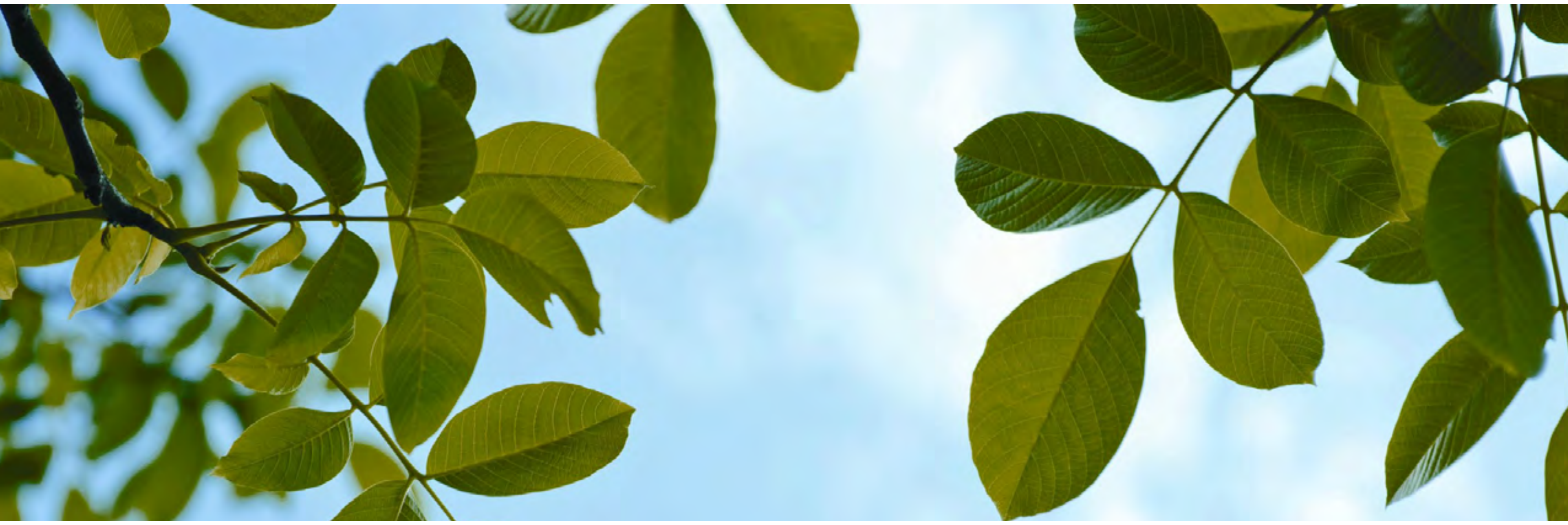
# Hawaii Energy Facts & Figures

May 2016





HAWAII STATE
**Energy Office**


State of Hawaii Department of Business, Economic Development, and Tourism
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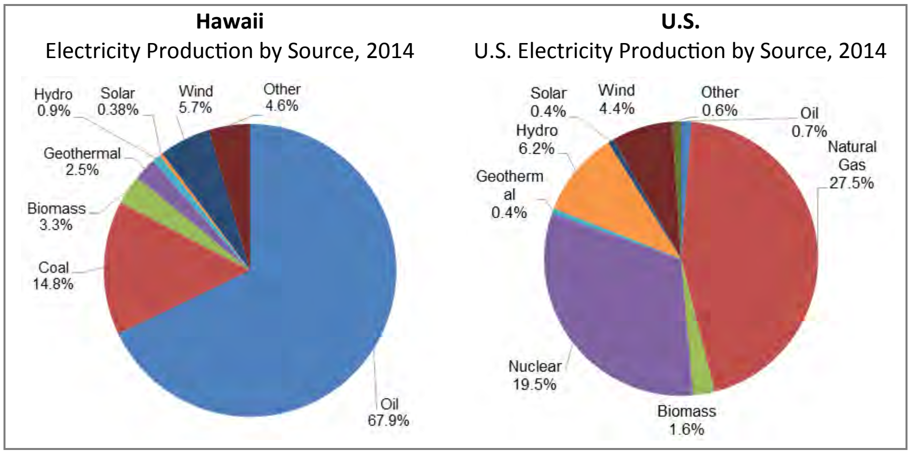
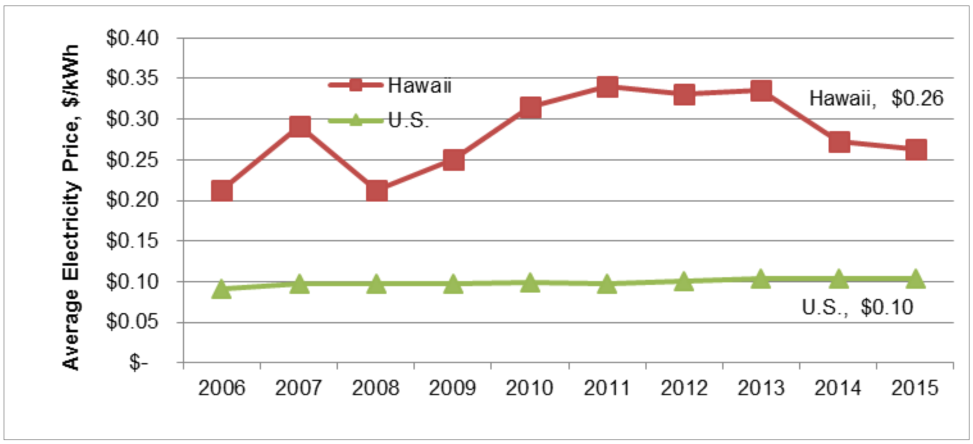
# Hawaii Energy Overview

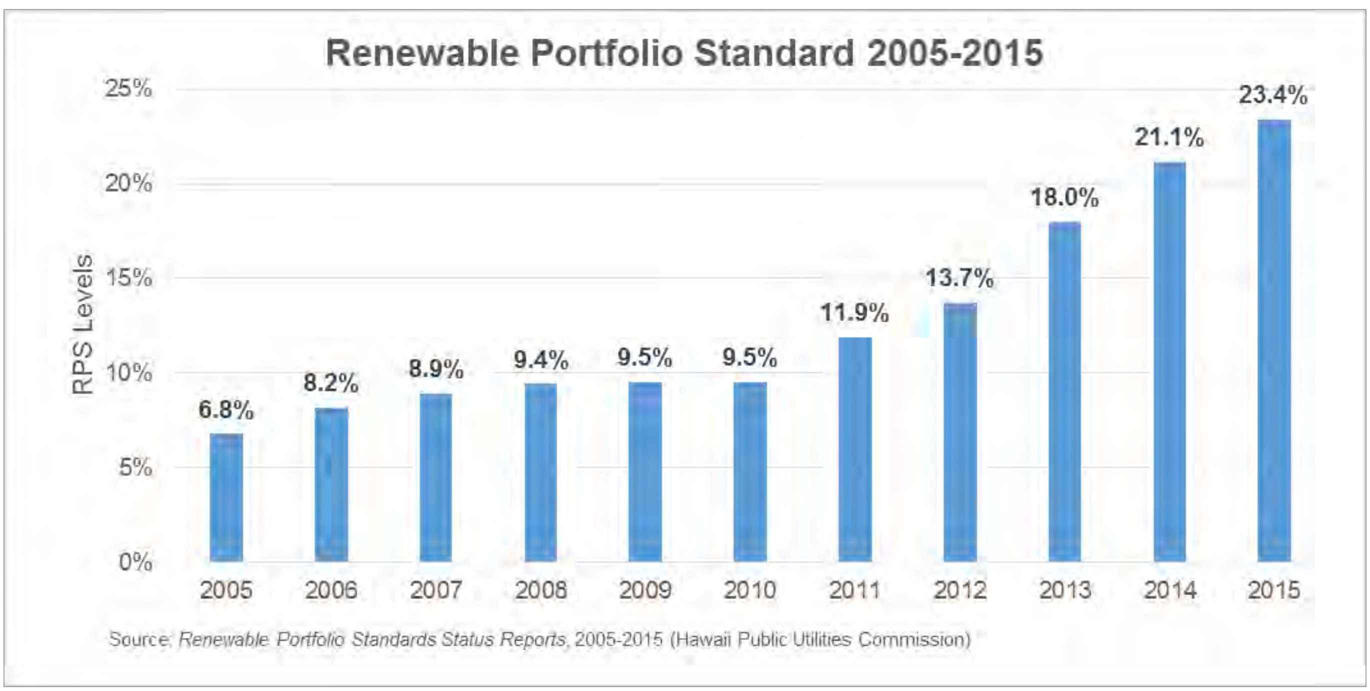
Hawaii is the only state that depends so heavily on petroleum for its energy needs. Whereas less than 1% of electricity in the nation is generated using oil. In 2014, Hawaii relied on oil for 67.9% and on coal for 14.8% of its electricity generation.[1]




Hawaii's electricity prices are almost two times higher than the U.S. average.[2, 3]

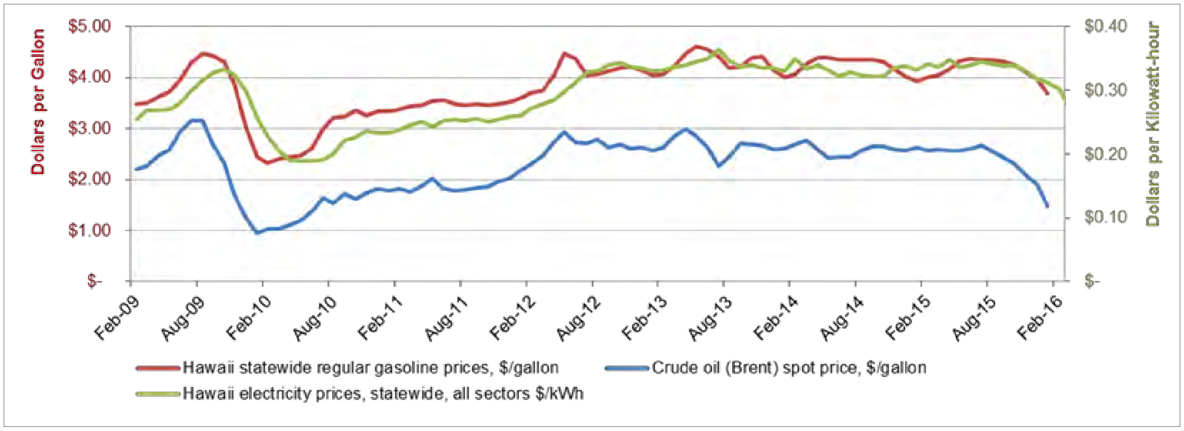



Although Hawaii's electricity production and costs are still heavily reliant on oil, renewable energy has been increasing[4] in all counties.

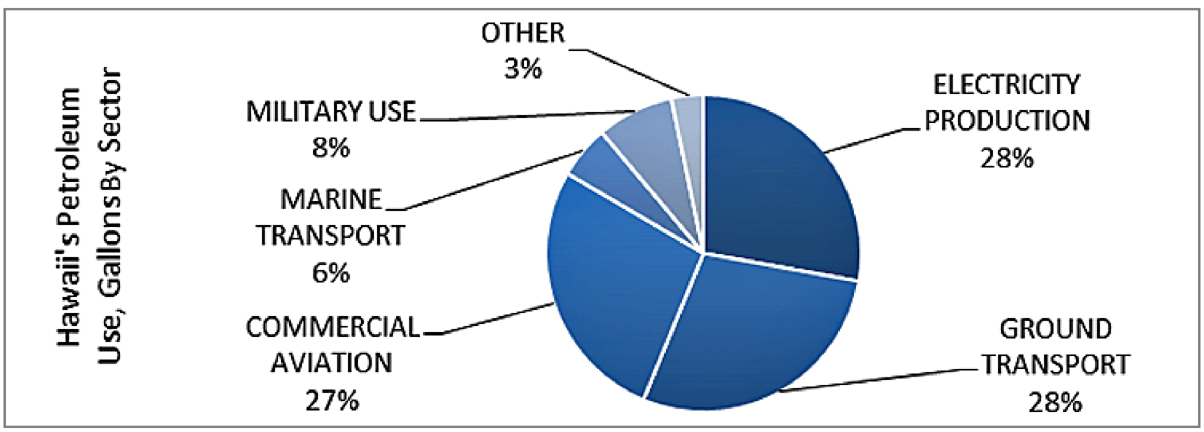


# Hawaii Energy Overview

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




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



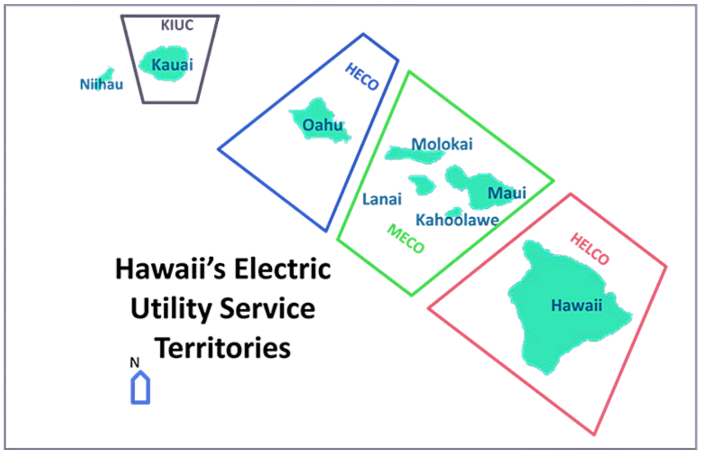

| | | | |
|---|---|---|---|
| 2015 Total Crude Oil Imports (million barrels per year)[7] | **36.2** | 2015 Fuel for electricity production (million gallons per year)[8] | **394** |
| 2015 Total petroleum use (million gallons per year)[9] | **1,519** | 2015 Fuel for air transportation (i.e. jet fuel) (million gallons per year)[10] | **362** |
| 2015 Hawaii's rank among 50 states for energy prices[11] | **1** | 2015 Fuel for ground transportation (million gallons per year)[12] | **459** |

# Electric Utilities

Each of Hawaii's six main islands has its own electrical grid, not connected to any other island. Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric (MECO) and Hawaii Electric Light Company (HELCO), serve about 93% of the state's electric utility customers.[13] The island of Kauai is served by Kauai Island Utility Cooperative (KIUC).

### COMPETITIVE BIDDING

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




HECO: A Request for Proposals (RFP) for 600-800 gigawatt-hours (or 200 MW) of as-available renewable electricity for use on Oahu is being redrafted per a July 2013 Order from the PUC. The redrafted RFP will remove references to the Lanai Wind Project and eliminate solicitations for an undersea transmission cable. Also in July 2013, the PUC opened a new docket (No. 2013-0169) to examine whether the Oahu-Maui Grid Tie may be in the public interest. This proceeding is still awaiting determination by the PUC.

MECO: On July 11, 2013, the PUC closed the competitive bidding proceedings to acquire up to 50MW of new, renewable firm dispatchable capacity generation resources on the island of Maui. The PUC will consider future requests from MECO to open another proceeding to conduct a RFP for firm generation upon a demonstration of need and a plan focused on customer needs.

HELCO: In February 2015, HELCO announced it had selected Ormat Nevada, Inc. on behalf of PGV II (Ormat) to provide HELCO with 25 MW of new geothermal power on the East side of Hawaii Island (Moana Geothermal Project). Unfortunately, in February 2016, HELCO notified the PUC and all other parties of Ormat's decision to cancel contract negotiations with HELCO based on Ormat's determination the project would not be economically and financially viable.[16]

### CONVERTING MW OF CAPACITY INTO MWh OF ELECTRICITY PRODUCTION

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

| CAPACITY FACTOR ASSUMPTIONS FOR RENEWABLE RESOURCES | Capacity Factors (assumed)* | MWh produced per MW capacity[17] |
|---|---|---|
| Biomass-Direct Firing | 80% | 7,000 |
| Wind (Oahu, Hawaii, Kauai)** | 35% | 3,100 |
| Wind (Lanai, Molokai) | 40% | 3,500 |
| Wind (Maui) | 45% | 3,900 |
| Geothermal | 96% | 8,400 |
| Hydro | 44% | 3,900 |
| Solar (rooftop) | 23% | 2,000 |
| Solar (utility) | 24% | 2,100 |
| Ocean | 35% | 3,100 |

Capacity factors presented in this table are assumptions used by Booz Allen, under contract to the National Renewable Energy Laboratory, in the *Hawaii Clean Energy Initiative Scenario Analysis*, Appendix C, Slide 26. March 2012.
*Actual capacity factors may vary from the assumptions presented here. **The Pakini Nui wind farm (on Hawaii island) generally has an annual capacity factor of over 60%.

The "capacity factor" is the percent of time a facility is expected to operate at full capacity (or its equivalent, in terms of energy production) over a one year period. For example, if a facility has a capacity of 1 MW and a capacity factor of 100%, it will generate (1MW) x (24 hours/day) x (365 days/year) = 8,760 MWh per year.

# Electric Utilities: Customers & Rates

Residential electricity use, rates, and average bills are shown below for 2014 and 2013. In general, rates were fairly stable and electricity use declined, so bills also declined.[18]

| Residential Electricity Use, Rates, and Average Bill, 2014 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Oahu | Hawaii | Kauai | Maui | Molokai | Lanai | State |
| Average use (kWh/ month) | 501 | 458 | 464 | 545 | 312 | 443 | 496 |
| Average cost per kWh | $0.35 | $0.42 | $0.43 | $0.38 | $0.47 | $0.46 | $0.37 |
| Average monthly bill | $178 | $192 | $199 | $206 | $147 | $203 | $185 |

| Residential Electricity Use, Rates, and Average Bill, 2013 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Oahu | Hawaii | Kauai | Maui | Molokai | Lanai | State |
| Average use (kWh/month) | 523 | 473 | 464 | 557 | 329 | 430 | 514 |
| Average cost per kWh | $0.35 | $0.42 | $0.44 | $0.38 | $0.46 | $0.46 | $0.37 |
| Average monthly bill | $181 | $199 | $205 | $211 | $153 | $199 | $189 |

### FEED - IN TARIFF (FIT)

The FIT queue is now closed.[19] Prior to this, renewable electricity suppliers with generators smaller than 5 MW would be eligible to participate in the HECO Companies' Feed in Tariff,[20] supplying as-available power to the utility at constant, contracted rates over 20 years.

| Feed-in Tariff (FIT) Rates, Hawaiian Electric Companies' Service Areas | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tier | Island | Photovoltaics (PV) | | Concentrating Solar Power (CSP) | | On-Shore Wind | | In-line Hydro | |
| | | rate (¢/kWh) | size limit | rate (¢/kWh) | size limit | rate (¢/kWh) | size limit | rate (¢/kWh) | size limit |
| 1 | All Islands | 21.8*<br>27.4** | 20 kW | 26.9*<br>33.1** | 20 kW | 16.1 | 20 kW | 21.3 | 20 kW |
| 2 | Oahu | 18.9*<br>23.8** | 500 kW | 25.4*<br>27.5** | 500 kW | 13.8 | 100 kW | 18.9 | 100 kW |
| 2 | Maui & Hawaii | 18.9*<br>23.8** | 250 kW | 25.4*<br>27.5** | 500 kW | 13.8 | 100 kW | 18.9 | 100 kW |
| 2 | Lanai & Molokai | 18.9*<br>23.8** | 100 kW | 25.4*<br>27.5** | 100 kW | 13.8 | 100 kW | 18.9 | 100 kW |
| 3 | Oahu | 19.7*<br>23.6** | 5 MW | 31.5*<br>33.5** | 5 MW | 12.0 | 5 MW | -- | -- |
| 3 | Maui & Hawaii | 19.7*<br>23.6** | 2.72 MW | 31.5*<br>33.5** | 2.72 MW | -- | -- | -- | -- |

* With tax credit of 35%. ** With tax rebate of 24.5%.

HECO and the Independent Observer submitted a joint plan to the PUC for administering the FIT queues in September 2013. The joint plan was accepted by the PUC on 12/5/14.[21] Future revisions or modifications to the FIT program will be addressed in Docket No. 2014-0192 or 2014-0183.

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

# Electric Utilities: Customers & Rates

## DISTRIBUTED ENERGY RESOURCE PROGRAMS

On August 26, 2014, under PUC Docket 2001-0206, the HECO companies delivered to the PUC the Reliability Standards Working Group's distributed generation interconnection plan (DGIP). The DGIP has been merged into the DER[22, 23] Docket (PUC Docket No. 2014-0192) along with other relevant proceedings, and is presently under review.

On October 12, 2014, the PUC under Docket No. 2014-0192 (Decision & Order No. 33258), issued new reforms relative to distributed energy resources (DER). One notable change is the closing of the Net Energy Meeting (NEM) program at existing levels, whereby "current NEM customers are grandfathered and new customers with NEM applications submitted by 10/12/15 are unaffected". Going forward the PUC has designed two (2) new program options for customers seeking DER resources: customer grid-supply (CGS), and customer self-supply (CSS).

## NET ENERGY METERING (NEM)[24]

Previously, customers who generated renewable solar, wind, hydro, or biomass energy on their own property could have been eligible for NEM to offset their own use. Under the NEM program, customers experience the following:

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

## CUSTOMER GRID-SUPPLY (CGS)[25]

The CGS program can be seen as a modified version of the NEM program. Under the CGS program:

- Customers receive a PUC approved credit (see table) for electricity exported to the grid and are billed at the retail rate for electricity they use from the grid.
- Similar to the NEM program, if the customer uses more electricity than is exported, the customer pays for the net amount.
- If the Customer's credits exceed their electricity charge, a residential customer pays a minimum bill of $25.
- Unlike the NEM program, any excess credits remaining at the end of the monthly billing cycle are forfeited.

| Island | Credit |
|---|---|
| Oahu | 15.07 ¢/kWh |
| Hawaii | 15.14 ¢/kWh |
| Maui | 17.16 ¢/kWh |
| Molokai | 24.07 ¢/kWh |
| Lanai | 27.88 ¢/kWh |

Fixed rates for electricity exported to the grid under the CGS program

## CUSTOMER SELF-SUPPLY (CSS)[26]

The CSS program is intended only for solar PV installations that are designed to not export any electricity to the grid. 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 any export of energy sent to the grid.
- Customers pay for the amount of electricity used from the grid.
- A residential customer will pay a minimum monthly bill of $25.

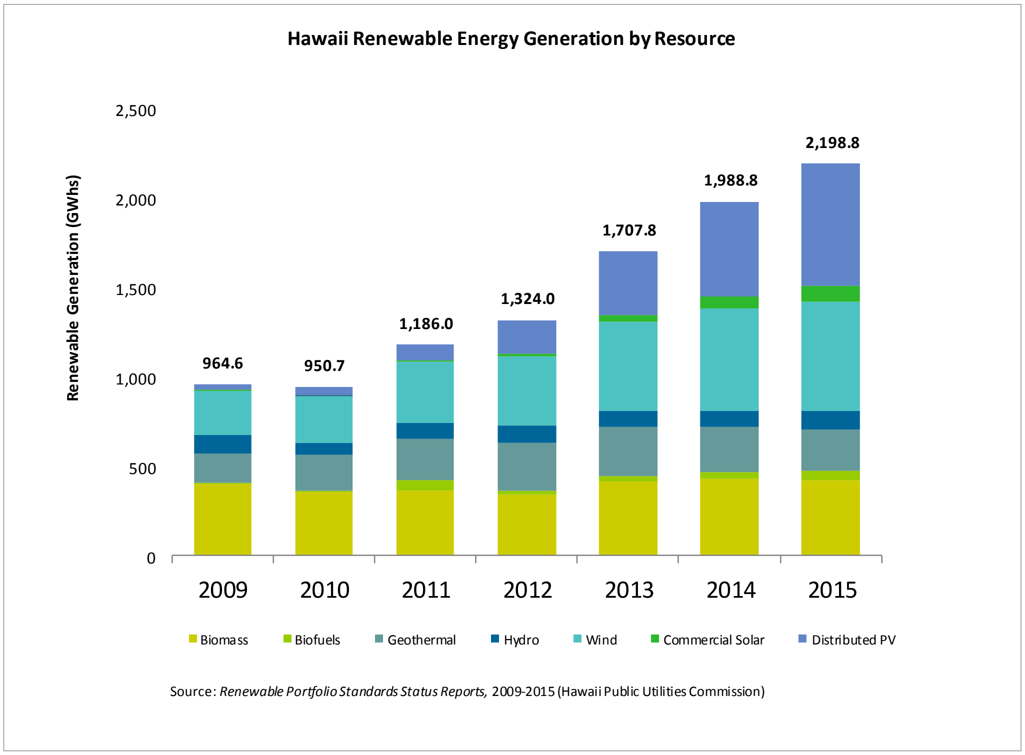
KIUC: New interconnections use Schedule Q[27] (100 kW or less) and "NEM Pilot"[28] (200 kW or less; 20¢/kWh for excess).

# Renewable Energy

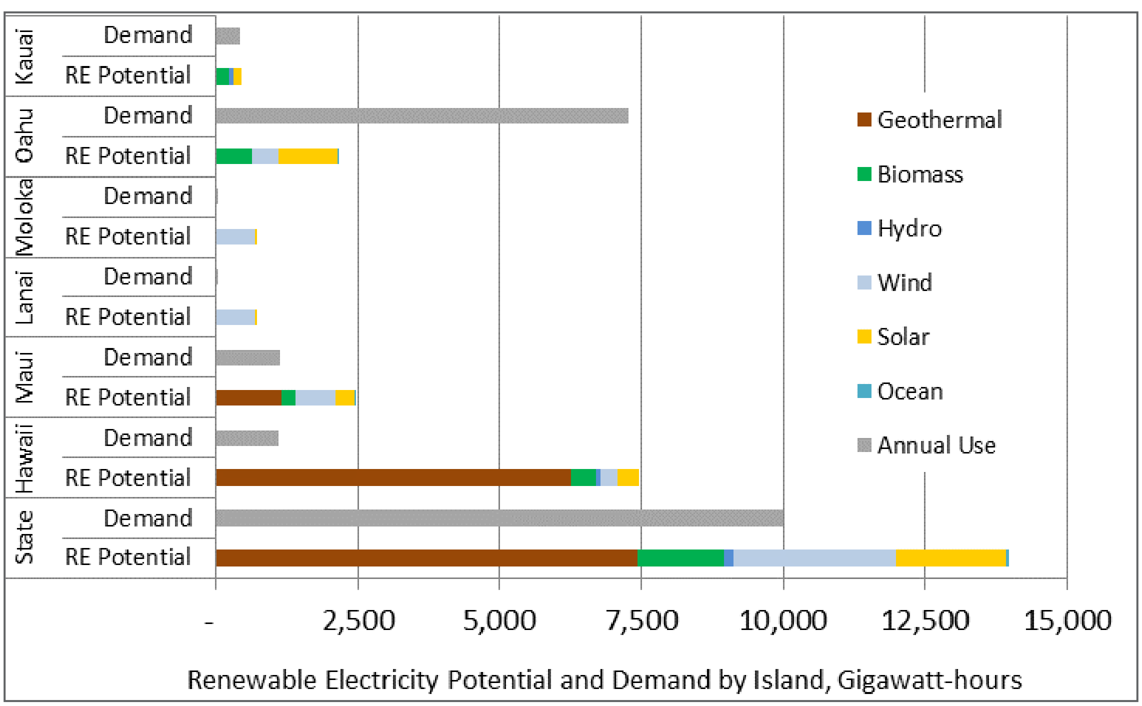
Renewable Energy[29] is energy from:

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

In 2015, approximately 23.4% of Hawaii's electricity was generated from renewable sources, where the primary sources were solar PV, wind, and biomass.[30]




Renewable resource potential, statewide, is greater than current electricity demand.[31]



# Renewable Energy

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

Firm generation (capacity) is available for production which can be (and in many cases must be) guaranteed to be available at a given time. Firm energy refers to the actual energy guaranteed to be available.

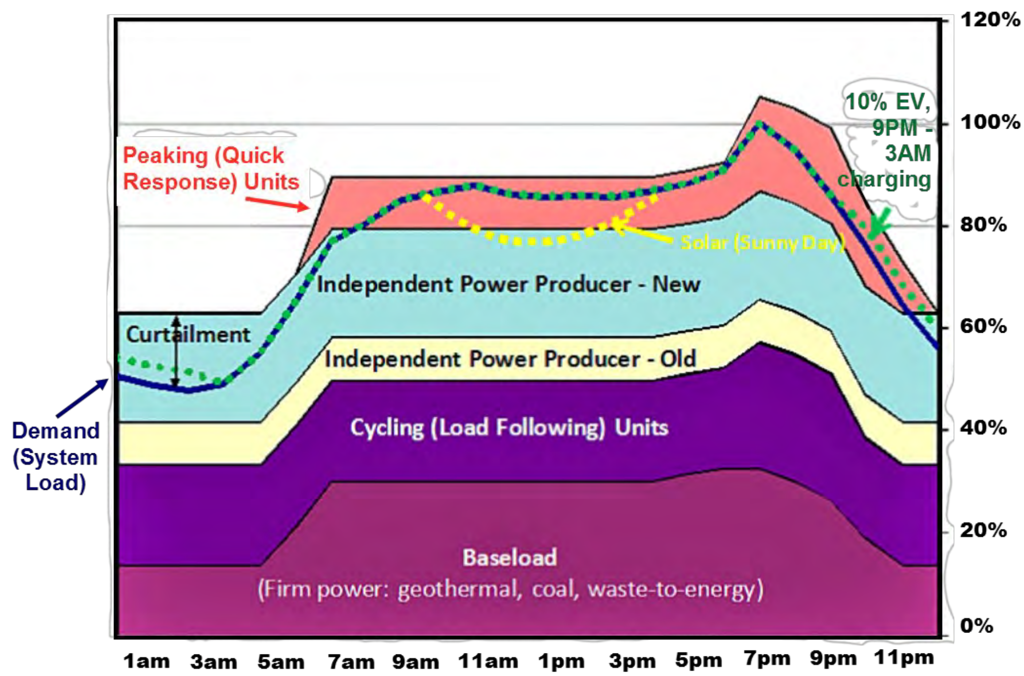
Baseload generation facilities produce energy at a constant rate. They generally do not react (ramp up or ramp down) quickly.

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

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

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

If managed properly, energy storage systems and electric vehicle charging can provide grid support at times of low load by utilizing energy that otherwise may have been curtailed.

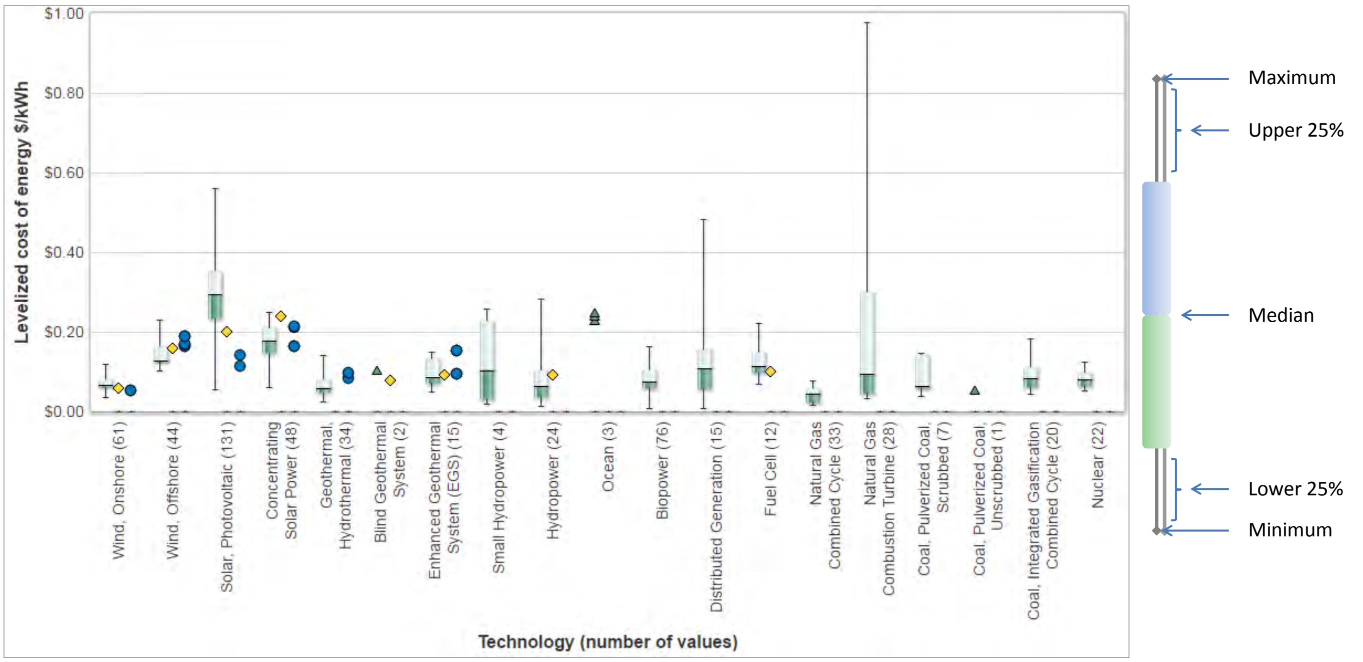



| | | | |
|---|---|---|---|
| Renewable generation required (i.e. Renewable Portfolio Standard, "RPS") by 12/31/2020[32] | **30%** | Renewable generation required (RPS) by 12/31/2030 | **40%** |
| Renewable generation required (RPS) by 12/31/2040 | **70%** | Renewable generation required (RPS) by 12/31/2045 | **100%** |

# Renewable Energy

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

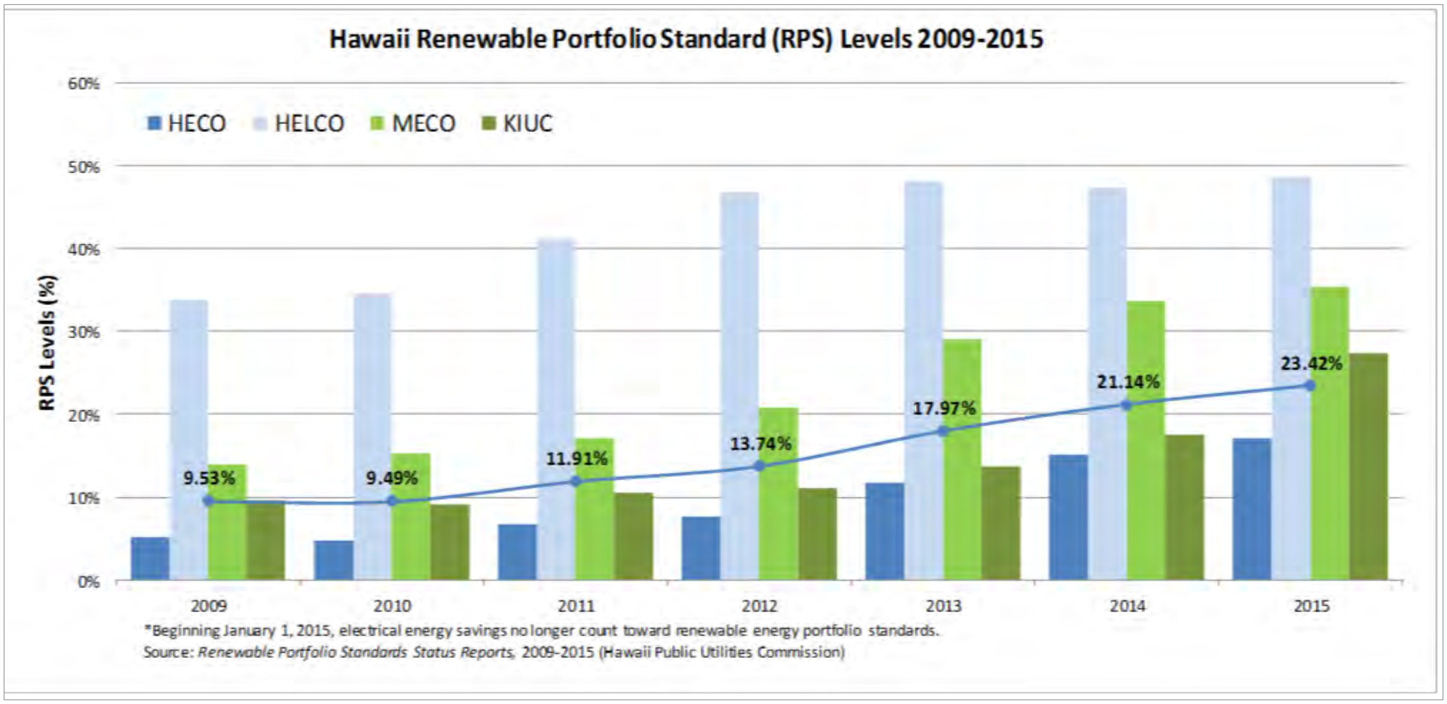
The Transparent Cost Database[33] compiles cost information from studies and projects across the United States. The box and whisker chart below shows the 2009-2015 data distribution using five numbers: The minimum (bottom of the whisker), lowest 25% (below green box), median, highest 25% (above blue box), and maximum point (top of the whisker). Where fewer than three data points are available, the individual data points (green diamonds) are shown. Yellow diamonds are U.S. Department of Energy estimates.



# Renewable Energy: RPS

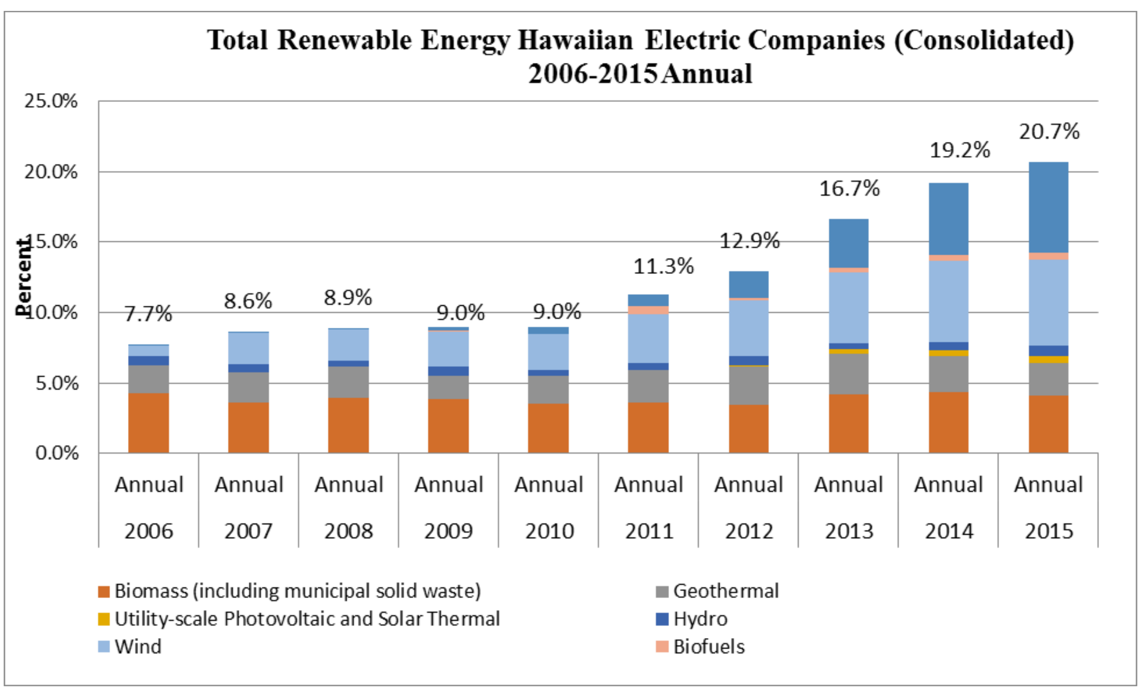
### Renewable Portfolio Standard ("RPS") Compliance[34]

The Hawaiian Electric Companies and Kauai Island Utility Cooperative are required to annually file their RPS status report which calculates the RPS as a percentage of electrical energy sales that is represented by renewable electrical energy.[35] Beginning January 1, 2015, renewable electrical energy generated by the utility, independent power producers, and customer-sited, grid-connected sources are counted towards the RPS. While electrical savings from energy efficiency and solar water heating will not be counted towards achievement of RPS compliance.[36]




### Total Renewable Energy ("Total RE")[37]

The Hawaiian Electric Companies file updates for their Total Renewable Energy metric on a quarterly basis, which differs from the RPS because it is based on total energy and not sales. The Total RE metric is the total renewable generation provided by independent power producers, the utility, and estimates for customer-sited, grid-connected renewable energy, divided by the total generation of the system provided by renewable and non-renewable resources including customer-sited, grid-connected resources.[38]



# Bioenergy

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

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

"Biofuel" sometimes is used interchangeably with bioenergy, however biofuels is more commonly used specifically to describe liquid bioenergy fuels. 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. One ton of biomass replaces approximately one barrel of oil.

Since biodiesel fuel imports for electricity production began in 2010, the relative cost of the imported biodiesel fuel has been significantly higher than for the fossil-based fuels used for electricity generation in Hawaii.[39] In December 2015, fuel oil averaged $52.27/bbl, diesel fuel averaged $77.00/bbl, and biodiesel averaged $170.60/bbl.[40]

Fuel ethanol could be blended with petroleum-based fuels. Hawaii's energy consumption estimates for major energy sources in 2013 are shown below:

**Hawaii's Energy Consumption Estimates**[41]

| | |
|---|---|
| Coal (Thousand Short Tons) | 753 |
| Natural Gas (Billion cubic feet) | 3 |
| Petroleum (Thousand Barrels) | 41,626 |
| Hydroelectric Power (Million Kilowatt-Hours) | 78 |
| Fuel Ethanol (Million Gallons) | 29 |

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

Studies conducted in 2010 indicate that 136,000 suitable acres could be available without displacing current farming in Hawaii; with biomass production of 10 - 20 tons of fiber per acre per year, potential would be about 1.4 - 2.7 million tons of biomass per year.[42] As a reference, two million tons of biomass, if burned in conventional biomass combustion processes, would generate energy equivalent[43] to two million barrels (84 million gallons) of oil.

Algae has also been receiving attention, due to high yields per acre and potential use of $CO_2$. The 8.3 million tons[44] of $CO_2$ produced by large energy facilities (power plants and refineries) in Hawaii could theoretically support the production of over 0.56 million gallons of oil per year.

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

# Bioenergy

## Bioenergy facilities[45]

| Technology | Project Name | Developer(s) | Capacity | Island | Location | Status |
|---|---|---|---|---|---|---|
| Biofuel | Aina Koa Pono Kau Renewable Fuel Facility | Aina Koa Pono | 16-24 MGY | Hawaii | Kau | Planning |
| Biofuel | Big Island Biodiesel | Pacific Biodiesel Technologies, LLC. | 5 MGY | Hawaii | Keaau | Active/Ongoing |
| Biofuel | Campbell Industrial Park Synthetic Natural Gas Facility | Hawaii Gas | 100 kW | Oahu | Kapolei | Active/Ongoing |
| Biofuel | Cellana Algae Kona Demonstration Facility | Cellana LLC | Demonstration MGY | Hawaii | Kailua-Kona | Active/Ongoing |
| Biofuel | Hawaii BioEnergy Integrated Biorefinery Facility | Hawaii BioEnergy | 10-20 MGY | Kauai | Kauai/Hawaii | Planning |
| Biofuel | Hawaii Pure Plant Oil | Hawaii Pure Plant Oil | Demonstration | Hawaii | Keaau | Active/Ongoing |
| Biofuel | HECO Campbell Industrial Park Generating Station | HECO | 110 MW | Oahu | Kapolei | Active/Ongoing |
| Biofuel | Honolulu International Airport Dispatchable Standby Generation Project | Hawaii Department of Transportation, HECO | 10 MW | Oahu | Honolulu | Active/Ongoing |
| Biofuel | Kauai Algae Farm | Hawaii BioEnergy | Microalgae | Kauai | Lihue | Active/Ongoing |
| Biofuel | Maui Energy Park (Mahinahina Energy Park) | Anaergia Services | 5 MW | Maui | Lahaina | Planning |
| Biofuel | Pacific Biodiesel Honolulu Plant | Pacific Biodiesel | 1 MGY Capacity | Oahu | Honolulu | Active/Ongoing |
| Biofuel | Phycal Algae Pilot Project | Phycal, Inc. | 150,000 GAL/Yr | Oahu | Wahiawa | Planning |
| Biofuel | Schofield Generating Station | Hawaiian Electric Company (HECO), US Army | 50 MW | Oahu | Wahiawa | Planning |
| Biomass | Green Energy Biomass-to-Energy Facility | Green Energy Team, LLC | 6.7 MW | Kauai | Koloa | Active/Ongoing |
| Biomass | HC&S Co-Generation Facility | Hawaiian Commercial & Sugar (HC&S), Alexander & Baldwin | 16 MW | Maui | Puunene | Active/Ongoing |
| Biomass | Hu Honua Bioenergy Facility | Hu Honua Bioenergy, LLC | 21.5 MW | Hawaii | Pepeekeo | Planning |
| Biomass | Kauai Biodigestion Project | Pacific Light & Power, Konohiki Hydro Power | 4.5 MW | Kauai | Kekaha | Planning |
| Waste-to-Energy | HPOWER | City & County of Honolulu, Covanta Energy | 88 MW | Oahu | Kapolei (Campbell Industrial Park) | Active/Ongoing |
| Waste-to-Energy | Maui County Integrated Waste Conversion and Energy Project | County of Maui, Anaergia Services (Maui Resource Recovery) | 15 MW | Maui | Puunene | Planning |
| Waste-to-Energy | Pelatron Q Biomass Project | Pelatron Q | 2.4 - 8 MW | Kauai | TBD | Planning |
| Waste-to-Energy | PVT Bioconversion Feedstock Processing Facility | PVT Land Company | Feedstock MW | Oahu | Nanakuli | Active/Ongoing |
| Waste-to-Energy | Waste-to-Enregy System at Joint Base Pearl Harbor-Hickam | Hawaii Air National Guard, Hawaii Center for Advanced Transportation Technologies (HCATT), Biomass Energy Systems, Inc | Demonstration MW | Oahu | Joint Base Pearl Harbor-Hickam | Active/Ongoing |

| | | | |
|---|---|---|---|
| Hawaii's current use of petroleum-based fuels (million gallons/yr) | 1,800 | Algae oil yields demonstrated on Kauai[46] | 2000 gal/ acre |
| Hawaii's current cost per gallon of biofuels[47] | $5 | Hawaii's potential liquid biofuel waste production (mil gal/yr)[48] | 97 |
| Hawaii's current cost per kWh for biofuel generated[49] | 60¢/kWh | Hawaii's potential ethanol production from energy crops[50] | 1,202 |

# Electric Vehicles


An electric vehicle (EV) uses electricity in place of gasoline, reducing the need for petroleum-based fuel. Since EVs can use electricity produced from renewable resources available in Hawaii (i.e. sun, wind, hydropower, ocean energy, geothermal energy), the transition from gasoline fueled vehicles to 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% less than the fossil fuel required to power a similar gasoline-fueled vehicle.[51] This is expected to get even better as renewable energy increases in Hawaii.

**Registered EVs and Public Charging Stations in Hawaii, March 2016**[52]

| County | Electric Vehicles | Level 2[53] Charging Station Ports | Level 3[54] Charging Station Ports | Total Ports |
|---|---|---|---|---|
| **Oahu** | 3,233 | 260 | 15 | 275 |
| **Maui** | 693 | 82 | 35 | 117 |
| **Hawaii** | 195 | 56 | 2 | 58 |
| **Kauai** | 145 | 33 | 1 | 34 |
| **Total statewide** | **4,266** | **431** | **48** | **484** |

**Fuel Cost Comparison**

| Vehicle | 2015 Nissan Versa | 2015 Honda Civic | 2015 Nissan LEAF[55] |
|---|---|---|---|
| Fuel Type | Gasoline | Gasoline | Electricity |
| Miles Per Gallon (MPG) | 35 mpg combined<br>324 miles total range | 33 mpg combined<br>462 miles total range | 114 combined MPG<br>84 miles total range |
| Fuel Costs | $2.50/gallon | $2.50/gallon | Electricity:<br>$ 0.36/kWh |
| Cost to Drive 25 Miles | $1.74 | $1.85 | $0.96 |
| Fuel Cost per Year[56] | $627.03 | $666.67 | $345.95 |

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.

**Hawaii EV Dealers and Showrooms by County**

| County | Nissan LEAF | GM/ Chevy Volt | Mitsubishi iMiEV | Toyota plug-in Prius | Ford Focus, C-MAX, Fusion Energi | BMW i3 & i8 | Cadillac ELR | Porsche Panamera S E-hybrid | Tesla Showroom | Kia Soul EV | Audi A3 E-Tron | Electric Smart Car |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oahu | 3 | 3 | 1 | 3 | 4 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| Maui | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | | |
| Hawaii | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| Kauai | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | | |
| State of Hawaii | 6 | 6 | 1 | 7 | 6 | 1 | 1 | 1 | 1 | 7 | | |

# Electric Vehicles

### Hawaii's electric vehicle laws and incentives include:

- Free parking is provided in state and county government lots, facilities, and at parking meters. (Act 168 of 2012, Hawaii Revised Statutes, 291-71, Note)
- Vehicles with EV license plates are exempt from High Occupancy Vehicle lane restrictions. (Act 168 of 2012, Hawaii Revised Statutes, 291-71, Note)
- 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. (Hawaii Revised Statutes 291-71)
- Non-EVs parked in a space designated and marked as reserved for EVs shall be fined not less than $50 nor more than $100. (Hawaii Revised Statutes 291-72)
- 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.
- Multi-family residential dwellings or townhomes cannot prohibit the placement or use of EV charging systems altogether. (Hawaii Revised Statutes, 196-7.5)
- EV Charging Station, Multi-Unit Dwelling Working Group. (Act 164, 2015)

**EV Quick Facts**

| | |
|---|---|
| The first car to arrive in Hawaii was Electric.[57] | Year 1899 |
| Amount of energy a fully charged Nissan LEAF has potential to tap | 24 kWh |
| Best temperature range to operate lithium ion batteries (most common EV batteries today). | 68°- 95° Fahrenheit |
| Hawaii ranks second in the nation behind California in the number of EVs registered in the state registered light cars and trucks in Hawaii are Electric.[58] | 4.2 out of every 1,000 registered light cars and trucks in Hawaii are EV |
| Cost for a government or commercial property owner to install a Level 2 charging station is | Approximately $4,000-$8,000 per station.<br>A relatively simple project in Hawaii can range from $4,000 to $25,000 to $100,000; however, prices vary considerably.[59] |

### EV Stations Hawaii

The Hawaii State Energy Office developed a mobile app designed to help drivers locate publicly available EV charging stations statewide. *EV Stations Hawaii* helps drivers pinpoint charging stations as well as provide detailed information of the station giving them the confidence that they can recharge while on the road. The free app is available for Apple and Android smartphones and mobile devices.

http://energy.hawaii.gov/testbeds-initiatives/ev-ready-program/ev-stations-hawaii-mobile-app

### EVs on the Move

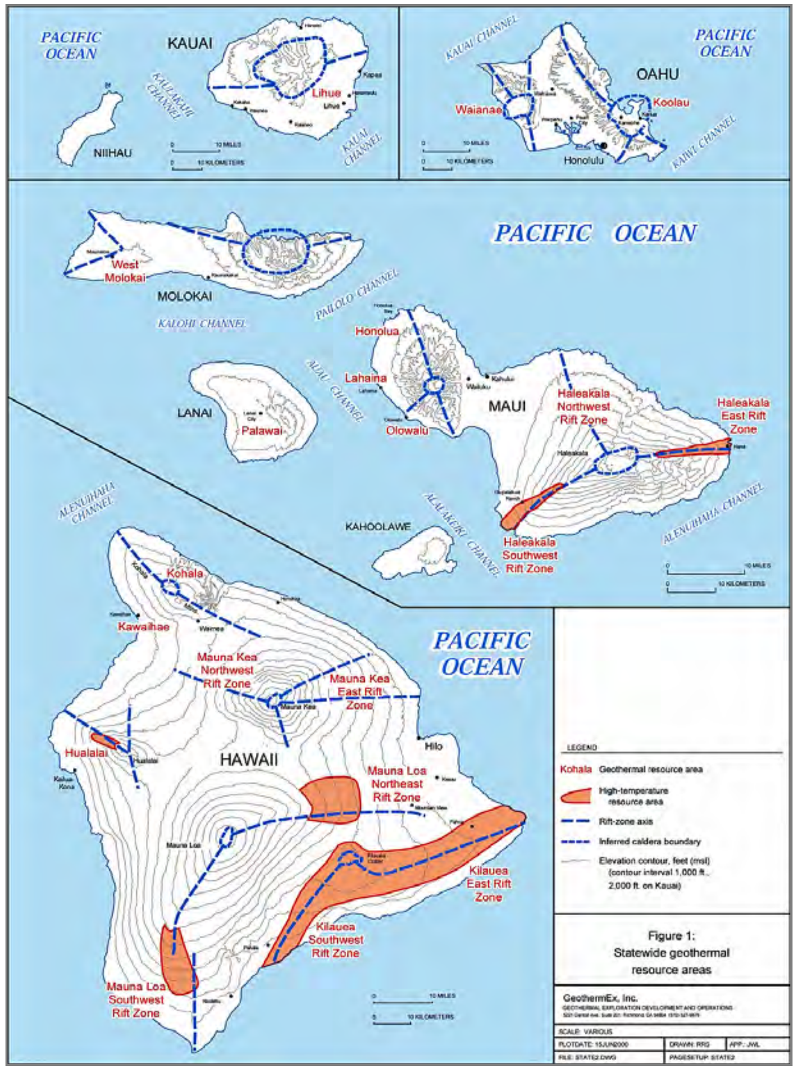
EVs have a greater initial purchase price[60] than comparable gasoline-fueled vehicles. Most experts, including Hawaii's auto dealers, believe that widespread acceptance of EVs will grow as a full battery charge provides greater driving range and the cost of EVs more closely matches the cost of conventional internal combustion engine (ICE) vehicles.

# Geothermal

Hawaii's single geothermal power plant, Ormat's Puna Geothermal Venture (PGV) facility located on the Island of Hawaii, produced 230.5 gigawatt-hours (GWh) in 2015; approximately 22% of the total electricity distributed on Hawaii Island in 2015.[61] The PGV facility, which began operating in 1993 and was expanded from 30 megawatts (MW) to 38 MW in 2011, produces both baseload and dispatched electricity.

In May 2012, the Hawaii Electric Light Company (HELCO) initiated a competitive bidding procedure seeking 50 MW of dispatchable geothermal firm capacity generation by opening a docket with the Hawaii Public Utilities Commission (PUC).[62] In February 2015, HELCO announced it had selected Ormat Nevada, Inc. on behalf of PGV II (Ormat) to provide HELCO with 25 MW of new geothermal power on the East side of Hawaii Island (Moana Geothermal Project). Unfortunately, in February 2016, HELCO notified the PUC and all other parties of Ormat's decision to cancel contract negotiations with HELCO based on Ormat's determination the project would not be economically and financially viable. HELCO also provided the PUC with a record of the unsuccessful competitive bidding process and HELCO's perspective on the key issues that impacted the final result. In March 2016, the Independent Observer assigned to this proceeding filed its report on the results of the process, including its final findings and recommendations moving forward. In February 2016, another prospective geothermal developer, Huena Power, filed a petition with the PUC questioning HELCO's process resulting in Ormat's selection, and asking for its project to be considered; this docket remains open.[63]

In 2012, Ormat submitted an Environmental Impact Statement Preparation Notice related to geothermal activities around Ulupalakua Ranch on Maui, however, there are currently no subsequent EISPN filings.[64]




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

# Geothermal

In April 2016, the Hawaiian Electric Companies (HECO, MECO, and HELCO) filed their updated draft Power Supply Improvement Plans, which included the 'Preferred Plans' for each utility forecasting 40 MW of geothermal development on Maui by the year 2040 and 40 additional MW of geothermal on Hawaii Island by the year 2030.[65]

Continued geothermal exploration will contribute to better understanding of Hawaii's geothermal resources. As mentioned above, Ormat is exploring on Maui, focusing on the southwest rift zone of Haleakala, with partial funding from the U.S. Department of Energy (USDOE). The University of Hawaii (UH) is also exploring rift zones on Hawaii Island using a non-invasive technique called magnetotellurics (MT) designed to detect subsurface electrical conductivity. Findings from this effort and other geothermal and groundwater resource analyses can be found at the Hawaii Groundwater & Geothermal Resources Center.[66] The Hawaii Play Fairway Project, managed by UH and supported by USDOE, will compile and integrate all geothermal-relevant data across the state into a map showing the probability of encountering a resource in the subsurface.[67] In essence, this will provide the first statewide geothermal resource assessment conducted since the late 1970s.

Geothermal resources are difficult to characterize without exploration and drilling since Hawaii's high-temperature resources are usually more than a mile beneath the surface. However, estimates from exploration efforts in the 1970s and '80s indicate that there may be more than 1,000 MW of geothermal reserves[68] (recoverable heat at drillable depths) on Maui and Hawaii islands, which would be sufficient to collectively power Maui, Hawaii Island, and about one quarter of Oahu or, alternatively, about 60% of Oahu's energy needs. Reaching that level of production would require interconnection of the islands' grids.

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

| | | | |
|---|---|---|---|
| Current geothermal production capacity in Hawaii | 38 MW | Contracted price for first 25 MW of electricity from PGV | 18.8¢ on peak<br>15.9¢ off peak per kilowatt-hour (kWh) |
| Estimated probable reserves, Maui & Hawaii | 1,000 MW | Contracted price for next 5 MW of electricity from PGV | 11.8¢ / kWh |
| Median levelized cost of geothermal energy, U.S.[69] | 6¢ kWh | Contracted price for next 8 MW of electricity from PGV | 9¢ / kWh |

# Hydropower

Hydroelectricity was the first renewable energy technology used to generate electricity in Hawaii; plants date back to 1888.[70] Early hydroelectric facilities were located in Honolulu and Hilo, and on the island of Kauai. During the sugar era, additional hydroelectric plants were installed to help power sugar operations.

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

Hawaii currently has about 30 megawatts (MW) of installed hydroelectricity capacity statewide, and about 50 MW of hydroelectric projects proposed or under development.[71] In 2015, hydropower accounted for approximately 1.3% of the total energy distributed by Hawaii's electric utilities statewide.[72]

Hydro is an important part of the energy portfolio on Kauai, where it represented about 8% of the electricity sold in 2015, and on the island of Hawaii, where it represented 5.9% of the island's total electrical sales in 2015.[73] Kauai Island Utility Cooperative (KIUC) continues to investigate new hydroelectric projects including in-line river hydropower and pumped storage hydropower which, if successful, could provide more than 20% of the island's annual electricity requirements.[74]

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

### Hawaii Hydropower Assessments

As part of the Oak Ridge National Laboratory's National New Stream Development project, approximately 145 MW of undeveloped hydroelectric potential from 47 hydro sites have been identified in Hawaii in reconnaissance and feasibility reports.[75] Most of the potential sites are small run-of-the-river projects.[76] The U.S. Army Corps of Engineers (USACOE) also conducted a Hydroelectric Power Assessment for the State of Hawaii in 2011.[77] This feasibility study 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.

Pumped storage hydro is a related technology. A non-hydro source of electricity (e.g., wind, solar, conventional generation) is used 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. KIUC is investigating the possibility of financing and owning a 25 MW pumped storage hydro facility on Kauai using the Puu Lua Reservoir,[78] which was one of the four project sites of focus in the 2011 USACOE Hydropower Assessment.

Another related technology is in-line hydro, which harvests energy within water pipelines. For instance, the Hawaii County Department of Water Supply (DWS) has three small in-line hydro power plants which each have capacities of under 100 kilowatts (kW). These facilities capture the energy in pipes carrying water to DWS customers in West Hawaii.

*Grand River Dam Authority (GRDA) Salina Pumped-Storage Project, Oklahoma*

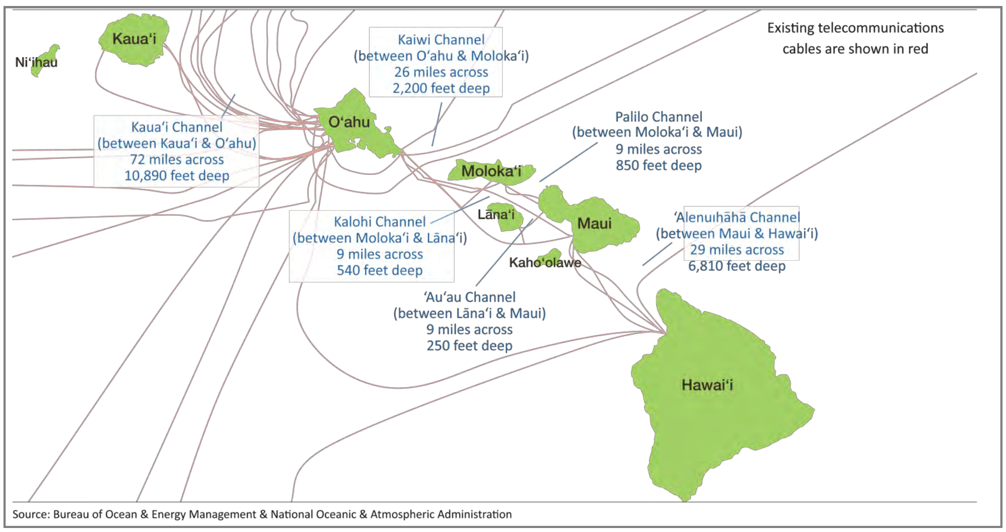
*Hawaii County Dept. of Water Supply's 45-kW in-line hydro plan in Kona*

| | | | |
|---|---|---|---|
| MW of hydroelectric capacity installed statewide | **37**[79] | Capacity of Wailuku River hydroelectric plant, the state's largest | **12.1**[80] MW |
| Year that Puueo hydro power plant, still in operation, began generating | **1910**[81] | Combined power Wailuku River, Waiau, and Puueo Hydro in 2013[82] | **16.45** MW |

# Oahu-Maui Grid Tie

The Interisland Cable Grid-Tie Project (a.k.a., the Oahu-Maui Interisland Transmission System) is an investigation (Docket No. 2013-0169) by the Hawaii Public Utilities Commission (PUC) into the viability of connecting the electricity grids of Maui and Oahu with a 200 MW High Voltage Direct Current (HVDC) cable. DBEDT is still awaiting a determination by the PUC on whether a grid-tie between Oahu and Maui is in the public interest. As Hawaii considers a path for achieving a 100 percent renewable portfolio in the electricity sector connecting the islands through integrated, modern grids should continue to be considered as a means to utilize our best natural resources at a scale that will reduce electricity costs and improve overall system efficiency. The main point here is that our communities need to be a key part of this discussion as we balance economic, technical, environmental and cultural considerations.

The type of system being proposed is a two-way "grid-tie" (not the one-way "gen-tie" transmission cable that was proposed earlier). This system would allow Oahu and Maui to coordinate operation of their respective electric grids, and provide flexibility to significantly add more clean, renewable energy generation in the most economical and equitable manner.




*Hawaii's islands are already connected by several telecommunications cables.*

*The 200 MW HVDC cable bundle is no more than 10 inches in diameter. The bundle shown in the picture is for transmission of 500 MW.*

In its analysis of the Oahu-Maui Grid Tie under Docket No. 2013-0169, DBEDT estimated the overall savings on both islands at up to $423 million (2020-2050) before taking into consideration the environmental benefits. Taking into account the reduction of greenhouse gases and other emissions, the net benefit would rise to $551 million. These figures include fuels savings of approximately $1 billion. Other significant benefits include: [83]

**Economic**

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

**Environmental**

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

# Oahu-Maui Grid Tie

**Public Policy**

- Helps the state meet RPS requirements and the objectives of the Hawaii Clean Energy Initiative (HCEI), i.e., 100% renewable energy by 2045;
- Reduced dependence on fossil fuels; and
- A model for potentially connecting with Hawaii Island in the future.

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

- Trans Bay Cable (California), 53 miles: 660 MW installed in 2010.
- Cross Sound Cable (New York - Connecticut), 24 miles: 330 MW installed in 2002.
- Neptune (New York-New Jersey), 50 miles: 660 MW installed in 2007.
- NorNed (Netherlands – Norway) (longest HVDC submarine cable), 360 miles: 700 MW installed in 2008.
- SAPEI (Italy) (deepest HVDC submarine cable, at 5,380 feet), 261 miles: 1,000 MW installed in 2011.

In April 2016, the Hawaiian Electric Companies filed their updated power supply improvement plan (PSIP) with the Public Utilities Commission (Docket No. 2014-0183). In their PSIP they acknowledge that it appears Oahu will need a substantial amount of off-island renewable resources in order to meet the 100 percent renewable energy goal in 2045. HECO plans to reassess the scope and requirement of an interisland cable, and as a follow-up action to their PSIP filing, HECO plans to (a) identify viable resource alternatives, such as wind and geothermal, and resource availability of location; (b) develop capital cost estimates for the alternatives, including cost to integrate the resources; and (c) complete the analyses comparing the alternatives and mixes of alternatives.[84]

| | | | |
|---|---|---|---|
| Longest undersea power cable | 360 miles | Deepest undersea power cable | 5,380 feet |
| Highest capacity undersea HVDC system | 2,000 MW | Estimated installed cost of Oahu to Maui grid tie[85] | $526 million |
| Year of installation, first HVDC undersea power cable | 1954 | Estimated net benefit of Oahu-Maui grid tie, (including social costs of carbon)[86] | $551 million |
| Expected undersea transmission cable life in years | 30-50 | 2012 legislation: regulatory structure for inter-island power cables | Act 165 |

# Ocean

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

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

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

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


*OPT's PB40 PowerBuoy in Kaneohe Bay, Oahu*

Currently, the U.S. Navy has 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 wave energy test site (WETS) at Kaneohe Bay, Oahu.  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).  The first new tenant, northwest energy innovations (NWEI), deployed its first Azura prototype wave buoy at the WETS 30-meter-deep berth.[87]

The Azura buoy is the fourth wave buoy attached to the 30 m berth since 2004, however, it is significant as it is the first grid-connected wave buoy in the U.S. to provide data for third-party (HINMREC) analysis.  The Navy plans to remove the Azura buoy in 2016 after the trial demonstration period is over.  Hawaii's own Sea Engineering, Hawaii Natural Energy Institute's marine services partner, performed the installation.  NWEI, with $5 million in additional funding from the Energy Department, will apply lessons learned from this current phase of development to modify the device design in order to improve its efficiency and reliability. NWEI plans to then test the improved design with a full-scale device rated between 500 kilowatts and one megawatt at WETS at even deeper test berths of 60 meters to 80 meters over the next several years, further supporting efforts to build a robust and competitive marine hydrokinetic (MHK) industry in the United States. In March 2016, the U.S. Marine Corps announced the launch of a second wave buoy to be connected to the WETS; the Fred Olson Lifesaver energy converter.[88]

# Ocean

The Natural Energy Laboratory of Hawaii Authority (NELHA) at Keahole Point, Kona, is among the world's premier OTEC research centers. Major milestones in OTEC were achieved at NELHA in the 1980s and '90s, including a 1-MW floating OTEC pilot plant, Mini-OTEC (the world's first demonstration of net power output from a closed-cycle plant) and other demonstrations in both open- and closed-cycle OTEC.

NELHA's cold seawater supply pipes are the deepest large-diameter pipelines in the world's oceans, extending to 2,000-foot depths. The laboratory's location, with access to both warm surface water and cold deep ocean water, makes it a prime site for OTEC R&D. Presently, Makai Ocean Engineering is operating a heat exchanger test facility at NELHA, testing components and materials. A 100 kilowatt (kW) OTEC generator has been added to the test facility and became operational in August 2015.

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

*OTEC heat exchanger test facility at NELHA*

| | | | |
|---|---|---|---|
| Number of berths expected at Kaneohe WETS | **3** | Projected Levelized Cost of Electricity (LCOE) for commercial ocean energy[89] | **23¢-25¢/kWh** |
| Energy potential of trade wind waves in Hawaiian waters[90] | **10-15 kW/meter** | Temperature of cold, deep seawater at NELHA[91] | **6°C (43°F)** |
| Number of operating hours achieved by OPT PowerBuoy PB40 at Kaneohe Bay[92] | **>5,600 hours** | Temperature range of warm surface seawater at NELHA[93] | **24° – 28.5°C (75° – 83°F)** |

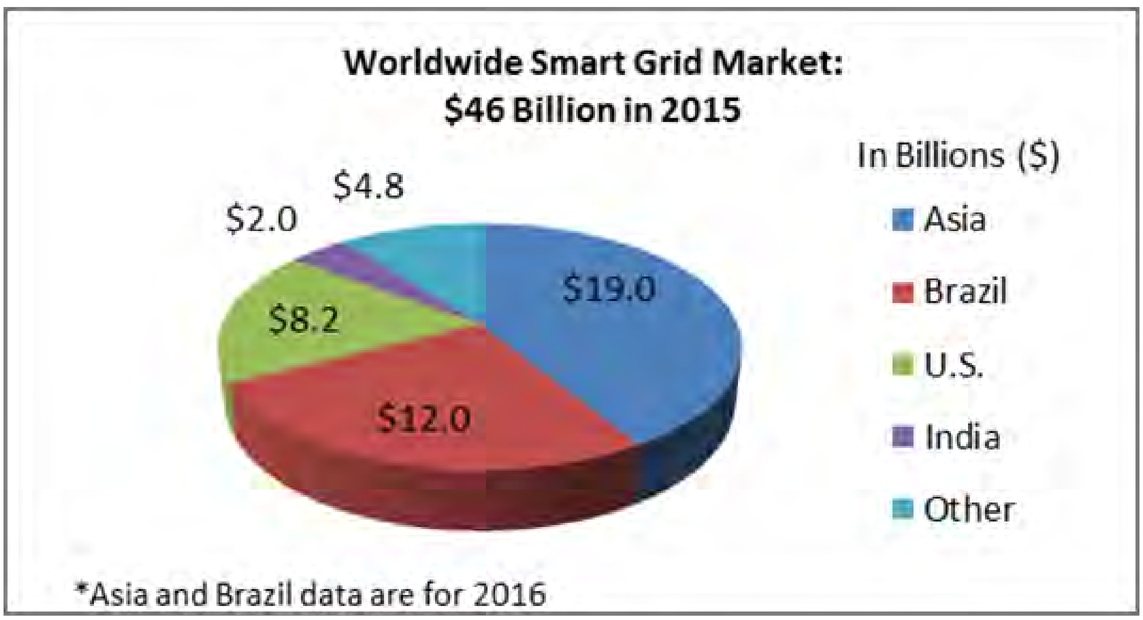
# Smart Grid

### What is Smart Grid?[94]

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

- Smart ("Advanced") Meters
  - Provide timely and detailed energy use information for customers
  - Allow for time of use rates
- Sensors, controls, and forecasting
  - Monitor conditions in real time
  - Allow higher penetration of renewables
- Energy Storage (batteries, capacitors, flywheels, pumped hydro, hydrogen)
  - Allow for increased renewable energy penetration
  - Stabilize the grid by conditioning power and smoothing fluctuations
- Demand Response (managing electricity use in response to available supply)
- U.S. Department of Energy gave $3.4 billion in grants for smart grid projects and grid upgrades in recent years[95]

### Smart Grid Market is Large[96]




### Potential Market in Hawaii

- Residential and commercial building energy management systems may become even more effective when connected to a utility-wide smart grid.
- Over 500,000 housing units and condos[97], and tens of thousands of commercial and government buildings statewide, can take advantage of smart grid technologies.
- Over $57 million has been invested in Smart Grid demonstration projects in Hawaii.[98]

# Smart Grid

**Existing Smart Grid Projects in Hawaii**

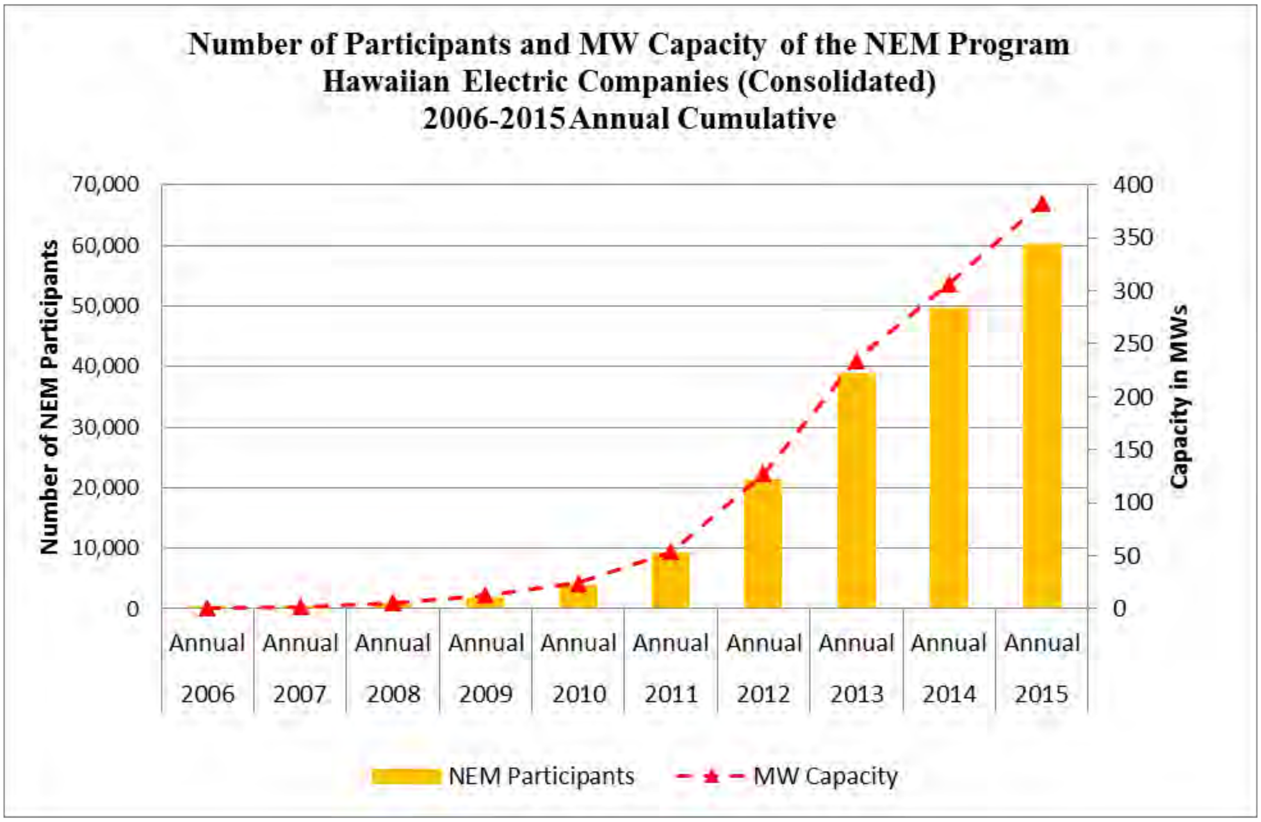
| Name | Description | Key Companies | Location |
|---|---|---|---|
| HECO Smart Grid and Smart Meter Initial Phase | First phase for an island wide rollout of smart grid technology and smart meters, pending approval by the Public Utilities Commission. During the initial phase, about 5,200 smart meters will be installed in homes and businesses.[99] | HECO, Silver Spring Networks, Blue Planet Foundation, Hawaii Energy | Moanalua Valley, parts of Pearl City, Kaimuki, Kahala, Diamond Head and Waikiki, Oahu |
| DOE Renewable and Distributed Systems Integration (RDSI) Maui Smart Grid Demonstration Project | Develop a distribution management system that aggregates distributed generation, energy storage, and demand response technologies with $7 million in DOE funds and $8 million in industry funds.[100] | HNEI, HECO/MECO, General Electric, First Wind | Maui Meadows and Wailea, Maui |
| JUMPSmart Maui Project | Develop advanced technologies that automate EV charging and demand response to allow more renewable energy on the grid. NEDO will invest $37 million in the project.[101] | NEDO, Hitachi, Mizuho, Cyber-Defense, US DOE, NREL, HECO/MECO, HNEI, MEDB, Maui County & DBEDT | Kihei, Maui |
| KIUC Smart Grid Demonstration | Installation of advanced metering infrastructure (AMI) and other smart grid technologies for grid management and energy efficiency information. Total cost of around $11 million for 33,000 meters in five years.[102] | KIUC, USDOE | Kauai |
| Honeywell Fast Demand Response | Industrial and Commercial programs available for designating non-essential facilities that can be turned off during critical energy situations with ten minutes' notice or less.[103] | HECO, Honeywell | Oahu |
| Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES) | Deploy distributed photovoltaics (PV), energy storage, and dynamic load control systems that show the system-level benefits of enhanced utility visibility and control of distribution system/edge-of-network electricity resources.[104] | HECO, U.S. DOE, Siemens, Alstom , DNV GL, AWS Truepower, Referentia Systems, Apparent, and Stem | Honolulu, HI |

On March 31, 2016, the Hawaiian Electric Companies filed an application with the Public Utilities Commission (Docket No. 2016-0087) requesting approval to commit funds and recover costs for a Smart Grid Foundation (SGF) Project. The purpose of the SGF Project is to implement the initial Smart Grid capabilities that will serve as the platform to support not only immediate customer benefits, but also as the cornerstone for additional projects that can expand customer options, such as optimizing the integration of distributed energy resources ("DER"), implementing demand response ("DR"), time-of-use ("TOU") rates and real-time-pricing ("RTP"), and increasing reliability through distribution automation ("DA").[105] The SGF project is currently pending the PUC's review and decision.

# Solar

Due to Hawaii's extremely high energy prices, superior solar resource, and progressive energy policies, the state has experienced unprecedented growth in solar generation. From 2007-2013, solar capacity nearly doubled annually. However since 2013, and due to new utility interconnection requirements, total solar capacity growth has slowed down.

The majority of photovoltaic systems have been installed under the utilities' net energy metering (NEM) program. Since its inception in 2001 over 60,000 customers installed systems under the NEM program in the Hawaiian Electric, Maui Electric, and Hawaii Electric Light service territories. The rapid growth of PV in Hawaii also garnered national and international attention from other utilities, the solar industry, and the National Renewable Energy Laboratory who benefited in seeing how we have met the challenges of installing so much distributed generation on the utilities' grids.[106]




On October 12, 2014, under Docket No. 2014-0192 (Decision & Order No. 33258), the PUC effectively ended the Hawaiian Electric Companies' NEM program, and created two new programs, customer grid-supply (CGS) and customer self-supply (CSS). Under the CGS program, the PUC established capacity limits for each service. The following table shows the total capacity of CGS systems that have passed completeness review as of April 5, 2016.[107]

| Island | Total Capacity MWac | Current Level MWac* | Remaining MWac |
|---|---|---|---|
| Hawaiian Electric | 25.0 | 7.5 | 17.5 |
| Maui Electric** | 5.0 | 0.6 | 4.4 |
| Hawaii Electric Light | 5.0 | 1.2 | 3.8 |

* Includes all applications that have passed completeness review
** Includes Maui, Molokai, and Lanai

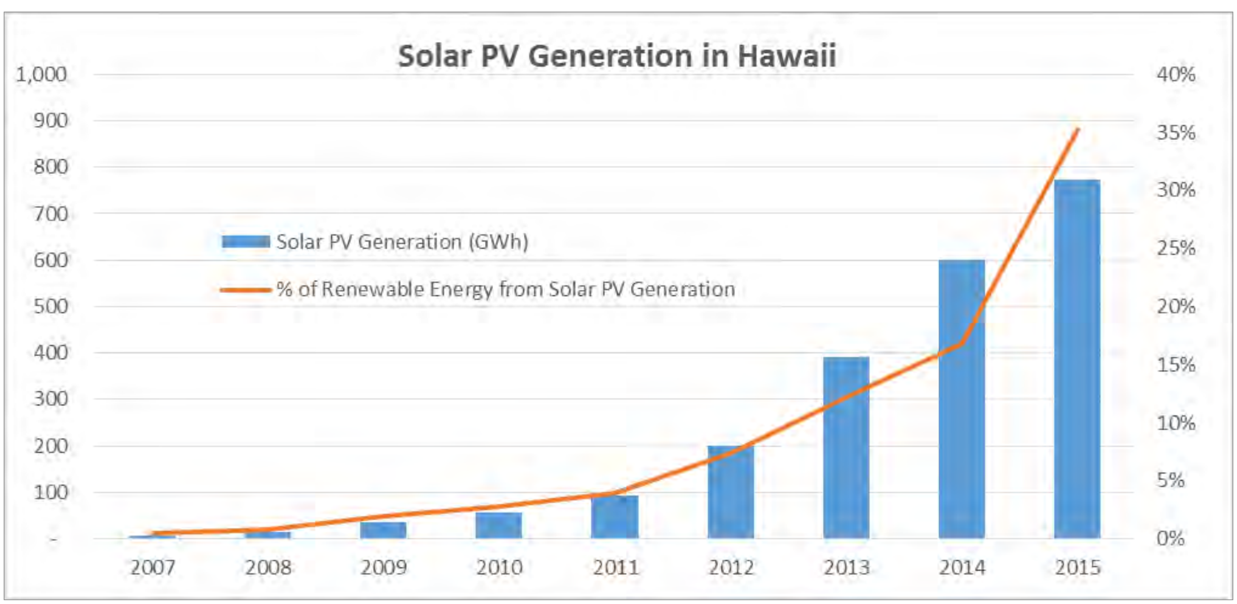
# Solar

The CSS program currently does not have any established capacity limits. As of April 5, 2016, the Hawaiian Electric Companies have received five applications for Oahu, and seven for Maui---only one application has passed the completeness review.[108]

Beyond distributed solar energy, utility scale solar energy has been an important component of the state of Hawaii's energy portfolio. The following table lists the existing active utility scale solar projects.[109]

| Name | Capacity | Island | Location |
|---|---|---|---|
| Anahola Solar | 12 MW | Kauai | Anahola |
| Cyanotech Solar Array | 500 kW | Hawaii | Kailua-Kona |
| Dole Plantation Solar Array | 500 kW | Oahu | Wahiawa |
| Hawaii FIT Forty, LLC | 570 kW | Oahu | Waianae |
| Hawaii FIT Two | 596.7 kW | Oahu | Waianae |
| Holaniku Test Facility | 500 kW | Hawaii | Keahole Point |
| Kalaeloa Renewable Energy Park | 5 MW | Oahu | Kalaeloa |
| Kalaeloa Solar Power II | 5 MW | Oahu | Kalaeloa |
| Kapaa Solar Project | 1 MW | Kauai | Kapaa |
| Kapolei Sustainable Energy Park | 1.1 MW | Oahu | Kapolei |
| Koloa (KRS2) Solar Farm | 12 MW | Kauai | Koloa |
| La Ola Solar Farm | 1.2 MW | Lanai | Lanai City |
| MP2 Solar Project | 300 kW | Kauai | Lawai |
| Pearl City Peninsula PV | 1.23 MW | Oahu | Pearl Harbor |
| Port Allen Solar Facility | 6 MW | Kauai | Eleele |
| Waianae PV-2 Solar Farm | 500 kW | Oahu | Waianae |
| Waimea Research Center PV Facility | 300 kW | Kauai | Waimea Research Center |
| Wilcox Memorial Hospital Solar Photovoltaic Farm | 500 kW | Kauai | Lihue |

In 2015, solar PV generation provided 35% of Hawaii's renewable energy. The graph below shows annual solar PV generation and solar PV generation as a percentage of total renewable energy generation in Hawaii.[110]



# Solar

The integration of large amounts of solar generation has proven to be a challenge for the utility due to the rapid growth of the solar industry, the intermittent nature of solar power, and the condition of Hawaii's islanded, centralized electric grid infrastructure. Potential solutions include advanced inverter settings, battery storage, and interconnecting the island grids. To this end, the Hawaii State Energy Office has provided input in various technical and regulatory investigative proceedings designed to clear the current backlog of PV systems awaiting interconnection by the HECO Companies as well as modernizing the electric utility system to allow for greater renewable penetration and transparency, network interoperability, and distributed intelligence.[111]

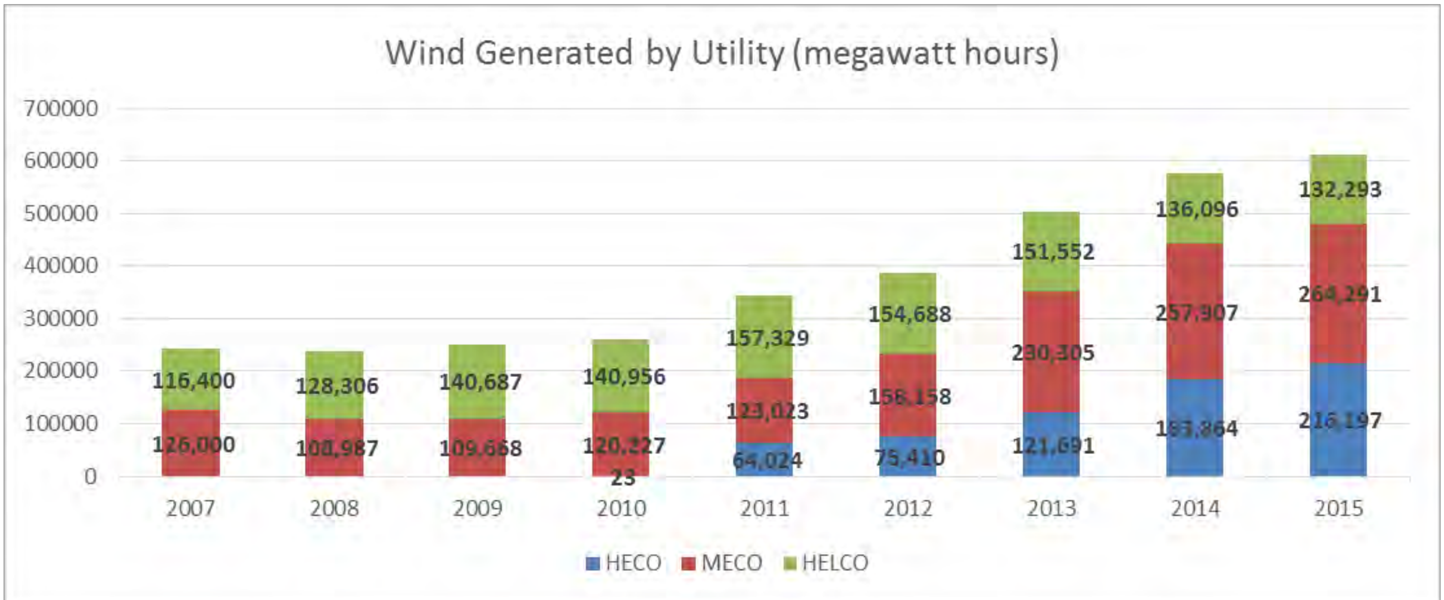
| | | | |
|---|---|---|---|
| Percentage of electricity generated by solar, 2015 statewide[112] | 8% | Nationwide rank of cumulative installed PV capacity per capita, 2014[113] | 1st |
| Power density of PV array[114] | 11-19 watts per square foot | Levelized cost of PV, Hawaii utility scale[115] | ~13-14.5¢ /kWh |
| Installed cost, U.S., residential[116] | $3.29/W | Installed cost, U.S., utility-scale[117] | $1.80/W |
| Statewide 2014 construction expenditures attributed to solar[118] | 7.4% | Acres per megawatt (Hawaii, utility-scale)[119] | 3.3 – 7.2 acres/ MW |

At the end of 2015, Honolulu led all cities in the nation in total solar PV capacity installed per capita, with 417 W-DC.[120]

# Wind

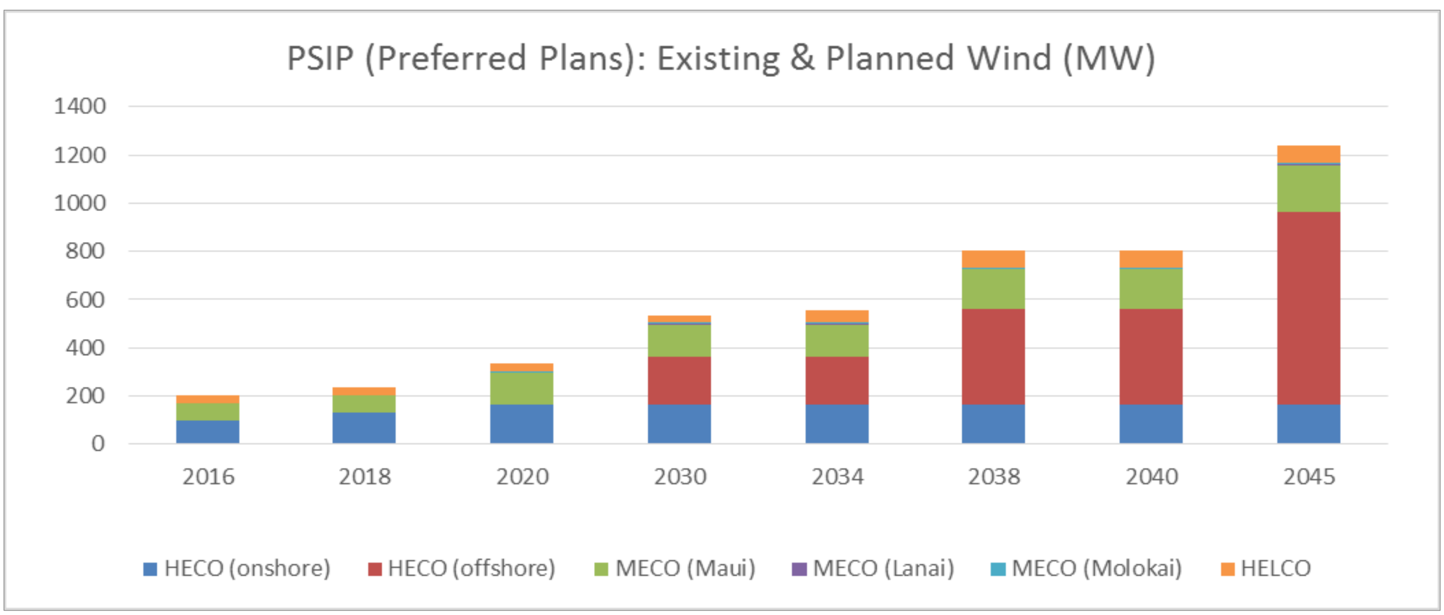
### Onshore Wind

Wind energy is Hawaii's second most utilized renewable energy resource, accounting for about 28% of Hawaii's total renewable energy portfolio in 2015, which equates to 6.5% of the total energy sold and distributed by Hawaii's electric utilities in 2015.[121]




Hawaii has one of the most robust and consistent wind regimes in the world, with capacity factors exceeding those commonly found elsewhere. In 2011, the capacity factor of the Pakini Nui Wind Farm on the Big Island was 65%; Kaheawa Wind Power I on Maui was 47%; and, the Hawi Renewables Wind Farm on the Big Island was 45%.[122]

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 draft Power Supply Improvement Plans (PSIPs) filed by Hawaiian Electric Companies' with the Hawaii Public Utilities Commission (PUC) in April 2016 include 'Preferred Plans' for each service area: Oahu (HECO), Maui County (MECO), and Hawaii Island (HELCO).[123]




*Existing and Planned Wind Projections Proposed in the Power Supply Improvement Plans (Preferred Plans)*

# Wind

The recent PSIPs submitted by the Hawaiian Electric Companies set forth numerous plans or cases for consideration. One plan, the Preferred Plan (Final Plan from Theme 2), estimates an additional 1,200 megawatts (MW) of wind will be needed, in combination of many other types of renewable energy, to get Hawaii to 100% renewable energy by the year 2045. These plans are subject to stakeholder review and approval by the PUC and do not guarantee any of the proposed MW will be installed, but they do provide options for planning consideration.

Existing wind energy projects in Hawaii are located on the islands of Oahu, Maui, and Hawaii.

**Existing Utility Scale Wind Projects**

| Project Name | Year Installed | Island | Developer | Capacity (MW) | Acres | Acres per MW |
|---|---|---|---|---|---|---|
| Hawi Renewable Development[124] | 2006 | Hawaii | Hawi Renewables | 10.5 | 250 | 23.8 |
| Kaheawa I Wind Farm[125] | 2006 | Maui | First Wind/ Sun Edison | 30 | 200 | 6.7 |
| Pakini Nui Wind Farm[126] | 2007 | Hawaii | Tawhiri Power | 20.5 | 67 | 3.3 |
| Kahuku Wind Farm[127] | 2011 | Oahu | First Wind/ Sun Edison | 30 | 578 | 19.3 |
| Kawailoa Wind Farm[128] | 2012 | Oahu | First Wind/ Sun Edison | 69 | 650 | 9.4 |
| Kaheawa II Wind Farm[129] | 2012 | Maui | First Wind/ Sun Edison | 21 | 143 | 6.8 |
| Auwahi Wind[130] | 2012 | Maui | Sempra Generation | 21 | 68 | 3.2 |

Note: There is a proposed 25 MW Na Pua Makani Wind Farm in Kahuku, Oahu, which could consist of up to 10 turbines and have an estimated project footprint of 46 acres.[131]

| | | | |
|---|---|---|---|
| Current installed wind in Hawaii (capacity)[132] | **202 MW** | Average land area per MW (wind in HI) | **9.7 acres** |
| Levelized cost of wind energy[133] | **7¢ per kWh** | Average height of a 2.3 MW turbine[134] | **456 ft.** |

### Challenges Facing Wind Energy Development in Hawaii

· Endangered avian and plant species can complicate the siting, development, and operation of wind projects in Hawaii's unique environments. Proactive measures, such as the development of area-wide habitat conservation plans, could be helpful for species protection as well as easier project siting in the future. The increased level of ecological monitoring required for new farms in Hawaii has helped to increase the amount of information available on impacted species and habitats.

· Given the height of 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; with developers working closely with local communities.

### Offshore Wind

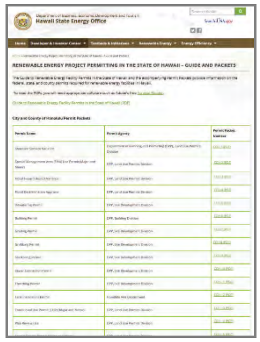
Attention to offshore wind in Hawaii has increased following notice of multiple unsolicited applications received by the U.S. Bureau of Ocean Energy Management (BOEM) for seafloor lease applications for wind farms off-shore of Oahu.[135] BOEM established the BOEM/Hawaii Intergovernmental Renewable Energy 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 3 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.

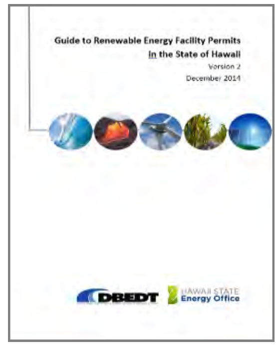
# Permitting

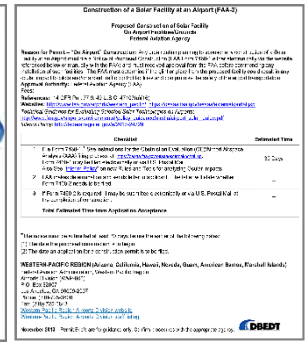
Permitting any large project in Hawaii, including a utility-scale renewable energy project, requires a thorough understanding of local processes, issues, and stakeholders. The tools described below provide information on these topics, as well as guidance to assist appropriate project siting and due diligence. These tools also seek to lower project "soft" costs by reducing the resources needed to undergo the permitting processes[136] 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. Some of these tools were featured by the National Association of State Energy Officials (NASEO) as a best-practice other state energy offices could use to abate soft costs associated with renewable energy permitting processes.[137]

### 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. The Energy Office aims to regularly update these resources as requirements, policies, and procedures change. (http://energy.hawaii.gov/developer-investor/project-permitting-assistance-and-resources)



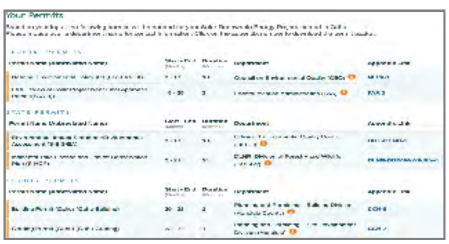


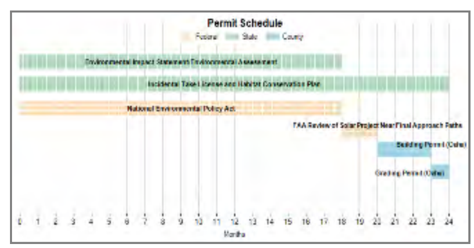



In addition to these resources, the Center provides lists of environmental consultants familiar with planning and permitting in Hawaii. While not exhaustive, this list identifies numerous firms with experience permitting and siting renewable energy projects in Hawaii.

### Renewable Energy Permitting Wizard (Hawaii State Energy Office)

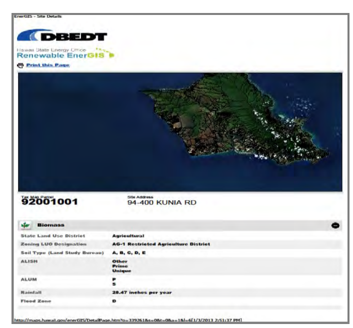
The *Permitting Wizard* was developed to help those proposing renewable energy projects understand the county, state, and federal permits that may be required for their individual projects. Software upgrades and content updates to the *Wizard* were last completed by the Hawaii State Energy Office in 2015. (http://wizard.hawaiicleanenergyinitiative.org/)






### 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. DBEDT is currently upgrading this tool. (http://energy.hawaii.gov/resources/renewable-energis-map)




### Hawaii Clean Energy Programmatic Environmental Impact Statement (U.S. Department of Energy)

In September 2015, the U.S. Department of Energy (USDOE) published the Hawaii Clean Energy Final Programmatic Environmental Impact Statement which assesses common impacts and best management practices associated with 31 clean energy technologies. (http://energy.hawaii.gov/testbeds-initiatives/hawaii-clean-energy-peis)

# Permitting

**Electronic permitting** is another effective method of streamlining the permit review process without removing any of the environmental or community safeguards in place.[138] Some examples of state and county agencies in Hawaii utilizing electronic permitting include:

### e-Permitting Portal (Hawaii Department of Health/DOH)


The DOH Environmental Health Administration (EHA) *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. (https://eha-cloud.doh.hawaii.gov/epermit/)

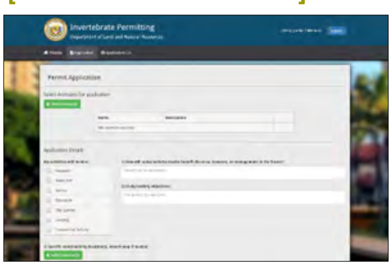
### Online Building Permits (City and County of Honolulu/CCH)


CCH'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. (http://dppweb.honolulu.gov/DPPWebDefault.aspxPossePresentation=OnlineBuildingPermit&PosseObjectDef=j_OnlineBP)

### Electronic Plan Review 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. (http://www.kauai.gov/Government/Departments/PublicWorks/BuildingDivision/ElectronicPlanReview/tabid/392/Default.aspx)

### [UNDER DEVELOPMENT] Online Permitting (Department of Land and Natural Resources)




DBEDT and DLNR are currently developing new online permitting tools for DLNR's Engineering Division and Division of Forestry and Wildlife. These tools are scheduled for public release in 2016.

### Facts about permitting renewable energy projects in Hawaii

- Permitting costs in Hawaii can range from 1% to 20% of overall project construction costs.[139]
- Large energy projects in Hawaii average 15 federal, state, and county permits.
- It can take 1-5 years to permit a large renewable energy project in Hawaii.
- Hawaii's Energy Policy: Balance technical, economic, environmental, and cultural considerations.

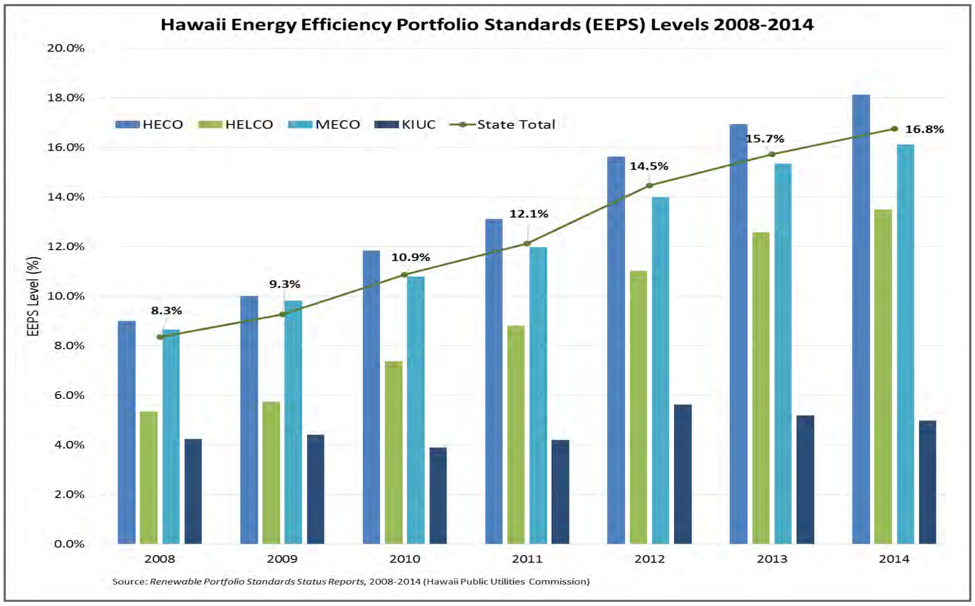
### Common solutions to renewable energy permitting issues in Hawaii

- Know the requirements and processes - retain professionals with experience in Hawaii.
- Meaningful community participation - engage public early in the project design process.
- Engage all stakeholders - identify and address all issues early in the process.
- Site projects appropriately - minimize environmental impacts, seek compatible areas.
- Be diligent - go slow in the beginning to go fast in the end.
- 1 submittal / 1 review - present agencies with well-planned projects, complete applications.
- Electronic permit processing - saves time, reduces back and forth, transparency, tracking.

# Energy Efficiency Portfolio Standards

As of January 1, 2015, Renewable Portfolio Standards (RPS) reporting by law no longer includes Energy Efficiency Portfolio Standards (EEPS). Under HRS 269-96, relating to energy efficiency portfolio standards, the Public Utilities Commission is responsible for establishing EEPS that will maximize cost-effective energy-efficiency programs and technologies.

Therefore, included in this edition is the last EEPS levels from 2008-2014. The EEPS requires that by 2030 annual energy savings amount to 30% of annual electricity sales statewide. An Energy Efficiency Potential Study, initiated by the Public Utilities Commission, indicates that there is the potential of exceeding this goal by 50% by 2030.




A major contributor to EEPS is Hawaii Energy (HE), a ratepayer-funded energy conservation and efficiency program that serves all islands except Kauai, which is handled by Kauai Island Utility Cooperative. HE is administered by Leidos Engineering, LLC, under contract with the Hawaii Public Utilities Commission. For HE's program year ending June 30, 2015, the program invested over $36 million to deliver more than 1.3 billion kilowatt hours (kWh) in lifetime customer-level energy savings at a cost of approximately 2.4 cents per kWh. The energy saved is enough to power 183,000 single-family homes for one year. The energy saved is equal to eliminating 2.2 million barrels of oil from being imported to Hawaii and burned to generate electricity. This is also equivalent to the reduction of 1.3 million tons of greenhouse gas emissions. HE delivered over $22.2 million in incentives driving customer energy bill savings of over $43.3 million for the first year and more than $435 million over the lifetime of the energy efficiency measures installed.

# Energy Performance Contracting

Energy performance contracting (EPC) provides building owners with the opportunity to design, install, and maintain energy-efficient equipment without significant upfront cost. Costs are paid over time from the energy savings. The Hawaii State Energy Office provides technical assistance on energy performance contracting to state and county agencies.

**Projects initiated since 1996:**

- University of Hawaii at Hilo
- Hawaii Health Systems Corporation
- Judiciary
- Department of Accounting and General Services Phase I
- Department of Accounting and General Services Phase II
- Department of Public Safety (4 prisons)
- Department of Transportation – Airports, Harbors, and Highways)
- University of Hawaii Community Colleges
- Counties of Hawaii and Kauai; C&C of Honolulu
- Honolulu Board of Water Supply

**Preliminary data show:**

- The projects include over 225 buildings/facilities and over 96 million square feet
- Annual cost savings for all projects is over $52 million, representing an average of over 47% savings
- Hawaii is ranked 1st in the nation per capita for energy performance contracting (Energy Services Coalition)

**Over 20 years, the projects will:**

- Save over $1.1 billion in electricity costs
- Provide over $642 million of direct (total investment) and indirect (repair/maintenance/taxes) impacts to the economy
- Create an estimated 3,615 jobs due to contract investments
- Energy savings for these projects over 20 years (over 2.2 billion kWh) is equivalent to powering an estimated total of 316,894 households for one year.

**Hawaii honored with national energy award for fourth consecutive year**

For the fourth consecutive year, the State of Hawaii was nationally recognized and awarded the Energy Services Coalition's (ESC)* *Race to the Top* for leading the nation in per capita energy performance contracting for state and county buildings. Hawaii leads the nation with $320.16 invested per capita; national average is $52.38 per capita. Hawaii is well ahead of second place Kentucky with EPC investment of $172.84 per capita and third place Delaware at $154.47 per capita.

**ESC is a national nonprofit organization composed of a network of experts from a wide range of organizations working together at the state and local levels to increase energy efficiency and building upgrades through energy performance contracting.*

| Energy Services Coalition Ranking | | | | | | |
|---|---|---|---|---|---|---|
| State | Population | Performance Contracting | Dollars per Capita | Job Years Created | Source Energy Saved | Tons Carbon Avoided |
| 1. Hawaii | 1,360,301 | $435,512,722.00 | $320.16 | 4,734 | 3,613,884 | 62,076 |
| 2. Kentucky | 4,339,367 | $750,000,000.00 | $172.84 | 8,152 | 6,223,500 | 106,901 |
| 3. Delaware | 897,934 | $138,707,463.00 | $154.47 | 1,508 | 1,150,994 | 19,771 |
| 4. Ohio | 11,536,504 | $1,252,683,627.00 | $108.58 | 13,616 | 10,394,769 | 178,551 |
| 5. Kansas | 2,853,118 | $278,951,861.00 | $97.77 | 3,032 | 2,314,742 | 39,760 |

The Hawaii State Energy Office has been providing technical assistance for performance contracting to state agencies and counties since 1996. The EPC projects vary widely and include courthouses, community colleges, hospitals, prisons, fire and police stations, wastewater treatment plants, airports, harbors, highways, and state and county office buildings.

# Energy Performance Contracting

## State and County Energy Performance Contracting Projects

Over $435 million in EPC contracts awarded in Hawaii since the program's inception has resulted in the creation of about 3,615 jobs and an energy savings of over $1.1 billion over the life of the contracts.

Over $7.7 million in rebate incentives from Hawaii Energy have been claimed to reduce the cost of the energy efficiency improvements through performance contracting projects.

| 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 |
| Dept. 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 |
| Dept. of Transportation | 2013-2035 | $237,885,610 | $730,027,690 |
| Honolulu Board of Water Supply | 2016-2036 | $33,125,198 | $56,653,139 |
| | **Total** | **$435,512,722** | **$1,120,778,715** |

## $151+ Million Airports Energy Performance Contract
### *Largest Energy Performance Contract in the Nation*

Hawaii is the first in the nation per capita investment for energy performance contracting. As of December 2013, the Hawaii Department of Transportation Airports Division reports it has:

- Executed a $151+ million agreement for energy performance contracting for 12 airports statewide
- Financed the project by selling $167.7 million of certificates in the municipal bond market
- Received an overwhelming response from market investors offering more than $1.1 billion in orders from local Hawaii and national investors

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

- Cut energy use by 49 percent
- Save at least $496 million in energy costs over the next 20 years

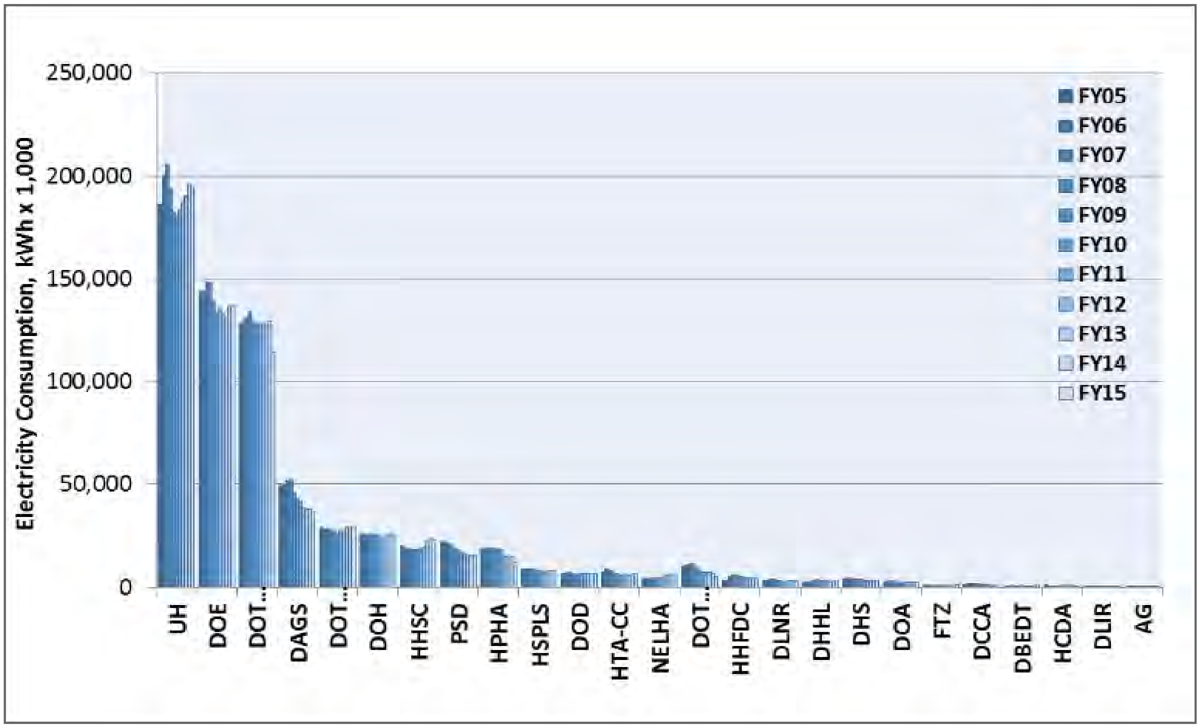
Improvements will include:

- Replacing 74,500 light fixtures and 372 transformers
- Installing 9,100 solar photovoltaic panels (about 2.7 MW)
- Upgrading and replacing chilled water and air conditioning systems
- Installing smart controls
- Addressing deferred maintenance such as roof repairs to accommodate the upgrades

# State of Hawaii Agencies Lead By Example

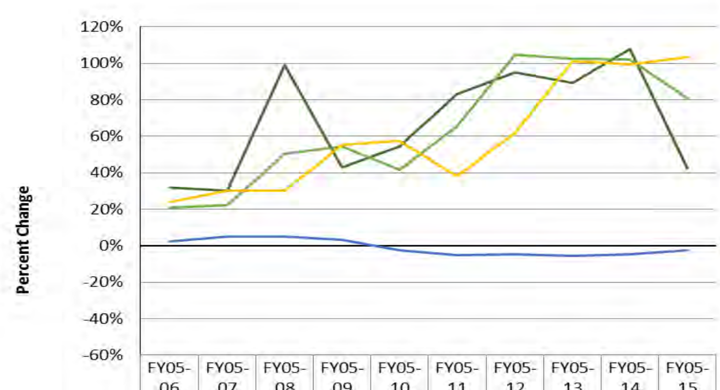
During FY15 state agencies' energy consumption decreased by 3.4% from FY14 levels and the state paid 11.0 % less than FY14. When comparing FY15 figures against the 2005 baseline year, energy consumption dropped 5.9%, but due to the increasing cost for fuel, electricity costs rose 81.0%. Consumption (kWh) by agency by year is shown in the chart below.

**Energy Consumption by State Agencies**




This chart shows the percentage of change from the baseline year (2005) and each following year. Shown are the price of oil, the average retail price of electricity (based on U.S. Energy Information Administration-826 reporting, dividing utility total revenues by total kWh sold and including fuel adjustment cost), total State of Hawaii electricity costs and the State of Hawaii electricity consumption (kWh).

**Energy Consumption Since 2005**




| | FY05-06 | FY05-07 | FY05-08 | FY05-09 | FY05-10 | FY05-11 | FY05-12 | FY05-13 | FY05-14 | FY05-15 |
|---|---|---|---|---|---|---|---|---|---|---|
| Price of Oil ($/bbl) | 31.8% | 30.0% | 99.1% | 43.0% | 54.2% | 83.1% | 94.9% | 89.1% | 107.9% | 42.3% |
| Total State Avg Retail Price (All Sectors; $/KWH) | 20.9% | 22.1% | 50.5% | 54.5% | 41.8% | 65.5% | 104.6% | 102.5% | 101.8% | 81.0% |
| Total SOH Building Electricity Cost ($) | 23.7% | 30.3% | 30.3% | 55.4% | 57.3% | 38.2% | 62.0% | 101.3% | 99.5% | 103.4% |
| KWH | 2.2% | 4.9% | 4.9% | 3.3% | -2.6% | -5.3% | -4.8% | -5.6% | -4.9% | -2.5% |

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

# State of Hawaii Agencies Lead By Example

- State agencies have received more than $9.43 million in efficiency rebates since 1996 from the Hawaiian Electric Company (HECO) and its subsidiaries and from Hawaii Energy. These rebates combined have resulted in estimated cumulative dollar savings of over $172 million and electricity savings of 993 million kilowatt-hours. Over the life of the equipment, the savings will be equivalent to approximately 132,000 households' annual electricity use. In FY15 state agencies received $1,293,819 in rebates.
- 142 state buildings have received ENERGY STAR® awards in 2015, acknowledging that they rank in the top 25% of similar buildings nationwide. Agencies are reviewing buildings to recertify existing buildings and to identify new buildings for certification.

### Power Purchase Agreements

- DOT-Airports signed a 20-year power purchase agreement in 2009 for a total of seven photovoltaic systems totaling 901 kW of capacity.
- Through a second round of power purchase agreements in 2011, DOT-Airports awarded development of photovoltaic renewable energy generation systems at 15 sites. Seven power purchase agreements have been signed for a total capacity of 606 kW. The remaining eight are pending, but are planned for an additional 2.69 MW. In an earlier power purchase agreement, DOT-Airports installed nearly 1.4 MW of photovoltaic systems at seven airports and harbors facilities in the state. A total of nearly 5.2 MW of photovoltaics has been installed. [Airports will install about 2.7 MW through their performance contracting project. These installations are not under a power purchase agreement, but will be owned by the Airports.]
- In January 2014, OpTerra Energy Solutions was awarded the Energy Efficiency and Sustainability Master Plan RFP. The Department of Education (DOE) is rebranding this program *Ka Hei*. Under the *Ka Hei* program, OpTerra will conduct whole school audits beginning 2015 to determine energy and water efficiencies for each DOE school. Based on these audits, DOE will determine the feasibility to fund these energy and water efficiency projects, either through the *Ka Hei* program or using bond funds.

### State Energy Building Code Update

The State Building Code Council unanimously voted on an update of the International Energy Conservation Code of 2015. Administrative Rules have been prepared for public hearing.

# Leadership in Energy and Environmental 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 March 2016, Hawaii has 152 LEED certified projects and 239 registered projects. This totals 391 total projects for a gross square footage of over 45 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 public: federal, state and county buildings.

Hawaii remains a member of the U.S. Green Buildings Council (USGBC), the non-profit entity which administers the LEED program.

The state requires all new construction and major renovation to meet LEED Silver standards, to the extent possible. The Hawaii State Energy Office continues to promote LEED training opportunities for state agency staff.

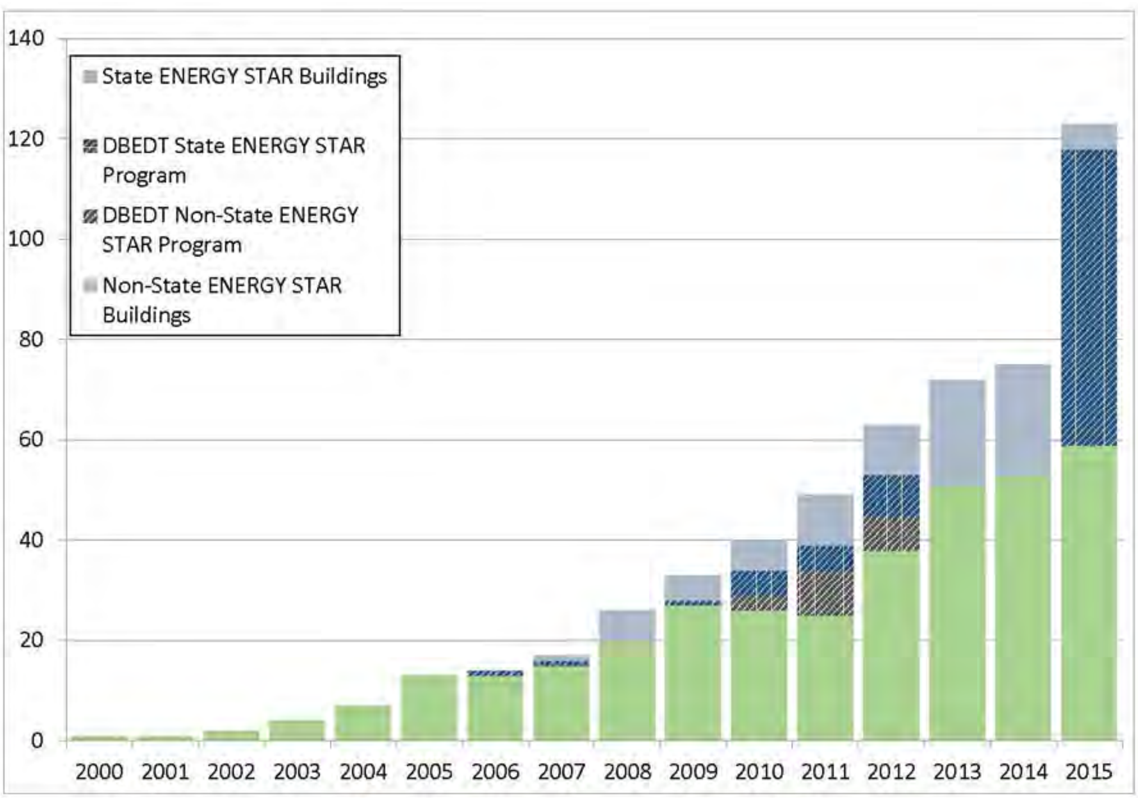
# ENERGY STAR® Buildings

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

**Energy Star Buildings in Hawaii**

The chart below shows the rapidly increasing number of ENERGY STAR certified buildings in the state. To qualify for ENERGY STAR certification, a building must be verified by a licensed professional engineer or architect as meeting ENERGY STAR requirements. The U.S. Environmental Protection Agency (EPA) then evaluates the verification submitted and, if approved, will verify the building as an ENERGY STAR building. Since 2000, 142 Hawaii buildings have received the ENERGY STAR certification. The certified buildings include 64 public (light blue) and 78 (light green) private buildings. During this time, the Hawaii State Energy Office has assisted with the benchmarking and certification of 59 state facilities (dark blue/hatched by DBEDT). Since building use is constant, buildings should be verified and certified as ENERGY STAR annually.

In 2016, the EPA announced their ENERGY STAR Top Cities. Honolulu ranked 22nd of the Top 25 Cities, with 69 buildings totaling over 9.6 million total square feet, saving $23M a year. For Top Mid-Size Cities, Honolulu ranked second; for Top Small Cities, Hilo ranked 8th with 9 buildings and Kahului/Wailuku/Lahaina ranked 9th with 8 buildings.



# Hawaii Green Business Program

The state's Hawaii Green Business Program assists and recognizes businesses that strive to operate in an environmentally, culturally and socially responsible manner. As a partnership between the state's Department of Health and the Department of Business, Economic Development, and Tourism; the Board of Water Supply; and the Chamber of Commerce of Hawaii, the program recognizes businesses that are committed to going green by implementing energy and resource efficiency practices. Not only does energy efficiency keep utility costs down and create a more sustainable environment, the businesses are also collectively contributing to Hawaii's energy efficiency goal. From 2009-2015, the program has assisted and recognized over 100 business and government entities from the hospitality, commercial office, retail, restaurant and food services sectors, and events resulting in the following savings:

· 17.022 million kWh of energy (equivalent to powering 2,262 homes for one year in Hawaii)
· 77.1 million gallons of water
· $4.501 million of energy cost

For more information on the Hawaii Green Business Program, visit energy.hawaii.gov/green-business-program

# GreenSun Hawaii Loan Program

The Hawaii State Energy Office is closing down the GreenSun Hawaii Loan Loss Reserve Program. Any future loan activity will be handled by the Green Energy Market Securitization (GEMS) Program. For more information on the GEMS Program, visit gems.hawaii.gov. Following is a summary of the GreenSun Hawaii Loan Loss Reserve Program and its accomplishments during its three years of operation.

**Program Objectives**

· A State of Hawaii credit enhancement program that was funded by a grant from the U.S. Department of Energy
· Provided local financial institutions with access to a loan loss reserve (LLR) which could cover up to 100% of actual losses
· Enabled participating lenders to:
  - Extend loan availability to a larger pool of borrowers
  - Offer more aggressive rates and terms than may otherwise be available without this credit enhancement
· Public-private partnership with the ability to leverage $4.25 million in federal funds into $85 million in energy efficiency and renewable energy equipment loans statewide

**Program Purpose**

Supported loans for all property owners

· Eligible Residential Loan Purposes:
  - ENERGY STAR refrigerators and air conditioners
  - Solar Thermal Hot Water System
  - Solar Electric (PV) System
  - Heat Pumps
  - Insulation installed with an ENERGY STAR air conditioner

· Eligible Non-Residential Loan Purposes:
  - Lighting Retrofits and Upgrades/Air Conditioning Retrofits and Upgrades
  - Solar Thermal Systems/Solar Electric (PV) Systems
  - Energy Efficiency Windows, Cool Roofs and all other installations eligible for Hawaii Energy/KIUC Rebates
  - Loan related fees
· Required energy efficiency improvements before renewable energy improvements were funded

# GreenSun Hawaii Loan Program

**Participants**
· 12 participating Lenders statewide
· 42 authorized Contractors statewide

**Impacts**
GreenSun Hawaii was a public-private partnership that had the ability to leverage $4.25 million in federal funds into $85 million in energy efficiency and renewable energy equipment loans statewide

Impacts include:
· GreenSun Hawaii covered 204 low-interest loans amounting to over $4.8 million
· The estimated energy savings for these installations is 29.9 million kWh of electricity over the life of the installations which will save participants' in excess of $13.2 million over the life of the installations
· Annual CO2 reduction of 2,247,000 lbs. (44.9 million lbs. over the life of the installations)

Energy savings over the life of the equipment is equivalent to powering 3,974 households

# ENDNOTES

[1] U.S. Energy Information Administration, “1990-2014 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/. (Please note 2015 data for Hawaii includes data from 1/2015 to 7/2015.)

[3] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_06_a. Table 5.6A Average Retail Price of Electricity to Ultimate Customers by End-use Sector—located at http://www.eia.gov/electricity/monthly/

[4] Source: 2005-2015 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008.

[5] DBEDT’s Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends/

[6] Volumes. Source: Biofuels Study; DBEDT; 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf

[7] DBEDT’s Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/. Data from 8/2014 to 7/2015.

[8] DBEDT’s Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/. Data from 8/2014 to 7/2015.

[9] 1 barrel = 42 U.S. gallons.

[10] DBEDT’s Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/. Data from 1/2015 to 12/2015.

[11] Electricity: http://www.eia.gov/state/rankings/#/series/31 (last accessed 4/3/16); natural gas: http://www.eia.gov/state/rankings/#/series/28 (last accessed 4/3/16)

[12] DBEDT’s Monthly Energy Trends, http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2/. Data from 8/2014 to 7/2015.

[13] The State of Hawaii Data Book 2014 Tables 17.07 and 17.10 & Hawaiian Electric Industries 2014 Annual Report, “Generation Statistics”.

[14] Hawaiian Electric Company, https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/selling-power-to-the-utility/competitive-bidding.

[15] Hawaiian Electric Company, https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/selling-power-to-the-utility/competitive-bidding.

[16] PUC Docket Number 2012-0212 (Application for Approval of a Power Purchase Agreement for Renewable Dispatchable Firm Energy and Capacity).

[17] The amount of electricity produced per year = facility capacity x 24 hours/day x 365 days/year x capacity factor.

[18] Residential electricity use, rates, and average bill obtained from DBEDT’s 2013 and 2014 Data Book, http://dbedt.hawaii.gov/economic/databook/db2013/ & http://dbedt.hawaii.gov/economic/databook/2014-individual/_17/. (Table 17.10)

[19] The FIT queue was closed pursuant to Docket No. 2013-0194, Order No. 32499.

[20] HECO, http://www.heco.com/fit/

[21] The FIT queue joint plan was accepted by the PUC on December 5, 2014 under Docket No. 2013-0194, Order No. 32499.

[22] Source: PUC Docket No: 2014-0192 filed by Hawaiian Electric Industries on 1/21/15, Page 1, first bullet point under “Summary of This Filing”.

[23] The DER docket proceeding was formally initiated on March 31, 2015 in PUC Order No. 32737, and calls for the utilities and other docket interveners from government, industry and advocacy groups to develop joint recommendations to 1) revise interconnection rules to allow for new distributed functions and capabilities such as energy storage or other grid-supportive services, 2) transition the current net energy metering (NEM) program, if necessary, and 3) create new market choices for non-exporting and "smart" exporting distributed energy systems. On October 12, 2015, the PUC issued Decision & Order (D&O) No. 33258 relative to the DER docket and contained three (3) major elements: (1) “Streamlines the interconnection process for customers by adopting new technical standards for advanced inverters and energy storage systems that utilize grid-supportive features; (2) Caps the {NEM} program at existing levels, including current NEM customers and those with applications pending in the queue at [the] time of this D&O; [and] (3) creates 3 new options for customers who wish to invest in rooftop solar and other distributed energy resources. These options include”: self- and grid- supply systems and time-of-use tariff. Full details of the D&O can be found under Docket No. 2014-0192 D&O No. 33258.

[24] Hawaiian Electric Company, Net Energy Metering. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/net-energy-metering

[25] Hawaiian Electric Company, Customer Grid Supply and Self Supply Programs. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/customer-grid-supply-and-self-supply-programs

[26] Hawaiian Electric Company, Customer Grid Supply and Self Supply Programs. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/customer-grid-supply-and-self-supply-programs

[27] Kauai Island Utility Cooperative (KIUC), http://kauai.coopwebbuilder.com/sites/kauai.coopwebbuilder.com/files/schedule_q_eff_092012.pdf

[28] http://kauai.coopwebbuilder.com/files/42_schedule_nem_effective_june_3_2011.pdf

[29] Hawaii Revised Statutes, Chapter 269-91.
[30] Source: 2007-2015 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008.
[31] National Renewable Energy Laboratory, Hawaii Clean Energy Initiative Scenario Analysis, 2012; and DBEDT.
[32] Chapter 269-91 et. seq., Hawaii Revised Statutes. http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.htm
[33] National Renewable Energy Laboratory, http://en.openei.org/wiki/Transparent_Cost_Database
[34] RPS Docket Number: 2007-0008.
[35] Hawaii Revised Statutes, Chapter 269-91.
[36] Hawaii Revised Statutes, Chapter 269-92.
[37] Hawaiian Electric Company. https://www.hawaiianelectric.com/about-us/key-performance-metrics/renewable-energy
[38] Total Renewable Energy Metric. Docket No. 2013-0141 Hawaiian Electric Companies Reply Statement of Position, Exhibit 3, Attachment 3. Jan 7, 2014.
[39] DBEDT, Biofuels Report to the Legislature in Response to Act 203, 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf
[40] DBEDT Monthly Energy Trends, http://dbedt.hawaii.gov/economic/energy-trends-2/.
[41] Naphtha data from facility-level data, USEPA (http://ghgdata.epa.gov/ghgp/main.do#/facility/) and USEIA (http://www.eia.gov/beta/api/qb.cfm?category=1017)
[42] Hawaii Natural Energy Institute, Bioenergy Master Plan, 2010. http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications
[43] Sugar industry rule of thumb, for combustion process without pre-drying of biomass (Hawaiian Commercial and Sugar, http://www.hcsugar.com/energy_and_the_environment.shtml).
[44] EPA Facility Level Information on Greenhouse Gases Tool, http://ghgdata.epa.gov/ghgp/main.do
[45] Hawaii State Energy Office. Hawaii Renewable Energy Projects Directory. https://energy.ehawaii.gov/epd/public/energy-projects-list.html
[46] With CO2 from power plant. General Atomics, DARPA-funded Kauai algae facility, Congressional Briefings, Washington, D.C. (March 2012).
[47] Source: Monthly Energy Trend, READ, DBEDT: The Potential for biofuels production in Hawaii, DBEDT.
[48] Source: Monthly Energy Trend, READ, DBEDT: The Potential for biofuels production in Hawaii, DBEDT.
[49] Source: Monthly Energy Trend, READ, DBEDT: The Potential for biofuels production in Hawaii, DBEDT.
[50] Source: Monthly Energy Trend, READ, DBEDT: The Potential for biofuels production in Hawaii, DBEDT.
[51] State of Hawaii, Driving EVs Forward: A Case Study of the Market Introduction and Deployment of the EV in Hawaii, 2012. http://energy.hawaii.gov/wp-content/uploads/2011/10/ReportMauiElectricVehicleAlliance_12_20_12.pdf
[52] http://dbedt.hawaii.gov/economic/energy-trends-2/
[53] 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.
[54] 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.
[55] 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. Nissan Leaf: 24 kWh battery; 0.34 kWh per mile.
[56] Based on fuel prices, 45% highway, 55% city driving, and 12, 078 annual miles per year from Hawaii State Data Book. http://dbedt.hawaii.gov/economic/databook/
[57] The Hawaiian Gazette., October 10, 1899, Page 4, Image 4 http://chroniclingamerica.loc.gov/lccn/sn83025121/1899-10-10/ed-1/seq-4/
[58] EIA https://www.yahoo.com/autos/s/california-washington-lead-other-states-electric-car-ownership-133329346.html
[59] 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)
[60] Ranging from mid-$30,000 to $40,000.
[61] 2015 Annual RPS Reports to the Hawaii PUC. RPS Docket Number: 2007-0008: http://dms.puc.hawaii.gov/dms/
[62] PUC Docket Number 2012-0092 (Instituting a Proceeding Related to a Competitive Bidding Process for 50 MW of Dispatachable Geothermal firm Capacity Generation on the Island of Hawaii).
[63] PUC Docket Number 2016-0027 (Petition for Declaratory Order and Complaint).
[64] Hawaii Office of Environmental Quality Control, EA and EIS Library.
[65] PUC Docket Number 2014-0183 (Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawaii Electric Light Company, Inc., and Maui Electric Company, Limited).
[66] http://www.higp.hawaii.edu/hggrc/
[67] http://www.higp.hawaii.edu/hggrc/projects/hi-play-fairway/
[68] GeothermEx, 2005; Assessment of Energy Reserves and Costs of Geothermal Resources in Hawaii.

[69] Levelized Cost of Energy Calculator and Transparent Cost Database, 46 values, last accessed Sept. 26, 2014. Minimum: $0.04; Maximum: $0.10; Median $0.06. http://en.openei.org/apps/TCDB/

[70] Myatt, Carl; Hawaii, The Electric Century; 1991

[71] Hawaii Renewable Energy Projects Directory: https://energy.ehawaii.gov/epd/public/energy-projects-map.html

[72] 2015 Annual RPS Reports to the Hawaii PUC. RPS Docket Number: 2007-0008: http://dms.puc.hawaii.gov/dms/

[73] 2015 Annual RPS Reports to the Hawaii PUC. RPS Docket Number: 2007-0008: http://dms.puc.hawaii.gov/dms/

[74] Kauai Island Utility Cooperative 2015 RPS Report. RPS Docket Number: 2007-0008: http://dms.puc.hawaii.gov/dms/.

[75] http://nhaap.ornl.gov/nsd/region20

[76] http://nhaap.ornl.gov/nsd/

[77] http://energy.hawaii.gov/wp-content/uploads/2011/10/HydroelectricPowerAssess.pdf

[78] Kauai Island Utility Cooperative 2013 RPS Report, RPS Docket Number: 2007-0008: http://dms.puc.hawaii.gov/dms/.

[79] Hawaii State Energy Office data.

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

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

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

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

[84] Hawaiian Electric Company. Docket No. 2014-0183, Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawaii Electric Light Company Inc., and Maui Electric Company, Limited. April 1, 2016.

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

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

[87] http://azurawave.com/projects/hawaii/

[88] http://www.pacom.mil/DesktopModules/ArticleCS/Print.aspx?PortalId=55&ModuleId=11503&Article=714141

[89] OpenEI Transparent Cost Database, last accessed Sept. 24, 2014, http://en.openei.org/apps/TCDB/. Based on Intergovernmental Panel on Climate Change (IPCC) Annex 3.

[90] Data from HINMREC. http://hinmrec.hnei.hawaii.edu/wp-content/uploads/2009/12/Wave-Resource-Report-October-11-2010.pdf.

[91] NELHA website, http://nelha.org/about/facilities.html

[92] Data from Ocean Power Technologies, Inc.

[93] NELHA website, http://nelha.hawaii.gov/wp-content/uploads/2013/05/PIP-Aug-2013.pdf.

[94] SmartGrid.gov: http://www.smartgrid.gov/the_smart_grid

[95] Recovery Act- Smart Grid Investment Grants: http://energy.gov/oe/technology-development/smart-grid/recovery-act-smart-grid-investment-grant

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

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

[98] Sum of stated investment in "Existing Smart Grid Projects in Hawaii"

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

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

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

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

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

[104] U.S. Department of Energy. Project Profile: Hawaiian Electric Company (SHINES). http://www.energy.gov/eere/sunshot/project-profile-hawaiian-electric-company-shines

[105] Hawaiian Electric Companies. Docket No. 2016-0087, Approval for Smart Grid Foundation Project. March 31, 2016.

[106] Hawaiian Electric Company, Net Energy Metering. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/net-energy-metering

[107] Hawaiian Electric Company, Customer Grid Supply and Self Supply Programs. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/customer-grid-supply-and-self-supply-programs

[108] Hawaii Electric Companies. Docket No. 2014-0192. Weekly interconnection queue report. April 5, 2016.

[109] Hawaii State Energy Office, Hawaii Renewable Energy Projects Directory. https://energy.ehawaii.gov/epd/public/energy-projects-list.html

[110] Source: 2007-2015 Annual RPS Reports to the Hawaii PUC. http://dms.puc.hawaii.gov/dms/. RPS Docket Number: 2007-0008.

[111] On April 28, 2014, the Hawaii Public Utilities Commission issued a series of decisions and orders calling for the HECO Companies to provide power supply and distribution resource plans, including resolution of PV interconnection delays. In particular, see decisions, orders, and participant responses in PUC Docket No. 2011-0206 (the "RSWG Docket"); Docket No. 2014-0192 ("the DER docket") and Docket No. 2014-0130 ("Rule 14H Docket"). http://dms.puc.hawaii.gov/dms/index.jsp.

[112] Source: 2007 -2015 Annual RPS Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/.

[113] Gideon Weissman, Rob Sargent, "Lighting the Way: The Top Stat es that Helped Drive America's Solar Energy Boom in 2014", Frontier Group, Environment America Research and Policy Center, September 2015, page 14.

[114] Module output ranges from about 11 to 19 watts per square foot. Sanchez, Justine; "PV Module Selection." In Home Power issue #163, October/November 2014.

[115] Based on latest PPA approved projects; reference Docket Numbers 2014-0356, 2014-0357, 2014-0359, 2014-0354.

[116] Represents median national price. "Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013;" Galen Barbose, Samantha Weaver, and Naim Darghouth; Lawrence Berkeley National Laboratory; September 2014.

[117] Represents median national price. Ibid.

[118] DBEDT, March 2014.

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

[120] Environment America, Shining Cities 2016: How Smart Local Policies Are Expanding Solar in America.

[121] 2015 Annual RPS Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/

[122] Wind capacity factors was computed by accessing EIA 860 and EIA 923 for the denominator and numerator, respectively.

[123] PUC Docket Number 2014-0183 (Instituting a Proceeding to Review the Power Supply Improvement Plans for Hawaiian Electric Company, Inc., Hawaii Electric Light Company, Inc., and Maui Electric Company, Limited).

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

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

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

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

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

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

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

[131] Draft Environmental Impact Statement for Na Pau Makani Wind Farm Project (April 2015).

[132] Project capacities are obtained from various utility filings, plans, and resources. (i.e., 2014 Annual RPS Reports to the Hawaii PUC, http://puc.hawaii.gov/reports/energy-reports/)

[133] US Department of Energy program estimate, Transparent Cost Database, 110 values, last accessed March 24, 2015. Minimum: $0.04; Median $0.07; Maximum $0.11. http://en.openei.org/apps/TCDB/

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

[135] http://www.boem.gov/State-Activities-Hawaii/

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

[137] NASEO Best Practices Review: Streamlined Renewable Energy Permitting Initiatives (Nov. 2013). http://www.naseo.org/data/sites/1/documents/publications/NASEO-Best-Practices-Review--Streamlined-RE-Permitting-Initiatives.pdf

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

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