



## **Hawaii Energy Facts & Figures November 2013**

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State of Hawaii Department of Business, Economic Development and Tourism

Hawaii State Energy Office · [energy.hawaii.gov](http://energy.hawaii.gov)

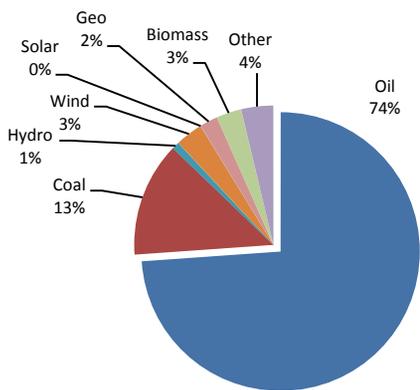
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# Hawaii Energy Overview

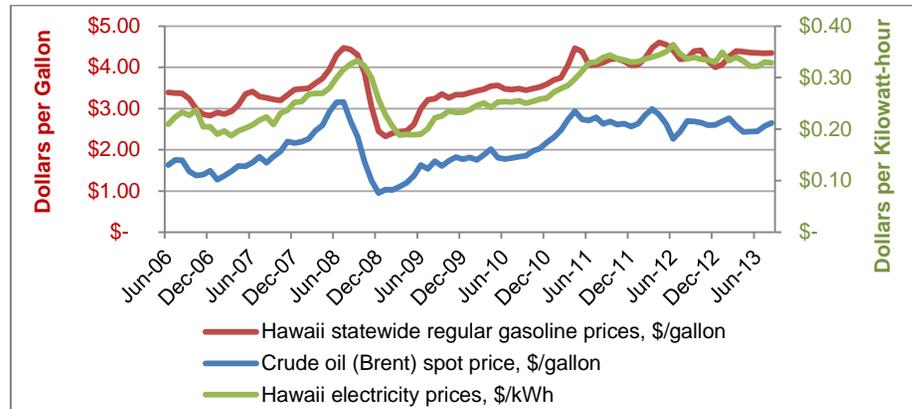
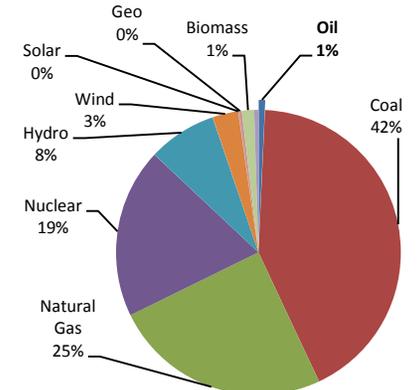
Hawaii is the only state that depends so heavily on petroleum for its energy needs. Whereas less than 1% of electricity in the nation is generated using oil, Hawaii relies on oil for 74% of its electricity generation.<sup>1</sup>

In Hawaii, both electricity and gasoline prices follow the price of petroleum. The graph below shows the prices of Brent crude oil, gasoline, and electricity.<sup>5</sup>

**Hawaii**  
Electricity Production by Source, 2011

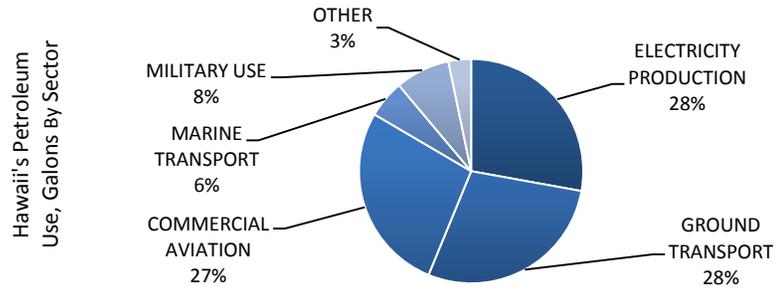
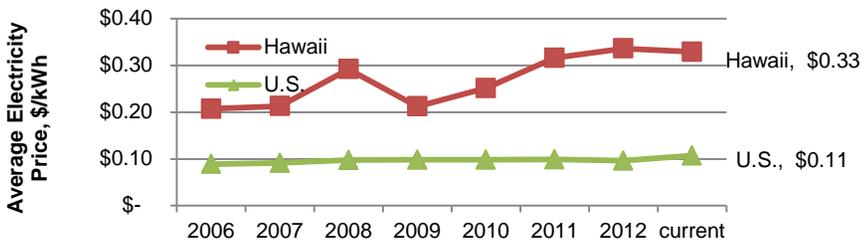


**U.S.**  
Electricity Production by Source, 2011



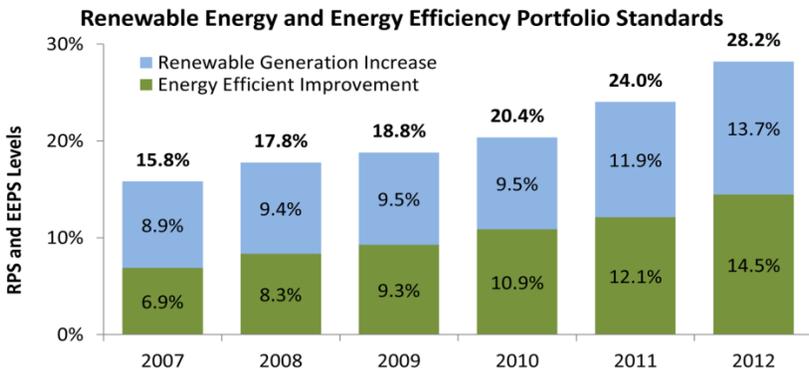
Hawaii's electricity prices are three times higher than the U.S. average.<sup>2 3</sup>

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



Although Hawaii's electricity production and costs are still heavily reliant on oil, energy efficiency and renewable energy have been increasing<sup>4</sup> in all counties.

Total petroleum use (million barrels per year) <sup>7</sup>	<b>44</b>	Hawaii's rank among 50 states for energy prices <sup>8</sup>	<b>1</b>
Total petroleum use (million gallons per year) <sup>9</sup>	<b>1850</b>	Fuel for electricity production (million gallons per year, approximate) <sup>10</sup>	<b>500</b>
Statewide % of electricity from oil (2011)	<b>74%</b>	Fuel for ground transportation (million gallons per year, approximate) <sup>11</sup>	<b>500</b>
Statewide % of electricity from coal (2011)	<b>13%</b>	Fuel for air transportation (i.e. jet fuel) (million gallons per year, approximate) <sup>12</sup>	<b>500</b>



# Electric Utilities

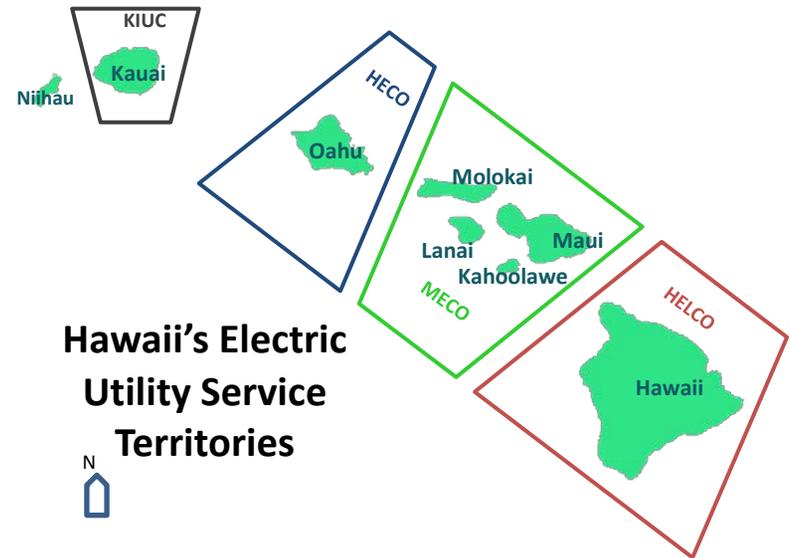
Each of Hawaii's six main islands has its own electrical grid, not connected to any other island. Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric (MECO) and Hawaii Electric Light Company (HELCO), serve about 95% of the State's population. The island of Kauai is served by Kauai Island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

2012	HECO	MECO			HELCO	HECO Companies Total	KIUC	STATE TOTAL
	Oahu	Maui	Lanai	Molokai	Hawaii		Kauai	
Annual Energy Use (GWh)	6,976	1,090	25	30	1,085	9,206	433	9,639
Firm capacity (MW)	1,783	262	10	12	292	2,359	125	2,484
Intermittent capacity (MW)	218	100	1	0	67	387	15	402
System Peak (MW)	1141	199	4	5	189	Not applicable	65	Not applicable <sup>13</sup>
Residential Customers	264,200	54,500	1,400	2,600	68,700	387,400	28,200	415,600
Commercial Customers	33,100	9,000	200	500	12,400	55,200	4,700	59,900
% of kWh used by Residential	25%	35%	29%	37%	38%	28%	36%	28%
% of kWh used by Commercial	75%	65%	71%	63%	62%	72%	64%	72%

## COMPETITIVE BIDDING

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

- 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. In July 2013, the PUC opened a new docket to examine whether the cable may be in the public interest.
- HECO: Hawaiian Electric is reviewing proposals received in March, 2013, for renewable energy projects eligible for possible waivers from the PUC's Competitive Bidding Framework. Proposed projects were required to be larger than 5 MW, on Oahu, with leveled energy cost below 17 cents/kilowatt-hour without the use of Hawaii State tax incentives.<sup>16</sup>
- HELCO: An RFP for up to 50 MW of geothermal capacity, for use on Hawaii Island, was released on 2-28-2013; 6 proposals were received and are under consideration. Generation is desired on-line 2018 to 2023, or earlier.



## CONVERTING MW OF CAPACITY INTO MWh OF ELECTRICITY PRODUCTION

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

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

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

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

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

# Electric Utilities: Customers & Rates

Residential electricity use, rates, and average bills are shown below for 2011 and 2012. In general, rates went up, but electricity use declined, so bills were basically stable.<sup>18</sup>

Residential Electricity Use, Rates, and Average Bill, 2011							
	Oahu	Hawaii	Kauai	Maui	Molokai	Lanai	State
Average use (kWh/month)	611	523	473	615	374	438	586
Average cost per kWh	\$ 0.32	\$ 0.42	\$ 0.43	\$ 0.36	\$ 0.43	\$ 0.44	\$ 0.35
Average monthly bill	\$ 196	\$ 219	\$ 206	\$ 220	\$ 161	\$ 193	\$ 203
Residential Electricity Use, Rates, and Average Bill, 2012							
	Oahu	Hawaii	Kauai	Maui	Molokai	Lanai	State
Average use (kWh/month)	561	498	465	578	348	425	545
Average cost per kWh	\$ 0.35	\$ 0.42	\$ 0.45	\$ 0.39	\$ 0.46	\$ 0.47	\$ 0.37
Average monthly bill	\$ 197	\$ 211	\$ 210	\$ 224	\$ 161	\$ 198	\$ 204

## FEED - IN TARIFF (FIT)

Renewable electricity suppliers with generators smaller than 5 MW may be eligible to participate in the HECO Companies' Feed in Tariff,<sup>19</sup> supplying as-available power to the utility at constant, contracted rates over 20 years. The FIT queue, managed by the Accion Group, currently lists 136 active (62 MW) and 62 reserve (35 MW) projects.<sup>20</sup>

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*	20 kW	26.9*	20 kW	16.1	20 kW	21.3	20 kW
		27.4**		33.1**					
2	Oahu	18.9*	500 kW	25.4*	500 kW	13.8	100 kW	18.9	100 kW
		23.8**		27.5**					
	Maui & Hawaii	18.9*	250 kW	25.4*	500 kW				
		23.8**		27.5**					
Lanai & Molokai	18.9*	100 kW	25.4*	100 kW					
	23.8**		27.5**						
3	Oahu	19.7*	5 MW	31.5*	5 MW	12.0	5 MW	--	--
		23.6**		33.5**					
	Maui & Hawaii	19.7*	2.72 MW	31.5*	2.72 MW				
		23.6**		33.5**					

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

The PUC is re-examining the FIT program, which is oversubscribed. HECO and the Independent Observer submitted a joint plan for administering the FIT queues in September 2013.

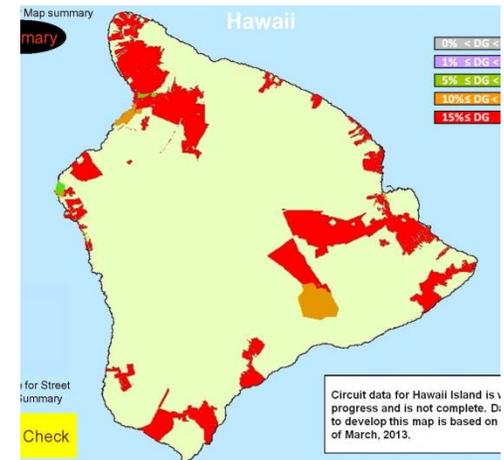
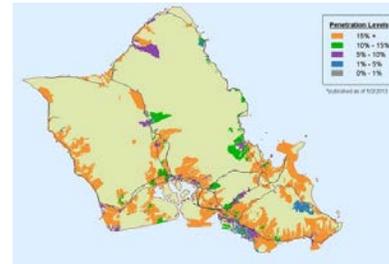
Rates may be modified by the PUC if Federal or State tax laws change.

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

## NET ENERGY METERING<sup>21</sup>

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

- If the customer uses more electricity than is produced, the customer pays for that net amount.
- If the customer produces more electricity than used, the customer pays a minimum bill (e.g. \$17 for Oahu residential customers) or customer charge, and excess credits are carried forward to the next month, for up to 12 months.
- About 9% of Hawaii's residential electric utility customers had NEM agreements as of September 2013.<sup>22</sup>
- As of June 2013, there were over 33,000 NEM systems, with a total capacity exceeding 250 MW, installed statewide.
- HECO Companies: The maximum individual system capacity is 100 kW.<sup>23</sup> According to new utility policy issued on 9/6/13, no interconnection studies will be needed for PV systems up to 100 kW capacity if the circuit is below 100% of daytime minimal load (DML). Equipment upgrades may still be required on circuits above 75% DML.<sup>24</sup> On-line maps show circuit penetration levels.<sup>25</sup>
- KIUC: The aggregate system limit (1% of KIUC's peak demand) was reached in 2008. New interconnections use Schedule Q<sup>26</sup> (100 kW or less) and "NEM Pilot"<sup>27</sup> (200 kW or less; 20¢/kWh for excess).



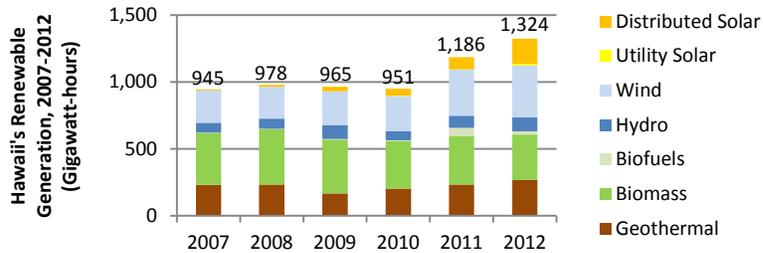
Sample Locational Value Maps for HECO, HELCO, and MECO Service Territories

# Renewable Energy

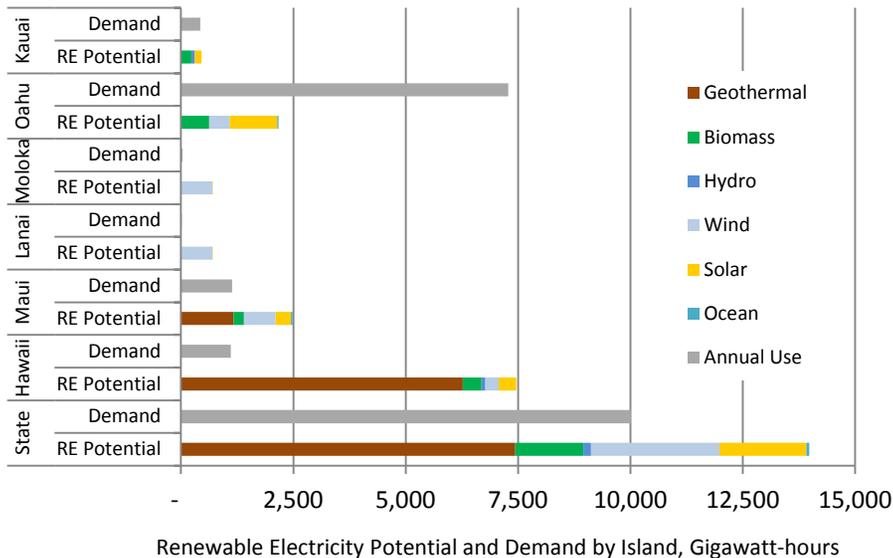
“Renewable Energy”<sup>28</sup> is energy from:

- 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 2012, 13.7% of Hawaii’s electricity was generated from renewable sources. Renewable electricity production is primarily from bioenergy, wind, and geothermal, with solar increasing rapidly.<sup>29</sup>



Renewable resource potential, statewide, is greater than current electricity demand.<sup>30</sup>



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

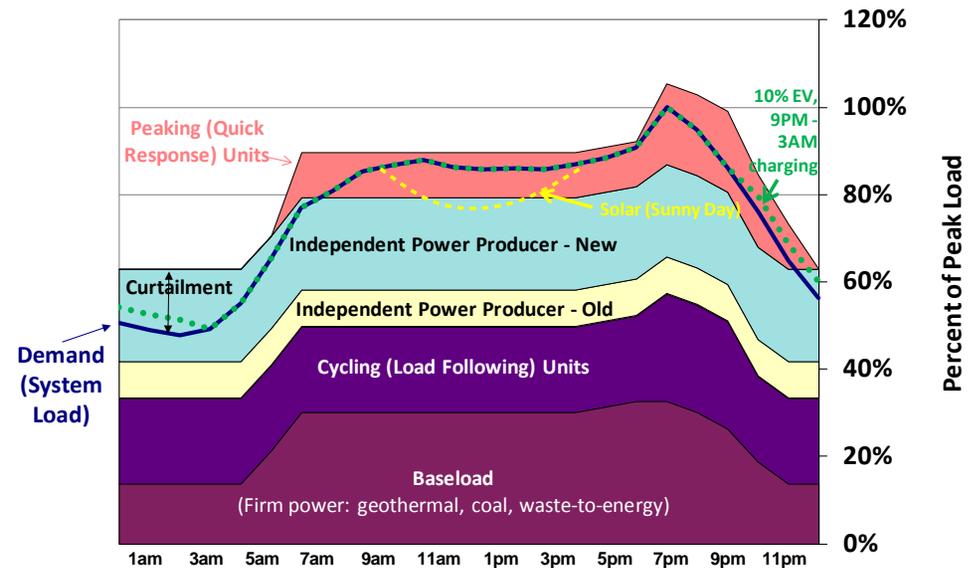
Baseload generation facilities produce energy at a constant rate. They generally do not react (ramp up or ramp down) quickly.

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

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

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

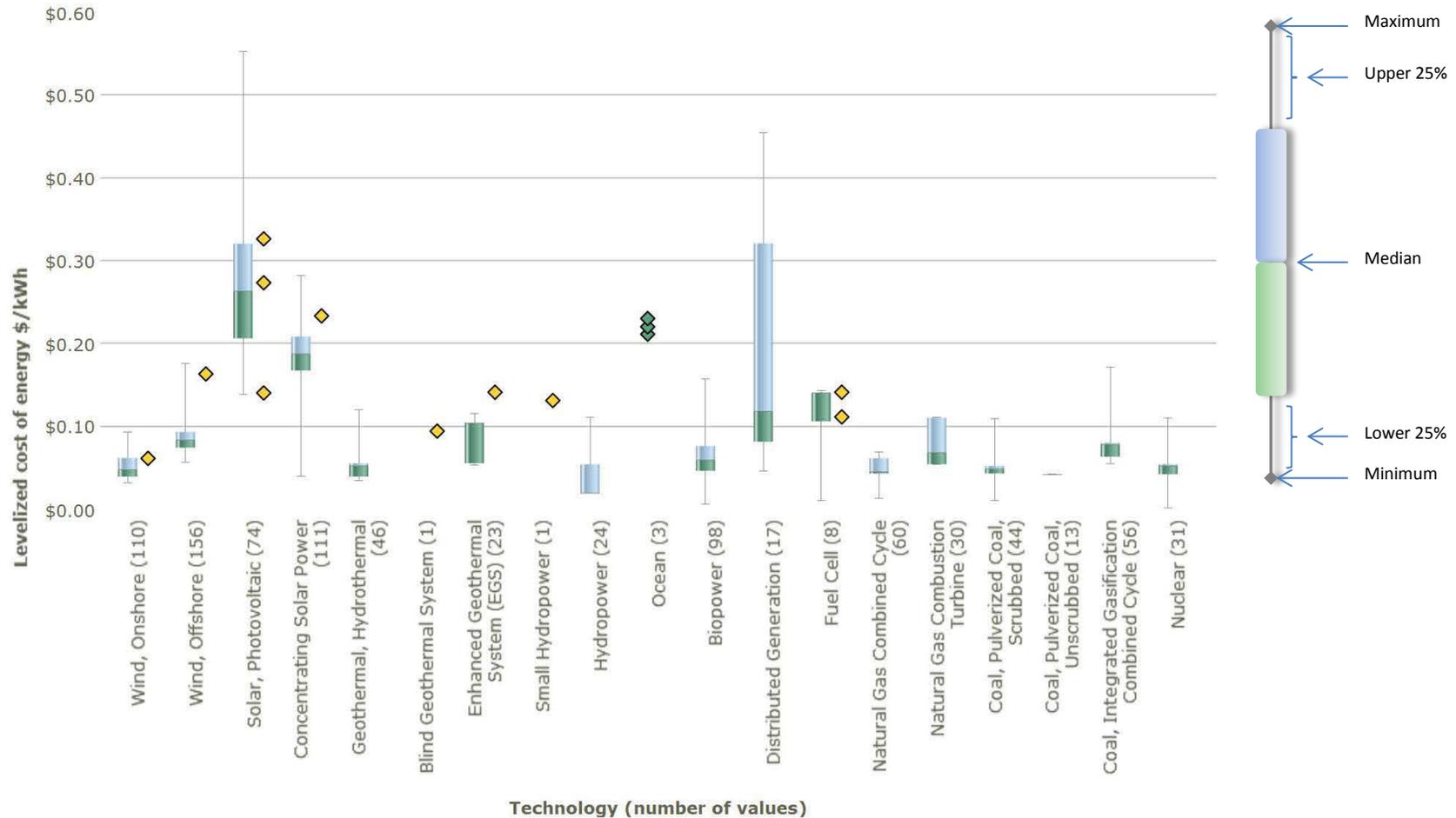
Electric vehicle charging, if managed so that it occurs at times of low load, can use energy that otherwise may have been curtailed.



Percent of Hawaii’s electricity from renewable sources (2012)	<b>13.7%</b>	Renewable generation required (i.e. Renewable Portfolio Standard, “RPS”) by 12/31/2015 <sup>31</sup>	<b>15%</b>
Renewable generation required (RPS) by 12/31/2020	<b>25%</b>	Renewable generation required (RPS) by 12/31/2030	<b>40%</b>

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

The Transparent Cost Database<sup>32</sup> compiles cost information from studies and projects across the United States. The box & whisker chart below shows the data distribution using five numbers: The minimum (bottom of the whisker), lowest 25% (below green box), median, highest 25% (above blue box), and maximum point (top of the whisker). Where fewer than three data points are available, the individual data points (green diamonds) are shown. Yellow diamonds are US Department of Energy estimates.



# Bioenergy

“Bioenergy” includes both electricity generation and fuel production from biomass.

Biomass is plant and animal matter, including energy crops, wood, grasses, algae, vegetable oils, and agricultural and municipal wastes. Bioenergy production potential in Hawaii depends on the availability of land and feedstock; CO<sub>2</sub> sources (for algae); markets and values for primary products (electricity, fuels) and by-products (animal feed); and overall revenues compared to costs.



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

**Hawaii’s Liquid Fuel Demand (approximate)**

Use	Fuel	Petroleum-based fuels (million gallons per year) <sup>33</sup>	Biofuel (mgy)	Goal
ELECTRICITY PRODUCTION	Fuel Oil	390		
	Diesel	90	4	
	Naphtha	30		
GROUND TRANSPORTATION	Gasoline	400	40	
	Diesel	50	1	
COMMERCIAL AVIATION	Jet Fuel	450		
MARINE TRANSPORTATION	Bunker Fuel	70		
	Diesel	130		
MILITARY USE	JP8 Jet	80		25% (32 mgy) renewable by 2018
	JP5 Jet	10		
	Diesel	40		
OTHER USES	Methane, Propane	60		
<b>TOTAL (Rounded)</b>		<b>1800 mgy (1.8 billion gallons/yr)</b>		

Bioenergy facilities:

- Kauai: Green Energy is building a 6.7 megawatt biomass-fired generator that will produce 11% of Kauai’s electricity once completed.
- Oahu: H-POWER<sup>34</sup> produces 7-10% of Oahu’s electricity from trash.
- Maui:
  - Hawaiian Commercial and Sugar (HC&S) generates 10% of Maui’s electricity from the fiber (bagasse) by-product of sugar production.
  - Maui County is planning a 15 MW waste to energy and a 1 MW landfill gas facility.
- Hawaii Island: Hu Honua is developing a 21.5 MW facility that will produce 10% of the Big Island’s electricity when completed.

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

Since biodiesel fuel imports for electricity production began in 2010, the relative cost per gallon of the imported biodiesel fuel has been significantly higher than for the fossil-based fuels used for electricity generation in Hawaii<sup>35</sup> (2011 average per gallon: fuel oil, \$2.81; diesel, \$3.07; biodiesel, \$5.22).

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

Studies indicate that 136,000 suitable acres could be available without displacing current farming in Hawaii; with biomass production of 10 - 20 tons of fiber per acre per year, potential would be about 1.4 - 2.7 million tons of biomass per year.<sup>36</sup> As a reference, two million tons of biomass, if burned in conventional biomass combustion processes, would generate energy equivalent<sup>37</sup> to two million barrels (84 million gallons) of oil. Or, two million tons could be converted (at 80 gallons per ton,<sup>38</sup> via thermochemical processes) into 160 million gallons of fuel.

Algae has also been receiving attention, due to high yields per acre and potential use of CO<sub>2</sub>. The 11 million tons of CO<sub>2</sub> produced by large energy facilities (power plants and refineries) in Hawaii could theoretically support the production of over 400 million gallons of oil per year.

**Hawaii Biofuel Projects**

Facility	Input (feedstocks)	Output (products)	Production Capacity
Aina Koa Pono	1. Remove invasive species. 2. Plant crops.	Renewable diesel, gasoline, biochar	24 million gallons per year (mgy) (planned)
Big Island Biodiesel	Used cooking oil, grease trap waste, crop oils	Biodiesel, glycerin, animal feed	5.5 mgy (built)
Cellana	Algae	Algae oil, animal feed	1.26 mgy (planned)
Hawaii BioEnergy, LLC Renewable Fuels Project	Eucalyptus, energy grasses, other	Renewable fuel oil, jet fuel, gasoline; feeds, fertilizers, electricity possible	Fuel oil replacement: 10 mgy; others: confidential (planned)
HawaiiGas Renewable Natural Gas (RNG) Plant	Animal and plant fats and oils	Renewable methane, hydrogen, propane	1 mgy (built)
Phycal	Algae	Fuel oil; renewable jet fuel; renewable diesel	100,000+ gallons per year pilot, followed by 3 mgy demonstration (planned)
UOP Honeywell Integrated Biorefinery	Woody materials, agricultural residues, algae	Renewable gasoline; diesel; jet fuel	62,000 gal/y, pilot (under construction); 50 mgy facility (potential)

Biofuel, a renewable energy source that can be stored and transported in a manner similar to fossil fuels, can often be used in existing equipment and be blended with petroleum fuels.

Hawaii’s current use of petroleum-based fuels (million gallons/yr)	<b>1,800</b>	Hawaii’s biofuel production potential (million gallons/year)	<b>100-300</b>
Potential land available (1000+ acres per parcel, previously farmed, not displacing current farming)	<b>136,000</b> acres	Algae oil yields demonstrated on Kauai <sup>39</sup>	<b>2000</b> gal/acre
Tons of biomass per acre per year <sup>40</sup>	<b>10 - 20</b>	Tons CO <sub>2</sub> from energy facilities <sup>41</sup>	<b>10</b> million
Biomass potential from 136,000 acres (million tons/year)	<b>1.4 – 2.7</b>	Pounds of animal feed per gallon of biodiesel from crop oil	<b>25</b>
1 ton of biomass replaces	<b>1</b> bbl oil	Animal feed used in Hawaii (million pounds/year) <sup>42</sup>	<b>100-200</b>
Levelized Cost of Biomass Energy <sup>43</sup>	<b>1¢-16¢/kWh</b>	Target cost per gallon, bio-based jet fuel <sup>44</sup>	<b>\$3</b>

# Electric Vehicles

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



Based on statewide averages, the amount of fossil fuel used to power an electric vehicle in Hawaii is 31% less than the fossil fuel required to power a similar gasoline-fueled vehicle.<sup>45</sup> This is expected to get even better as renewable energy increases in Hawaii.

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

## Registered Electric Vehicles (EVs) and Publically Available Charging Stations in Hawaii, September 2013

County	Electric Vehicles	Level 2 <sup>46</sup> Charging Stations	Ports <sup>47</sup>	Level 3 <sup>48</sup> Charging Stations
Oahu	1427	221	246	4
Maui	291	32	39	1
Hawaii	95	29	46	0
Kauai	56	32	37	1
<b>State of Hawaii</b>	<b>1869</b>	<b>314</b>	<b>368</b>	<b>6</b>

- Public charging, including fast charging, is needed as a convenience for EV drivers and to reduce range anxiety.
- The cost for a government or commercial property owner to install a Level 2 charging station is typically approximately \$6,000-\$8,000 per station.<sup>49</sup>

EVs have a greater initial purchase price<sup>50</sup> than comparable gasoline-fueled vehicles. Most experts, including Hawaii's auto dealers, believe that widespread acceptance of EVs will grow as a full battery charge provides greater driving range and the cost of EVs more closely matches the cost of conventional internal combustion engine (ICE) vehicles.

## Hawaii EV Dealers by County

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

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

## Fuel Cost Comparison

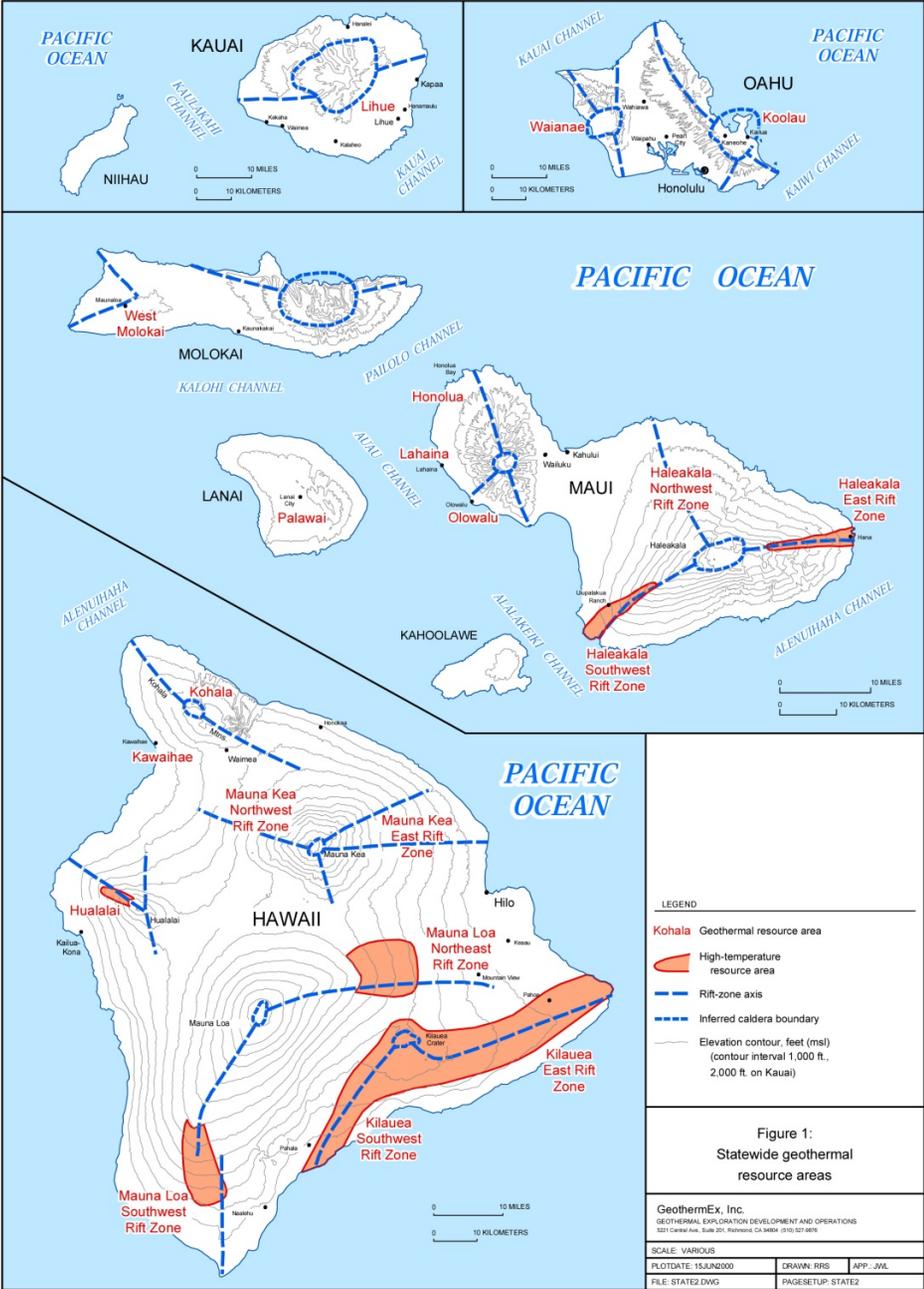
Vehicle	2012 Nissan Versa	2012 Honda Civic	2012 Nissan Leaf <sup>51</sup>
Fuel Type	Gasoline	Gasoline	Electricity
Miles Per Gallon (mpg)	27mpg Combined	32mpg Combined	99 Combined mpge
Fuel Costs	\$ 4.10/gallon	\$ 4.10/gallon	Electricity: \$ 0.345/kWh
Fuel Cost per Mile	\$ 0.1519 / mile	\$ 0.1282 / mile	\$ 0.1173 / mile
Fuel Cost per Year <sup>52</sup>	\$ 1,370 / year	\$ 1,156 / year	\$ 1,058 / year

Hawaii's electric vehicle policies and incentives include:

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

Electric Vehicle Land Speed Record	<b>303</b> miles per hour	Electric Vehicle Distance Record on a Single Charge	<b>423</b> miles <sup>53</sup>
Average distance driven by US driver in one day (easily accomplished by current EV technology).	<b>35</b> miles per day	Best temperature range to operate lithium ion batteries (most common EV batteries today).	<b>68° - 95°</b> Fahrenheit
EPA rating for 2013 Ford Fusion Energi plug in hybrid	<b>108</b> mpg city, <b>92</b> mpg hwy	Hawaii national rank for public EV charging stations per capita.	<b>1</b>

# Geothermal



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

Hawaii’s single geothermal power plant, the Puna Geothermal Venture (PGV) facility located on the Island of Hawaii, produced 266 gigawatt-hours (GWh) in 2012<sup>54</sup>. This represents approximately 23% of the total electricity consumed on Hawaii Island as well as **20% of the renewable electricity** generated statewide. The facility, which began operating in 1993, produces both baseload and dispatchable electricity.

The Hawaii Electric Light Company (HELCO) received six responses to its Request for Proposals for an additional 50 MW of dispatchable geothermal power for the island of Hawaii. This amount of geothermal capacity could allow HELCO to retire one of its fossil fuel power plants.

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

Geothermal resources are difficult to characterize without exploration and drilling since Hawaii’s high-temperature resources are usually more than a mile beneath the surface. However, estimates from exploration efforts in the 1970s and ‘80s indicate that there may be more than 1,000 MW of geothermal reserves<sup>55</sup> (recoverable heat at drillable depths) on Maui and Hawaii islands, sufficient to provide more than 200% of the State’s Renewable Portfolio Standards goal. Reaching that level of production would require interconnection of the islands’ grids.

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

Current geothermal Production Capacity in Hawaii	<b>38</b> MW	Contracted price for first 25 MW of electricity from PGV <sup>56</sup>	<b>20.7¢</b> on peak <b>15.7¢</b> off peak per kilowatt-hour (kWh)
Estimated probable reserves, Maui & Hawaii	<b>1,000</b> MW	Contracted price for next 5 MW	<b>11.8¢ / kWh</b>
Levelized cost of geothermal energy <sup>57</sup>	<b>3¢ - 12¢</b> per kWh	Contracted price for next 8 MW	<b>9¢ / kWh</b>

# Hydropower

Hydroelectricity was the **first renewable energy technology** used to generate electricity in Hawaii; plants date back to the late 1800s. Early hydroelectric facilities were located in Honolulu and Hilo. During the sugar era, additional hydroelectric plants were installed to help power sugar operations.

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



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

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

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

As part of the Oak Ridge National Laboratory's National New Stream Development project, approximately 145 MW of undeveloped hydroelectric potential have been identified. That potential comes from 47 hydro sites identified in reconnaissance and feasibility reports. Most of the potential sites are small run-of-the-river projects.<sup>60</sup>

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

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



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

MW of hydroelectric capacity installed statewide	<b>31</b> <sup>61</sup>	Capacity of Wailuku River hydroelectric plant, the state's largest	<b>12.1</b> <sup>62</sup> MW
Year that Puueo hydro power plant, still in operation, began generating	<b>1910</b> <sup>63</sup>	Electricity generated by Wailuku Hydroelectric Plant in 2012 <sup>64</sup>	<b>26,798,694</b> kWh
Year that Hawaii's first hydro plant, on the Nuuanu Stream, began operation	<b>1888</b> <sup>65</sup>	Gigawatt-hours generated by hydro in Hawaii during 2012 <sup>66</sup>	<b>104</b>

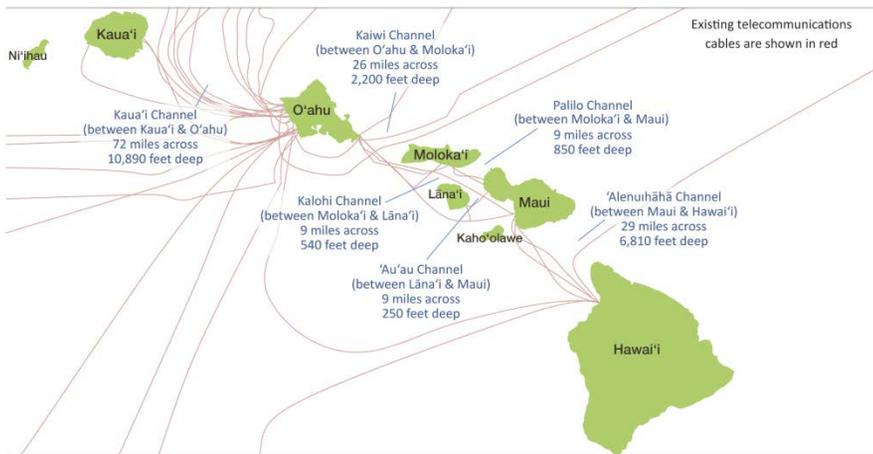
# Inter-Island Cable Grid-Tie

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

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

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

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



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



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

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

DBEDT estimates the overall savings on both islands at up to \$423 million (2020-2050) before taking into consideration the social cost of carbon. Should the social cost of carbon be taken into consideration, the net benefit would rise to \$551 million. These figures include fuel savings of approximately \$1 billion. Other significant benefits include:<sup>67</sup>

## 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 (CO2) emissions;
- Higher penetration of renewable energy generation; and
- Increased flexibility in siting new renewable generation.

## Public Policy

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

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

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

Longest undersea power cable	<b>360</b> miles	Deepest undersea power cable	<b>5,380</b> feet
Highest capacity undersea HVDC system	<b>2,000</b> MW	Estimated transmission cost per kWh at 40% capacity factor <sup>68</sup>	<b>10¢</b>
Year of installation, first HVDC undersea power cable	<b>1954</b>	Estimated installed cost of cable and converter stations	<b>\$ 800 million</b>
Expected undersea transmission cable life in years	<b>30-40</b>	Estimated oil cost savings over 30 years <sup>69</sup>	<b>\$ 7,000 million</b>
Diameter of cable bundle	<b>10</b> inches	2012 legislation: regulatory structure for inter-island power cables	<b>Act 165</b>

# Ocean

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

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

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

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

The **Hawaii National Marine Renewable Energy Center (HINMREC)** at the University of Hawaii-Manoa is one of three federally-funded centers for marine energy research and development in the nation. HINMREC is working with the Department of Defense to establish a multiple-berth wave energy test center at Kaneohe Bay, Oahu.

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

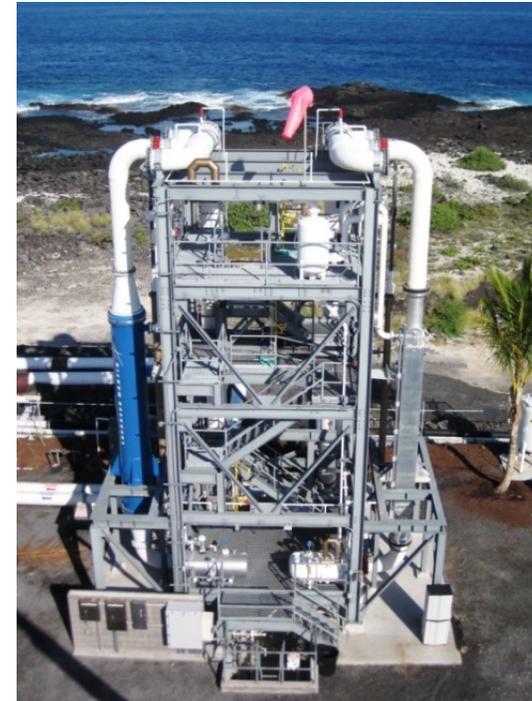


*OPT's PB40 PowerBuoy in Kaneohe Bay, Oahu*

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

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

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



*OTEC heat exchanger test facility at NELHA*

Number of berths expected at Kaneohe wave test center	<b>3</b>	Projected Levelized Cost of Electricity (LCOE) for commercial ocean energy <sup>70</sup>	<b>21¢-23¢/kWh</b>
Energy potential of trade wind waves in Hawaiian waters <sup>71</sup>	<b>15-25</b> kW/meter	Temperature of cold, deep seawater at NELHA <sup>72</sup>	<b>6°C (43°F)</b>
Number of operating hours achieved by OPT PowerBuoy PB40 at Kaneohe Bay <sup>73</sup>	<b>&gt;5,600</b> hours	Temperature range of warm surface seawater at NELHA <sup>74</sup>	<b>24° – 28.5°C</b> <b>(75° – 83°F)</b>

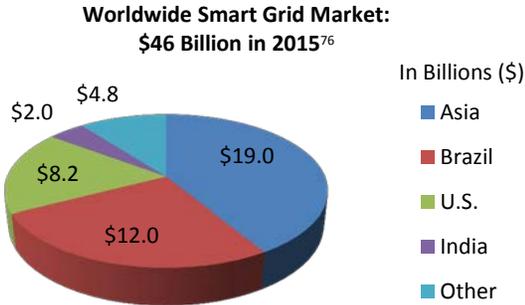
# Smart Grid

**What is Smart Grid?**<sup>75</sup>

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

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

**Smart Grid Market is Large**



\*Asia and Brazil data are for 2016

- DOE gave \$3.4 billion in grants for smart grid projects & grid upgrades in recent years.<sup>77</sup>

**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<sup>78</sup>, 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.<sup>79</sup>

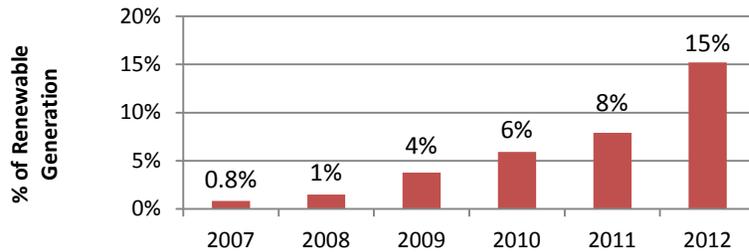
**Existing Smart Grid Projects in Hawaii**

Name	Description	Key Companies	Location
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. <sup>80</sup>	HNEI, HECO/MECO, General Electric, First Wind	Maui Meadows, Wailea
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. <sup>81</sup>	NEDO, Hitachi, Mizuho, Cyber-Defense, US DOE, NREL, HECO/MECO, HNEI, MEDB, & Maui County	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. <sup>82</sup>	KIUC, U.S. DOE	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. <sup>83</sup>	HECO, Honeywell	Oahu

# Solar

Due to Hawaii's extremely high energy prices, great solar resource, and progressive energy policies, the state has experienced unprecedented growth in solar generation. Solar energy in 2012 provided fifteen percent of Hawaii's renewable energy generation.

Solar Energy as a % of Total Renewable Generation in Hawaii<sup>84</sup>

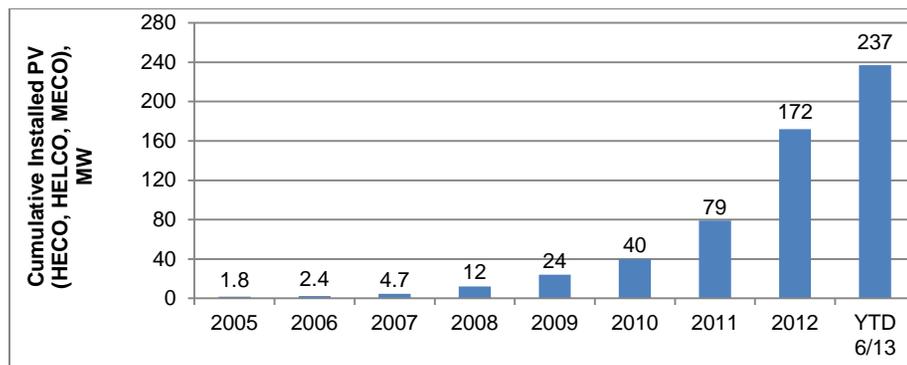


Most photovoltaic systems are net metered. Both residential and commercial entities participate in the program. There are approximately 33,000 photovoltaic systems currently installed, providing a capacity of 252 MW.

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity (MW)	% Residential	% Commercial
HECO <sup>85</sup>	23,034	97%	3%	170	65%	35%
HELCO	4,299	92%	8%	31.9	56%	44%
MECO	4,554	92%	8%	35.3	57%	43%
KIUC <sup>86</sup>	1,125	92%	8%	15	22%	78%
<b>TOTAL</b>	<b>33,012</b>	<b>95%</b>	<b>5%</b>	<b>252.2</b>	<b>57%</b>	<b>43%</b>

Photovoltaic (PV) system installations on commercial and residential properties have been increasing rapidly; capacity has approximately doubled every year since 2006. The graph below shows growth in the HECO companies' net metered capacity (KIUC reached capacity in 2010, so have other programs; see page on Electric Utilities: Customers).

Residential and Commercial Photovoltaic (PV) Capacity<sup>87</sup> by Year, Except Kauai



Progressive energy policies include:

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

Power Purchase Agreements (PPA) are contracts between independent power producers and the electric utility. Utility-scale PV systems have PPAs with utilities on several islands.<sup>88</sup>

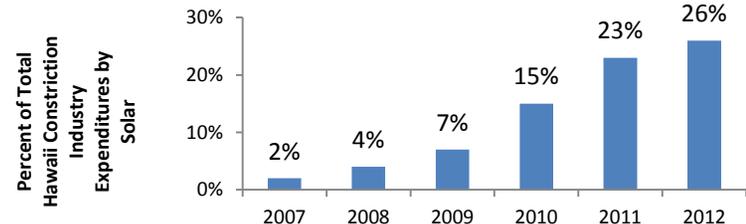
The integration of large amounts of solar generation can be challenging, due to the intermittent nature of solar as well as Hawaii's small, individual, non-interconnected island grids. Potential solutions include battery storage as well as interconnecting the island grids.

Existing Utility Scale Solar Projects

Project Name	Year Installed	Island	Developer	Capacity
La Ola Solar Farm	2006	Lanai	Castle & Cooke	1.1 MW
Kapolei Sustainable Energy Park	2011	Oahu	Forest City, Hoku	1.18 MW
Kapaa Solar Project	2011	Kauai	Kapaa Solar, KIUC	1.21 MW
Port Allen Solar Facility	2012	Kauai	A&B, McBryde, KIUC	6 MW

Rooftop distributed solar has become one of the state's leading industries, accounting for almost 26% of all construction expenditures in 2012.

Solar Industry as a Percent of Construction in Hawaii, 2007-2012<sup>89</sup>

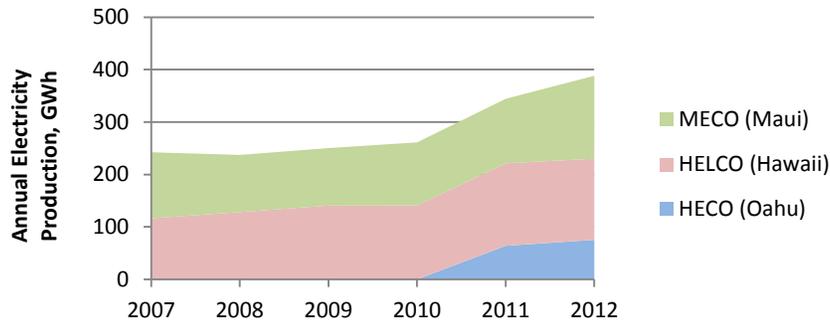


MW of PV in use in Hawaii, 2012	<b>223 MW</b>	Solar energy as a percent of renewable generation, 2012	<b>15%</b>
Percentage of electricity generated by solar, statewide <sup>90</sup>	<b>2-3%</b>	Nationwide rank of cumulative installed PV capacity per capita <sup>91</sup>	<b>3rd</b>
Average statewide solar capacity factor <sup>92</sup>	<b>19-20%</b>	Levelized cost of photovoltaics <sup>93</sup>	<b>14¢-55¢ /kWh</b>
Typical power density of PV array <sup>94</sup>	<b>10 watts per square foot</b>	Watts per PV module (i.e. "panel") <sup>95</sup>	<b>60 - 445 watts/panel</b>
Installed cost, Hawaii, residential <sup>96</sup>	<b>\$5,750 /kW</b>	Installed cost, Hawaii, commercial. <sup>97</sup>	<b>\$4,540 /kW</b>
Statewide construction expenditures attributed to solar <sup>98</sup>	<b>26%</b>	Acres per megawatt (Hawaii, utility-scale) <sup>99</sup>	<b>3.3 - 7.2 acres/MW</b>

# Wind

- Wind energy is Hawaii's second most utilized renewable energy resource, accounting for about 29% of the state's total renewable energy generation in 2012.<sup>100</sup>
- Hawaii has one of the most robust and consistent wind regimens in the world, with capacity factors exceeding those commonly found elsewhere. In 2011, the capacity factor of the Pakini Nui wind farm on the Big Island was 65%; Kaheawa I on Maui was 47%; and the Hawi wind farm on the Big Island was 45%.<sup>101</sup>
- Existing projects in Hawaii are located on the islands of Oahu, Maui, and Hawaii. Although the island of Kauai has several excellent resource areas, large populations of endangered or threatened avian species on Kauai may limit wind energy development on Kauai.

**Electricity Produced from Wind Energy in Hawaii, by Island and Service Area<sup>102</sup>**



## Challenges Facing Wind Energy Development in Hawaii

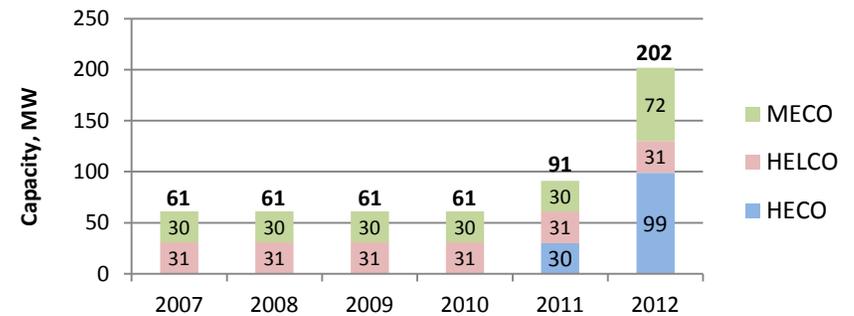
- Several excellent wind resource sites could provide over 1000 MW of wind energy, which could produce 94%<sup>103</sup> of the State's Renewable Portfolio Standards goal. Since over 70% of Hawaii's energy load is on Oahu but over 90% of the existing wind potential is on the outer islands, reaching that level of production would require interconnection of the islands' grids.
- Endangered avian and plant species can complicate the siting and development of wind projects in Hawaii's unique environments. Proactive measures, such as the development of area-wide habitat conservation plans, could be helpful for species protection as well as easier project siting in the future.

- Given the height of wind turbines and limited sites suitable for wind development in Hawaii, visual impacts may be of concern; they should be identified early and addressed carefully, working with local communities.

## Existing Utility Scale Projects

Project Name	Year Installed	Island	Developer	Capacity (MW)	Acres	Acres per MW
Hawi Renewable Development <sup>104</sup>	2006	Hawaii	Hawi Renewables	10.5	250	23.8
Kaheawa I Wind Farm <sup>105</sup>	2006	Maui	First Wind	30	200	6.7
Pakini Nui Wind Farm <sup>106</sup>	2007	Hawaii	Tawhiri Power	20.5	67	3.3
Kahuku Wind Farm <sup>107</sup>	2011	Oahu	First Wind	30	578	19.3
Kawaiiloa Wind Farm <sup>108</sup>	2012	Oahu	First Wind	69	650	9.4
Kaheawa II Wind Farm <sup>109</sup>	2012	Maui	First Wind	21	143	6.8
Auwahi Wind <sup>110</sup>	2012	Maui	Sempra Generation	21	68	3.2

**Installed Wind Energy Production Capacity by Service Area<sup>111</sup>**



Current installed wind capacity in Hawaii <sup>112</sup>	<b>202 MW</b>	Wind Resource Potential for all Hawaiian Islands <sup>113</sup>	<b>1087 MW</b>
Average land area used per MW of wind	<b>9.7 acres</b>	Total number of wind related habitat conservation plans in Hawaii <sup>114</sup>	<b>4</b>
Height of 2.3 MW wind turbine <sup>115</sup>	<b>456 ft.</b>	Levelized cost of wind energy <sup>116</sup>	<b>5¢ per kWh</b>

# Permitting

- Permitting costs in Hawaii can range from **1% to 20% of overall project construction costs.**<sup>117</sup>
- Large energy projects in Hawaii **average 15 federal, state, and county permits**, with some facilities requiring over 40 such approvals.
- It can take **1-5 years to permit** a large renewable energy project in Hawaii.
- Permitting costs are a risk** paid without assurance of project construction.

## Common permitting issues for renewable energy projects in Hawaii

- Hawaii's many protected cultural, historic, and ecologic resources
- Hawaii's many overlapping land use jurisdictions
- Renewable energy projects present new technological and permitting issues
- Time and effort spent going back and forth between applicant and permitting agency
- Public interest in renewable energy projects, use of resources and land
- Utility interconnection requirements/approvals, grid capacity issues

## Common solutions to renewable energy permitting issues in Hawaii

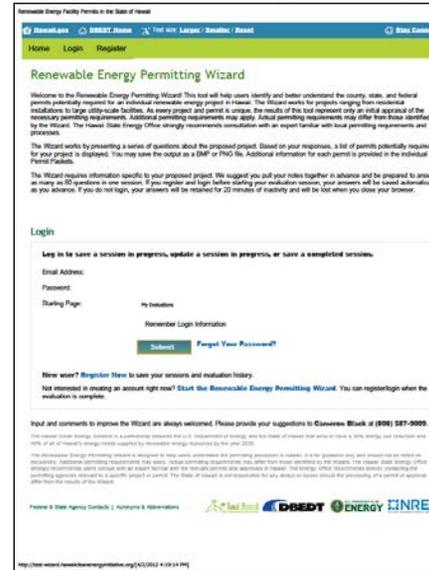
- Electronic permit processing – maximizes staff time, reduces back and forth, transparency
- Educate developers and agencies – permitting guides, websites, seminars
  - Check out the **Guide to Renewable Energy Facility Permits in the State of Hawaii** and the corresponding **Permit Packets** for information on over 160 county, state, and federal permitting processes

<http://energy.hawaii.gov/developer-investor/project-permitting-assistance-and-resources>

- Lawmaking – responsible allowances for renewables, clarity in permitting processes
- Engage public early in the project development process
- Connect developers to consultants familiar with Hawaii regulations

## Electronic tools to facilitate renewable energy permitting in Hawaii

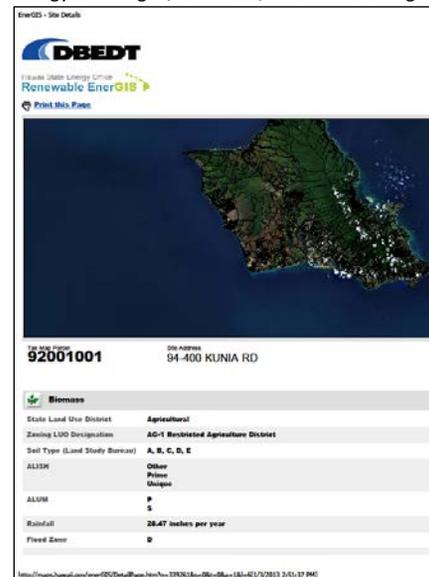
### State Energy Office Permit Wizard wizard.hawaiiicleanenergyinitiative.org



### Dept. of Health e-Permitting Portal eha.doh.doh.hawaii.gov/epermit/View/home.aspx



### DBED Renewable EnerGIS energy.hawaii.gov/resources/renewable-energis-map



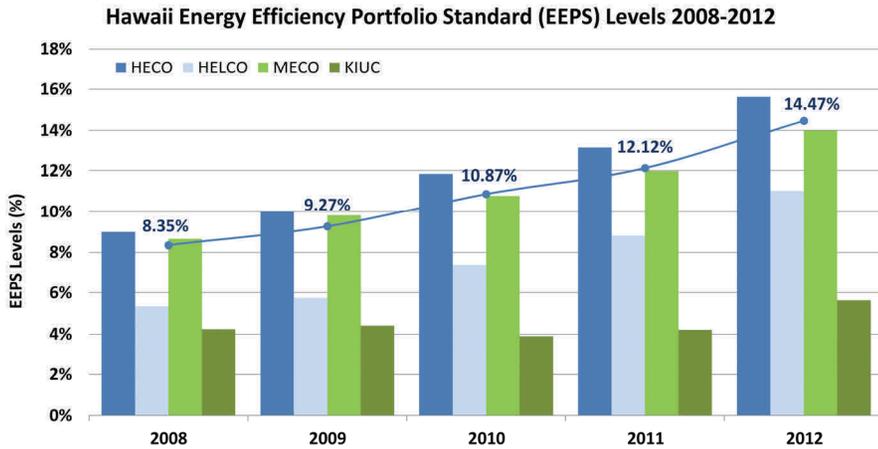
### C&H/DPP Online Building Permits dppweb.honolulu.gov/dppweb



# Energy Efficiency

## Energy Efficiency Portfolio Standards (EEPS)

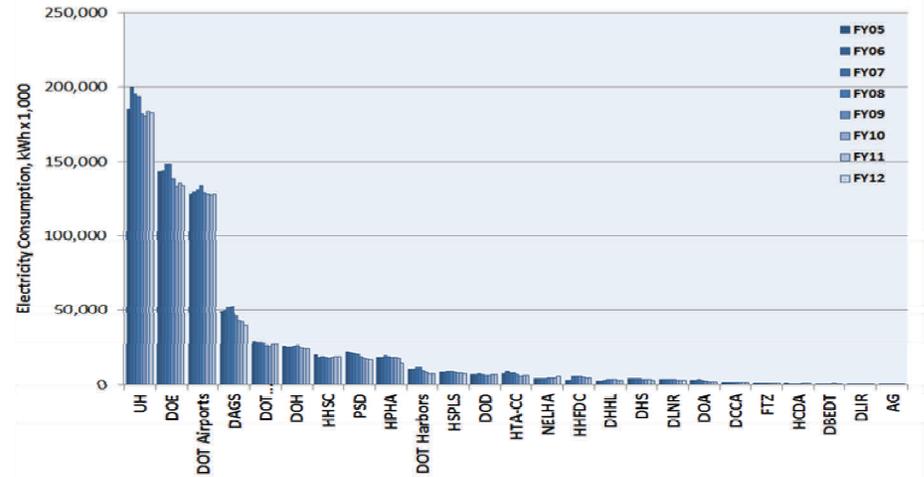
This graph shows Hawaii Energy Efficiency Portfolio Standard (EEPS) levels from 2008-2012. The EEPS requires that by 2030 annual energy savings amount to 30% of annual electricity sales statewide. In 2008 the statewide EEPS level was 8.35%. By 2012 the EEPS level rose to 14.47%. A major contributor to EEPS is Hawaii Energy (HE), a ratepayer-funded program administered by the Hawaii Public Utilities Commission and serving all islands except Kauai. HE proposed funding for FY13 is nearly \$35 million. For FY12, HE estimated budget was just over \$32 million with \$25.7 million spent. Of expended funds, \$17.1 million went directly to commercial and residential customers who invested \$81.7million of their own money to save 159.2 GWh and a total bill cost savings of \$51.7 million – or a lifetime savings of 1,339 GWh/\$407.6M. Kauai Island Utility Cooperative also offers efficiency programs for its customers.



Source: Renewable Portfolio Standards Status Reports, 2008-2012 (Hawaii Public Utilities Commission)

## Lead By Example

During FY12 state agencies' energy consumption decreased by 1.2% from FY11 levels, but the state paid 19.4% more than FY11. When comparing FY12 figures against the 2005 baseline year, energy consumption dropped 5.7%, but due to the increasing cost for electricity, costs rose 93.8%. Consumption (kWh) by agency by year is shown in the chart below.



## Green Buildings

**State Office Tower Certified Prestigious LEED Gold**  
First large office building, public or private, in the state to be certified Gold under LEED for Existing Buildings: Operations & Maintenance.



Leadership in Energy and Environmental Design (LEED) for Existing Buildings: Operations and Maintenance

### Green Building Strategies

#### Water Efficiency

Water reduction: 39%  
All fixtures low-flow and low-flush

#### Energy and Atmosphere

ENERGY STAR Rating: 96 (i.e., top 4% in energy efficiency among similar buildings nationally)  
Improved indoor air quality

#### Materials and Resources

Waste diversion rate: 58%

#### Indoor Environmental Quality

50% of all cleaning products are green cleaning products

## GreenSun Hawaii



GreenSun Hawaii is a public-private partnership with the ability to leverage \$3.75 million in federal funds into \$75 million in energy efficiency and renewable energy equipment loans statewide. Impacts include:

- GreenSun Hawaii currently covers low-interest loans amounting to over \$2 million.
- The estimated energy savings for these installations is 11.1 million kWh of electricity over the life of the installations which will save participants' in excess of \$4.4 million over the life of the installations.
- Annual CO2 reduction of 837,000 lbs. (16.7 million lbs. over the life of the installations)
- Energy savings over the life of the equipment is equivalent to powering 1,507 households.

## State and County Performance Contracting

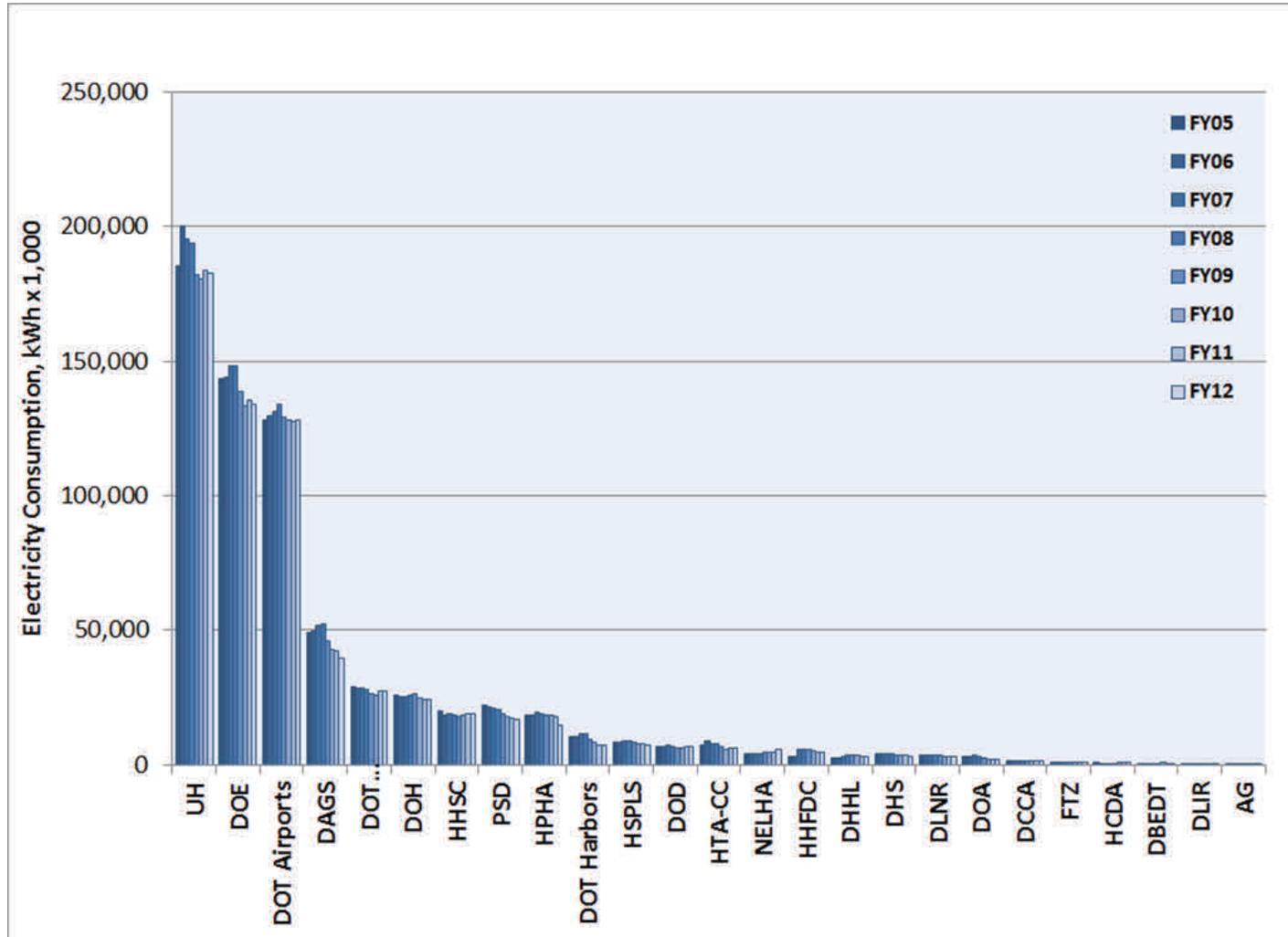
Energy savings for these projects over 20 years (1.1 billion kWh) is equivalent to powering an estimated 171,623 households for one year.

Agency	Facilities	Investment Value (2011\$)	Average Annual Savings	Savings Over 20 Years
UH-Hilo	NA	\$11.3M	\$770,644	\$15.4M
HHSC	5 hospitals	\$32.6M	\$2.3M	\$45.1M
Judiciary	5 courthouses	\$2.1M	\$423,684	\$8.5M
City and County of Honolulu	4 buildings	\$16.6M	\$1.1M	\$21.9M
County of Hawaii	28 buildings	\$2.9M	\$343,489	\$6.9M
County of Kauai	34 buildings	\$904,102	\$53,782	\$1.1M
DAGS Phase I	10 Downtown Buildings	\$34.5M	\$3M	\$60M
UHCC	4 Oahu campuses, Kauai CC	\$32.8M	\$4.5M	\$90M
Public Safety	Halawa high security and med security, OCC, 1 jail	\$25.5M	\$2.3M	\$46M
DAGS Phase II	33 buildings	\$22.5M	\$1.5M	\$30M
City and County of Honolulu	Kailua Wastewater Treatment Plant	\$12M	\$772,000	\$15.4M
<b>Total</b>		<b>\$193.7M</b>	<b>\$15M</b>	<b>\$341.3M</b>

# State of Hawaii Agencies Lead By Example

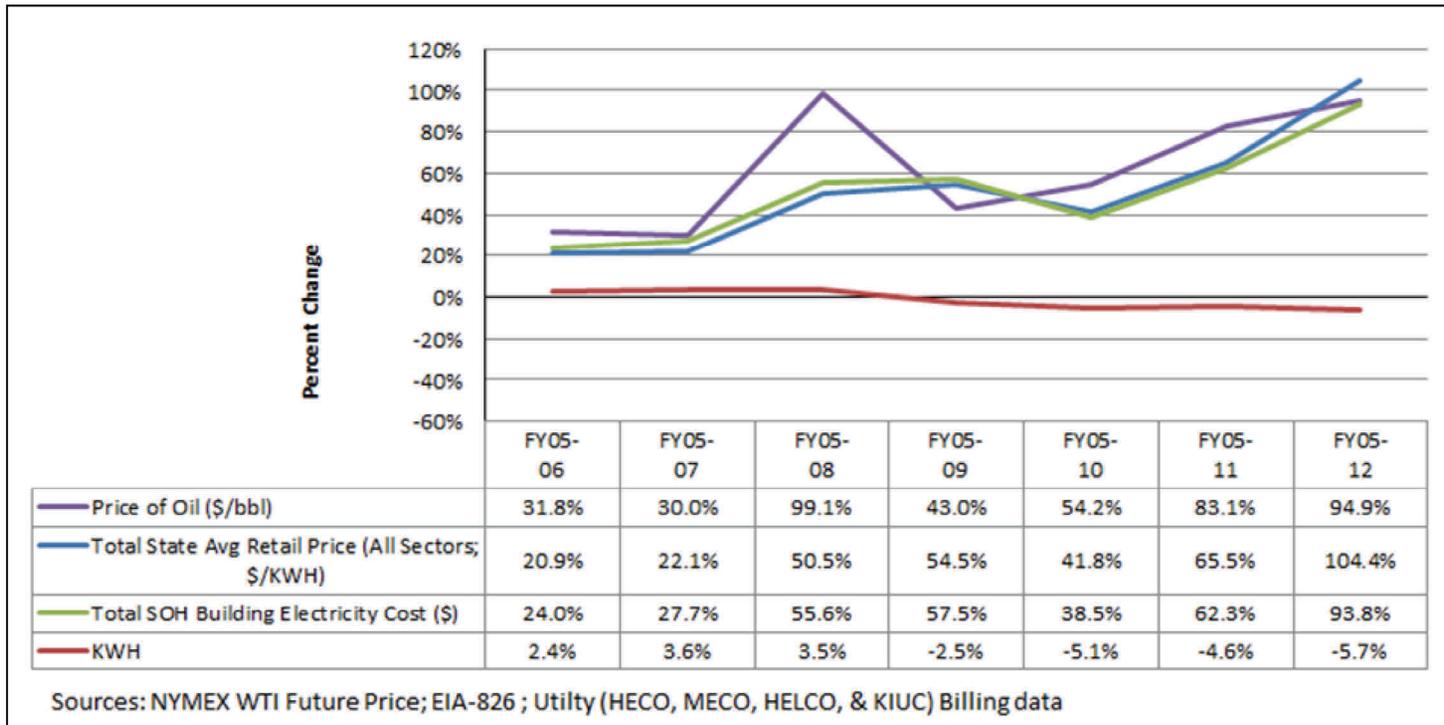
## Overview

During FY12 state agencies' energy consumption decreased by 1.2% from FY11 levels, but the state paid 19.4% more than FY11. When comparing FY12 figures against the 2005 baseline year, energy consumption dropped 5.7%, but due to the increasing cost for electricity, costs rose 93.8%.



## State of Hawaii Agencies Lead By Example

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



- State agencies have received more than \$6.69 million in efficiency rebates since 1996 from the Hawaiian Electric Company (HECO) and its subsidiaries and from Hawai'i Energy. These rebates combined have resulted in estimated cumulative dollar savings of over \$153.6 million and electricity savings of over 67 million kilowatt-hours. Over the life of the equipment, the savings will be equivalent to approximately 157,000 households' annual electricity use. In FY12 state agencies received \$495,784 in rebates.
- 21 State Buildings have been benchmarked and verified as Energy Star (upper 25% in energy efficiency for similar buildings in the U.S.).

# State of Hawaii Agencies Lead By Example

## Performance Contracting

For the second year in a row, Hawaii was ranked first in the nation in energy savings performance contracting (ESPC) by the Energy Services Coalition (ESC). Hawaii's investment of \$132.25 per capita earned the state a second consecutive ESC Race to the Top award in 2013. The national average is \$36.36/person and total savings for state agencies from performance contracting is \$66 million.

## Leadership in Energy and Environmental Design (LEED)

- The State Office Tower (SOT) received the prestigious LEED Gold for Existing Buildings: Operations and Maintenance. It is the only major office building, public or private, to receive this distinction in the state. The ENERGY STAR rating is 96, which means that the SOT ranks in the top four percent in energy efficiency among similar buildings nationally.
- To date, sixteen state facilities have been certified as meeting LEED standards or have been completed and are awaiting certification by USGBC. A significant number of additional buildings which are anticipated to meet LEED Silver standards or better are either being planned or are in the design phase.
- Hawaii remains a member of the U.S. Green Buildings Council (USGBC), the non-profit entity which administers the LEED program. DAGS is developing LEED application guidelines to be used by state agencies.
- There are over 30 LEED Accredited Professionals on staff at six state agencies; DAGS, DBEDT, DOE, DOT, HPHA and UH. There are currently additional state personnel in training for this goal. The state requires all new construction and major renovation to meet LEED Silver standards, to the extent possible. DBEDT continues to offer LEED training opportunities for state agency staff. Six years ago, there was only one LEED Accredited Professional (AP) working for the state.
- A total of 18 workshops and other events relating to LBE topics were held in FY12, attracting at least 930 participants, including many from state agencies. In some cases, DBEDT provided American Reinvestment and Recovery Act (ARRA) funds so that other executive agencies' staff members could attend the training.

## Power Purchase Agreements

- DOT-Airports signed a 20-year power purchase agreement in 2009 for a total of seven (7) photovoltaic systems totaling 901 kW of capacity.

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

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

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

# Performance Contracting for State and County Agencies

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

## **Seven (7) projects initiated since 1996:**

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

## **Preliminary data show:**

- Total investment of all projects represented in 2011 dollars is \$193,781,027. Another project with the State Department of Transportation (15 airports, 5 harbors, and highway facilities) is under development and is estimated to result in over \$166 million in investment value for a total of about \$359 million for all projects.
- The projects will include over 145 buildings and over 4.5 million square feet.
- Annual cost savings for all projects is \$37.5M, representing an average of 27% savings.
- Hawaii is ranked 1st in the nation for performance contracting. (Energy Services Coalition)

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

- Save over \$341M in electricity costs.
- Save the equivalent in energy to power over 316,000 homes a year in Hawaii.
- Create 8,983 jobs. (National Association of Energy Service Companies)
- Provided over \$472M of direct (total investment) and indirect (repair/maintenance/taxes) impact to the economy.
- Claim over \$1.5 million in utility rebate incentives.

# Performance Contracting for State and County Agencies

## State & County Performance Contracting Projects 1990-2012

Agency	Facilities	Investment Value (2011\$)	Average Annual Savings	Savings Over 20 Years
UH-Hilo	NA	\$11.3M	\$770,644	\$15.4M
HHSC	5 hospitals	\$32.6M	\$2.3M	\$45.1M
Judiciary	5 courthouses	\$2.1M	\$423,684	\$8.5M
City and County of Honolulu	4 buildings	\$16.6M	\$1.1M	\$21.9M
County of Hawaii	28 buildings	\$2.9M	\$343,489	\$6.9M
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<b>Total</b>		<b>\$193.7M</b>	<b>\$15M</b>	<b>\$341.3M</b>

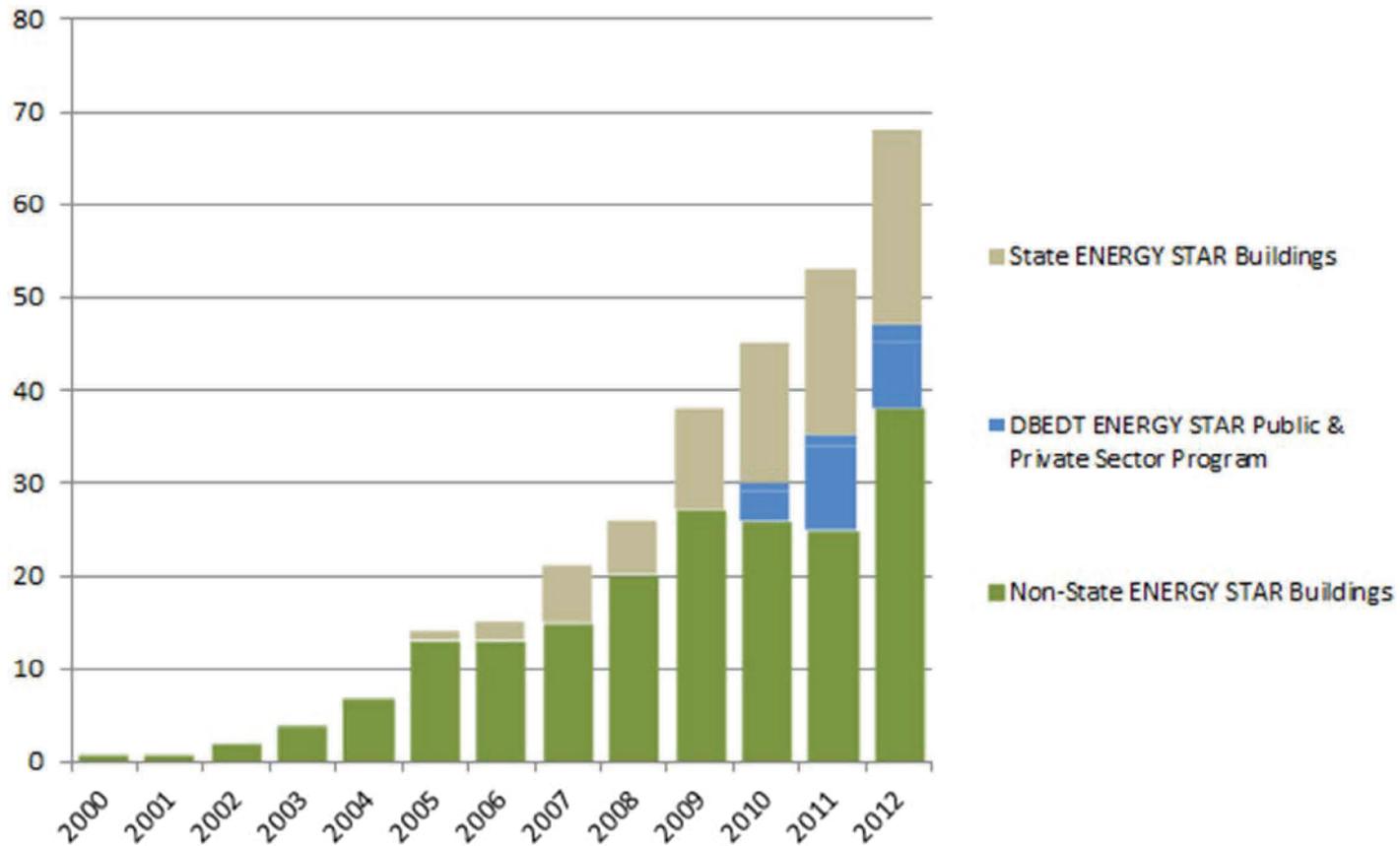
Energy savings for these projects over 20 years (1.1 billion kWh) is equivalent to powering an estimated 171,623 households for one year. Jobs maintained or created: 4,501 (Source: National Association of Energy Service Companies)

Additional projects not included below, but under development, include: Department of Transportation (15 airports/5 harbors and highways facilities), City and County of Honolulu Board of Water Supply, City and County of Honolulu Honouliuli and Sand Island Waste Water Treatment Plants, and the University of Hawaii at Hilo.

# ENERGY STAR Buildings

Agencies and private sector building owners and managers can benchmark buildings to compare energy usage with other buildings in their portfolio or similar buildings nationally to identify investment priorities. If a building's performance, as reflected in its ENERGY STAR score, ranks in the top 25% of all buildings of its type, it can be certified as an ENERGY STAR building. Since 2000, 68 Hawaii buildings have received the ENERGY STAR certification. They include 30 public and 38 private buildings. During this time, DBEDT has assisted with the benchmarking and certification of 25 public and private (buildings should be certified annually). The chart below shows the rapidly increasing number of ENERGY STAR certified buildings in the state.

### Total ENERGY STAR Certified Buildings in Hawaii



# GreenSun Hawaii Loan Program (March 2013)

## Program Objectives

- A state of Hawaii credit enhancement program funded by a grant from the U.S. Department of Energy
- Provides local financial institutions with access to a loan loss reserve (LLR) which may cover up to 100% of actual losses
- Enables participating lenders to:
  - Extend loan availability to a larger pool of borrowers
  - Offer more aggressive rates and terms than may otherwise be available without this credit enhancement
- Public-private partnership with the ability to leverage \$3.75 million in federal funds into \$75 million in energy efficiency and renewable energy equipment loans statewide

## Program Purpose

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

## Participants

- 13 Participating Lenders statewide
- 41 Authorized Contractors statewide

## Impacts

- GreenSun Hawaii currently covers 78 low interest loans amounting to over \$2 million
- Estimated energy savings of 556,000 kilowatt hours annually (11.1 million over the life of the installations)
- Savings in the participants' electricity bill in excess of \$221,000 annually (\$4.4 million over the life of the system)
- Annual CO2 reduction of 837,000 lbs. (16.7 million lbs. over the life of the installations)
- Energy savings over the life of the equipment is equivalent to powering 1,507 households



## End Notes / References

- 1 U.S. Energy Information Administration, [http://www.eia.gov/electricity/data/state/annual\\_generation\\_state.xls](http://www.eia.gov/electricity/data/state/annual_generation_state.xls)
- 2 DBEDT's Monthly Energy Trends, [http://dbedt.hawaii.gov/economic/data\\_reports/energy-trends/](http://dbedt.hawaii.gov/economic/data_reports/energy-trends/)
- 3 Current price data, July 2013: [http://www.eia.gov/electricity/monthly/epm\\_table\\_grapher.cfm?t=epmt\\_5\\_6\\_a](http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a)
- 4 *Hawaii's Energy Resources Coordinator's Annual Report, 2012*. <http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications>
- 5 Brent: U.S. Energy Information Administration., dataset RBRT (monthly). Gasoline & electricity prices: DBEDT's Monthly Energy Trends
- 6 Volumes. Source: *Biofuels Study*; DBEDT; 2012. [http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy\\_Act203\\_Dec2012.pdf](http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf)
- 7 From the U.S. Energy Information Administration, 2011 data, <http://www.eia.gov/state/print.cfm?sid=HI>
- 8 [http://www.eia.gov/state/seds/data.cfm?infile=/state/seds/sep\\_fuel/html/fuel\\_use\\_pa.html&sid=US](http://www.eia.gov/state/seds/data.cfm?infile=/state/seds/sep_fuel/html/fuel_use_pa.html&sid=US)
- 9 electricity: <http://www.eia.gov/state/rankings/#/series/31>; natural gas: <http://www.eia.gov/state/rankings/#/series/28>
- 10 1 barrel = 42 U.S. gallons.
- 11 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](http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf)
- 12 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](http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf)
- 13 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](http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf)
- 14 Grids are separate.
- 15 Hawaiian Electric Company, <http://www.heco.com/waiverprojects>
- 16 Hawaiian Electric Company, <http://generationbidding.heco.com>
- 17 <http://www.heco.com/> > clean energy > selling power to Hawaiian Electric
- 18 The amount of electricity produced per year = facility capacity x 24 hours/day x 365 days/year x capacity factor.
- 19 Electricity data is from DBEDT's *Monthly Energy Trends*, [http://dbedt.hawaii.gov/economic/data\\_reports/energy-trends/](http://dbedt.hawaii.gov/economic/data_reports/energy-trends/)
- 20 HECO, <http://www.heco.com/fit/>
- 21 Accion Group, <https://www.hecofitio.com/heco/accionhome.asp>
- 22 Database of State incentives for Renewable Energy, [http://www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=HI04R&re=0&ee=0](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=HI04R&re=0&ee=0)
- 23 HECO companies, Oct. 14, 2013; "Solar Photovoltaic Interconnection, Informational Briefing, Hawaii State Legislature."
- 24 HECO, <http://nem.heco.com>
- 25 HECO companies, Oct. 14, 2013; "Solar Photovoltaic Interconnection, Informational Briefing, Hawaii State Legislature."
- 26 Oahu: <http://www.heco.com/vcmcontent/StaticFiles/pdf/LVM/LVMHECOPublic.pdf>
- 27 Maui, Molokai, Lanai: <http://www.heco.com/vcmcontent/StaticFiles/pdf/LVM/LVMMECOPublicNEW.pdf>
- 28 Hawaii: <http://www.heco.com/vcmcontent/StaticFiles/pdf/lvm/LVMHELCPublic.pdf>
- 29 Kauai Island Utility Cooperative (KIUC), [http://kauai.coopwebbuilder.com/sites/kauai.coopwebbuilder.com/files/schedule\\_q\\_eff\\_092012.pdf](http://kauai.coopwebbuilder.com/sites/kauai.coopwebbuilder.com/files/schedule_q_eff_092012.pdf)
- 30 [http://kauai.coopwebbuilder.com/files/42\\_schedule\\_nem\\_effective\\_june\\_3\\_2011.pdf](http://kauai.coopwebbuilder.com/files/42_schedule_nem_effective_june_3_2011.pdf)
- 31 Hawaii Revised Statutes, chapter 269-91.
- 32 Hawaii Public Utilities Commission, *Renewable Portfolio Standards Status Reports, 2007-2012*. <http://dms.puc.hawaii.gov/dms/>. Docket 2007-0008.
- 33 National Renewable Energy Laboratory, *Hawaii Clean Energy Initiative Scenario Analysis, 2012*, and DBEDT.
- 34 Chapter 269-91 et.seq., Hawaii Revised Statutes. [http://www.capitol.hawaii.gov/hrscurrent/Vol05\\_Ch0261-0319/HRS0269/HRS\\_0269-0091.htm](http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.htm)
- 35 National Renewable Energy Laboratory, <http://en.openei.org/apps/TCDB/>
- 36 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>)
- 37 The Honolulu Program of Waste Energy Recovery (HPOWER) is the waste-to-energy facility of the City and County of Honolulu.
- 38 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](http://energy.hawaii.gov/wp-content/uploads/2011/10/BiofuelsStudy_Act203_Dec2012.pdf)
- 39 Hawaii Natural Energy Institute, *Bioenergy Master Plan, 2010*. <http://energy.hawaii.gov/resources/hawaii-state-energy-office-publications>
- 40 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](http://www.hcsugar.com/energy_and_the_environment.shtml))
- 41 *Biofuels Digest*, <http://www.biofuelsdigest.com/bdigest/2012/11/12/everyday-low-fuel-prices-drop-in-advanced-biofuels-for-under-100-per-barrel>, November, 2012.
- 42 With CO<sub>2</sub> from power plant. General Atomics, DARPA-funded Kauai algae facility, Congressional Briefings, Washington, D.C. (March 2012).

40 Conservative estimate for industry. Specific projects may have significantly higher yields.

41 US. EPA data for Hawaii, CO<sub>2</sub> only, 20 facilities, <http://ghgdata.epa.gov/ghgp/main.do>

42 From work by Anthony Ostrowski, Oceanic Institute.

43 Transparent Cost Database, 98 values, last accessed October 10, 2013. Minimum: \$0.01; Maximum: \$0.16; Median \$0.06. <http://en.openei.org/apps/TCDB/>

44 Defense Advanced Research Projects Agency.

45 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](http://energy.hawaii.gov/wp-content/uploads/2011/10/ReportMauiElectricVehicleAlliance_12_20_12.pdf)

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

47 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.

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

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

50 Ranging from mid-\$30,000 to \$40,000.

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

52 9,020 miles per year, from Hawaii State Data Book. <http://dbedt.hawaii.gov/economic/databook/>

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

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

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

56 Avoided cost as of October 1, 2013, <http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=23d98435a651d110VgnVCM1000005c011bacRCRD&vgnnextchannel=10629349798b4110VgnVCM1000005c011bacRCRD&vgnnextfmt=default&vgnnextrefresh=1&level=0&ct=article>

57 Levelized Cost of Energy Calculator and Transparent Cost Database, 46 values, last accessed October 10, 2013. Minimum: \$0.03; Maximum: \$0.12; Median \$0.05. <http://en.openei.org/apps/TCDB/>

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

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

60 <http://nhaap.ornl.gov/nsd/>

61 Hawaii State Energy Office data.

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

63 [www.heco.com](http://www.heco.com), accessed January 2013.

64 DBEDT, Weekly Photovoltaic Permits, <http://dbedt.hawaii.gov/economic/>

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

66 Renewable Portfolio Standards reports for 2012 submitted to the Hawaii Public Utilities Commission. <http://dms.puc.hawaii.gov/dms> RPS Docket Number: 2007-0008

67 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.

68 Navigant Consulting, Inc., *Status and Perspective on the Big Wind/Cable Project*, <http://energy.hawaii.gov/wp-content/uploads/2011/10/Navigant-2011.pdf>

69 Assumes 400 MW, 40% capacity factor, 10,000 Btu/kWh, \$100/bbl oil, 6 mmbtu/bbl.

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

71 Data from HINMREC.

72 NELHA website, <http://nelha.org/about/facilities.html>

73 Data from Ocean Power Technologies, Inc.

74 NELHA website, <http://nelha.org/about/facilities.html>

75 Smart Grid .gov: [http://www.smartgrid.gov/the\\_smart\\_grid](http://www.smartgrid.gov/the_smart_grid)

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

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

78 Hawaii Data Book: <http://hawaii.gov/dbedt/info/economic/databook/db2011/section01.pdf>  
79 Sum of stated investment in "Existing Smart Grid Projects in Hawaii"  
80 University of Hawaii RDSI Demonstration Project: <http://www.smartgrid.epri.com/doc/Hawaii%20RDSI%20Final.pdf>  
81 DBEDT Press Release: <http://energy.hawaii.gov/wp-content/uploads/2011/09/NR-MOU-Signing-NEDO-Hawaii.11.22.11.pdf>  
82 KIUC Smart Meter FAQs: <http://website.kiuc.coop/content/smart-meter-faqs>  
83 Honeywell Press Release: <http://honeywell.com/News/Pages/Honeywell-And-Hawaiian-Electric-To-Use-Demand-Response-To-Integrate-Renewables-And-Reduce-Fossil-Fuel-Dependence.aspx>  
84 Source: 2007-2012 Annual RPS Reports. <http://dms.puc.hawaii.gov/dms/> RPS Docket Number: 2007-0008  
85 From HECO website, [http://www.hawaiianelectric.com/vcmcontent/StaticFiles/pdf/PVsummary\\_2ndQtr2013.pdf](http://www.hawaiianelectric.com/vcmcontent/StaticFiles/pdf/PVsummary_2ndQtr2013.pdf)  
86 Source: 2001-2012 NEM, FIT Annual Reports, PUC Dockets.  
87 From HECO website, [http://www.hawaiianelectric.com/vcmcontent/StaticFiles/pdf/PVsummary\\_2ndQtr2013.pdf](http://www.hawaiianelectric.com/vcmcontent/StaticFiles/pdf/PVsummary_2ndQtr2013.pdf)  
88 Source: 2001-2011 NEM, FIT Annual Reports, PUC Dockets.  
89 <http://www.heco.com/portal/site/heco/menuitem.20516707928314340b4c0610c510b1ca/?vgnextoid=3be8e20c52a1b310VgnVCM1000005041aacRCRD&vgnnextfmt=default>  
90 Calculated, using 2012 installed capacity, 17% capacity factor, and statewide 2012 kWh sales.  
91 Hawaii Clean Energy Initiative Scenario Analysis (2008-2010).  
92 Source: August 2008 PV and CSP Resource Maps, NREL.  
93 US Department of Energy program estimate, Transparent Cost Database, 74 values, last accessed October 10, 2013. Minimum: \$0.14; Maximum: \$0.55; Median \$0.26.  
<http://en.openei.org/apps/TCDB/>  
94 Ranges from 6 – 15 watts per square foot, commercially available. Includes spacing. North American Board of Certified Energy Practitioners. *PV Installer Resource Guide*.  
<http://www.nabcep.org/wp-content/uploads/2012/03/NABCEP-PV-Installer-Resource-Guide-March-2012-v.5.2.pdf>  
95 California Energy Commission. List of Eligible SB1 Guidelines Compliant Photovoltaic Modules, Updated as of March 1, 2013. [http://www.gosolarcalifornia.org/equipment/pv\\_modules.php](http://www.gosolarcalifornia.org/equipment/pv_modules.php)  
96 Solar Energy Industries Association, "U.S. SOLAR MARKET INSIGHT REPORT Q4 2011 & 2011 YEAR-IN-REVIEW,"  
[http://www.seia.org/sites/default/files/TSF\\_SMI%202011%20YIR\\_survey%20incentive\\_0.pdf](http://www.seia.org/sites/default/files/TSF_SMI%202011%20YIR_survey%20incentive_0.pdf)  
97 Solar Energy Industries Association, "U.S. SOLAR MARKET INSIGHT REPORT Q4 2011 & 2011 YEAR-IN-REVIEW,"  
[http://www.seia.org/sites/default/files/TSF\\_SMI%202011%20YIR\\_survey%20incentive\\_0.pdf](http://www.seia.org/sites/default/files/TSF_SMI%202011%20YIR_survey%20incentive_0.pdf)  
98 Source: DBEDT, March 2012.  
99 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.  
100 From RPS reports to the Public Utilities Commission from Maui Electric Company (MECO), Hawaii Electric Light Company (HELCO), and Hawaiian Electric Company (HECO).  
101 EIA 923 forms.  
102 RPS reports.  
103 Hawaii Clean Energy Initiative Scenario Analysis (2008-2010), using capacity factors of 35% for Oahu, Hawaii, and Kauai resources; 40% for Molokai and Lanai; 45% for Maui.  
104 [http://www.edf-re.com/about/press/construction\\_of\\_hawi\\_wind\\_farm\\_to\\_begin\\_in\\_november\\_2005](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](http://www.nrel.gov/news/features/feature_detail.cfm/feature_id=1748)  
105 <http://www.businesswire.com/news/home/20120705005753/en/Wind-Announces-Completion-Kaheawa-Wind-II-Project>  
106 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>  
107 [http://hawaii.gov/dlnr/dofaw/hcp/Kahuku\\_HCP\\_Text.pdf](http://hawaii.gov/dlnr/dofaw/hcp/Kahuku_HCP_Text.pdf)  
108 [http://oehc.doh.hawaii.gov/Shared%20Documents/EA\\_and\\_EIS\\_Online\\_Library/Oahu/2010s/2010-09-23-OA-EISPN-Kawailoa-Wind-Farm.pdf](http://oehc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Oahu/2010s/2010-09-23-OA-EISPN-Kawailoa-Wind-Farm.pdf)  
109 <http://www.businesswire.com/news/home/20120705005753/en/Wind-Announces-Completion-Kaheawa-Wind-II-Project>  
110 [http://www.semprausgp.com/\\_downloads/pdfs/Final\\_EIS\\_for\\_Auwahi\\_Wind.pdf](http://www.semprausgp.com/_downloads/pdfs/Final_EIS_for_Auwahi_Wind.pdf)  
111 RPS reports. <http://dms.puc.hawaii.gov/dms/> RPS Docket Number: 2007-0008  
112 RPS reports and PUC fillings.  
113 Hawaii Clean Energy Initiative Scenario Analysis (2008-2010). <http://energy.hawaii.gov/programs/hcei>  
114 <http://hawaii.gov/dlnr/dofaw/hcp>  
115 Siemens turbines at Kawailoa, 90 m hub height.

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<sup>116</sup> US Department of Energy program estimate, Transparent Cost Database, 110 values, last accessed October 10, 2013. Minimum: \$0.03; Maximum: \$0.09; Median \$0.05.  
<http://en.openei.org/apps/TCDB/>

<sup>117</sup> *Renewable Energy Permitting Barriers in Hawaii*, National Renewable Energy Laboratory (2012). <http://www.nrel.gov/docs/fy13osti/55630.pdf>