via injection wells at similar depths as the production wells. PGV uses air to cool its turbines, which eliminates the need to use and dispose of water for cooling purposes. PGV's dispatchability also enables it to support the grid's integration of other sources of the renewable energy.

DIRECT USE GEOTHERMAL

While currently not used in Hawaii, direct use geothermal offers promise in areas with industrial or agricultural processing and hot groundwater at or near the surface. Direct use geothermal systems do not generate electricity, but extract heated groundwater for direct uses, including: large-scale pool heating; space heating, cooling, and on-demand hot water for buildings of most sizes; district heating (i.e., heat for multiple buildings in a city); heating roads and sidewalks to melt snow; and, some industrial and agricultural processes. Because hot water for direct use is typically close to the surface, drilling and development capital costs are relatively small compared to deeper geothermal systems.

Geothermal

GEOTHERMAL PRICING

Geothermal electricity pricing can compare well with energy produced from petroleum fuels and other forms of renewable electricity in Hawaii. GeothermEx, Inc. estimates the levelized power cost of geothermal for a hypothetical 30 MW plant on Hawaii would be between 7¢ to 8.7¢ per kilowatt-hour (kWh), with operation and maintenance costs between 4¢ to 6¢ per kWh and capital costs between $2,500 to $5,000 per installed kilowatt (Assessment of Energy Reserves and Costs of Geothermal Resources in Hawaii, GeothermEx, Inc., 2005). When operational, PGV sold power to HELCO at the following costs (average FY18 price, Hawaii Public Utilities Commission Annual Report FY 2018):

- First 25 MW (firm): $0.1190/kWh on-peak, $0.1206/kWh off-peak
- Additional 5 MW (firm): $0.1275/kWh on-peak and off-peak
- Additional 8 MW (cycling): $0.0648/kWh on-peak and off-peak

GEOTHERMAL HISTORY IN HAWAII

Prior to PGV, the first geothermal production well in Hawaii was drilled in 1976 by the University of Hawaii in the lower Kilauea East Rift Zone on the southeast side of Hawaii island: the Hawaii Geothermal Project – Well A (HGP-A). In 1982, the U.S. Department of Energy developed a 3 MW experimental power plant at the site, which was shut down in the late 1980s.

GEOTHERMAL PLANNING, POTENTIAL, AND EXPLORATION

Geothermal resources in Hawaii are difficult to fully characterize without exploration and drilling because Hawaii's high-temperature resources – some of the world's hottest – are generally found deep beneath the ground surface. Hawaiian Electric's Power Supply Improvement Plan (PSIP) Update Report: December 2016 (Hawaii Public Utilities Commission Docket No. 2014-0183) forecasts 40 MW of new geothermal development on Maui by 2040 and an additional 40 MW of geothermal on Hawaii island by 2030. Studies indicate the islands of Maui and Hawaii combined have a minimum potential geothermal capacity of 525 MW, with a more likely combined capacity of 1,535 MW (GeothermEx, Inc., 2005). Other Hawaiian islands, particularly Kauai and Oahu, do not show as much potential for geothermal development, but are still under consideration for additional study and possible use, as are Molokai and Lanai.

Geothermal's promise as a firm, cost-competitive source of baseload renewable energy continues to encourage exploratory efforts to better understand Hawaii's geothermal resource potential. Typical 'non-invasive' exploratory data gathering techniques used in Hawaii include: literary and oral research; magnetotellurics (MT), which uses electromagnetic signals to detect subsurface electrical conductivity; water sampling to detect chemical composition; and, computer modeling. Recently completed surficial geophysical studies in the Saddle Road area of Hawaii island indicate the potential presence of geothermal and groundwater activity in this region (Final Report: Magnetotelluric and AudioMagnetotelluric Surveys on DHHL Lands Mauna Kea East Flank, 2016).

Geothermal

The Hawaii Groundwater and Geothermal Resources Center (HGGRC) catalogs much of the completed and ongoing geothermal-related explorations in Hawaii. Visit HGGRC at https://www.higp.hawaii.edu/hggrc/.

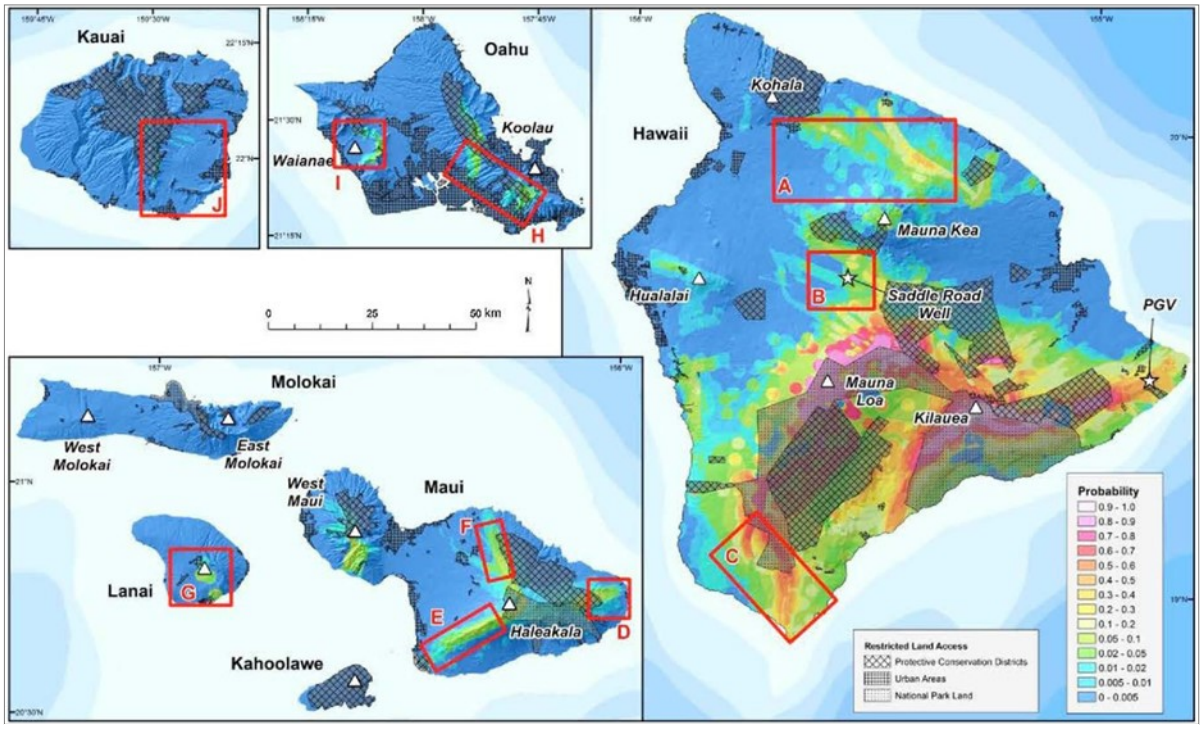


Fig. 15. Phase 2 Updated Hawaii Geothermal Resource Probability Map, Hawaii Play Fairway Project

The ongoing Hawaii Play Fairway Project, managed by HGGRC and funded up to $1.5M by the U.S. Department of Energy Geothermal Technologies Office, will provide the first statewide geothermal resource assessment conducted since the late 1970s. Phase I, completed in 2015, involved the identification, compilation, and ranking of existing geologic, groundwater, and geophysical datasets relevant to subsurface heat, fluid, and permeability in Hawaii. Phase II, completed in 2017, involved the collection new groundwater data in 10 locations across the state and new geophysical data on Lanai, Maui, and central Hawaii island, modeling the typography of the areas of interest to better characterize subsurface permeability, and the development of an updated geothermal resource probability map. Phase III involves the collection and analysis of scientific data from existing well sites and may include drilling of a geothermal test well ("slim hole") at one of the high probability locations determined through Phases I and II. Results from the Hawaii Play Fairway Project will also indicate areas warranting additional geothermal resource exploration.

ENVIRONMENTAL CONSIDERATIONS

Geothermal energy offers some environmental benefits because it can generate minimal emissions and manufactured wastes if designed and regulated properly and provides a constant (24 hours a day) source of reliable power at around 90 percent output capacity to replace firm power fossil fuels. However, if not regulated, designed, and operated properly, geothermal exploration and production technologies have the potential to negatively impact the surrounding environment and human populations. Numerous federal, state, and county regulations are in place to govern geothermal developments.

In Hawaii, concerns about geothermal's impacts to human health and the environment are well documented and have led to more stringent local regulations in some cases (i.e., night-time drilling ban on Hawaii island within one mile of nearest residence). One of the primary concerns in Hawaii is the release of hydrogen sulfide, a poisonous gas that can cause acute and chronic respiratory conditions in humans and acidic environmental conditions.

Geothermal

Air monitoring, materials handling, and other controls are required to regulate planned and unplanned emission releases. The noise and lighting caused by drilling and plant operations can also impact nearby communities and often requires mitigation or avoidance measures. Also of concern is the potential risk to groundwater from the injection or inadvertent release of used geothermal fluids being extracted or injected back into the earth. Stringent well operations and drilling regulations, treatment of these fluids to match their extraction composition, and injection far below groundwater tables can mitigate this risk. Any new geothermal developments in Hawaii require thoughtful planning, comprehensive environmental impact analysis, and considerable community engagement prior to deciding on the viability of a given project.

CULTURAL CONSIDERATONS

The extraction and use of Hawaii's geothermal resources, including water and volcanic materials, requires careful consideration of the cultural values placed on those resources and their contemporary cultural uses. The native religion of the Hawaiian people has many deities connected to Hawaii's natural resources, including Pele, widely known as the goddess of fire and volcanoes. Some Native Hawaiian religion practitioners have opposed geothermal in Hawaii for religious reasons, which is documented by a lengthy history of litigation and administrative procedures. Conversely, some Native Hawaiian religion practitioners view geothermal as a gift to the people of Hawaii. As with all large energy developments, any new geothermal developments in Hawaii must include extensive consultation with Native Hawaiians and others to identify and discuss cultural impact considerations.

Hydropower

Hydropower or hydroelectricity was the first renewable energy technology used to generate electricity in Hawaii – plants date back to 1888. Early hydroelectric facilities were in Honolulu, Hilo, and on the island of Kauai. The Puueo Hydropower facility on Wailuku River on Hawaii Island was originally built in 1910 and remains operational today. During the sugarcane era, additional hydroelectric plants were installed to help power sugar operations and likely contributed to a significant percentage of the area population's overall energy needs. The technology is fully commercial and reliable but is limited by fluctuating water levels in Hawaii's streams and irrigation ditches. Due to Hawaii's geology, run-of-the-river and run-of-the-ditch systems, which have no dams, are the prevalent hydropower technology.

CURRENT PRODUCTION

Several small home-scale plants, commercial and municipal installations, and utility-scale hydropower facilities are currently in operation in Hawaii. Hawaii currently has about 27 megawatts (MW) of installed hydroelectricity capacity statewide. Hawaii's largest hydropower plant is the 12.1 MW Wailuku River plant on Hawaii Island and the smallest is the 6.7 kWac Ainako Hydro project developed and used by a community group on Hawaii Island. The Hawaii County Department of Water Supply (DWS) has three small in-line hydropower plants under 100 kilowatts that capture the energy from pipes carrying water to DWS customers in West Hawaii. In 2018, hydropower accounted for 0.72 percent of the total energy distributed by Hawaii's electric utilities statewide (2018 Renewable Portfolio Standard Status Reports). In 2018, hydropower represented 6.6 percent of the total electricity sold by KIUC on Kauai and 5.9 percent of the electricity sold by HELCO on the island of Hawaii, the two islands with the most hydropower in operation.

Fig. 16. Wailuku River Hydropower Plant, HELCO

HYDROPOWER PRICING

Per the Hawaii Public Utilities Commission's Annual Report Fiscal Year 2018, the average 2018 fiscal year energy prices for some of Hawaii's hydropower plants are:

- **Green Energy Hydro**: $0.1182/kWh
- **Kauai Coffee Hydro**: $0.201/kWh
- **Kekaha Agricultural Association Hydro**: $0.0857/kWh
- **Makila Hydro**: $0.134/kWh (on-peak), $0.127/kWh (off-peak)
- **Wailuku River Hydro**: $0.128/kWh (on-peak), $0.13/kWh (off-peak)

PUMPED STORAGE HYDROPOWER

Pumped storage hydro uses a non-hydro source of electricity (e.g., wind, solar, conventional generation) to pump water from one reservoir to a second, higher reservoir. The water stored in the upper reservoir can be released as needed, running through a turbine on the way back down and generating power like a normal hydropower unit. KIUC continues to pursue the development of a new 25 MW pumped storage hydropower project on the westside of Kauai, utilizing the Puu Lua Reservoir, Puu Opae Reservoir, and Kokee Ditch, which could provide more than 20 percent of the island's annual electricity requirements. Other reservoirs on Hawaii, Maui, and Oahu (Lake Wilson, Nuuanu) have also garnered attention for their pumped storage use potential.

HAWAII HYDROPOWER ASSESSMENT

The U.S. Army Corps of Engineers (USACOE) conducted a Hydroelectric Power Assessment for the State of Hawaii in 2011, which is a feasibility study that identifies, evaluates, and recommends solutions to address the potential hydroelectric power needs in the State of Hawaii. USACOE studied more than 160 hydro sites and ocean energy areas across Hawaii as part of this assessment.

Hydropower

Table 10: **HYDROPOWER PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
Ainako (Wenko) Hydro	Hawaii	Hilo	6.7 kWac	Existing/Operational
Gay & Robinson Olokele Hydro Project	Kauai	Kaumakani	1.3 MW	Existing/Operational
Green Energy Hydro	Kauai	Koloa	125 kW	Existing/Operational
Hamakua Springs Country Farms Hydroelectric Project	Hawaii	Pepeekeo	93 kW	Existing/Operational
Kahaluu Shaft Hydro	Hawaii	Kahaluu	42 kW	Existing/Operational
Kaloko Tank No. 2 Hydro	Hawaii	Kaloko	50 kW	Existing/Operational
Kauai Coffee Kalaheo Hydro Facility	Kauai	Kalaheo	1 MW	Existing/Operational
Kauai Coffee Wainiha Hydro Facility	Kauai	Wainiha Valley	4 MW	Existing/Operational
Makila Hydro Plant	Maui	Lahaina	500 kW	Existing/Operational
Palm Valley Farm (Hoowaiwai Farm Estate) Hydro	Hawaii	Papaikou	80 kW	Existing/Operational
Puueo Hydroelectric Plant	Hawaii	Hilo	3.25 MW	Existing/Operational
Waiahi (Lower) Hydropower Plant	Kauai	Lihue	800 kW	Existing/Operational
Waiahi (Upper) Hydropower Plant	Kauai	Lihue	500 kW	Existing/Operational
Waiau Hydroelectric Plant + Repowering Project	Hawaii	Hilo	1.1 MW	Existing/Operational
Waiawa Hydropower Plant (KAA Hydro Waimea)	Kauai	Waimea	500 kW	Existing/Operational
Wailuku River Hydroelectric Plant	Hawaii	Hilo	12.1 MW	Existing/Operational
Waimea Hydropower Plant (KAA Hydro Mauka)	Kauai	Waimea	1.25 MW	Existing/Operational
Waimea Wastewater Treatment Plant Hydro	Hawaii	Waimea	32 kW	Existing/Operational
Gay & Robinson Olokele Hydro Project Expansion	Kauai	Kaumakani	6 MW	Proposed/Under Development
Hawaii Water Service Co. (Waikoloa Resort Utilities) Inline Hydro Plant	Hawaii	Waikoloa Village	100 kW	Proposed/Under Development
Innovative Power Projects Pumped Storage Project (Proposed)	Maui	South Maui (unknown)	40 MW + 8 Hrs Storage	Proposed/Under Development
Molokai Irrigation System Hydropower Plant	Molokai	Molokai Ranch	100 kW	Proposed/Under Development
West Kauai Energy Project (Puu Opae Pumped Storage Hydro Project)	Kauai	Kekaha	25 MW	Proposed/Under Development

ENVIRONMENTAL CONSIDERATIONS

Hydropower projects have the potential for significant agricultural, cultural, ecological, environmental and other impacts including those to other water users. Any proposed projects with potential to impact Hawaii's surface waterways will undergo intense regulatory and community scrutiny to ensure protection of the impacted species and ecologies, and adequate water for downstream users (taro and other farmers, recreational users). If done properly, hydropower can support and benefit the resources, water uses, and other activities that depend upon Hawaii's surface waters.

Ocean and Marine Hydrokinetic Energy

Surrounded by the Pacific Ocean, Hawaii is rich in ocean and marine renewable energy resources. Ocean or marine energy includes both hydrokinetic and thermal resources. Hydrokinetic technologies tap the movement in the ocean—waves, currents and tides—to generate electricity. Ocean Thermal Energy Conversion (OTEC) makes use of the temperature differences between warm surface waters and cold, deep ocean waters. Hawaii has superior potential for wave energy and OTEC, however, does not currently depend on wave or OTEC for any substantive energy production. Ocean current and tidal resources are not as promising in Hawaii due to its relatively mild tidal shifts compared to other parts of the world. Ocean energy technology continues to evolve as numerous ocean energy research, development, and demonstration projects are taking place in Hawaii and elsewhere in the world.

CURRENT PRODUCTION

The first ocean wave-generated electricity ever transmitted to the grid in the United States was generated by an Ocean Power Technologies (OPT) PowerBuoy at Kaneohe Bay in 2010. In a cooperative program with the U.S. Navy, three OPT buoys were deployed from 2004 to 2011. The U.S. Navy partnered with the Hawaii National Marine Renewable Energy Center (HINMREC) at the University of Hawaii-Manoa, one of three federally-funded centers for marine energy research and development in the nation, to establish a multiple-berth deep water wave energy test site (WETS) in Kaneohe Bay, Oahu. Located on the seafloor approximately 200-260 feet deep, approximately 6,500-8,200 feet offshore, the purpose of the WETS is to collect and analyze wave buoy equipment performance (grid-connected), cost, and durability (which will help guide industry design improvements), as well as monitor environmental impacts from wave energy technologies (EMF, sediment, ecology).

Fig. 17. Wave Energy Test Site, Kaneohe Bay, Oahu, HINMREC

With the WETS infrastructure secured in place, various wave energy conversion units will be connected and tested for one year or more. According to reports, the WETS is the first grid-connected wave test facility in the U.S. for commercial-scale WECs. Data from the wave buoys connected to the WETS will be collected and analyzed by the U.S. Navy, USDOE, and HINMREC. The first new tenant, Northwest Energy Innovations (NWEI), deployed its first Azura prototype wave buoy at the WETS 30-meter-deep berth. Other companies with wave energy devices connected to the WETS include Fred Olsen Ltd. And Columbia Power Technologies. Ocean Energy plans to connect its 1.25 MW capacity prototype OE Buoy built by Vigor to WETS in 2019.

Fig. 18. Lifesaver Wave Energy Device at WETS, Kaneohe Bay, Oahu

OCEAN THERMAL ENERGY CONVERSION (OTEC)

The Natural Energy Laboratory of Hawaii Authority (NELHA) at Keahole Point, Kona, Hawaii, is among the world's premier OTEC research centers. NELHA's Hawaii Ocean Science and Technology (HOST) Park houses enterprises that test renewable energy technologies on the cusp of commercialization. Major milestones in OTEC were achieved at NELHA in the 1980s and 1990s, including a 1 MW floating OTEC pilot plant, Mini-OTEC (the world's first demonstration of net power output from a closed-cycle plant) and other demonstrations in both open- and closed-cycle OTEC.

Ocean and Marine Hydrokinetic Energy

NELHA's cold seawater supply pipes are the deepest large-diameter pipelines in the world's oceans, extending to 2,000-foot depths; providing a temperature variance between 6°C (43°F) at lower depths to 24° – 28.5°C (75° – 83°F) near the surface. The laboratory's location, with access to both warm surface water and cold deep ocean water, makes it a prime site for OTEC R&D. Presently, Makai Ocean Engineering is operating Hawaii's only operational OTEC Pilot Project: a heat exchanger test facility at NELHA that tests components and materials. A 100-kilowatt (kW) OTEC generator has been added to the test facility and became operational in August 2015. A 1 megawatt (MW) OTEC demonstration facility at NELHA is in the planning stages and power plants up to 100 MW in capacity have previously been proposed for locations off Oahu.

Fig. 19. OTEC Pilot Project, Keahole Point, Kona

OCEAN AND MARINE ENERGY PRICING

To date no power purchase agreements for ocean or marine energy projects have been filed with the Hawaii Public Utilities Commission.

TIDAL POWER

Hawaii's lack of extreme tidal shifts has thus far discouraged the deployment of demonstration projects to convert tidal shifts to electrical energy.

ENVIRONMENTAL CONSIDERATONS

Ocean and marine energy generation projects have the potential for significant ecological, recreational, commercial, environmental, cultural, and other impacts. Any proposed projects with potential to impact Hawaii's ocean waters and uses will undergo intense regulatory and community scrutiny to ensure conservation of the impacted species and ecologies, protection of commercial and recreational ocean uses, and safeguards in case of unintended releases (water or equipment detached from seafloor).

Photovoltaic (Utility-Scale)

Due to Hawaii's high-electricity prices, abundant solar resource, and progressive energy policies, the state has experienced unprecedented growth in solar generation. In recent years solar has become the primary renewable energy resource in Hawaii. Most solar generation is provided by distributed customer photovoltaic (PV) systems discussed more below (Distributed Energy Resource Programs). While there are many large commercial and utility solar (PV) installations in Hawaii on rooftops, carports, and the ground, the term "utility-scale" for the purposes of this document refers primarily to larger ground-mounted solar farms that sell power to the local electric utility.

Fig. 20. EE Waianae Solar Project, Eurus Energy, Waianae, Oahu

Table 11: **CURRENT PRODUCTION**

Utility-scale PV contributed approximately 8.6 percent towards Hawaii's RPS in 2018. There are also numerous large solar projects under development or procurement expected to go online in 2019 and more projects scheduled for completion by 2022.

Table 12: **UTILITY-SCALE PV PRICING**

Per the Hawaii Public Utilities Commission's Annual Report Fiscal Year 2018, the average 2018 fiscal year energy prices for some of Hawaii's solar PV projects are:

AES Lawai: $0.110/kWh (PPA price)	**KRS1 Anahola**: $0.128/kWh
EE Waianae Solar: $0.145/kWh	**KRS2 Koloa**: $0.122/kWh
Kalaeloa Renewable Energy Park: $0.216/kWh	**Kuia Solar**: $0.11/kWh (PPA price)
Kalaeloa Solar Two: $0.2183/kWh	**Port Allen/McBryde**: $0.20/kWh
Kapaa Solar: $0.20/kWh	**SolarCity/Tesla Solar (Lihue)**: $0.139/kWh
Kapolei Sustainable Energy Park: $0.236/kWh	**South Maui Renewable Resources**: $0.1106/kWh

Per the power purchase agreements filed with the Hawaii Public Utilities Commission, energy prices for some of the more recent utility-scale solar PV projects proposed or under development are:

AES Kekaha (PMRF): $0.1085/kWh	**Lanikuhana Solar**: $0.13/kWh
AES Kuihelani + AES Waikoloa: $0.08/kWh	**Mililani 1 Solar Project**: $0.09/kWh
AES West Oahu: $0.1056/kWh	**Molokai New Energy Partners**: $0.18/kWh
Hale Kuawehi Solar Project: $0.09/kWh	**Waiawa Solar Power**: $0.10/kWh
Hoohana Solar 1 Project: $0.10/kWh	**Waipio PV**: $0.121/kWh
Kawailoa Solar: $0.127/kWh	**West Loch PV Project**: $0.0954/kWh

Photovoltaic (Utility-Scale)

Table 13: **UTILITY-SCALE PV PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
AES Lawai Solar Project	Kauai	Lawai	20MWac/28MWdc + 100MWh	Existing/Operational
Aloha Solar Energy Fund I Solar Project	Oahu	Nanakuli	5 MWac / 6.2 MWdc	Existing/Operational
Cyanotech Solar Array	Hawaii	Kailua-Kona	500 kW	Existing/Operational
Dole Plantation Solar Array	Oahu	Wahiawa	500 kW	Existing/Operational
EE Waianae Solar	Oahu	Waianae	27.6 MWac	Existing/Operational
Hawaii American Water Solar Array	Oahu	Hawaii Kai	250 kW	Existing/Operational
Hawaii FIT Forty, LLC	Oahu	Waianae	570 kWdc	Existing/Operational
Hawaii FIT Two	Oahu	Waianae	596.7 kWdc	Existing/Operational
Kahumana PV	Oahu	Waianae	245 Kw	Existing/Operational
Kalaeloa Renewable Energy Park	Oahu	Kalaeloa	5 MW	Existing/Operational
Kalaeloa Solar Power II	Oahu	Kalaeloa	5 MW	Existing/Operational
Kapaa Solar Project	Kauai	Kapaa	1 MW	Existing/Operational
Kapolei Sustainable Energy Park	Oahu	Kapolei	1 MW	Existing/Operational
KRS1 Anahola Solar Farm	Kauai	Anahola	12 MWac	Existing/Operational
KRS2 Koloa Solar Farm	Kauai	Koloa	12 MWac	Existing/Operational
Kuia Solar Project	Maui	Lahaina	2.87 MWac / 3.794 MWdc	Existing/Operational
La Ola Solar Farm (Lanai Sustainability Research)	Lanai	Lanai City	1.2 MWac	Existing/Operational
MP2 Kaneshiro Solar Project	Kauai	Lawai	300 kW	Existing/Operational
Pearl City Peninsula PV	Oahu	Pearl Harbor	1.23 MW	Existing/Operational
Port Allen (McBryde) Solar Facility	Kauai	Eleele	6 MW	Existing/Operational
SolarCity Tesla Solar Project	Kauai	Lihue	13 MWac / 17 MWdc	Existing/Operational
South Maui Renewable Resources Solar Project	Maui	Kihei	2.87 MWac / 3.794 MWdc	Existing/Operational
University of Hawaii-West Oahu Solar PV System	Oahu	Kapolei	500 kW	Existing/Operational
Waianae PV-2 Solar Farm	Oahu	Waianae	500 kW	Existing/Operational
Waihonu North Solar Farm	Oahu	Mililani	5 MW	Existing/Operational
Waihonu South Solar Farm	Oahu	Mililani	1.5 MW	Existing/Operational
Waimea Research Center PV Facility	Kauai	Waimea Research Center	250 kW	Existing/Operational
Waipio Solar Facility	Oahu	Joint Base Pearl Harbor-Hickam	11 MWac / 14.3 MWdc	Existing/Operational
Wilcox Memorial Hospital Solar Photovoltaic Farm	Kauai	Lihue	500 kW	Existing/Operational

Photovoltaic (Utility-Scale)

UTILITY-SCALE PV PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY

Project Name	Island	Location	Capacity	Project Status
AES Kekaha (PMRF) Solar Project	Kauai	Barking Sands, Kekaha	14MWac/19.3MWdc + 70MWh	Proposed/Under Development
AES Kuihelani Solar Project	Maui	Waikapu	60 MW + 240 MWh BESS	Proposed/Under Development
AES Waikoloa Solar Project	Hawaii	Waikoloa	30 MW + 120 MWh BESS	Proposed/Under Development
AES West Oahu Solar	Oahu	Kapolei	12.5 MWac / + 50 MWh BESS	Proposed/Under Development
Coconut Island Microgrid	Oahu	Kaneohe Bay	500 kW	Proposed/Under Development
H-POWER Photovoltaic Systems	Oahu	Kapolei (Campbell Industrial Park)	3 - 3.5 MW	Proposed/Under Development
Hale Kuawehi Solar Project	Hawaii	Waimea	30 MW + 120 MWh BESS	Proposed/Under Development
Hawaii Agriculture Research Center/Pioneer Hi-Bred Solar Energy Facility	Oahu	Kunia	500 kW	Proposed/Under Development
Hawaii SunShot Desal Project	Hawaii	Kailua-Kona	Demonstration	Proposed/Under Development
Hoohana Solar 1 Solar Project	Oahu	Kunia	52 MW + 218 MWh BESS	Proposed/Under Development
Hoolehua Water System Solar System	Molokai	Hoolehua	1 MW	Proposed/Under Development
Kawailoa Solar	Oahu	Kawailoa / Haleiwa	49 MW	Proposed/Under Development
Lanikuhana Solar (Mililani Solar)	Oahu	Mililani	14.7 MW	Proposed/Under Development
Mauka FIT One PV Project	Oahu	Kahuku	3.5 MW	Proposed/Under Development
Mililani I Solar Project	Oahu	Mililani	39 MWac + 156 MWh BESS	Proposed/Under Development
Molokai New Energy Partners Solar Project	Molokai	Umipaa/Kaunakakai	4.88 MWac + 3 MW BESS	Proposed/Under Development
Na Puu Water Inc. Photovoltaic Array	Hawaii	Puuanahulu-Puu Waawaa	650 - 780 kW	Proposed/Under Development
Ocean View Solar Projects (26)	Hawaii	Ocean View	6.75 MW Total	Proposed/Under Development
Paeahu Solar Project	Maui	Wailea	15 MW + 60 MWh BESS	Proposed/Under Development
Parker Ranch Microgrid	Hawaii	Waimea	400 kE	Proposed/Under Development

Photovoltaic (Utility-Scale)

UTILITY-SCALE PV PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY

Project Name	Island	Location	Capacity	Project Status
Proposed Hoopili Solar Farm	Oahu	East Kapolei	5 MW	Proposed/Under Development
University of Hawaii-Kapiolani Community College Solar + Storage Project	Oahu	Kahala / Kaimuki	1.738 MWh + 6.31 MWh BESS	Proposed/Under Development
Waiawa Solar Power Project	Oahu	Pearl City	36 MWac + 144 MWh BESS	Proposed/Under Development
Waipio (Waiawa) PV	Oahu	Waiawa	46 MWac	Proposed/Under Development
West Loch PV Project	Oahu	Joint Base Pearl Harbor-Hickam	20MWac/28MWdc + 20MW BESS	Proposed/Under Development

Photovoltaic (Utility-Scale)

HAWAII BRIGHTFIELDS INITIATIVE

Contaminated and underutilized sites can be preferred for renewable energy development for numerous reasons: pre-developed sites tend to be more develop-ready (graded, on-site utilities or infrastructure, site access, permits) and closer to the power grid; re-use of sites can preserve untouched lands; and, projects that support site remediation for renewable energy support multiple State of Hawaii policies. In 2018 HSEO partnered with the U.S. Environmental Protection Agency and the Hawaii Department of Health Hazard Evaluation and Emergency Response (HEER) Office retain services from the National Renewable Energy Laboratory (NREL) to create a master database of contaminated sites in Hawaii with data relevant to determine site renewable energy development potential. HSEO and HEER are now validating the data for publication in a GIS layer and to pursue individual site assessments and redevelopment and intend to publish these resources in the second half of 2019.

ENVIRONMENTAL CONSIDERATIONS

Because they often require the flattening of large areas of land prior to development, utility-scale PV projects have the potential for significant agricultural, cultural, ecological, and other impacts. Field studies and surveys for various resources – both human-made and natural – must be completed to fully understand the viability of developing a site for solar energy production. In Hawaii large solar farms can compete with local agricultural needs and can stress Hawaii's agricultural industry. Solar developers should not target land currently used or planned for use by agricultural operations or land that has been identified or classified as good for agricultural use. Any proposed projects with potential to impact Hawaii's agricultural sector or its natural environment will undergo intense regulatory and community scrutiny to ensure protection of these resources. If done properly, PV projects can benefit Hawaii's agricultural industry.

Wind

Humans have been harnessing wind energy for centuries. Wind energy, while not firm, is a proven renewable energy resource in Hawaii that can operate 24-hours a day. Wind energy is Hawaii's second most utilized renewable energy resource behind distributed solar, accounting for the following in 2018 (2018 Renewable Portfolio Standard Status Reports):

- 23.9 percent of Hawaii's total renewable energy portfolio
- 6.6 percent of the Hawaii's overall energy use
- 3.1 percent of Oahu's energy use
- 23.1 percent of Maui's energy use
- 13.8 percent of Hawaii island's energy use

CURRENT WIND PRODUCTION

There are currently eight existing utility-scale wind energy projects in Hawaii located on the islands of Oahu, Maui, and Hawaii. Demonstrating Hawaii's limited geography, the average acres per megawatt (MW) ratio of these eight Hawaii wind farms is 13.8 acres/MW, ranging from 38.1 MW/acre (Lalamilo Wind Farm) to 3.2 MW/acre (Auwahi Wind Farm). No wind farms exist on Kauai largely due to Kauai's protected seabird populations. There are also numerous smaller, distributed wind turbines (up to 100 kW) currently in operation throughout Hawaii. Hawaii's wind farms also support other needs including agriculture through co-location of grazing, infrastructure improvements funded by the wind project (water, fencing), resources for protected species research and conservation, and energy to pump municipal water supplies.

Fig. 21. Kaheawa Wind Power I, Maui, TerraForm Power

WIND PRICING

Per the Hawaii Public Utilities Commission's Annual Report for fiscal year 2018, the average 2018 fiscal year energy prices for some of Hawaii's wind energy projects are:

Table 14:

Auwahi Wind Farm: $0.21720/kWh	**Kahuku Wind Power**: $0.2055/kWh
Hawi Wind Farm: $0.1216/kWh (on-peak), $0.1241/kWh (off-peak)	**Kawailoa Wind**: $0.219/kWh
Kaheawa Wind Power I: $0.13624/kWh (on-peak), $0.12793/kWh (off-peak)	**Pakini Nui Wind Farm**: $0.118/kWh (on-peak), $0.112/kWh (off-peak)
Kaheawa Wind Power II: $0.20767/kWh	**Lalamilo Wind Farm Repowering Project** sells power directly to Hawaii County

Per the power purchase agreements filed with the Hawaii Public Utilities Commission, energy prices for two of the more recent large wind projects proposed or under development on Oahu are:

Na Pua Makani Wind Farm: $0.139/kWh	**Palehua Wind Project**: $0.109/kWh

Wind

Table 15: **WIND PROJECTS IN THE HAWAII RENEWABLE ENERGY PROJECTS DIRECTORY**

Project Name	Island	Location	Capacity	Project Status
Auwahi Wind Farm	Maui	Ulupalakua	21 MW	Existing/Operational
Hawi Wind Farm	Hawaii	Upolu Point	10.56 MW	Existing/Operational
Kaheawa Wind Power I	Maui	Kaheawa	30 MW	Existing/Operational
Kaheawa Wind Power II	Maui	Kaheawa	21 MW + 10 MW BESS	Existing/Operational
Kahuku Wind Farm	Oahu	Kahuku	30 MW	Existing/Operational
Kawailoa Wind	Oahu	Kawailoa / Haleiwa	69 MW	Existing/Operational
Lalamilo Wind Farm Repowering Project	Hawaii	Lalamilo	3.3 MW	Existing/Operational
North Kohala Microgrid Project	Hawaii	North Kohala	100 kW	Existing/Operational
Pakini Nui Wind Farm	Hawaii	Ka Lae (South Point)	20.5 MW	Existing/Operational
Na Pua Makani Wind Project	Oahu	Kahuku	24 MW	Proposed/Under Development
Palehua Wind Project	Oahu	Waianae	46.8 MW	Proposed/Under Development

HISTORY OF WIND IN HAWAII

In Hawaii the first wind farm was built in the 1980s by Hawaiian Electric Company (HECO) in Kahuku, Oahu: a 9-megawatt (MW) wind farm that was later supplemented by a 3.2 MW wind turbine at the same location, the 360-ft. MOD-5-B, which was then the world's largest horizontal axis wind turbine. The Kahuku wind farm experienced winds that were more turbulent than expected and mechanical problems with the first-generation turbines resulted in low energy production. In the mid-1980s, Maui Electric Company (MECO) hosted a 340-kilowatt (kW) wind turbine demonstration unit for several years at its Maalaea facility and operated it until the end of its useful life.

WIND POTENTIAL IN HAWAII

Hawaii has one of the most robust and consistent wind regimes in the world, with capacity factors exceeding those commonly found elsewhere. In 2011 the U.S. Energy Information Administration (EIA) estimated the capacity factor of the Pakini Nui Wind Farm on the Big Island at 65 percent, Kaheawa Wind Power I on Maui at 47 percent, and the Hawi Renewables Wind Farm on the Big Island at 45 percent. Hawaii's strong wind regime and aggressive renewable energy goals are reflected by the amount of wind power Hawaii's electrical utilities plan to integrate into their respective grids by the year 2045. The Hawaiian Electric Companies' Power Supply Improvement Plan (PSIP) Update Report: December 2016 plans for up to an additional 64 megawatts (MW) of onshore wind on Oahu by the year 2045, and up to 200 to 800 MW of offshore wind of Oahu by 2045. The Hawaiian Electric Companies plan for between 42 MW to 150 MW of new onshore wind on Maui by 2045, up to 5 MW of new wind on Molokai by 2020, and up to 102 MW of additional wind on Hawaii Island. The current plan estimates this amount of wind, in combination of many other types of renewable energy, could be needed to get Hawaii to 100 percent renewable energy by the year 2045. This plan is subject to stakeholder review and approval by the Hawaii Public Utilities Commission and does not guarantee any of the proposed MW will be installed, but they do provide options for planning consideration.

Wind

OFFSHORE WIND

In response to an invitation from then-Gov. Neil Abercrombie, in 2011-2012 the Bureau of Ocean Energy Management (BOEM) established the BOEM/ Hawaii Intergovernmental Renewable Energy Task Force to promote planning and coordination, and to facilitate effective and efficient review of requests for commercial and research seafloor leases and right-of-way grants for power cables on the federal outer continental shelf (OCS), which begins three nautical miles offshore Hawaii. Members of the Task Force, whose meetings and matters are open to the public, include representatives of federal, state, and local government agencies. Attention to offshore wind in Hawaii has increased following notice of multiple unsolicited applications received by BOEM for seafloor lease applications for wind farms off-shore of Oahu; currently, still undergoing BOEM review. Multiple public meetings were conducted in 2016, with community members and other stakeholders voicing concerns, recommendations, and other opinions about the prospect of wind turbines off of Oahu's South and Northwest shores. In its last update, BOEM notified its Hawaii Task Members it is still working to determine whether an area offshore Oahu is suitable for commercial wind leasing. BOEM's determination is still pending.

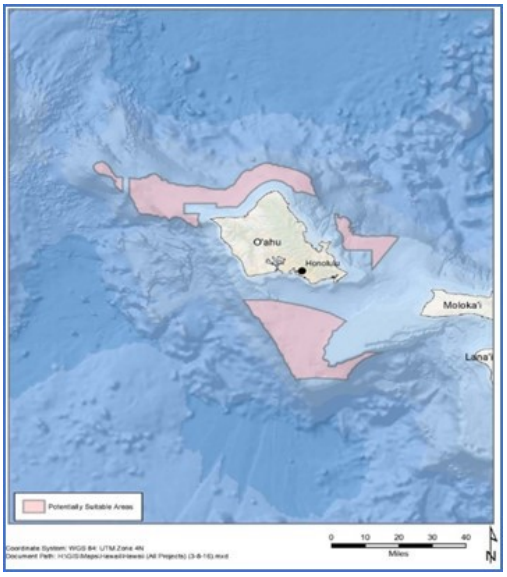


Fig. 22. Areas Suitable for Wind Offshore of Oahu, US Bureau of Ocean Energy Management

ENVIRONMENTAL CONSIDERATIONS

Given the size of today's utility-scale turbines and their potential impacts, careful consideration and stakeholder input is needed in the project siting phase. Many potential impacts must be considered:

- The presence of protected or endangered birds or bats, plant species, or critical habitats in or around the project site will significantly impact the siting, development, and operation of wind projects in Hawaii. Significant ecological monitoring is required early in the project siting phase. The appropriate regulation of certain species with less available data, such as the Hawaiian Hoary Bat, is evolving as regulators and wind developers continue to better understand the species and the measures available to limit their harm. Completed and upcoming research on the Hawaiian Hoary Bat by the Hawaii Department of Land and Natural Resources and the U.S. Geological Survey will help inform all stakeholders. The increased level of ecological monitoring required for proposed and existing wind farms in Hawaii has also expanded the amount of information available on the impacted species and habitats. In 2018 four Hawaii wind projects initiated the process to increase the taking of the endangered Hawaiian hoary bat, Hawaiian nene goose, and the Hawaiian petrel. In June 2018, the U.S Fish and Wildlife Service published notice of its intent to prepare a Programmatic Environmental Impact Statement addressing the potential impacts from the alternatives described in habitat conservation plans (HCPs) for the increased takes proposed by these projects.
- Given the size of large-scale wind turbines and limited sites suitable for wind development in Hawaii, visual and cultural impacts must be thoroughly identified and assessed early in the project siting phase. Developers need to work closely with local communities early in the process to identify important community resources and values, which are core to the appropriateness of project siting. View planes are valued by local residents and the tourism industry and are valued by Native Hawaiian religion practitioners to communicate between sites of cultural significance. Developers must account for day and night visuals, including warning lights required for aviation safety.
- Due to the military, commercial, and recreational air traffic in Hawaii, early due diligence and outreach is needed to identify and address potential encroachment issues caused by wind turbines near flight paths.
- Hawaii topography and infrastructure can make on-land transport of large wind equipment difficult in certain areas. Roadwork may be required in some cases, as well as roadway shutdowns and other approvals. Temporary storage of large equipment also can be challenging.
- The intermittent nature of Hawaii's wind resource can make integration into the electrical grid a challenge. Mitigation measures, such as forecasting, controls, and improved communication technologies can help mitigate some of these concerns. Storage technologies are increasingly incorporated to help integrate wind power more smoothly into the electrical grid.

Utility Renewable Energy Procurement

Each Hawaiian Island with a utility presence has its own independent electrical grid (Niihau and Kahoolawe do not have electrical utilities), which can make the integration of high amounts of renewable energy challenging. MECO and HELCO are subsidiaries of HECO, which is owned by the publicly-traded, investor-owned parent company, Hawaiian Electric Industries. Collectively referred to as Hawaiian Electric Companies, HECO, MECO, and HELCO provide power to the vast majority (about 95 percent) of Hawaii's population. KIUC services the remaining population on Kauai. In addition to its electrical utilities, Hawaii's has one franchised gas utility, Hawaii Gas, that services the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii Island through installed gas pipeline infrastructure in some areas, bulk storage facilities, and mobile gas equipment and tanks.

REGULATORY OVERSIGHT

The Hawaii Public Utilities Commission regulates Hawaii's electrical utilities including the review and approval of certain individual renewable energy projects and programs. The Hawaii Public Utilities Commission's Document Management System provides an online service to review dockets and filings related to renewable energy projects and programs. Most significant renewable energy projects and programs in Hawaii will have a corresponding docket and docket number created when the utility initially files a power or fuel purchase contract with the Hawaii Public Utilities Commission. The Hawaii Division of Consumer Advocacy (DCA) protects and advances the interests of Hawaii's consumers of regulated public utilities and transportation services. DCA is a party to all dockets involving renewable energy projects and programs. Other public and private entities can become parties to individual dockets under certain proceedings.

COMPETITIVE BIDDING FRAMEWORK

HECO, MECO, and HELCO are required to follow the "Competitive Bidding Framework" for new generation projects greater than 5 MW on Oahu and 2.72 MW on Molokai, Lanai, Maui, and Hawaii Island. For more information on ongoing competitive bidding processes or requests for proposals from HECO, MECO, and HELCO, visit Hawaiian Electric's Producing Clean Energy website. Alternatively, HECO, MECO, and HELCO may apply to the Hawaii Public Utilities Commission to receive a waiver of the competitive bidding requirements for certain projects that are not eligible or compatible with the competitive bidding process, which can include self-build projects initiated by the utilities and projects that do not conform to ongoing requests for proposals. Because it is not subject to the Competitive Bidding Framework, KIUC has more flexibility on procuring or developing new renewable energy projects but must still seek Hawaii Public Utilities Commission approval for large renewable energy projects. KIUC offers a variety of programs and tariffs.

POWER PURCHASE AGREEMENTS AND FUEL SUPPLY CONTRACTS

Power purchase agreements (PPA) are contracts between independent power producers (e.g., wind farm, solar farm, biomass plant) and Hawaii's regulated electric utilities in which the producer sells energy to the utility at a contracted price. Similarly, fuel supply contracts are used by Hawaii's utilities to purchase fuel (biofuel) that is converted to electricity and sold to Hawaii ratepayers. These contracts provide the mutual benefit of allowing the utility to purchase a lower cost energy resource as well as enabling the renewable energy developer to secure a longer-term revenue contract. In Hawaii the Public Utilities Commission must review and approve all PPAs and fuel supply contracts through its docket process.

SCHEDULE Q PROCUREMENTS

Schedule Q describes the standard rates, terms, and conditions that apply when the utility purchases as-available or excess energy from customers with small cogeneration and/or small power production facilities of 100 kW or less in capacity.

Distributed Energy Resource (DER) Programs

A number of potential customer cited renewable generation programs are available in the state:

- Net Energy Metering
- Net Energy Metering Plus
- Customer Grid Supply
- Customer Grid Supply Plus
- Customer Self-Supply
- Smart Export
- Standard Interconnection Agreement
- Feed-In Tariff

NET ENERGY METERING (NEM)

NEM is now closed to new applicants. Previously, the NEM program was available to permanent customers who own (or lease from a third party) a solar energy generating facility, that was located on their own property, and had a capacity of 100 kWh or less. Under the NEM program:

- Customers receive a credit at retail rate for electricity exported to the grid.
- If a customer uses more electricity than is exported (net-consumer), the customer is charged for that net amount of electricity used.
- If a customer exports more electricity than is used (net-producer), the customer is charged a minimum bill (e.g. $17 for Oahu residential customers) and is allowed to carry any excess credits forward to the next month.
- At the end of the customer's 12-month billing cycle any excess credit are forfeited or used to reimburse any energy charges previously paid.

NET ENERGY METERING PLUS (NEM PLUS)

NEM Plus program affords existing NEM customers with a signed NEM agreement to add additional non-export renewable capacity to their existing NEM system. According to HECO, NEM Plus allows customers to "install new panels, battery storage or a combination of both under this program. The output from the NEM Plus system is used solely on-site and is not allowed to export to the grid. The addition of the NEM Plus system does not affect the customer's existing NEM agreement."

CUSTOMER GRID-SUPPLY (CGS)

The CGS program allows customers to install private rooftop solar or other renewables that export energy to the electric grid throughout the day. When the Hawaii Public Utilities Commission established this interim program, they established a cap for each of the HECO Companies' service territories. These caps were established as the Public Utilities Commission concluded that it was not in the public interest to allow unconstrained growth in the grid-supply option, particularly if such growth comes at the expense of future opportunities to acquire even lower-cost renewable energy from other sources or prevents the HECO Companies from offering community-based renewable energy options for their customers. By September 2016, all three HECO Companies met their designated cap limits and additional capacity was added to CGS from capacity available from NEM applications that were cancelled or withdrawn.

Table 16: **Overall CGS program capacity limits.**

Island	Original Capacity (MWac)	Added Capacity (MWac)	Total Capacity (MWac)*
Hawaiian Electric	25.00	26.31	51.31
Maui Electric**	5.00	9.12	14.12
Hawaii Electric	5.00	4.91	9.91

* *As of Nov. 7, 2017, the CGS program reached the total capacity allotted.*
** *Includes Maui, Molokai and Lanai*

Distributed Energy Resource (DER) Programs

Table 17: **Fixed rates for electricity exports to the grid under the CGS program.**

Island	CGS Credit Rates***
Hawaii	15.14¢/kWh
Maui	17.16¢/kWh
Molokai	24.07¢/kWh
Lanai	27.88¢/kWh
Oahu	15.07¢/kWh

****Export credits may only be used during the month they are generated. Excess monthly credits expire with the utility cost reductions benefiting all customers.*

CUSTOMER GRID-SUPPLY PLUS (CGS PLUS)

The CGS Plus program is the next iteration of the original CGS program. Similar to CGS program, the CGS Plus program allows customers to install private rooftop solar or other renewables that export energy to the electric grid throughout the day. However, the CGS Plus program does differ from the CGS program, in that it requires the use of equipment that allows the utility to manage output to maintain safe, reliable grid operations.

Table 18: **CGS Plus program's export fixed rates through October 20, 2022.**

Island	CGS Plus Credit Rates****
Hawaii	10.55¢/kWh
Maui	12.17¢/kWh
Molokai	16.77¢/kWh
Lanai	20.88¢/kWh
Oahu	10.08¢/kWh

*****Export credits will be trued-up on an annual basis and any remaining credits left over at the end of the year will expire with the utility cost reductions benefitting all customers.*

Table 19: **The CGS Plus program has capacity limits that varies by utility and will remain open until the following installed capacity is reached.**

Island	CGS Plus Program Capacity
Hawaii	7 MW
Maui	7 MW
Oahu	35 MW

Distributed Energy Resource (DER) Programs

CUSTOMER SELF-SUPPLY (CSS)

The CSS program is intended only for private rooftop solar installations that are designed to not export any electricity to the grid. Customers are not compensated for any export of energy. CSS systems are also eligible for expedited review and approval of applications in areas with high levels of PV. Under the CSS program:

- Customers are not compensated for electricity exported to the grid.
- Customers pay for the amount of electricity used from the grid.
- A residential customer is charged a minimum monthly bill of $25 for residential customers.

SMART EXPORT

Smart Export allows customers to install a private rooftop solar or other renewable system and a battery energy storage system. Customers are expected to charge the battery storage system from the rooftop solar or other renewable system during the daylight hours (9:00 a.m. – 4:00 p.m.) and use that energy to power their home in the evening. However, customers can receive a credit for any energy exported to the grid during the evening, overnight and early morning hours. Energy exported to the grid during the daylight hours is not compensated. Under Smart Export, customers receive a monthly bill credit for energy delivered to the grid, which helps to offset the cost of energy pulled from the grid when the customer's system is not producing enough energy to meet the household demand.

Table 20: **Fixed export credits through October 22, 2022.**

Island	12:00 a.m. to 9:00 a.m.	9:00 a.m. to 4:00 p.m.	4:00 p.m. to 12:00 a.m.
Hawaii	11.00¢/kWh*	No Credit	11.00¢/kWh*
Maui	14.41¢/kWh*	No Credit	14.41¢/kWh*
Molokai	16.64¢/kWh*	No Credit	16.64¢/kWh*
Lanai	20.79¢/kWh*	No Credit	20.79¢/kWh*
Oahu	14.97¢/kWh*	No Credit	14.97¢/kWh*

** Export credits will be trued-up on an annual basis and any remaining credits left over at the end of the year will expire with the utility cost reduction benefitting customers.*

Table 21: **HECO's Smart Export program has capacity limits that differ by island.**

Island	Program Capacity
Hawaii	5 MW
Maui	5 MW
Oahu	25 MW

STANDARD INTERCONNECTION AGREEMENT (SIA)

All permanent customers are eligible to interconnect a renewable or non-renewable energy generating facility through the SIA program. These systems are not compensated for any power exported to the grid, and in some cases, are restricted from exporting power. Lastly, there are no capacity restrictions for SIA systems.

Distributed Energy Resource (DER) Programs

FEED-IN TARIFF (FIT)

The FIT queue is now closed. Prior to this, renewable electricity suppliers with generators smaller than 5 MW were eligible to participate in the HECO Companies' FIT Program, supplying as-available power to the utility at constant, contracted rates over 20 years.

Table 22: **Hawaiian Electric Companies' Feed-in Tariff Rates**

Tier	Island	Photovoltaics (PV)		Concentrating Solar Power (CSP)		On-Shore Wind		In-line Hydro	
		Rate (¢/kWh)	Size Limit	Rate (¢/kWh)	Size Limit	Rate (¢/kWh)	Size Limit	Rate (¢/kWh)	Size Limit
1	All	21.8* 27.4**	20 kW	26.9* 33.1**	20 kW	16.1	20 kW	21.3	20 kW
2	Oahu	18.9*	500 kW	25.4*	500 kW	13.8	100 kW	18.9	100 kW
	Maui & Hawaii	23.8**	250 kW	27.5**	500 kW				
	Lanai & Molokai		100 kW		100 kW				
3	Oahu	19.7*	5 MW	31.5*	5 MW	12	5 MW	--	--
	Maui & Hawaii	23.6**	2.72 MW	33.5**	2.72 MW	--	--	--	--

*With tax credit of 35 percent **With tax rebate of 24.5 percent

FIT aggregate limits: Oahu 60 MW; Hawaii Island 10 MW; Maui, Lanai, Molokai (combined) 10 MW

In December 2014, the PUC accepted HECO and the Independent Observer's joint plan to administer the FIT queues. Future revisions or modifications to the FIT Program will be addressed in Docket No. 2014-0192 or 2014-0183.

Renewable Energy Resources

The State of Hawaii offers numerous resources and tools to support appropriate and informed renewable energy development in Hawaii:

RENEWABLE ENERGY PROJECTS DIRECTORY

The Renewable Energy Projects Directory is an interactive map of existing and proposed renewable energy projects statewide, showcasing the variety of renewable energy resources that are moving the state closer to reaching energy independence. The Directory also serves to inform all stakeholders of planned and existing renewable energy projects of interest. Visit the Hawaii Renewable Energy Projects Directory

PERMITTING

Permitting any large project in Hawaii, including a utility-scale renewable energy project, requires a thorough understanding of local processes, issues, and stakeholders. The development of numerous large-scale renewable energy projects over the last ten years has provided community members, regulators, and developers a more informed opinion of future projects in terms of potential benefits and impacts. With some of the more desirable locations now developed or otherwise not available, appropriate project siting and regulation will remain a challenge moving forward.

Some strategies to support the siting and permitting of renewable energy projects in Hawaii:

- Know the requirements and processes - retain professionals with experience in Hawaii.
- Review past studies/permits (EIS) for the site - where available, lessons learned from earlier efforts can provide a wealth of information.
- Meaningful community participation - engage public early in the project siting and design process.
- Identify the appropriate community contacts - seek out community members with knowledge of the area.
- Engage all stakeholders - identify and address all stakeholders and issues early in the process.
- Site projects appropriately - seek compatible areas to minimize environmental impacts.
- Be diligent - go slow in the beginning to go fast in the end.
- One submittal/one review - present agencies with well-planned projects, complete applications.
- Electronic permit processing - saves time, reduces back and forth, transparency, tracking.

The tools described below provide information on these topics, as well as guidance to assist appropriate project siting and due diligence. These tools also seek to lower project “soft” costs by reducing the resources needed to undergo the permitting processes without removing any of the environmental or community safeguard processes in place. Many local federal, state, and county agencies contributed to the development to these tools.

DEVELOPER & INVESTOR CENTER, SELF-HELP SUITE (HAWAII STATE ENERGY OFFICE)

The Hawaii State Energy Office’s interactive *Developer & Investor Center* and *Self-Help Suite* provide comprehensive information on the siting, permitting, and development of renewable energy facilities in Hawaii. HSEO will regularly update these resources as requirements, policies, and procedures change. The Center focuses on permitting assistance through its *Project Permitting Assistance and Resources* website, which also provides a permit Guidebook and individual briefs on numerous county, state, and federal permit processes.
Visit the Developer & Investor Center

In addition to these resources, the Center provides lists of environmental consultants familiar with planning and permitting in Hawaii. While not exhaustive, this list identifies numerous firms with experience permitting and siting renewable energy projects in Hawaii.
Visit Project Permitting Assistance and Resources

Renewable Energy Resources

RENEWABLE ENERGY PERMITTING WIZARD (HAWAII STATE ENERGY OFFICE)

The *Permitting Wizard* was developed to help those proposing renewable energy projects understand the county, state, and federal permits that may be required for their individual projects. After answering a series of questions about their proposed project, a Permit Plan for the project is produced, identifying the permits required, prerequisites approvals and recommended sequencing, and estimated time of issuance. Software upgrades and content updates to the Wizard were last completed by the Hawaii State Energy Office in 2015, however, the Energy Office seeks to update the Wizard content periodically.
Visit the Renewable Energy Permitting Wizard

RENEWABLE ENERGIS MAPPING TOOL (HAWAII STATE ENERGY OFFICE, OFFICE OF PLANNING)

Renewable EnerGIS provides renewable energy resource and site information for specific Hawaii locations selected by the user. EnerGIS helps users understand the renewable energy potential and permitting requirements for specific selected sites.
Visit the Renewable EnerGIS Map

HAWAII CLEAN ENERGY PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (U.S. DEPARTMENT OF ENERGY)

In September 2015 the U.S. Department of Energy published the *Hawaii Clean Energy Final Programmatic Environmental Impact Statement* which assesses common impacts and best management practices associated with 31 clean energy technologies.
Visit Hawaii Clean Energy Programmatic Environmental Impact Statement

ELECTRONIC PERMITTING

Electronic permitting is another effective method of streamlining the permit review process without removing any of the environmental or community safeguards in place. Some examples of state and county agencies in Hawaii utilizing electronic permitting include:

ePERMITTING PORTAL (HAWAII DEPARTMENT OF HEALTH)

The Hawaii Department of Health's Environmental Health Administration e-Permitting Portal provides access to environmental permit applications. e-Permitting allows for efficient and accurate electronic application compilation and submission, tracking, processing, management, and fee payment.
Visit the e-Permitting Portal

ONLINE BUILDING PERMITS (CITY AND COUNTY OF HONOLULU)

Oahu's Department of Planning and Permitting website provides for the electronic submission and processing of building permits required for residential solar heating, photovoltaic, and electric vehicle charger installations in the City and County of Honolulu. Building Permit status can also be monitored online.
Visit Department of Planning and Permitting

Renewable Energy Resources

ELECTRONIC PLAN REVIEW (EPLAN) AND BUILDING PERMIT STATUS (COUNTY OF KAUAI)

Kauai's Department of Public Works, Building Division, offers online tools to submit building permits electronically (Electronic Plan Review or "ePlan") and get information on Building Permit status, details, and other relevant information.
Visit Electronic Plan Review

ONLINE PERMITTING (DEPARTMENT OF LAND AND NATURAL RESOURCES)

In late 2016 the Department of Land and Natural Resources (DLNR) launched new electronic permit and asset management tools for DLNR's Engineering Division and Division of Forestry and Wildlife, Native Invertebrates Program. These resources are designed to support the electronic submission, processing, and issuance of select DLNR permits.
Visit Division of Forestry and Wildlife
Visit Engineering Division

Clean Transportation

Hawaii's transformation to a clean energy economy requires the integration of transportation. In tackling transportation HSEO has a near-term focus in ground transportation and maintains a long-term perspective that includes alternatives fuels and efficiency in aviation and marine transportation. To reduce Hawaii's consumption of petroleum within the ground transportation sector, HSEO is looking to implement tactics that will make a transformational investment in Hawaii's clean energy economy with a specific emphasis on projects that facilitate the adoption and deployment of grid-connected, battery-electric zero emission vehicles (EV), and will make an impact on the transition toward the ultimate elimination of imported fuel in ground transportation.

Performance metrics are an important means of quantitatively evaluating progress and specifically, the advancement of clean transportation strategies and policies. As HSEO continues to expand its assessment of clean transportation in Hawaii, it will incorporate additional clean transportation facts and figures.

Future plans call for developing a statewide clean energy ground transportation plan.

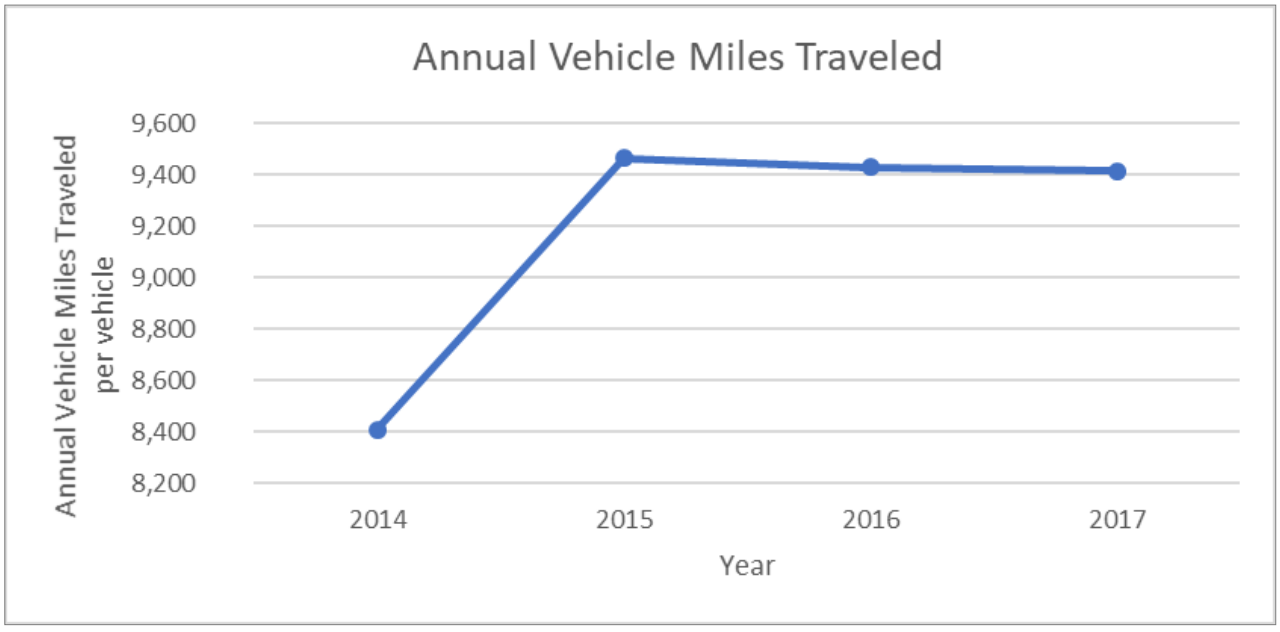
HAWAII'S CLEAN TRANSPORTATION LAWS AND PROCLIMATIONS

Hawaii's clean transportation policies are now at the forefront of the legislative agenda in Hawaii.

- HRS §226-18(a)(2) - Hawaii State Planning Act; Objectives and policies for facility systems – energy. Increased energy security and self-sufficiency through the reduction and ultimate elimination of Hawaii's dependence on imported fuels for electrical generation and ground transportation;
- HRS §103D-412 - Hawaii's vehicle procurement guidelines require State and County agencies to follow a hierarchy when leasing or purchasing light-duty motor vehicles that are not covered by federal procurement rules: (1) EV or PHEV; (2) Hydrogen FCEV; (3) Alternative fuel vehicle; (4) Hybrid; (5) Fuel economy leader
- HRS §225P-3 - Hawaii climate change mitigation and adaptation commission; general functions, duties, and powers aligning Hawaii with the goals of the Paris Agreement.
- City and County of Honolulu, Maui County, Hawaii County, and Kauai County committed to eliminate fossil fuels use within ground transportation by 2045 – mirroring the 100 percent RPS time frame for the electric sector. Notably the City and County of Honolulu, Maui County and Kauai County pledged to lead the way by transitioning all of their fleet vehicles to 100 percent clean energy by 2035.

VEHICLE MILES TRAVELED

Fig. 23: The graph below reflects Hawaii's average annual vehicle miles traveled per registered vehicle.[10]



Clean Transportation

Table 23: **Hawaii 2016 Travel to Work**
U.S. Census Bureau's American Community Survey[11]

Description	Percentage	Hawaii National Rank
Mean travel time to work of workers 16 years and over who did not work at home (minutes)	27.7	11
Percent of workers 16 years and over who traveled to work by car, truck, or van – drove alone	66.9	49
Percent of workers 16 years and over who traveled to work by car, truck, or van – carpooled	13.6	1
Percent of workers 16 years and over who traveled to work by public transportation	6.7	7

Table 24: **County Public Transit Ridership**

County	2017 County Transit Passenger Ridership	2018 County Transit Passenger Ridership
City & County Honolulu	66,362,079	65,282,210
Maui	1,879,072	1,998,710
Kauai	710,129	760,415
Hawaii	766,472	742,250

BICYCLING

Bicycling significantly reduces transportation emissions while also reducing traffic, in addition to being a healthy, fun, and low-impact form of exercise. Alternative forms of transportation such as bicycling is a means by which to decarbonize the transportation sector by reducing demand for energy as opposed to shifting transportation energy demand to a renewable fuel source such as biofuels or renewable electricity.

Bicycle Transit System

Biki is Honolulu's bicycle transit system launched by Bikeshare Hawaii in June 2017. It is currently the sixth most-used bikeshare program in the nation. Bikeshare Hawaii benefits Hawaii residents and visitors by providing a low-cost, convenient, zero emissions transportation option that is healthy for users, the community, and the environment.[12] Biki currently operates in Honolulu with self-service "Biki Stops" located from Chinatown to Diamond Head.

Table 25: **Biki by the numbers.**

	2017	2018
Number of Biki bikes	1,000	1,300
Number of self-service Biki stops	100	130
Number of Biki members	6,000	13,800
Average rides per month	66,000	100,000

Clean Transportation

Table 26: **Bicycle Lanes and Laws**

County	Miles of Bikeways[13] (including protected bike lanes, bike paths, bike routes, and shared use paths)	Bike Laws
Oahu	205 Miles In May 2019, the City & County of Honolulu released their draft updated Oahu Bike Plan, noting implementation of the entire proposed bikeway network would add 577 miles of new. bikeways. View the Oahu Bike Plan.	The Hawaii Bicycling League offers a comprehensive list of City & County of Honolulu bicycle regulations. Visit the Hawaii Bicycling League site.
Maui	60.4 miles	The Maui Bicycling League offers a comprehensive list of Maui county bicycle regulations. Visit the Maui Bicycling League site.
Hawaii	27.4 miles	The University of Hawaii Hilo offers a comprehensive list of Hawaii County bicycle regulations. Visit the UH Hilo Bike Share site.
Kauai	31.7 miles	

ELECTRIC VEHICLES

An EV uses electricity in place of gasoline, reducing the need for petroleum-based fuel as the electric sector continues the path towards 100 percent RPS. Since EVs can use electricity produced from renewable resources available in Hawaii (i.e. sun, wind, hydropower, ocean energy, geothermal energy), the transition from gasoline fueled vehicles to EVs supports Hawaii's energy independence goals.

Based on statewide averages, the amount of fossil fuel used to power an electric vehicle in Hawaii is 34-40 percent less than the fossil fuel required to power a similar gasoline-fueled vehicle.[14] This is expected to improve as renewable energy increases in Hawaii.

Table 27: **Registered EVs[15] and Public Charging Stations[16] in Hawaii**

County	Electric Vehicles	Level 2[17] Charging Station Ports	Level 3[18] Charging Station Ports	Total Ports
Oahu	7,454	297	12	309
Maui	1,016	80	27	107
Molokai	35	-	1	1
Lanai	41	2	-	2
Hawaii	508	36	7	43
Kauai	306	32	1	33
Total statewide	**9,360**	**447**	**48**	**495**

Clean Transportation

Fig. 24: **EV Trends in Hawaii 2014-2018**

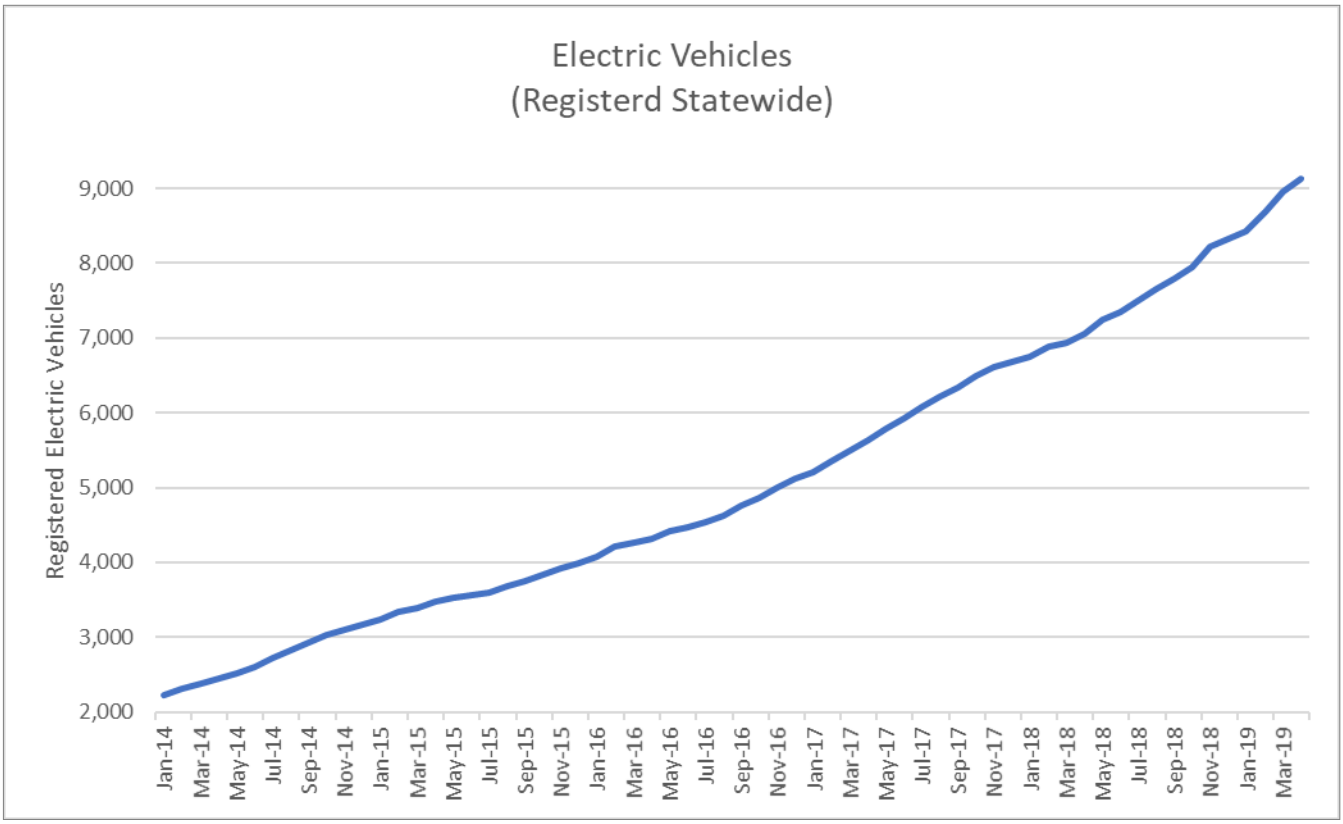


Table 28: **Fuel Cost Comparison**

Vehicle	**2019 Nissan Versa**	**2019 Honda Civic**	**2019 Nissan LEAF**[19]
Fuel Type	**Gasoline**	**Gasoline**	**Electricity**
Miles Per Gallon (MPG)	34 mpg combined 367 miles total range	33 mpg combined 409 miles total range	108 combined MPG 226 miles total range
Fuel Costs	$3.57/gallon	$3.57/gallon	Residential Electricity Rate: $0.31/kWh[20] Schedule TOU-RI for mid-day EV Charging: $0.14/kWh[21]
Fuel Cost per Year[22]	$991.73	$1,021.78	Residential Electricity Rate: $803.24 Schedule TOU-RI for mid-day EV Charging: $362.75

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

Clean Transportation

HAWAII'S ELECTRIC VEHICLE LAWS AND INCENTIVES

- Free parking is provided in state and county government lots, facilities, and at parking meters.
- Vehicles with EV license plates are exempt from High Occupancy Vehicle lane restrictions.
- Parking lots with at least 100 public parking spaces are required to have at least one parking space, equipped with an EV charging system, reserved exclusively for EVs.
- Non-EVs parked in a space designated and marked as reserved for EVs shall be fined not less than $50 nor more than $100.
- Hawaiian Electric Co. offer EV time-of-use rates designed to incentivize customers, through lower rates, to charge their EVs during off-peak times of day.
- Hawaiian Electric Co. offer time-of-use rates for electric bus charging for a total of up to 20 bus fleet customers on Oahu, Maui and Hawaii islands with lower prices that encourage charging during midday.
- Multi-family residential dwellings or townhomes cannot prohibit the placement or use of EV charging systems altogether.
- EV Charging Rebate Program for installation of eligible new or upgraded multi-user electric vehicle charging systems, (HB 1585, 2019).
- Energy performance contract includes the provision of EV charging infrastructure for a portion of avoided vehicle maintenance or fuel costs pursuant to a vehicle fleet energy efficiency program, (HB 401, 2019).
- EVs and alternative fuel vehicles are subject to an annual vehicle registration surcharge fee of $50, which will be collected beginning with the first registration renewal and will be deposited into the State Highway Fund. Effective 1/1/2020 (SB409, 2019).

For more information about state and federal laws, regulations and incentives:
Visit HSEO's site on State and Federal Laws & Incentives
Visit the U.S. Department of Energy's Alternative Fuels Data Center

EV QUICK FACTS

Table 29:

Hawaii ranks sixth in the nation behind California, Washington, Oregon, Colorado and District of Columbia of total EV sales.	1.75 percent of total state sales[23]
As an eligible beneficiary, the State of Hawaii has been allocated $8.125 million from the Volkswagen Environmental Mitigation Trust. The Hawaii State Energy Office will administer Trust funds and execute eligible environmental mitigation projects to reduce vehicle emissions in Hawaii.	Hawaii and Washington were the only states to receive a top-of-the-class A+ per the Volkswagen Settlement State Scorecard for their plans to use all of their Trust money to fund electric bus purchases, both for transit agencies and school districts, and electric vehicle charging infrastructure.[24]
Cost for a government or commercial property owner to install a Level 2 charging station.	Approximately $4,000-$8,000 per station. A relatively simple project in Hawaii can range from $4,000 to $25,000 to $100,000; however, prices vary considerably.[25]

Endnotes

[1] U.S. Energy Information Administration, "1990-2015 Net Generation by State by Type of Producer by Energy Source (EIA-906, EIA-920, EIA-923)", http://www.eia.gov/electricity/data/state/
[2] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends/
[3] Volumes. Source: Energy Information Administration, State Energy Data System
[4] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[5]DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2
[6] 1 barrel = 42 U.S. gallons
[7] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[8] Electricity: http://www.eia.gov/state/rankings/#/series/31 (last accessed 5/17/17); natural gas: http://www.eia.gov/state/rankings/#/series/28 (last accessed 5/17/17)
[9] DBEDT's Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/
[10] http://dbedt.hawaii.gov/economic/databook/2016-individual/_18/
[11] http://census.hawaii.gov/acs/acs-2016/; http://files.hawaii.gov/dbedt/census/acs/ACS2016/ACS2016_1_Year/state_rank/2016_acs_1yr_sumranktab_final.pdf
[12] https://gobiki.org/about-us/
[13] https://www.honolulu.gov/bicycle
http://hidot.hawaii.gov/highways/files/2013/02/Bike-Plan-appendixc.pdf
https://www.kauai.gov/Portals/0/PW_Bldg/BikePathProject/Articles/Bike_path_overview.pdf?ver=2015-04-20-160259-343
[14] Level 3, also known as "fast charging," can provide an 80% charge for some vehicles in less than 30 minutes, depending on vehicle and charger specifications. Not all vehicles can use fast charging
[15] EV figures updated DBEDT monthly energy trends (May 2018) http://dbedt.hawaii.gov/economic/energy-trends-2/
[16] EV Stations Hawaii app (http://energy.hawaii.gov/testbeds-initiatives/ev-ready-program/ev-stations-hawaii-mobile-app)
[17] Level 2 charging is at 240 volts. All electric vehicles are equipped for this type of charging. 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
[18] Level 3, also known as "fast charging," can provide an 80% charge for some vehicles in less than 30 minutes, depending on vehicle and charger specifications. Not all vehicles can use fast charging
[19]Fuel cost comparisons show approximate savings between internal combustion engine and electric vehicles. The example shows that fuel costs are lower for the Nissan Leaf than for a comparable gasoline fueled vehicle. 2019 Nissan Leaf: 62 kWh battery; 31 kWh/100 miles
[20] Electricity rate based on Schedule R - Residential Service rate for April 2019 was 36.01 cents. Source: Monthly Energy Trend, READ, DBEDT http://files.hawaii.gov/dbedt/economic/data_reports/energy-trends/Energy_Trend.pdf
[21] Electricity rate based on Schedule TOU-RI Mid-Peak or Midday Rate (Residential Rate - $0.12). Source: HECO Website: https://www.hawaiianelectric.com/documents/billing_and_payment/rates/hawaiian_electric_rates/heco_rates_tou_ri.pdf
[22] Based on fuel prices and 9,415 annual miles per year from Hawaii State Data Book. http://dbedt.hawaii.gov/economic/databook. Figure does not include operations and maintenance costs, which are generally shown to be lower for electric vehicle ownership
[23] https://autoalliance.org/economy/consumer-choice/electric-vehicles/HI/
Additional information is also available at: https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/
[24] https://uspirg.org/sites/pirg/files/reports/USP%20VW%20Scorecard%20May19.pdf
[25] Hawaii State Energy Office, Report to the Maui Electric Vehicle Alliance Driving EVs Forward: A Case Study of the Market Introduction and Deployment of the EV in Hawaii (PDF) http://energy.hawaii.gov/wp-content/uploads/2011/10/ReportMauiElectricVehicleAlliance_12_20_12.pdf