Hawai‘i’s Energy Facts & Figures

2020 Edition

HAWAII STATE
Energy Office

ENERGY.HAWAII.GOV

Hawai'i's Energy Facts & Figures provides an overview of Hawai'i's energy sector and quantifies progress in the areas of energy efficiency, renewable energy, clean transportation, and decarbonization.

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Hawai'i's embrace of clean energy is rooted in a commitment to end its historical dependence on fossil fuels. This transition will support the state's economy, the environment, and energy security. In 2015, Act 97 was enacted, requiring 100 percent of Hawai'i's electricity sales to come from renewable resources by 2045. In 2017, the mayors of Hawai'i's four main counties signed proclamations committing to transform Hawai'i's public and private ground transportation to 100 percent renewable fuel sources by 2045. That was followed in 2018 by the passage of Act 15 requiring Hawai'i to become net carbon negative "as soon as practicable, but no later than 2045."

The recognition of opportunities, tracking of progress, and informed and respectful evaluations of synergies and options will depend upon access to the best available information and data presented in an accessible and understandable format. This document is just one of the information sources provided for Hawai'i citizens, communities, and decision-makers. Information sources include:

- *Hawai'i's Energy Facts & Figures* (this document): Energy facts and figures on an annual basis, with some information on trends, laws, and policies.
- *Hawaii State Energy Office, Annual Report:* Activities, projects, and accomplishments of the Hawaii State Energy Office over the previous fiscal year.
- Hawaii State Energy Office Website (energy.hawaii.gov): In-depth information on a variety of energy topics; links to energy dashboards and data sets; on-line tools; listings of projects, directories, and maps; reports and documents; contact information; subscriptions to newsletters and social media; upcoming events; and archives.
- *Monthly Energy Trends*: Data by island, and for the state, on monthly prices of crude oil, gasoline, diesel, and electricity; quantities of petroleum imported from foreign countries; fuel consumption; registered vehicles; and electricity generation and sales.
- Energy Dashboard: Tables and graphs on electricity, transportation, economy, environment, and efficiency.

Some energy data is available quickly (for example, the spot price of a particular fuel). Other data is available monthly or quarterly (for example, average price or total use), usually with some lag time. In the case of data sets involving comprehensive national data, the most current data available in mid-2020 only went through the end of calendar year 2018; electricity data went through calendar year 2019. Prices paid under renewable electricity power purchase agreements were averages for State fiscal year 2019, encompassing the period July 1, 2018-June 30, 2019.

For this report, the data presented is prior to the impacts of COVID-19. Data showing the impacts of COVID-19 on an annual basis is expected to become available for some data sets with the 2021 report. Some of the data sources listed above and in the endnotes, such as *Monthly Energy Trends* and the "Performance Metrics" website of Hawaiian Electric, have monthly and quarterly data that can be used for shorter term comparisons of pre-and post-COVID energy supplies and demand.

For screen reader users. The Hawaii State Energy Office recognizes the use of diacritical markings of the Hawaiian language such as the 'okina (also called a glottal stop) and the kahakō (also called a macron). Please note that screen readers may not read or pronounce the Hawaiian words correctly.

1. Overview of Energy in Hawai‘i

Hawai‘i’s people and economy rely on energy for everything from fuel for cars and airplanes to electricity for lights, water, ventilation, cooling, heating, computers, cooking, communication, security, and myriad other uses.

These energy needs are met by a combination of renewable and non-renewable energy sources, as shown in Figure 1. According to data from the United States Energy Information Administration, in 2018 (the most recent year for which complete data is available) Hawai‘i’s energy needs were met by:

- 31.109 trillion British thermal units (Btu) equivalent of renewable energy;
- 14.367 trillion Btu of coal;
- 0.192 trillion Btu of natural gas; and
- 247.227 trillion Btu of petroleum products (this includes jet fuel, gasoline, diesel, fuel oil, naphtha, and other distillates).[1]

Many people are not aware of the relatively large quantities, expense, and emissions from these imported fuels. The amount of fuel imported into Hawai‘i exceeds the amount of any other product imported into the state. A 2019 study showed that Hawai‘i’s imports of more than six million tons of petroleum, petroleum products, and coal were 57 percent of the total tons of cargo imports through ports in Hawai‘i, and exceeded the imports of all other products and materials imported into the state.[2] This remained true even when including inbound air cargo and mail (approximately 400,000 tons in 2016).[3] This is shown in Figure 2.

Hawai‘i’s energy consumption of 293 trillion Btu in 2018 was slightly lower than it had been in 2003. As shown in Figure 3, Hawai‘i’s energy overall energy demand increased rapidly between 2003 and 2007, dropped in 2008, and increased gradually between 2008 and 2018.

Figure 1 - Hawai‘i’s Energy, By Source, 2018; Trillion Btu (TBtu) and Percent of Total

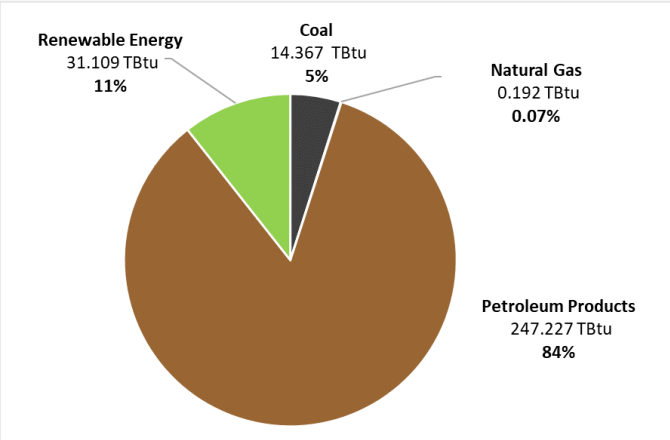


Figure 2 - Tons of Cargo Imported to Ports in Hawai‘i, 2016

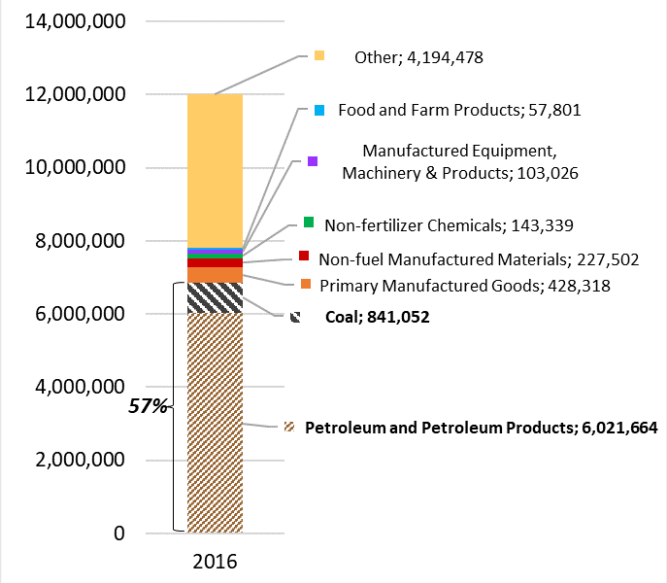
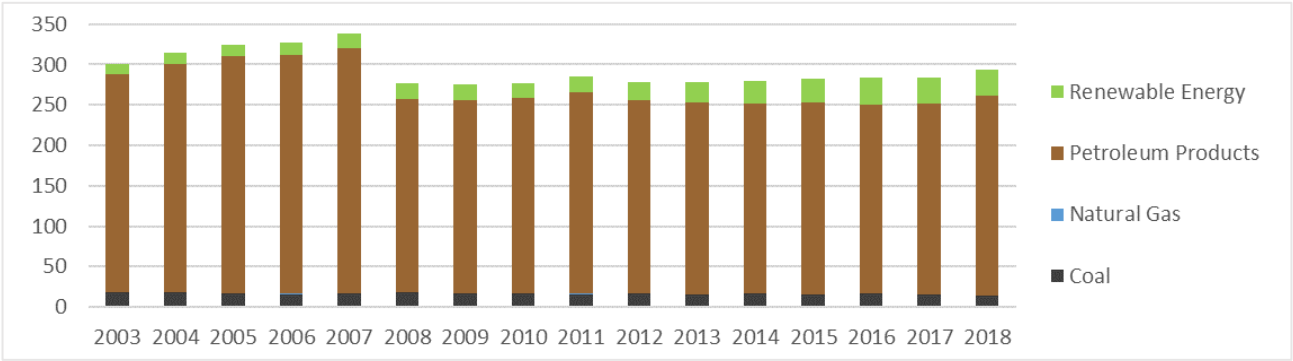
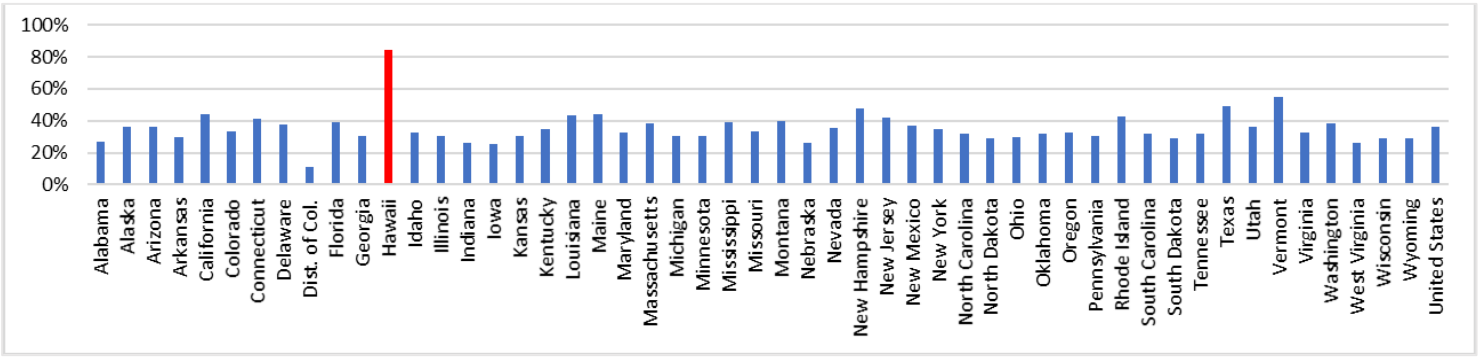


Figure 3 - Hawai‘i’s Energy Demand, Trillion Btu Per Year by Source, 2003-2018



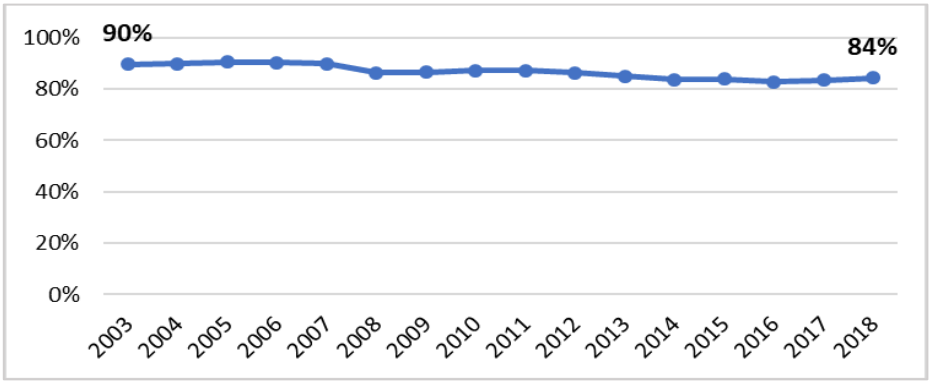
As the only state still primarily reliant on oil-fired electrical generation, and with a significant demand for jet fuel, Hawai'i depends more on petroleum for its energy needs than does any other state,[4] as shown in Figure 4.

Figure 4 - Dependence of States on Petroleum for their Energy Needs, 2018



Over the past several years, Hawai'i's petroleum dependence has gradually been reduced, from 90 percent in 2003 to 84 percent in 2018. This can be seen in Figure 5.[5]

Figure 5 - Gradual 15-year Decline Seen in Percent of Hawai'i's Energy From Petroleum Between 2003 and 2018



Petroleum is still one of Hawai'i's primary imports. Of total Hawai'i imports for 2018, 60 percent (by dollar value) were petroleum-related commodities; the import value of these foreign and domestic fuels in 2018 was $3.3 billion.[6]

Since 2010, Hawai'i has imported the majority of its foreign crude oil from Indonesia, Russia , and Libya, as shown in Figure 7. As shown in Figure 6, more than 90 percent of foreign crude imports arrived from Libya and Russia in 2019, with the remaining arriving from South Sudan and Argentina.[7]

Figure 7 - Percentage of Crude Imports to Hawai'i, by Country of Origin, 2010-2019

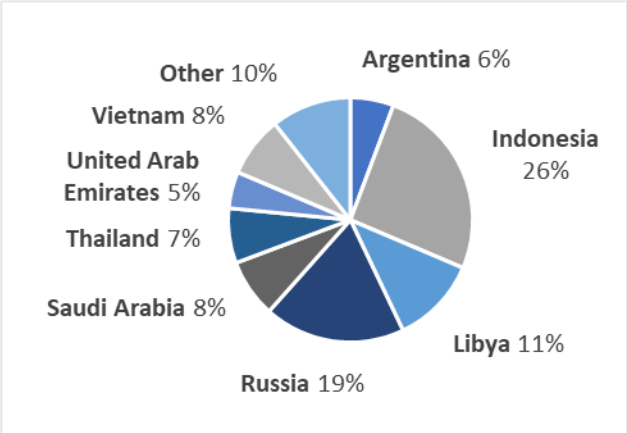


Figure 6 - Percentage of Crude Imports to Hawai'i, by Country of Origin, 2019

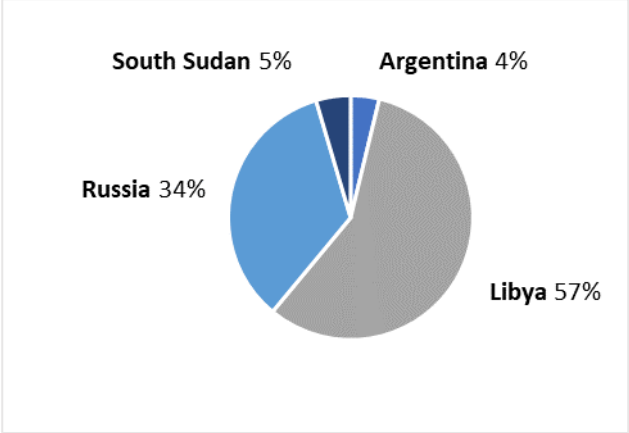


Figure 8 shows how petroleum was used in Hawai'i in 2018. The air transportation sector accounted for the highest percentage of petroleum use, followed by ground transportation and electricity production, with the remainder used for marine transportation, commercial, industrial and residential uses.[8,9]

As shown in Figure 9, both electricity and gasoline prices correlate closely with the price of petroleum.[10]

With a variety of sources (both fossil and renewable), and many energy end-uses (including air transportation, ground transportation, electricity production, and direct heat for water, cooking, etc.), tracking energy flows can be complicated.

As illustrated by the Sankey diagram[11] in Figure 10, there are several important parts of an energy system: sources, uses, electricity generation, and the efficiency of converting energy to services such as lighting, heated water, and power to the wheels of a vehicle. Rejected energy is the energy, usually emitted as waste heat, that is not used directly for a needed service. Also shown are non-electricity energy flows, primarily petroleum to transportation.

Figure 8 - Hawai'i's Petroleum Use by Sector, 2018

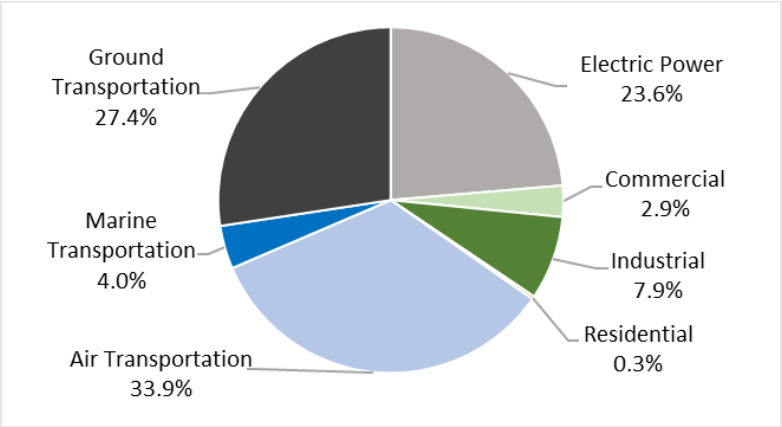
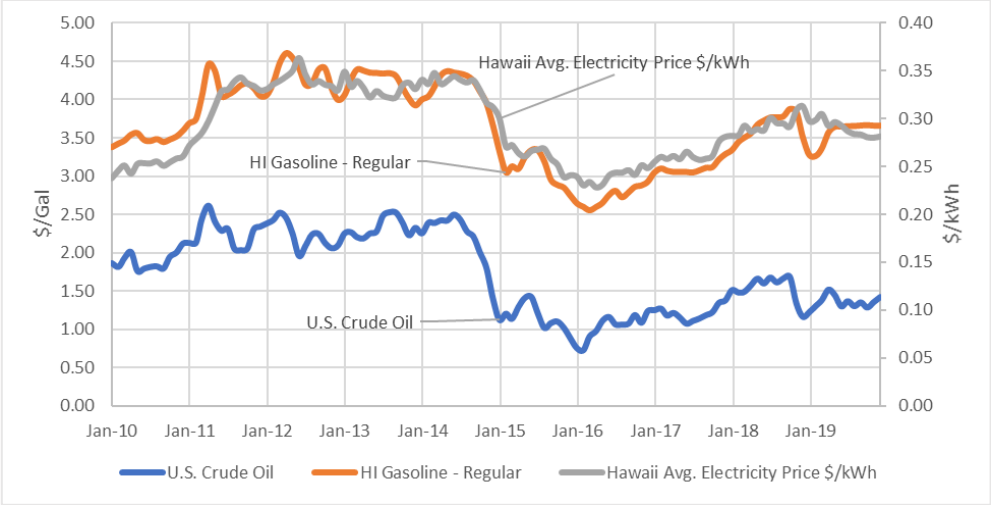


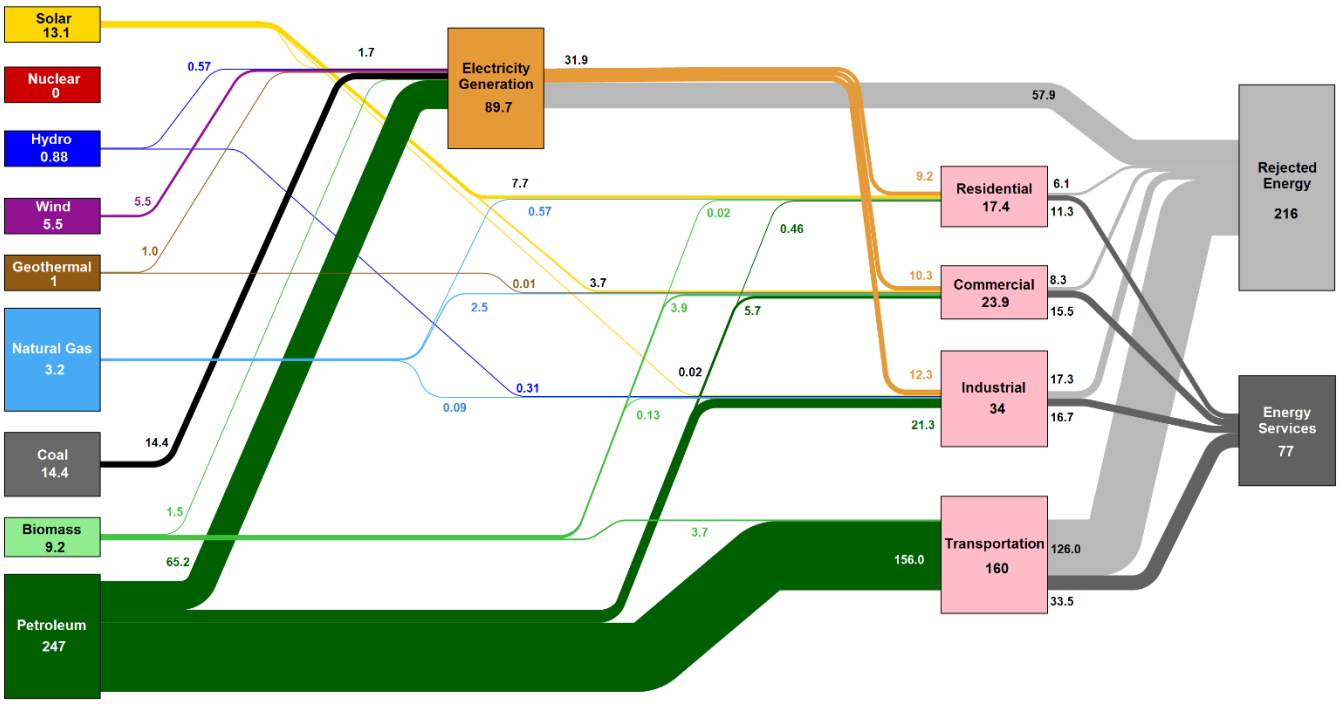
Figure 9- Visible Correlation Between Prices of Crude Oil, Gasoline, and Electricity



The facts and figures in this document are grouped in the following categories:

1. Overview of Hawai'i's energy;
2. Electricity production and use;
3. Transportation;
4. Alternative fuel use and production in Hawai'i;
5. Energy sector workforce and jobs;
6. Decarbonized, clean energy economy; and
7. Beyond Hawai'i.

Figure 10 - Sankey Diagram of Hawai'i's Energy Sources and Uses in 2018



Source: LLNL June, 2020. Data is based on DOE/EIA SEDS (2019). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 49% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent Rounding. LLNL-MI-410527

Table 1 - Notable Energy Numbers for Hawai'i

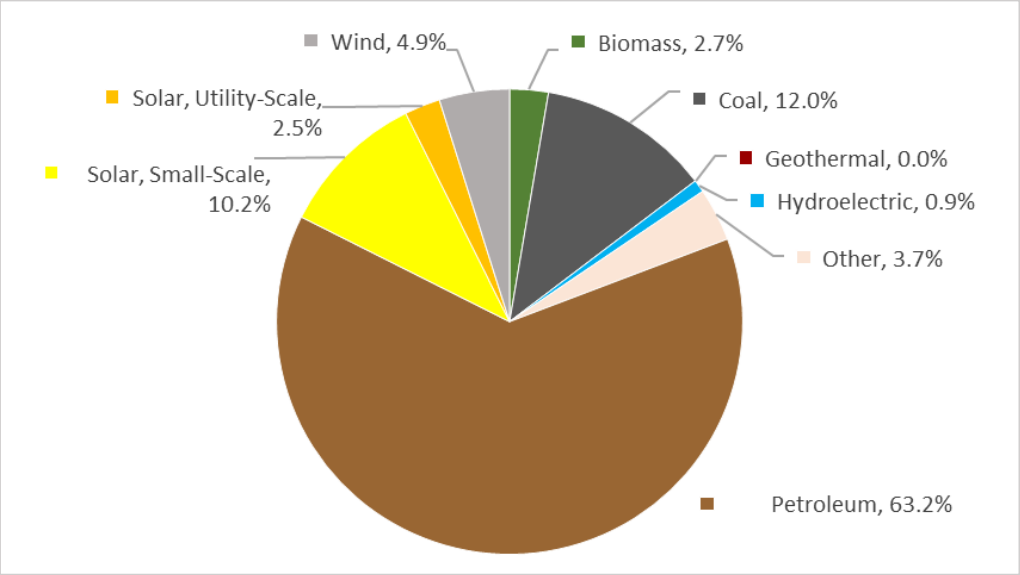
	2018	2019		2018	2019
Total foreign crude oil imports (million barrels)[12]	34.9	26.4	Fuel for electricity production (million gallons)[13]	385	387
Total foreign refined petroleum imports (million gallons)[14]	1,845	646	Imported foreign fuel for air transportation (e.g., jet fuel) (million gallons)[15]	336	437
Hawai'i's Ranking: Average Retail Price of Electricity to Residential Sector[16]	1	1	Fuel for ground transportation (million gallons)[17]	511	513

2. Electricity Production and Use

Hawai'i's electricity production by source in 2019 is shown in Figure 11. The largest source is petroleum, at 63.2 percent, followed by coal at 12 percent, for a fossil fuel total of 75.2 percent.[18] Solar energy provided 12.7 percent (10.2% small scale and 2.5 percent large scale), wind energy accounted for 4.9 percent, biomass for 2.7 percent, and hydroelectric for 0.9 percent of Hawai'i's electricity in 2019.

- Fossil 75.2%
  - Petroleum 63.2%
  - Coal 12%
- Renewable 20.3%
  - Solar 12.7%
  - Wind 4.9%
  - Biomass 2.7%
  - Hydro 0.9%
- Other 3.7%

Figure 11 - Hawai'i's Electricity Production by Source (2019)

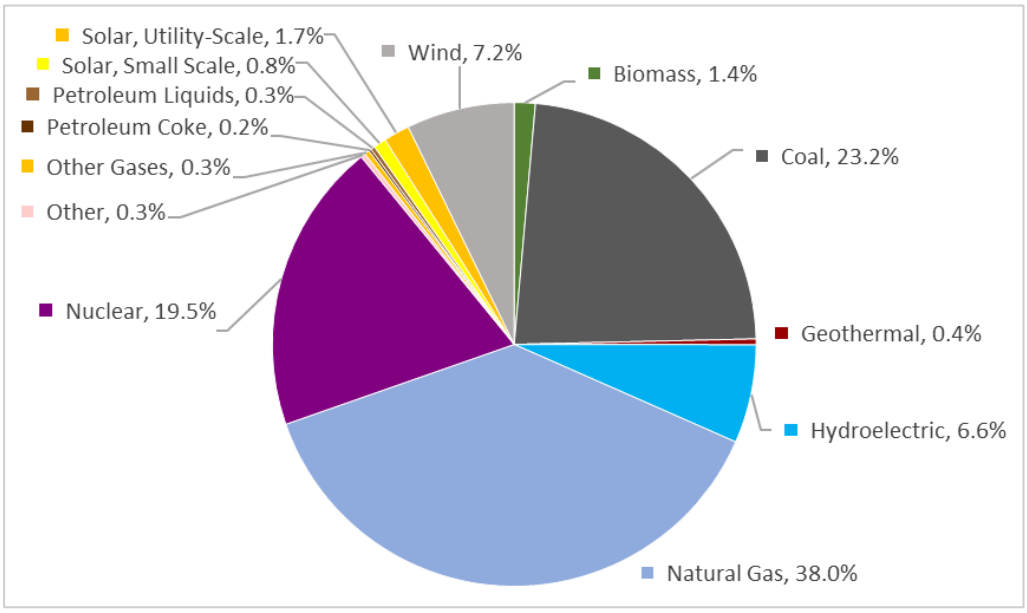


As mentioned previously (Figure 4), Hawai'i's dependency on petroleum is significantly higher than other states, due in significant amount to its use of petroleum for electricity production.

As shown in Figure 12, only 0.3 percent of electricity in the United States is generated using petroleum. Electricity generation in the continental United States is primarily from the following energy sources:

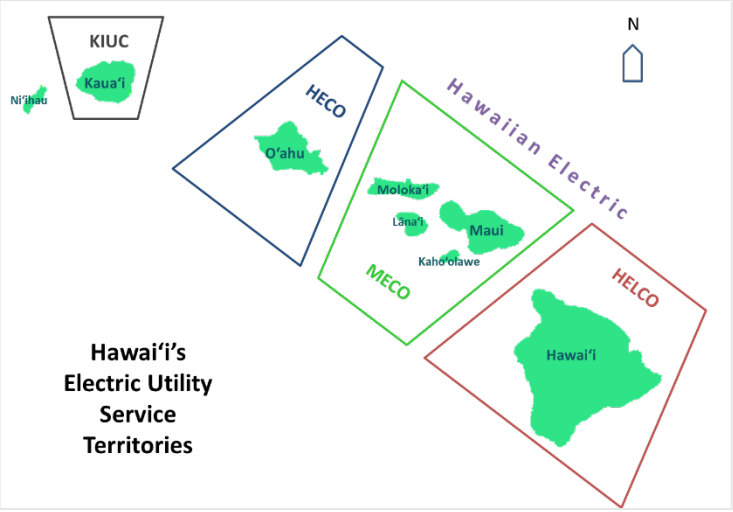
- Natural gas (38%);
- Coal (23.2%);
- Nuclear (19.5%);
- Wind (7.2%);
- Hydroelectric (6.6%);
- Solar (2.5%);
- Biomass (1.4%); and
- Geothermal (0.4%)

Figure 12 - United States Electricity Production by Source (2019)



Hawai‘i’s Electric Utilities

Figure 13 - Hawai‘i’s Electric Utility Service Territories



The two primary electric utilities serving Hawai‘i are Hawaiian Electric and Kaua‘i Island Utility Cooperative (KIUC). Hawaiian Electric, an investor-owned utility, is the largest supplier of electricity in the state and provides electricity to the majority of Hawai‘i’s population. KIUC operates as a cooperative. Both are regulated by the Hawai‘i Public Utilities Commission.

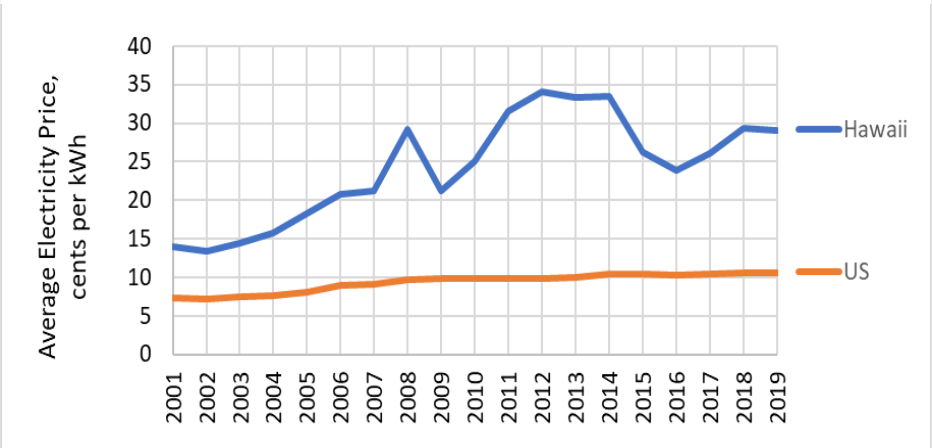
The service territories of the utilities are shown in Figure 13. In December, 2019, Hawaiian Electric announced that “Hawaiian Electric will adopt a ‘doing business as’ model, with the three individual corporate entities remaining but all doing business as Hawaiian Electric” beginning in January, 2020, with the “transition to the Hawaiian Electric name” taking place over several months. The three entities are Hawaiian Electric Company, Inc. (HECO), serving the island of O‘ahu; Maui Electric Company, Limited (MECO), serving the islands of Maui, Moloka‘i, and Lāna‘i (Maui County), and Hawai‘i Electric Light Company, Inc. (HELCO), serving the island of Hawai‘i. The combination is shown in Figure 13. [19]

Average Electricity Rates in Hawai‘i

As shown in Figure 14, Hawai‘i’s average electricity prices are more than double the national average, and have fluctuated over the years in a manner similar to the fluctuations in the price of oil (shown previously, in Figure 9).

This makes many of the energy efficiency measures and renewable energy technologies even more cost-effective in Hawai‘i than they are in other U.S. locations.

Figure 14 - Hawai‘i’s electricity prices are more than double the U.S. average



Residential Electricity Use, Rates, and Monthly Bills

Monthly utility sales, rates, and bills for residential customers were generally lower in 2019 compared to 2011, as shown in Figure 15 and Table 2 (kWh); Figure 16 and Table 3 (average rates); and Figure 17 and Table 4 (bills). [20,21,22]

Figure 15 - Average Monthly Residential Electricity Sales Per Household (kWh)

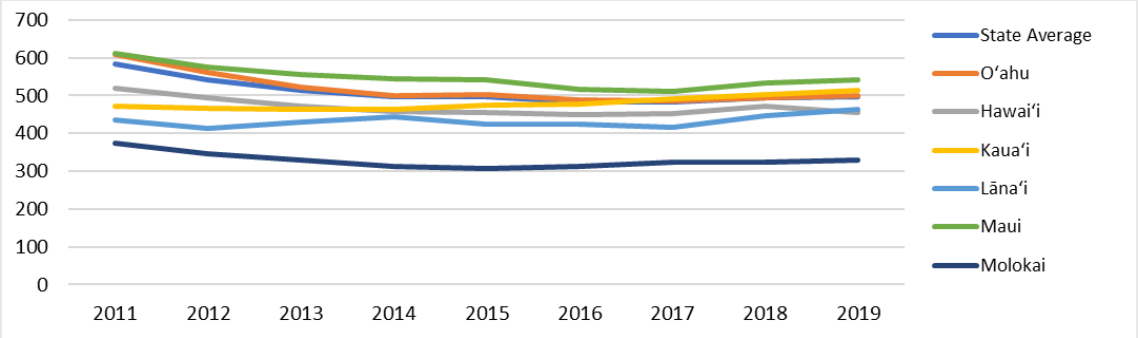


Table 2 - Average Monthly Residential Electricity Sales per Household (kWh)

Year	State Average	O'ahu	Hawai'i	Kaua'i	Lāna'i	Maui	Moloka'i
2011	**584**	609	520	473	435	612	373
2012	**543**	561	494	465	413	574	345
2013	**514**	523	473	464	430	557	329
2014	**496**	501	458	464	443	545	312
2015	**497**	504	454	474	424	541	306
2016	**484**	488	450	478	425	517	312
2017	**482**	486	451	491	417	510	324
2018	**494**	493	471	503	447	533	325
2019	**497**	500	454	515	464	543	328

Figure 16 – Average Utility Revenues Per Residential kWh ($)

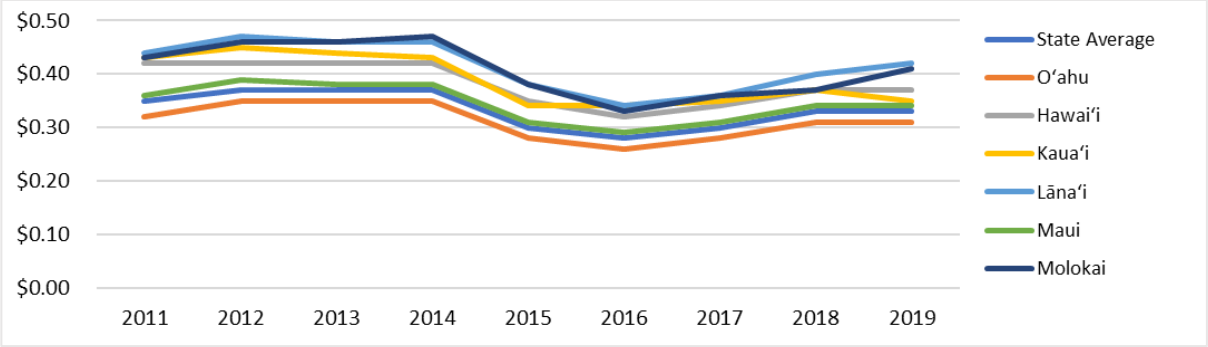


Table 3 - Average Utility Revenues per Residential kWh ($)

Year	State Average	O'ahu	Hawai'i	Kaua'i	Lāna'i	Maui	Moloka'i
2011	**$0.35**	$0.32	$0.42	$0.43	$0.44	$0.36	$0.43
2012	**$0.37**	$0.35	$0.42	$0.45	$0.47	$0.39	$0.46
2013	**$0.37**	$0.35	$0.42	$0.44	$0.46	$0.38	$0.46
2014	**$0.37**	$0.35	$0.42	$0.43	$0.46	$0.38	$0.47
2015	**$0.30**	$0.28	$0.35	$0.34	$0.38	$0.31	$0.38
2016	**$0.28**	$0.26	$0.32	$0.34	$0.34	$0.29	$0.33
2017	**$0.30**	$0.28	$0.34	$0.35	$0.36	$0.31	$0.36
2018	**$0.33**	$0.31	$0.37	$0.37	$0.40	$0.34	$0.37
2019	**$0.33**	$0.31	$0.37	$0.35	$0.42	$0.34	$0.41

Figure 17 - Average Monthly Residential Electric Utility Bill

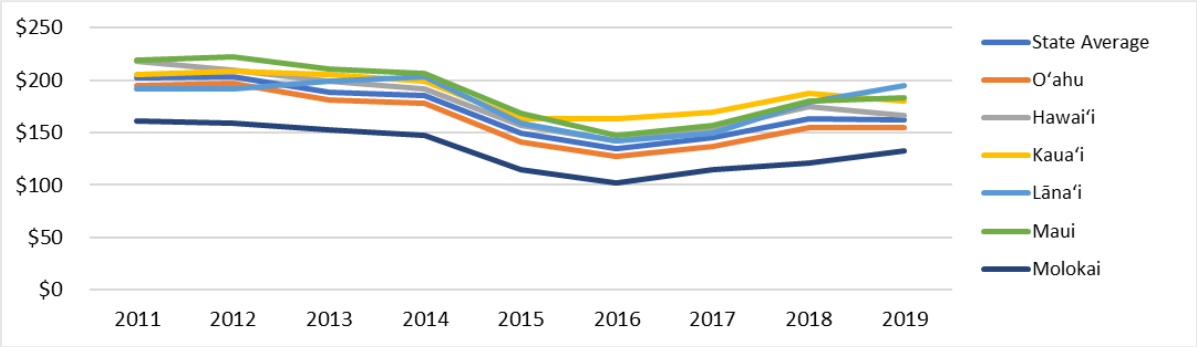
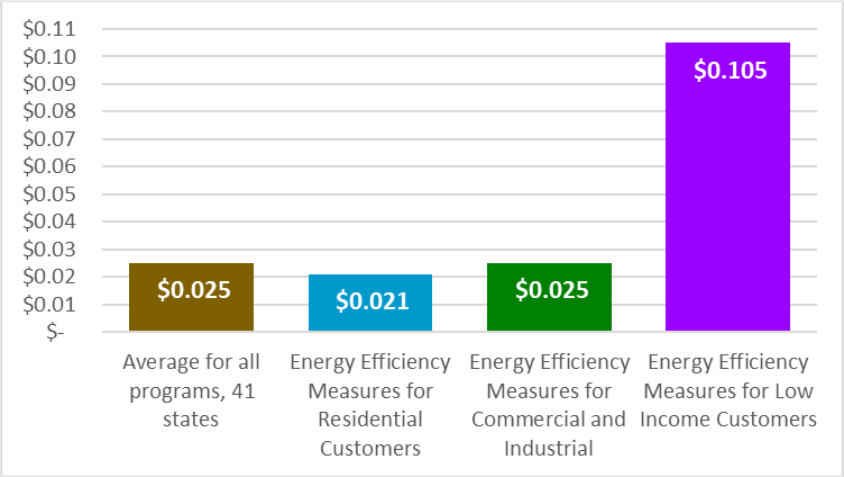


Table 4 – Average Monthly Residential Electricity Bill ($)

Year	State Average	O'ahu	Hawai'i	Kaua'i	Lāna'i	Maui	Moloka'i
2011	**$202**	$195	$218	$205	$192	$219	$161
2012	**$203**	$197	$210	$209	$192	$222	$159
2013	**$189**	$181	$199	$205	$199	$211	$153
2014	**$185**	$178	$192	$199	$203	$206	$147
2015	**$149**	$141	$157	$163	$159	$168	$115
2016	**$135**	$127	$142	$163	$142	$147	$102
2017	**$145**	$137	$154	$170	$150	$157	$115
2018	**$163**	$155	$175	$187	$179	$180	$121
2019	**$162**	$155	$166	$180	$195	$183	$133

Energy Efficiency

Figure 18 - Energy Efficiency: Costs of Saved Electricity (2016$/kWh) Across 41 States in the U.S.



The saying, "energy efficiency first," reflects the understanding that it is generally cheaper and more resource-efficient to avoid using a kilowatt-hour than it is to generate or purchase a kilowatt-hour. A study published in 2020 collected information from forty-one states and found that the national sales-weighted average cost per kilowatt-hour saved was generally less than three cents per kilowatt-hour saved: $0.025 for all programs; $0.021 for residential; $0.025 for commercial and industrial; and $0.105 for the highest-cost programs, which focused on assisting low income customers. This compares to the U.S. average retail price of electricity in the same period of about ten cents per kWh and, in Hawai'i, between twenty and thirty-four cents.[23]

This is the basis for the rule of thumb that each dollar spent on efficiency (for current programs, in aggregate) saves **ten times** that amount on energy bills. As shown later (Table 5), Hawai'i savings for program year 2019 was **fifteen** to one.

Energy Efficiency Portfolio Standards (EEPS)

Hawai'i has a State Energy Efficiency Portfolio Standard, contained in section 269-96 of the Hawai'i Revised Statutes, to reduce electricity consumption in Hawai'i by 4,300 gigawatt-hours by 2030. To fund the energy efficiency program, a Public Benefits Fee surcharge is collected via utility customers' electricity bills. The program is assigned to the Hawai'i Public Utilities Commission (PUC) for administration. Kaua'i Island Utility Cooperative (KIUC) runs the energy efficiency program in its service territory (on the island of Kaua'i). In the service territories of the Hawaiian Electric Companies (the islands of O'ahu, Maui, Moloka'i, Lāna'i, and Hawai'i), the energy efficiency program is operated by Hawai'i Energy under contract to the PUC. Every five years, the PUC reports on the programs to the State Legislature.[24] Findings in the report to the 2019 Legislature included,

> **"The EEPS goal has been effective at accelerating deployment of energy efficiency resources throughout the State**. During the First EEPS Performance Period (2009-2015), Hawai'i achieved an estimated 2,030 GWh of electricity savings, exceeding the 2015 goal of 1,375 GWh of energy savings by nearly 50%. An additional 530 GWh of savings was achieved in 2016-2017…"
>
> "…**Energy efficiency remains a lower cost resource than most other energy options, while providing many other important benefits to Hawai'i's electric utilities and ratepayers**. However, Hawai'i's energy landscape has evolved significantly since the EEPS goal was established in 2009. Given the substantial increase in renewable energy available in Hawai'i (such as solar PV and wind), it is no longer a given that energy efficiency will always displace fossil fuel generation. As customers continue to invest in low-cost renewable energy and increasingly, energy storage, energy efficiency programs and investments must be integrated with other clean energy initiatives..." and
>
> "… the incentives and services delivered by the Hawai'i Energy program … were delivered at a cost far below the avoided cost of electricity generation. These impacts are expected to generate over three billion dollars of utility bill savings for customers over the life of the installed efficiency measures."

The Public Benefits Fee Surcharge added to the electricity bills of Hawaiian Electric Company customers for the 2020-2021 Program Year, based on 2.0 percent of the forecasted revenues and reduced by the amount of the Green Infrastructure Fee, is 0.5882 cents per kWh for residential customers and 0.3441 cents per kWh for commercial and industrial customers. This is a reduction from the previous levels of 0.7437 and 0.614 cents per kWh, respectively.[25] The amounts collected are used to fund the activities of Hawai'i Energy, the Public Benefits Fee Administrator (PBFA) in the service territories of the Hawaiian Electric Company (i.e., the islands of O'ahu , Maui, Moloka'i, Lāna'i, and Hawai'i).

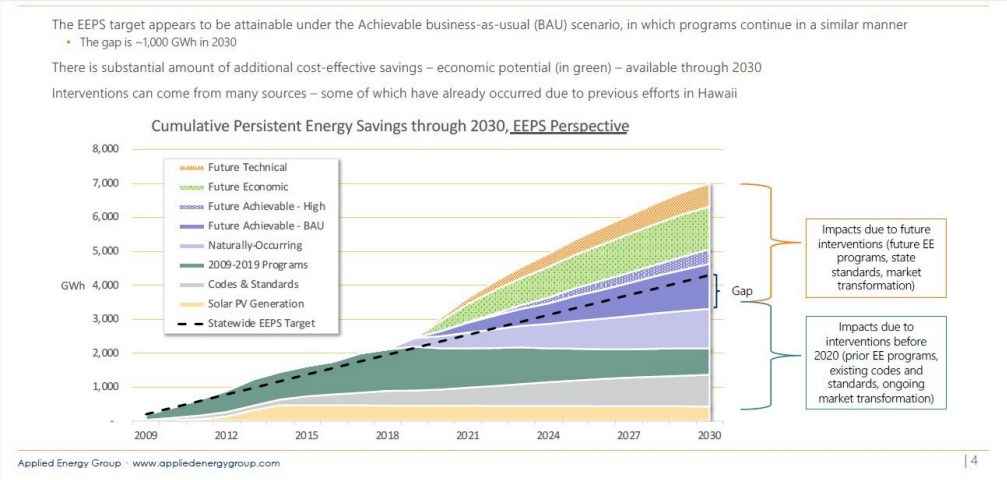
The Resource Cost Adjustment Surcharge Provision for KIUC is not applied to residential or streetlight service. For the other rate schedules, the fee is 0.000881 cents per kWh.[26]

Statewide Market Potential Study

The results from the Hawai'i Statewide Market Potential Study, performed for the Public Utilities Commission and released in August of 2020, indicate that additional energy efficiency efforts are needed to meet the energy efficiency targets of 2030. However, the future achievable, economic, and technical potential are roughly double the energy efficiency savings to date. Key findings are highlighted in the figures and text below.[27]

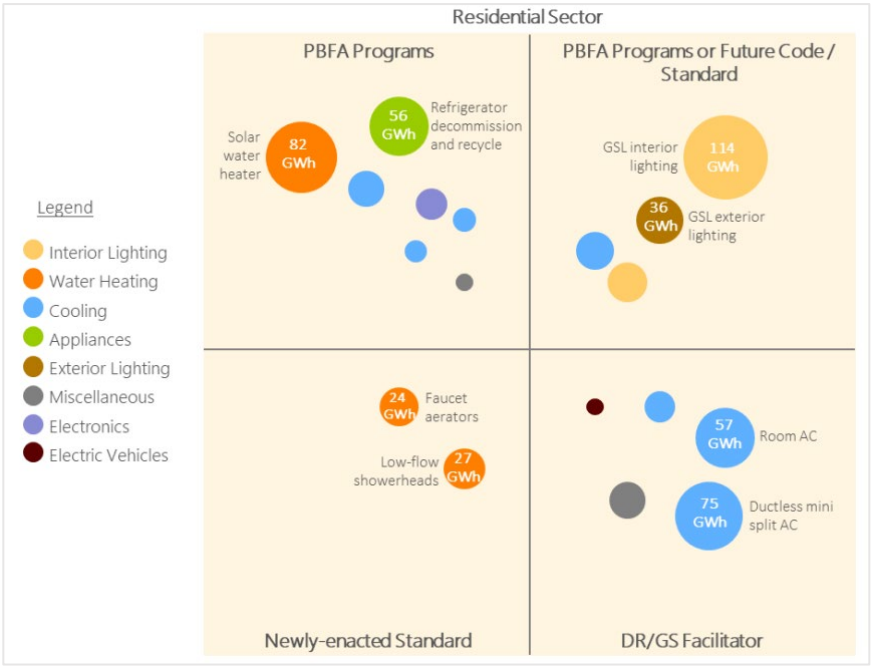
One of the report's summary charts is shown in Figure 19. The "Solar PV Generation" amounts in the Figure (bottom wedge) are photovoltaics installed prior to 2015, when PV was counted as an energy efficiency measure. Photovoltaics installed after 2015 are counted as renewable generation.

Figure 19 - Energy Efficiency Potential to 2030



Codes and standards are shown next, as a consistently increasing wedge. The third wedge from the bottom (dark green), shows the continuing savings from equipment installed under Hawai'i Energy programs between 2009-2019. The fourth wedge (light purple) shows naturally-occurring efficiency gains, and the fifth wedge (dark purple) shows "future achievable" savings, with Business as Usual (BAU).

Figure 20 – Residential Sector Energy Efficiency



As shown in Figure 20, energy efficiency measures can be categorized in four general areas: Public Benefits Fee Administrator (PBFA) programs; PBFA or future code/standard programs; demand response (DR)/grid services (GS) facilitator programs; and newly-enacted standards.

The PBFA residential programs (top two quadrants in Figure 20) have significant energy savings potential in several areas, the largest of which are interior lighting (114 GWh), solar water heating (82 GWh), and refrigerator swaps (56 GWh).

Other areas of potential are currently categorized under the heading of demand response (lower right-hand quadrant), and include two types of air conditioning, at 75 GWh and 57 GWh, for a total of 132 GWh.

The "commercial" sector (actually non-residential, since it includes government, educational, and others), as a larger energy using sector than residential, has even greater savings potential.

The types, and relative magnitude of potential by type of measure, are shown in Figure 21. The four types of interior lighting, combined, have a potential of 134, 122, 89, and 24 GWh, for a total of 369 GWh. Exterior lighting is also significant, as is air conditioning.

Figure 21 - Commercial Sector Energy Efficiency

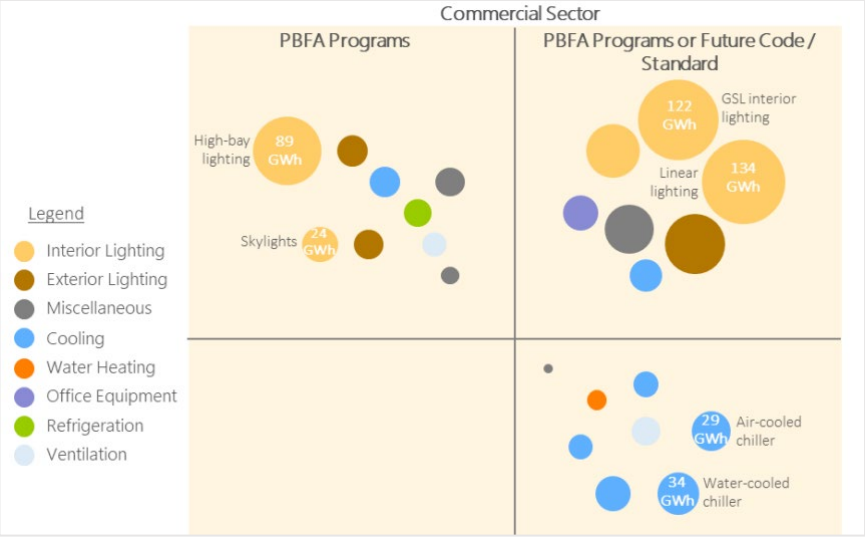
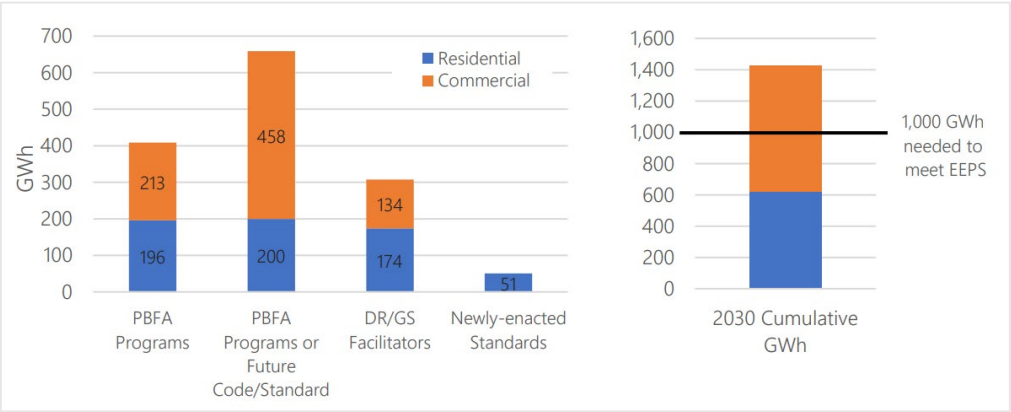


Figure 22 shows the projected cumulative savings from the most impactful measures total (about 1400 GWh) are greater than the amount remaining to meet the EEPS goal of 4300 GWh by 2030. However, as described elsewhere, increased energy efficiency – beyond the 4300 GWh goal set in 2008 – is required by objectives of affordability, carbon reduction, and renewable proportionality.

Figure 22 - Cumulative Savings From Most Impactful Measures



Hawai'i Energy

Hawai'i Energy is the Public Benefits Fee Administrator for the electric utility service territories served by the Hawaiian Electric Companies.

Energy efficiency program costs for the program year 2019-2020 were approximately $32 million, first year savings were 134.3 million kWh, and lifetime bill savings for the measures installed is projected to be more than $481 million (over $15 saved per $1 spent). Levels of participation and results are shown in Table 5.[28]

Table 5 - Hawai'i Energy's Efficiency Program, Program Year 2019-2020
Fees Collected, Number and Type of Participants, and Results (kWh and $ Savings)

Area	Fees Collected	Number of Participants		Customer kWh Savings per Year	Customer Bill Savings per Year	Customer Bill Savings Over Measure Life
		Residential	Businesses			
Island of O'ahu	$ 22,602,627	10,225	794	98,329,925	$ 27,284,279	$ 347,221,864
Maui Nui	$ 4,083,081	1354	132	17,299,056	$ 5,593,490	$ 65,249,681
Island of Hawai'i	$ 4,038,439	1,433	116	18,701,111	$ 6,164,402	$ 69,306,999
Total for 3 counties	**$ 30,724,147**	**13,012**	**1,042**	**134,330,092**	**$ 39,042,171**	**$ 481,778,544**

Government Agencies' Energy Efficiency Programs

As shown in Figure 23, Hawai'i state agencies' electricity use in 2019 was 17.5 percent less than it was 2005 (the baseline year). HSEO tracks and reports on electricity purchased by state agencies as part of the "Lead By Example" (LBE) initiative.

As shown in Figure 24, even with generally decreasing amounts of electricity use by State agencies from year to year (the orange line), electricity bills (the gray line) go up and down due to the varying price of electricity (the blue line), which is largely affected by the price of oil (the yellow line).

Figure 23 - Comparison of State Agencies' Electricity Consumption in kWh: FY05 to FY19

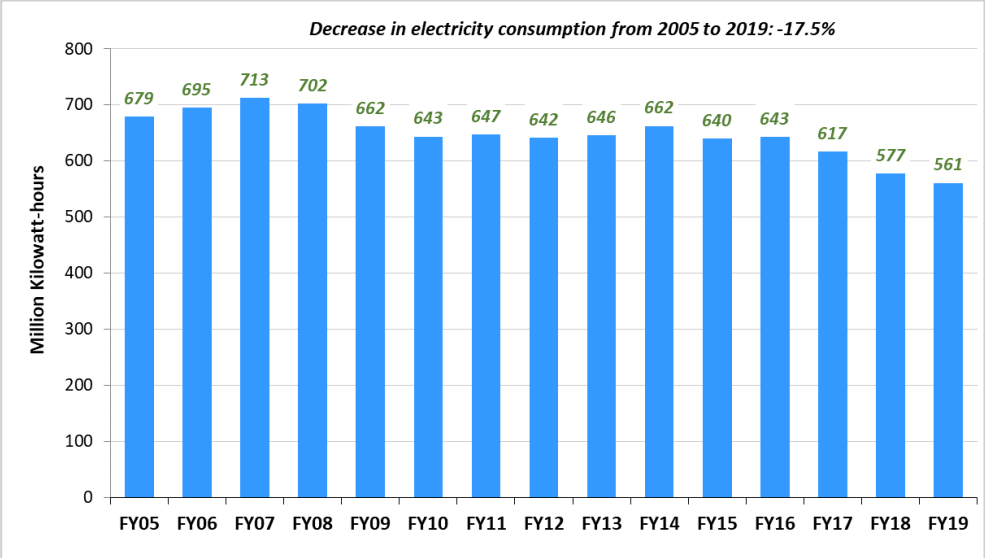
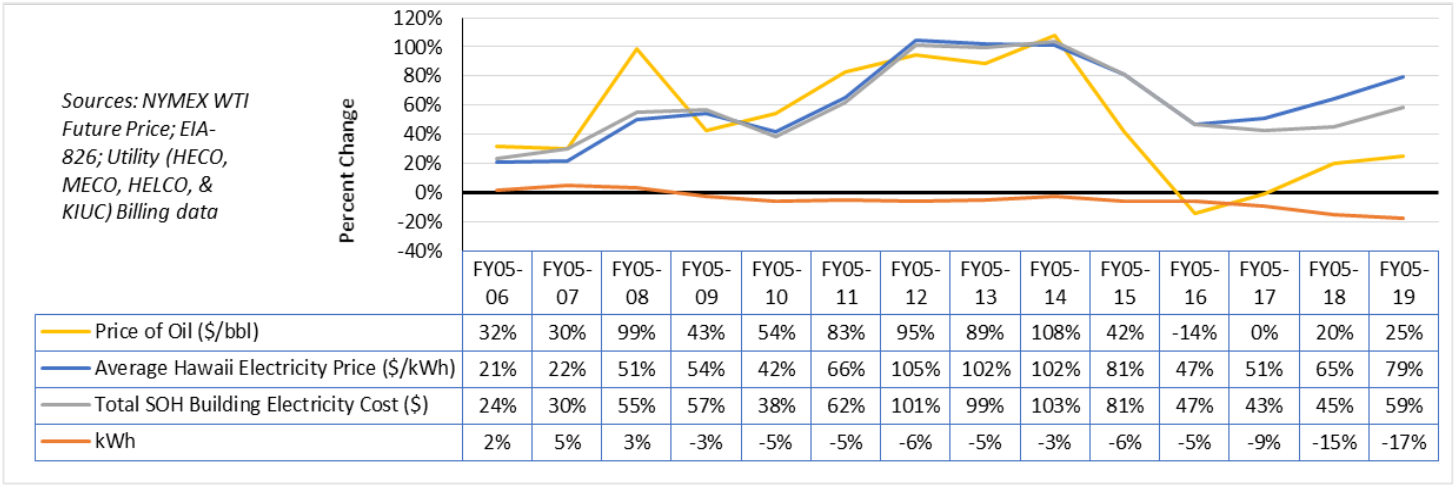


Figure 24 – State Government Agency Electricity Cost Variability by Year (2005 baseline)



	FY05-06	FY05-07	FY05-08	FY05-09	FY05-10	FY05-11	FY05-12	FY05-13	FY05-14	FY05-15	FY05-16	FY05-17	FY05-18	FY05-19
Price of Oil ($/bbl)	32%	30%	99%	43%	54%	83%	95%	89%	108%	42%	-14%	0%	20%	25%
Average Hawaii Electricity Price ($/kWh)	21%	22%	51%	54%	42%	66%	105%	102%	102%	81%	47%	51%	65%	79%
Total SOH Building Electricity Cost ($)	24%	30%	55%	57%	38%	62%	101%	99%	103%	81%	47%	43%	45%	59%
kWh	2%	5%	3%	-3%	-5%	-5%	-6%	-5%	-3%	-6%	-5%	-9%	-15%	-17%

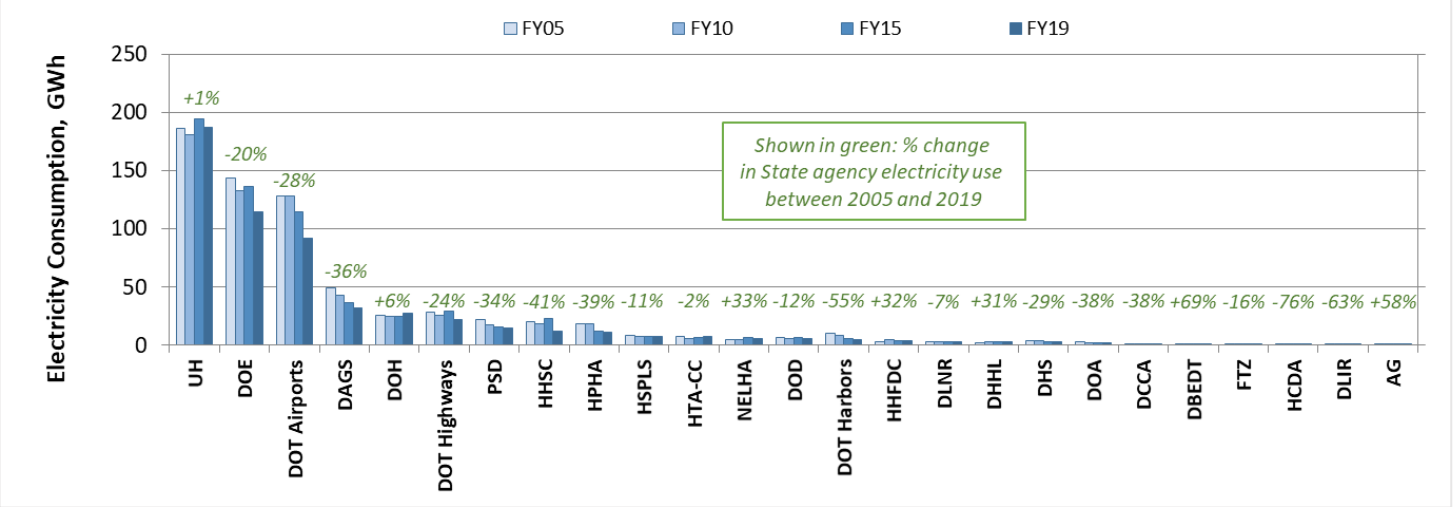
Several factors have contributed to the decline shown by the orange line: participation in energy efficiency programs; energy-efficient design in construction and renovation; and energy performance contracts.

Since 1996, state agencies have received nearly $13.1 million in efficiency rebates.[29] Combined, these rebates have resulted in more than $302 million estimated cumulative dollar savings and 1.6 billion kWh electricity savings. Over the life of the equipment, these savings would be enough to power about 192,000 households for a year.[30] From June 2019 through March 2020, state agencies received $420,000 in rebates.

The state also requires all new construction and major renovation to meet "Leadership in Energy and Environmental Design" (LEED) Silver standards, to the extent possible.[31]

Figure 25 shows the relative magnitude of electricity purchases by the various agencies, and the percentage change from 2005 to 2019.

Figure 25 - GWh Consumption by Agency in 2005, 2010, 2015, and 2019; Percent change from 2005 to 2019



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

State and County Energy Performance Contracts

With an Energy Performance Contract (EPC), a State or County agency enters into an agreement with a private Energy Services Company (ESCO) to purchase and install an Energy Conservation Measure (possibly including photovoltaics), in which the agency will use a portion of the electricity bill savings from those energy conservation measures to, over time, reimburse the ESCO for the cost of the equipment, installation, and possibly maintenance. This allows the private contractor to purchase and install equipment that reduces energy and water use in government-owned facilities, based on the future savings from the energy conservation measures, with no required up-front payment by the government agency. Under the agreement, the ESCO will guarantee the savings – and pay for any shortfall.

The savings provided to government operations from performance contracts have been significant. Since the performance contracting program was introduced by the State Energy Office in 1996, state and local government agencies have saved an estimated $1.1 billion in energy costs over the life of the contracts, and a cumulative amount of electricity equal to the amount used by 396,586 homes in one year. The projects comprise over 112 million square feet in 295 existing buildings and facilities.

For eight consecutive years (2012-2019), Hawai'i has garnered national recognition from the *Race to the Top* award from the Energy Services Coalition. The award is given to the state with the highest per capita investment in performance contracting projects. The Energy Services Coalition also recognized Hawai'i for signing the single largest performance contract by a state agency (Hawai'i State Department of Transportation, Airports Division, performance contract for nearly $209.8 million). Hawai'i remains the *Race to the Top* all-time per-capita investment leader, as shown in Table 6.[32]

Table 6 – Energy Services Coalition Ranking of States as of October, 2020

State	Population	Performance Contracting	Dollars per Capita
1. Hawai'i	1,360,301	$507,133,904	$372.81
2. Washington	6,724,540	$1,424,458,811	$211.83
3. Delaware	897,934	$184,776,551	$205.78
4. Kentucky	4,339,367	$750,000,000	$172.84
5. Massachusetts	6,547,629	$1,027,848,634	$156.98

Saving Energy Through Building Design

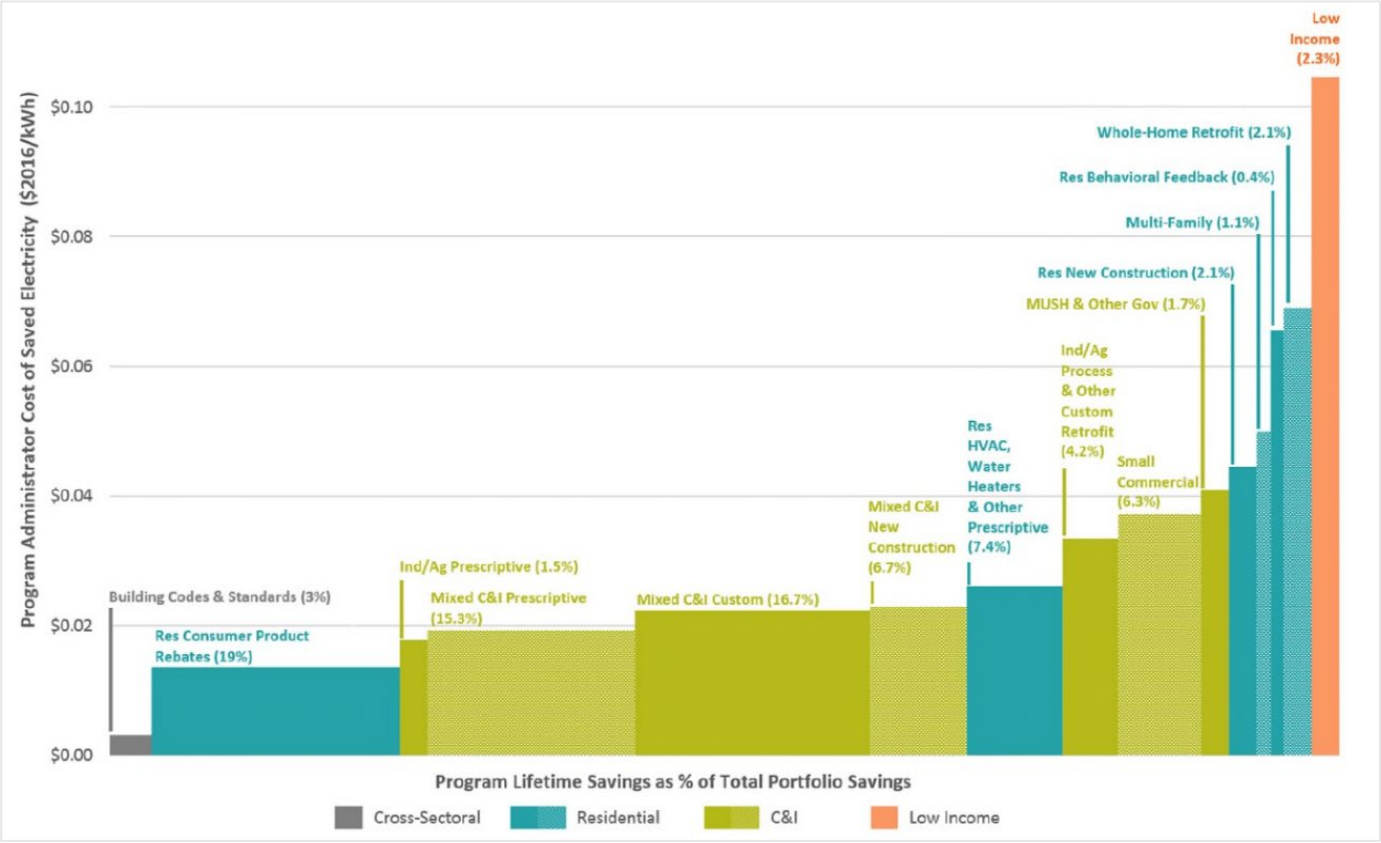
Buildings use a great deal of energy, and potential energy savings are significant. According to the U.S. Department of Energy:[33]

> "The buildings sector accounts for about 76% of electricity use and 40% of all U.S. primary energy use and associated greenhouse gas (GHG) emissions… Opportunities for improved efficiency are enormous. By 2030 building energy use could be cut more than 20% using technologies known to be cost effective today and by more than 35% if research goals are met. Much higher savings are technically possible."

Building Codes; State Energy Building Code Council; County Energy Codes

In a study published in 2020 that collected information from forty-one states, efforts to improve energy-efficient building codes and standards were recognized as a very low-cost measure (far left), at significantly less than one cent per kWh saved, as shown in Figure 26.[34]

Figure 26 - Cost-effectiveness of Various Energy Efficiency Measures



International Energy Conservation Code (IECC)

With the adoption of the 2015 IECC (as amended) by the City and County of Honolulu in June 2020, all of Hawai'i's counties have now adopted the 2015 IECC with Hawai'i amendments.[35] The estimated net savings from the 2015 IECC with Hawai'i amendments is 12,962 MWh in 2019; 1,083,590 MWh in 2029 (year 10); 1,991,059 MWh in 2032; and 4,702,738 MWh in 2038 (year 20). Savings are greater in commercial buildings, that are expected to save about 33 percent compared to the 2006 IECC. The savings estimates will rise as a result of additional amendments adopted by the counties.[36]

Residential Code Savings: Fully conditioned 2015 IECC residences may achieve a 6 to 9 percent improvement in energy efficiency. Those following the Tropical Climate Zone compliance path could realize a savings of up to 48 percent compared to the model code by opting to utilize natural ventilation and choosing the highest-efficiency options when adopting the 2015 IECC with amendments.[37]

Leadership in Energy and Environmental Design (LEED)

According to State Market Briefs released by the U.S. Green Building Council (USGBC), as of October 2020, Hawai'i had 132 LEED certified projects with a gross square footage of over 9.3 million square feet. The certified buildings included numerous private developments, as well as federal, state, and county public buildings. Also, there are 948 LEED Credentialed professionals, plus 236 with LEED Specialties, and an additional 107 LEED Green Associates, based in Hawai'i. [38] In 2019, Hawai'i was back among the top 10 states for LEED certified project square footage per capita. With 4.08 million LEED-certified gross square footage and 12 projects certified, Hawai'i rated 5th highest state in the U.S. this year.[39]

ENERGY STAR® Buildings

Since 2000, 174 Hawai'i buildings covering over 32 million square feet have received the ENERGY STAR certification, including over 100 public buildings. [40] During this time, HSEO has helped to benchmark 416 state facilities (with over 2600 individual buildings) and to obtain ENERGY STAR certification for 83 state school facilities. The Hawaii State Office Tower achieved ENERGY STAR certification in 2019.

Appliance Efficiency Standards

Federal efficiency standards are in place for a variety of consumer products. [41,42] According to the U.S. Department of Energy (DOE),[43]

> "Appliance and equipment efficiency standards have served as one of the nation's most effective policies to improve energy efficiency and to save consumers energy and money… DOE is currently required to periodically review standards and test procedures for more than 60 products, representing about 90% of home energy use, 60% of commercial building energy use, and 30% of industrial energy use…"

Also, according to the United States Environmental Protection Agency,[44]

> "State appliance standards establish minimum energy-efficiency levels for appliances and other energy-consuming products... States are finding that appliance standards offer a cost-effective strategy for improving energy efficiency and lowering energy costs for businesses and consumers… some of the products with the largest potential for savings in each sector [are being] considered by an Appliance Standards Awareness Project (ASAP)…"

According to the 2020 report by the Appliance Standards Awareness Project, the national appliance standards that are in place are saving Hawai'i households about $945 a year on utility bills, and businesses $158 million per year.[45] The 2020 "States Go First" report estimated potential cumulative future (by 2035) savings in Hawai'i of 44 GWh of electricity, 3 billion gallons of water and 455 metric tons of CO_2 if Hawai'i were to adopt the 2020 State Appliance Standards Recommendations.[46]

Examples of Success

Hawaii Green Business Program

To help businesses implement energy and resource efficiency practices, the Hawaii Green Business Program was established as a partnership between the HSEO, the Department of Health, the Board of Water Supply, and the Chamber of Commerce of Hawai'i.[47] From 2009 through 2018, over 125 business and government entities—including sectors such as hospitality, commercial office, retail, restaurant, food services, grocery, venue and green events have saved: [48]

- 23.5 million kWh of energy (equivalent to powering 3,620 homes for one year in Hawai'i);
- 244.1 million gallons of water; and
- $6.6 million in energy costs.

Hawaii Green Infrastructure Authority

The Hawaii Green Infrastructure Authority ("HGIA") was created by the Legislature to make clean energy investments accessible and affordable for Hawai'i's consumers. HGIA was capitalized with the proceeds from the Green Energy Market Securitization ("GEMS") Bond, an innovative market-driven financing mechanism, to advance Hawai'i's Energy Efficiency Portfolio Standards ("EEPS") and to support efforts to the 100 percent renewable portfolio standard ("RPS") goal in the electricity sector by 2045. The Hawaii Green Infrastructure Authority is Hawai'i's Green Bank.

Shown in Table 7 are HGIA Program results utilizing some $67.5 million in loan capital to leverage $37.3 million in private capital, for a total $104.8 million in clean energy investments within the Hawaiian Electric's service territory.

Table 7 - Hawaii Green Infrastructure Authority Program Results as of June 30, 2020

Excess Operational Revenues over Expenditures fiscal Year ended 6/30/20[49]	$ 2,706,733
Jobs Created / Retained Since Inception	1,087
State of Hawai'i Tax Revenues Generated Since Inception	$ 13,212,684
Aggregate Gross Electricity Cost Savings over lifetime	$ 289,047,767
Aggregate Utility Bill Savings over lifetime	$ 185,809,274
Total Estimated kWh Production / Reduction Over Lifetime Since Inception	801,847,888
Total Petroleum Displaced Over Lifetime (Estimated Barrels)	492,321
Total Greenhouse Gas Avoided Over Lifetime (Estimated Metric Tons CO_2)	241,167
% Underserved Residential Households Served[50]	77.0%

The funds managed by HGIA are loans, not grants, and must be paid back.

Distributed Energy Resources

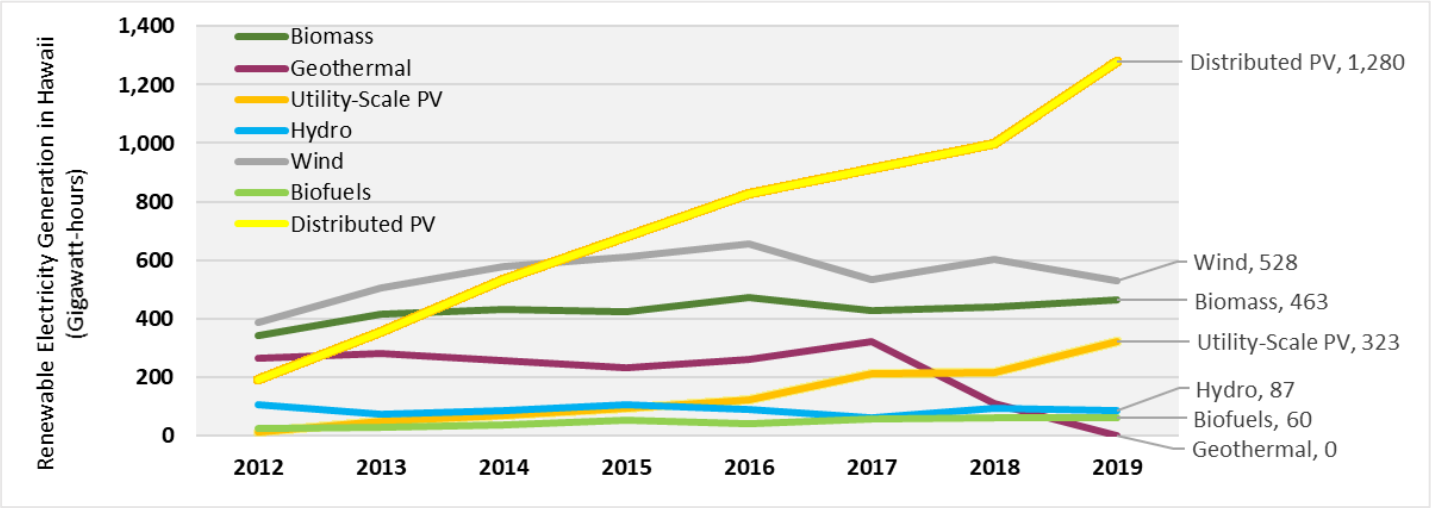
The term "Distributed Energy Resources" (DER) has been evolving over the years. Currently, in the Hawai'i Public Utilities Commission Docket No. 2019-0323, the term is broadly defined:

> **"DER" includes "distributed generation, energy efficiency, demand response, electric vehicles, and distributed energy storage."**

The definition provided above is broader than that which had been common previously, which generally referred to on-site generation of electricity from renewable resources; electricity generation from fossil fuels, such as backup generators running on diesel or propane; combined heat and power (or heat, power, and cooling systems) generating both electricity and heat for use on site; and battery storage.

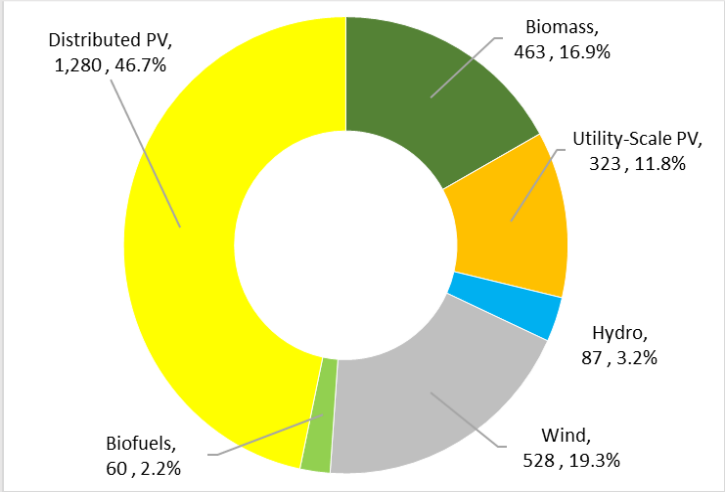
The vast majority of "customer sited DER" systems in Hawai'i are photovoltaic (PV) installations that are connected to the electrical grid. DER installations have been increasing, as shown in Figure 28, and are currently the largest collective source of renewable energy generation in Hawai'i.[51]

Figure 28 – Distributed PV is the Fastest-Growing Source of Renewable Electricity in Hawai'i
Renewable Energy Production, Gigawatt-hours, 2011-2019



Renewable Electricity

Figure 27 - Renewable Electricity Generation in Hawai'i, Gigawatt-hours (GWh) and Percent by Source, 2019



In 2019, over 2,000 gigawatt-hours (2,741 GWh) of renewable electricity was generated from a variety of sources, as shown in Figure 27.[52] Sources were:

- Distributed photovoltaics (PV) at 1,280 GWh, providing nearly half (47%) of the total; followed by
- Wind at 528 GWh(19%);
- Biomass at 463 GWh (17%);
- Utility-scale PV at 323 GWh (12%);
- Hydro at 87 GWh (3%); and
- Biofuels at 60 GWh (2%) of the renewable electricity total.

The amount contributed by the various sources to the renewable energy total has changed over the years, as shown in Figure 28 (comparative amounts) and Figure 32 (stacked amounts).

Renewable Portfolio Standards (RPS)

Much of the increase in renewable generation in Hawai'i may be attributed to Hawai'i's renewable portfolio standard (RPS) law, which defines "renewable energy" as electricity generated or produced using the following sources:[53]

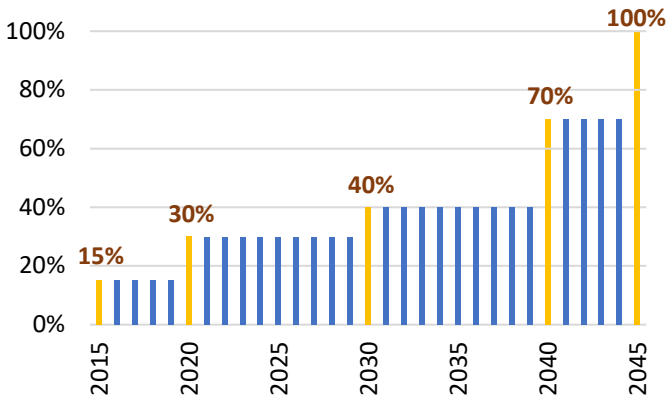
- Biofuels
- Biogas
- Biomass, including solid waste
- Falling water (hydropower)
- Geothermal
- Hydrogen produced from renewable energy sources
- Ocean water, currents, and waves, including ocean thermal energy conversion
- Sun
- Wind

By law, each of the electric utilities – Hawaiian Electric, serving the islands of O'ahu, Maui, Moloka'i, Lāna'i, and Hawai'i; and the Kaua'i Island Utility Cooperative (KIUC), serving the island of Kaua'i – report their Renewable Portfolio Standard (RPS) levels to the Public Utilities Commission on an annual basis.

Hawai'i's Renewable Portfolio Standards, shown in Figure 29, are currently 15 percent, rising to:

- 30% by December 31, 2020;
- 40% by December 31, 2030;
- 70% by December 31, 2040; and
- 100% by December 31, 2045.[54]

Figure 29 - Renewable Portfolio Standards in Hawai'i



The definition of "Renewable Portfolio Standard" is "the percentage of electrical energy sales that is represented by renewable electrical energy."[55] It includes, in the numerator, the gigawatt-hours generated by rooftop solar systems and utility-scale renewable energy. The denominator is the gigawatt-hours of electricity sold by the utility, which does not include electricity produced by rooftop systems and used on-site (also referred to as "behind the meter").

Hawaiian Electric

As shown in Figure 30, top left, Hawaiian Electric has exceeded the required RPS levels to date. The contributions of the individual entities are also shown. The Hawaiian Electric companies provide quarterly data on their RPS performance and a variety of other metrics (including "System Renewable Energy," which does not include customer-sited renewable generation, and "Total Renewable Energy," which adds customer-sited generation to the denominator) on their website.[56] Data from the RPS reports filed with the PUC is provided in Table 8.[57]

Figure 30 - Reported RPS Levels, Hawaiian Electric Companies, 2013-2019

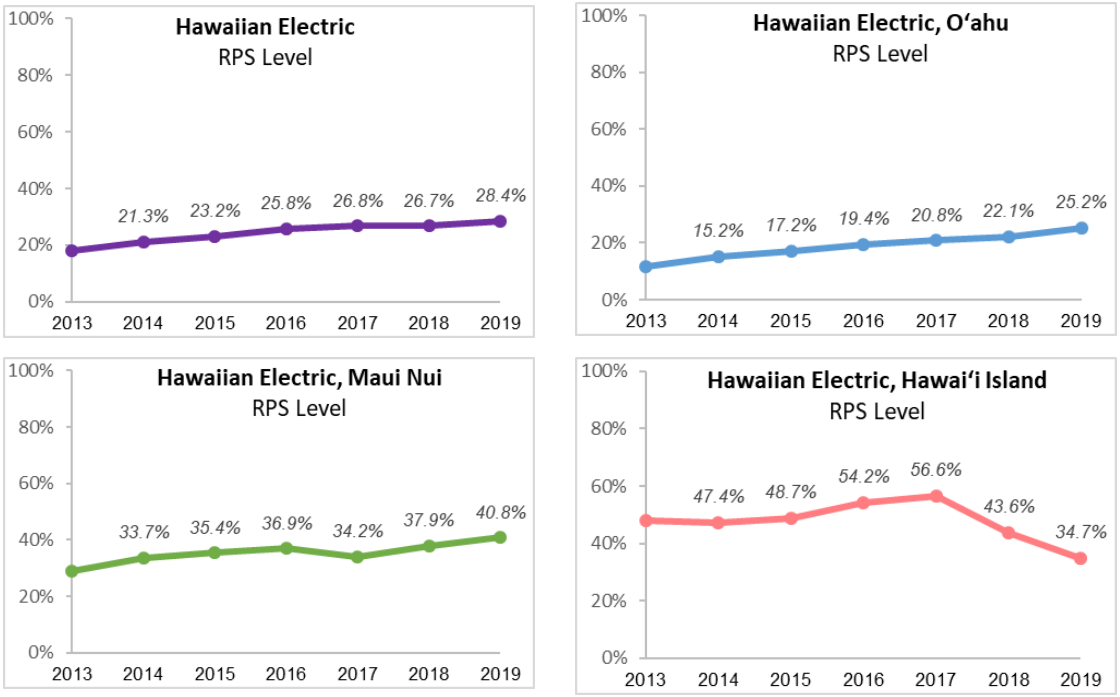


Table 8 - Renewable Energy Generation and Sales, Hawaiian Electric, MWh, 2013-2019

	(in MWh)	2013	2014	2015	2016	2017	2018	2019
Hawaiian Electric	**Renewables**	1,648,451	1,913,561	2,080,772	2,283,119	2,328,393	2,324,218	2,480,290
	Biomass	415,691	433,164	416,716	423,118	381,138	389,730	414,357
	Geothermal	281,417	255,027	230,495	260,116	322,609	110,089	-
	Utility PV	33,925	44,255	51,211	66,872	142,868	149,149	218,057
	Hydro	40,155	51,155	73,098	55,076	30,285	62,734	35,414
	Wind	503,548	577,867	612,781	656,678	532,874	602,008	527,887
	Biofuels	29,789	37,093	53,412	38,475	55,982	62,034	59,996
	Distributed PV	343,926	515,000	643,059	782,784	862,637	948,474	1,224,579
	Total Sales	9,069,513	8,976,242	8,956,498	8,845,335	8,690,433	8,688,772	8,739,984
	RPS	**18.18%**	**21.32%**	**23.23%**	**25.81%**	**26.79%**	**26.75%**	**28.38%**
Hawaiian Electric, O'ahu	**Renewables**	801,009	1,029,070	1,159,629	1,292,042	1,362,162	1,444,033	1,655,628
	Biomass	374,569	390,011	385,846	418,735	381,138	389,730	414,357
	Geothermal	-	-	-	-	-	-	-
	Utility PV	27,303	37,363	40,750	53,723	128,939	132,366	194,661
	Hydro	-	-	-	-		-	-
	Wind	121,691	183,864	216,197	233,531	191,560	200,644	148,296
	Biofuels	28,508	36,175	52,424	37,491	55,023	61,082	52,645
	Distributed PV	248,938	381,657	464,412	548,562	605,502	660,211	845,669
	Total Sales	6,858,536	6,781,665	6,754,083	6,660,195	6,548,697	6,525,670	6,563,104
	O'ahu RPS	**11.68%**	**15.17%**	**17.17%**	**19.40%**	**20.80%**	**22.13%**	**25.23%**
Hawaiian Electric, Maui Nui	**Renewables**	330,067	381,351	402,832	412,307	373,980	416,061	459,984
	Biomass	41,122	43,153	30,870	4,383		-	-
	Geothermal	-	-	-	-		-	-
	Utility PV	5,097	5,324	7,904	9,078	9,705	12,859	19,172
	Hydro	4,745	8,150	9,823	968	650	347	-
	Wind	230,305	257,907	264,291	277,456	231,688	254,698	236,916
	Biofuels	1,281	918	988	984	959	952	942
	Distributed PV	47,517	65,899	88,956	119,438	130,978	147,205	202,954
	Total Sales	1,134,873	1,132,056	1,137,630	1,117,742	1,094,786	1,099,020	1,127,338
	Maui RPS	**29.08%**	**33.69%**	**35.41%**	**36.89%**	**34.16%**	**37.86%**	**40.80%**
Hawaiian Electric, Hawai'i Island	**Renewables**	517,375	503,140	518,311	578,770	592,251	464,124	364,678
	Biomass	-	-	-	-		-	-
	Geothermal	281,417	255,027	230,495	260,116	322,609	110,089	-
	Utility PV	1,525	1,568	2,557	4,071	4,224	3,924	4,224
	Hydro	35,410	43,005	63,275	54,108	29,635	62,387	35,414
	Wind	151,552	136,096	132,293	145,691	109,626	146,666	142,675
	Biofuels	-	-	-	-	-	-	6,409
	Distributed PV	47,471	67,444	89,691	114,784	126,157	141,058	175,956
	Total Sales	1,076,104	1,062,521	1,064,785	1,067,398	1,046,950	1,064,082	1,049,542
	Hawai'i RPS	**48.08%**	**47.35%**	**48.68%**	**54.22%**	**56.57%**	**43.62%**	**34.75%**

Kaua'i Island Utility Cooperative

The RPS levels reported by Kaua'i Island Utility Cooperative (KIUC), which have tripled since 2013 and currently exceed fifty percent, are shown in Figure 31. Data is provided in Table 9.[58]

Figure 31 - Reported RPS Levels, Kaua'i Island Utility Cooperative (KIUC), 2013-2019

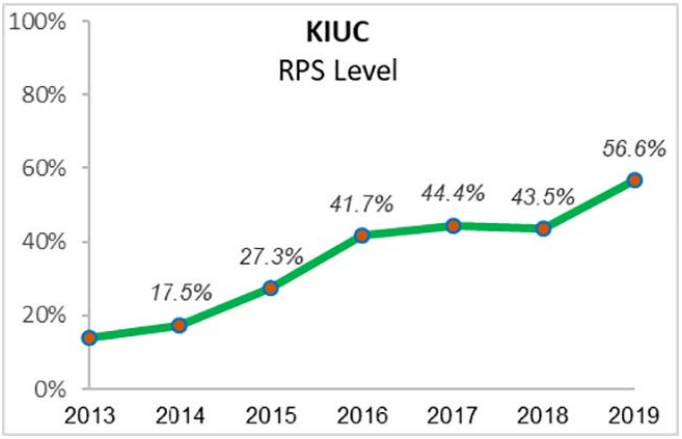


Table 9 - Renewable Energy Generation and Sales, Kaua'i Island Utility Cooperative, MWh, 2013-2019

	(in MWh)	2013	2014	2015	2016	2017	2018	2019
KIUC	**Renewables**	59,385	75,197	118,027	182,904	197,445	196,094	260,797
	Biomass	-	-	5,465	49,656	46,192	49,315	48,885
	Geothermal	-	-	-			-	-
	Utility-Scale PV	14,324	24,301	40,650	54,926	69,504	67,882	105,112
	Hydro	33,351	34,086	33,646	34,301	30,755	29,264	51,673
	Wind	-	-	-			-	-
	Biofuels	-	-	-			-	-
	Distributed PV	11,710	16,810	38,266	44,021	50,994	49,633	55,127
	Total Sales	431,478	429,924	432,076	439,088	445,098	451,114	460,710
	RPS	**13.76%**	**17.49%**	**27.32%**	**41.66%**	**44.36%**	**43.47%**	**56.61%**

Figure 32 - Combined Statewide RPS Level Combining both of Hawai'i's Electric Utilities

Statewide

The Hawaii State Energy Office also tracks progress on a statewide basis by combining the utilities' RPS reports. The data is provided in Table 10 and the resulting graph is Figure 32.

Renewable generation by type of resource is shown in Figure 33.

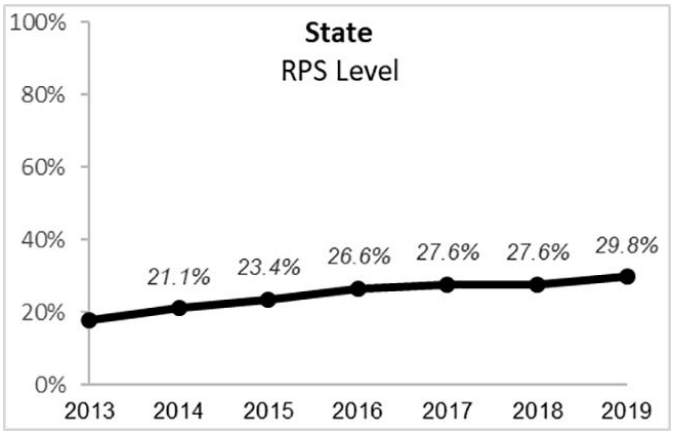
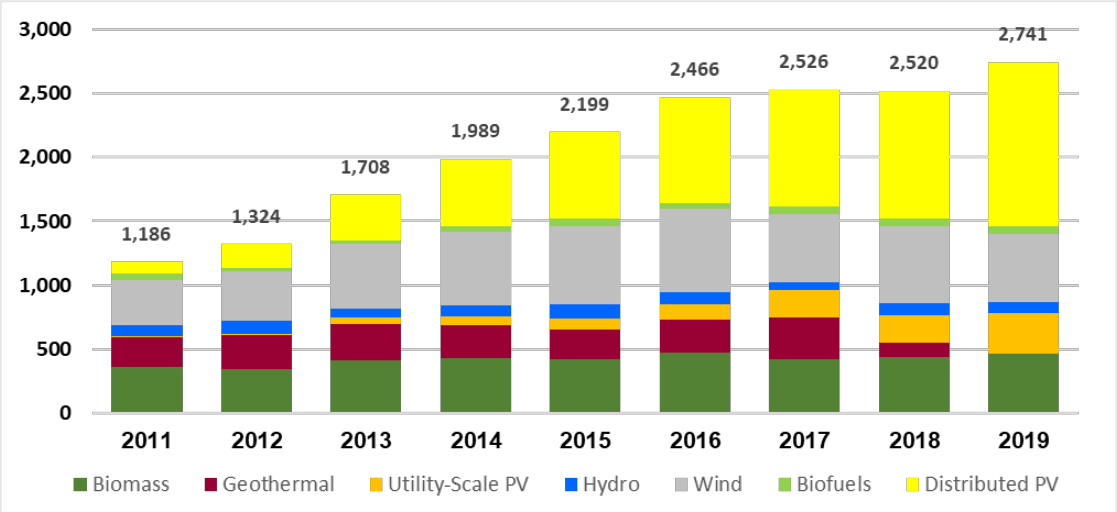


Table 10 - Renewable Energy Generation and Sales, Statewide, MWh, 2010-2019

	(in MWh)	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
STATE	**Renewables**	1,707,836	1,988,758	2,198,799	2,466,023	2,525,838	2,520,312	2,741,087
	Biomass	415,691	433,164	422,181	472,774	427,330	439,045	463,242
	Geothermal	281,417	255,027	230,495	260,116	322,609	110,089	-
	Utility-Scale PV	48,249	68,556	91,861	121,798	212,372	217,031	323,169
	Hydro	73,506	85,241	106,744	89,377	61,040	91,998	87,087
	Wind	503,548	577,867	612,781	656,678	532,874	602,008	527,887
	Biofuels	29,789	37,093	53,412	38,475	55,982	62,034	59,996
	Distributed PV	355,636	531,810	681,325	826,805	913,631	998,107	1,279,706
	Total Sales	9,500,991	9,406,166	9,388,574	9,284,423	9,135,531	9,139,886	9,200,694
	RPS	**17.98%**	**21.14%**	**23.42%**	**26.56%**	**27.65%**	**27.57%**	**29.79%**

Figure 33 - Renewable Electricity Generation in Hawai'i, By Source, GWh, 2011-2019



Renewable Energy Resources

The use of locally available energy sources is a component of Hawai'i's energy objectives and policies, to reduce dependence on imported fuels. As stated in the Hawai'i State Planning Act:

> **§226-18 Objectives and policies for facility systems—energy.** (a) Planning for the State's facility systems with regard to energy shall be directed toward the achievement of … Increased energy security and self-sufficiency through the reduction and ultimate elimination of Hawai'i's dependence on imported fuels for electrical generation and ground transportation…

Renewable energy resources available in Hawai'i are, in alphabetical order:

- Bioenergy
- Geothermal Energy
- Hydropower
- Ocean Energy
- Solar Energy
- Wind Energy

Bioenergy

"Bioenergy" includes:

- Biofuels
- Biogas, including landfill and sewage-based digester gas
- Biomass, including biomass crops, agricultural and animal residues and wastes, municipal solid waste, and other solid waste

Biofuel Projects and Production

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

Currently, the only commercially produced biofuel in Hawai‘i is biodiesel produced by Pacific Biodiesel. The company’s facility on Hawai‘i Island, with a capacity of 5.5 million gallons per year, produces fuel for use in the transportation sector as well as for use in power plants on O‘ahu, Maui, and Hawai‘i Island. The facility is able to use waste cooking oil as well as oils from locally-grown biofuel crops such as algae, sunflower, and pongamia.[59]

Power plants in Hawai‘i designed specifically to use biofuel, in addition to petroleum-based biodiesel, include:

- **Daniel K. Inouye International Airport Emergency Power Facility**, in partnership between Hawaiian Electric and the Hawai‘i Department of Transportation
- **Schofield Generating Station**, in partnership between Hawaiian Electric and the United States Army
- **Campbell Industrial Park (CIP-1) Generating Station**, owned and operated by Hawaiian Electric

In addition, some of the fossil fueled power plants on Hawai‘i Island and in Maui County use small quantities of biofuel to supplement fossil fuels and to reduce emissions of those facilities.

In 2019, biofuels generated 59,996 megawatt-hours or approximately 0.65 of the electrical energy sold statewide.

Biogas Project and Production

Biogas is currently produced on O‘ahu by a facility owned and operated by Hawai‘i Gas. The biogas is provided by the City and County of Honolulu’s Department of Environmental Services, from the Honouliuli Wastewater Treatment Plant in ‘Ewa Beach. This gas production system uses biodigestion to convert organic materials and wastes into nearly 800,000 therms of biogas annually, for distribution and use on O‘ahu.

Biomass Energy Projects and Production

Biomass includes biomass crops grown primarily or secondarily for energy conversion (energy crops), agricultural and animal residues and wastes, municipal solid waste, and other solid waste (waste-to-energy).

The Green Energy Biomass-to-Energy facility on Kaua‘i is the first “closed loop” biomass plant in the United States that gets all its feedstock from its own local wood plantations. The facility also reuses its own water, carbon dioxide, and ash generated by its steam generators for its plantation needs. Before its plantations were self-sufficient, the facility used up to 3 acres per day of harvested invasive albizia trees. In 2019, the Green Energy facility generated 48,884 megawatt-hours, which was 10.6 percent of the electrical energy sold on Kaua‘i (0.53 percent of the electrical energy sold statewide).

Currently, there is only one operational waste-to-energy facility in Hawai‘i, the H-POWER facility on O‘ahu owned by the City and County of Honolulu and operated by Covanta. Operational in 1990 and expanded in 2015, H-POWER processes over 700,000 tons of waste annually, including residential waste, commercial waste, bulky waste, and sewage sludge, reducing the volume of waste going to the landfill by 90 percent. In 2019, waste-to-energy generated 414,357 megawatt-hours, which was 6.3 percent of the electricity sold by the utility on O‘ahu (4.5 percent of the electricity sold statewide).

Biomass and Waste-To-Energy Pricing

In Fiscal Year 2019, the amounts paid for electricity from Hawai‘i’s two operating utility-scale biomass and waste-to-energy projects were: [60]

Green Energy Biomass-to-Energy Facility (baseload)	$0.2549/kWh
H-POWER (firm)	$0.1741/kWh (on-peak), $0.1207/kWh (off-peak)

Geothermal

The Puna Geothermal Venture (PGV) facility owned and operated by Ormat Technologies and located in Pāhoa on the east side of Hawai'i Island, with a capacity of 38 MW, was closed in May 2018 due to the Kīlauea eruption and remains closed as of October 2020.[61] In its last full year of operation (2017), PGV generated nearly 31 percent of the electricity distributed by the electric utility on Hawai'i Island.

Hydropower

Hydropower Projects and Production

Several small home-scale plants, commercial and municipal installations, and utility-scale hydropower facilities are currently in operation in Hawai'i, totaling around 30 megawatts (MW) of installed hydroelectricity capacity statewide. Kaua'i and Hawai'i Island are the only islands on which utility-scale hydropower projects are operating.

Hawai'i's largest hydropower plant is the 12.1 MW Wailuku River plant on Hawai'i Island, and the smallest is the 6.7 kW Ainako Hydro project developed and used by a community group on Hawai'i Island. Also, the Hawai'i County Department of Water Supply (DWS) has three small in-line hydropower plants under 100 kilowatts that capture the energy from pipes carrying water to DWS customers in West Hawai'i.

In 2019, hydropower represented 11.2 percent of the total electricity sold by KIUC on Kaua'i and 3.4 percent of the electricity sold by Hawaiian Electric on Hawai'i island, the only two islands that generated reported hydroelectricity that year. In 2019, hydropower represented 0.94 percent of the total energy distributed by Hawai'i's electric utilities statewide.

Hydropower Pricing

In Fiscal Year 2019, the amounts paid for electricity from Hawai'i's hydropower facilities were: [62]

Kaua'i Coffee Hydro	$0.20/kWh
Gay & Robinson Olokele	$0.178/kWh
Kekaha Agricultural Association Hydro	$0.0917/kWh
Wailuku River Hydro	$0.1598/kWh (on-peak), $0.1536/kWh (off-peak)

Ocean Energy

Ocean or marine energy includes both hydrokinetic and thermal resources. Hydrokinetic technologies tap the movement of water 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. Research on OTEC is ongoing at the Natural Energy Laboratory of Hawaii Authority (NELHA) on Hawai'i Island, and demonstrations of wave energy technologies are taking place at the Wave Energy Test Site on O'ahu. Cold, deep ocean water can also be used for sea water air conditioning (SWAC), which is being done on Hawai'i Island at NELHA and is under development for Downtown Honolulu.

Ocean current and tidal resources are not as promising in Hawai'i due to relatively mild tidal shifts compared to other parts of the world.

Hawai'i's electric utilities do not currently report any electricity generation from wave or OTEC facilities.

Solar Energy

Energy from the sun is used directly for water heating (please see the section on Energy Efficiency) as well as for electricity production on-site (please see the section on Distributed Energy Resources) and from utility-scale installations (information provided below).

Photovoltaic (Utility Scale) Projects and Production

In 2019, utility-scale PV accounted for 3.5 percent of the electricity sold statewide:

- 22.8% of Kaua‘i’s electrical energy sales
- 2.5% of O‘ahu’s electrical energy sales
- 1.7% of Maui’s electrical energy sales
- 0.4% of Hawai‘i Island’s electrical energy sales

Utility-Scale Solar Pricing

In Fiscal Year 2019, the amounts paid for electricity from Hawai‘i’s larger photovoltaic facilities were: [63]

AES Lāwa‘i	Test energy only, $0.0472; PPA price, $ 0.110/kWh		**KRS2 Kōloa**	$ 0.122	/kWh
EE Wai‘anae Solar	$ 0.145	/kWh	**Kuia Solar**	$ 0.1106	/kWh
Kalaeloa Renewable Energy Park	$ 0.216	/kWh	**Lāna‘i Sustainability Research**	$ 0.28276	/kWh
Kalaeloa Solar Two	$ 0.2250	/kWh	**Port Allen/McBryde**	$ 0.20	/kWh
Kapa‘a Solar	$ 0.20	/kWh	**SolarCity/Tesla Solar (Lihue)**	$ 0.139	/kWh
Kapolei Sustainable Energy Park	$ 0.236	/kWh	**South Maui Renewable Resources**	$ 0.1106	/kWh
KRS1 Anahola	$ 0.128	/kWh			

Wind

Wind energy is Hawai‘i’s second most utilized renewable energy resource behind distributed solar.

Wind Energy Projects and Production

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

In 2019, wind energy accounted for 5.7 percent of Hawai‘i’s electricity:

- 2.25 percent of O‘ahu’s electrical energy sales
- 21 percent of Maui’s electrical energy sales
- 13.6 percent of Hawai‘i Island’s electrical energy sales

Wind Pricing

In Fiscal Year 2019, the amounts paid for electricity from Hawai‘i’s wind energy facilities were:

[64]

Auwahi Wind Farm	$ 0.20796	/kWh	**Kahuku Wind Power**	$ 0.2083	/kWh
Hāwī Wind Farm	$ 0.1586 $ 0.1510	/kWh on-peak, /kWh off-peak	**Kawailoa Wind**	$ 0.2220	/kWh
Kaheawa Wind Power I	$ 0.13718 $ 0.12881	/kWh on-peak, /kWh off-peak	**Pakini Nui (Tawhiri) Wind Farm**	$ 0.1152 $ 0.1135	/kWh on-peak, /kWh off-peak
Kaheawa Wind Power II	$ 0.23187	/kWh	**Lalamilo Wind Farm Repowering Project**	sells power directly to Hawai‘i County	

Offshore Wind

Hawai‘i’s electric utilities do not currently report any electricity generation from offshore wind.

3. Transportation

Hawai'i's transformation to a clean energy economy requires the integration of transportation. In tackling transportation HSEO has a near-term focus in ground transportation and maintains a long-term perspective that includes alternative fuels and efficiency in aviation and marine transportation.

As shown in Figure 34, the transportation sector is a major user of energy in Hawai'i. The transportation sector consumed about 55 percent of the primary energy used in Hawai'i in 2018.[65]

Figure 34 - Total Energy Consumption in Hawai'i by Sector, Trillion Btu per Year, 1960-2018

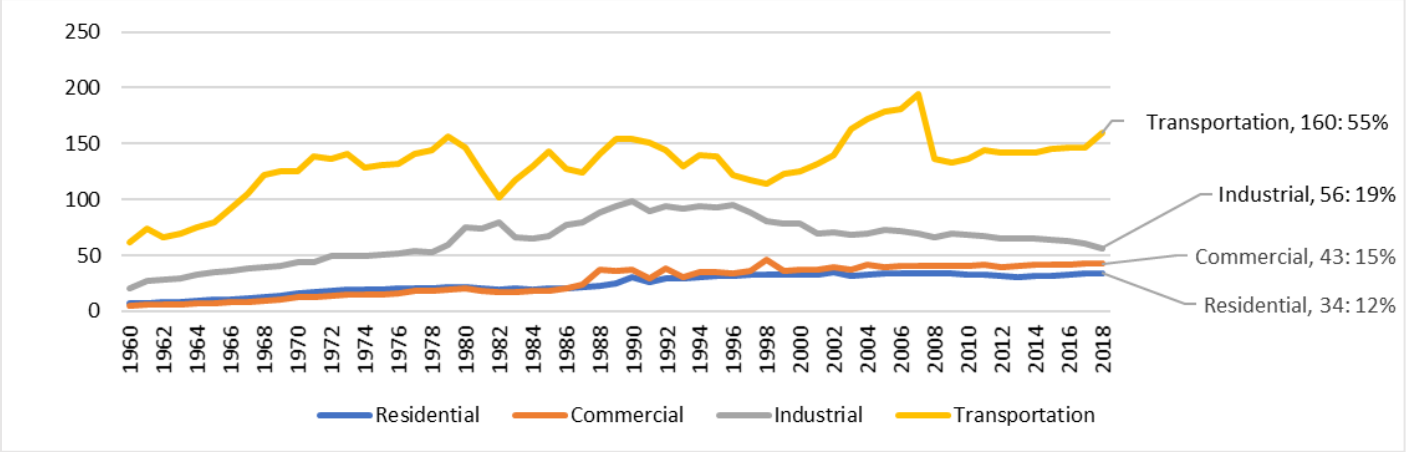
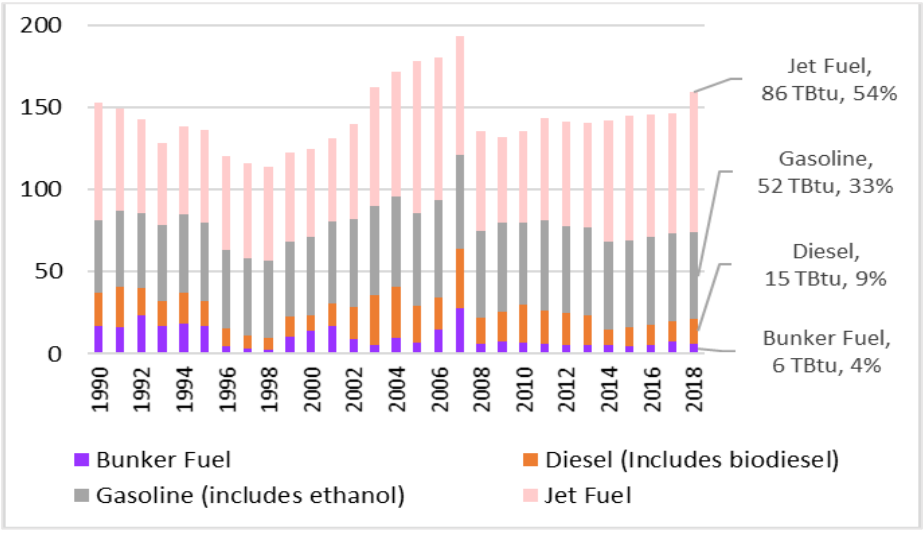


Figure 35 - Transportation Fuel Use in Hawai'i, Trillion Btu per Year

Within the transportation sector, major fuel types, shown in Figure 35, were the following of the transportation fuel total in 2018.[66]

- Jet fuel at 54%;
- Gasoline (including ethanol) at 33%;
- Diesel (including biodiesel) at 9%; and
- Bunker fuel, at 4%



Hawai'i's Clean Transportation Laws and Proclamations

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

- HRS §226-18(a)(2) – Hawai'i State Planning Act; Objectives and policies for facility systems – energy. Increased energy security and self-sufficiency through the reduction and ultimate elimination of Hawai'i's dependence on imported fuels for electrical generation and ground transportation;
- HRS §103D-412 – Hawai'i's vehicle procurement guidelines require state and county agencies to follow a hierarchy when leasing or purchasing light-duty motor vehicles that are not covered by federal procurement rules: (1) Electric Vehicle (EV) or Plug-in Hybrid Electric Vehicle (PHEV); (2) Hydrogen fuel cell electric vehicle (FCEV); (3) Alternative fuel vehicle; (4) Hybrid; (5) Fuel economy leader;

- HRS §225P-3 – Hawai‘i climate change mitigation and adaptation commission; general functions, duties, and powers aligning Hawai‘i with the goals of the Paris Agreement.
- City and County of Honolulu, Maui County, Hawai‘i County, and Kaua‘i County committed to eliminate fossil fuels use within ground transportation by 2045 – mirroring the 100 percent RPS time frame for the electric sector. Notably the City and County of Honolulu, Maui County, Hawai‘i County, and Kaua‘i County pledged to lead the way by transitioning all of their fleet vehicles to 100 percent clean energy by 2035.

Ground Transportation Sector

Ground transportation energy demand is driven by the quantity of transportation (passenger-miles and ton-miles) needed; the modes (e.g., car, truck, bus, bicycle) used to meet the transportation needs; the fuels (e.g., gasoline, diesel, biodiesel, hydrogen, electricity, human power) needed to propel the various modes; and the primary energy sources (e.g., petroleum, solar, cooking oil, other materials) used to create the fuels.

To reduce Hawai‘i’s consumption of petroleum within the ground transportation sector, the HSEO is looking to implement tactics that will make a transformational investment in Hawai‘i’s clean energy economy. As the designated agency to administer the Volkswagen Settlement Environmental Trust on behalf of the State HSEO developed a Beneficiary Mitigation Plan that focused on market ready zero emission technologies. To that end there is a specific emphasis on projects that facilitate the adoption and deployment of electric drive vehicles and charging infrastructure. This focus complements the commitments of the counties to convert their fleets to 100 percent renewable energy by 2035 and builds on the momentum created from the counties’ adoption of battery electric transit buses.

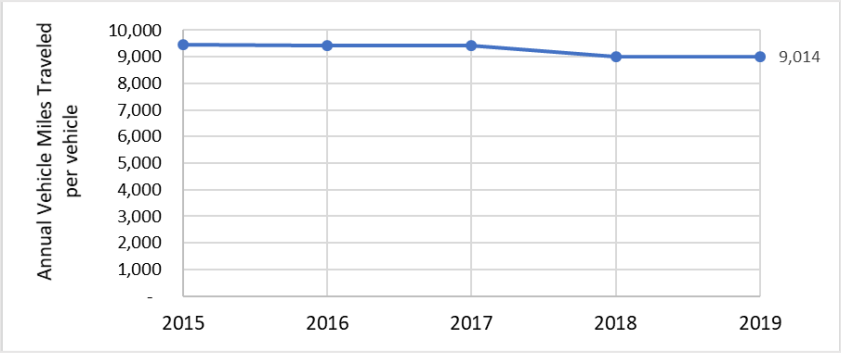
As Hawai‘i moves forward in the effort to decarbonize the economy a broad view of decarbonization strategies will need to be taken. As with electricity consumption, a focus on greater efficiency on mobility services is a fundamental requirement for Hawai‘i to achieve its goals. HSEO’s 2015 Hawai‘i Clean Energy Initiative Transportation Energy Analysis[67] identified mobility efficiencies as having the largest potential to reduce fossil fuel consumption, 29 – 34 MGY, by 2030. Vehicle miles traveled, transit-oriented development, and multi-modal strategies are currently available, cost effective means to reduce carbon that have the added benefit of mitigating the footprint of renewable energy projects necessary to decarbonize the electric sector. HAVEN has highlighted the issues of land utilization as a material issue that must be addressed from the community level to state government in order to come up with a solution that meets the needs of all of Hawai‘i. As with electricity, efficiency in ground transportation must be a key strategy for Hawai‘i.

Performance metrics are a foundational component for quantitatively evaluating progress and specifically, the advancement of transportation decarbonization strategies and policies. As the HSEO continues to expand its assessment of clean transportation in Hawai‘i HSEO will be incorporating additional clean transportation facts and figures.

Vehicles Miles Traveled

As shown in Figure 36, Hawai‘i’s average vehicle miles traveled (VMT) is approximately 9,000 miles per registered vehicle. [68]

Figure 36 - Statewide Average Miles Traveled Per Vehicle, 2015-2019



Modes of Travel

The American Community Survey found that Hawai'i workers ranked first in the percent of workers who carpooled, ninth in the number of workers who used public transportation, and forty-ninth in the nation for number of workers who drove alone. [69]

Table 11 - Hawai'i's Journey-to-Work Data from U.S. Census Bureau, American Community Survey

Description	Finding	Hawai'i National Rank
Mean travel time to work of workers 16 years and over who did not work at home (minutes)	27.6 minutes	12
Percent of workers 16 years and over who traveled to work by car, truck, or van – drove alone	67.3%	49
Percent of workers 16 years and over who traveled to work by car, truck, or van – carpooled	14.7%	1
Percent of workers 16 years and over who traveled to work by public transportation	5.7%	9

County public transit ridership, shown in Table 12, declined in all four counties between 2018 and 2019.

Table 12 - County Public Transit Ridership, 2018 and 2019

County	FY 2018 County Transit Passenger Ridership	FY 2019 County Transit Passenger Ridership
City & County of Honolulu	63,536,387	60,946,817
Maui	1,729,788	1,713,582
Kaua'i	685,474	682,383
Hawai'i	742,250	623,402

Bicycling

Bicycling reduces transportation emissions while also reducing traffic, in addition to being a low-impact form of exercise. Alternative forms of transportation such as bicycling are a means by which to decarbonize the transportation sector by reducing demand for vehicle fuels.

Table 13 - Biki by the numbers

	2017	2018	2019
Number of Biki bikes	~1,000	~1,300	~1,300
Number of self-service Biki stops	100	130	136
Number of Biki members	6,000	13,800	21,000*
Average rides per month	66,000	100,000	120,000**

*rounded to down to nearest 1k. ** rounded to down to nearest 10k

Biki is a Honolulu bicycle transit system launched by Bikeshare Hawai'i in June 2017. Biki retained its top six cities/region docked-bike share system trips ridership ranking from the National Association of City Transportation Officials in 2019 and has been a top ridership station-based bike system in all three years of its operations (2017, 2018 and 2019). Biki currently operates in Honolulu with self-service "Biki Stops" located from Chinatown to Diamond Head. [70,71]

Table 14 - Bicycle Lanes and Laws

County	Miles of Bikeways (including protected bike lanes, bike paths, bike routes, and shared use paths)[72]	Bike Laws
O'ahu	205 miles. The City & County of Honolulu's 2019 draft O'ahu Bike Plan includes a proposed network of 577 miles of new bikeways.	The Hawai'i Bicycling League site offers a comprehensive list of City & County of Honolulu bicycle regulations.
Maui	60.4 miles	The Maui Bicycling League site offers a comprehensive list of Maui county bicycle regulations.
Hawai'i	27.4 miles	The University of Hawai'i Hilo (UH Hilo Bike Share site) offers a comprehensive list of Hawai'i County bicycle regulations.
Kaua'i	31.7 miles	

Alternative Transportation Fuels (Including Electric Vehicles)

"Alternative fuels" (and "alternate fuel," used interchangeably) are defined in State[73] and Federal law[74] to include:

- Alcohol (methanol, ethanol, and others) and mixtures of alcohol and gasoline with at least of 85% alcohol;
- Natural gas;
- Liquefied petroleum gas (LPG), also known as Propane;
- Hydrogen;
- Fuels, including biodiesel, derived from biological materials;
- P-series fuels (Patent number 5,697,987); and
- Electricity (including electricity from solar energy).

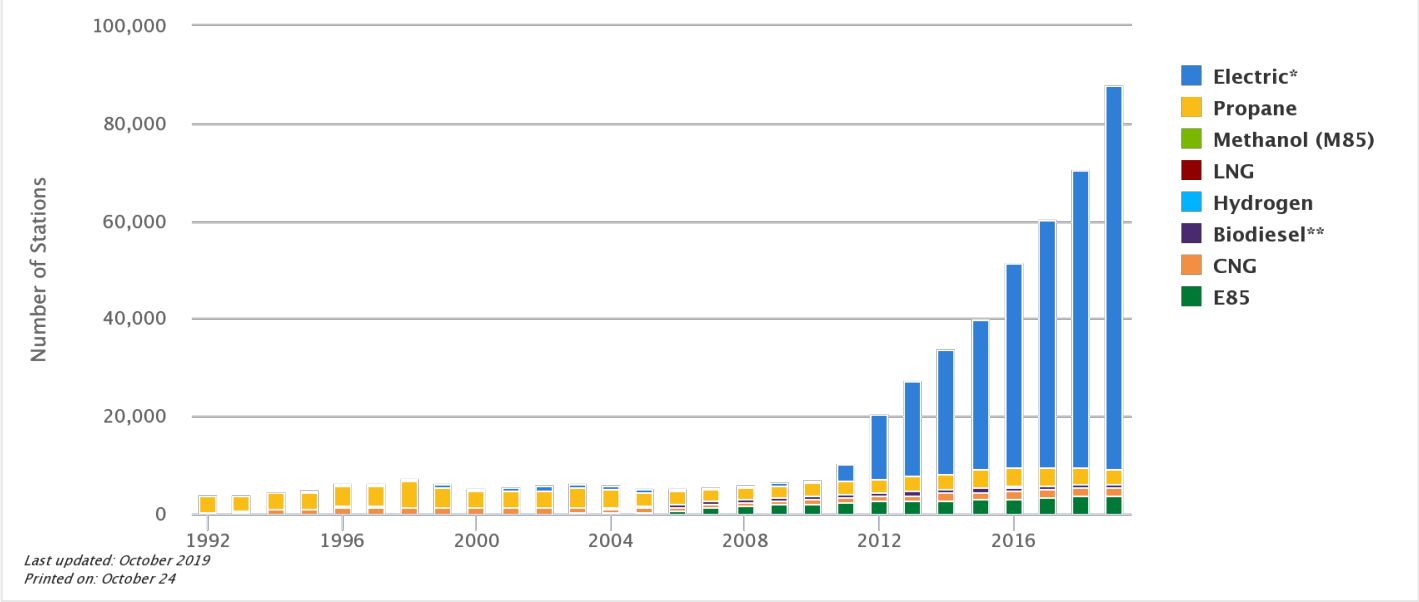
The State's alternative fuels standard goal, Section 196-42 of the Hawai'i Revised Statutes, sets forth an objective of 20 percent of Hawai'i's ground transportation needs to be met by non-petroleum sources by 2020:[75]

> **State support for achieving alternate fuels standards.** The State shall facilitate the development of alternate fuels and support the attainment of a statewide alternate fuels standard of ten per cent of highway fuel demand to be provided by alternate fuels by 2010, fifteen per cent by 2015, twenty per cent by 2020, and thirty per cent by 2030.

Several alternative fuels are in use in Hawai'i, including ethanol blended in gasoline at a rate of 10 percent in most areas; biodiesel, produced locally by Pacific Biodiesel; hydrogen, available on O'ahu to owners of Toyota Mirai vehicles; and electricity, available statewide and described in greater detail below. The production and use of alternative fuels is included in the section titled "Alternative Fuel Use and Production in Hawai'i."

The Alternative Fuels Data Center, operated by the U.S. Department of Energy, lists a number or alternative fuel stations by type. As shown in Figure 37, there has been a sharp increase in electric vehicle fueling stations nation-wide.[76] The database and locator map lists 288 "public access" fueling stations in Hawai'i (6 providing biodiesel; 1 providing hydrogen; and 281 providing electric vehicle charging).[77]

Figure 37 - U.S. Alternative Fueling Stations by Fuel Type



Electric Vehicles

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

As shown in Table 15, there are over 12,000 electric vehicles registered in Hawai'i as of October 2020. This number continues the steady increase in electric vehicle registrations illustrated by Figure 38. There are also 286 public electric vehicle charging stations, as shown in Table 16.

Table 15 - Registered Electric Vehicles in Hawai'i, October 2020[78]

County	Electric Vehicles
O'ahu	9,960
Maui	1,521
Hawai'i	862
Kaua'i	373
Statewide	12,716

Figure 38 - Electric Vehicles Registered in Hawai'i, 2014-2019

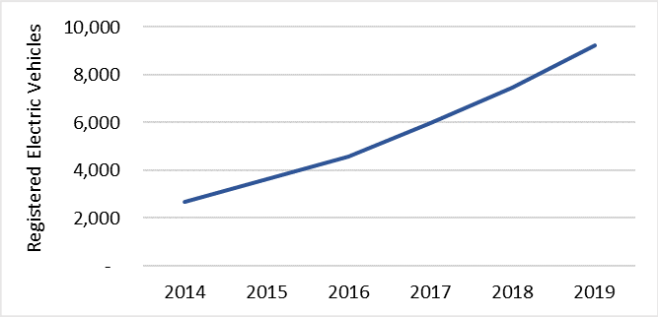


Table 16 - Public Charging Stations in Hawai'i as of October 2020[79]

Stations	Level 2 outlets	DC Fast outlets
286	574	96

Table 17 - Fuel Cost Comparison Between an Electric Vehicle and a Similar Gasoline-Powered Vehicle

Vehicle	2020 Mitsubishi Mirage Hatchback	2020 Honda Civic Sedan	2020 Nissan LEAF PLUS
Fuel Type	**Gasoline**	**Gasoline**	**Electricity**
Miles Per Gallon (mpg)	39 mpg	36 mpg	3.645 Miles/kWh
Range	331 miles	446 miles	226 miles
Fuel Cost per Year	$ 752.78	$ 815.52	$ 610.83 if charging at residential electricity rate
			- or -
			$ 242.34 if charging at Schedule TOU-RI at mid-day
Fuel cost per year is based on gasoline at $3.257/gallon (October 2020 O'ahu average from monthly energy trends); annual travel of 9,014 miles per year; and EV charging with either: (a) effective residential electricity rate: $0.247/kWh, residential baseline; or (b) Schedule TOU-RI for mid-day EV Charging: $0.096/kWh. (November 2020 rates with applicable surcharges https://www.Hawaiianelectric.com/products-and-services/save-energy-and-money/time-of-use-program.)			

Fuel cost comparisons show approximate savings between energy efficient internal combustion engine and electric vehicles. The example presented in Table 17 illustrates that fuel costs for an electric vehicle can be materially less than for a fuel efficient gasoline fueled vehicle.

Hawai‘i’s Electric Vehicle Laws and Incentives

- Vehicles with EV license plates are exempt from High Occupancy Vehicle lane restrictions.
- Parking lots with at least 100 public parking spaces are required to have at least one parking space, equipped with an EV charging system, reserved exclusively for EVs.
- Non-EVs parked in a space designated and marked as reserved for EVs shall be fined not less than $50 nor more than $100.
- Hawaiian Electric offers EV time-of-use rates designed to incentivize customers, through lower rates, to charge their EVs during off-peak, high renewable energy periods during mid-day.
- Hawaiian Electric offers time-of-use rates for electric bus charging for a total of up to 20 bus fleet customers on O‘ahu, Maui and Hawai‘i Island with lower prices that encourage charging during midday.
- Multi-family residential dwellings or townhomes cannot prohibit the placement or use of EV charging systems altogether.
- Hawai‘i offers an EV Charging Rebate Program (Act 142 of 2019) for installation of eligible new or upgraded multi-user electric vehicle charging systems.
- Energy performance contracts may include EV charging infrastructure (Act 144 of 2019).
- EVs and alternative fuel vehicles are subject to an annual vehicle registration surcharge fee of $50, which will be collected beginning with the first registration renewal and will be deposited into the State Highway Fund (Act 280 of 2019).

For more information about state and federal laws, regulations and incentives, visit:

- HSEO’s site on State and Federal Laws & Incentives
- The U.S. Department of Energy’s Alternative Fuels Data Center

Table 18 - EV Quick Facts

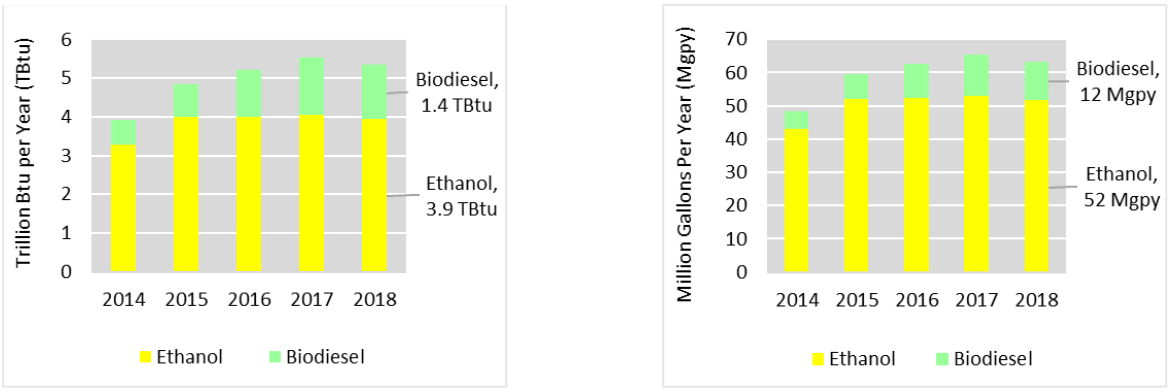
Hawai‘i ranks sixth in the nation behind California, Washington, Oregon, Colorado and District of Columbia of total EV sales:	1.75 percent of total state sales
As an eligible beneficiary, the State of Hawai‘i has been allocated $8.125 million from the Volkswagen Environmental Mitigation Trust. The Hawaii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

4. Alternative Fuel Use and Production in Hawai‘i

Ethanol and Biodiesel

As described in the previous section, renewable fuels used in vehicles in Hawai‘i include ethanol, biodiesel, hydrogen, and electricity. Propane is used on-site in utility vehicles such as forklifts. Information on ethanol and biodiesel fuel use in Hawai‘i is shown below in Figure 39. Both graphs illustrate the same two fuels over the same time period. The graph on the left presents the amounts on the basis of energy content, in trillion Btu per year; the graph on the right shows the same fuel use, on the basis of volume, in million gallons per year. The two graphs illustrate that fuels with a higher energy content per gallon (i.e., those that are more energy dense), provide more energy (Btu, shown in the graph on the left) than it might appear on the basis of volume (gallons, shown in the graph on the right).[80]

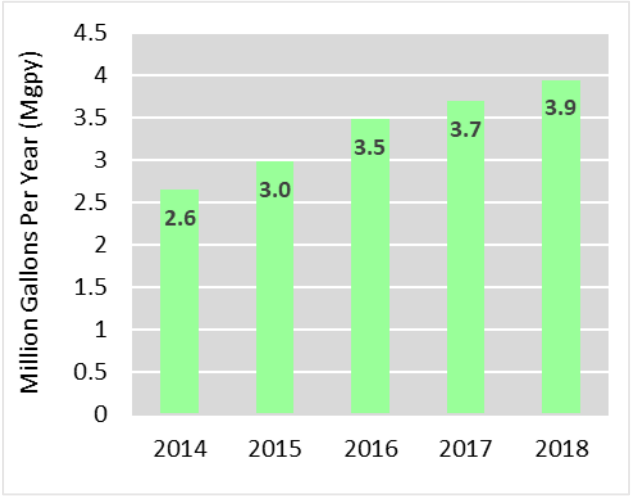
Figure 39 - Ethanol and Biodiesel Fuel Use in Hawai‘i, 2014-2018
Left: energy content; Right: volume



Ethanol fuel is primarily used in the transportation sector. Hawai‘i does not have any in-state ethanol production.

Biodiesel fuel is used both for transportation and in electricity production. Biodiesel fuel is produced in Hawai‘i; quantities are shown in Figure 40.[81]

Figure 40 - Biodiesel Production in Hawai‘i, 2014-2018



Hydrogen

Hydrogen has several uses and applications. It is used as a transportation fuel, as mentioned in the previous section. It can also be produced from renewable sources, stored, and then used in vehicles or to produce electricity. Finally, it can be blended and distributed through pipelines for use in homes and businesses as a component of utility gas.[82]

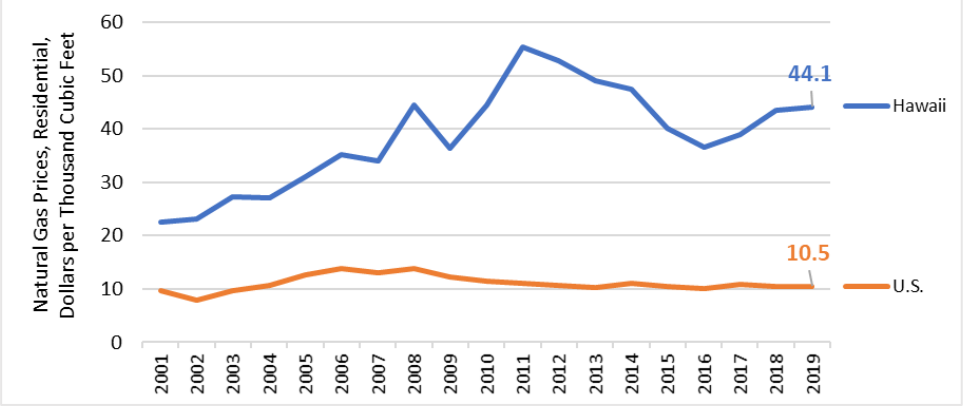
Utility and Bottled Gas

Hawai‘i’s utility gas service is provided by The Gas Company, LLC, doing business as Hawai‘i Gas, on the islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, Lāna‘i, and Hawai‘i.[83] On the leeward side of O‘ahu, the company maintains a network of underground distribution pipelines delivering a mixture of synthetic natural gas, renewable natural gas, imported natural gas, hydrogen, and propane-air mixture (i.e., “natural gas”) in Honolulu. In other areas of O‘ahu and on the islands of Kaua‘i, Maui, Moloka‘i, Lāna‘i, and Hawai‘i, the distribution systems deliver Liquefied Petroleum Gas (also known as LPG or propane) from storage tanks via underground pipeline to customers.[84]

Suppliers of bottled fuel gas (generally, butane or propane) in the unregulated market include hardware and camping stores and a variety of fuel distributors such as Airgas, Amerigas, and Hawai'i Gas.[85]

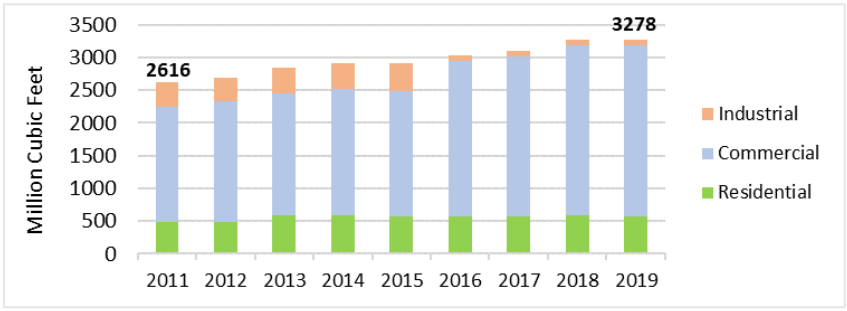
Hawai'i's utility gas prices are the highest in the United States and, as shown in Figure 41, Hawai'i's price of $44 per thousand cubic feet in 2019 is more than four times the U.S. average price of $10.50 per thousand cubic feet.[86]

Figure 41 - Hawai'i's Gas Prices are More than Quadruple the U.S. Average



The quantity of natural gas reported by the Energy Information Administration as delivered in Hawai'i to residential, commercial, and industrial customers increased, as shown in Figure 42, from 2616 million cubic feet in 2011 to 3278 million cubic feet in 2019.[87]

Figure 42 - Utility Gas Deliveries to Customers in Hawai'i, 2011-2019



Renewable Natural Gas (RNG)

Renewable natural gas production in Hawai'i, shown in Table 19, has increased. As described in the *2019 Renewable Energy Report*,[88]

> "Hawai'i Gas produces SNG [synthetic natural gas] using mainly a blend of liquid naphtha, steam, water and hydrogen gas … non-petroleum feedstocks include not only the hydrogen made from recycled water at the Honouliuli WWTP [wastewater treatment plant], and RNG from the Honouliuli WWTP Biogas Project, but also the water and a portion of the carbon monoxide used to produce SNG at the SNG Plant. Under a revised methodology looking at total non-petroleum feedstocks, in 2019, total non-petroleum feedstocks accounted for 11.4 percent of the total feedstock used to produce SNG and RNG, based on a thermal ratio."

Both hydrogen and methane are produced from renewable and non-petroleum feedstocks and are included in the product distributed by Hawai'i Gas.

Table 19 - Percent of Utility Gas Produced from Non-Petroleum Feedstocks in Hawai'i, 2011-2019

Calendar year	% renewable (old methodology)	% non petroleum (new methodology)
2019	4.27%	11.4%
2018	3.04%	
2017	3.00%	
2016	2.80%	
2015	2.80%	
2014	2.60%	
2013	2.40%	
2012	2.40%	
2011	2.40%	

5. Energy Sector Workforce and Jobs

In 2020, the National Association of State Energy Officials (NASEO) and the Energy Futures Initiative (EFI) published the *2020 U.S. Energy & Employment Report* (USEER) as "a tool for state policymakers to understand the impact of evolving energy markets; to help prepare their communities, infrastructure, and workforce for these changes; and to harness the economic and environmental benefits that result," with a separate report on a "jobs wage data survey." [89]

Figure 43 - Estimates of Energy Sector Employment in Hawai'i

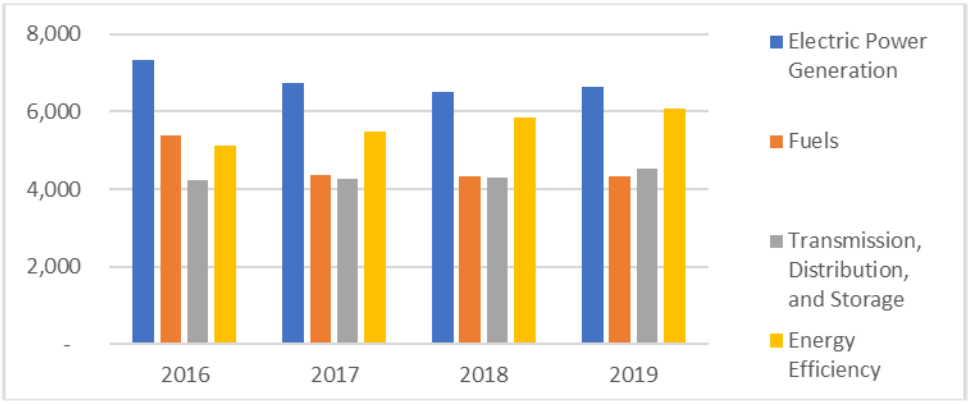


Figure 44 - Excerpt from 2020 USEER Report

HIRING DIFFICULTY

Over the last year, 25.9 percent of energy-related employers in Hawaii hired new employees. These employers reported the greatest overall difficulty in hiring workers for jobs in Electric Power Transmission, Distribution, and Storage.

Table HI-2
Hiring Difficulty by Major Technology Application.

Technology	Very Difficult (percent)	Somewhat Difficult (percent)	Not at All Difficult (percent)
Electric Power Generation	23.1	63.7	13.2
Electric Power Transmission, Distribution, and Storage	20.6	68.7	10.7
Energy Efficiency	37.1	49.7	13.2
Fuels	27.1	50.7	22.2
Motor Vehicles	41.2	46.3	12.4

Employers in Hawaii gave the following as the top three reasons for their reported difficulty:

1. Competition/ small applicant pool
2. Lack of experience, training, or technical skills
3. Difficulty finding industry-specific knowledge, skills, and interest

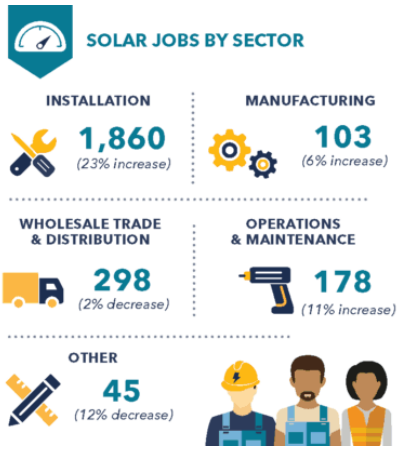
Employers reported the following as the three most difficult occupations to hire for:

1. Sales, marketing, or customer service — $35.35 median hourly wage
2. Electrician/construction workers — $28.59 median hourly wage
3. Installation workers — $27.91 median hourly wage

The reports indicate that, while traditional energy sector employment had decreased over the four years of studies, employment in emerging sectors — including energy efficiency, solar electric power generation, biofuels, and data science — had increased.

A Hawai'i-specific sub-report (excerpt provided in Figure 44) indicated difficulty in filling most positions, for reasons of limited applicant pool; lack of experience, training, or skills; and difficulty finding industry-specific skills.

Another report, the Solar Foundation's *Solar Jobs Census 2019 (Hawai'i),* found Hawai'i was the top 10th state for solar jobs growth in 2019 and 5th in solar jobs per capita, with a total of 2,484 solar jobs in installation, manufacturing, wholesale, and operations and maintenance sectors.[90]



6. Decarbonized, Clean Energy Economy

In 2018, the Legislature established a Zero Emissions Clean Economy Target, Section 225P-5, Hawai'i Revised Statutes:[91]

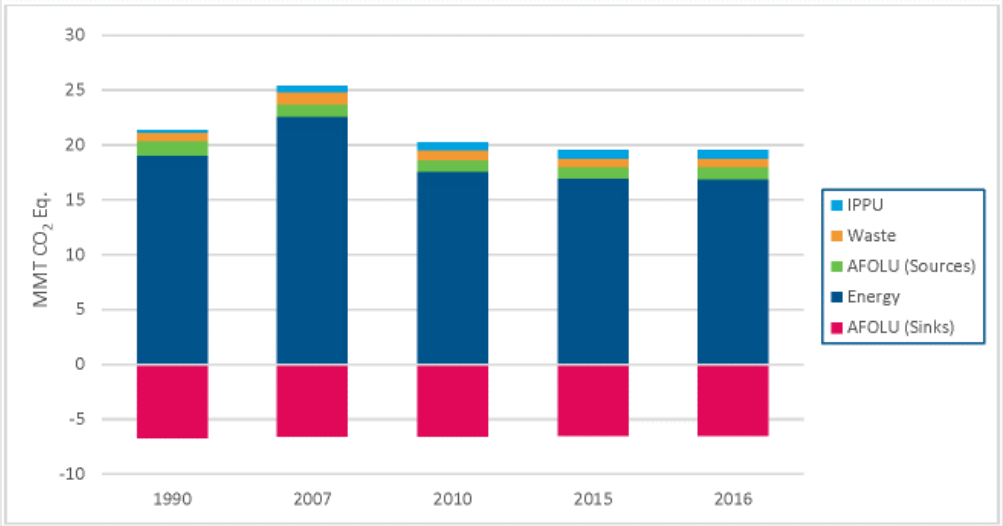
> **"…to sequester more atmospheric carbon and greenhouse gases than emitted within the State as quickly as practicable, but no later than 2045."**

Since the emissions of atmospheric carbon and greenhouse gases (GHG) in the State of Hawai'i are predominantly from the energy sector, as shown in Table 20, several of the duties of the Chief Energy Officer of the Hawaii State Energy Office relate to the reduction of these gases,[92] also referred to as decarbonization goals.

Table 20 - Greenhouse Gas Emissions in Hawai'i, 2016

Category	2016 MMT	Sector	Percent of total	% From Energy
Stationary Combustion	7.79	Energy	36%	88%
Ground Transportation	4.05	Energy	19%	
Domestic and Military Aviation	3.84	Energy	18%	
International Marine and Aviation Bunker Fuels	1.54	Energy	7%	
CO_2 from Wood Biomass and Biofuel Consumption	1.53	Energy	7%	
All Other Sources (IPPU, AFOLU, Waste)	2.64		12%	

Figure 45 - Hawai'i GHG Emissions by Sector, Selected Years



The Zero Emissions Clean Economy Target enacted in 2018 (and quoted above) supersedes the previous greenhouse gas target, established by Act 234 of 2007, to reduce GHG emissions statewide to 1990 levels by 2020.[93]

The most recent official state inventory of greenhouse gas emissions in the state, dated December, 2019, lists emissions that occurred in Hawai'i in 2016.[94]

Excerpts from the report, provided in Figure 45 and in Table 21, indicate that the emissions included in Act 234 of 2007 had declined, by the end of 2016, to below 1990 levels.

Table 21 - Hawai'i GHG Emissions by Sector, Selected Years (MMT CO_2 Equivalent)

Sector/Category	1990	2007	2010	2015	2016
Energy[a]	19.09	22.65	17.62	16.97	16.94
IPPU	0.17	0.55	0.66	0.77	0.78
AFOLU (Sources)	1.31	1.12	1.02	1.03	1.08
AFOLU (Sinks)	(6.70)	(6.52)	(6.55)	(6.50)	(6.51)
Waste	0.75	1.05	0.92	0.77	0.78
Total Emissions (Excluding Sinks)	**21.33**	**25.37**	**20.22**	**19.54**	**19.58**
Net Emissions (Including Sinks)	**14.63**	**18.85**	**13.67**	**13.04**	**13.07**
Aviation[b]	3.79	4.11	3.16	3.99	3.84
Net Emissions (Including Sinks, Excluding Aviation)[b]	**10.84**	**14.73**	**10.51**	**9.04**	**9.23**

[a] Emissions from International Bunker Fuels are not included in totals, as per IPCC (2006) guidelines.

[b] Domestic aviation and military aviation emissions, which are reported under the transportation source category under the Energy sector, are excluded from Hawaii's GHG emissions reduction goal established in Act 234.

Notes: Totals may not sum due to independent rounding. Parentheses indicate negative values or sequestration.

The requirements of Hawai'i's current Zero Emissions Clean Economy Target, however, are broader (they include emissions from aviation and marine fuels), lower (net negative – a drop of about 13 MMT - rather than a drop of 4 MMT), and faster (to be met "as soon as practicable") than the previous target.

Another view of carbon emissions from the energy sector can be provided by a Sankey diagram, such as in Figure 45, illustrating Hawai'i's energy sector emissions. The diagram was prepared by Lawrence Livermore National Laboratory, based on national factors and assumptions, using the Energy Information Administration database.[95]

Figure 46 - Estimated Carbon Dioxide Emissions from Hawai'i's Energy Sector in 2017: 17.7 Million Metric Tons

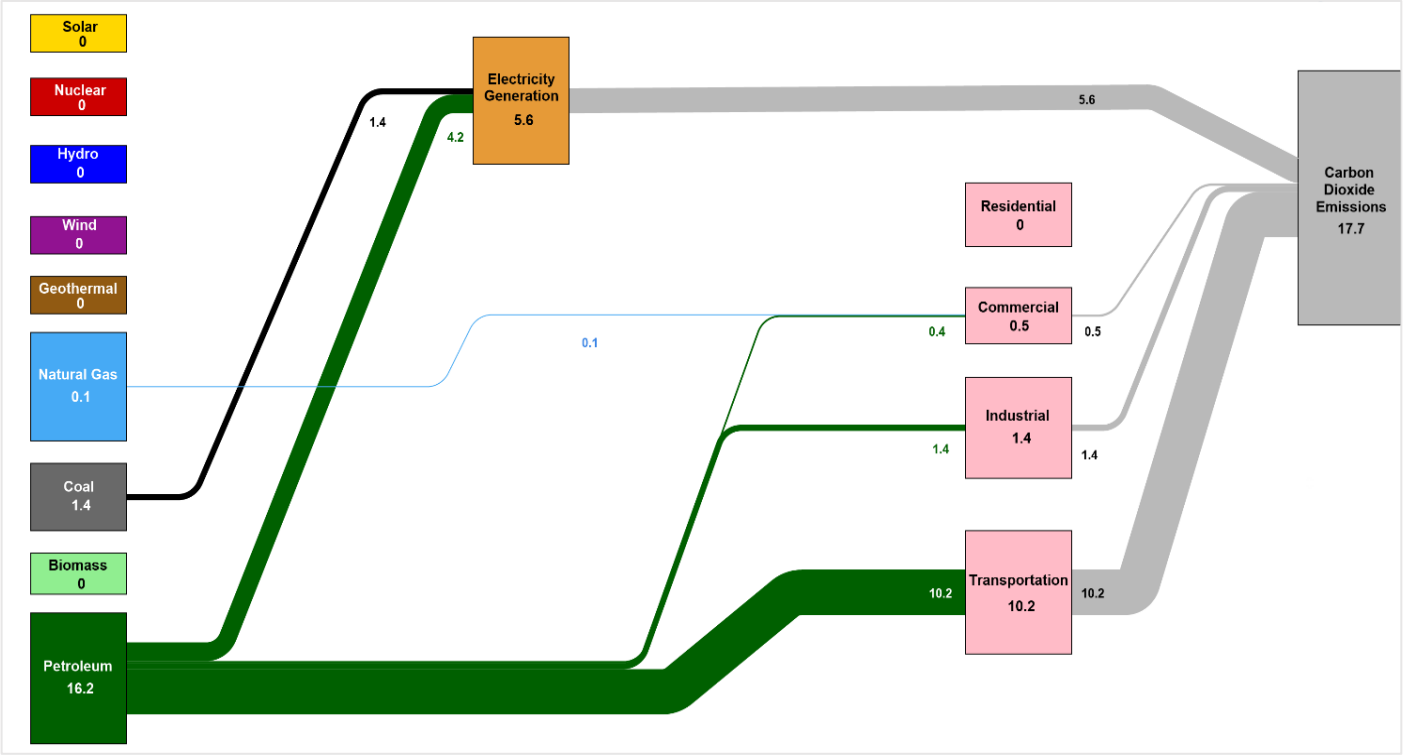
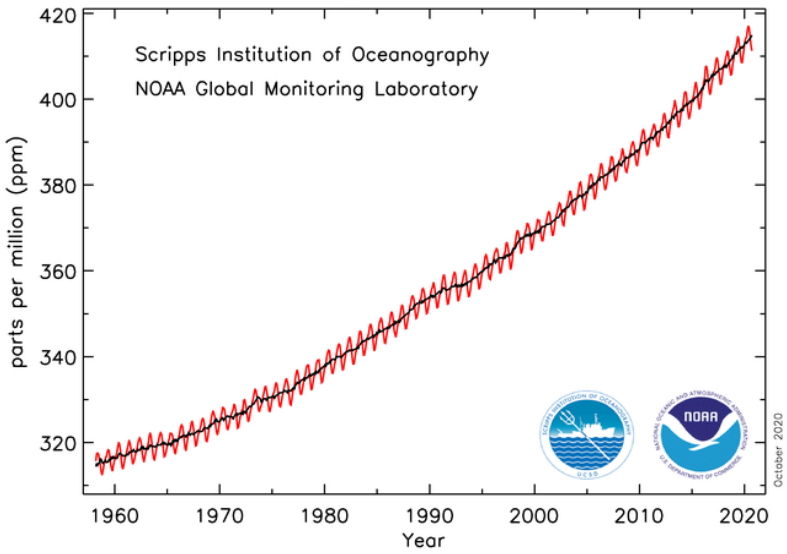


Figure 47 - Atmospheric CO_2 Measurements Recorded at Mauna Loa Observatory Since 1960

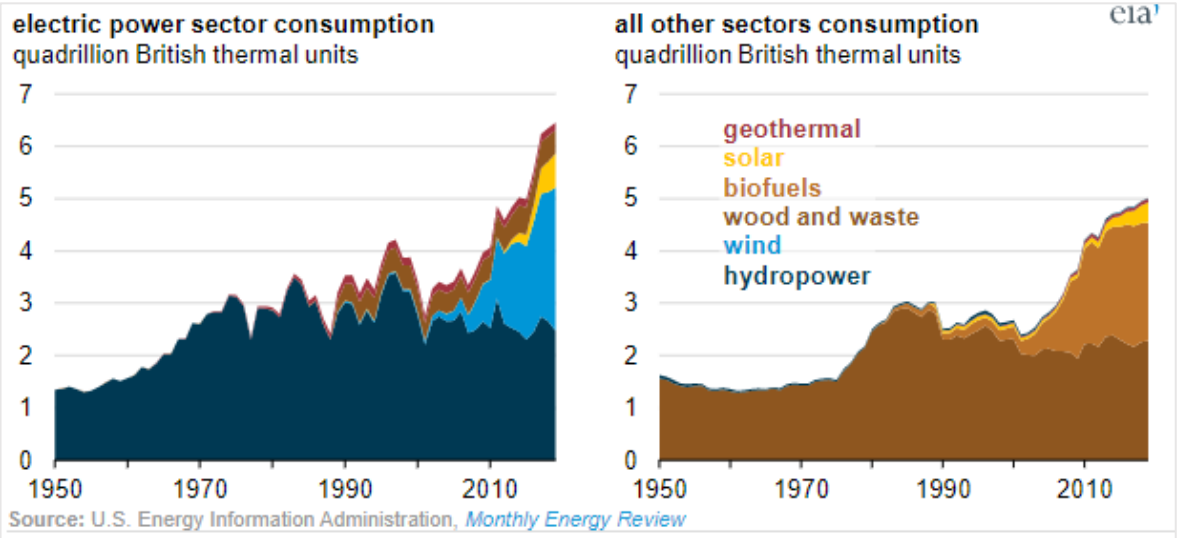
Measurements of global atmospheric carbon, recorded at Mauna Loa Observatory and elsewhere, continued to rise.[96] Data from 1960 to 2020 is shown in Figure 47.



7. Beyond Hawai'i

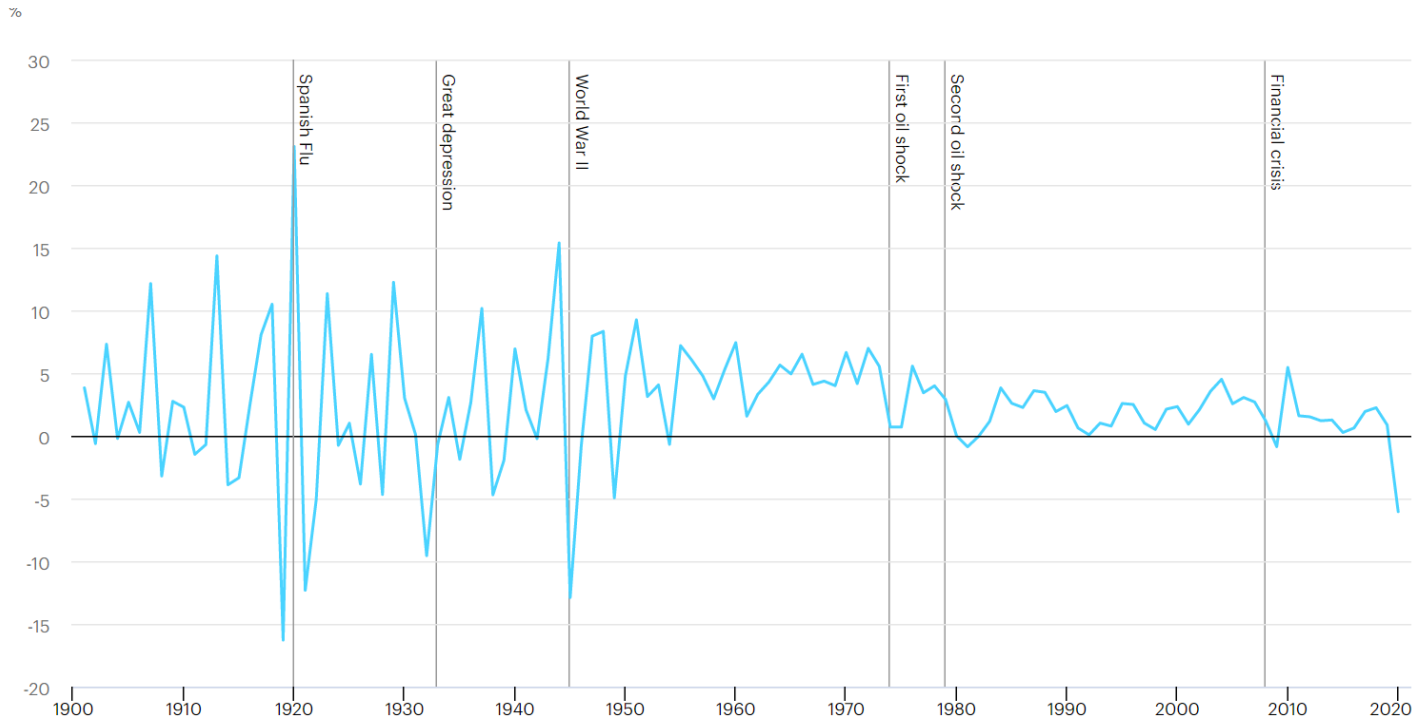
Several of the trends observed locally (increased energy efficiency, and use of renewable energy) are also being observed nationally and internationally.[97] As shown in Figure 48, in the graph on the left, hydropower has in recent years been joined by energy production from a combination of wind, solar, wood, and geothermal resources in the production of electricity in the U.S. Likewise, in non-electricity energy areas, energy production from wood and waste continues, with increasing contributions from biofuels, solar, and geothermal resources for fuels and heat.

Figure 48 - U.S. Renewable Energy Consumption By Sector, 1950-2019



Finally, the 2020 Global Energy Review included a historical look back at rates of change in energy demand over the years, with major global events superimposed on the graph, shown in Figure 49.[98]

Figure 49 - Rate of Change of Global Primary Energy Demand, 1900-2020 (from IEA, April 2020)



8. Endnotes

About these endnotes: Sources, with links, are provided to allow the reader to find information, context, and updates from the original source whenever possible. Since it's preferable for facts to keep their citations with them - regardless of where they may go in the document, or another document, or a presentation - the practice of "ibid" (to indicate that the source of a stated fact is the same as for the immediately preceding citation) is not used here.

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8 U.S. Energy Information Administration. 2020. "Electricity Data Browser," https://www.eia.gov/electricity/data/browser/

9 U.S. Energy Information Administration. 2020. State Energy Data System. https://www.eia.gov/opendata/qb.php?category=40606&sdid=SEDS.PATXB.HI.A

10 State of Hawai'i. Department of Business, Economic Development, and Tourism. *Monthly Energy Trends*. http://dbedt.hawaii.gov/economic/data_reports/energy-trends/

11 Lawrence Livermore National Laboratory. "Energy Flow Charts: Charting the Complex Relationships among Energy, Water, and Carbon." https://flowcharts.llnl.gov/content/assets/images/charts/Energy/Energy_2018_United-States_HI.png

12 State of Hawai'i. Department of Business, Economic Development, and Tourism. *Monthly Energy Trends*. http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2

13 State of Hawai'i. Department of Business, Economic Development, and Tourism. *Monthly Energy Trends*. http://dbedt.hawaii.gov/economic/data_reports/energy-trends-2

14 1 barrel = 42 U.S. gallons

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19 Hawaiian Electric website. https://www.hawaiianelectric.com/states-3-largest-utilities-to-be-united-under-one-name-hawaiian-electric .

20 State of Hawai'i. Department of Business, Economic Development, and Tourism. 2011-2019 editions of the *State of Hawaii Data Book.* Table 17.10, calculated: average annual use, divided by 12. https://dbedt.hawaii.gov/economic/databook/

21 State of Hawai'i. Department of Business, Economic Development, and Tourism. 2011-2019 editions of the *State of Hawaii Data Book.* Table 17.10. https://dbedt.hawaii.gov/economic/databook/

22 Calculated, from the source numbers that were used to develop the previous two tables; monthly sales (kWh), times rate per kWh. Numbers shown in the previous tables have been rounded, so the more accurate results shown in this table may not match the results of multiplying the numbers shown in the previous two tables.

[23] Goldman, Charles A., Ian Hoffman, Sean Murphy, Natalie Mims Frick, Greg Leventis and Lisa Schwartz. 2020. *Energies 2020.* "The Cost of Saving Electricity: A Multi-Program Cost Curve for Programs Funded by U.S. Utility Customers." https://emp.lbl.gov/publications/cost-saving-electricity-multi-program

[24] State of Hawai'i, Public Utilities Commission. 2018. *Report to the 2019 Legislature on Hawaii's Energy Efficiency Portfolio Standards*. https://puc.hawaii.gov/wp-content/uploads/2018/12/EEPS-2019-Legislative-Report_FINAL.pdf

[25] Tariff Filing by Hawaiian Electric Company, Inc. to the Public Utilities Commission, dated June 29, 2020. https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A20F29B43748F00937. The amount ($44,496,000 reduced by the Green Infrastructure Fee amount of $13,190,200), is allocated 45% to residential and 55% to commercial and industrial programs.

[26] Kaua'i Island Utility Cooperative, Tariff No. 1, https://website.kiuc.coop/sites/kiuc/files/documents/tariff-rcas-rev2020-0201.pdf

[27] Applied Energy Group. 2020. *State of Hawaii Market Potential Study*. https://www.hawaiieeps.org/8-5-2020-market-potential-study-rel

[28] Hawai'i Energy. 2020. *Deepening Connections: Annual Report 2019-2020*. https://hawaiienergy.com/images/about/information-and-reports/ProgramYear2019_AnnualReport.pdf ; with additional information from Hawai'i Energy, personal correspondence, October 23, 2020.

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

[30] Starting in 2019, the calculation of number of households is based on a relationship between equipment life and energy savings that assumes an average equipment useful life of 13 years. Thus, the total household Figure is decreased from the 2018 reported 208,000 households.

[31] State of Hawai'i, Hawai'i Revised Statutes, Section 196-9(b)1 – Energy Efficiency and environmental standards. https://www.capitol.hawaii.gov/hrscurrent/vol03_ch0121-0200d/HRS0196/HRS_0196-0009.htm

[32] Energy Services Coalition. "ESPC Race to the Top Tally." https://www.energyservicescoalition.org/espc/table

[33] United States Department of Energy, Quadrennial Energy Review. 2015. https://www.energy.gov/downloads/chapter-5-increasing-efficiency-buildings-systems-and-technologies

[34] Goldman, Charles A., Ian Hoffman, Sean Murphy, Natalie Mims Frick, Greg Leventis and Lisa Schwartz. 2020. *Energies 2020.* "The Cost of Saving Electricity: A Multi-Program Cost Curve for Programs Funded by U.S. Utility Customers." https://emp.lbl.gov/publications/cost-saving-electricity-multi-program; original paper: https://emp.lbl.gov/publications/cost-saving-electricity-through

[35] On July 14, 2015, the State Building Code Council (SBCC) unanimously voted to adopt the International Energy Conservation Code (IECC) 2015, with the Tropical Climate Zone Code for residential dwellings and other energy-saving amendments. Gov. David Ige signed and approved Hawai'i's amendments to the IECC 2015 on March 20, 2017 as a Hawai'i Administrative Rule.

[36] The Cadmus Group, Inc. 2016. *Analyses and Proposal of Hawaii Amendments to the 2015 International Energy Conservation Code*. Report Prepared for the Department of Business, Economic Development, and Tourism, State of Hawaii. https://energy.hawaii.gov/wp-content/uploads/2016/07/Analyses-and-Proposal-of-Amendments.pdf

[37] The Cadmus Group, Inc. 2016. *Analyses and Proposal of Hawaii Amendments to the 2015 International Energy Conservation Code*. Report Prepared for the Department of Business, Economic Development, and Tourism, State of Hawaii. https://energy.hawaii.gov/wp-content/uploads/2016/07/Analyses-and-Proposal-of-Amendments.pdf

[38] U.S. Green Building Council. *USGBC State Market Brief: Hawaii*. https://www.usgbc.org/resources/state-market-brief

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[45] Appliance Standards Awareness Project. *State Benefits from Federal Appliance Standards* https://appliance-standards.org/map/benefits-from-federal "Efficiency Standards for Appliances & Lighting: Hawaii" https://appliance-standards.org/sites/default/files/fedappl_hi.pdf

[46] Appliance Standards Awareness Project. "Savings Estimate for Hawaii." https://appliance-standards.org/sites/default/files/state_savings_state_standards/Hawaii.pdf and https://appliance-standards.org/states

[47] State of Hawai'i. *Hawaii Green Business Program Description*. https://greenbusiness.hawaii.gov/description/

[48] State of Hawai'i. Hawaii Green Business Program. *Hawaii Green Business Program Awardees by Sector*. https://greenbusiness.hawaii.gov/awardees/

[49] Excess Operational Revenue over Expenditures are before loan repayments returned to the PUC per Order No. 34930 Amending Decision and Order No. 32318 By Changing the Priority uses of GEMS Program Loan Repayments, bad debt expense and unrealized gains or losses on investments.

[50] Underserved defined as low and moderate-income households. Minimum target for Underserved = 51%.

[51] State of Hawai'i, Public Utilities Commission. 2020. Docket No. 2007-0008. Renewable Portfolio Standard Annual Reports. https://dms.puc.hawaii.gov/dms/dockets?action=details&docketNumber=2007-0008

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[53] State of Hawai'i. Hawai'i Revised Statutes, Section 269-92. https://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0092.htm

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[61] Docket No. 2019-0333, https://dms.puc.hawaii.gov/dms/dockets?action=details&docketNumber=2019-0333, has information on the application for approval of an amended and restated power purchase agreement between HELCO and PGV.

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[67] International Council on Clean Transportation. 2015. *Hawaii Clean Energy Initiative Transportation Energy Analysis*. https://energy.hawaii.gov/wp-content/uploads/2011/09/Final_TransEnergyAnalysis_8.19.15.pdf

[68] State of Hawai'i. Databook. Section 18 – Transportation; Table 18.17, "Motor Vehicle Fuel Consumption and Vehicle Miles." http://files.hawaii.gov/dbedt/economic/databook/2019-individual/18/181719.xls

[69] State of Hawai'i, Department of Business, Economic Development and Tourism. Census. "American Community Survey 2016." http://census.hawaii.gov/acs/acs-2016/

[70] https://nacto.org/wp-content/uploads/2020/08/2020bikesharesnapshot.pdf

[71] Self reported by Biki

[72] https://www.honolulu.gov/bicycle; http://hidot.hawaii.gov/highways/files/2013/02/Bike-Plan-appendixc.pdf; https://www.kauai.gov/Portals/0/PW_Bldg/BikePathProject/Articles/Bike_path_overview.pdf?ver=2015-04-20-160259-343

[73] Hawai'i Revised Statutes, Section 103D-412: "alternative fuels means alcohol fuels, mixtures containing eighty-five per cent or more by volume of alcohols with gasoline or other fuels, natural gas, liquefied petroleum gas, hydrogen, biodiesel, mixtures

containing twenty per cent or more by volume of biodiesel with diesel or other fuels, other fuels derived from biological materials, and electricity provided by off-board energy sources."
Hawai'i Revised Statutes, Section 196-42: ""Alternate fuels" shall have the same meaning as contained in 10 Code of Federal Regulations Part 490; provided that it shall also include liquid or gaseous fuels produced from renewable feedstocks such as organic wastes, or from water using electricity from renewable energy sources."

[74] United States Code. Code of Federal Regulations, Title 10, part 490. https://www.govinfo.gov/app/details/CFR-2011-title10-vol3/CFR-2011-title10-vol3-part490 The definition is on page 1226 of the PDF: https://www.govinfo.gov/content/pkg/CFR-2020-title10-vol3/pdf/CFR-2020-title10-vol3.pdf

[75] State of Hawai'i. Hawai'i Revised Statutes, Section 196-42. https://www.capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0196/HRS_0196-0042.htm

[76] U.S. Department of Energy, Alternative Fuel Data Center. https://afdc.energy.gov/data/10332

[77] U.S. Department of Energy, Alternative Fuel Data Center. Fueling Station Locator. https://afdc.energy.gov/stations/#/analyze?region=US-HI

[78] State of Hawai'i, Department of Business, Economic Development and Tourism. Monthly Energy Trends. September 2020

[79] https://afdc.energy.gov/stations/states. Includes legacy chargers but does not include residential electric charging infrastructure.

[80] U.S. Energy Information Administration. https://www.eia.gov/beta/states/states/hi/data/dashboard/renewables. The data was provided in billion Btu per year, and converted to trillions of Btu for the graph on the left and to millions of gallons for the graph on the right. Energy content for biodiesel: 119,500 Btu per gallon; ethanol: 76,330 Btu per gallon, lower heating values, since exhaust gases are hot (higher heating value is used when the energy in the products of combustion has been captured, and exhaust gases from the process are cool). Source: Alternative Fuels Data Center, Fuel Properties Comparison Table (https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf) dated 10/29/2014, accessed 11/3/2020.

[81] U.S. Energy Information Administration. https://www.eia.gov/beta/states/states/hi/data/dashboard/renewables. The data was provided in thousands of barrels per year, and converted to millions of gallons per year. There are 42 gallons in a barrel. Series Key: SEDS.BDPRP.HI.A

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[84] Filing by Hawai'i Gas with the Public Utilities Commission, Docket No. 2017-0105, "DESCRIPTION OF APPLICANT." https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A17H02B42645H00182

[85] https://www.manta.com/mb_45_B33D87N3_12/propane_gas_bottled/hawaii

[86] U.S. Energy Information Administration, "Natural Gas Prices." Data Series: Residential Price; Period: Annual; Show Data By: Area. https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm

[87] U.S. Energy Information Administration, "Natural Gas Summary." Area: Hawaii; Period: Annual; Show Data By: Data Series. https://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_SHI_a.htm

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[92] For example, "Identify, track, and report key performance measures and milestones related to the State's energy and decarbonization goals; Identify market gaps and innovation opportunities, collaborate with stakeholders, and facilitate public-private partnerships …that will support the State's energy and decarbonization goals; Create and review proposed state actions that may have a significant effect on the State's energy and decarbonization goals." State of Hawaii. Hawaii Revised Statutes, Section 196-72. https://www.capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0196/HRS_0196-0072.htm

[93] State of Hawai'i Greenhouse Gas Program. https://health.hawaii.gov/cab/hawaii-greenhouse-gas-program/

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[95] Lawrence Livermore National Laboratory, https://flowcharts.llnl.gov/commodities/carbon

[96] U.S. Department of Commerce, National Oceanic & Atmospheric Administration. Global Monitoring Laboratory. https://www.esrl.noaa.gov/gmd/ccgg/trends/

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