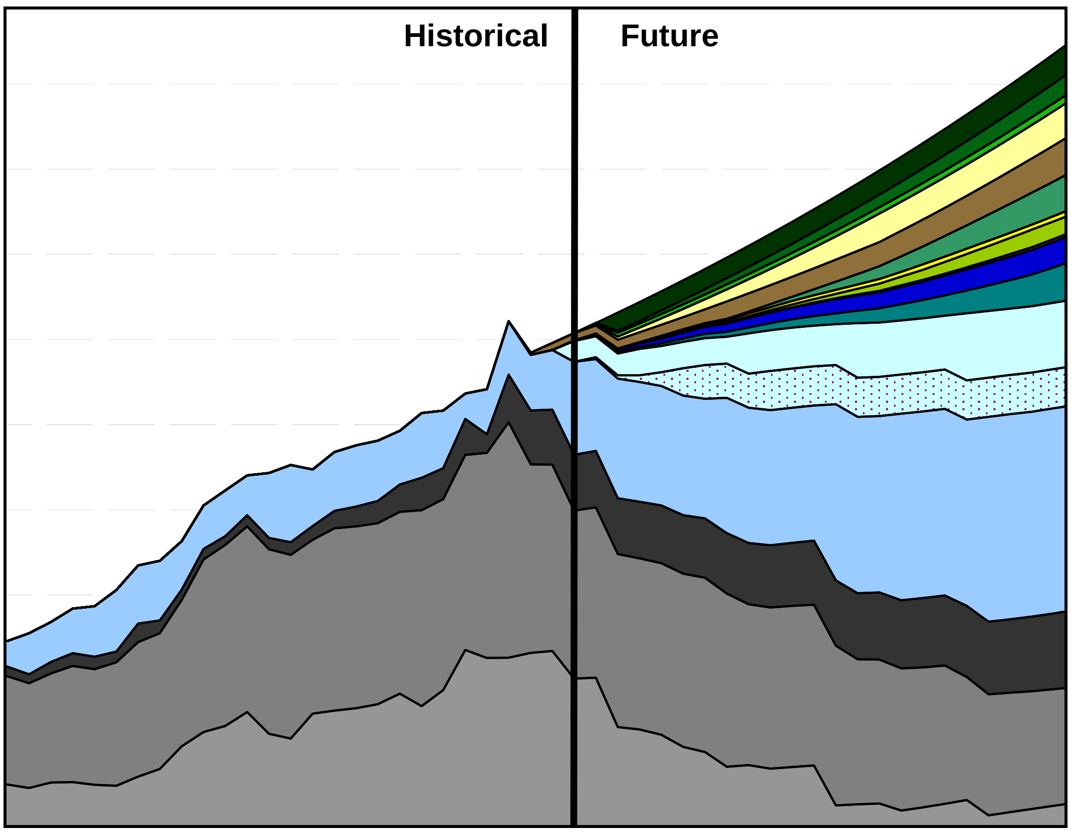
Analysis and Recommendations for the Hawai‘i County Energy Sustainability Plan

October 3, 2007



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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Air Conditioning
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
B100	100% Biodiesel
B2	2% Biodiesel Blend
B20	20% Biodiesel Blend
B90	90% Biodiesel Blend
BCAP	Building Codes Assistance Project
Boe	Barrels of Oil Equivalent
Btu	British Thermal Unit
CDP	Community Development Plan
CFL	Compact Fluorescent Light Bulb
CT	Combustion Turbine
DBEDT	Department of Business, Economic Development, and Tourism
DSM	Demand Side Management
E10	10% Ethanol Blend
E85	85% Ethanol Blend
ECAC	Energy Cost Adjustment Clause
EIA	Energy Information Administration, U.S. Department of Energy
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
GWh	Gigawatt-hours (one billion watt-hours)
HCATT	Hawai‘i Center for Advanced Transportation Technology
HECO	Hawai‘i Electric Company (parent company of HELCO)
HELCO	Hawai‘i Electric Light Company
HEP	Hamakua Energy Partners
HNEI	Hawai‘i Natural Energy Institute
HPwES	Home Performance with EnergyStar
HRS	Hawai‘i Revised Statutes
IECC	International Energy Conservation Code
IESNA	Illuminating Engineering Society of North America
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRP	Integrated Resource Plan
IRP-3	HELCO's Third Integrated Resource Plan
kW	Kilowatts (one thousand watts)
kWh	Kilowatt-hour (one thousand watt-hours)
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
MEC	Model Energy Code
MECO	Maui Electric Company
MMBtu	Million British Thermal Units

Mpg	Miles per Gallon
MSFO	Medium Sulfur Fuel Oil
MW	Megawatts (one million watts)
MWh	Megawatt-hours (one million watt-hours)
NEG	Net Excess Generation
NELHA	Natural Energy Laboratory of Hawai‘i Authority
NYMEX	New York Mercantile Exchange
O&M	Operations and Maintenance
OTEC	Ocean Thermal Energy Conversion
PAYS	Pay As You Save
PGV	Puna Geothermal Venture
PHEV	Plug-in Hybrid Electric Vehicle
PSH	Pumped Storage Hydro
PUC	Public Utilities Commission
PURPA	Public Utilities Regulatory Policies Act
PV	Photovoltaic
QF	Qualified facility
RESNet	Residential Energy Services Network
RPS	Renewable Portfolio Standard
RSHG	Residential Solar Heat Gain
SEER	Seasonal Energy Efficiency Ratio
SHGC	Solar Heat Gain Coefficient
SWH	Solar Water Heater
TOD	Time-of-day

EXECUTIVE SUMMARY

Hawaiʻi Island depends heavily upon imported petroleum products to meet its energy needs. Petroleum products shipped in from the mainland United States and foreign countries currently satisfy the fuel demand for approximately 70% of electricity generation and virtually all transportation needs. Growth in population, tourism, and the economy has resulted in significant and steady increases in energy demand in the commercial, transportation, and residential sectors.

High petroleum prices are a main factor driving up Hawaiʻi County's electricity price, which was more than three times the national average in 2006. Gasoline prices are among the highest in the nation. Due to this reliance on imported petroleum-based fuels, the County is vulnerable to the volatility of global oil markets and sends hundreds of millions of dollars out of the local economy each year. Fossil fuel use poses environmental problems that include oil spills, air pollution, and the release of greenhouse gases that cause global climate change.

In recognition of Hawaiʻi County's dependency on fossil fuel, the Hawaiʻi County Council directed the Hawaiʻi County Department of Research Development to create a plan to transition the Island from fossil fuel use for transportation energy and electric generation to a system based on greater efficiency and renewable energy. In September, 2006, the Hawaiʻi County Council issued Resolution 419-06, which provided funding for the creation of an energy sustainability plan. The goals of this Resolution included:

> "The identification of opportunities and incentives for Hawaiʻi County to enhance and maximize energy self-sufficiency and conservation and to employ renewable and alternative power resources and the use of biofuels within County facilities and Hawaiʻi Island."

The report contained herein, *Analysis and Recommendations for the Hawaiʻi County Energy Sustainability Plan,* represents the preliminary findings to support this County goal.

In 2005, The Kohala Center and Yale University's School of Forestry and Environmental Studies launched a program to create a roadmap for sustainability, culminating in the May 2006 publication of the *Hawaiʻi County Energy Baseline Analysis.*[1]. The baseline report characterized the County's energy supply and demand, the local, state, and federal energy regulatory structure, and the social and cultural characteristics of Hawaiʻi as they relate to energy. This report also served as a key data source for the analysis contained herein to support the County Resolution.

Energy supply – the types and sources of energy made available to meet demand (e.g., solar, oil)
Energy demand – energy needed to provide the service

As part of this effort, the energy system was examined holistically, including electricity generation and transportation fuel use, with the goal of identifying lowest cost, technologically feasible opportunities that can be employed in the near term.

[1] Available online at: http://learning.kohalacenter.org/resource/resmgr/pdf/hcbea.pdf

Opportunities were identified to maximize energy efficiency and conservation as well as to develop economically viable renewable generation. To this end, sixty-six recommendations to the County were developed and are presented and discussed in this report.

The broad focal areas of this report include energy efficiency and increased energy generation from renewable sources. Energy efficiency improvements include measures to improve buildings, transportation, and water use. Renewable generation categories include the use of biofuels in transportation, distributed generation solar technologies, and large scale electricity production options for the utility, Hawai'i Electric Light Company (HELCO), such as geothermal power, wind farms, and pumped storage hydropower. For each of these areas of focus, in addition to several smaller categories, recommendations were crafted to support the County's goals of maximizing efficiency and renewable generation. The group or groups capable of implementing the areas of focus were identified and the potential impacts on the energy system were characterized through 2030.

Energy efficiency – reduce demand from existing services without affecting the type or quality of that service

In order to compare the benefits of the different options, it is necessary to evaluate the primary energy use. For example, when discussing a reduction in electricity use caused by an efficiency measure, one should quantify the total energy extracted from nature (i.e., the primary energy) that was required to generate the electricity. Within the State of Hawai'i, each kilowatt-hour of fossil-fuel generated energy saved avoids the combustion of approximately 10,350 Btu.[2]

Primary energy – energy resources as extracted from nature

The cumulative effect of the recommendations contained in this report is expressed in Figures ES-1, ES-2, and ES-3 below. These figures compare historic energy use and future energy use under two scenarios; (1) a business as usual scenario (Figure ES-1) where energy in the future is generated and consumed in the same manner as in the past and (2) a more sustainable scenario (Figure ES-2) that implements those recommendations presented in this report. In both scenarios, energy consumption would increase due to increased individual demand, population rise, and additional tourism. However, the amount of energy increase and the manner in which the energy is generated differ dramatically. Figure ES-3 provides a breakdown of the efficiency measures and technologies implemented to provide the results shown in Figure ES-2.

Figure ES-1 shows projected energy demand through 2030 and the means of generation if Hawai'i County were to continue supplying and consuming energy the way it does today (business as usual). As shown, energy demand would continue to increase. A portion of energy generation would continue to be from renewables (mainly geothermal in addition

[2] For the purpose of this study, the energy content of gasoline, diesel, and the fuels used in power plants are assumed to be equal to their primary energy, despite having undergone processing after extraction; Btu calculation provided by Steven Alber, State Energy Planner, DBEDT, July 2007, calculation performed by Douglas Oshiro, DBEDT.

to wind); however, imported fossil fuels would remain the backbone of the energy supply.

Figure ES-2 shows the cumulative contribution of all renewable energy technology and energy saving measures presented in the report. As shown, both efficiency measures and renewable generation play an important role in increasing overall energy independence. The efficiency wedge (in green) illustrates the potential to reduce demand, while the renewable generation wedge (in blue) represents opportunities to employ alternative energy generated on Hawaiʻi Island to reduce the use of imported fossil fuels. Both the green and blue wedges are made up of numerous initiatives that are presented in this report. Whereas each recommendation may contribute a modest improvement on its own, the aggregate impact of the various measures on the energy system would be tremendous. This illustrates a central conclusion of this report: energy sustainability would be achieved as the result of numerous and innovative efficiency measures and a more diversified energy portfolio that emphasizes renewable sources.

Figure ES-3 shows the contribution of each energy-saving measure and renewable generation technology, which were summarized in Figure ES-2. The efficiency measures (green wedge in Figure ES-2) are segmented into different actions, such as reducing energy losses through improved electrical transmission, improving the energy efficiency in buildings, and increasing the fuel efficiency of transportation. The renewable energy measures (blue wedge in ES-2) are broken down into options such as increased electrical generation from greater geothermal and wind, and from increased use of biofuels for vehicular transportation.

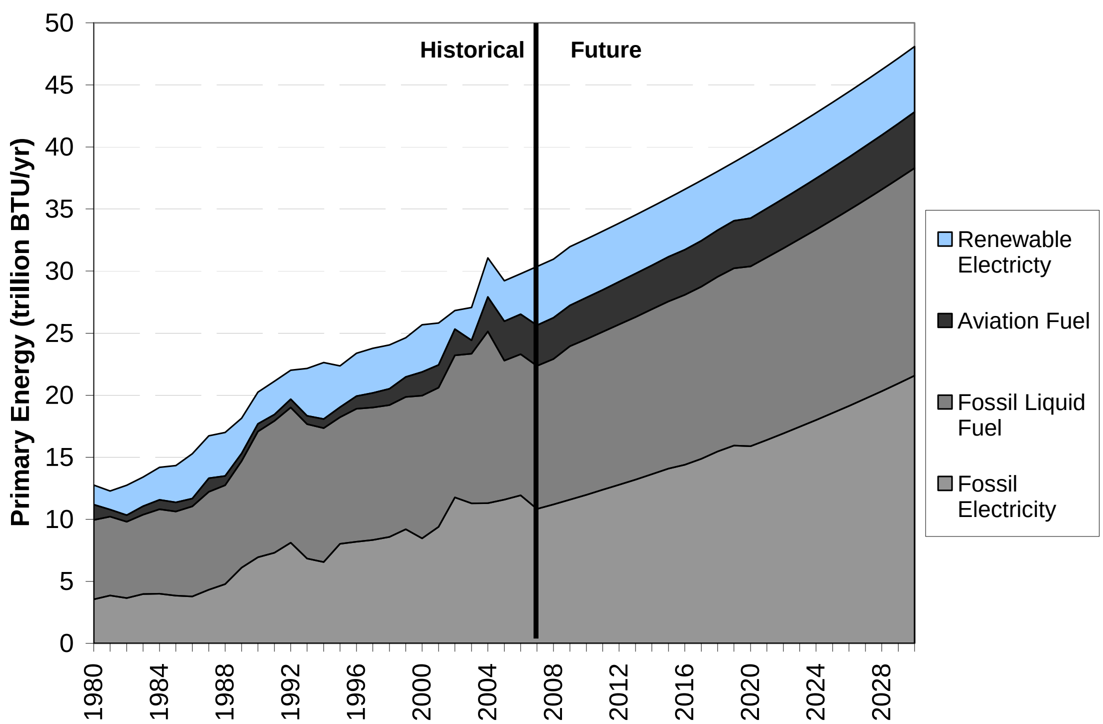

Figure ES-1: Projected energy supply fuel sources using business as usual scenario

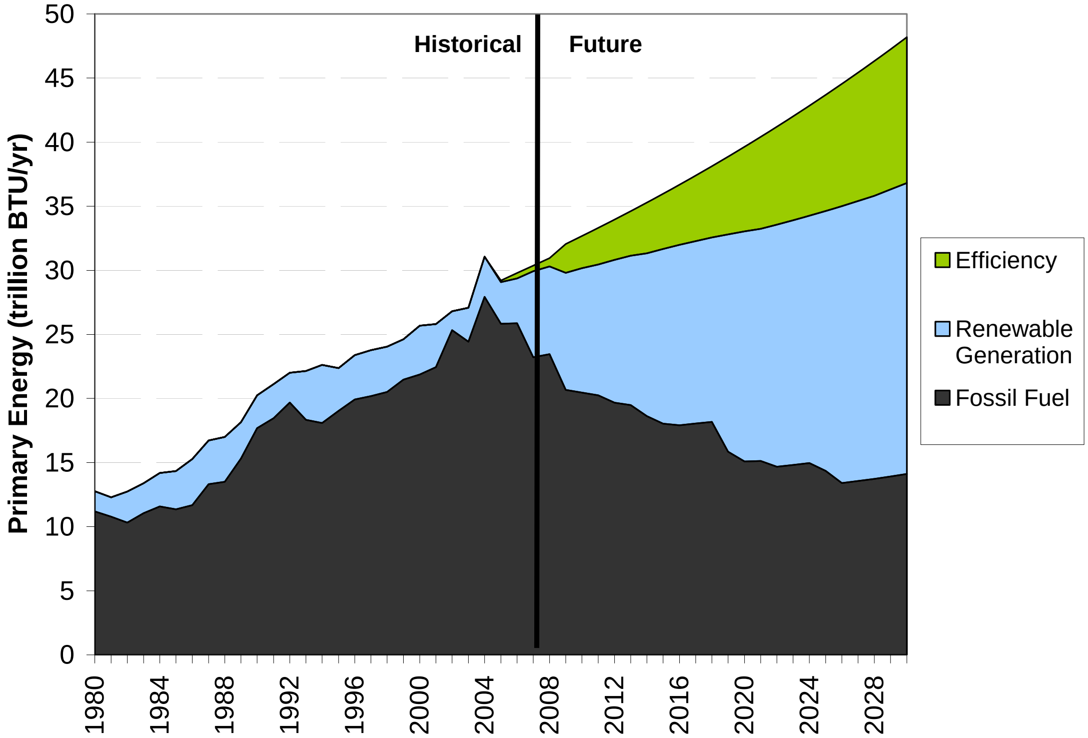

Figure ES-2: Estimated potential for all efficiency and renewable generation recommendations in the proposed Hawai‘i Island Sustainable Energy Plan

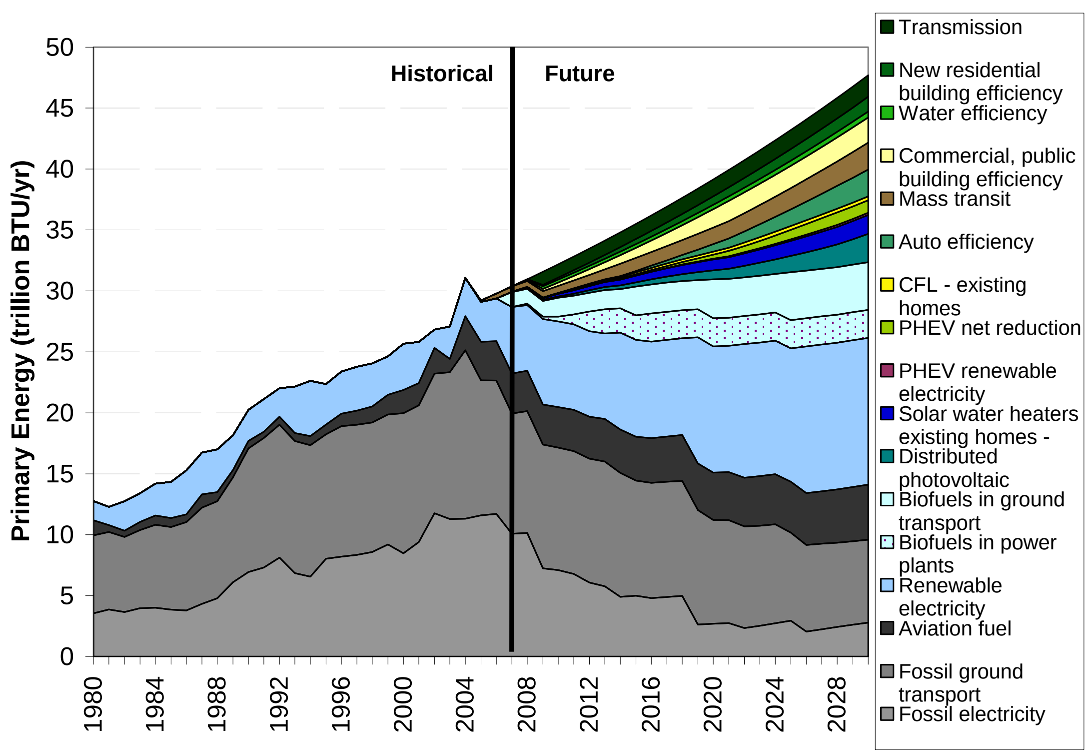

Figure ES-3: Primary energy use in Hawai‘i County with future energy efficiency and renewable energy actions

A summary of the assumptions that support this model are provided in Table ES-1 and each contributing factor is discussed in greater detail throughout the body of the report.

Table ES.1: Assumptions for aggressive efficiency and renewable energy scenario

Category	Assumptions
Transmission improvements	Line losses are reduced by 1.8% of total generation.
New residential building efficiency	Each year, 1,000 new homes are constructed which utilize 240 kWh/month of electricity as compared to the current average home which utilizes 591 kWh/month.
Water use efficiency	Leaks in the Hilo water transmission and distribution system are repaired, saving approximately 5 million kWh/year in pumping energy. A water conservation strategy reduces water use by 20%. Two microturbines (0.04 MW) are added per year until 2030, which achieve 75% utilization.
Commercial & public building efficiency	Electricity use by these sectors is 36% of total demand and efficiency measures reduce demand by 1.5% per year until a 21% reduction is met.
Mass transit and rideshare	Current growth trajectories, which are very high, are reduced to annual increases of 20% through 2015, followed by 5% annual growth between 2015 and 2030, resulting in 310,000 trips in 2030.
Automobile efficiency	The average passenger vehicle efficiency is increased from 23 mpg to 30.2 mpg in 2030 using a graduated feebate strategy (i.e., CAFEplus)
CFL use in existing homes	Each year, 2,000 homes change to compact fluorescent lights, saving 65 kWh/month, increasing until 32,000 new homes have made the change.
Plug-in hybrid electric automobiles	Beginning in 2010 with a small pilot program, the sales of plug-in hybrids would grow to a green fleet of approximately 40,000 vehicles by 2030. Under time-of-day pricing, the automobiles use electric power for 74% of the miles driven and a 12 kWh charge provides 40 miles of driving.
Solar water heaters for existing homes	Of the roughly 65,000 residences, approximately 10% currently have solar water heaters. Three and a half percent of existing homes add this technology each year (2,300 units), saving 190 kWh/month. Solar water heaters on new homes are included in new building efficiency.
Distributed photovoltaic power	Starting at 1.5 MW in 2007, an additional 110% of capacity is added each year. In 2030 a total of 130 MW of photovoltaics are online with 13 MW installed in 2030 alone.
Biofuels in transportation	Biofuel use in transportation is assumed to meet the Renewable Fuel Standard with 8.5% of ground transportation fuel being met by biofuel until 2010; 10% for 2010 to 2014; 15% for 2015 to 2020; 20% for 2020 to 2025; and 25% 2025-2030. The Superferry would use biodiesel and have one trip per day starting in 2009.
Biofuels in power plants	Biodiesel is used to replace diesel and/or cellulosic ethanol is used to replace naphtha in existing power plants, increasing until reaching 2.3 trillion Btu in 2016.
Renewable electricity on grid	Geothermal capacity increases by 20 MW in 2009 and 10 MW in 2014. In 2019, 40 MW of wind coupled with 30 MW of pumped hydro storage goes online. In 2022, 10 MW of intermittent renewable generation goes online, followed by 20 MW of firm renewable in 2026.

Of the various options presented to the County, those with the most immediate impact include:

- Retiring the HELCO Shipman and Puna steam power plants, replacing them with geothermal generation, and adding pumped storage hydro coupled with wind power;
- Improving building design and performance through codes and incentives, and increasing the use of technologies such as solar water heaters and compact fluorescent light bulbs;
- Improving the fuel efficiency of vehicles;
- Increasing the use of mass transit.

Based on the aggressive scenario represented in Figure ES-3, in 2030, all efficiency measures could cover 23% of the expected primary energy use and renewable generation could cover 46%, leaving approximately 31% of primary energy demand to be met using fossil fuels. This report describes the specific actions that can be taken to achieve the County's goals, beginning with energy efficiency and followed by renewable generation. ***The overarching goals are to minimize energy use to the greatest extent possible and to meet remaining demand with energy generated from locally generated renewable resources.***

Energy Efficiency of Buildings

A combination of regulations and incentives for builders and residents represents the optimal strategy for improving the energy efficiency of buildings.

The current Hawaiʻi County **Model Energy Code** exempts energy efficient construction of **new residential homes**. The County can incorporate specific energy savings requirements into the residential code, such as minimization of roof heat gain, requirements for wall insulation, low-emissivity windows and doors, passive envelope cooling techniques (e.g., use of overhangs), and more efficient air conditioning units. Additions and alterations to existing homes should be subject to these same requirements. These Code updates would mean little in the way of additional costs to the builder but would result in a lifetime of savings to the resident. An additional code requirement should be to place any single-structure residential developments in excess of 6,000 square feet into the more stringent commercial Model Energy Code.

Model Energy Code – energy efficiency criteria incorporated into County building codes for new residential and commercial buildings

Beyond regulations, there are many **incentives** that can encourage builders to incorporate energy efficiency measures. In addition to existing state and federal tax credits and utility rebates, the County can promote efficiency through an environmental labeling system for homes, assist builders in paying for energy certifications, streamline the permitting process for efficient buildings, reduce the efficiency verification backlog by hiring a third-party verifier, incentivize the Hawaiʻi BuiltGreen and the nationally recognized LEED programs, and establish a County energy efficiency tax credit. The federal EnergyStar program provides a labeling system for energy efficiency in homes and buildings that should be utilized by the County as a guide. A tax credit could be indexed to either the EnergyStar or BuiltGreen programs.

Building envelope – the “shell” of the structure (i.e., the walls, roof, doors, and windows)

While the average home in Hawai‘i County uses approximately 600 kWh of electricity per month, one successful contractor on Oahu constructs energy efficient homes that use 60% less energy with upfront construction costs often lower than conventional home prices. These homes emphasize building envelope design to improve energy efficiency and feature such technologies as solar water heaters, compact fluorescent lighting, and cool roofs.

If the construction efficiency measures described above are implemented, and new homes in Hawai‘i County realize this 60% reduction in energy consumption, in 2030 an estimated 1.2 trillion Btu per year of primary energy would be saved, which is the energy equivalent of 9 million gallons of diesel per year.

Existing residential homes would likely be exempt from any changes to the Model Energy Code with the exception of remodels and additions. There are still measures that homeowners can take to dramatically reduce their energy usage and cost. Switching from incandescent lighting to **compact fluorescent light bulbs (CFLs)** is a simple action with significant impact. Using only a quarter of the electricity and lasting considerably longer than incandescent bulbs, this technology pays for itself in reduced energy bills in about two months and can save the homeowner hundreds of dollars per year. The main obstacle to widespread use of this technology is lack of consumer information. To meet its goals of energy efficiency, the County should aggressively promote the use of CFLs.

If 2,000 homes per year switch to this technology until a total of 32,000 homes switch, the annual primary energy demand reduction would be 300 billion Btu per year (i.e., 2 million gallons of diesel).

“Pay As You Save” – a program that eliminates upfront costs of home energy systems by allowing consumers to pay for the system through their electricity bill

Another technology appropriate for retrofitting existing homes is the **solar water heater**. With a $1,000 rebate from the utility, a 35% tax credit from the State, and a 30% tax credit from the federal government, the home owner ends up paying only a fraction of the system cost upfront. Although the remaining upfront cost is still significant, the investment pays for itself in the form of energy savings in as little as three years. When the **Public Utility Commission (PUC)** institutes the **“Pay As You Save” (PAYS)** program authorized by State Senate Bill SB2957 Act 240, SLH 2006, residents would be able to pay for upfront costs over time through electricity bill savings with no down payment required. This should greatly reduce the financial barrier for those who do not have the funds needed to pay for the system. It would also encourage the installation of solar water heaters on rental units as it is a way renters can pay for the system as it is used. It is recommended that the County heavily promote this technology and the PAYS program upon PUC implementation. A

County-promoted energy online calculator could show consumers that solar water heating can reduce their yearly electricity expenses by more than $800. It is also recommended that the **Public Benefit Fund** increase the rebate from $1,000 to $1,500.

If 3.5% of existing homes add a solar water heater every year until 2030, 1.6 trillion Btu of primary energy (i.e., 12 million gallons of diesel) would be saved.[3]

Public Benefit Fund – a funding mechanism administered by a third-party to pay for energy efficiency programs

The federal **EnergyStar** program qualifies energy efficient household appliances, providing consumers with information on energy use. Unfortunately, the **"EnergySaver"** guides that come with appliances at retail stores use the much lower mainland electricity prices to estimate annual energy costs and savings. To inform residents of the true energy costs of appliances, the County can create a **Hawai'i Island EnergySaver** guide using local electricity rates to encourage the purchase of energy efficient appliances. The quickest pay back for the cost premium of EnergyStar appliances in Hawai'i County occurs with air conditioners, followed by refrigerators, dish washers, and then clothes washers. In addition to creating point-of-sale information, the County or the Public Benefit Fund could create point-of-sale incentives, which decrease the cost premium of efficient appliances. It would be the responsibility of retailers to use the local EnergySaver information to promote efficient models.

Improving the efficiency of **commercial and public sector buildings** is also a key part of achieving the County's goals. The commercial energy code should be updated to reflect the new standards of ASHRAE/IESNA 90.1-2004. Such updates also could include "cool roof" requirements, rainwater harvesting, and energy life cycle costing for large projects. County incentives can spur efficiency, including establishing a labeling system for efficient projects, establishing financial incentives for building performance, requiring commissioning agents for all large commercial construction projects, encouraging the Hawai'i BuiltGreen program, and providing rewards for certifying building operators in energy efficiency.

By requiring high standards for energy efficiency in County-owned and financed buildings, the County would be **leading by example**. Requiring LEED or EnergyStar certification of County buildings would save in energy costs, demonstrate the County's commitment to efficiency, and develop local expertise in constructing energy efficient buildings.

The electricity use by the commercial and public sectors is 36% of total electric demand. If a 1.5% annual decrease in energy demand is achieved, which corresponds to a total 21% reduction by 2030, the annual efficiency gains would be 2.1 trillion Btu of primary energy (i.e., 16 million gallons of diesel) in 2030.

[3] This only includes the contribution of solar water heaters on existing buildings. The contribution of solar water heaters on new buildings is included in the section on new residential homes.

<u>Energy Efficiency in Transportation</u>

Improving the efficiency of the transportation sector can be achieved by increasing fuel efficiency of the car and light truck fleet with feebates, increasing the use of mass transit, ridesharing, and bicycles, and, when the technology becomes available, promoting plug-in hybrid vehicles.

> **Feebates –** a revenue-neutral program which charges fees to purchasers of inefficient automobiles and awards rebates to purchasers of more efficient models

To spur automotive fuel efficiency, the County can encourage the State to initiate a strong **feebate program** in which automobiles are assessed a fee or given a rebate depending on their fuel efficiency. The program can be revenue neutral, with fee revenue paying for rebates and modest program administration charges. This would create no net financial burden on residents yet guide automobile purchasing practices towards more efficient vehicles.

> **Pivot point –** the set point at which automobiles with higher fuel efficiencies receive a rebate and those with lower efficiencies pay a fee

Taking into account the time for fleet turnover, a successful feebate program could increase the average fuel efficiency of cars and light trucks from 23 miles per gallon to 30 miles per gallon by 2030, reducing transportation fuel use by roughly 2.2 trillion Btu or 18 million gallons of diesel per year. A 10 % take back effect was assumed as energy efficiency improvements typically result in slightly increased consumption.

> **Take back effect –** the phenomenon where improvements in energy efficiency lead to additional energy use; in the case of automobiles, greater fuel efficiency is shown to lead to an increase in miles driven

To demonstrate its commitment to automotive fuel efficiency, the County can lead by example and require that new purchases for its vehicle fleet meet the energy efficiency standards set forth in Hawai‘i Revised Statutes §103D-412 for State vehicle fleets. The County should also require its heavy-duty vehicle fleets to meet **Alternative Fuel Standards** such as the use of **B20** in all diesel-powered vehicles.

The increase in use of **mass transit** in Hawai‘i County over the past two years is a great success story. Ridership has nearly doubled since Hawai‘i Mass Transit implemented the “Hele-on” free bus policy. Increased usage is saving consumers money on fuel and car maintenance, decreasing traffic congestion, creating safer roads, and decreasing demand for automotive fuel. In addition, Hawai‘i Mass Transit is launching a **rideshare program** to encourage carpooling. To expand on this success, the County is actively promoting bus use and rideshare in conjunction with a marketing class from the University of Hawai‘i at Hilo. By providing more buses and more bus routes, the County can continue this rapid growth in public transportation.

If 20% annual increases in ridership occur through 2015, followed by annual growth of 5% through 2030, the energy savings of these programs would total 2.2 trillion Btu or roughly 18.4 million gallons of diesel per year.

Where appropriate, the County should require spacing for **bicycle lanes** during the construction of new subdivisions, roads or improvements on existing roadways. Although bicycle lanes are typically most effective in dense urban areas, towns such as Kona, Hilo, and Waimea have sufficiently compact downtown areas to support the use of bicycles. Pending the popularity of bicycle use in these areas, the County should be prepared to offer bicycle rack areas for residents to lock their bikes while riding in and around town. Due to the distance and terrain between the larger town centers on the Island, high demand for bike lanes on these highways is not anticipated. However, the County should ensure that safe bike paths exist wherever possible for any bikers who may wish to travel longer distances. An additional consideration is to purchase cross-island buses with bicycle racks so that riders can use a combination of bicycle and public transportation to travel around the Island; such bus models are readily available from other communities.

Plug-in hybrid electric vehicles are an emerging vehicle technology capable of operating as an electric vehicle using an electric charge, as a typical fossil-fuel engine using gasoline or diesel fuel, or as a hybrid electric vehicle (on a combination of electricity and motor fuel). These vehicles simply "plug-in" to a wall outlet like another appliance in order to charge their batteries. General Motors recently announced its intention to produce plug-in hybrids in passenger car and SUV models starting in 2010 and other companies are expected to pursue similar paths.

Since these cars get much of their energy from the electric grid, the environmental performance of their operation depends on the fuel mix that goes into electricity production. In Hawai'i County, a plug-in hybrid using electricity from the current fuel mix would use fossil fuels on the grid at a rate of 41 miles per gallon of gasoline equivalent. By increasing the share of renewable energy on the grid, a more distinct advantage can be created.

Since these vehicles use utility-generated electricity, the grid must be able to accommodate their charging capacity. Of particular importance is predicting the effect of these vehicles on the **load curve**, an essential tool in electricity planning. Since the utility does not store electricity, the amount of electricity generated at any given time must match the amount demanded by consumers. On the Island of Hawai'i, residents tend to run many of their appliances and electric products at the same time, creating a daily peak in electricity demand between 7:00 p.m. and 9:00 p.m. Later at night, after residents go to sleep, electricity demand can drop by over 50%. The utility must have adequate capacity to generate enough electricity to cover these peaks, even if they last for a only few minutes; apart from the utility's obvious need to provide satisfactory customer service, the sensitivity of electricity grids means that an

> **Load curve –** a chart showing the demand for electricity over time throughout a 24-hour period

inability to meet peak demand could result in brownouts or rolling blackouts. If the plug-in hybrids are charged during evening peak hours, this increases peak demand and requires that the utility utilize its most expensive peak generating units.

Time-of-day pricing – charging electricity users more when demand is high and less when demand is low, reflecting actual generation cost fluctuations

By contrast, owners of these cars could avoid contributing to this peak demand problem by plugging them in during off-peak times. This can be encouraged through a strong **time-of-day pricing** system, which charges customers more for electricity used during peak hours and less for electricity used during off-peak hours, a structure that closely reflects the utility's generating costs. A time-of-day pricing scheme is currently proposed (pending PUC approval) for up to 300 homes in the County. Another option would be to offer electric vehicle charging rates and to use technology to control charging stations to prevent use during peak demand periods. If the utility is able to successfully manage charging these vehicles, plug-in hybrids could prove to be a new source of revenue for the utility and allow it to use excess nighttime capacity, especially available renewable generation that must sometimes be curtailed at night due to low demand. Such a charging structure also provides load curve benefits by making demand more consistent throughout the day and night. Given the sensitivity of electricity grids to demand fluctuations, a more balanced load curve also benefits electricity transmission.

Another solution to the potential load problem associated with plug-in hybrids comes in the form of an emerging technology, **"Vehicle to Grid"** or **V2G**, which is currently in development for use with electric vehicles such as PHEVs. Using V2G, the batteries in PHEVs could essentially serve as small, mobile electricity storage and supply systems for the electric grid. Instead of presenting a potential load curve problem, PHEVs would offer a compelling partial-solution to load curve problems associated with electricity peaks and valleys. V2G is also envisioned as acting as a buffer to the intermittency of certain forms of renewable power like wind, for which an unpredictable supply represents a barrier to use. Capable of capturing power generated by wind energy, V2G could store this power for the grid.

If this technology proves viable, and if by the year 2030, forty thousand of the cars on the Island (about 15%) are plug-in hybrids, the net efficiency gains from these vehicles would be 1.0 trillion Btu or 9 million gallons of gasoline per year, assuming that 74% of miles driven are on an electric charge and there is a take back effect of 10%.

These fuel reduction estimates do not account for ongoing advancements in PHEV technology that promise to increase the battery range to 100 miles per charge and further reduce expected fuel demand through mile per gallon ratings of more than 100 mpg. In the absence of V2G technology, the PUC and the utility should work to create a strong time-of-day pricing scheme to help make plug-in hybrid operation significantly less expensive than traditional automobiles and capture fuel reduction and load curve benefits.

When PHEVs become available, the County should lead by example and adopt them as a pilot program into their fleet.

Energy Efficiency of the Water System

With most of the County's water supply coming from ground water that requires extensive pumping, water usage is linked to energy use. In fact, the **Department of Water Supply** is the largest consumer of electricity in the County, representing 5% of total use. There are five main areas for potential improvement: repair the most extensive leaks in the water system, create a water conservation policy, develop more storage capacity to prevent the need for peak pumping, institute a pump system maintenance and efficiency program, and install generating pressure reducing valves.

Generating pressure reducing valve – an apparatus that captures energy from the pressure in the water system that must be reduced before distribution to the customers

As recently as 2006, the Hilo area water system had extensive **water transmission leaks** that resulted in up to 44% of pumped water being lost during transmission. In 1999, the Department of Water Supply launched a program to identify leaks and estimate the cost of their repair and found that the median pay back time is less than one year. The repairs that have been conducted have been largely successful, with Island-wide leaks reducing from 23% to 12%.

With continued implementation of this program, the Department of Water Supply can reduce electricity usage by 5 million kWh per year, or the equivalent primary energy of 500,000 gallons of diesel.

A comprehensive **water conservation policy** would further reduce water and energy demand. Currently, the Department of Water Supply requires voluntary and mandatory conservation of its customers only during low water events such as droughts, equipment malfunctions, or storage problems. There is no day-to-day water conservation policy. Conservation could include rainwater harvesting on large commercial properties, installing water re-use systems, creating a progressive pricing scheme that rewards water efficiency, and creating point-of-sale incentives for water efficient appliances.

If a conservation policy were to reduce water demand by 20%, the primary energy savings would be 270 billion Btu in 2030 (i.e., 2 million gallons of diesel).

The number of viable sites for **generating pressure reducing valves** needs to be closely examined by the Department of Water Supply and these valves should be installed where cost effective.

If it is found that two of these units can be installed each year, each rated at 40 kW and achieving 75% utilization, 150 billion Btu of primary energy (1 million gallons of diesel) would no longer need to be taken from the grid each year by 2030.

Energy Efficiency through Reduced Electric Transmission Losses

> **Line losses –** electricity that is lost during transmission over power distribution lines.

With a majority of the electric generation capacity on the East side of the Island and a large and increasing demand on the West side, adequate cross-island **transmission** is essential to grid stability and the minimization of **line losses**.[4] Current system-wide losses are between eight and nine percent of generation; improved transmission lines would cut these losses to less than seven percent. Plans are already underway for the utility to improve three of these lines, alleviating some of the concerns for overcrowding and reducing line losses.

If these upgrades are implemented, it would reduce generation fuel by an estimated 1.8 trillion Btu of primary energy in 2030 annually (i.e., 14 million gallons of diesel).

Renewable Electricity Production by the Utility

In 2006, over 76% of electricity generation in Hawai'i County was from petroleum-based fuels (diesel, medium sulfur fuel oil, and naphtha), 17% was from geothermal at Puna Geothermal Venture, 5% was from hydropower, and 2% was from wind power. The share of generation from wind power will increase to over 10% of generation with the addition of the Hawi and South Point wind farms.

The utility must plan for new generation capacity to meet expected peak demand while creating a system that can also effectively operate at low off-peak levels. Since the Island is an isolated grid, the utility cannot obtain electricity from another region in the event of a serious supply disruption. The penalty for failing to meet demand is severe: blackouts and system damage can occur. HELCO must therefore meet all requirements for power from its own resources and/or from independent power producers under contract to HELCO, a grid structure that is unusual for most of the United States.

All forms of generation are not created equal and some possess distinct advantages over others. It is helpful to segment the different types of generation in the County into five groups:

1. **Non-regulating baseload plants** are units that are intended to be run all of the time, except during repairs. "Non-regulating" refers to their inability to adapt their output to maintain frequency and voltage consistency. The only unit in this category, **Puna Geothermal Venture (PGV)** facility, could become regulating baseload units with technological improvements.
2. **Regulating baseload plants** are also intended to run all or most of the time, but these units are equipped with automatic generation controls to rapidly allow for adjustment to manage frequency and voltage. As these plants are most efficient

[4] Longer-term solutions should consider reducing or eliminating the need for cross-island transmission. As the island's population and hospitality industry continue to grow along the Kona and Kohala coasts, the demand for electricity rises accordingly. The West side of the island possesses an abundance wind and solar resources that offer clean, cheap, and geographically close potential power resources. In particular, the Western demand is ideally suited to a pumped storage hydro installation, which would make use of abundant renewable resources to provide for the significant peak demand brought on by the hospitality industry (resorts, hotels, condominiums).

when operating all day, it is desirable to have baseload generation that does not exceed minimum demand. The Puna and Hill plants, which run on a fuel called MSFO, are examples of regulating baseload plants.

3. **Intermediate or cycling plants** fill in the gaps between baseload generation and peaking plants, running for the portion of the day when demand is higher than the minimum load and compensating for extra baseload or peak demand. The Puna CT-3, Keahole CT2, CT4, CT5, CT7, and Shipman plants are all cycling/intermediate generators.
4. **Peaking plants** provide power for short periods of the day when demand is the highest. Kanoelehua CT-1 is a peaking plant.
5. **Intermittent sources**, which are variable and depend on natural conditions, include photovoltaic power, wind power, and some forms of hydropower. Two new wind farms have recently come online, the Upolu farm located on Upolu Point near Hawi and the Apollo farm located in South Point.

A model was created for this report to assess the feasibility of meeting the County's renewable energy goals by incorporating more renewable generation in the electrical grid. Four scenarios were examined: three were taken directly from the **utility's Integrated Resource Planning (IRP)** process (the "Baseline," the "Preferred Option," and "Maximum Renewables"). A fourth scenario entitled the "Energy Sustainability Plan" was generated for this study and examines the effect of plant retirements. All four of these scenarios were assessed in concert to determine how the quantification of energy generation by source and total scenario cost compare.

Baseload plants– power plants intended to be run all of the time except during repairs
Intermediate or cycling plants – power plants intended to run some of the time
Peaking plants – power plants that generally run only when there is high demand
Intermittent sources – power generation that is variable and determined by natural sources such as wind

The IRP process is the mechanism by which the utility develops a "preferred" plan that it submits to the Public Utilities Commission (PUC) for approval. The goal of IRP is the identification of resources or the mix of resources for meeting near and long term consumer energy needs in an efficient and reliable manner at the lowest reasonable cost.[5] Nearing the completion of the third planning cycle (IRP-3), the Preferred Plan chosen by the utility involves the addition of a combined cycle unit (i.e., an efficiency improvement) at the Keahole facility in 2009, followed by 10 MWs equivalent of wind power in 2016[6] and 25 MW of firm renewable energy in 2022. In the IRP-3, there are no listed plans for power plant retirements.

Integrated Resources Planning – the mechanism by which the utility seeks to identify the resources or mix of resources for meeting consumer energy needs in an efficient and reliable manner at the lowest reasonable cost

[5] Integrated Resource Planning (IRP) Draft Document
[6] The IRP-3 preferred plan actually calls for 37 GWh per year of an intermittent source in 2016, which was modeled as 10 MW of wind power.

A comparison of the four scenarios was performed for this report and a summary is presented below in Figure ES-4. The figure presents a timeline of action under the three plans outlined in the IRP as well as for the Energy Sustainability Plan that was developed for this report.

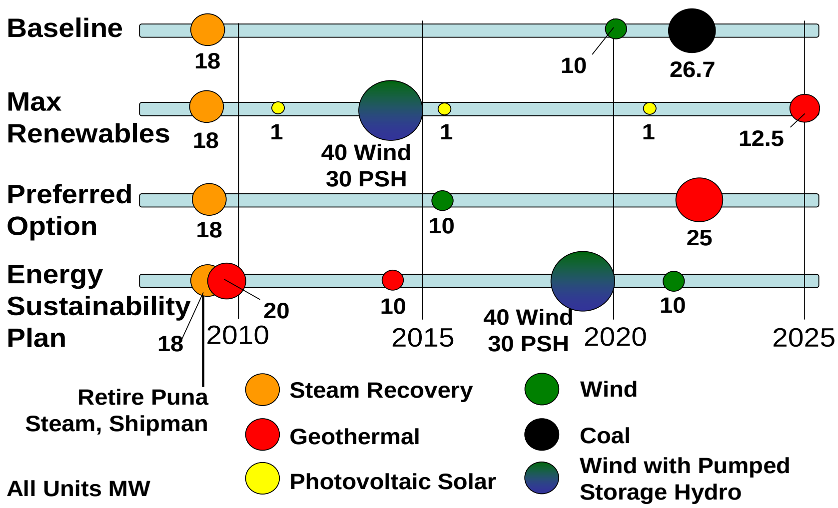

Figure ES-4. Comparison of Energy Generation Scenarios

In the Energy Sustainability Plan scenario, two of HELCO's least efficient fossil fuel plants (the Puna baseload plant and the Shipman intermediate plant) are retired as soon as possible. This generation capacity is replaced by increasing geothermal production at **Puna Geothermal Venture (PGV)** by 20 MW, equipped with automatic generation controls to allow for grid regulation. PGV, which currently has 30 MW of capacity, is permitted to increase generation output by an additional 30 MW at its existing site, for a total of 60 MW. Of the 20 MW PGV increase, up to 8 MW could be met with a steam recovery unit, which would avoid the need to drill additional wells. In 2014, this Energy Sustainability Plan calls for increasing geothermal output by an additional 10 MW. Five years later, a 40 MW wind farm coupled with a 30 MW pumped hydro storage is added. The use of pumped storage hydro system in conjunction with an intermittent energy source like wind can effectively alleviate the intermittency concerns associated with renewable power. This scenario also calls for 37 GWh per year of an intermittent renewable (possibly wind) in 2022. To match the IRP scenarios, the Energy Sustainability Plan scenario goes until 2025, with the minimum and maximum loads of the Energy Sustainability Plan scenario and the IRP Preferred Plan being quite similar.

Pumped storage hydro – a system that pumps water up an incline into a reservoir during periods of low electricity demand and then, during high demand, releases that water down the incline through a turbine to produce electricity

If this Energy Sustainability Plan scenario were implemented, renewable electricity generation would replace 12 trillion Btu of fossil fuel primary energy in 2030, the equivalent of 94 million gallons of diesel per year.

This is more than double the expected fossil fuel displacement from renewable utility generation expected to occur in 2007, which is 5.3 trillion Btu of primary energy.

Note: Since the time horizon of this report measures the effects of energy efficiency and renewable energy actions in 2030, the Energy Sustainability Plan adds an additional 20 MW of firm renewable generation in 2026.

> **Independent power producer –** privately owned power plants that sell electricity to the utility under a power purchase agreement

There are five essential factors that must be considered when evaluating the costs and savings potential from each of these scenarios:

1. **Base savings –** The current difference between what HELCO pays for its own power and what it pays its Independent Power Producers.
2. **Efficiency gains from retirement –** By retiring the least efficient fossil fuel plants, the remaining (more efficient) plants decrease the average unit cost of power.
3. **De-linking avoided cost savings** – Avoided costs paid to independent power producers are currently linked to HELCO's fuel costs. This has the perverse effect of raising the cost of renewable energy production (e.g., wind) to the high cost of oil and eliminates the financial benefits of cheap renewable power for the consumers. Payments for renewables should be de-linked from oil prices. A law was passed by the State Legislature in 2006 calling for delinking by the PUC. At this time, no docket addressing delinking has been submitted to the PUC.
4. **The future cost of greenhouse gases** – In light of the Governor's recent signature enacting the **Global Warming Solutions Act** (Act 234, Session Laws of Hawai'i 2007) and utilities across the nation funding reductions in the greenhouse gas emissions, it is becoming increasingly likely that a price could be put on such emissions in the near future.
5. **Energy storage costs –** This factor captures the cost of energy storage, including pumped storage hydro, which allows for increased use of intermittent renewables.

> **Avoided cost –** the rate the utility pays qualified independent power producers of nonfossil fuels, based on what they "avoid" paying by purchasing rather than producing electrical energy.

Using Energy Information Administration oil price estimates, it was found that the net present value of the Energy Sustainability Plan scenario resulted in a savings of $230 million over the baseline scenario presented in the IRP-3.[7] By contrast, HELCO's IRP-3 Preferred Plan results in a net present value savings of $33 million over the base case.

[7] Assuming a 5% discount rate.

The Energy Sustainability Plan scenario cost savings are segmented as follows: The base and efficiency savings minus the storage costs totaled $38 million. Unlinking the avoided costs resulted in the largest savings: $129 million. Assuming a cost of carbon at $20 per ton of CO_2, $63 million in the cost of carbon would be saved over the IRP-3 base case.[8]

Several actions can be taken to achieve the benefit of the Energy Sustainability Plan scenario: 1. The County, PUC, and the community can convince the utility that accelerated renewable generation should be pursued. 2. The PUC can delink avoided cost and renewable generation through a strong **competitive bidding process**, with the effect of driving down costs and passing the savings on to the consumer. 3. The PUC can strengthen the **Renewable Portfolio Standard** by removing efficiency from the calculation in order to focus on increasing renewable generation. 4. The PUC can implement utility risk sharing for oil prices, rather than passing through all increases in oil price to the public, and mandate that consistent oil forecasts are used for setting the base rate and the IRP process. 5. Since greenhouse gas regulations seem inevitable, the utility should include the cost of releasing greenhouse gases in its planning, thus including the expected financial and environmental advantages of an accelerated renewables plan.

Competitive bidding – the process of soliciting proposals for a project from a variety of developers and choosing the best proposal based upon criteria set forth in the request for proposals

Renewable Portfolio Standard – Hawai‘i Revised Statute Section 269-92 requires each electric utility to meet minimum percentages of generation using renewable

Biofuel Use in Power Plants and Transportation

There are numerous options in the production of biofuels. **Ethanol** can be produced from multiple crops or through emerging processes for cellulosic materials. **Biodiesel** can be produced from oil crops, waste oil including used cooking oil, and algae. In addition to the production of these liquid fuels, biomass can be directly combusted to produce electricity from steam turbines, which includes waste-to-energy technology.

Liquid biofuels can be utilized for transportation and, in some cases, as substitutes for petroleum-based fuel in power plants. A study by the Hawai‘i Agriculture Research Center highlighted the tremendous potential for biofuels in the State of Hawai‘i, estimating that over 100 million gallons of biodiesel could be produced per year in the County of Hawai‘i alone.

A current incentive to produce biofuels for the transportation market is the **Alternative Fuel Standard (AFS).** The State created the AFS to facilitate the development of alternative fuels by having an escalating share of highway fuels provided by alternative fuels, starting with 10% in 2010 and increasing

Alternative Fuel Standard – a state law requiring the development and use of alternative fuels

[8] In the absence of a price for carbon, this assumption is based on current and future carbon prices based on the European Union Emissions Trading Scheme and Regional Greenhouse Gas Initiative. The actual price for carbon in Hawai‘i may be more or less than $20/ton of carbon equivalent.

to 20% by 2020. Coinciding with AFS, the State created producer tax credits to incentivize producers to construct biorefineries. To date, no plants have been built.

Parties who are interested in developing biofuels in Hawaiʻi County cite several key challenges:

1. For energy crop production on the Island, agricultural and mill pilot projects are needed to prove crop yields and production costs to investors;
2. Long-term purchase contracts are needed to mitigate some of the risk of the investment;
3. Infrastructure upgrades need to be executed including repairs to the agriculture water systems.

Representing an intersection between energy and agriculture, the cultivation of feedstocks and refining of biofuels introduce new complexities for both of these well-established industries. Several broad concerns are inherent in the development of a biofuel market: energy security, food security, economic viability, impact on natural resources, and end-use efficiency tradeoffs. To best understand the net energy yield, the pollutants released, the resource trade-offs, and the additional energy security associated with the various strategies, the County could fund a life cycle analysis to determine the net benefits.

In many respects, the capacity of the County of Hawaiʻi government to determine the development path of a nascent biofuels industry is limited. State agencies, HECO, and large private investment would play a significant role in developing this market.
In June 2007, HECO announced that it and its subsidiaries would commence steps to transition its existing plants from petroleum diesel to biodiesel. HECO and its partner in this venture, BlueEarth Biofuels LLC, would import palm oil crops with a provision to use locally grown feedstocks when available. This plan provides significant encouragement to grow the market for locally grown and produced biodiesel. HECO stated that a key component of its plan is to encourage the development of locally grown biofuels feedstock to provide the fuel for their operations. Though not having fully developed its plans for use of biodiesel, the utility could meet its Renewable Portfolio Standard goals by using biodiesel in its diesel generators and turbines, as well as investigating the potential for blending ethanol with naphtha.

If the utility uses 2.3 trillion Btu of biofuels per year by 2030, and the transportation sector (including the Superferry) uses 3.7 trillion Btu per year, 12.5% of the expected primary energy would be met by biofuels. If the biofuel of choice was biodiesel, approximately 46 million gallons per year would need to be produced, requiring 115,000 acres of agricultural land with yields of 400 gallons per acre. Such a yield may be representative of kukui as the energy crop of choice, with higher yields attainable by palm oil and algae. If ethanol is utilized, 58 million gallons would be needed to meet the energy requirement. The amount of land needed to produce this much ethanol is highly dependent on the type of energy crop chosen (e.g., cellulostic or sugar) and the yields that would be determined through the pilot plot study. Likely, to meet the total demand for biofuel, some combination biodiesel and ethanol would be produced, determined by market conditions and the ability for the agricultural production and processing to reduce costs and maximize efficiencies.

The potential for biofuels production on Hawai‘i Island could increase economic opportunities in farming, extracting, and refining. However, a local biofuels industry also would introduce new pressure on fragile natural resources and existing infrastructure. There are several urgent steps the County should consider in response to this new industry:

1. The County should fund a life cycle analysis to determine the net benefits associated with various biofuel strategies;
2. The County should make available County lands for biofuels feasibility pilot projects;
3. The County should carefully examine capital investment needs for additional infrastructure requirements. New industries, State agencies, and the utility companies should be required to contribute to the improvement of necessary infrastructure upon which they will rely;
4. The County should examine the full range of costs and benefits to the County of having biofuels feedstocks grown on the Island; and,
5. The County should determine the potential impact biocrop cultivation would have on local food production.

One final note, should a local biofuel production industry develop in Hawai‘i County, the most appropriate end-use for biofuels becomes an additional concern. Given the inefficiencies of HELCO’s power plants and the number of existing alternatives for electricity generation, biofuels may be more appropriate for use in the transportation sector where fewer alternatives exist.

Distributed Generation of Photovoltaic Power

Solar power using photovoltaic technology currently represents a small portion of total electricity generation. The global market for photovoltaic systems is rapidly growing and the efficiency of solar modules continues to increase. Photovoltaic systems are typically used as **distributed generation**, as opposed to a form of centralized power generation. When distributed generation units are attached to the electrical grid, they have the potential to get credit for excess energy going back to the grid. To facilitate this, Hawai‘i Revised Statute (HRS) Section 269-101.5 currently requires the utility to allow **net metering**. System sizes are currently limited to 50kW, with cumulative net metering agreements kept below 0.5% of the utility’s peak demand. Exemptions can be made on a case-by-case basis to allow net metering for systems larger than 50 kW. Peak demand is approximately 200 MW; cumulative net metering limits are therefore set at approximately 1 MW. Increasing the net metering standards would allow more photovoltaic installations to sell power to the grid. This must be balanced with the need for the utility to utilize effectively this intermittent

> **Distributed generation –** non-utility electrical power generated by small sources such as PV panels, micro wind turbines, and some cogeneration systems

generation. Off-grid systems that do not wish to pursue a grid connection are not limited by net metering laws.

Net energy metering – measuring the difference between electricity supplied through the grid and electricity generated by an eligible customer-generator that is fed back to the grid in a billing period

For photovoltaic systems, existing federal and state tax credits cover up to 30% and 35%, respectively, of the system cost. These generous tax incentives result in estimated payback periods as low as two years for commercial installations and eight years for residential installations. A Pay As You Save program for residential photovoltaic systems would eliminate the need for a down payment, allowing homeowners and renters to pay for the upfront cost of a system over time through their monthly electricity bills.

County buildings are unable to claim the federal and state tax credits or use accelerated depreciation, increasing the payback time to 14 years for County installations. The County can, however, use a third-party (i.e., private corporation) PV developer that would retain ownership of the PV installation and charge a fee for electricity provided. The County may be able to negotiate lower costs due to the tax credits and accounting savings enjoyed by the third part PV provider. This is a great option for County facilities.

With ambitious and incremental growth starting immediately, photovoltaics may reach a total installed capacity of between 80 and 130 MW by 2030. This capacity would exceed the net metering allowances, so these installations would either need to use all of the energy on site, allow some of the energy to be wasted, or invest in energy storage.

The primary energy displaced by 130 MW of photovoltaic modules would be approximately 2.3 trillion Btu annually (i.e., 17 million gallons of diesel equivalent).

Personnel to Implement the Hawaiʻi County Sustainable Energy Plan

For many of these recommendations to be realized, the necessary personnel must be in place to implement them. Although Hawaiʻi County would spend an estimated $750 million in 2007 on energy, there are currently no County-funded personnel assigned exclusively to the management of energy issues. In order to achieve the County goals for efficiency and renewable generation, it is recommended that the County create three full-time positions:

1. A **green building expert** who would be responsible for retrofitting existing County buildings with energy efficiency measures, facilitating third-party installations of solar photovoltaic systems, assisting in energy efficiency certification for all new County buildings, and recommending and interpreting updates of the model energy code to the County;
2. An **energy policy analyst** who would be responsible for the implementation and ongoing update of the Sustainable Energy Plan, recommending County positions on State level legislation and PUC dockets, and participating in energy forums and boards; and,

3. An **energy and sustainability advisor** at the cabinet level who would facilitate the delivery of accurate and timely information to the administration, cut across departments and develop consensus between department administrators, and work directly with the Mayor to establish County energy policy.

Implementation

There are numerous actors who each play an important role in meeting the energy goals of the County. A summary of potential actions is provided here:

County Government

The highest impact actions that the County can take to meet its energy goals include improving the Model Energy Code for residential and commercial buildings; creating incentives for builders to find innovative ways to improve efficiency; mandating that all County buildings obtain EnergyStar labeling or LEED certification; issuing requests for proposals for third party solar installations on County properties; distributing information to residents on compact fluorescent light bulbs, solar water heaters, mass transit, and EnergyStar appliances; increasing the number of buses and routes used for mass transit; encouraging the State to create a feebate system to improve automobile efficiency; and transitioning the County fleet to efficient vehicles.

Other County actions that would also have a positive contribution are continuing the leak detection and repair program at the Department of Water Supply; creating a water conservation policy; adding generating pressure reducing valves to the water system; eliminating the weight tax for efficient vehicles; and creating a County pilot program for plug-in hybrid vehicles when they become publicly available.

In addition to actions that the County can directly execute, the County can also express its support for the recommendations upon which the State, PUC, and utility must act.

Consumers

At present, solar hot water heaters and energy efficient lighting represent the best actions for consumers in terms of energy conservation and financial savings. Both of these technology retrofits pay for themselves several times over. Additional high impact actions that consumers can take include eliminating use of air conditioners (or if necessary, purchasing an efficient air conditioner), using the free mass transit and ride share systems, and purchasing the most efficient car that meets their needs.

Other actions by residents that could help the County meet its energy goals include participating in the Community Development Planning process; providing feedback to the Consumer Advocate; advocating for the retirement of the least efficient fossil fuel plants; purchasing other EnergyStar appliances; installing cool roof technologies such as radiant barriers; and, if building a new home or addition, hiring a builder who optimizes energy efficiency.

Consumers who support the goals of the Energy Sustainability Plan can assist in its implementation by writing letters of support to local newspapers, telling friends and family about energy efficient actions that they can take, and expressing their support for energy sustainability measures to their County Council Member.

Hawai'i Electric Light Company (HELCO)
As one the most influential organizations in the County's energy sector, the support of the electric utility (HELCO) would greatly enhance the ability of the County in achieving its goals of efficiency and renewable generation. The utility can accelerate the use of renewable generation by retiring the Shipman and Puna steam facilities, working with Puna Geothermal Venture to increase their capacity to 60 MW, and issuing a request for proposals for a 40 MW wind/30 MW pumped storage hydro development.

The utility can also negotiate its contracts at below avoided cost to lower rates; use consistent oil forecasts for setting their base rate and planning in the IRP process; incorporate the cost of greenhouse gas emissions in their planning; launch the time-of-day pricing system with more smart-meters and a larger price differential; and expand block pricing with a larger price differential.

State of Hawai'i
In addition to the many initiatives that have already passed at the state level, the State could institute a feebate to encourage energy efficient automobile purchases and implement the Global Warming Solutions Act to reduce greenhouse gas emissions.

Other actions that would have a positive effect for the County's energy goals include the elimination of the state sales tax, registration fee, and weight tax for energy efficient vehicles; and weighting the Alternative Fuel Standard and Renewable Portfolio Standard to reflect the life cycle benefits of various biofuel production schemes.

The State should also encourage maximizing renewable energy production at the Natural Energy Lab Hawai'i Authority (NELHA).

Public Utilities Commission
The PUC regulates the electric utility and could require the utility to adopt an IRP plan that focuses on accelerating the use of renewable generation; separate energy efficiency from the Renewable Portfolio Standard; enforce the competitive bidding process; delink avoided costs from the price of oil; incorporate risk sharing of future oil prices in the utility base rate; require that the utility uses the same oil forecasts in settings the base rate and IRP planning; require that the utility incorporate the cost of greenhouse gas emissions in IRP planning; and expand the time-of-day pricing system with more smart meters and a larger price differential.

Building and Construction Industry
In order to meet the County's energy goals, builders can work with the County on developing Model Energy Code requirements; determine which existing incentives for energy efficiency can be claimed for the projects on which they are working; and conform with recommendations in the "Field Guide for Energy Performance, Comfort,

and Value in Hawai‘i Homes”[9] (for residential structures) and “Hawai‘i Commercial Building Guidelines for Energy Efficiency”.[10]

The Commercial Sector

Commercial enterprises should assess the financial viability of installing solar water heaters or photovoltaic modules; introduce water saving techniques and water reuse processes; utilize compact fluorescent light bulbs or advanced tube type fluorescent systems, programmable thermostats, and efficient air conditioners; and require efficient construction. Appliance retailers can provide EnergySaver flyers specific to Hawai‘i County’s electricity costs and promote the purchase of EnergyStar products.

Researchers

To help meet the County goals for the Sustainable Energy Plan, researchers can run agricultural and mill pilot projects for biofuel development; conduct a life cycle assessment on various production schemes for biofuels; and continue to encourage and support research and development into emerging energy technologies such as **hydrogen**, **ocean thermal energy conversion**, and **wave energy**.

The recommendations outlined in this report should serve as a catalyst for discussion and as a platform for community engagement. The report aims to inspire a productive dialogue among residents, policy makers, industry, and non-governmental organizations.

Hawai‘i Island has long demonstrated a commitment to sustainability and a strong ethic of environmental stewardship. State and County leaders have taken proactive steps to diversify energy supply and encourage energy efficiency. These policies include providing tax incentives for renewable energy generation, instituting a free public bus system on Hawai‘i Island, funding research into and development for alternative energy technologies, installing energy efficient appliances in public buildings and other facilities, and a number of other important initiatives.

This report builds on these efforts to offer a comprehensive and ambitious plan for future energy management on Hawai‘i Island. The recommendations strengthen existing policies, address current policy gaps, and suggest additional courses of action. A multifaceted approach that examines all aspects of supply and demand is essential because energy challenges cannot be effectively addressed in isolation.

[9] Available online at: http://www.Hawai‘i.gov/dbedt/info/energy/efficiency/fieldguide/
[10] Available online at: http://www.Hawai‘i.gov/dbedt/ert/cbg

1. PUBLIC INVOLVEMENT AND OUTREACH

1.1 PUBLIC INVOLVEMENT AND OUTREACH: Sustainable Energy Plan Stakeholder and Public Meetings

In order to meet the goals of the County's Energy Sustainability Plan, community feedback and stakeholder participation are essential components of this process. In May and August 2007, seven meetings were held in which the preliminary ideas for the plan were discussed. One of these meetings featured key stakeholders related to the energy industry and the other meetings were open public forums. The goals of these meetings were to elicit feedback on the proposed ideas contained in the Preliminary Report, generate additional ideas, and provide an opportunity to evaluate the direction of the plan.

Following these meetings, the participants were invited to submit their comments on this report, *Analysis and Recommendations for the Hawai'i County Energy Sustainability Plan*. A total of approximately 200 people attended the meetings held in May and August. Comments received both verbally at the meeting and subsequently in writing were used to revise, add, and eliminate components of the recommendations that make up the plan. In an iterative process, the revised plan was presented to focus groups in the local communities throughout the summer and refined based on the feedback of the participants. Figure 1.1 details the timeline for the creation of the Hawai'i County Energy Sustainability Plan.

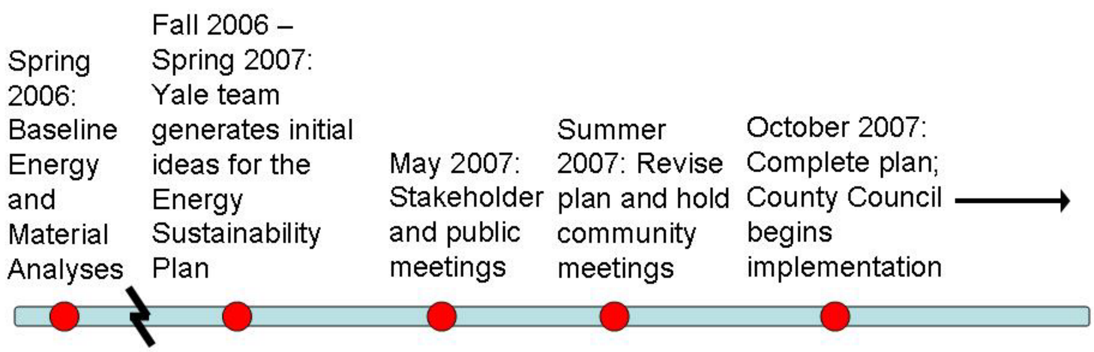

Figure 1.1: Timeline for Hawai'i County Energy Sustainability Plan

1.2 PUBLIC INVOLVEMENT AND OUTREACH: Community Development Planning

Hawai'i County's General Plan details the overall strategy for the long-term development of the Island. The plan has considerable breadth, formulating goals related to economic development, energy use, transportation, environmental quality, disaster preparedness, historical and natural preservation, housing, recreation, and land use. Updates are required every ten years, with the most recent version released in February 2005.[11] The key energy related goals of the General Plan are to "strive for energy efficiency" and

[11] Available at: http://www.Hawaii-County.com/la/gp/2005/main.html

"establish the Big Island as a demonstration community for the development and use of natural resources."[12] To reach these goals, the plan explicitly lists fifteen policies (e.g., "encourage the development of alternate energy resources") and four standards. The list of County policies specifically advocates for expansion of geothermal power and solar water heaters, in conjunction with intensified research in energy technologies.

The "highest order" vision expressed in the General Plan is further refined through the Community Development Plans (CDPs). Nine planning regions address the issues raised in the General Plan through community-wide involvement with a focus on solutions relevant to each region. The County Council will adopt completed CDPs as ordinances, making them legally enforceable.[13] Because the CDPs foster region-specific, community-driven solutions, it is essential that the Energy Sustainability Plan work in tandem with the CDPs. To date, the CDPs of Kona and Puna are near completion and North and South Kohala are initiating the process.

Kona Community Development Planning Process

There are seventeen preferred energy actions listed in the Kona CDP,[14] sixteen of which have been included in this report. These recommendations include:

- Installing photovoltaic modules on County facilities (Recommendation 4.6)
- Capturing landfill gas (Section 10)
- Installing in-line hydro generation in Department of Water Supply lines (Recommendation 7.2)
- Installing photovoltaic modules to pump water (Recommendation 7.3)
- Providing consumer information on renewable energy and efficiency (Recommendations 4.2, 4.3, 4.7, 6.8, 6.9, 6.10, 8.2, 8.3, and 8.11)
- Transitioning the public and private fleets to hybrids and alternative fuel vehicles (Recommendations 8.5, 8.9, 8.11, 8.12, 8.13, and 8.14)
- Expanding public transit and park and ride programs (Recommendations 8.1 and 8.2)
- Expanding energy efficiency programs through the Demand Side Management program (numerous, including Recommendations 4.1, 4.2, 4.3, 6.1, 6.3, 6.7, 6.8, 6.9, 6.10, 6.13)
- Expanding the utility rebate programs (Recommendation 4.1)
- Requiring energy efficiency certification of new buildings and updating the Model Energy Code (Recommendations 6.2, 6.12, and 6.14)
- Giving priority to energy efficient projects (Recommendations 6.1 and 6.11)
- Creating energy zones for use with renewable energy or crops (Recommendation 5.1)
- Creating annual energy reporting requirements (Recommendation 2.2)
- Dedicating a percentage of County Fair Share Assessments or Impact Fees to be invested to expand non-vehicular transportation alternatives (Recommendation 8.2)
- Implementing land use policies that lead to decrease in vehicular travel (Section 10)
- Promoting the continuation of National Energy Laboratory of Hawai'i Authority's development of alternative energy products and storage (Recommendation 5.8)

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[12] County of Hawaii General Plan, Chapter 3, February, 2005.
[13] Ibid.
[14] Kona Community Development Plan, "Working Group: Energy, Final Actions" December 12, 2006.

- Encouraging the development of ocean power from power buoys (Recommendation 5.9)

The two recommendations in the Kona CDP not explicitly included in this plan are:

- Requesting an increase in the number of alternative refueling stations

Regarding refueling stations, the Alternative Fuel Standard would require ethanol blends that would not necessarily require additional refueling infrastructure and biodiesel blends can also be met with existing infrastructure.

Puna Community Development Planning Process

The Puna CDP Alternative Energy Working Group produced an energy strategy with five key areas of interest: 1) solar development, 2) a revolving fund, 3) education, 4) energy efficiency, and 5) renewable generation.[15]

The authors of this report were concerned with the cost of implementing a revolving loan fund per se and have proposed a less expensive means of achieving the goal of a revolving fund: Recommendations 4.3 and 4.4 support a "Pay As You Save" program for residential photovoltaic modules and solar water heaters. The creation of the Model Energy Code that encourages solar water heaters on new construction and meets minimum energy requirements is discussed in Recommendations 6.2, 6.12, and 6.14.

Education is essential and the analysis in this report explicitly supports public education of energy issues through ten recommendations: Recommendations 4.2, 4.3, 4.7, 6.8, 6.9, 6.10, 8.2, 8.3, and 8.11.

This report also supports the efficiency measures stated in the Puna CDP, including efficiency standards for County buildings (Recommendations 2.1 and 6.14) and training measures for electricians so that qualified personnel can support renewable energy maintenance (Recommendation 2.4).

The analysis in this report also supports numerous provisions to promote solar and biofuel development (Recommendations 4.1 through 5.7), but does not include a provision for an ocean thermal energy conversion (OTEC) facility at Puna due to the uneconomical nature of the technology at the current time. (OTEC is discussed in Section 5.3.) Should this technology become more economically feasible in the future, its potential should be revisited.

[15] Puna Community Development Plan, "Alternative Energy Working Group" February 15, 2007.

2. PERSONNEL AND TRAINING

2.1 PERSONNEL AND TRAINING: County Employees

Implementing the County's Energy Sustainability Plan while maintaining the ability to adapt to changing circumstances requires sufficient personnel capacity. In the County of Hawaiʻi, residents spend a considerable portion of their income on energy; a typical household may spend nearly $5,000 per year on gasoline and electricity.[16] In 2005, an estimated $600 million was spent in Hawaiʻi County on energy, including electricity, gasoline, diesel, gas utilities, and aviation fuel.[17,18] In 2007, these expenditures are expected to increase nearly 30% to an estimated $770 million[19] due to increased energy price and demand. Energy expenditures will account for 16% of the expected Gross County Product of $4.6 billion in 2007. In the past decade, the energy expenditures for the whole United States was typically between 6% and 8% of the Gross Domestic Product, less than half the proportion of Hawaiʻi County.[20]

Despite these significant energy expenses, there are no full time County-funded personnel dedicated to energy. The Energy Coordinator position, working in County Research and Development, is funded through a federal program administered through the Department of Business, Economic Development & Tourism. The following three positions would serve to implement the various technical, legislative, policy, and market-based recommendations of the Energy Sustainability Plan.

Recommendation 2.1: Hire a green building expert for Hawaiʻi County.

A green building expert should be hired as a full time employee in the Building Department, responsible for retrofitting existing County buildings with energy efficiency measures, facilitating installations of solar water heaters and third-party photovoltaic systems, assisting in energy efficiency certification for all new County buildings, updating the Model Energy Code, and interpreting the Model Energy Code for the Building Department and the County. Assuming that the level of this position is SR24H, annual cost would be approximately $85,000, including benefits and $10,000 per year for travel expenses.[21] Since this position would serve to decrease the energy used by the County and replace existing energy from the grid with cost-effective on-site renewable generation, the position would likely pay for itself and may even represent a positive contribution to County funding.

[16] For gasoline: assuming two cars driven a total of 18,000 miles per year, at a fuel efficiency of 23 miles per gallon, with gasoline price of $3.25 per gallon. For electricity: assuming household use of 600 kWh per month at $0.327 per kWh.
[17] Based on 74.1 million gallons of gasoline at $2.60 per gallon, 13.9 million gallons of diesel at $2.81 per gallon, 1,116 million kWh of electricity at $0.279 (residential) and $0.253 (other), 27.6 million gallons of aviation fuel at $1.75 per gallon, and liquid petroleum gas sales of $5 million.
[18] These calculations do not include fuel expenditures by HELCO and independent power producers to avoid double counting.
[19] Based on estimates of 80 million gallons of gasoline at $3.10 per gallon, 20 million gallons of diesel at $3.50 per gallon, 1,200 million kWh of electricity at $0.327 (residential) and $0.300 (other), 30 million gallons of aviation fuel at $1.90 per gallon, and liquid petroleum gas sales of $5 million.
[20] Energy Information Administration, Annual Energy Review, 2007.
[21] Assuming a base salary of $57,720; retirement, social security, Medicare, worker's compensation, and unemployment insurance totaling $15,192; medical coverage of $2,165; and a travel budget of $10,000.

Recommendation 2.2: Hire an energy policy analyst for Hawai‘i County.

A second full time employee should be an energy policy analyst with County Research & Development, responsible for the implementation of the Energy Sustainability Plan, formulating County opinion on State level legislation, advocating in the County's interest for Public Utility Commission (PUC) dockets related to the utilities, renewable energy, and energy efficiency, and participating in Integrated Resources Planning, Hawai‘i Energy Policy Forum, Community Development Planning, Natural Energy Laboratory of Hawai‘i Authority's planning board, and Energy Emergency Preparedness. This employee would be responsible for creating an annual report on energy use in Hawai‘i County and the progress being made in the Energy Sustainability Plan. It is expected that the cost of this employee would be comparable to the green building expert.

Recommendation 2.3: Create a cabinet-level position to advise Hawai‘i County administration on energy and sustainability issues.

The third full time employee would be an energy and sustainability advisor at the cabinet or deputy level who would facilitate the delivery of accurate and timely information to the administration. Such a position can also serve to cut across departments and to develop consensus between department administrators. A similar position was recently created in Maui County to assist the administration on energy-related issues. It is expected that this position would cost approximately $124,500 per year.[22]

The combined cost of these three positions is approximately $300,000 per year. The upfront cost could realistically be returned directly to the County in the form of decreased energy bills through energy efficiency and renewable generation.

2.2 PERSONNEL AND TRAINING: Training for Renewable Energy Technology Maintenance and Repair

Recommendation 2.4: Ensure that adequate training is offered and required for the repair and maintenance of renewable energy and energy efficiency technologies.

Renewable energy and energy efficiency technologies require new skills for those who would perform maintenance and repairs. Solar water heaters, photovoltaic modules, wind turbines, and generating pressure reducing valves in the water supply are several of the technologies that require specialized training. Building for energy efficiency also requires adequate training and information sharing for contractors and architects; for example, radiative barriers and proper window placement are specialized options that demand specific knowledge. The County needs to review training requirements for its employees and ensure that adequate training is offered for these technologies. If training or hiring additional expertise is deemed impractical, the County could instead consider

[22] Assuming a salary of $88,932, fringe benefits of $23,407, medical insurance costing $2,165, and travel expenditures of $10,000.

using third-party contractors for technology system installations and on-going maintenance as a part of performance contracts or power purchase agreements.

3. ELECTRICITY SUPPLY – CENTRALIZED

3.1. ELECTRICITY SUPPLY – CENTRALIZED: Current Electricity Use and Future Scenarios

Historical Electricity Generation and Price

Much of Hawai‘i County’s current generation capacity was constructed in the 1960s and early 1970s when relatively low oil prices were expected to remain low for the foreseeable future. This generation capacity locked in an energy production system primarily dependent on fuel oil, both number two (diesel) and number six (medium sulfur fuel oil or MSFO). As a result, Hawai‘i Island has some of the highest energy prices in the country.

Also known as bunker fuel, MSFO was a cheap source of energy. Produced as a byproduct of Oahu-based refineries, this heavy fuel oil is solid at room temperature. It is rarely used in mainland installations due to air quality concerns regarding its high sulfur content and the competition from low cost natural gas. In Hawai‘i, however, where strong trade winds ameliorate local air pollution concerns and natural gas is not available, MSFO seemed to be a perfect fit.

Baseload generation on the Island was primarily produced by MSFO and bagasse, a combustible biomass byproduct of sugarcane processing. Cycling and intermediate generation was provided by diesel combustion turbines (Keahole CT2, Puna CT3, and more recently by Keahole CT4 and CT5 and an MSFO unit (Shipman 1, 3, and 4). Peaking generation was provided by a number of smaller diesel generators as well as the Kanoelehua CT1 diesel combustion turbine. Figures 3.1 and 3.2 show the evolution of Hawai‘i County’s installed generation capacity and actual generation by fuel source over the period 1990 to 2009. The increasing capacity (Figure 3.1) was needed to meet the peak demand, while the increasing generation (Figure 3.2) shows the total demand.

Following the closure of Hawai‘i’s sugar cane factories in the 1980s, bagasse was phased out as an energy source. Imported coal replaced the capacity of bagasse until coal was phased out in 2004. Beginning in the 1990s, several independent power producers (IPPs) brought a range of alternative (geothermal, wind) and fossil fuel (naptha) plants online, creating the energy mix that currently powers the HELCO grid. In the early 1990s, Puna Geothermal Venture (PGV) opened a 30 MW geothermal plant that helped provide baseload generation. Hamakua Energy Partners commenced operations on a 60 MW naphtha baseload plant in 2000. Two independently owned wind farms, the 10 MW Upolo plant and the 20 MW Apollo plant, have recently come on line to provide intermittent generation capacity for the grid. Despite the increase in alternative sources, petroleum-derived fuels remain the source of roughly 69 percent of electricity generated in Hawai‘i County as of 2007. Of the remaining 31 percent, approximately 17 percent would source from geothermal, 11 percent from wind, and 3 percent from hydroelectric.

The Island’s dependence on imported oil leaves it vulnerable to trends in the world oil market, where the price for oil is currently near record highs and widely predicted to remain well above $40 per barrel.

However, high electricity prices in Hawai‘i County, which have closely mirrored the price of fuel, are the result of legislation as well as fuel source. Although the cost of generating alternative energy is often far below the production price for fossil-fuel fired plants, the prices paid to independent power producers (IPPs) are based on “avoided cost”, a calculation of what it would have cost the utility company to simply buy more fossil fuel. Pricing IPP production based on avoided cost leads to a perverse pricing scenario whereby the price of energy from a wind farm is directly linked to the price of oil.

Under the Public Utilities Regulatory Policies Act of 1978 (PURPA), HELCO is contractually obligated to pay IPPs up to avoided cost. In Hawai‘i County, avoided cost is a direct reflection of the cost of generation from oil derivatives and, as a result, the electricity rates do not reflect the large percentage of renewables on grid. A comparison of HELCO’s cost of producing power and the price paid to IPPs over the past 15 years illustrates that IPP costs mirror HELCO costs (See Figure 3.3). As will be explained later, de-linking avoided cost from the price of oil is essential. With de-linking, increased renewable generation will translate into reduced rates for rate-payers, accurately reflecting the lower cost of alternative energy sources.

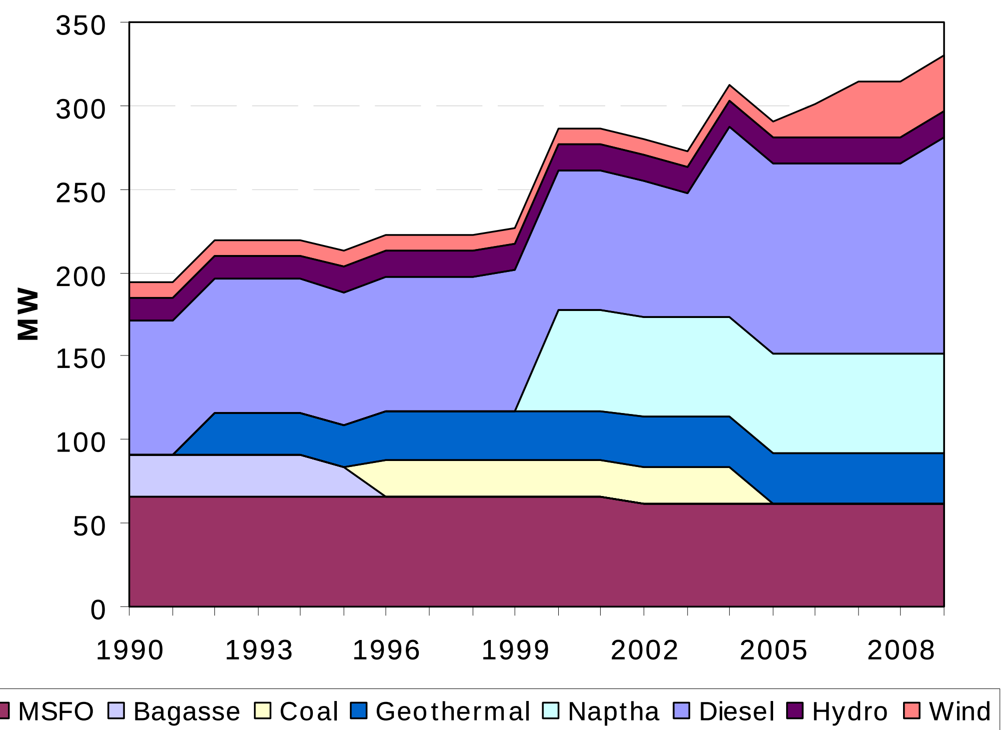

Figure 3.1: Installed generation capacity, 1990-2009[23]

[23] Installed capacity data from DBEDT datasheet on HELCO’s operations, 2006, compiling data from HELCO annual reports to the PUC.

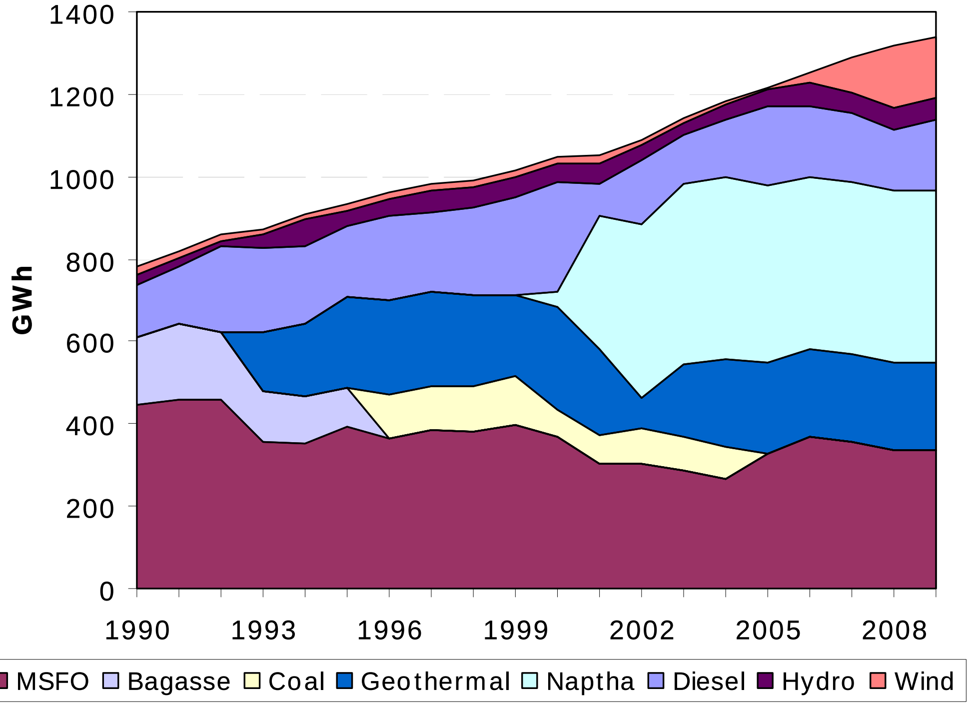

Figure 3.2: Electricity generation, 1990-2009[24]

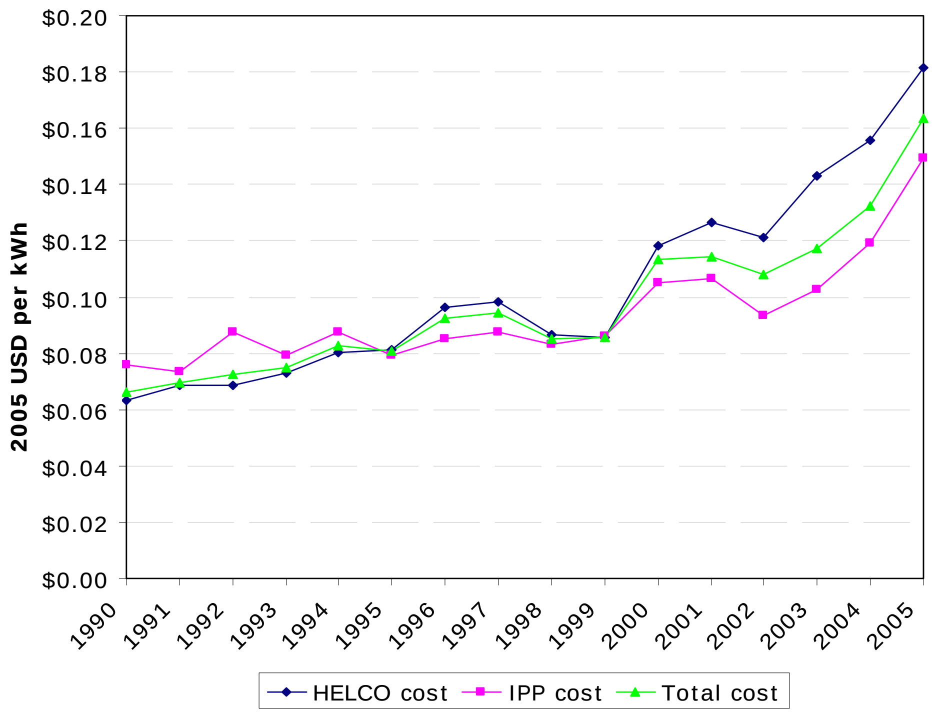

Figure 3.3: Cost per kWh by producer[25]

[24] 1990-2006 generation data from Pat Moore, 2007. HELCO generation 1988-2006. 2007-2009 generation based on author's projections, with the wind component assuming a 55% generation coefficient for wind in Hawaii County used in Global Energy Concepts. 2004. *Select Hawai'i Renewable Energy Project Cost and Performance Estimates*. Renewable Energy Resource Assessment and Development Program.

Electricity Scenarios

Recommendation 3.1: Examine potential supply options for maximizing cost-effective generation from renewable energy.

An energy supply model including different future supply options up to 2025 was developed to examine the effectiveness of different generating capacity options in spurring consumer electricity cost savings. Four scenarios were examined: the “Least Cost” and “Max Renewables” scenarios developed by HELCO leading up to the Third Integrated Resource Plan (IRP-3), the “Preferred Option” proposed by HELCO in the IRP-3,[26] and a fourth scenario created for this study to meet the County’s energy goal of self-sufficiency, entitled the “Energy Sustainability Plan” scenario. Scenario benefits, such as environmental performance and cost, were calculated relative to HELCO’s “Least Cost” scenario. As HELCO’s “Least Cost” scenario did not result in the lowest cost in this analysis, the scenario is termed the “Baseline Scenario” for the remainder of this report to avoid confusion.

In all scenarios, the 18 MW Keahole ST-7 steam recovery unit is installed in 2009. After that, future installed capacity by scenario varies significantly, as detailed below:[27]

- Baseline scenario
    - 10 MW wind, 2020
    - 26.7 MW coal, 2022
- Max Renewables scenario
    - 1 MW photovoltaic modules, 2012
    - 40 MW wind/30 MW pumped storage hydro system, 2014
    - 1 MW photovoltaic modules, 2016
    - 1 MW photovoltaic modules, 2021
    - 12.5 MW geothermal, 2025
- HELCO IRP-3 Preferred Option scenario
    - 37 GWh/year intermittent source, 2016 (10 MW wind equivalent)[28]
    - 25 MW firm renewable in 2022
- Energy Sustainability Plan scenario
    - Retire the 14.1 MW Puna baseload plant, 2009
    - Retire the 14.4 MW Shipman intermittent plant, 2009
    - 20 MW geothermal, 2009
    - 10 MW geothermal, 2014
    - 40 MW wind/30 MW pumped storage hydro system, 2019
    - 37 GWh/year renewable source, 2022[29]

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[25] HELCO and IPP cost data from DBEDT datasheet on HELCO’s operations, 2006. HELCO costs include fuel, operation and maintenance, and a portion of marginal revenues proportionate to fuel and O&M costs. IPP costs are the cost paid to IPPs by HELCO for purchased electricity.

[26] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

[27] For more details on how these scenarios and our supply model were developed, please see Appendix A. Additionally, some existing plants could potentially use sustainable biofuels. See Section 5.1 for more on potential biofuel options.

[28] Note that this is left vague in the IRP-3 to preserve flexibility, though they use wind as a proxy for calculations. This value is equivalent to 10 MW wind.

Accounting for factors beyond simple electricity demand is essential to the analysis of options for new generation capacity. In particular, peak and minimum system loads are critically important to maintaining system stability and minimizing costs. Electricity generated in Hawai‘i can be segmented into five different categories, depending on what role it plays in the system.

1. **Regulating baseload generation** is constant generation equipped with automatic generation controls that can ramp up or curtail generation to help maintain frequency and voltage consistency. Most of the existing baseload units owned by HELCO (e.g., Puna and Hill) are MSFO-fired generators equipped with these controls. The ability to curtail or ramp up provides an important service for the grid. However, as curtailing baseload generation imposes high shutdown and start-up costs, well-managed grids seek to avoid baseload generation in excess of minimum demand.[30]
2. **Non-regulating baseload generation** always produces electricity since output cannot be curtailed or expanded quickly. The function of this type of baseload generation is otherwise identical to regulating baseload units, which meet the minimum load requirements. The current Puna Geothermal Venture plant is the major non-regulating baseload unit on the Island.[31]
3. **Intermediate or cycling plants** run for the portion of the day when demand is higher than the minimum system load, filling the gap between baseload units and peaking plants. These plants also provide a regulating reserve that can be ramped up in response to the loss of intermittent energy sources or a shutdown of a portion of the baseload generation. The Puna CT-3, Keahole CT2, CT4, CT5, CT7, and Shipman plants are cycling/intermediate generators.
4. **Peaking units** provide power for the short period of the day when demand is the highest. Intermediate generation units can also serve as peaking units if not already operating at full capacity. These plants are primarily diesel units.
5. **Intermittent sources** depend on inherently unpredictable conditions such as sunshine and wind speed. Given the potential for the wind not to blow and the sun not to shine during peak hours, HELCO needs to have the installed capacity, excluding intermittent sources, to meet the maximum expected peak demand. Likewise, as intermittent renewables cannot be curtailed, calculations of the minimum baseload

[29] This is modeled as 10 MW of wind, though it is too early to project what the most viable and cost competitive renewable option would be for 2022. Ideally this energy would be provided by a firm renewable source.

[30] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

[31] No fundamental technical limitation prevents the PGV plant from installing automatic generation controls to make it a regulating baseload generator, Puna Geothermal Venture, personal communication, March 2007. To maintain system stability with expanded baseload production, it is expected that HELCO would require the installation of automatic generation control systems on any additional geothermal generation capacity.

generation should include intermittent capacity. As discussed in Recommendation 3.5, the limitations of intermittent sources reinforce the importance of storage options, which effectively transform intermittent sources to firm generation.

For each of the four scenarios, the maximum and minimum generation was derived, as shown in Figure 3.4. Note that the HELCO IRP-3 Preferred Option scenario and the Baseline scenario are almost identical in terms of peak and minimum capacity. The Energy Sustainability Plan scenario has a slightly lower maximum generation relative to the baseline prior to 2014, and a higher minimum prior to 2022. Compared to the Baseline, this scenario has a higher maximum after 2019 and a lower minimum generation after 2022. The Energy Sustainability Plan scenario remains comfortably above the "base" peak predicted by HELCO in the IRP-3,[32] and would likely be sufficiently under the "high" peak scenario. If the "high" peak scenario proves more likely, the date of installation of the pumped storage hydro system and wind farm could be moved up to ensure that peak demand is met.

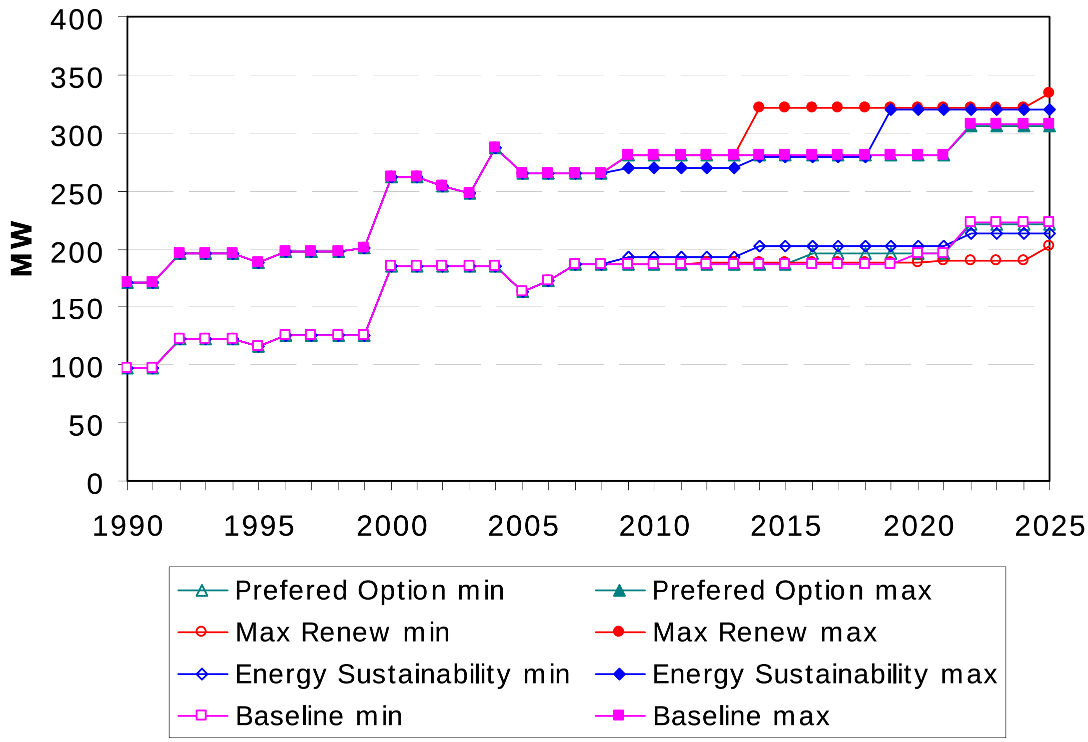

Figure 3.4: Maximum and minimum loads by scenario[33]

In addition to peak and minimum load, the power system on the Island needs to maintain both frequency and voltage throughout the grid. Frequency is maintained at 60 hertz when power demanded is equal to power supplied at any given time. When more power is demanded than is supplied, the system frequency drops, while excess supply causes the

[32] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[33] 1990-2008 data based on DBEDT datasheet on HELCO's operations, 2006. 2009-2025 data from scenario model projections.

frequency to rise. HELCO must keep system frequency close to 60 hertz, as a deviation of 0.5 hertz in either direction could damage electrical equipment.[34] To maintain frequency, the level of generation must be constantly adjusted to match changes in demand. This is complicated both by non-regulating units such as the Puna Geothermal Venture plant and intermittent units like wind farms, which can suddenly and unpredictably supply or cease supplying power to the grids. As the amount of intermittent energy in the grid increases, it becomes increasingly difficult to manage frequency fluctuations. Units are required to remain on standby to make up any potential shortfall from the cessation of generation by intermittent sources, and need to be prepared to quickly curtail generation should the intermittent sources start up.

HELCO's Max Renewables and the Hawai‘i County Energy Sustainability Plan scenarios rely less on intermittent sources as a percent of total generation than the other two scenarios (see Figure 3.5). This is primarily because the pumped hydro storage system accompanying future wind development transforms wind into a firm resource, while both the baseline plan and the HELCO IRP-3 preferred plan include no storage options accompanying their 10 MW wind installations.[35] As discussed in Recommendation 3.5, pumped storage hydro and other storage systems can play an important role in regulating frequency by absorbing or releasing electricity as needed. Storage units can also help in meeting peak demand, while lowering the minimum generation in the system by recharging the reservoir or batteries during off-peak periods.

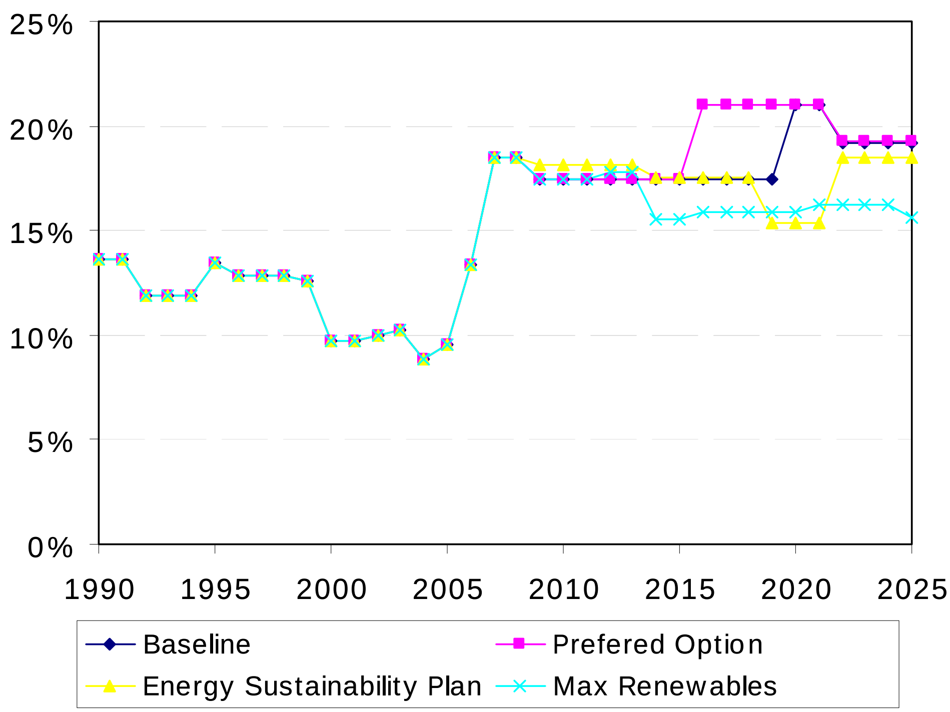

Figure 3.5: Percent intermittent electricity generation by scenario[36]

[34] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[35] Ibid.
[36] 1990-2008 data based on DBEDT datasheet on HELCO's operations, 2006. 2009-2025 data from scenario model projections.

Generation projections by scenario allow the calculation of the future price of electricity generation in each scenario. Using Energy Information Administration projections of future oil prices and varying the fuel component of generation costs proportionately to changes in oil prices, the fuel-related cost of generation was derived up to 2025.[37] Figure 3.6 shows the cost per kWh of electricity generated by diesel and MSFO sources, holding non-fuel operations and maintenance costs and marginal HELCO profits proportional to generation costs constant.[38] It also shows the avoided cost paid to independent power producers, based on the assumption that avoided cost payments are driven primarily by fuel prices.[39] Independent power producer costs are also shown for the case in which avoided cost payments are explicitly unlinked from fuel prices. Delinking of avoided cost is discussed in detail in Recommendation 3.9.

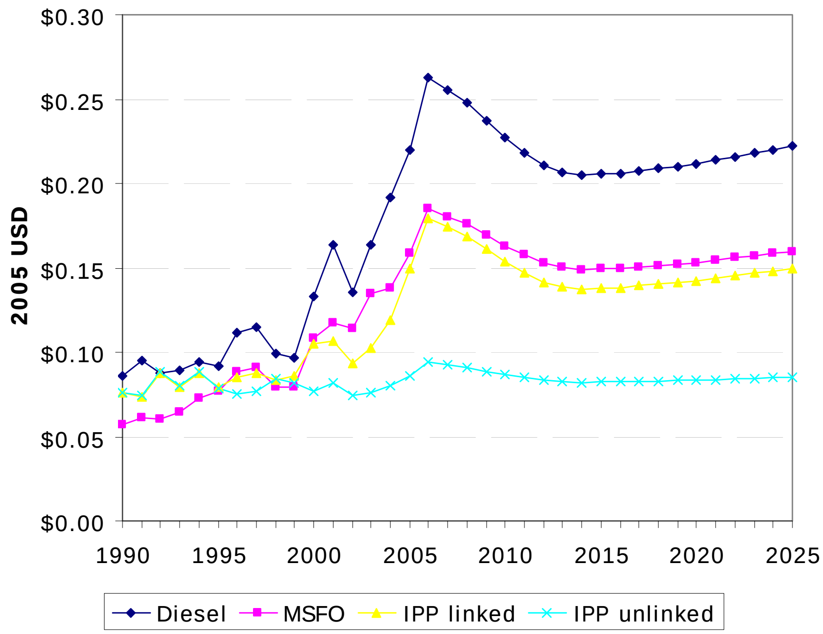

Figure 3.6: Cost per kWh by generation type[40]

[37] U.S. Department of Energy, Energy Information Agency. 2007. *AEO Crude Oil Price Projections*. Available: http://www.eia.doe.gov/oiaf/forecasting.html

[38] Non-fuel O&M costs are held constant at $0.0324 per kWh from 2006-2025, based on historic non-fuel O&M cost data from DBEDT datasheet on HELCO's operations, 2006. Marginal profits for 2006-2025 are held at $0.0242 per kWh, and this value is derived by multiplying average profits per kWh over the period from 2000-2005 by generation costs as a percent of total cost (Ibid). This is based on the simplifying assumption that HELCO earns the same rate of return on generation, transmission, and customer service costs.

[39] Historically, the fuel price-driven portion of avoided cost payments for IPPs has been less than the cost of HELCO generation. This is projected to continue as long as fuel prices remain high.

[40] Unlinked avoided costs (ACU) for any given year (t) are modeled by the equation:

$ACU_t = ACL_t * ({Fuel_{1990}}/{Fuel_t}) * 2/3 + ACL_t * 1/3$ such that unlinked avoided costs are held roughly constant at 1990 values, increasing slightly with the price of fuel due to overall increases in fuel-related costs (e.g. O&M, component costs, shipping costs, etc.). Fuel is taken from DBEDT datasheet on HELCO's operations, 2006. For 1990-2005. $Fuel_t$ from 2006-2025 is given by the equation:

As long as oil prices remain high, one can reasonably expect avoided cost paid to IPPs to remain below the cost of generation for HELCO (ignoring, for the moment, any system costs imposed by intermittent independent power producers). Based on the fuel price projections above, Table 3.1 shows the expected cost of energy in Hawai‘i County for each of the four scenarios developed here. Note that this figure assumes that additional generation capacity is primarily financed by private independent power producers. The reduction in generation cost seen in the Max Renewables and Energy Sustainability Plan scenarios relative to the other two primarily reflects their greater reliance on non-fuel independent power producers. This figure does not explicitly factor the cost of any scenario-specific storage options into electricity prices.[41]

Table 3.1: Linked cost per kWh of generation by scenario

Scenario	2005	2010	2015	2020	2025
Baseline	$0.1619	$0.1657	$0.1501	$0.1566	$0.1595
Preferred Plan	$0.1619	$0.1657	$0.1501	$0.1566	$0.1605
Max renew	$0.1619	$0.1657	$0.1426	$0.1500	$0.1580
Energy Sustainability Plan	$0.1619	$0.1657	$0.1447	$0.1452	$0.1555

The benefits of greater installed renewable generation capacity go beyond the difference between fuel costs and linked independent power producer costs: renewable energy generates less carbon pollution than fossil fuel sources. While conventional air pollutants do not pose a particularly severe problem for Hawai‘i County, global warming caused by carbon dioxide released by fossil fuel combustion does have potential consequences for Hawai‘i and the rest of the world.[42]

Increasingly, governments around the world are regulating the emissions of carbon dioxide by putting a price on carbon emissions. Major financial institutions in the United States, as well as many major corporations, believe that a price on carbon in the U.S. is very likely in the near future.[43] A number of utilities such as Duke Energy, Cinergy, and recently TXU are including a price of carbon in planning future investments in generation capacity. Given the momentum on this issue, and in light of the recent Supreme Court ruling on regulating greenhouse gases,[44] it is realistic to plan for a range of possible carbon prices starting in 2010. These considerations are especially timely given that Hawai‘i’s Global Warming Solutions Act of 2010 mandates that the State reduce its

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$Fuel_t = Fuel_{t-1} * ({Oil_t}/{Oil_{2005}})$, where projected oil prices for time *t* are based on EIA estimates. Note that unlinked IPP costs only model non-oil IPP generation costs. The Naptha-based Hamakua IPP is always considered linked.

[41] Note that these costs are directly weighed against the benefits of increased renewable generation in Figure 3.8 and Table 3.2.

[42] With the recent publication of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, there is an increasing consensus in the scientific community that global mean temperature increases observed over the last century have been primarily driven by anthropogenic releases of carbon dioxide and other greenhouse gases.

[43] Citigroup Global Markets. 2006. *Carbon Limits are Coming.*

[44] Supreme Court Ruling, Massachusetts et al. vs. Environmental Protection Agency et al., April 2, 2007.

carbon dioxide emissions to 1990 levels by 2020.[45] Figure 3.7 shows the projected emissions of carbon dioxide and other greenhouse gas emissions for each of the four scenarios, converted into standard CO_2-equivalence units (CO_2e) based on their relative greenhouse gas potential. Note that only the Energy Sustainability Plan scenario meets the target goal for Hawai‘i's Global Warming Solutions Act.

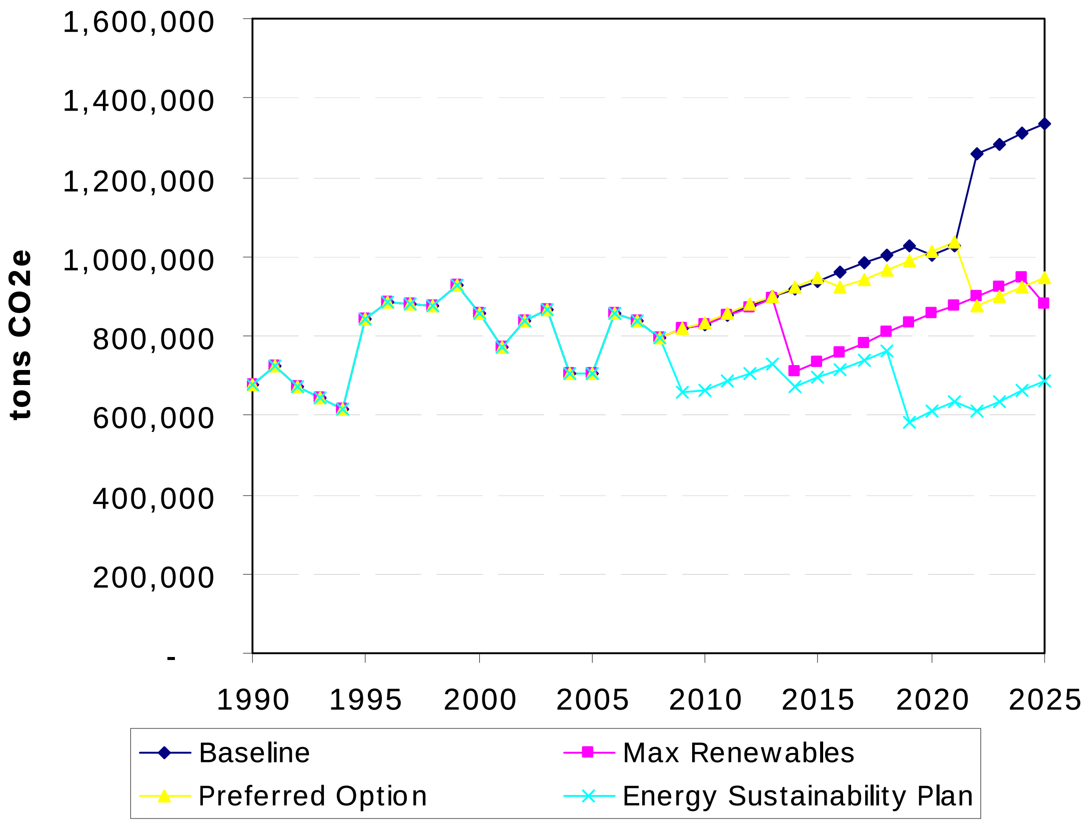

Figure 3.7: Annual greenhouse gas emissions by scenario, in CO_2e[46]

There are five distinct factors that determine potential savings from greater renewable capacity. The first is the base cost savings, or the difference in HELCO generation costs and linked avoided cost paid. Base cost savings increase when the percent of total power provided at avoided cost increases, assuming that avoided cost payments remain below HELCO's generation costs. The second factor is potential efficiency gains from retiring existing capacity. If the least efficient plants are retired and replaced by expanded geothermal generation, then the cost per kWh of generation from the remaining fuel-based plants is reduced. Third is the potential benefit if avoided cost paid to independent power producers is unlinked from the price of fuel. This idea is explored in more detail in Recommendation 3.9. Fourth, there are savings from reduced CO_2 emissions in a future carbon pricing regime. Finally, there are the costs associated with the construction of storage facilities for the Max Renewables and Energy Sustainability Plan scenarios.

[45] Honolulu Star Bulletin. 2007. "Hawai‘i Passes Law to Cap Emissions at 1990 Levels". May 7th.
[46] Derived from emissions per MMBtu data in the DBEDT datasheet on HELCO's operations, 2006.

These five factors are shown in Figure 3.8, which calculates the net present value of cost savings relative to the baseline scenario for each of the four scenarios for the period 2007 to 2025, using a discount rate of 5 percent.

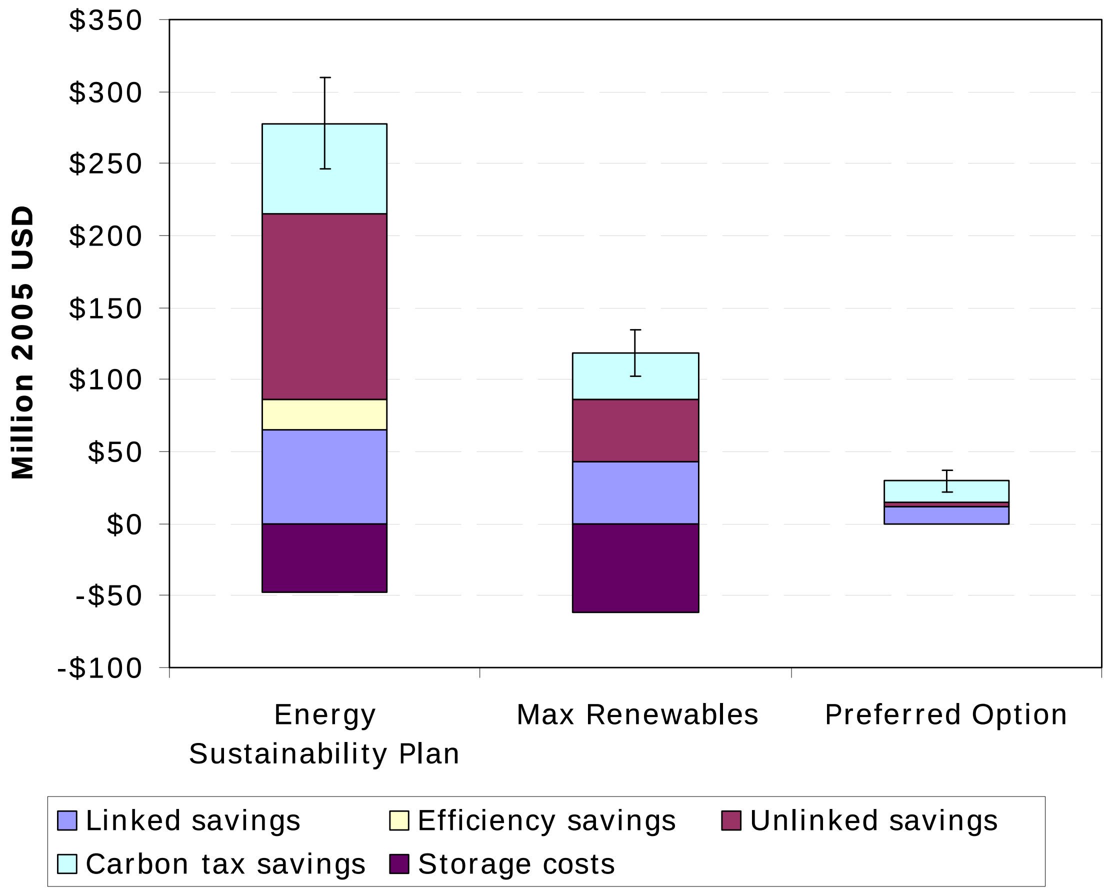

Figure 3.8: Net present value of savings relative to baseline, 5% discount rate, 2007-2025[47]

Because the delinking of avoided cost and a future price on carbon emissions are both uncertain, it is useful to conduct a brief sensitivity analysis on how the net present value of each scenario might change in the absence of these potential cost savings. As shown in Table 3.2, the cost savings relative to the baseline for all three scenarios are fairly small when only linked costs are taken into account, with the Max Renewables scenario actually performing worse than the baseline, losing a total of roughly $18 million. The Energy Sustainability Plan is the best scenario in this case, followed distantly by HELCO's Preferred Plan. If delinked costs are included, the cost savings of both the Energy Sustainability Plan and Max Renewables scenarios becomes much larger, while those of the Preferred Plan scenario increase only marginally. In this case, the preference ranking would be Energy Sustainability Plan, Max Renewables, and then the Preferred Plan. If cost savings under a carbon price regime are included, the Energy Sustainability

[47] The carbon tax shown here assumes a price of $20 per ton, with a range of $10 to $30 designated by error bars.

Plan and Max Renewables scenarios save the most, and the preference ordering remains unchanged. Thus the delinking of avoided cost and the potential for a future carbon price are critical considerations when weighing the different scenarios. Finally, if one uses the NYMEX-based oil price projections developed by HELCO and the advisory group in the IRP-3 process, the savings under the Energy Sustainability Plan and Max Renewables scenarios become larger still. Note that if one examines linked only cost savings under the NYMEX price projections, the Max Renewables scenario is still more costly than the baseline, albeit slightly.

Table 3.2: Sensitivity analysis of cost savings relative to baseline scenario

Benefits over baseline	Energy Sustainability Plan	Max renew	HELCO IRP-3
Linked only	$38,000,000	($18,000,000)	$14,000,000
Unlinked included	$167,000,000	$25,000,000	$17,000,000
Carbon price included	$230,000,000	$57,000,000	$33,000,000
NYMEX oil prices[48]	$325,000,000	$104,000,000	$43,000,000

The net present value of choosing the Energy Sustainability Plan scenario over the Baseline plan is projected to be as much as $325 million, though this may vary depending on future oil prices. Additionally, the Energy Sustainability Plan scenario would reduce Hawai‘i County’s dependence on fossil fuel imports by up to 1,200,000 barrels of oil equivalent (BOE) in 2025, roughly 3,200 BOE less imported per day than the Baseline. Overall, fossil fuel imports for power generation would be 44% lower in the Energy Sustainability Plan scenario than in the Baseline scenario. Table 3.3 shows the number of barrels oil equivalent imported by scenario in 2025, the percent reduction in BOE imports relative to the Baseline scenario, and the percent of total electricity generation from renewable sources for each scenario.

Table 3.3: Fossil fuel imports (in barrels of oil equivalent) by scenario in 2025[49]

Scenario	BOE imported 2025	BOE relative to baseline	% Renewable
Baseline	2,700,000	100%	27%
HELCO IRP-3	2,000,000	76%	38%
Max renewables	1,900,000	71%	42%
Energy Sustainability Plan	1,500,000	56%	52%

Hawai‘i County’s electricity prices will remain among the highest in the country as long as the majority of Hawai‘i’s electricity generation continues to come from oil derivatives. This Energy Sustainability Plan scenario offers a strategy to decrease overall electricity prices on the Island while reducing the environmental impact of electricity generation. The next section will delve into more depth on some specific components of the Energy Sustainability Plan scenario supply recommendations, including discussing options for energy storage, expanded geothermal generation, and unlinking avoided cost.

[48] This uses the NYMEX oil price scenario developed by the advisory board in the IRP-3 process as an alternative estimate to the relatively conservative EIA figures.
[49] BOE conversion data for different fuels from EIA 2006.

3.2. ELECTRICITY SUPPLY – CENTRALIZED: Recommendations for Future Policies

Time-of-Day Pricing

Recommendation 3.2: Explore residential and commercial time-of-day pricing systems to flatten the electricity load curve by having customers run appliances at off-peak times. Consider replacing some existing electricity meters with "smart meters".

Hawai'i County's spread between peak and minimum loads is relatively small. Occurring in the evening from 5:00 to 9:00 PM, current peak load is near 200 MW while minimum load is roughly 90 MW and occurs between 12:00 and 4:00 AM (see Figure 3.9). Expected peak load largely drives the decision to install additional energy generation capacity, since the system must have sufficient capacity to generate at the highest possible expected demand. Hence any actions that "flatten the load curve" can yield significant savings by reducing the need for peaking capacity. Since peaking generation relies on high-cost diesel turbines, reductions at peak load would produce higher marginal benefits than reductions at any other time.

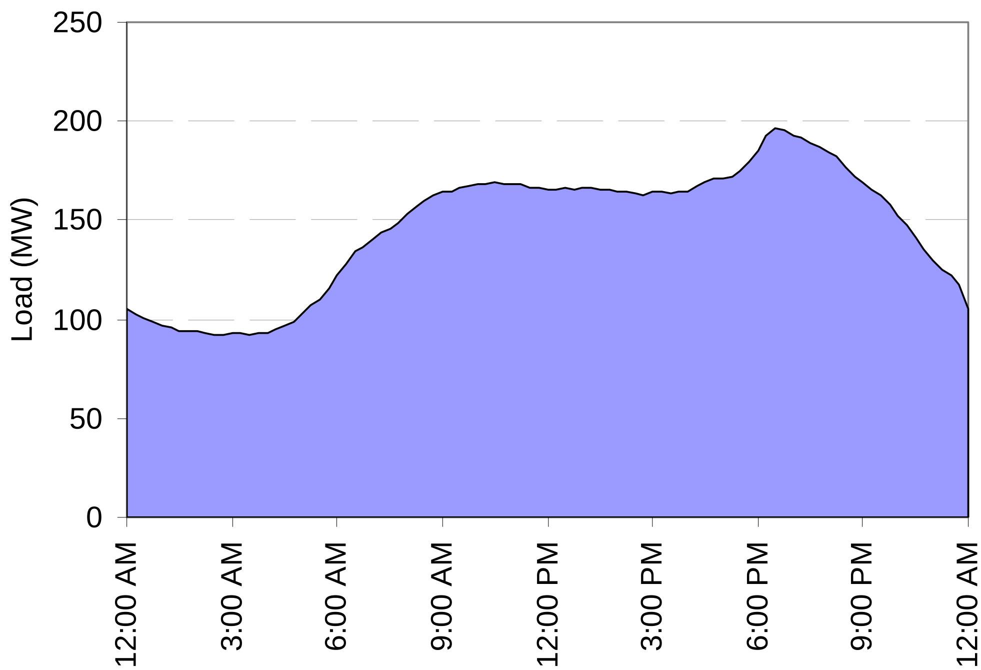

Figure 3.9: Maximum peak electricity usage, December 19th 2005[50]

Like most of the United States, Hawai'i County has an energy pricing system that charges a static daily price for each kWh of electricity used for residential users, while allowing some variations in electricity prices based on time of day for commercial users. In reality, the cost of generation varies considerably by time of day depending on which

[50] Data from HELCO, figure originally used in Hawai'i County Baseline Energy Use Analysis, 2006. Note that this peak was surpassed on December 27th 2006, with a 201.3 MW peak use according to HELCO 2007a. *Consumer Lines*, February edition, v.XXVI no. 2.

generation units are running. During off-peak times, when most or all power generation is provided by MSFO (no. 6 fuel oil) and geothermal baseload units, electricity costs are relatively low (likely somewhere around $0.18 per kWh for MSFO, given current fuel and generation costs). When electricity is generated by diesel fueled peaking units during peak load, prices rise considerably.

Using "smart meters", several U.S. utility companies have experimented with time-of-day pricing systems for residential users. In matching a time of day to recorded energy use, smart meters enable electricity bills to more accurately reflect the actual cost of generation associated with their use patterns. Such a system could be designed to have zero or positive net effect on energy costs for those who do not change their electricity use behavior by rewarding those who switch their electricity use patterns to off-peak times while penalizing peak users. For example, an individual choosing when to do an evening load of laundry could decide to wait until after 9:00 PM, knowing that doing so would incur lower energy costs. Given that residential electricity use constitutes 39 percent of total electricity use on the Island, as well as a disproportionately large share of peak demand, providing residents an incentive to minimize their peak electricity use could provide a powerful tool for cost savings. If a time-of-day pricing system shifted 10 MWh per day of peak usage to off-peak times in 2007, it would yield an annual savings of roughly $240,000 in avoided fuel alone (assuming that 10 MWh of diesel generation is replaced by 10 MWh of MSFO generation daily).[51]

Substantive limitations on implementing effective residential time-of-day pricing systems include the installation of expensive meters and relatively low elasticity of demand for residential electricity use. First, time-of-day pricing would require electricity meters capable of recording energy use by time of day. These meters are expensive, potentially costing up to $500.[52] However, the energy savings from the utility from avoided peak generation can significantly offset this cost. In Italy, for example, the utility Enel SpA experienced a roughly four-year payback period for smart meters.[53] Smart meters can also allow time of day net metering for residents with distributed generation systems, and may reduce meter reading costs relative to the current low-tech system of manual meter readers employed by HELCO.

The second barrier to residential time-of-day pricing is the relatively low price elasticity of demand. This term refers to the effect of raising prices on energy use patterns. If a time-of-day pricing system is implemented, many consumers may consider the costs imposed by changing routines (e.g., doing laundry later) greater than the potential savings gained. A better understanding of Hawai'i County's price elasticity of demand for energy is essential in assessing the effectiveness of a time-of-day pricing system. Anecdotally, the relatively small consumer response to the recent dramatic increases in

[51] Note that this value only reflects the cost of electricity production by an average HELCO-owned diesel and MSFO facility.
[52] Canadian Broadcasting Corporation. 2005. "Smart meters: FAQ". CBC News Online, November 3rd.
[53] Pareto Associates. 2001. "Smart Meters for Smart Competition: Handing Power Back to Consumers." Report for the Customer Energy Coalition. St. Kilda, Australia.

electricity prices on the Island tends to suggest relatively low demand elasticity, at least in the short term.

HELCO recently filed a docket with the PUC to create a pilot program that tests the effectiveness of time-of-day pricing. The implementation of this program is pending approval by the PUC. Once implemented, this pilot program would be limited to 300 residential meters, and would use the price schedule shown in Table 3.4. While this program would provide some interesting results, there are a number of reasons to think that the pilot program would have limited success. First, the increment between mid-peak and peak pricing does not adequately reflect the actual cost difference between generation costs in the periods. Peak prices should be considerably higher than mid-peak prices. Second, the price increment is likely too small to significantly alter behavior. A difference in 2.5 cents per kWh between mid-peak and peak is almost negligible when electricity is 32 cents per kWh. Even the 10 cent difference between peak and off-peak prices is not particularly high as a percent of total energy prices. It is recommended that HELCO and the PUC revise the pilot project pricing schedule to create larger cost gradations between periods that effectively encourage behavior change among consumers.

Table 3.4: Time of use price schedule for HELCO pilot project[54]

Time of use pricing	Increment	Expected cost (cents per kWh)
Off-peak	– $0.05	26.6575
Mid-peak	+ $0.025	34.1575
Priority Peak	+ $0.05	36.6575

Should time-of-day pricing prove cost-effective in reducing peak demand, HELCO may wish to consider beginning to install smart meters when replacing existing meters at end of life. This would begin the long-term transition toward smart meter use on the Island, which may be beneficial given the ancillary benefits of smart meter use (e.g., easier net metering, reduced meter reading costs, etc.).

Block Pricing

Recommendation 3.3: Strengthen HELCO's new residential block pricing system to encourage energy efficiency for large users and reduce the impact of high prices for those who can least afford to pay.

The average annual electricity bill in 2007 for a Hawai‘i County residence is projected to be around $2,200[55], however, these costs are not borne evenly. Some residential users consume significantly more electricity than others. However, the effects of increasing electricity prices in Hawai‘i are strongly regressive, as poorer residents tend to spend more on electricity as a percent of their total income. From one perspective, smaller electricity users are being forced to pay large costs to meet the burden imposed on the

[54] Robert Arrigoni, Hawai‘i County Research and Development, personal communication, April 2007.
[55] This is based on trend projections of residential energy use, number of residential customers, and energy price for 2007 based on data in the DBEDT datasheet on HELCO's operations, 2006.

system by large electricity users. Likewise, larger electricity users tend to have more opportunities for energy efficiency and use reductions than smaller electricity users, who will be more susceptible to the economic incentives created by current energy prices.

Block pricing systems charge a tiered energy price based on use, with smaller users paying less per kWh than larger users. Higher prices for larger residential energy users create an incentive for those users to install more efficient systems and reduce overall energy use. Returning for a moment to the concept of demand elasticity, residents with higher incomes will often be less likely to change their use patterns in response to price signals than residents with lower incomes do; i.e. higher income residents have lower demand elasticity than lower income residents. Block pricing seeks to rectify this imbalance by charging a higher price to large users, assuming that energy use is directly correlated with incomes. Block pricing may provide an opportunity to increase the incentive for large residential energy users to reduce energy use while compensating smaller energy users for the costs imposed by rising peak demand. While the distributional implications of such a system are social concerns beyond the scope of this report, the potential energy efficiency savings will be discussed.

HELCO has filed a docket with the PUC to implement a block pricing system. Tiers are established for users under 300 kWh/month, 300 to 1000 kWh/month, and over 1000 kWh/month. To put this in perspective, roughly 52% of residential customers use less than 500 kWh per month.[56] Table 3.5 shows the new tiered pricing system. While this represents a good first step, it is unlikely that the relatively small rate differentiation between use classes would result in any substantive demand reduction, particularly with residential customers. HELCO should consider a larger pricing spread for future residential tiered pricing systems, to create a stronger energy efficiency incentive for larger users.

Table 3.5: HELCO Schedule R tiered pricing system, in cents per kWh[57]

Schedule R tiered pricing[58]	< 300 kWh	300-1000 kWh	> 1000 kWh
Variable charge	12.7581	14.8686	15.7427
Base fuel charge	16.7889	16.7889	16.7889
Total charge	**29.5470**	**31.6575**	**32.5316**

In addition to the tiered pricing system, HELCO has requested the PUC allow a new minimum monthly charge for part-time residents who own but do not always occupy homes on the Island. As the utility must have available installed capacity to meet the projected demand should all these homes be occupied, they impose a cost by raising the potential peak independent of their actual power use. This new part-time resident minimum monthly fee is expected to impact roughly 2.8% of residences,[59] and should help lower the costs imposed by peaking costs for regular electricity users in Hawai‘i.

[56] Robert Arrigoni, Hawai‘i County Research and Development, personal communication, 2007.
[57] Ibid.
[58] Note that this refers to average kWh used per month.
[59] Robert Arrigoni, Hawai‘i County Research and Development, personal communication, 2007.

This new program should be carefully monitored, and that HELCO should adjust the charge accordingly with the price of providing peaking power.

Transmission Line Upgrades

Recommendation 3.4: Promote the upgrade of the transmission lines to decrease transmission losses and maintain system voltage.

As part of the recently released IRP-3 report, HELCO plans to upgrade three major transmission lines: the 7300, 7200, and 6800 lines. These lines connect major energy users on the west side of the Island to the major cross-island transmission lines. In Hawai'i County, the majority of the installed generation capacity (roughly 70 percent), including all current baseload generation units, is located on the east side of the Island, while the majority of the demand is concentrated in and around the Kona area on the west side of the Island (see Figure 3.10). All three lines are of concern. In an emergency, when one line is out of commission, loads on the other two lines would risk exceeding their emergency ratings. The 7300 line, in particular, risks exceeding its non-emergency rated capacity under normal operations. Overloading of lines could lead to line sagging and additional line outages, as well as possible low voltage conditions that would increase the risk of system collapse.[60] Additionally, voltage concerns are forcing HELCO to operate the diesel-fired Keahole CT-4 and CT-5 plants for uneconomically lengthy periods of time to provide counterbalancing generation on the east side of the Island.[61]

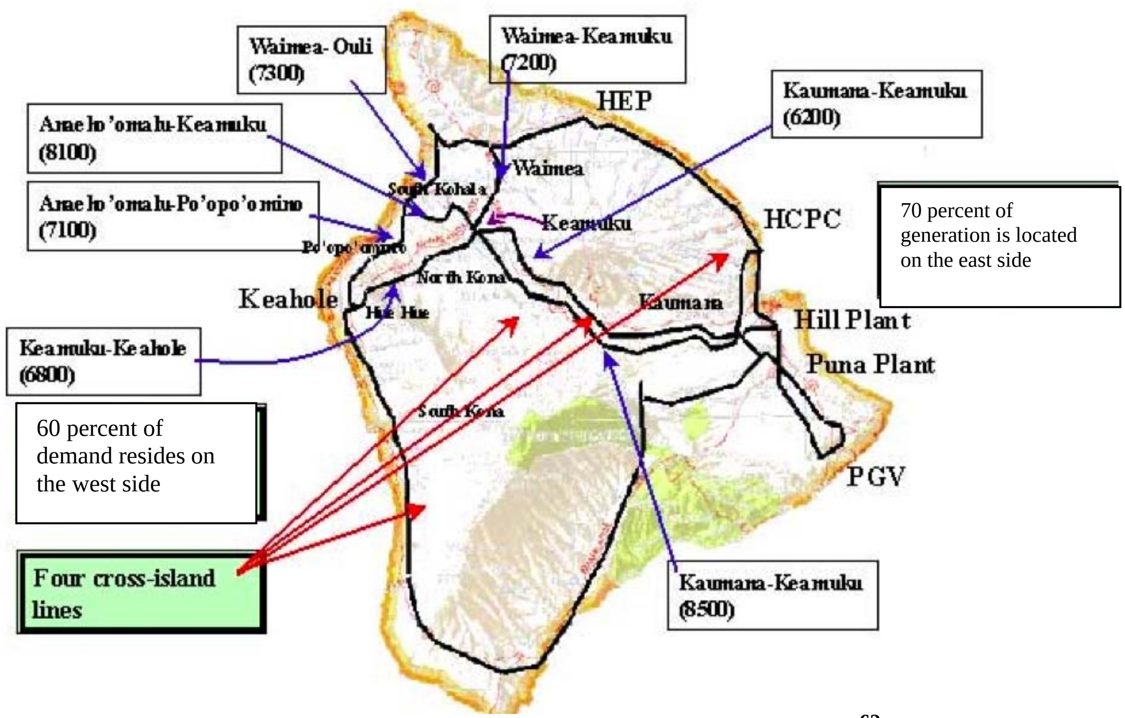

Figure 3.10: Major Hawai'i County transmission lines[62]

[60] HELCO. 2004. HELCO Operational Issues: Bulk Energy Storage.
[61] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[62] Figure from HELCO 2004. HELCO Operational Issues: Bulk Energy Storage.

HELCO is planning to rebuild and upgrade these three lines, starting in 2007 with the 7300 line. This is expected not only to alleviate concerns of overloading, but also to increase the overall efficiency of transmission by decreasing system losses. Hawai‘i’s electricity grid currently loses between eight and nine percent of all energy passing though the system.[63] Upgrading the three lines, coupled with the Keahole CT-7 steam recovery unit coming on line on the west side of the Island, is expected to reduce system losses to slightly under 7 percent per year.[64] Improving the lines would cost roughly $27.2 million, with the 7300, 7200, and 6800 improvements costing $2.2, $6, and $19 million, respectively.[65] Reducing the system loss rate would save 24 GWh of electricity in 2010, increasing to 30 GWh by 2025. Assuming that this additional energy would have to be provided by diesel generators at the margin,[66] this would save roughly $3.5 million per year (see Figure 3.11). Over the period from 2010 to 2025, the net present value of these transmission savings, at a 5% discount rate, would be $34.4 million, with the initial investment paying for itself in 13 years.

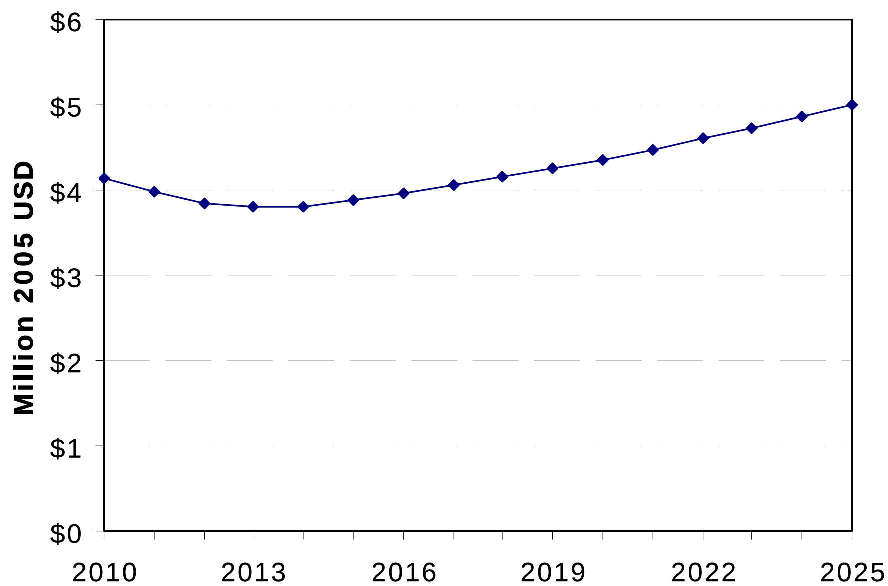

Figure 3.11: Annual savings from transmission loss reductions by year, 2010-2025[67]

Given the obvious financial viability of line reconductoring, HELCO should continue with their plans to upgrade the three lines. Reducing transmission losses would also help

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[63] Note that system losses calculated include energy used by generating facilities, though this amounts to less than 0.2% of total generation.
[64] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[65] HELCO. 2004. HELCO Operational Issues: Bulk Energy Storage.
[66] HELCO has a strong incentive to maximize generation from MSFO-based sources while minimizing diesel-based generation, given the large cost differential between the two. As a simplification for this calculation it is assumed that any additional generation is provided by the diesels.
[67] This projection uses IRP-3 demand projections and EIA oil price projections, and assumes that all energy savings directly translate into diesel unit output reductions. Note that this only measures savings in terms of generation costs, not retail costs.

alleviate the location demands on future generation installations, as the grid would be able to better handle additional generation sited on the eastern side of the Island.

Energy Storage: Pumped Storage Hydro with Wind, Batteries

Recommendation 3.5: Promote the development of a pumped storage hydro system to increase the intermittent capacity of the grid and smooth the electricity load curve, reducing the need for expensive diesel peaking generation.

Renewable energy has the potential to lower electricity costs in Hawaiʻi, reduce dependence on imported oil and associated price volatility risks, and reduce air pollution and Hawaiʻi's contribution to global climate change. However, with the exception of geothermal power, the primary renewable energy sources currently being developed in Hawaiʻi County face a major shortcoming: their intermittent nature. Wind turbines and solar modules only produce energy when the wind is blowing or the sun is shining. These conditions change rapidly and unpredictably, which stresses the power generation and transmission systems, rendering renewable energy unreliable as a generation source during critical peak use periods. As an isolated island micro-grid, Hawaiʻi County is unable to import energy from other grids in response to changing intermittent generation output. This means that the utility has to operate a cycling reserve of generation to hedge against unpredictable reductions in output, increasing the real cost of generating electricity from renewable sources.

Installed generation capacity needs for the system are largely driven by peak demand. HELCO must be able to supply the maximum possible expected demand; power shortages are not an option. If the wind stops blowing at 8 PM in the middle of a December evening, when energy use is at its highest peak for the entire year, HELCO must have firm quick-starting backup generation ready to fill in the gap. Thus, intermittent generation cannot displace the need for other installed capacity to meet an increasing peak demand, though it can offset actual generation from other sources. Large, unpredictable changes in energy supply can change the frequency of energy in the system. Should system frequency fluctuations exceed 0.5 hertz, electrical equipment across the Island could be damaged. Similarly, HELCO must maintain consistent voltage across the system, ensuring that transmission lines are not overloaded and balancing the geographic distribution of generation. As the percent of total electricity coming from intermittent sources reaches levels seen in few if any other energy systems in the world, maintaining system stability becomes increasingly challenging.[68]

To expand the generation of intermittent renewable sources, such as wind, solar, and to a lesser extent hydro, significantly beyond current levels would require mechanisms for "firming" up the generation. In particular, the County would need to examine storage systems, such as batteries or pumped storage hydro, which would allow energy generated off-peak to be stored for peak usage. These systems can help offset the need for expensive diesel-run peaking units to run during peak hours and can reduce costs associated with curtailing excess generation during periods of minimal use. Storage

[68] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

systems themselves are quite costly. However, these costs have to be weighed against the potential benefits of allowing a greater share of Hawai‘i’s energy to come from potentially cheaper, renewable sources.

Given its location and geography, the most viable storage option for Hawai‘i County would likely be a pumped storage hydro system. Pumped storage hydro systems are composed of two adjacent reservoirs of water, one at a significantly higher elevation than the other. Water from the lower reservoir is pumped up to the upper reservoir during off peak periods when generation costs are low and there may be unused non-curtailed generation available. During peak periods, or whenever the extra generation is needed, water is released from the upper reservoir and passes through a generator on the way down to the lower reservoir, producing electricity. Pumped storage hydro systems are fairly efficient, with roughly 70% to 85% of electricity used to pump water regained in generation.[69] However, the low energy density of pumped storage hydro systems requires either a large body of water or a large elevation gradient to function efficiently. Figure 3.12 provides a sample diagram of a pumped storage hydro installation in Tennessee. This installation stores off-peak energy from coal and not from renewables. It is also a much larger installation than would be necessary for the County.

A relatively small 30 MW pumped storage hydro system in Hawai‘i County could allow an additional 40 MW of wind or similar intermittent generation to be integrated into the grid.[70] A pumped storage hydro system would also provide a number of important ancillary services, as it would effectively allow what the utility considers to be the least desirable type of power generation, intermittent sources, to act as the most desirable peaking units. Pumped storage hydro systems can help regulate system frequency by quickly adjusting generation or curtailment in response to changing electricity demand and supply. These adjustments in output can occur in a matter of seconds, much faster than the response time of large steam units.[71]

When planning a potential pumped storage hydro system in Hawai‘i County, a number of important considerations need to be taken into account. Perhaps the most important is location: given the high value of land in many areas, site acquisition could contribute significantly to initial costs, though there may be opportunities to avoid this problem. Location is also determined based on how the plant is used. If the pumped storage hydro system were connected solely to a large wind farm, the system would have to be located relatively close to the wind farm to minimize transmission costs. On the other hand, if the pumped storage hydro system is connected to the general grid rather than any particular source, location is less significant, though siting on the west side of the Island could help regulate system voltage. Using a pumped storage hydro system to help flatten the overall load on the grid would provide a number of benefits, but would also potentially put a strain on the transmission system.

[69] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.; This efficiency represents only the pumped storage hydro unit and does not include the generation efficiency (e.g., wind).
[70] HELCO. 2004. HELCO Operational Issues: Bulk Energy Storage.
[71] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

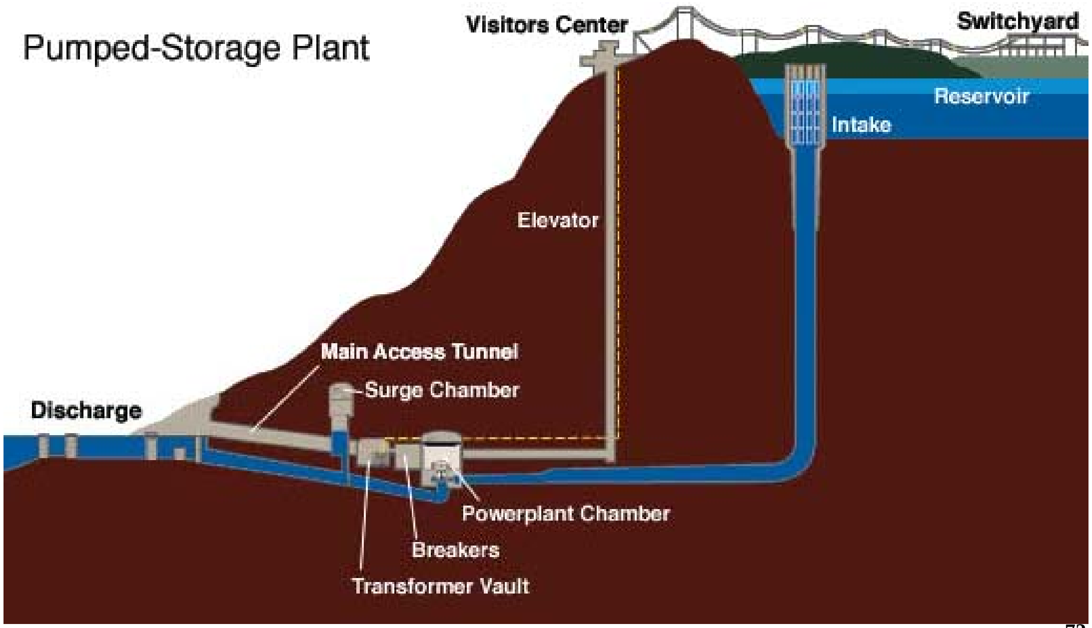

Figure 3.12: Sample diagram of a pumped storage hydro facility in Tennessee[72]

The decision to connect a pumped storage hydro system to a particular generator or to the overall grid needs to be examined further before the best option can be determined. As Hawai'i County moves forward in examining the potential for a pumped storage hydro system, they should closely examine the system currently planned in Maui. Shell is in the process of constructing a 40 MW wind farm in Ulupalakua Ranch, which would be accompanied by a 30 MW pumped storage hydro system.

In addition to providing a source of power storage, a pumped storage hydro system could potentially be integrated into the water system, serving as a reservoir of drinking water or for use in irrigation of agriculture. While Hawai'i currently uses groundwater for virtually all domestic water needs, this may change in the future if demand outstrips potential groundwater supplies. A reservoir system, especially if located on the west side of the Island, could prove useful. Additionally, standing reservoirs could be used as a water source for firefighting activities.

In the IRP-3, HELCO examined potential pumped storage hydro systems at two sites:

- Puu Anahulu: 30 MW and 5 hours of storage (150 MWh total) operating at a 21% capacity factor with 850 feet of gross head, and 510 cubic feet per second flow. For this system, the upper reservoir would be 17 acres, and the lower would be 16 acres.
- Puu Enuhe: 30 MW and 5 hours of storage (150 MWh total) operating at a 11% capacity factor with 1,230 feet of gross head and 350 cubic feet per second flow. The upper reservoir would be 9 acres and the lower 16 acres.

[72] Diagram of the 1,600 MW Raccoon Mountain pumped storage hydro facility in Tennessee, owned and operated by the Tennessee Valley Authority. Note that a proposed Hawai'i County system would be much smaller, and would likely operate though external pipes rather than underground tunnels.

This report does not provide a specific cost estimate of either site, though an earlier "Bulk Energy Storage" report by HELCO estimated that a 30 MW installation would cost around $86.4 million.[73] Unfortunately, details regarding the considerations that went into calculating this figure are not provided in the text.

Another study contracted by MWH Americas, Inc. of the potential for developing two separate 25 MW pumped storage hydro systems on Hawai‘i Island estimated total construction costs to be around $239 million.[74] For the calculation of storage cost in our supply scenarios developed in Section 3.1, HELCO's cost estimate of $86.4 million was used. As described earlier, the cost of a pumped storage hydro system could be potentially larger than the financial benefits (in terms of lower energy costs) if avoided cost payments remain linked to fuel prices and if carbon emissions remain unregulated.

Given the large potential benefits associated with increasing the amount of firm non fuel-based generation in Hawai‘i County in meeting the County's sustainability goals, the County should begin planning for a potential 30 MW pumped storage hydro system to be installed at some point in the next seven to twelve years. The County should examine potential sites, as well as options for funding the system either through HELCO or special issue municipal bonds. There may be options to obtain land for reservoir siting from the Department of Land and Natural Resources or the Kamehameha Schools at low cost, and these should be explored further.

Power Plant Retirements

Recommendation 3.6: Encourage HELCO to develop a retirement schedule for the oldest and least efficient power plants.

In Hawai‘i County, not all power plants are created equal; some power plants get a considerably greater energy output per unit of fuel input than others. This difference in plant efficiency is primarily a function of plant age and capacity utilization, with older plants tending to be less efficient. When plants are forced to run below optimal capacity, this curtailment tends to reduce overall efficiency. This is an important consideration in planning for minimum load periods to avoid having to curtail baseload generation (and thereby reduce efficiency).

Figure 3.13 shows the efficiency of each of the current fuel-based generation plants in Hawai‘i.[75] This means that for every 100 units of energy contained in the fuel use in power plants, 70 to 85 units are lost as waste heat. While it is impossible to achieve 100% efficiency, there are cogeneration natural gas plants that achieve 60% efficiency.

[73] HELCO. 2004. HELCO Operational Issues: Bulk Energy Storage.

[74] Study cited in HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

[75] In the decade preceding 2004, efficiency data suggest the power plant efficiencies have been generally consistent. Efficiency was calculated using the EIA definition such that efficiency = 3.4 * MWh output / MMBtu input (EIA. 2004. *EIA-906/920 Monthly Time Series File for Hawai‘i County*). MMBtu input data from DBEDT datasheet on HELCO's operations, 2006, and MWh output data from HELCO 2007. Generation Data, 1988-2004. Personal communication.

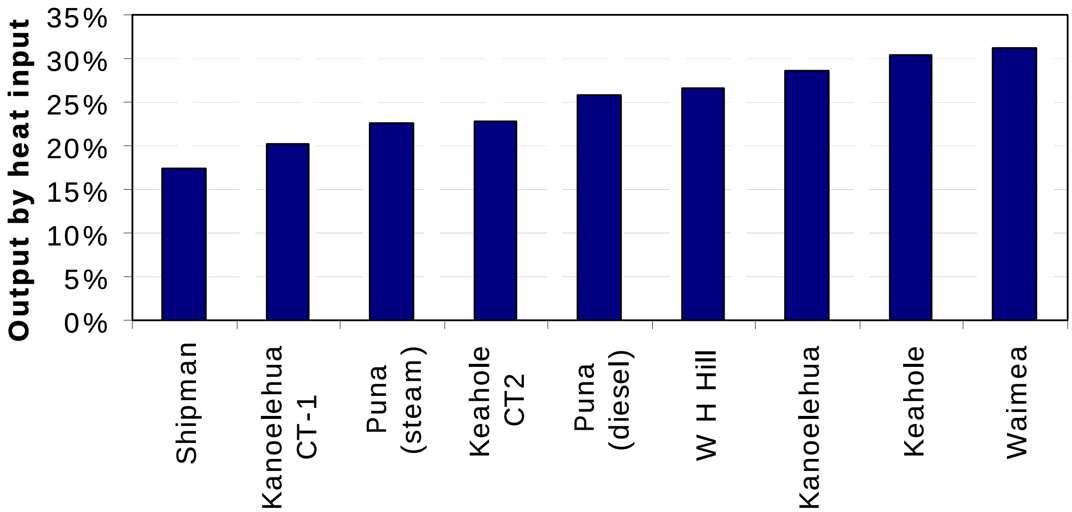

Figure 3.13: HELCO plant efficiencies, 2004[76]

In the development of the Energy Sustainability Plan scenario, plant retirement options were determined by examining both current plant efficiencies and system constraints. Retirement of older and less efficient plants can allow that generation to be replaced with cheaper alternatives. As Hawai'i County is currently locked into an energy infrastructure primarily composed of oil derivatives, plant retirements may be the best method to meet the energy goals of the County and to reduce costs prior to 2022, when the first new firm capacity would be required to meet rising demand. Retiring the least efficient plants would increase the overall average system efficiency. However, retirement of plants can only be effective when it does not put undue pressure on the power system. In general, retired capacity should be replaced with like capacity that provides, at a minimum, the same frequency and voltage regulating services, does not decrease peaking generation potential, and does not require excess curtailment of baseload generation.

The Shipman cycling/intermediate plant, Kanoelehua CT-1 peaking plant, and Puna baseload plant had the lowest efficiency of any fuel-based generation plants on the Island in 2004.[77] Both Shipman and Puna use the relatively cheap MSFO, while Kanoelehua CT-1 uses diesel fuel in a combustion turbine. The currently operating Shipman units first went on line in 1955 and 1958, while the Puna plant was built in 1970 and Kanoelehua CT-1 in 1964.[78] Given that Kanoelehua CT-1 is a peaking plant, it is run only for a short period every year, and its generation is significantly lower than the other two plants, generating only 0.3 GWh in 2006, compared to 41.4 GWh for the Shipman plant and 89.8 GWh for the Puna plant.[79]

[76] Data from Energy Information Agency, 2004.

[77] Note that the efficiencies of plants tend to remain relatively constant over the period from 1990-2004, though the efficiency of the Shipman plant is likely closer to 21% when running at more normal capacity. See Appendix A for details.

[78] DBEDT 2001. Island of Hawai'i Electrical Generation Capacity Based on HELCO Generation Resource Contingency Plan Update #7.

[79] HELCO 2007. Generation Data, 1988-2004. Personal communication.

In the Energy Sustainability Plan scenario, it is recommended that HELCO retire the Puna steam and Shipman units in 2009 and replace them with an expanded 20 MW of geothermal output. The Puna Geothermal Venture facility is located close enough to the existing Puna steam plant that expanding its output would likely have a minimal effect on system voltage and line losses. The 20 MW of increased geothermal capacity envisioned in the Energy Sustainability Plan scenario would be expected to produce roughly 150 GWh annually, and could do so at a significantly lower cost than either the MSFO or diesel-based generation it would be replacing assuming that oil prices remain high.[80]

Despite their inefficiencies, the Puna steam and Shipman units are the lowest cost electrical generation on the system (with exception of the HEP plant).[81] Low cost, however, should not be confused with efficiency. These plants have fully depreciated in value due to their old age. Costs associated with these plants reflect only the cost of operation and maintenance (O&M), and not the cost of capital to construct them. The key O&M cost is the price of fuel, all of which is passed on to the customer. Low cost to HELCO is not a compelling reason to keep them in operation. To the contrary, maintaining these units simply because they have been fully paid for by the utility effectively justifies never retiring infrastructure even in the face of cost-effective alternatives, such as that which is available from PGV (discussed in Recommendation 3.7).

The recent decision by HECO to explore the use of biofuels as a fuel in its generation units places even greater importance on plant efficiency. Locally grown biofuels feedstocks, whereas a potential boon for the local economy, also would place other land and resource uses in competition with that required for growth of feedstocks. Effective management of available land and resource would be essential to mitigate any potential conflicts of this competition. Using feedstocks grown locally in inefficient power plants would not be compatible with this goal. This is discussed in greater detail in Section 5.1.

HELCO currently has no specific timeframe for the retirement of existing generation capacity. Given the high cost of operation of these aging oil-based generation units, and the rapid pace of new, cleaner, and less expensive alternative generation technologies, HELCO should explicitly incorporate unit retirement and replacement planning in the context of the IRP process, and explicitly address retirement options in the IRP-4. In efforts to reach its energy goals of reducing system costs and improving energy security, the County should monitor the relative efficiency of each of the existing plants, and push for the retirement of older units when less expensive comparable alternatives are available either through HELCO or independent power producers.

[80] See Recommendation 3.7.
[81] Relative plant efficiencies were provided by HELCO in their written comments to the draft of this report. Comments provided in a HELCO letter dated July 23, 2007.

Geothermal Power Development

Recommendation 3.7: Promote the expansion of Puna Geothermal Venture to its permitted limit of 60 MW.

Renewable energy holds the potential to improve the environment while lowering energy costs in Hawaiʻi County. For this potential to be realized, however, requires overcoming the barriers posed by the intermittent nature of many popular renewable sources such as wind and solar. As discussed in detail in Recommendation 3.5, intermittent renewable options create difficulties in maintaining frequency and voltage requirements for the system, and cannot be relied upon to provide power during peak times in the absence of accompanying energy storage systems.

However, Hawaiʻi Island is endowed with a remarkable geothermal resource that can provide a firm source of cheap renewable baseload generation. Geothermal energy was first explored in Hawaiʻi County in 1976. A publicly-funded demonstration project intended to encourage commercial development of geothermal energy was undertaken with the drilling of a small 3 MW well called the Hawaiʻi Geothermal Project – Abbott (HGP-A) well[82]. Puna Geothermal Venture (PGV) opened its facility in the early 1990s, currently generating up to 30 MW and permitted for an additional 30 MW, for a combined total of 60 MW.

Although an ideal energy resource in theory, as it is the only currently available renewable energy that provides both inexpensive and non-intermittent generation, geothermal has a contentious history in Hawaiʻi County. Health concerns related to releases of hydrogen sulfide (H_2S) have been poorly addressed in the past and created political tension within the Puna community. The native Hawaiian community has also been involved in opposition to geothermal development in the Kilauea Eastern Rift Zone for spiritual and ecological reasons. Volcanoes and lava are core components of Hawaiian culture and spirituality, and some Hawaiian leaders believe that geothermal energy constitutes an inappropriate use of the power of Pele, the Goddess of the volcanoes. The Hawaiian community also demonstrated against a proposal to drill within the Wao Kele O Puna forest; this proposal occurred prior to the arrival of PGV on the Island by an unrelated entity.

The thirty-year history of geothermal energy in the Puna area has been notable for political opposition as much as power generation. Negligence during the operation of HGP-A and an unrealized plan to drill within the Wao Kele o Puna forest reserve were amplified by two unanticipated blowouts during the drilling of two PGV wells in 1991, creating concerns for public health, the environment, and spiritual integrity.

Since 1991, Puna Geothermal Venture has made a concerted effort to become a good neighbor and diminish lingering resentment. PVG has been described as having an open communication and outreach process that includes attending community association

[82] The title Abbott was from an eminent volcanologist at University of Hawaiʻi – Manoa.

meetings to field questions and concerns. In receiving 20% of the royalties paid on the resource, Native Hawaiians also benefit directly from the PGV operation.[83]

Any future expansion or development of the geothermal resource in the KERZ must consider the history of geothermal energy in Hawai‘i County. Whatever decisions are made in the future, geothermal remains, from an energy standpoint, an ideal source of electricity generation: cheap, renewable, firm, and reliable.

Table 3.6 shows the various costs associated with the current Puna Geothermal Venture site. At a 20% rate of return on capital investments, electricity generation would cost Puna Geothermal Venture slightly over 9 cents per kWh. However, they are currently being paid avoided costs of roughly 18 cents per kWh by HELCO, giving it an effective annual rate of return of almost 40 percent. As explained in Recommendation 3.9, this disparity between generation costs and avoided cost payment by HELCO arises due to the effective linking of avoided cost and the price of fuel. It is easy to see that the majority of the potential benefits of retiring a portion of existing baseload generation and replacing it with expanded geothermal production depends on the unlinking of avoided cost from fuel cost.

Table 3.6: Costs of production for the current Puna Geothermal Venture operation[84]

Puna Geothermal Venture generation costs	
Capacity (MW)	30
Generation (MWh)	252,200
Capital costs ($)	85,430,000
Rate of return	20%
Annualized capital costs ($)	17,086,000
Fixed and variable O&M ($)	6,000,000
Cost of generation per kWh (cents)	9.15

In the Energy Sustainability Plan scenario, the current Puna Geothermal Venture operations are expanded by 20 MW in 2009, replacing an equivalent 20 MW of baseload (and, in the case of the Shipman plant, intermediate) generation. Geothermal output is expanded an additional 10 MW in 2014, up to its maximum permitted production of 60 MW. Ramping up PGV production to 60 MW would not involve any expansion of geothermal resource use outside of the current site. Additionally, a portion of this generation would not require any new wells, as a third heat recovery unit could be added to the two existing turbines. Given that PGV re-injects heated water at the temperature that most mainland geothermal plants extract, there is a significant quantity of heat that could potentially be economically recovered in the current generation process. Figure

[83] Puna Geothermal Venture, “Do Native Hawaiians and environmentalists oppose geothermal power?”, Accessed: July 2007, Available: http://www.punageothermalventure.com/FAQS/20/do-native-hawaiians-and-environmentalists-oppose-geothermal

[84] Financial data from Global Energy Concepts. 2004. *Select Hawaii Renewable Energy Project Cost and Performance Estimates*. Renewable Energy Resource Assessment and Development Program. Rate of return on capital investments based on our conversations with PGV. Generation costs calculated by dividing the sum of annualized capital costs and fixed and variable O&M by expected annual generation.

3.14 shows the undiscounted annual benefits of replacing 20 MW of geothermal generation relative to MSFO generation for 2009 to 2013, and 30 MW geothermal generation for 2013 to 2025, similar to what would happen in the Energy Sustainability Plan scenario.[85] It provides three different possible benefit trajectories: unlinked costs, linked costs, and fixed costs. While linked and unlinked avoided cost scenarios are explained above, the fixed cost options would be for HELCO to negotiate a long-term purchasing contract with Puna Geothermal Venture to pay a fixed price of 10 cents per kWh for additional generation. While fixed cost contracts could be potentially risky should HELCO baseload generation costs fall below 10 cents per kWh, this possibility is highly unlikely given the current plausible range of projections for future oil prices.

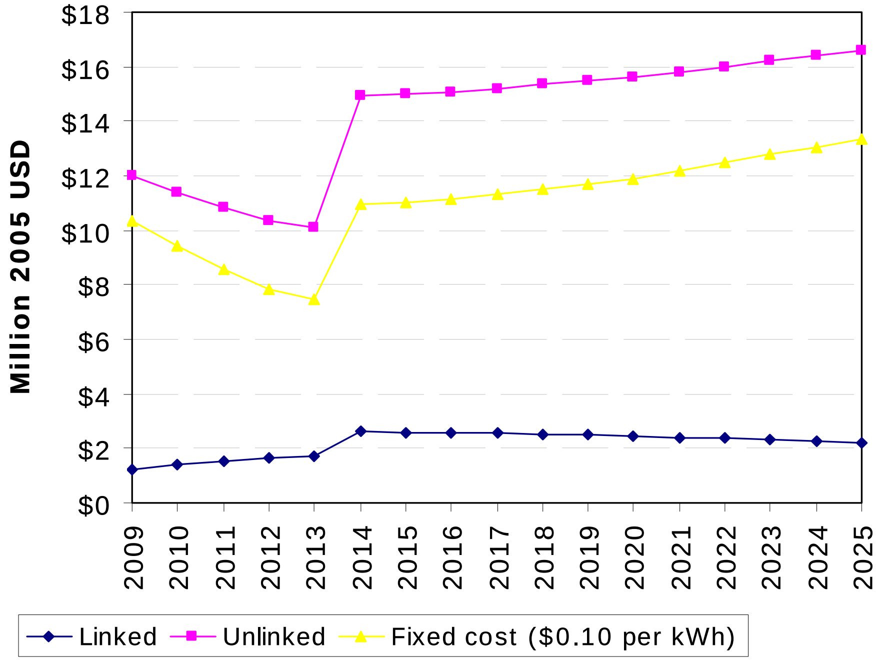

Figure 3.14: Benefits of geothermal generation relative to MSFO[86]

If geothermal generation is expanded to replace existing MSFO baseload, it would have to meet a number of important criteria. First, new geothermal generation should, as part of the power purchasing agreement with HELCO, be incorporated into the automatic generation control system to help manage system frequency and voltage fluctuations. The existing 30 MW PGV system does not incorporate automatic generation control, though there are no fundamental technical barriers to installing such systems for either new or existing generation capacity, other than cost. While automatic generation controls would increase the cost of geothermal energy, this cost increment would be insignificant

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[85] Note that the additional 10 MW of geothermal production in 2014 only offsets existing MSFO baseload production in the Energy Sustainability Plan scenario when compared to a scenario that helps meet demand growth by expanding MSFO baseload generation.

[86] Cost difference between Geothermal and MSFO generation in the Energy Sustainability Plan scenario. Note that installed geothermal capacity increases 20 MW in 2009 and an additional 10 MW in 2014. These calculations do not take into account the relative generation efficiencies of the specific plants retired under the Energy Sustainability Plan scenario, but instead use the average cost per kWh of MSFO generation derived from DBEDT datasheet on HELCO's operations, 2006.

compared to the cost difference between fixed cost or unlinked avoided cost geothermal generation and MSFO generation.

Second, to effectively replace existing baseload capacity, geothermal must provide a reliable and consistent output. There have been cases reported in other geothermal fields where well casings and liners have failed leading to a drop in output. This occurred in PGV in 2002, when annual geothermal generation dropped dramatically from over 200 GWh to 74 GWh, before returning to normal output in 2003. With the exception of 2002, however, their generation has been relatively stable over its 14 year lifetime. Figure 3.15 shows how much the output of different generation plants in Hawai‘i County changes year to year, normalized relative to the Hill plant. Two PGV bars are given: PGV, which includes all years of generation, and PGV’, which excludes 2002. If 2002 is included, PGV has higher output variability than any other baseload plant. If 2002 is excluded, however, PGV has the most consistent output of any baseload unit other than the Hill and HEP plants (third bar from the left in Figure 3.15). Thus a better understanding of the likelihood of 2002-type disruptions is important in assessing the viability of expanded geothermal baseload generation in Hawai‘i County.

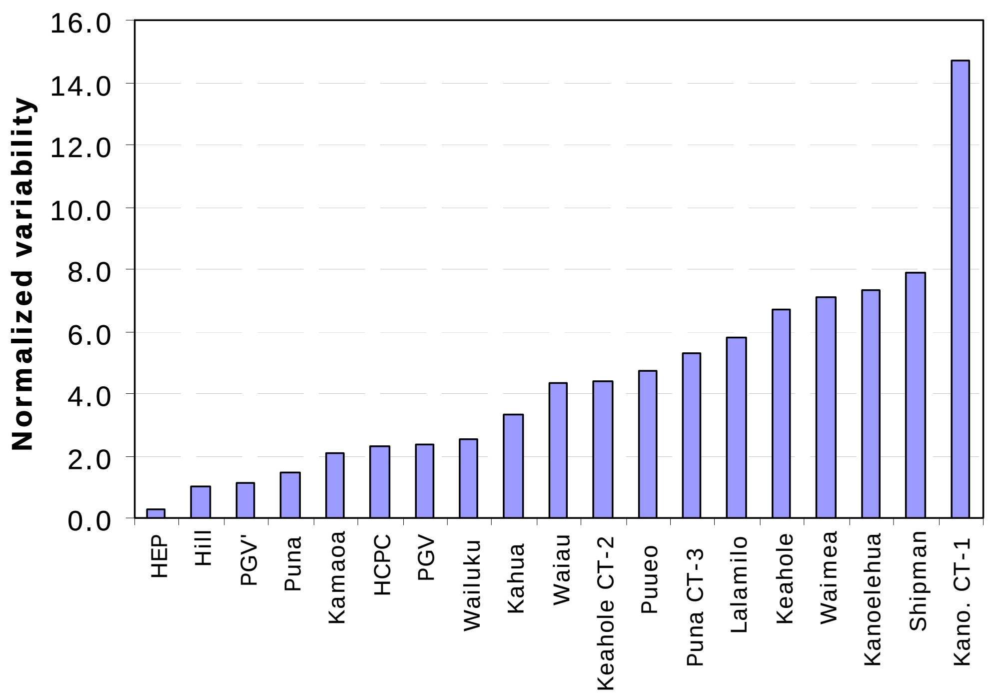

Figure 3.15: Normalized generation variability, 1990-2004[87]

[87] This standardized variability is calculated by dividing the standard deviation of 1990-2004 generation (excluding generation from the initial year of plant operation) by the average generation over that period. It is than normalized by dividing each generation unit variability by the Hill unit variability.

Competitive Bidding

Recommendation 3.8: Enforce the use of competitive bidding for non-fossil fuel generation by encouraging the PUC to deny waivers. Incorporate timetables to allow bidding on new projects into the IRP-4.

The PUC issued Decision and Order No. 22588 on June 30, 2006, setting forth a framework for the competitive bidding when acquiring or building new energy generation in Hawai‘i. The order requires the utility to initiate competitive bidding processes for additional generation, so long as such a process allows the utility to provide safe and reliable service at reasonable rates. While the utility can bid into the process, an independent observer would be required to provide oversight to ensure a competitive process. To circumvent the competitive bidding process, the utility must be issued a waiver.[88]

One issue that affects competitive bidding is the PURPA’s designation of qualified facilities (QFs), which must be cogeneration facilities or small power production facilities whose primary energy source is renewable.[89] The PUC requested input on the legality of the options to deal with QFs in a competitive bidding process. After taking into account responses from HECO, the Consumer Advocate, and Hawai‘i Renewable Energy Alliance, the PUC altered the framework such that:[90]

1. When competitive bidding does not apply (i.e., waiver or exemption), the utility is still obligated to offer to purchase capacity from a QF at avoided cost.
2. When competitive bidding does apply, the utility must apply to the PUC and they would defer QF obligations pending the completion on the competitive bidding process.
3. If a non-QF is the winning bidder, a QF would have no right to supply the resource, unless the non-QF winner cannot meet the needed capacity, in which case the QF can sell power at the avoided cost set by the winning bid.
4. When the winning bidder is the utility’s self-build option, the QF would not have the right to supply the resource.
5. If a QF is the winning bidder, they can then sell to at this bid price, unless the price is modified in the contract negotiations.

Competitive bidding has the potential to eliminate the avoided cost component of independent power producer pricing. In the presence of enough competitive bids, this would tend to drive down the price of energy from independent power producers to be more in line with their generation costs. For Hawai‘i County, where avoided costs are currently two to three times higher than generation costs for many renewable independent power producers, competitive bidding could be an effective way to ensure that renewables help reduce electricity prices. The relative effectiveness of the competitive bidding process depends on the number of competing bidders and the status of ongoing

[88] Hawai‘i PUC Decision and Order No. 22588, June 30, 2006.
[89] FERC website, http://www.ferc.gov/industries/electric/gen-info/qual-fac.asp, last accessed February 20, 2007.
[90] Hawai‘i PUC Decision and Order No. 23121, December 8, 2006.

efforts to delink avoided cost for fuel costs. If there are few firms bidding, then the price paid in a competitive bidding framework would be similar to the current avoided costs paid. On the other hand, if the PUC succeeds in decoupling avoided cost and fuel costs, competitive bidding would make little difference in the cost of energy, as the bulk of potential savings would likely be realized by delinking.

A potential problem with competitive bidding is that the independent bidders would be locked into their energy price, unless their proposal states otherwise, and absorb some of the risk. The utility, on the other hand, can bid lower with the expectation that they can seek a rate increase should costs rise in the future.[91] Utility risk sharing, discussed in Recommendations 3.10 and 3.11, could help mitigate this. There is also the risk of creating a perverse situation if the price of generation for HELCO falls significantly, such that independent power producers are paid considerably more than they would be under avoided cost. However, for this to occur in Hawai‘i County, the price of oil would have to fall dramatically, a prospect that seems highly unlikely at this time.

The Keahole CT-7 project, and other non-fossil fuel generators that are under review, are considered under development and, thus, exempt from this process.[92] As HELCO is not planning on installing any new capacity until 2020, in the absence of any plant retirement they will not have to worry about the new competitive bidding rules in the near term.[93] HELCO expects that their request for proposals for additional renewable generation post-2020 would be done through the competitive bidding framework. They are in the process of working to determine if distributed generation systems might fall under competitive bidding requirements, though existing rules do exempt projects smaller than one percent of the utility's total firm capacity, including independent power producers.[94]

In addition to identifying needed resources, the Integrated Resources Planning process serves to identify "those resources for which competitive bidding is appropriate, and those for which waivers are necessary."[95] "[A]n evaluation of bids in a competitive bidding process may reveal desirable projects that were not included in an approved IRP. These projects may be selected if it can be demonstrated that the project is consistent with an approved IRP and that such action is expected to benefit the utility and its ratepayers".[96]

For competitive bidding to be effective, the utility must plan far enough in advance for companies to be able to engage in a robust bidding process. The IRP process provides an important forum for future projects to be outlined, with specific timelines for taking bids. If the period between project proposal and the acceptance of bids it too short, it would eliminate many of the potential benefits of competition in the bidding process. Likewise, delaying accepting bids in an effort to ensure a waiver of the competitive bidding rules

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[91] Hawai‘i PUC Decision and Order No. 22588, June 30, 2006.
[92] "Framework for Competitive Bidding" State of Hawai‘i Public Utilities Commission, June 30, 2006.
[93] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[94] Ibid.
[95] Hawai‘i PUC Decision and Order No. 22588, June 30, 2006.
[96] Framework for Competitive Bidding" State of Hawai‘i Public Utilities Commission, June 30, 2006.

would be fundamentally counterproductive. HELCO should seek to incorporate competitive bidding requirements into the IRP-4, and avoid seeking waivers if at all possible. Likewise, the County should advocate to the PUC for them to robustly enforce the use of competitive bidding for all new renewable power projects.

Avoided Cost

Recommendation 3.9: Support ongoing Public Utility Commission efforts to delink avoided costs paid to renewable independent power producers from the cost of fuel.

When developing power purchasing agreements with independent power producers, HELCO has agreed to pay them at the cost of generation avoided by purchasing their energy rather than installing additional HELCO-owned capacity. These "avoided cost" payments to independent power producers are mandated under PURPA, and closely mirror the generation costs of existing HELCO facilities. Until recently, avoided costs were similar to the cost of generation at most IPPs, ranging between 7 and 9 cents per kWh between 1990 and 1999. However, with the price of oil increasing dramatically over the past few years, the avoided cost paid to non fuel-based generators has become increasingly divorced from actual costs of generation. While the costs of generation for Hawai'i's wind, hydro, and geothermal plants range from 6 to 9 cents per kWh, avoided costs paid to these plants have risen to almost 18 cents per kWh. Figure 3.16 shows how avoided costs have closely mirrored increases in fuel costs over the past 15 years. While some may argue that these higher payments may encourage renewable development, linked avoided costs have significantly diluted the incentive for HELCO or the County to expand renewable generation as a means of reducing consumer electricity prices.

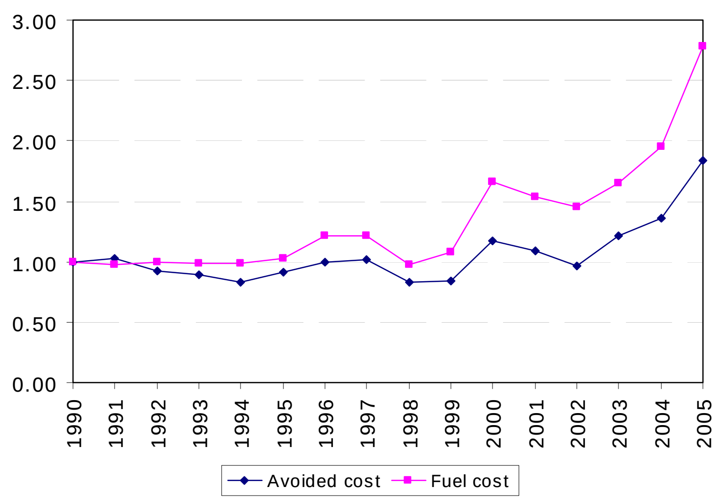

Figure 3.16: Normalized avoided cost and fuel cost per kWh[97]

[97] Based on avoided cost and fuel cost per kWh data from Pat Moore, HELCO, personal communication, 2007 and DBEDT Data Sheet on HELCO's Operations, 2006, respectively.

Recognizing the problem of avoided costs linked to rising fuel prices, in 2006 the Hawai‘i State Senate passed Senate Bill 3185, which was subsequently signed into law. This bill contained, among other things, language mandating that:

> “The commission's determination of the just and reasonable rate shall be accomplished by establishing a methodology that removes or significantly reduces any linkage between the price of fossil fuels and the rate for the nonfossil fuel generated electricity to potentially enable utility customers to share in the benefits of fuel cost savings resulting from the use of nonfossil fuel generated electricity. As the commission deems appropriate, the just and reasonable rate for nonfossil fuel generated electricity supplied to the public utility by the producer may include mechanisms for reasonable and appropriate incremental adjustments, such as adjustments linked to consumer price indices for inflation or other acceptable adjustment mechanisms".[98]

The PUC was tasked with the implementation of this directive, though how it would occur is still unknown. It is also currently unclear if these changes would apply to existing avoided cost contracts, or only to new contracts. Regardless of how events transpire, this strong state-level initiative for delinking avoided cost from fuel prices cannot be ignored by Hawai‘i County when developing options for future energy capacity. As shown in the supply scenarios developed in Section 3.1, **the delinking of avoided cost is perhaps the single most important step that the State could take towards reducing future energy prices**. Upwards of 46% of the potential savings of the Energy Sustainability scenario depends on the unlinking of avoided costs.

In the course of writing future power purchasing agreements, HELCO has to determine whether to pay independent power producers at avoided cost or at a fixed cost. The relative benefits of fixed cost contracts depend considerably on the outcome of the state-level avoided cost delinking effort. Contracts using delinked avoided costs would tend to result in lower payments per kWh to independent power producers than fixed price contracts, while linked avoided costs would tend to yield higher payments. The County of Hawai‘i should strongly support efforts by the PUC to delink avoided costs from fuel costs, for both existing and new contracts. It is recommended that HELCO closely monitor the outcomes of these efforts, and consider using fixed cost contracts for new power purchasing agreements should avoided costs remain linked to fuel costs.

Utility Risk Sharing

Recommendation 3.10: Encourage the PUC to incorporate utility risk sharing through modification of the energy cost adjustment clause.

The Energy Cost Adjustment Charge (ECAC) is a rate adjustment mechanism that passes changes in fuel cost to electricity ratepayers. This effectively insulates the utility from the dramatic fluctuations in oil prices and places all of the risk on the ratepayers. With 77% of HELCO’s generation relying on petroleum-based fuels in 2006,[99] the ratepayers are vulnerable to oil price spikes at both the gas pump and the electrical outlet. Figure

[98] State of Hawai‘i 2006. *Senate Bill 3185*. Available: http://www.capitol.Hawaii.gov/session2006/Bills/SB3185_CD1_.htm

[99] Hawai‘i Electric Light Company, Inc. “Electricity Production & Purchased Power Summary” 2006.

3.17 demonstrates how HELCO's residential electricity rates correspond with fluctuating crude oil prices.[100]

In 1999, when oil prices were below $20 per barrel for light sweet crude, the ECAC was approximately zero. Seven years later, in 2006, oil prices had increased to over $70 per barrel, and residents of Hawai'i were charged an additional 9.73 cents per kilowatt-hour for the ECAC, making their rate over 29 cents per kilowatt-hour.[101] A family that uses 600 kilowatt-hours per month would pay $175 per month, $58 of which was due to these pass-through costs tied to the price of oil.

In fact, in 2006, the average total residential electricity price in the U.S. was 9.57 cents per kilowatt-hour – less than Hawai'i's ECAC charge alone.[102] Because the utility can pass along increased fuel prices to its customers, and its customers have no alternative from where to purchase electricity, there is no pricing incentive for the utility to diversify their energy sources and limit the risk associated with oil price volatility.

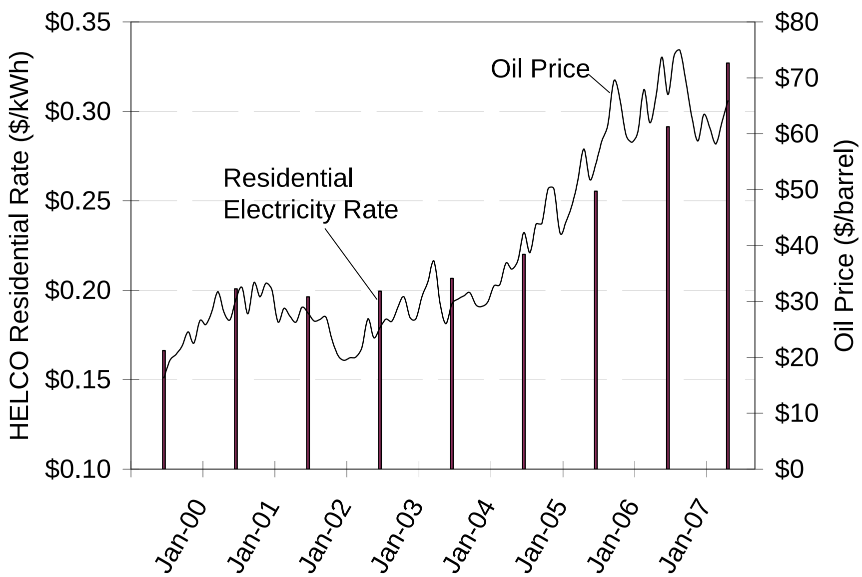

Figure 3.17: HELCO's residential rates and crude oil price

Nevertheless, the Consumer Advocate, under questioning by the PUC, observed that the ECAC was "an effective means of sharing the operating and performance risks between HELCO's ratepayers and shareholders."[103] Further, the Consumer Advocate concluded

[100] HELCO's residential rates are taken from State of Hawai'i, Public Utility Commission Annual Reports. Oil prices are for NYMEX light sweet crude, with data taken from the New Mexico Institute of Mining and Technology.
[101] State of Hawai'i, Public Utility Commission Annual Reports
[102] Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State" http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html, accessed April, 2007.
[103] From excerpts of Consumer Advocate testimony for PUC Docket No. 05-0315, as provided by HELCO.

that the IRP process was the appropriate mechanism by which decisions regarding resource diversity should be made.[104]

Recommendation 3.11: Encourage the Public Utilities Commission to require that the utility use consistent oil price forecasts for setting both the base rate at which they get paid and determining plant retirement and planning in the Integrated Resources Planning process.

In 2006, a bill was passed and signed into law giving the PUC the ability to "fairly share the risk of fuel cost changes between the public utility and its customers."[105] Hawai'i County should support the use of risk sharing to encourage the utility to divest from fossil fuel-based generation. Additionally, the fossil fuel price projections used to define the base rate should be consistent with price projections used in the Integrated Resources Planning process. Using consistent fossil fuel forecasts to set the base rate and in the IRP process would promote the use of fair and reasonable values. The utility would have a disincentive to use low-value oil forecasts during the IRP process because that would push the base rate they receive down. Conversely, using unduly high forecasts when setting the base rate would hurt the utility's ability to justify the planning of utility-owned fossil fuel generation during the IRP process and run the risk of early retirement of existing facilities.[106]

Rocky Mountain Institute estimated that a new 100 MW oil fired power plant would bring utility shareholders $4 million per year, but expose ratepayers to oil risks totaling $8 million per year for each $1 increase in the price of a barrel of oil. Energy Cost Adjustment Clause costs to ratepayers were $400 million statewide.

Renewable Portfolio Standard

Recommendation 3.12: Support efforts to amend the definition of renewable energy in the Renewable Portfolio Standard to separate and create independent standards for renewable generation and energy efficiency.

In 2004, Hawai'i's legislature enacted an enforceable Renewable Portfolio Standard, which was signed into law by Governor Lingle. This standard requires that each electric utility meet minimum percentages of net sales of renewable energy, as follows:[107]

8% by 2005
10% by 2010
15% by 2015
20% by 2020

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[104] Ibid.
[105] SB3185 SD2 HD2 CD1; Act 162, June 2006.
[106] Datta, K., N. Mims, Rocky Mountain Institute, "Rocky Mountain Institute Testimony Supporting SB2185 SD2 HD1" March 21, 2006.
[107] Hawai'i Revised Statutes §269-92

Renewable energy includes electricity produced by wind, solar, hydropower, landfill gas, biomass, geothermal, ocean thermal energy conversion, wave energy, biofuels, and hydrogen or fuel cell energy if the primary source is renewable.[108]

The creation of Hawai‘i's enforceable Renewable Portfolio Standard is a symbol of leadership in the energy field and should be recognized as a strong move towards renewable energy generation. There are currently twenty-four states plus the District of Columbia that have enforceable standards, covering more than half of the U.S. electrical load and utilizing several approaches to achieve a range of goals.[109],[110] The Lawrence Berkeley National Laboratory recently conducted an independent review of twenty-eight cost impact analyses on the effects of these standards.[111] This review found that 70% of the cost studies project electricity rate increases of less than one percent when the peak renewable target is reached. Hawai‘i's Renewable Portfolio Standard was found to have the third most favorable result – a net decrease in retail price by 4%.[112] It should be noted that the Hawai‘i cost impact study used in this review was released in 2001,[113] before the enforceable Renewable Portfolio Standard went into effect and its current goals determined.

Review of the Renewable Portfolio Standard must be conducted and presented to the legislature in 2009, with follow-up reports due every five years. The PUC is expected to contract with the Hawai‘i Natural Energy Institute for this peer-reviewed independent study, whose numerous goals include assessing effects of the Renewable Portfolio Standard on consumer rates and utility return on investment. The current standards can be revised, and the standards for five and ten years beyond the existing standards are set.[114]

The utilities and affiliates within Hawai‘i can aggregate their renewable contributions.[115] In a report for 2005, HECO, MECO, and HELCO[116] demonstrated that they achieved a consolidated Renewable Portfolio Standard percentage of 11.7%, well exceeding the goal of 8% renewable generation for that year.[117] Of the statewide total of 11.7%, 7.6% was

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[108] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State Energy Program, http://www.eere.energy.gov/state_energy_program/project_brief_detail.cfm/pb_id=740

[109] Chen, C., R. Wiser, M. Bolinger "Weighing the Costs and Benefits of State Renewables Portfolio Standards: A Comparative Analysis of State-Level Policy Impact Projections" Ernest Orlando Lawrence Berkeley National Laboratory, March 2007.

[110] Additional information on RPS, available at http://www.eere.energy.gov/states/maps/renewable_portfolio_states.cfm

[111] Ibid.

[112] Ibid.

[113] GDS Associates, Inc. (GDS). 2001. Analysis of Renewable Portfolio Standard Options for Hawai‘i. Submitted to the State of Hawai‘i Department of Business, Economic Development, & Tourism. Marietta, Georgia: GDS Associates, Inc. Available at: http://www.Hawaii.gov/dbedt/info/energy/publications/rps01.pdf

[114] Hawai‘i Revised Statutes §269-95

[115] Hawai‘i Revised Statutes §269-93

[116] HECO is the utility for Oahu; MECO provides for Maui, Molokai, and Lanai; and HELCO provides for Hawai‘i Island.

[117] W. Bonnett, "2005 Renewable Portfolio Standard Status Report" December 8, 2006.

met using renewable generation (including solar water heating) and 4.1% was met using "quantifiable energy conservation".[118]

HELCO leads the utility in renewable generation, supplying 28% of the renewable generation statewide despite only using 11% of generated electricity, as shown in Figures 3.18 and 3.19. Using HELCO's methodology for calculating the Renewable Portfolio Standard percentage, Hawai'i Island's renewable generation and qualified energy conservation totals 29%, already exceeding the statewide goal set for 2020. MECO was found to be at 14%, while HECO, which accounts for 77% of the statewide electricity generation, achieved 8.8%.[119] Thus, despite being a small generator, Hawai'i Island is a vital contributor to the statewide Renewable Portfolio Standard goals. Of the County's contribution, two-thirds were met at Puna Geothermal Venture, 15% by conservation, 12% by hydropower, and small contributions from wind power, photovoltaic power, and solar water heaters.[120] The contributions from wind power have increased significantly with recently added capacity.

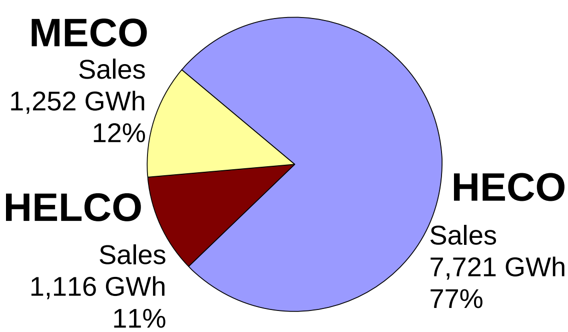

Figure 3.18: Electricity sales in Hawai'i by utility, 2005

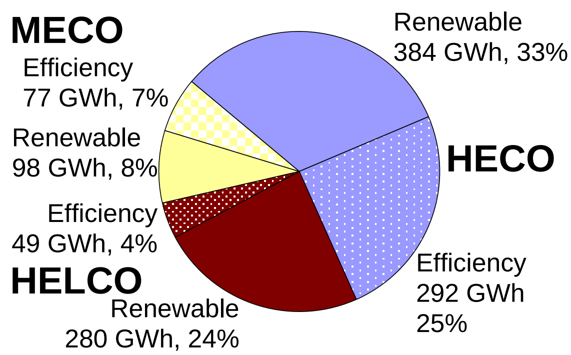

Figure 3.19: Contribution to the Renewable Portfolio Standard by utility, 2005

By allowing demand reductions to be included in the calculation of the renewable portfolio, the target for 2010 was easily surpassed in 2005. Under the current calculation methodology, efficiency measures are being double-counted; by reducing total electricity sales and holding renewable generation constant, the percentage of renewable generation increases twice.[121] In accordance with the energy sustainability goals of the County, it is recommended that the County supports the separation of renewable generation and efficiency. The utility would be responsible for meeting the generation requirements,

[118] Ibid.
[119] Ibid.
[120] Ibid.
[121] A simple example to illustrate this point – Case 1: demand is 110 GWh with 30 GWh of renewable generation, yielding an RPS percentage of 30/110 = 27%; Case 2: through conservation, demand is reduced 10 GWh to 100 GWh and the 30 GWh of renewable generation is held constant, yielding as RPS percentage of (30+10)/(110-10) = 40%. The conservation increased the numerator by 10 and decreased the denominator by 10, essentially being counted twice.

while the third party demand side management organization would be responsible for meeting demand requirements.

Recommendation 3.13: Endorse action by the Public Utility Commission, Hawai‘i Natural Energy Institute, and the peer reviewers to set goals for the Renewable Portfolio Standard that are high enough to encourage increased renewable generation.

The County can also serve a role in ensuring that the Hawai‘i Natural Energy Institute, the PUC, and the peer reviewers set reasonable, but ambitious targets for renewable generation. The current standards are not aggressive enough when the efficiency measures are allowed to contribute to the goals. By disallowing efficiency in the calculation and maintaining the current Renewable Portfolio Standard goals, a meaningful incentive to move away from the petroleum-based generation would be created. With the potential to decrease rates, improve environmental performance, and increase energy security, the County should serve as a clear voice in the creating ambitious goals for the Renewable Portfolio Standard.

Net Metering

Recommendation 3.14: Increase net metering limits to 250 kW per system with total capacity limits of no less than 1.0% of the utility’s peak demand. [122]

Under HRS §269-101, the State of Hawai‘i permits net metering for photovoltaic, wind, biomass, and hydroelectric systems in commercial, residential, and government sectors. Net metering encourages the development of small-scale renewable energy generation systems by compensating for their intermittency and reducing the investment pay back period.[123] Hawai‘i’s net metering legislation is important for increasing the penetration of small-scale renewable energy technology in the County of Hawai‘i.

Net metering tracks energy consumption and production from distributed generation sources. Generation beyond consumer demand causes the meter to spin backwards and generate net excess generation (NEG) electricity credits. NEG calculation is as follows: *Kilowatt-hours from utility - Kilowatt-hours self-generated and fed to the grid = Net kilowatt-hours*. Credits for excess electricity generated under net metering are applied to the next utility bill. Credits can be carried over to future bills for a maximum period of twelve months.

Closely associated with net metering are the specific interconnection rules that establish standards for connecting small-scale distributed generation systems to the grid. For example, these standards can specify specific equipment requirements for connecting

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[122] DSIRE, “Hawai‘i Incentives for Renewables and Efficiency: Net Metering”, Accessed: April 2007, http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=HI04R&state=HI&CurrentPageID=1

[123] The Apollo Alliance, *New Energy for States: Energy Saving Policies for Governors and Legislators*, 2007, 5.

renewable energy systems to the grid. Hawai‘i’s interconnection standards require systems to meet national standards established by the Institute for Electrical and Electronics Engineers and Underwriters Laboratory, and that installation must be compliant with the National Electrical Code and local codes. However, Hawai‘i’s utilities are not allowed to require the installation of additional controls, additional tests, or insurance by their net metering customers.[124]

In Hawai‘i, net metering is limited to 50kW per system with total connections totaling 0.5% of a particular utility’s peak demand.[125]
Several potential improvements to the State of Hawai‘i net metering legislation are:
1. Net metering limits should be raised to 250 kW per system and total system connection to at least 1.0% of the utility’s peak demand to allow for future expansion of both the use and capacity of distributed generation technology.
2. Change the payment structure so that customers are paid for net excess generation on a per kWh basis at the end of each year, rather than forfeiting this potential revenue to the utility. Rate of payment for net excess generation should be the utility’s avoided cost.

Integrated Resource Planning-3

Recommendation 3.15: Support the incorporation of a more ambitious renewable energy target into the preferred option of the IRP-3

Preceding the most recent draft of HELCO’s IRP-3, the utility promised to avoid the construction of any new fossil fuel-based generation facilities after the 2009 Keahole CT-7 steam recovery unit. While this promise is reflected in the preferred plan chosen by HELCO in the IRP-3, the utility has failed to appreciate the potential cost savings for end users of expanding the use of renewable energy on the Island. In particular, HELCO did not examine the benefits of lower generation costs in cases where avoided cost payments are unlinked from fuel price, or where new power purchasing agreements are negotiated with fixed prices. Given that current extraordinarily high electricity prices are driven by high international oil prices, and that the price of oil is expected to remain high for the foreseeable future, expanded renewable energy generation on the Island provides the best option for lowering electricity prices. Additionally, with expected regulations on emissions of carbon dioxide and other greenhouse gases at the federal level in the next few years, and with the recent passage of the Hawai‘i Global Warming Solutions Act regulating greenhouse gas emissions, renewable generation options would become increasingly cost-competitive.

Given these considerations, and in light of the results of the generation scenario model developed in Section 3.1, it is recommended that HELCO reconsider the choice of plans presented in the IRP-3, and consider both replacing a portion of existing baseload generation with expanded geothermal and installing a pumped storage hydro system in

[124]HRS § 269-111, safety and performance standards, Accessed: April 2007, http://www.dsireusa.org/documents/Incentives/HI04R.htm
[125] These limits are subject to exceptions on a case-by-case basis at the discretion of the Hawai‘i Public Utility Commission, http://www.dsireusa.org/documents/Incentives/HI04R.htm

conjunction with a large wind farm. This would help reduce electricity prices on the Island, reduce dependence on imported energy, and establish Hawai‘i County as a model for sustainable energy development for the world to emulate.

4. SUPPLY – DECENTRALIZED

4.1 SUPPLY – DECENTRALIZED: Solar Energy

Solar energy offers significant benefits for Hawai‘i County: long term cost savings, reduced vulnerability to volatile oil prices, decreased transmission line losses, a more diversified energy system, and reductions of greenhouse gases and other air pollutants. Potential abounds for the widespread use of solar hot water heaters and photovoltaic modules across Hawai‘i’s residential and commercial markets. This emerging market creates jobs and could generate local economic activity in addition to providing a valuable service with significant benefits for the sustainability of the energy system. Solar power and other distributed generation technologies also are an essential component for providing power to those communities not connected to the electrical grid.

Hawai‘i County’s solar power installations continue to grow in number and application. Approximately 1.5 MW of new solar capacity is scheduled for installation in 2007 at various commercial sites, not including residential or government-owned installations. HELCO estimates that with continued subsidies and the falling price of solar technology, total installed solar generating capacity on the Island may exceed 80 MW by 2030.[126] An industry professional estimates that addition to capacity could continue to grow at approximately 110% per year, increasing total installed capacity to 130 MW by 2030. An addition of 130 MW of distributed solar generation would offset 2.3 trillion Btus of primary energy, or the equivalent of 17 million gallons of diesel needed for electrical generation.[127]

Residential and commercial-scale buildings alike can take advantage of solar technologies, which range in size and application. The following section includes a brief description of several forms of photovoltaic and solar water heater modules as an illustration of the numerous options that exist on the solar market.

Photovoltaic Modules

Photovoltaic (PV) systems take a variety of forms: stand-alone modules, systems with battery storage or backup generators, hybrid wind-PV systems, grid-connected systems, and large-scale systems for grid distributed energy. The range of PV systems provides customers with options to match a system to their specific energy needs and use profile.

Stand-alone PV systems with or without battery/generators have particular utility for areas of Hawai‘i County with limited or no access to centralized power, or for residences that prefer off-grid power. Small, light weight, and relatively easy to install and maintain, stand-alone systems without back up are generally best for uses that require low levels of power. Batteries and backup generators offer an additional degree of reliability for PV systems, typically providing enough power for a fully-equipped home.

[126] HELCO solar installed capacity estimates from a letter containing written comments to the draft of this report. Comments provided in a HELCO letter dated July 23, 2007.
[127] Personal communication with Steven Burns, July 2007.

Grid-connected PV systems avoid a battery pack or generator by allowing grid-supplied energy to serve as a back up power source. Grid-connected PV has applications in areas with insufficient solar exposure, for larger homes that consume more power than the PV modules produce, in cases where a battery pack/generator is undesirable or impractical, or for large-scale commercial customers that prefer to require a connection to the grid. These modules can capitalize on net metering legislation, which allows them to sell excess generation back to the grid and can help offset any use of grid-supplied energy.

Solar Water Heaters

Solar water heater systems heat water with the sun rather than by electricity. The difference between active and passive systems makes each more suitable to specific energy-use profiles. Active systems tend to have a higher upfront cost and higher efficiency than passive systems, and are best used to heat large quantities of water, making them appropriate for larger homes, pool heating, and commercial applications. Passive systems are better suited to households that use less than 80 gallons of water per day, though multiple units can be connected for increased output. Since passive systems are generally longer lasting and more reliable than active systems, the capacity to connect multiple units can make them desirable for larger homes or small-scale commercial applications as well.[128]

An alternative to solar water heaters that is beginning to gain acceptance is on-demand water heaters. These heaters, also known as instantaneous or tankless, do not run on solar power, but rather use electricity or propane fuel. However, they still offer energy efficiency benefits over conventional water heaters. Conventional storage water heaters store heated water in a tank while on-demand water heaters heat water as needed, thus avoiding the standby heat losses associated with conventional storage. Solar water heater tax credits and rebates do not apply to on-demand water heaters.

Residential Solar Energy

On average, water heating accounts for 20-40% of household energy use and represents the single largest electricity end-use in homes without central air conditioning.[129] Replacing a conventional electric water heater with a solar water heater could conserve the equivalent of as much as 600 kWh worth of primary energy per month.[130] With approximately 10% household penetration, solar water heating systems already benefit the County energy system by reducing energy demand associated with water heating.[131] Expansion of the program would only enhance these benefits.

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[128] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Accessed: July 2007, Available: http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12760

[129] Inter-island Solar Supply. Information sheet for April 2007.

[130] Conventional water heaters represent an average of 200 kWh per month in end-use electricity demand. As Hawai‘i’s fossil-fuel fired power plants are at most 30% efficient, the power plants require more than 3 times the fuel equivalent of the end use output. In this case, producing 200 kWh for residential water heating requires the combustion of more than 600 kWh of fuel equivalent (3 times as much as the output). EIA. 2004. EIA-906/920 Monthly Time Series File for Hawai‘i County.

[131] HELCO meeting, March 2007.

Rebates and tax credits
Several federal, state, and utility-administered tax credits and rebates enhance the affordability of investments in renewable energy technology. Table 4.1 provides a summary of state tax credits for solar thermal, wind, and photovoltaic systems, installed after July 1, 2006. [132] After deducting any utility rebate, the lesser of the two values is applied to the state tax liability. Therefore, one must have a tax liability to get this credit, but it can be applied over multiple years to fully realize the maximum benefit.

Table 4.1: State tax credits for renewable energy systems

	Solar Thermal Systems (e.g., Solar Water Heaters)	Wind Systems	Photovoltaic Systems
Single family	35% or $2,250	20% or $1,500	35% or $5,000
Multi-family	35% or $350/unit	20% or $200/unit	35% or $350/unit
Commercial	35% or $250,000	20% or $500,000	35% or $500,000

Governor Lingle signed Act 240 into law on June 26, 2006, raising the tax credits to the amounts shown in Table 4.1, eliminating the need to reduce the amounts by any federal tax credit, and eliminating the sunset date for these provisions.[133] Additional federal tax credits, such as a 30% tax credit for solar water heaters, further improve the financing options for distributed generation systems.

Recommendation 4.1: Request that the third-party demand side management program increases the rebates for solar water heaters to at least $1,500.

The instant rebate of $1,000 for solar hot water heaters significantly reduces the upfront cost to consumers. Created through HELCO's Demand Side Management program, the solar hot water rebate adds to the federal and state tax credits available for these systems. For example, a 120-gallon solar water heater may cost $6,000 to install,[134] but the consumer would receive a $1,000 rebate from HELCO, a state tax credit of $1,750, and a federal tax credit of $1,500. The combined effect of these rebates and tax credits reduces the true cost for the consumer to about $1,750. With monthly savings on utility bills as high as $70,[135] the upfront cost could be recovered in approximately three years.[136] After the initial investment is paid back, the consumers would experience these continued savings in their electricity bill.

By 2009, a third-party will take over the demand side management program. Currently, approximately 60% of the demand side management fund is paid to the utility for lost

[132] Department of Business, Economic Development & Tourism, "Hawai'i Renewable Energy Income Tax Credits" http://www.Hawaii.gov/dbedt/info/energy/publications/TaxCreditBrchre06b.pdf, July, 2006.
[133] Hawai'i Act 240, June 26, 2006.
[134] Estimate from Inter-Island Solar Supply
[135] Ibid.
[136] Assumes a 5% discount rate.

margins and shareholder incentives. The third-party program will be limited to 10% for overhead and expenses, freeing up considerable capital to expand the program offerings. In accordance with the County's energy goals, it is recommended that a portion of this demand side management money be used to increase the rebate on solar water heaters to at least $1,500 per residential unit, reducing the payback time by approximately one year and increasing the incentives for tax payers with smaller tax liabilities.

Recommendation 4.2: Encourage all homeowners to install solar water heaters. The County should provide every builder and homeowner with payback period and estimated savings information tailored to his or her household location and personal hot water needs.

The County has already achieved excellent results with its solar water heating incentive program. As new buildings are built and homeowners continue to invest in existing properties, expanding the number of solar water heater installations should remain high on the County's list of priorities. In general, homeowners have expressed high levels of satisfaction with the performance of their solar hot water heaters and the cost savings that the systems yield.

Under the current residential electricity rate of 32.7 cents per kWh, solar energy makes economic sense. With the incentives programs, residential photovoltaic electricity generation systems have a payback period of approximately eight years while solar water heaters have a very quick payback period of three to four years.[137] An 80-gallon solar water heater tank, which is sufficient for one to four people, should pay itself off within four years under the right climatic conditions. A 120-gallon tank, which serves four to six people in a house, can be expected to pay for itself in less than three years (see Figure 4.1). Large systems require greater capital outlay but accrue more savings over time because of greater avoided electricity costs.

One of the County's priorities should be distributing this information to homeowners so that they can make good decisions about investing in solar water heaters. This technology offers significant long-term savings for Hawai‘i families. With new proposed programs that may reduce the risk and the upfront costs for families, solar water heaters should be installed on every sunny roof. An ambitious goal for solar water heater development would be to increase installation of solar water heating units to 3.5% of Hawai‘i's existing housing stock every year, which would result in 87% market penetration by 2030.

[137] Assumes a 5% discount rate

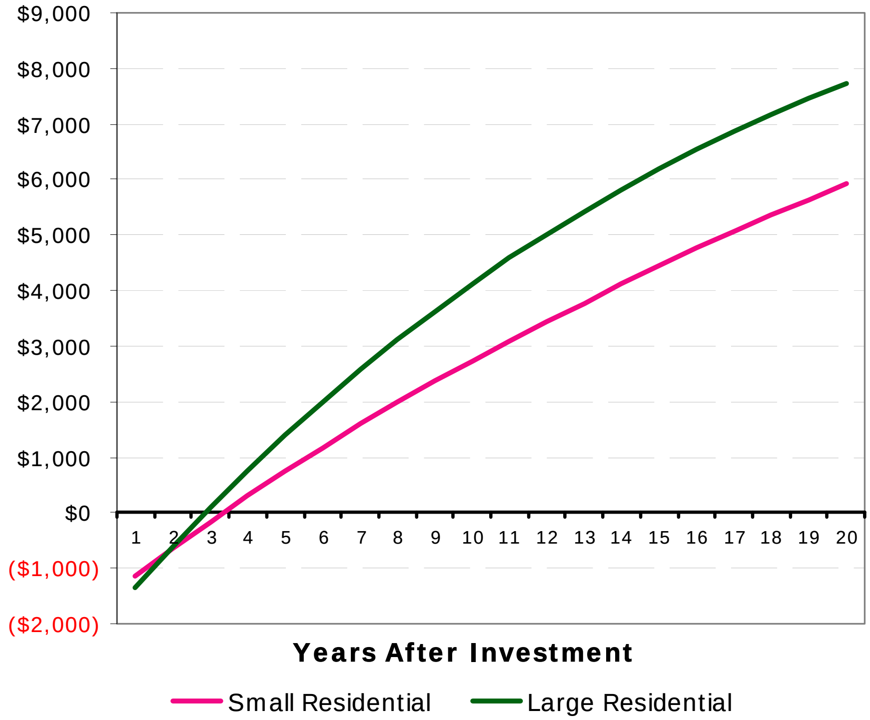

Figure 4.1: Residential solar water heaters present value of investment

Recommendation 4.3: Once launched, the County should promote the Hawai'i Solar Water Heating Pay As You Save Program that was created by State Senate Act 240 in 2006. The County should also promote solar hot water system financing available through the ongoing Residential Emergency Repair Program (RERP) administered by the Office of Housing and Community Development.

While solar and many other distributed generation systems offer an array of long-term benefits for society and individual consumers, they require large upfront capital investments. The systems pay themselves back over time because maintenance costs are very low and the sun-supplied fuel is free. While many Hawai'i residents have already installed solar modules and solar water heaters on their homes, others cannot afford to pay for their systems out of pocket. Hawai'i has some mechanisms for distributed generation financing, including zero or low interest loans from a local credit union, low interest loans from mortgage companies to add a system to the mortgage, and generic bank loans. However, none of these programs have gained widespread use.

Solar Water Heaters

In 2006, Governor Lingle signed the State Senate Bill SB2957 Act 240 directing the Public Utilities Commission to establish a "Pay As You Save" (PAYS) pilot program for solar water heaters that will be administered through the utility. This program is entitled the SolarSaver Pilot Program" and appears to be the best choice for convenient homeowner financing. Such a program makes financial transactions simpler because consumers only have to deal with one organization – the local utility – for their general utility payments and their financing needs. This is significantly easier than seeking out a separate lending organization. The PAYS model is also a good risk management tool for consumers and the utility – as long as the project produces cost savings, the utility gets paid back and the consumer soon begins to save money without making the risky initial investment. If the consumer fails to uphold his or her end of the deal, SB2957 grants the utility permission to disconnect the home's electricity service.

Like all incentive programs, this program's success is dependent on public awareness of the incentive. Through newspaper articles, advertisements, homeowner associations, and other means, the County could foster this program, encouraging new and existing homeowners to become aware of the program and its potential cost savings. This program is applicable for home retrofits only.

Since the PAYS program is just about to launch, this is an excellent opportunity for data collection and detailed program tracking. SB2957 specifically delegates this monitoring function to the PUC. The PUC, in conjunction with the County, HELCO, and solar water heater installation providers, should closely track consumer participation in the program. The County should administer short surveys one year and five years after the installation to gauge consumer satisfaction, payback periods, and expected versus actual energy savings. Since SB2957 outlines a pilot program, understanding program success will be instrumental to its continuation and to determining any program revisions that may be needed. The PUC will decide the timeframe for the pilot program and will evaluate the results when the pilot program concludes.

Additional funding may be available for low and moderate income homeowners through the Residential Emergency Repair Program (RERP) administered by the Office of Housing and Community Development.[138] Through this program, qualifying homeowners may receive loans to finance repairs or improvements to their primary residence. Solar hot water systems are eligible under the RERP program, which administers loans of $2500 to $25000 at 3% interest, with loan payments deferred over 15 years. Special needs applicants aged 62 or older may also be eligible for loan forgiveness amounting to 30% of the principal balance. Hawai‘i County should aggressively expand this program for solar hot water systems, recognizing that the lower income households are least able to pay the initial upfront cost of a solar system yet likely to benefit most from lower energy bills associated with solar water heaters.

Recommendation 4.4: Create a Hawai‘i Alternative Energy "Pay As You Save" Program for families and businesses to install photovoltaic or small wind generation on their property. Such programs should be administered through the utility.

<u>Photovoltaic Electricity Generation</u>
The County's goal of increased energy self sufficiency can be fostered by creating a PAYS program for solar electricity generation, in addition to solar water heater installations.

[138] Robert Arrigoni, Hawai‘i County Energy Coordinator, personal communication, June 8, 2007.

Many states have established funds to help defray the high capital costs of distributed power generation. There are three dominant models for such a financing program. The first is a loan fund administered directly by the government using public funds. The second is a public-private partnership model in which banks play a role in financing and the government serves as a guarantor. The third is a system run primarily by a private business; this type of system works most effectively as a PAYS program,

Three models that have been implemented in other states are described below.

1. A **PAYS** program is likely to be the simplest to administer. Homeowners and businesses pay only a small portion, or in some cases none, of the upfront cost themselves. They pay the rest back to the utility through their utility bill in regular installments that are pegged to their savings. PAYS agreements can be transferred from homeowner to homeowner because the agreement is pegged to the *meter* and not to the *person*. Hawai'i is currently in the pilot project phase. New Hampshire has a successful PAYS program for energy efficiency investments. The program is administered by the state's utilities; the utilities front the cost for the equipment and gradually are paid back through the customer's electric bill. After the system is paid back, the customer keeps all of the savings.[139,140]

2. Montana implemented an **alternative energy loan account** in 2001. The funds in the account come from penalties collected from air quality violations and fines. The fund administers low interest loans of up to $10,000 to homeowners and businesses with the requirement that the loans be repaid within five years.[141]

3. Iowa has a different loan fund model. Iowa's **Alternate Energy Revolving Loan Program** provides zero-interest loans for up to half of the project cost (up to $250,000) for solar, biomass, wind, and hydropower projects. The program is funded by Iowa utilities, but all loans must be matched with funds from another source (usually a commercial bank).[142]

All of these models make distributed generation systems available to people who would benefit greatly from accrued savings on their electricity bill but who may not have the capital to make large upfront expenditures. These programs reduce the risk for the individual purchaser by guaranteeing that their monthly savings will exceed their monthly payment on the system.

One drawback of government-administered low interest loans in the categories of "tax exempt financing" or "subsidized energy financing" is that the purchaser cannot claim the

[139] Paul A. Cillo and Harlan Lachman. The National Association of Regulatory Utility Commissioners, More Distributed Generation with Pay-As-You-Save. November 2001. http://www.paysamerica.org/EEI_Pays_2nd_paper.pdf. Last accessed April 2007.
[140] New Hampshire Office of Energy and Planning. http://www.nh.gov/oep/programs/energy/pays.htm. Last accessed April 2007.
[141] 2001 Montana Legislature Bill No. 506. http://data.opi.state.mt.us/bills/2001/billhtml/SB0506.htm
[142] The Iowa Department of Natural Resources, Solar Energy. http://www.iowadnr.com/energy/renewable/solar.html. Last accessed April 2007.

federal tax credit on the portion of the purchase supported by such financing. The most appropriate program for Hawai‘i would be a PAYS program administered by HELCO or another non-government entity, since purchasers can still claim tax credits on loans from private parties and non-profits. The program would work very similarly to the solar water heater pilot program described in Act 240 SB2957. On Maui, MECO offers a program that serves as a good model for Hawai‘i. For solar water heaters, MECO provides interest free loans that customers must pay back within 5 years. Customers must supply a down payment of one-third the system cost, but most customers recover this amount in the first year through the state tax credit.[143]

Commercial Sector Solar Energy

Hawai‘i’s high electricity rates, generous rebates and tax incentives, accelerated depreciation rules, and year-round solar exposure create an ideal environment for the installation of solar systems on commercial buildings. With an estimated payback time of less than two years, solar water heaters and solar electricity generation are sensible business investments for a wide range of establishments. Although several private companies already use solar power, many other buildings could be outfitted with the technology in the coming years. Office buildings, auto dealerships, big box stores, commercial centers, and resorts/hotels/condominiums represent some of the commercial structures where solar technology could be applied successfully.

In addition to the cost savings that would be realized by avoided electricity costs, solar powered businesses would be able to promote a green image that is likely to give them a public relations advantage over competitors. The Mauna Lani, the Island’s only resort that is heavily invested in on-site solar generation, hosted Toyota’s company conference about hybrids and the future of the carmaker. Toyota chose the resort expressly because of its investment in renewable energy.[144,145]

Recommendation 4.5: Require all new big box stores and large hotels, condos, and resorts to submit a feasibility plan for installing solar water heaters and photovoltaic electricity generation systems on their roofs.

Big box stores and other businesses should be encouraged to have a third party (such as SunEdison or Soltage) install and own the systems. In such an arrangement, the third party company typically owns the modules, sells the tax benefits, and sells the electricity to the big box store for less than the standard utility rate. This arrangement reduces the risk for the big box store and still offers cost savings and public relations benefits.

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[143] Maui Electric Company, Ltd. Interest Free Solar Loan Example. http://www.heco.com/portal/site/meco/menuitem.ed4aed221358a44973b5c410c510b1ca/?vgnextoid=e635602c67c5e010VgnVCM1000005c011bacRCRD&vgnextchannel=acda6b4edaa8a010VgnVCM1000005c011bacRCRD&vgnextfmt=default. Last accessed April 2007.
[144] John Crouch, Powerlight, personal communication, March 2007.
[145] Lexis Rx 400h. http://www.greencar.com/index.cfm?content=features37. Last accessed April 2007.

Under Hawai‘i’s current (as of April 2007) commercial electricity rate of approximately 30 cents per kWh and current tax incentives, large commercial installations of photovoltaic modules can expect a payback time of under two years, as shown in Figure 4.2.

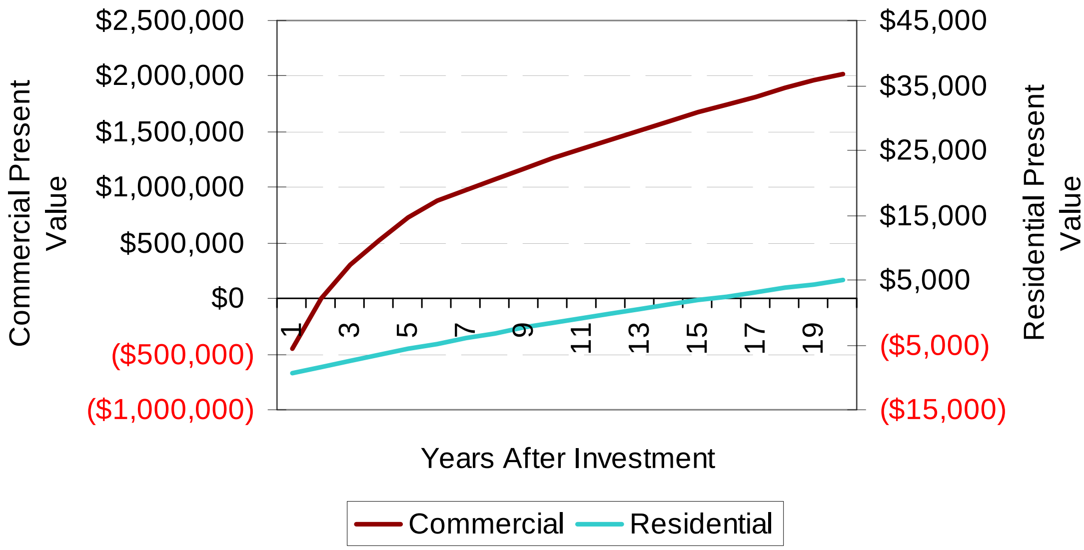

Figure 4.2: Commercial and residential solar photovoltaic systems present value of investment

Public Sector Solar Energy

Recommendation 4.6: Require County planners to issue a Request for Proposals from private companies for photovoltaic and solar water heating systems on all new buildings that receive public funding. Planners should implement the winning proposal unless the facility is determined unsuitable.

Installing distributed generation on public buildings provides many benefits ranging from cost savings to increased energy independence to reduced pollution. In addition, mounting solar technology on County buildings is a clear way to demonstrate the administration’s support for sustainable energy, support the market for alternative energy technology, and demonstrate the success of the technology in Hawai‘i’s unique climate and conditions. The County should require that all building plans include a Request for Proposals for on-site renewable generation and that the proposal is implemented unless the site is deemed inappropriate for the technology. For example, California law mandates that all state buildings and parking structures have solar energy systems unless there is no room or it is not deemed cost effective.[146] When calculating cost-effectiveness, the law requires departments to also account for benefits of decreased air

[146] An act to add Section 14684 to the Government Code, relating to solar energy. www.leginfo.ca.gov/pub/01-02/bill/sen/sb_0051-0100/sbx2_82_bill_20011007_chaptered.html. Last accessed April 2007.

pollution.[147] The County should require the use of lifecycle cost in any economic determination.

Visible distributed generation units and solar water heaters on schools can serve as an important educational tool for Hawai‘i's children as well as provide cost savings and the other benefits detailed above. Hawai‘i, like Missouri and a number of other states, is already moving ahead with installing renewable energy systems on schools and government buildings. The Department of Education has $5 million to buy photovoltaic systems for schools.

However, rather than purchasing and installing the systems itself, the County would save money by issuing a request for proposals for a third party investor to buy, install, and manage the system. The third party would supply the capital for the photovoltaic system, install the system, and own it until a previously agreed upon date. On this date, the school or government would acquire full or partial ownership of the system.

There are multiple advantages to third party ownership. First, private companies can collect federal and state tax credits. Second, private companies can take advantage of accelerated depreciation rules that allow them to claim all of their tax benefits in the first six years of operation. Third, businesses can deduct operation and maintenance expenses from their overall taxable burden. All of these tools are critical to a renewable generation project's economic performance in the current energy market, but they are not available to non-taxable entities like schools and County facilities. In contrast, the only revenue source for a publicly funded project is avoided electricity costs. Figure 4.3 shows how the tax credits, accelerated depreciation, and operating expense add-backs improve the financial performance of a large solar installation. If the system is installed and operated by a private organization, the payback period is approximately two years, whereas if a government agency sets up the system it may not pay itself off for approximately eighteen years.

The management of Kona International Airport is also exploring photovoltaic possibilities. The airport is currently in discussions about whether to install its own photovoltaic system or solicit third party requests for proposals. Airports are excellent sites for large solar panel arrays since they generally own large areas of land that is not suitable for many other uses, given the high levels of noise and air pollution.

[147] Ibid.

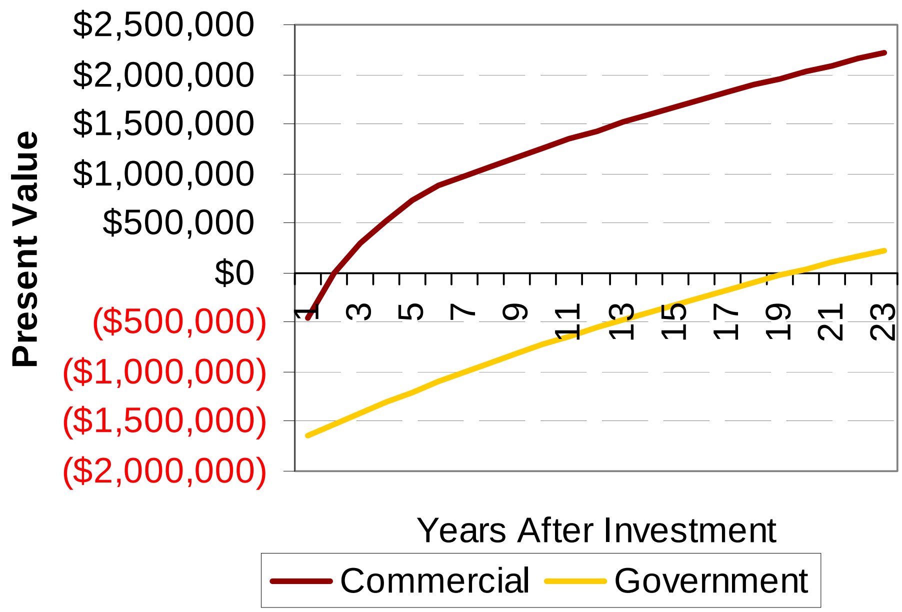

Figure 4.3: Commercial and government photovoltaic systems present value of investment

The soon-to-be-built West Hawai'i Civic Center will take advantage of the benefits of private ownership of distributed generation. The Civic Center will issue a request for proposals for a photovoltaic system on the facility. A system of approximately 100 kW will be installed, owned, and maintained by a third party. The Civic Center will only have to pay for the electricity it uses from the array, which must be provided at a cost lower than projected retail rate of electricity over the contract's 20 year term. The County should institutionalize this practice by requiring that all new and existing County buildings have third-party distributed generation so that requests for proposals for solar energy systems are not the exception, but the rule.

Information Dissemination

Recommendation 4.7: Design an online calculator for homeowners to determine the costs and savings associated with installing a photovoltaic, solar water heating, or wind system. The new demand side management program should administer the calculator.

Providing accurate energy information to the public is an important goal for Hawai'i County in its quest for a sustainable energy future. One recommendation is for the future administrator of the new demand side management program to create a web based energy calculator tailored to Hawai'i County (and other counties) The administrator could update the web site as utility rates and incentives changed. Also, having a centralized online clearinghouse for consumer-level energy conservation initiatives would enable project comparisons and payback calculations.

Because Hawai‘i has high solar insolation and high electricity costs compared to the rest of the United States, a County of Hawai‘i -specific energy calculator would help homeowners and business owners determine potential energy savings with a specific energy conservation measure or energy efficient purchase. The calculator would also include federal tax credits and Hawai‘i State tax credits, among other elements, as shown in Figure 4.4.

<table>
<tr><th colspan="4">Home Energy Calculator</th></tr>
<tr><td>Input</td><td>Location on Island (Hilo side v. Kona side)</td><td>Average electricity cost (per kWh)</td><td>Average monthly electricity usage (kWh)</td></tr>
<tr><td>Deliver</td><td colspan="3">Recommended size of PV, solar water heating, or wind system</td></tr>
</table>

<table>
<tr><td>Input</td><td>Savings from 30% federal tax credit</td><td>Savings from state tax credit</td><td>Operation & Maintenance Cost</td></tr>
<tr><td rowspan="2">Deliver</td><td colspan="3">Upfront cost of PV/SWH/Wind system</td></tr>
<tr><td colspan="3">Savings for 20 year operation of system at current electricity prices and usage</td></tr>
</table>

Figure 4.4: Elements of the homeowner energy calculator

5. SUPPLY – FUELS

5.1 SUPPLY – FUELS: Biofuels

Background and Options

The feedstocks eventually refined into biofuels can take many forms: ethanol may come from existing sugar crops or emerging processes for cellulosic materials while biodiesel can be produced from waste cooking oils, oil crops, and even algae. End-uses for biofuels include the transportation sector and, in some cases, power plants as substitutes for petroleum-based fuel. In addition to liquid fuels, solid biofuels include waste-to-energy and wood combustion facilities that combust biomass directly to produce electricity from steam turbines.

Representing an intersection between energy and agriculture, the cultivation of feedstocks and refining of biofuels introduce new complexities for both of these well-established industries. Several broad concerns are inherent in the development of a biofuel market: energy security, food security, economic viability, impact on natural resources, and end-use efficiency tradeoffs.

A crucial concern for energy security considerations is the origin of the biofuel feedstock, since importing these fuel materials does little to relieve energy dependency. Although imported feedstocks, such as palm oil for biodiesel, do spread the import risk across different types of energy markets, such risk diversification does not solve the core problem of dependency on foreign fuels. In contrast, locally grown energy crops coupled with local biofuels production processes could improve energy security and allow the County to ensure that the process adheres to environmentally sound practices.

Locally grown energy crops, however, introduce other variables, including tradeoffs between food production and energy production, the use of genetically modified organisms, introduction of potentially invasive species, land and water use, lag time to production, uncertainty of crop yield, labor costs, and the fate of byproducts and waste.

Should a local production industry develop, the most appropriate end-use for biofuels becomes an additional concern. Given the inefficiencies of HELCO’s power plants and the number of existing alternatives for electricity generation, biofuels may be more appropriate for use in the transportation sector where fewer alternatives exist.

As the era of biofuels in Hawai‘i is rapidly approaching, these considerations have an unusual urgency. The Hawai‘i Agricultural Research Center and the University of Hawai‘i-Hilo have initiated research projects into several potential feedstocks. The utility consortium owned by Hawaiian Electric Company (HECO) also recently announced plans to run its diesel-powered plants on biodiesel. In August 2006, the Hawai‘i Biofuels Summit called together representatives from the government, fuel industry, landowners, and investors with a goal of understanding the existing barriers to development and the potential actions that can be taken to alleviate these problems.

While several suggested actions emerged from the summit, the most prominent included:[148]

- Streamlining the permitting and re-zoning processes
- Providing incentives for in-state production

The following recommendations consider these and other ideas to explore the development of a sustainable, vibrant, locally-based biofuel industry.

Recommendation 5.1: Create energy zones to facilitate energy crop growth and fuel processing and streamline the permitting process.

This streamlined permitting and re-zoning is well advised and an action that the County should take to spur local growth.

Recommendation 5.2: Support the use and collection of all waste oil for biodiesel through high fees for waste oil landfill disposal and high penalties for improper disposal.

No major biofuels operations currently exist on the Island. Pacific Biodiesel has been producing biodiesel in the State for over 10 years using waste oil (e.g., used cooking oil) as its feedstock. This production scheme has the added benefit of waste elimination – a valuable asset in a state with limited landfill capacity. Currently, some of the used cooking oil from Hawaiʻi Island is collected and shipped to Oahu for processing. There is a plan being considered to build a processing plant on Hawaiʻi Island.[149] However, the potential for waste oil biofuel is limited: it is estimated that a maximum of 250,000 gallons of biodiesel per year can be produced using Hawaiʻi Island waste oil. As current Island-wide diesel usage in transportation, industry, and power generation is estimated at about 34 million gallons per year, the potential for waste oil biodiesel has tangible limits despite the very positive effects of waste oil recovery and petroleum displacement.

Economic Incentives

Ethanol and biodiesel availability is often contingent on adequate subsidies and tax incentives. State of Hawaiʻi incentives include:[150]

- A producer tax credit that gives 30 cents per gallon for ethanol, with a statewide cap of $12 million per year (i.e., limited to the first 40 million gallons of capacity). Plants

[148] Rocky Mountain Institute, "Hawaiʻi Biofuels Summit Technical Synopsis" prepared for the Department of Business, Economic Development & Tourism, September 28, 2006.
[149] Personal discussion, K. King, Pacific Biodiesel, April, 2007.
[150] D. Koplow, "Biofuels – at what cost? Government support for ethanol and biodiesel in the United States" prepared for The Global Subsidies Initiative of the International Institute for Sustainable Development, Geneva, Switzerland, 2006.

must enter production before January 1, 2012 and have at least 75% capacity utilization.[151]

- An ethanol blend mandate requires that gasoline in the State contain 10% ethanol,[152] applicable to 85% of the gasoline sold.
- An Alternative Fuel Standard requires that the State "facilitate the development of alternative fuels and support the attainment of a statewide alternative fuel standard of ten percent of highway fuel demand to be provided by alternative fuels by 2010, fifteen per cent by 2015, and twenty percent by 2020." Ethanol from cellulosic materials is considered the equivalent of 2.5 gallons of noncellulosic ethanol.[153]
- A preference for biofuels was codified as follows: "Notwithstanding any other law to the contrary, contracts for the purchase of diesel fuel or boiler fuel shall be awarded to the lowest responsible and responsive bidders, with preference given to bids for biofuels or blends of biofuel and petroleum fuel."[154] A five-cent per gallon premium is allotted for the purchase of biodiesel and the biodiesel portion of fuel blends for diesel engines and boilers.[155]
- A State procurement policy that requires an escalating percentage of purchased and leased State vehicles to be energy-efficient, beginning at 20% of new vehicles in 2006 and increasing to 75%. "Energy-efficient vehicles" include those capable of using alternative fuels, including ethanol and biodiesel. An agency may offset the purchase requirement by one vehicle for every 450 gallons of biodiesel (B100) used.[156]
- There is also an exemption for E10 and E85 (ethanol blends), and B2 and above (biodiesel blends) from the 4% sales tax. This exemption was reinstated in June 2007. The exemption applies to biomass-derived fuels or fuels with a petroleum and biomass-derived mixture such as ethanol-blended fuels to power motorized vehicles. The exemption originally went into effect to encourage new rules requiring at least 85 percent of motor fuel sold in the State to contain at least 10 percent ethanol.[157]

There are also numerous available federal subsidies. A partial list includes the following:

- The Volumetric Tax Credit for Biodiesel allows a tax credit of $1.00 per gallon of biodiesel produced from virgin oils or fats, and $0.50 per gallon from recovered oils or fats;
- A Federal Small Producer Tax Credit encourages small-scale production of biofuels (i.e. less than 60 million gallons per year) by providing $0.10 per gallon tax credit on the first 15 million gallons produced;
- Blenders' Credits provides blenders of biodiesel with a 1-cent reduction in the diesel excise tax for every percentage of biodiesel, made from virgin vegetable oil, which is blended with diesel. incentives for fuel blenders to use biofuels;

[151] Hawai‘i Revised Statutes §235-110.3
[152] Hawai‘i Revised Statutes §486J-10
[153] Hawai‘i Revised Statutes §196-42
[154] Hawai‘i Revised Statutes §103D-1012
[155] Hawai‘i Revised Statutes §103D-1012
[156] Hawai‘i Revised Statutes §103D-412
[157] HB1757 HD1 SD3 CD2 (Act 209) signed in to law in June 2007, information available at http://www.hawaii.gov/gov/news/releases/Folder.2007-01-31.1527/News_Item.2007-06-26.5749

- The Energy Policy Act of 1992 (EPAct) focuses on replacing petroleum-based fuels with alternative non-petroleum fuels. 1998 amendments a credit for including biodiesel in a 20% blend with petroleum diesel (B20) as an option for covered fleets to meet a portion of their annual Alternative Fuel Vehicle (AFV) acquisition requirements. For each 450 gallons of biodiesel purchased and consumed, a full vehicle credit is awarded.
- Title IX of the 2002 Farm Bill make payments to biofuel producers to offset part of their cost of buying commodities that are used to expand eligible bioenergy (commercial fuel grade ethanol and biodiesel) production.
- The recent federal act, New Direction for Energy Independence, National Security, and Consumer Protection Act (H.R. 3221) has appropriated significant funds for research into biofuel.

Life Cycle Benefits

Recommendation 5.3: Procure funds to sponsor a research project to quantify the life cycle energy benefits and the added energy security of biofuel under a variety of production schemes.

The Alternative Fuel Standard could be an effective method to increase locally produced energy and decrease the environmental impact of energy use. All biofuels are not created equal, however, and among the numerous production schemes that can be envisioned, a wide array of net energy yields and environmental impacts are realized.

If the goals of using biofuels include mitigating environmental harm and increasing energy security, several key questions must be considered. The costs and benefits of biofuels cannot be measured by displaced oil alone; life cycle impacts and net energy yields throughout the entire supply chain must be assessed to provide a robust understanding of environmental impact. Considered holistically, the potential benefits vary widely between different crops and different production schemes. A recent paper from the Proceedings of the National Academy of Sciences compared these effects for corn-based ethanol production and soybean-based biodiesel production. It was found that corn-based ethanol yielded 25% more energy than invested in its production, whereas soybean-based biodiesel yielded 93% more energy. The study also shows great disparities between these two options regarding agricultural releases of nitrogen, phosphorus, and pesticides, with releases being much higher for the corn-based ethanol.[158] The creation of a similar life cycle analysis study with Hawai‘i- specific conditions (costs, inputs, agricultural productivity) and crops tailored to local production would be instrumental in presenting an accurate understanding of the positive and negative aspects of biofuel production, allowing for informed selection of preferred feedstocks. Such a study should include comparisons between scenarios with domestic agricultural production and importation of foreign feedstock, a key factor in determining the added benefit of energy security with biofuels. This study could also examine the

[158] Hill, J., E. Nelson, D. Tillman, S. Polasky, and D. Tiffany, “Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels” Proceedings of the National Academy of Sciences, July 25, 2006, **103** (30): 11206-11210.

potential benefit of supply chain criteria proposals, including the Roundtable on Sustainable Palm Oil.[159]

Recommendation 5.4: Modify the Alternative Fuel Standard to weight biofuels by their energy yield and energy security benefit.

Recommendation 5.5: Modify the Renewable Portfolio Standard to weight biofuels by their energy yield and energy security benefit.

The results of such a study would likely demonstrate that particular crop choices and production schemes are significantly more advantageous than others with regard to mitigating environmental harm and increasing energy security. In order to ensure that the use of biofuels best meets the energy security and environmental performance goals of the County, it is recommended that the State modify the Alternative Fuel Standard and the Renewable Portfolio Standard to provide a rational weighting system that captures the wide range of benefits between the variety of options in the production of biofuel. In essence, the State should recognize that not all biofuels have the same energy yield or environmental impacts. There is precedent for such a weighting scheme in the Hawai‘i Revised Statutes with regard to cellulosic ethanol. Biofuel rating schemes are currently in discussion; a group of researchers at the University of California, Berkeley are proposing a biofuels index to capture the positive or negative environmental impacts throughout the life cycle of particular fuels.[160] In an effort for fairness, since other renewable technologies are not weighted, the "best" biofuel production scheme could be given full credit in the Alternative Fuel Standard and Renewable Portfolio Standard, with other rating relative to its performance.

Research and Development

Recommendation 5.6: Procure funding for experimental production plot studies to assess the feasibility of cellulosic and biodiesel crop growth and harvesting on Hawai‘i Island

Before large scale investment can proceed in the production of energy crops, investors are waiting for the proof of concept. This can be facilitated by funding pilot studies that cover the cost of buying seeds, growing and maintaining test plants, and harvesting the crops. Several landowners have agreed to provide ten to twenty acre plots to assess the effect of diverse altitudes, soil conditions, and climatic zones.[161]

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[159] The Roundtable on Sustainable Palm Oil is an association founded by the World Wildlife Fund created to promote sustainable palm oil use throughout its entire supply chain. With much palm oil growth occurring in Southeast Asia and the potential for rain forest destruction, unsustainable growth is large and must be addressed.
[160] Sanders, R., "Biofuels Index Would Aid Consumers, Market" Renewable Energy Access, April 25, 2007.
[161] William Steiner, Dean of the College of Agriculture, Forestry & Natural Resource Management at the University of Hawai‘i at Hilo, personal communication, 2007.

In particular, development of an energy crop industry should contribute to, rather than detract from, sustainable agriculture. Research projects that examine potential crop yields, growth patterns, and other factors should focus on using species that are already present on the Island such as kukui nut (Aleurites moluccana), macadamia nuts, avocado, and coconut. These four species have among the highest oil content of any species, exceeded only by palm oil.

Additional research should investigate the potential for using agroforestry practices for commercial production of biofuel feedstocks. Monocrop planting often necessitates intensive inputs of resources such as water, nutrients, and pesticide/herbicide treatments, a familiar process in Hawai'i's sugar cane and pineapple industries. A more environmentally sound methodology is that of agroforestry, a combination of agriculture and forestry that integrates trees and crops to create more diverse, productive, and healthy ecosystems that remain profitable and commercially viable. For example, a vision for an agroforestry system on Hawai'i Island: kukui nut trees as an oil crop interspersed with timber species and, potentially, a smaller crop such as shade-grown coffee. Access to the robust body of research, development, and supporting literature on tropical agroforestry should be readily available to the Hawai'i research community. Biofuel crop development that adheres to agroforestry standards could meet feedstock production requirements, reduce costs and environmental impacts by limiting the inputs necessary, improve productivity, and enhance the health of Hawai'i's ecosystems.

Recommendation 5.7: Procure funding for the a pilot plant mill that would produce animal feed and oil from test crops, to be located at the University of Hawai'i at Hilo

A recommendation of this study is to assist University of Hawai'i at Hilo to secure funding for the creation of a pilot plant mill, which would produce animal feed and oil from the test crops. The capacity and desire for this project has been demonstrated by the Dean of the College of Agriculture, Forestry & Natural Resource Management at the University of Hawai'i at Hilo, Prof. William Steiner. There are prepared plans for such a mill that could process 2,500 pounds of fruit or nuts per hour, yielding between 800 and 1,200 pounds of oil.[162] Senate Bill 1669 is the proposed legislation to fund this project.

With the energy crop study and the pilot mill, information would then be available to more accurately assess the life cycle impacts of the biofuel production and the economic viability of production schemes.

There are many factors to consider when assessing the viability of biofuel production on Hawai'i Island. Water use, land use, genetically modified organisms, intentional and unintentional introduction of non-native species, lag time to production, and uncertainty of crop yields are just a handful of the variables that can affect production and economic viability. Although pilot projects are necessary to truly determine the potential for each crop, some reasonable estimates can be made. In a comprehensive report by Hawai'i

[162] William Steiner, Dean of the College of Agriculture, Forestry & Natural Resource Management at the University of Hawai'i at Hilo, personal communication, 2007.

Agricultural Research Center, a variety of crops and climatic areas were assessed for the potential to produce oil crops for biodiesel. It was found that potential yields could provide over 100 million gallons of oil for biodiesel production in Hawai‘i County.[163] Since oil feedstocks to biodiesel yields are often over 95% (i.e., nearly all of the oil is converted to biodiesel), this level could cover all diesel demand for highway, non-highway, and utility use three times over. Several parties throughout the State have already looked into producing biodiesel, with the most likely plans relying on a business model that imports the oil to Hawai‘i.

Proposed Procurement of Biodiesel from Palm Oil and Hawaiian Feedstocks by HECO

In June 2007, HECO announced plans to transition its existing diesel-fired power plants from petroleum diesel to biodiesel. As a subsidiary of HECO, HELCO will be party to this transition along with HECO on Oahu and MECO on Maui. If fully implemented, this transition would mark a fundamental shift in fuel supply for three of Hawai‘i’s utilities.

At two Public Meetings held in Hilo and Kona in June 2007, HECO personnel presented a plan whereby the utility and its subsidiaries would seek to transition all of its operations to biodiesel.[164] HECO currently uses petroleum diesel and oil derivates for approximately 70% of its electricity generating operations and is the largest utility purchaser of diesel in the United States.[165] As a first step in this process, HECO has partnered with BlueEarth Biofuels LLC in order to fuel HECO’s new Campbell Industrial Park Generating Station on Oahu. As planned, this facility would be a new 110-megawatt peaking plant run entirely on biodiesel. While HECO initially plans to import this biodiesel from sustainably grown palm oil crops, the company envisions a transition to locally grown feedstocks in following years. This plan provides significant market encouragement for locally grown biocrops and biodiesel production.

This decision comes within the context of an ongoing discussion at the state level to look at the feasibility of employing biodiesel on a large scale on Hawai‘i. In 2006, the State Legislature adopted House Concurrent Resolution 195 (HCR 195) encouraging "…Hawai‘i's landowners, investors, County governments, and regulated electric utilities to pursue development and conversion of fuel crops for electricity generation, and requesting the Hawai‘i Energy Policy Forum to make recommendations."[166] Other events followed on the heels of resolution HCR 195: First, Governor Lingle convened the Biofuels Summit held August 19-25, 2006 and coordinated by the Hawai‘i Department of Business, Economic Development, and Transportation (DBEDT) and the Rocky Mountain Institute (RMI). During her remarks at the summit, Governor Lingle

[163] Poteet, M., "Biodiesel Crop Implementation in Hawai‘i" Hawai‘i Agricultural Research Center, 2006.
[164] As presented by HECO at the Public Meeting to present the associated Environmental Policy, June 28, 2007 at UH-Hilo, 200 W. Kawili St, Hilo. This was one of a series of meetings convened at various places statewide.
[165] HECO, Ibid.
[166] Summary of Final Report in Response to HCR 195, summarized in http://www.hawaiienergypolicy.hawaii.edu/pages/hcr195.html

affirmed the State's commitment to helping develop a biofuels industry in Hawaiʻi with the intent of reducing dependence on imported oil and improving energy security.[167] Secondly, the Hawaiʻi Agriculture Bioenergy Workshop was convened, where a group of stakeholders from state and local government, the private sector, and research institutions, met to discuss in broad terms the viability and problems associated with developing a biofuels industry in the State of Hawaiʻi.[168]

As such, the actions of HECO are in line with the goals of the executive and legislative branches of Hawaiʻi's State government. HECO's stated intent is "to transform Hawaiian utilities into a model of diverse, sustainable supply and efficient use."[169] As discussed in their *Environmental Policy for the Procurement of Biodiesel from Palm Oil and Hawaiian Feedstocks by Hawaiian Electric Company*[170] the move to sustainably grown, and ultimately locally produced, biodiesel is an attempt to move Hawaiʻi away from dependence on imported fuel supplies. HECO's overall strategy to contribute to oil import reductions, of which shifting to biodiesel is a (significant) part, was presented as follows to the public:

1. Greening existing assets;
2. Expanding renewable supplies;
3. Continuing with implementation of Demand Side Management (DSM) programs.[171]

Details were not provided for the 'greening' of existing assets or expanding the DSMs.

County Response

HECO's plan may represent a significant contribution to reduce the state of Hawaiʻi's reliance on imported oil. As the largest single utility-sector consumer of petroleum diesel in the country, HECO currently burns almost 100 million gallons of petroleum diesel per year to generate electricity.[172] Successful development of a local biofuels industry that can help supply utilities could be an economic boon for local agriculture and the relevant support industries, such as extraction, refining, and further research and development. If the growth of feedstocks can be achieved in a genuinely sustainable manner, Hawaiʻi biofuels could serve as an important role model to other regions of the world seeking to employ similar technology and strategy. The economic and political conditions in Hawaiʻi certainly lend themselves to such a favorable outcome.

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[167] Press release for Governor Lingle's website, available at http://www.hawaii.gov/gov/news/enewsletter/2006/August19-25,2006

[168] Summary of Final Report in Response to HCR 195, summarized in http://www.hawaiienergypolicy.hawaii.edu/pages/hcr195.html

[169] *Environmental Policy for the Procurement of Biodiesel from Palm Oil and Hawaiian Feedstocks by Hawaiian Electric Company*. Prepared by HECO and NRDC, June 2007.

[170] Ibid.

[171] As presented by HECO at the Public Meeting to present the associated Environmental Policy, June 28, 2007 at UH-Hilo, 200 W. Kawili St, Hilo.

[172] *Environmental Policy for the Procurement of Biodiesel from Palm Oil and Hawaiian Feedstocks by Hawaiian Electric Company*. Prepared by HECO and NRDC, June 2007.

Unfortunately, however, the large scale production of biodiesel has thus far been associated with enormous environmental degradation in many regions that grow biofuel feedstock. By the same token, there are many questions to be addressed and issues to be resolved before such a large undertaking can begin. Among the numerous existing constraints that need to be fully addressed before this plan is implemented:[173]

1. Physical Constraints
    a. Limited port storage
    b. No current extraction or refining capacity on Hawaiʻi Island
    c. Impact to existing local infrastructure (roads, etc.)
2. Environmental Constraints
    a. Land use issues and competition with food crops
    b. Water use constraints
    c. Introduction of invasive and exotic species
    d. Management of GMOs
    e. Use of pesticides and herbicides
3. Financial Constraints
    a. Long term purchase contracts to mitigate some of the risk of the capital investment
4. End-use efficiency
    a. Power plant inefficiencies
    b. Transportation sector may be preferred biofuels target

In addition, it is unclear whether HECO's public commitment to the purchase of RSPO-certified, sustainably grown biofuels and Hawaiian feedstocks reflects a supply chain requirement or simply a purchasing preference. Furthermore, the RSPO-certification program is a voluntary supply chain arrangement that has not been yet been proven in practice. The utility consortium "does not know whether it is possible to contract for a reliable and cost-effective source of oil that meets the foregoing [sustainability] criteria."[174]

The influence of the Hawaiʻi County government on the development of the biofuels industry, even a local market confined to the Island, has its limitations. Large private investment and electric utilities, responding to market indicators, would play a significant role in determining the existence and/or extent of a Hawaiʻi biofuels industry. Additionally, many water and land use issues would be handled at a state level through the Department of Land and Natural Resources. Key stakeholders and decision-makers in a Hawaiʻi biofuels industry would include:

- HECO utilities;
- Private sector biofuels companies and their investors;

[173] Summarized from a presentation given by Kyle Datta at the Energy Stakeholders Meeting, May 22, 2007.
[174] *Environmental Policy for the Procurement of Biodiesel from Palm Oil and Hawaiian Feedstocks by Hawaiian Electric Company*. Prepared by HECO and NRDC, June 2007.

- Hawai‘i Department of Land and Natural Resources; responsible for managing coastal lands, harbors, water resources, state-owned lands, and other areas;
- Hawai‘i Department of Agriculture; responsible for overseeing new species, plant pest control, and other matters affecting agriculture;
- Local labor unions.

The County of Hawai‘i Department of Planning would have direct involvement due to its jurisdiction over zoning and some coastal management issues. Other County agencies such as the Office of the Mayor, County Council, Department of Water Supply, and Environmental Management must remain informed of potential issues and impacts such a large new agricultural base could have on the Island of Hawai‘i. In particular, while the biofuels industry promises to revive Hawai‘i's struggling agricultural sector, environmental and resource related concerns are equally crucial components of the long-term sustainability and desirability of this industry. The County thus has a dual responsibility to allow the emerging market to function properly yet carefully monitor its development and intervene where necessary. For example, there are mechanisms by which the County can request that specific and important studies be performed by state agencies. The County also can serve as a source of information to the local population as to developments and decisions regarding biofuels.

In terms of recommendations as to how the County should respond to HECO's plan, this report reiterates the need (stated above in Recommendations 5.1 and 5.6) for the County to encourage and facilitate research and development into biofuels.

Recommendation 5.6: Procure funding for experimental production plot studies to assess the feasibility of cellulosic and biodiesel crop growth and harvesting on Hawai‘i Island.

Recommendation 5.1: Create energy zones to facilitate energy crop growth and fuel processing and streamline the permitting process.

The County should also encourage and advocate for proper research into the costs and benefits of this new industry. There is an urgent need for a comprehensive life-cycle analysis as presented above under Recommendation 5.3:

Recommendation 5.3 (Restated): Procure funds to sponsor a research project to quantify the life cycle energy benefits and the added energy security of biofuel under a variety of production schemes.

The County also should modify for its own benefit the findings of the Hawai‘i Energy Policy Forum which was commissioned to develop recommendations in response to HCR 195.[175] This document was intended to clarify the state response to encourage and sustainably manage this potential new industry. Such a document, modified to address the County's concerns, could serve as a guideline to aid the County to develop an informed position biofuels on County lands. Relevant recommendations are as follows:

[175] Full set of recommendations are available at http://www.hawaiienergypolicy.hawaii.edu/pages/hcr195.html

- Develop a “Bioenergy Master Plan” that examines capital investment requirements, land-use and water supply issues, and supporting infrastructure requirements;
- Seek to coordinate local infrastructure improvements with future needs;
- Make available County lands for pilot projects;
- Provide assistance to local growers.

Existing Solid Biomass

Recommendation 5.8: The County should examine the lifecycle benefits and long-term land use tradeoffs associated with plantation agriculture for solid fuels. At this time, it is not recommended that County lands be leased or otherwise used for this purpose.

On private land, the establishment of a limited number of small-scale wood combustion power plants sourced from existing plantation forests whose primary purpose is not fuel production may represent an acceptable component of the energy supply for Hawai‘i County. Like biofuel crops for liquid fuel, significant land use tradeoffs and resource concerns come along with the cultivation of wood crops for solid biofuels.

5.2 SUPPLY – FUELS: Waste to Energy

Recommendation 5.9: The County should not pursue the establishment of a waste-to-energy facility due to low levels of waste, the possibility of diverting recyclable material to such a plant, the fluctuating nature of the Hawai‘i Island waste stream, the inability of waste-to-energy plants to respond to advancements in technology, and the high capital costs associated with construction and operation[176]

There is considerable interest in Hawai‘i County, both among elected officials and the general population, in exploring the possibility a waste to energy (WTE) plant. Both advocates and opponents have made their positions clear as to the usefulness of WTE in addressing Hawai‘i County’s significant and growing solid waste management problem. There are currently only two permitted disposal facilities (landfills) on the island; South Hilo Landfill and Pu'uanahulu Landfill on the Kona side. At current waste generation and disposal rates, the South Hilo Landfill will reach capacity and be forced to close within the next two to four years. A WTE plant would take waste organic, plastic, cardboard, construction, and other debris and incinerate it in order to generate energy. This solution ostensibly would have the dual effect of ridding the county of excess solid waste and generating needed electrical power. The county issued in 2005 a request for proposals (RFP) for a waste reduction technology and WTE is a favored technology.

A study, also sponsored by the Kohala Center, entitled *Waste Management on the Big Island: Mapping a vision for an economically and ecologically sustainable Hawai‘i* (Waste Management Report) was published in August 2006 and discussed the solid waste management issues currently faced by the County of Hawai‘i.[177] This report identified numerous problems with a WTE energy scheme and concluded that a WTE plant is not the appropriate remedy for Hawai‘i County’s solid waste management issues. Instead, the Waste Management Report recommended implementation of an aggressive program of improved waste diversion, and recycling, reuse, and composting in order to alleviate the acute waste management problems.

The report contained herein regarding energy sustainability endorses the findings of the Waste Management Report with respect to its recommendations on WTE on Hawai’i County. While a comprehensive review of waste management practices is beyond the scope of this report, a summary of key findings and conclusions of the Waste Management Report as they relate to WTE is presented below.[178]

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[176] Meleah Houseknecht, *Waste Management on the Big Island: Mapping a vision for an economically and ecologically sustainable Hawai‘i*, The Kohala Center, November 2006: 5.

[177] Houseknecht, M. Waste Management on the Big Island: Mapping a vision for an economically and ecologically sustainable Hawai’i. A Report for the Kohala Center for Pacific Environments, August 2006.

[178] For a full discussion of current municipal solid waste policies and issues, and for recommendations as to next steps, please refer to the Waste Management Report, available at http://learning.kohalacenter.org/.

Background to County Solid Waste Management Problems

The County is in urgent need of updating its solid waste management system and looking for innovative ways to reduce its waste stream, particularly the portion going to final disposal from the east side of the Island. Exacerbating current waste disposal problems is an increase in generation rates of waste. There was a 30% increase in waste generation between 2002 and 2005, with much of the increase occurring on the west coast. It is presumed that high importation of packaged goods and increased construction debris due to high tourist activity is chiefly responsible for this upswing.

Hawai‘i County's currently operates what is essentially a rural waste management system. There is no public island-wide program for curb-side collection of residential trash or recyclables, which make up approximately 40 percent of the island's waste stream. Approximately 85 percent of residents haul their waste to one of 21 convenience centers (know on the island as "transfer stations"). Containers at the transfer stations are removed by County personnel to one of the island's two landfills (generally the nearer of the two) and emptied.

The County's solid waste streams are comprised of the following:

Packaging wastes
Packaging, including food packaging (such as plastic, glass, and metal containers and readily disposable wrappings), shipping packaging (such as wooden pallets, plastic film, cardboard, etc.), and other product packaging, make up a significant portion of the waste stream.

Readily biodegradable organic wastes
Another large portion of the waste stream is comprised of organic wastes that, when given the biochemical ability to do so, can easily biodegrade into useable soil or soil amendment. These include what is known in Hawai‘i as "greenwaste" (yard, brush, and landscaping waste comprised of both leafy and woody debris), food waste, some soiled paper discards that are not otherwise recyclable, and sewage wastes.

Construction and demolition (C&D) wastes
Of particular concern for Hawai‘i County is the volume of waste generated by the construction industry. Much of this waste is inert, such as demolished concrete, stone, brick, wood, etc., but the sheer volume of these materials can be sufficient to cause concern. Much of the waste generated by construction activities is recyclable. In Hawai‘i County, C&D waste makes up a large portion of the waste stream—it is estimated to encompass over 15 percent of the waste currently disposed of, and because much of it is illegally dumped this may even be a significant underestimate.[179]

[179] Jason Macy, Vice President/General Manager, West Hawaii Concrete, personal communication, 9 March 2006.

Household hazardous wastes and other consumer product wastes of concern
While they make up a relatively small percentage of the overall waste stream, product wastes such as discarded electronics, unused paint, cleaning products, and personal care items, can pose a serious risk to health and the environment. They are generally collected on special household hazardous waste days or through special collection events.

Due to the lack of consensus and shortage of time in dealing with the solid waste problem, no decision has been made at the County level as to how to proceed. This situation has made WTE technology all the more attractive.

Despite its apparent appeal in solving the County's solid waste problem, the Waste Management Report identified the following problems with WTE:

1. It may not be the most effective use of limited County funds;
2. It effectively eviscerates any recycling or reuse value of the waste streams;
3. It does not conform to the state's goals for reducing waste generation and disposal and runs counter to U.S. EPA's rankings for environmentally sound municipal solid waste.

Limited Solid Waste and Funds
The County is examining the possibility of developing a WTE incineration facility to burn the waste currently being disposed of at the South Hilo Landfill. The estimated cost for such a facility is approximately $35 million dollars.[180] There are several problems arising from this. An average of approximately 230 tons per day of waste are disposed of at the South Hilo Landfill. However, in order to be profitable, economies of scale dictate that most incinerators currently operating in the U.S. (almost 75 percent) are built with a capacity of 500 tons per day or more and nearly half of US WTE facilities have a capacity of over 1,000 tons per day. There simply may not be enough waste available to keep the plant functioning at an economically viable level. Compounding this problem is that the County would most likely sign a "put-or-pay" contract, whereby it agrees to supply a certain amount of waste to the incineration facility. If this waste is not delivered, the County will have to pay a fee. Perverse incentives may be created encouraging the County to cap its recycling potential at a level so as to ensure that the WTE plant receives a minimum amount of waste required for them to run the plant efficiently and as contractually obligated.

To put this in some perspective, Wheelabrator Technologies Inc. generates electricity using waste fuels. They own sixteen WTE plants in the northeast United States, Florida, Washington, and California. With one exception, each of their plants use between 500 and 2,250 tons of solid waste every day, with an electric power capacity of between 14.5 and 60 MW. This volume of waste far exceeds not just that which is landfilled in the

[180]As reported in the Waste Management Report, Engineers at the Department of Environmental Management developed cost estimates for various waste management facilities under consideration.

South Hilo Landfill but also the entirety of what is generated in the entire county on a daily basis.[181]

One of the Wheelabrator facilities, located in New Hampshire, utilizes 200 tons per day of solid waste with a peak generation of 4.5 MW.[182] This is more in line with volumes generated for disposal at the South Hilo Landfill. However, it is important to recognize that facilities on the mainland receive waste from a larger population and the waste received is post diversion. In other words, supply of appropriate waste (i.e., waste with recyclable and compostable material removed) is not a limiting factor on the mainland. By contrast, having a facility on the Island whose size would put it so close to the margin of economic viability effectively reduces the flexibility of the waste management system to respond to changes in the available waste stream. It may also mean that waste otherwise appropriate for recycling, reuse, or composting would be incinerated.

Compare the estimated capital cost of a new WTE facility ($35 million) to the cost of improvements to recycling and composting infrastructure at the transfer stations and landfills. As stated in the Waste Management Report, in order to improve recycling rates from the current 30%to 55%, investment is needed for the collection and processing of, biodegradable organics and C&D wastes, as well as significantly increasing the diversion rates of the materials currently being recycled. To do this the County Council would first need to fully fund the proposed East Hawai‘i Sort Station and move forward with the construction of a composting facility. The combined cost of both facilities has been estimated at $8.36 million.[183]

Biodegradable organics comprise 54 percent of the East Hawai‘i waste stream, and the most cost effective and technically feasible way to divert these organics would be to compost them. The County currently diverts a reasonably high proportion of its greenwaste (approximately 66 percent). In order to effectively utilize this greenwaste, a commercial scale composting facility is also needed. Approximately 16,000 short tons of fertilizers, soil conditioners and related products are imported onto the island each year[184] and used to treat almost 43,700 acres of land.[185]

Upgrades to residential trash transfer stations could be completed as part of scheduled improvements. The County is planning to upgrade to its transfer stations at an estimated

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[181] Information on Wheelabrator was accessed at http://www.wheelabratortechnologies.com/WTI/CEP/overview.asp

[182] Information on Wheelabrator facility in Claremont, NH available at http://www.wheelabratortechnologies.com/WTI/CEP/claremont.asp.

[183] Engineers at the Department of Environmental Management currently estimate the infrastructure costs for a composting facility at $1.5 million, and the lowest bid received by the county for construction of a full complement of recycling-related facilities to accompany the East Hawaii Reload Facility currently under construction is approximately $6,860,000.

[184] Department of the Army Corps of Engineers, Institute of Water Resources, 2003, “Waterborne Commerce of the United States,” Part 4—Waterways and Harbors, Pacific Coast, Alaska and Hawaii, Publication IWR-WCUS-03-4.

[185] United States Department of Agriculture, Farm Service Agency, 2006, “Programmatic Environmental Assessment, Conservation Reserve Enhancement Program,” http://www.fsa.usda.gov/Internet/FSA_File/hicreppeafinal.pdf page 2-3.

cost of approximately one million dollars each.[186] Recycling and reuse infrastructure could thereby be improved at little to no additional cost. To put these costs in some perspective, the annual budget for the County's Department of Environmental Management, the county agency that oversees solid waste collection and management, including recycling, is $24 million. The $35 million cost associated with a new WTE facility does not include the financial risks associated with the centralization of investment in a single mechanically complex facility and the risk associated with contractual obligations of providing sufficient waste to the facility. An improved recycling program would provide greater operational flexibility at lower cost.

Recycling

As stated above, a WTE on Hawai'i County would be operating at a capacity on the edge of economic viability. Waste that otherwise could be recycled may be used as fuel for a WTE plant in order to make it economically viable. The following benefits from recycling would be reduced:

Discarded materials are valuable commodities

The most obvious reason to invest in reuse and recycling is that most discarded items are still made of valuable materials. When discarded items are landfilled it is literally throwing away potential inputs to agricultural or industrial processes. In turn the value of the extraction, labor, and processing embodied in the item is lost forever. Incineration captures (some of) the *energy* embodied in a product, but can not capture the added value associated with other aspects of producing that product, while recycling often can.

Recycling saves energy over production using virgin materials

When extraction and initial processing of materials can be eliminated from the materials use cycle it saves energy. The energy savings entailed in the use of recycled (rather than virgin) materials varies enormously, but ranges from 40 percent savings for paper and glass recycling to as high as 96 percent for aluminum recycling.[187]

Recycling creates jobs

Recycling offers greater economic development opportunities compared to other waste management options. Compared to landfilling or incineration, recycling tends to be a labor-intensive process, rather than a capital-intensive process—on a per tonne basis, sorting and processing recyclables can create as many as 11 jobs for every one job created by the operation of a landfill or incinerator.[188] In addition, recycling makes materials available as inexpensive feedstock for new and often innovative local industries.

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[186] Schrandt, Colleen and Lane Shibata, 2006, "Audit of the County of Hawai'i's Recycling and Diversion Grants Program." A report to the Finance Committee, County of Hawai'i, conducted and submitted by the Legislative Auditor's Office, County of Hawai'i, June 2006.

[187] U.S. Department of Energy, Energy Information Administration, Energy Kid's Page, "Recycling Paper and Glass" and "Recycling Metals," http://www.eia.doe.gov/kids/energyfacts/saving/index.html.

[188] Platt, Brenda and Neil Seldman, 2000, "Wasting and Recycling in the United States," a report written for GrassRoots Recycling Network, p. 27.

Recycling materials can contribute to the self-sufficiency of island communities
One of the most prominent aspects of Hawai‘i County's material flow profile (a snapshot of all of the materials entering, being used on, being disposed of on, and exiting the island) is the fact that it is so heavily dominated by imported goods. Materials, once imported, become local resources that can then be used in the island economy to offset the need to consume additional imported resources or wasted through landfilling or incineration.

Stated Goals of Hawai‘i Legislature and the EPA
In 1991, the state of Hawai‘i enacted the "Hawai‘i Integrated Solid Waste Management Act," (HRS §342G) which created the Office of Solid Waste Management within the state Department of Health (DOH). The Act also set forth goals for reducing the solid waste stream prior to disposal—25 percent by January 1, 1995 and 50 percent by January 1, 2000. In order to meet these goals, the Act directed counties to develop and adopt integrated solid waste management plans and submit them to the DOH by January 1, 1993. These plans were intended to serve as a roadmap for how each county planned to reach the state's waste reduction and diversion goals through (in explicit order of priority): source reduction, recycling and bioconversion, including composting, and landfilling and incineration (with the "respective roles of landfilling and incineration…left to each county's discretion"). The state's waste reduction goals, along with several other goals and mandates set forth in the Act, are yet to be met.

The US EPA has ranked the most environmentally sound strategies for MSW. Source reduction (including reuse) is the most preferred method, followed by recycling and composting, and, lastly, disposal in combustion facilities and landfills.

5.3 SUPPLY – FUELS: Hydrogen

Recommendation 5.8: Hydrogen is a potential solution to energy needs in the long-term. The County should support Hawai‘i State hydrogen research and commercialization programs. Furthermore, Hawai‘i County should streamline permitting processes, train fire marshals in hydrogen safety, and work with hydrogen developers to ensure that County policies are hydrogen-friendly.

Hydrogen has the potential in the long term to satisfy energy requirements for generating electricity, providing transportation fuel, and providing heating and cooling needs.[189] However, there are significant barriers to its short and mid term application as a viable energy source.

What is Hydrogen Energy?
Hydrogen (chemical symbol H) is the most plentiful element in the universe.[190] In its natural or free state it exists as hydrogen gas (H_2). Despite its great abundance, hydrogen rarely occurs on Earth in its natural state. Rather, it exists in combination with other elements as a part of compounds; for instance with oxygen in water, with carbon in hydrocarbons, and with carbon and oxygen in alcohols.[191] In order to be utilized in generating useable energy, hydrogen first must be separated from its compound and put in its "free" state as a gas (H_2). Once produced and available as a gas, hydrogen can be used to generate electricity. Hydrogen acts as an energy "carrier" or battery to produce energy in a two-step process. First, hydrogen must be isolated, creating a state that contains a high amount of energy. Then, this stored energy can be reclaimed at the time and in the manner that best suits the end user's needs.

It is important to note that hydrogen itself is not a source of energy. Rather, hydrogen provides a mechanism to store energy. Because hydrogen gas is rare in a natural state on Earth, it first must be manufactured by splitting compounds such as water and hydrocarbons. Dividing such molecules requires energy. This energy can be reclaimed from hydrogen during the second step when hydrogen recombines with other elements. This is the process that occurs in a fuel cell when hydrogen gas recombines with oxygen. Energy is released as a result of the reaction and water is formed as a byproduct (See Figure 5.1). This is a fundamentally different process than for oil products or coal, where the energy sources are burned to produce heat which then can be converted again into a useable energy.[192]

[189] *Nurturing a Clean Energy Future in Hawaii: Assessing the Feasibility of the Large-Scale Utilization of Hydrogen and Fuel Cells in Hawaii.* Prepared by Hawaii Natural Energy Institute , UH-Manoa and Sentech, Inc. for Hawaii DBEDT, 2002
[190] From National Renewable Energy Laboratory website on hydrogen available at http://www.nrel.gov/hydrogen/
[191] Primer on Hydrogen from DBEDT website, available at http://www.hawaii.gov/dbedt/info/energy/hydrogen/
[192] J. Rifkin, *The Hydrogen Economy.* Penguin Putnam, 2002.

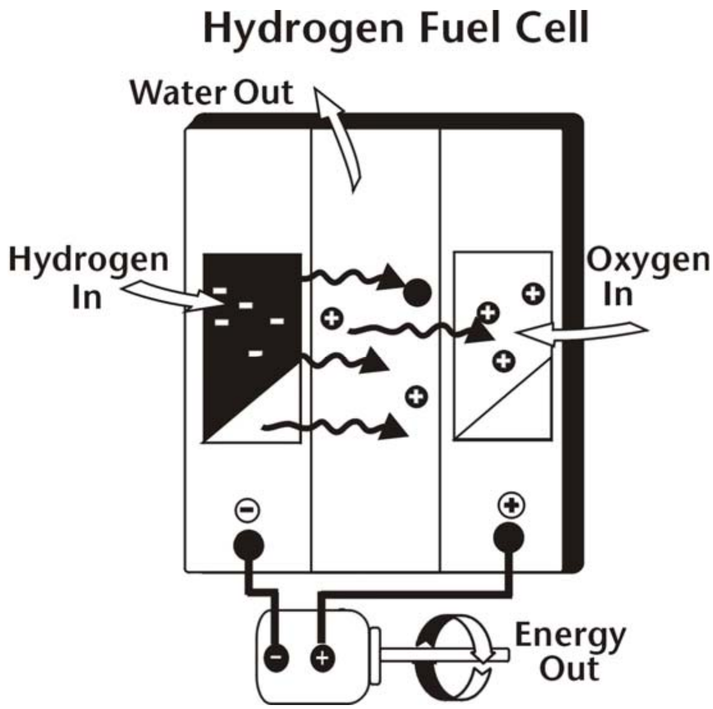

Figure 5.1. Basic processes in a hydrogen fuel cell[193]

One method by which hydrogen can be freed from other compounds is through a process called reformation, whereby a hydrocarbon (for instance natural gas, CH_4) is combined with oxygen and water to produce hydrogen gas (H_2), carbon dioxide (CO_2), and water vapor (H_2O). Virtually any hydrocarbon, even those derived from some algae and bacteria, can be used for this process. Reformation accounts for approximately 95% of hydrogen production today.[194] Whereas it is the cheapest method currently available, it also produces carbon dioxide, a greenhouse gas, as a byproduct.[195]

<u>Reformation:</u>

$$CH_4 + O_2 + H_2O + \text{heat} \rightarrow H_2 + CO_2 + H_2O$$

Another method of extracting hydrogen is through electrolysis. This method uses an electric current to "lyse," or break apart, water into its component parts of oxygen and hydrogen. The advantage of this process is that the only byproduct is oxygen.

Electrolysis:

$$H_2O + \text{electricity} \rightarrow H_2 + O$$

The drawback to both these processes is that they are both energy intensive and expensive. Producing hydrogen gas requires more energy than it ultimately yields after

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[193] EIA hydrogen information page, available at http://www.eia.doe.gov/kids/energyfacts/sources/IntermediateHydrogen.html

[194] C. Elam, et. al. *Realizing the hydrogen future: the International Energy Agency's effort to advance hydrogen energy technologies.* International Journal of Hydrogen Energy 28, 2003. pp. 601-607.

[195] Sentech article

recombination. A potential remedy to this is to have the energy required for electrolysis come from renewable energy sources. Hawai'i County could be an ideal location for hydrogen production due to its renewable energy capacity. Off-peak electricity produced by renewable resources such as geothermal, wind, and thermal, could provide the energy required to produce hydrogen. As an example of potential use, an Island community in Norway is considering the use of a wind farm to produce power for residents as well as for an electrolysis system to manufacture hydrogen.[196] Iceland currently derives 100% of its electrical generation from renewable sources (geothermal and hydro-electric power). Iceland plans to produce hydrogen gas using geothermal electricity, and then to utilize hydrogen fuel cells to power its vehicles and fishing fleet. When realized, this plan would make Iceland 100% energy self-sufficient with all power needs produced by locally available renewable energy resources.[197]

Despite the fact that hydrogen development is technologically feasible, there are significant and numerous barriers to its use as a viable, near- or middle-term, and large-scale energy source. Barriers include:[198]

- Primary energy source for hydrogen production: 95% of hydrogen is produced from hydrocarbons often originating from fossil fuels using processes such as reclamation described above. Until large scale electrolysis can be deployed, production does not reduce dependence on hydrocarbons. In addition, carbon dioxide, a greenhouse gas, is a byproduct of this production;
- Storage: Hydrogen gas must be compressed in order to be effectively stored. It is usually stored at pressures and temperatures that cause the hydrogen to be in a liquid form. These storage units present a technological challenge in that they must be relatively large and strong enough to hold hydrogen liquid at an economically viable price. For vehicles, the tanks must also be light enough to be transported. This is also a logistical issue in that every end user in every sector (transport, residential, industrial, and commercial) would require a storage unit.
- Distribution: Hydrogen in liquid form is very cold and difficult to transport. Special containers, pipelines, and vehicles would be needed to transport hydrogen.

Put simply, the basic infrastructure required to use hydrogen as an energy carrier simply does not exist. To the contrary, Hawai'i, like the majority of the rest of the world, has an energy infrastructure arranged to accommodate fossil fuels. Hydrogen production from renewable sources as opposed to hydrocarbons currently is not cost effective and hydrogen will not be a viable energy source in Hawai'i in the near term.

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[196] C. Elam, et. al. *Realizing the hydrogen future: the International Energy Agency's effort to advance hydrogen energy technologies.* International Journal of Hydrogen Energy 28, 2003. pp. 601-607

[197] Renewable Energy U.K article available at http://www.reuk.co.uk/Renewable-Energy-in-Iceland.htm.

[198] Barriers in infrastructure were summarized from an article in Popular Mechanics available at http://www.popularmechanics.com/technology/industry/4199381.html?page=1.

Hydrogen Initiatives Outside of Hawai‘i

However, it is also clear that there is intense interest in developing hydrogen on a national and international scale. Numerous groups continue to conduct research and advocate for increased use of hydrogen. The International Energy Agency (IEA), established in 1974 by the Organization for Economic Cooperation and Development (OECD) following the oil crisis, started the Production and Utilization of Hydrogen Program (aka Hydrogen Implementing Agreement).[199] This multinational organization states its mission is to "facilitate, coordinate, and maintain innovative [research and development] activities through international cooperation and information exchange. Seven areas are targeted: Technology, Energy Security, Environmental, Economic, Market, Deployment, and Outreach."[200] In 2004, governments all over the world spent $1 billion dollars and private funding sources a further $4 billion dollars in research into hydrogen technology.[201]

In the U.S., the recently passed $8.6 billion Energy Bill included support for the presidents' $1.2 billion hydrogen initiative started in 2001. This plan seeks cost effective hydrogen-powered fuel cell vehicles by 2020. The administration also announced a partnership between the U.S. Departments of Energy and Agriculture to support efforts to turn biomass into hydrogen.[202]

In the transportation field, member companies of the National Hydrogen Association received portions of $43.5 million in awards from the Federal Transit Authority (FTA) in support of a program to make ten percent of all bus purchases in the US hydrogen fuel cell buses by 2015. Fuel cell buses could represent an effective means of introducing a public to hydrogen powered vehicles.[203] This is but one example of many such research initiatives.

Hawai‘i State and County Initiatives

The State of Hawai‘i has initiated steps towards a renewable hydrogen economy. To meet the goal of seeking state-of-the-art solutions for its energy challenges, the State has implemented 1) pilot projects to assess the potential for large amounts of hydrogen production on the Kona coast, and the technical and financial feasibility of hydrogen in Hawai‘i; 2) the hydrogen capital investment fund, and 3) other activities that further the State's renewable hydrogen initiative. The Island of Hawai‘i is the focus of these and other State efforts, outlined in the 2006 State Act 240 SB2957, because of the its high proportion of renewable energy generation and its potential for increasing such generation.[204]

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[199] Information about this organization is available at http://www.ieahia.org/.
[200] Available at http://ieahia.org/page.php?s=glance&p=plan.
[201] Article commemorating the 25th anniversary of the HIA, available at http://www.azom.com/details.asp?newsID=1981.
[202] Article in Environment New Service available at http://www.ens-newswire.com/ens/may2005/2005-05-26-10.asp
[203] Article from RenewableEnergyAccess from October 23, 2006, available at www.renewableenergyaccess.com
[204] A Bill for an Act Relating to Energy. SB 2957. http://www.capitol.Hawaii.gov/session2006/Bills/SB2957_CD1_.pdf. Last accessed April 2007.

The U.S. Air Force now operates a 23-passenger fuel cell shuttle bus, two fuel cell vans that shuttle crew to aircraft, and one fuel cell aircraft tug. The vehicles are supported by a modular fueling station that can be packed up and flown to another location if necessary.[205]

A hydrogen initiative underway in Hawaiʻi County encourages the efforts of Hawaiʻi Natural Energy Institute, the University of Hawaiʻi, and the Hawaiʻi Center for Advanced Transportation Technology, and other participants, to produce hydrogen on the Island. Hydrogen Program Manager for the Hawaiʻi Natural Energy Institute director Mitch Ewan reported that the Department of Energy's $800,000 grant has been matched by the State of Hawaiʻi for a total of $1.6 million. The Park will be located at the NELHA site on Hawaiʻi Island's Kona side and will include an 85 kW electrolyzer that produces 10-12 kilograms (kg) of hydrogen per day (a kg of hydrogen provides the approximately equivalent amount of energy as a gallon of gasoline), a hydrogen storage apparatus, and a dispensing station. The project is scheduled for completion between May and November 2008.[206]

In addition, a grant proposal under consideration by the state and federal governments would examine hydrogen buses. If funded, this bus would serve as a shuttle between Hilo and Hawaiʻi Volcanoes National Park. Stakeholders have also discussed partnering with Volcano National Park to provide small buses for internal park loops. If the hydrogen is produced by solar, wind, geothermal, or another carbon-free resource, the fuel production process would emit no carbon dioxide or other pollutants. The only tailpipe emission from hydrogen combustion in a fuel cell bus is water vapor.

County Implementation of Hydrogen

Over the long term, hydrogen has the potential to increase the utilization of renewable energy sources on Hawaiʻi Island. Hawaiʻi County is well-suited to reap many of the benefits of energy from hydrogen and has energy resources that are well suited for the hydrogen production. Hydrogen plants could utilize intermittent power generated by wind turbines and photovoltaic modules. HELCO is seeking the PUC's approval to provide renewable resource power at a reduced rate to support technology validation of a hydrogen fueling system by HNEI at the Hawaiʻi Hydrogen Power Park to be located at NELHA's Gateway Energy Center.

[205] Hawaii Center for Advanced Transportation Technologies. http://www.htdc.org/hcatt/. Last accessed April 2007.
[206] Mitch Ewan, Hawaii Natural Energy Institute, personal communication. April 2007.

If sited appropriately, and provided that relevant stakeholders are amenable, a future hydrogen-generating plant could utilize the excess off-peak capacity of wind, solar, or geothermal power. Electricity from the renewable source could also be off-grid and go directly to the hydrogen plant without first entering the HELCO system. The production of hydrogen gas from renewable power also could be an important source of energy storage.

Sentech Incorporated performed economic feasibility studies for hydrogen production from geothermal and wind energy on Hawaiʻi Island.[207] The studies found that investing in hydrogen infrastructure could be an effective use of excess energy from renewable sources and would help improve the efficiency and reliability of the Island's energy system. The studies also found that, as of 2004, producing hydrogen with wind power is more expensive than producing it with oil or gasoline.[208] This balance would have to change before hydrogen is an economically viable alternative using such renewable energies. Even then, significant investment in infrastructure would still be required.

Due to its excellent base of renewable energy resources, Hawaiʻi Island could be an excellent proving ground for hydrogen technologies. Hydrogen projects are already receiving support from state- and federal-level agencies. Potential hydrogen programs would increase transportation services for Island residents, reduce dependence on imported fuel, and provide significant economic development opportunities while reducing pollution and greenhouse gas emissions.

The County should support such efforts and work together with hydrogen researchers and potential partners to ensure that hydrogen development proceeds in a way that yields the greatest benefits for Hawaiʻi. The County can support hydrogen development by streamlining permitting for hydrogen projects, training fire marshals in hydrogen safety, and working closely with hydrogen developers on County policy-making.

It should also be emphasized, however, that hydrogen remains a long-term solution that would require significant research, development, and investment. As such, the development of this technology shall remain largely the purview of private enterprise working in partnership with research institutions and the federal government. The County of Hawaiʻi does not have available the financial resources to significantly aid in the development of hydrogen technology to a point where it is a viable large-scale energy alternative. For example, a hydrogen fuel cell bus is a relatively new technology and at $1.2 million the bus is three to four times more expensive than a conventional diesel-powered bus and two to three times more than a hybrid gas-electric bus. As a means to reducing dependence on imported fuel, the County would be better served investing available funds in expanding existing bus routes with conventional buses and increasing ridership.

[207]Kenneth Lee. Economic Feasibility of Producing Hydrogen Using Excess Electricity from Wind Turbines on the Big Island of Hawaii. World Renewable Energy Congress VIII, Denver CO, September 2004. http://www.sentech.org/Lee,%20K_Economic%20Feasibility%20Hawaii.pdf. Last accessed April 2007.
[208] Ibid.

At the same time, the County should encourage and support research into hydrogen. The County should welcome the use of local lands and resources by those public and private entities that have available the financial and technological resources required to develop hydrogen technology. The County also should advertise those conditions stated above (i.e., readily available renewable sources of energy) that make it an ideal natural laboratory for those seeking to develop hydrogen. This approach would have the added benefit of attracting highly-skilled jobs to the Island. At such a time that hydrogen is a demonstrated technology capable of helping the County reduce dependence on imported fuels, the County should consider implementing these technologies.

5.4 SUPPLY – FUELS: Ocean Energy

***Recommendation 5.9: Hawai'i is ideally placed to take advantage of energy derived from ocean technologies. The County should encourage local research and development projects so that the Island may benefit when these technologies become commercially viable. The County should streamline permitting processes, make available County lands where applicable, and work with wave energy developers to ensure that County policies facilitate ocean energy research*.**

Tropical oceans absorb the energy equivalent of roughly 250 billion barrels of oil every day in solar radiation. This energy represents at least 4,000 times the amount currently consumed by humans.[209] Ocean energy technologies seek to capture this abundant renewable energy source and convert it to electricity. Ocean Thermal Energy Conversion (OTEC) and wave energy technologies have potential applications on Hawai‘i Island given its ample coastline, ocean gradients, and wave action.

Ocean Thermal Energy Conversion

OTEC is a technology that relies on the difference in temperature among layers of the ocean to produce electricity. This thermal gradient is created by solar energy that is stored in the ocean. Water temperatures in equatorial oceans essentially consist of two layers. The upper layer is warmed by insolation and the lower layer (starting at about 100m below the surface) contains cold water originating in the Earth's high latitudes. These two layers provide the heat source and heat sink required for a heat engine.[210]

Types of OTEC Systems

There are two types of OTEC technology that have been demonstrated. A closed-cycle OTEC system utilizes the temperature difference between warm surface water and colder deep water to vaporize and recondense a working fluid that powers a turbine.[211] Relatively warmer surface seawater is pumped through a heat exchanger which vaporizes the working fluid, thereby turning a turbine. Colder seawater is passed through a second heat exchanger thereby condensing the vapor back into a liquid, which is then recycled through the system.[212] A temperature difference of at least 20°C is required in order to sufficiently heat and cool the working fluid. Tropical ocean water taken from depth (often about 3,000 feet) is at least 20°C colder than surface water and is therefore ideal for this application. Figure 5.2 below presents a conceptual diagram of a closed-cycle OTEC system.

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[209] http://www.otecnews.org/articles/vega/01_background.html
[210] Vega, L. *Ocean Thermal Energy Conversion Primer*. Marine Technology Society Journal., v.6, No. 4 Winter 2002/2003, pp. 25-35.
[211] http://www.energybulletin.net/16811.html
[212] http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50010

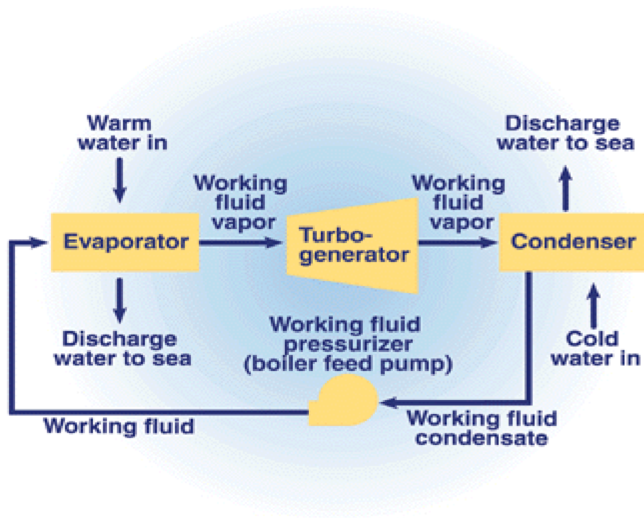

Figure 5.2.Closed-cycle OTEC System

In an open-cycle OTEC system, seawater is the working fluid. The warmer surface seawater boils inside a vacuum chamber maintained at low pressure. Water boils at a lower temperature when it is at lower pressure. The resulting steam is then used to drive a turbine. The steam is subsequently cooled and recondensed back into liquid using cold deep seawater. A by-product of this process is large quantities of fresh water produced as it condenses on the outside of the steam condensing chamber. Very large amounts of water must be pumped to create enough steam to run the turbine as less than one half of one percent of the incoming ocean water becomes steam.[213] Figure 5.3 below presents a conceptual diagram of an open-cycle OTEC system.

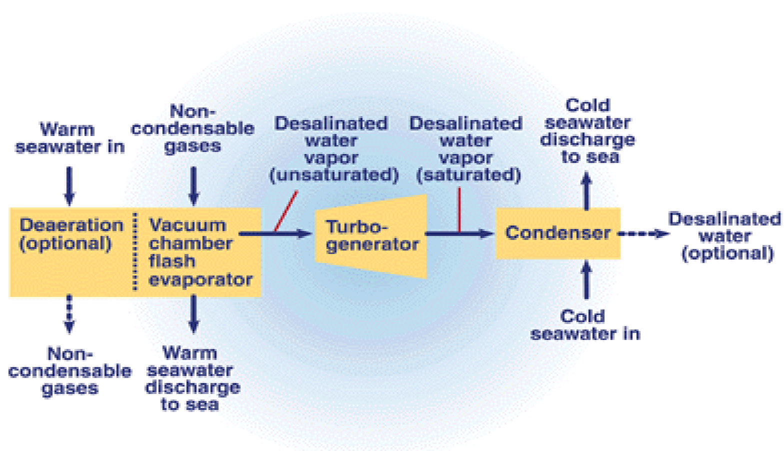

Figure 5.3. Open-cycle OTEC System.

Hawaiʻi is ideally suited for OTEC technology. OTEC depends on a temperature differential between warm surface seawater and cold deep water of about 20°C. The cold

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[213] Technology summary is available at
http://www.oceansatlas.org/unatlas/uses/EnergyResources/Background/OTEC/OTEC2.html

water should be no more than 1,000 meters below the surface due to the high cost of pumping water. This temperature gradient is found in tropical and sub-tropical zones. Whereas OTEC can be implemented on floating facilities, land-based facilities are preferred for a number of reasons. They are easier to maintain and to protect from stresses associated with storms and heavy seas. They are also closer to the transmission grid and end-users that the generation plant would serve, thereby reducing transmission losses. Particularly favored are Islands with narrow shelves and steep offshore slopes, namely volcanic Islands whose geologic arrangement minimizes the length of the required cold-water intake pipe.[214] Each of the above conditions exists on the Island of Hawaiʻi.

Implementation of OTEC

OTEC was first demonstrated in 1979 on a barge off the Natural Energy Laboratory of Hawaiʻi (NELHA) by the State of Hawaiʻi and a consortium of private-sector entities. This plant ("Mini-OTEC") operated for three months, generated 50 kilowatts (kW) of gross power with net power of approximately 18 kW.[215] Larger land-based demonstration systems also have been built and operated. A 100 kW open-cycle plant was operated on the Island nation on Nauru by a consortium of Japanese companies. Between 1993 and 1998, the Pacific International Center for High Technology Research (PICHTR) designed, constructed, and operated a 210-kW open-cycle OTEC demonstration plant at Keahole Point in Hawaiʻi. This plant set the record for OTEC power production at 255 kilowatt gross and 103 kW net production. This plant also diverted approximately ten percent of the steam produced to a condenser to produce fresh water.[216] NELHA continues to consider OTEC technology for their facility on the Kona coast of Hawaiʻi Island. NELHA is in the process of issuing a Request for Proposals for OTEC to power its facility.

Advantages of OTEC

There are numerous advantages to OTEC.[217] The following features of OTEC are particularly beneficial to Hawaiʻi given its substantial reliance on imported fuel sources.

- Emissions. There are virtually no hazardous or toxic emissions associated with OTEC. This is all the more remarkable given the amount of energy that potentially could be generated using this technology;

- Fresh water production. Both open- and closed-cycle OTEC systems produce large quantities of fresh water as by-products of the process. This is especially significant for Hawaiʻi given its reliance on energy-intensive groundwater;

[214] Technological requirements are discussed and available at http://www.nrel.gov/otec/design_location.html#land
[215] Summary of this pilot project is available at http://www.oceansatlas.org/unatlas/uses/EnergyResources/Background/OTEC/OTEC2.html
[216] Vega, L. *Ocean Thermal Energy Conversion Primer.* Marine Technology Society Journal., v.6, No. 4 Winter 2002/2003, pp. 25-35.
[217] Advantages are summarized from an article available at http://www.oceansatlas.org/unatlas/uses/EnergyResources/Background/OTEC/OTEC2.html

- Baseline power. OTEC is a firm renewable resource. It is not subject to intermittency and can be used for baseline power;

- Energy independence. OTEC plants would provide energy independence to those areas that implement it;

- Aquaculture. Commercially valuable ocean fauna, such as lobster and salmon, are best suited to cold, nutrient rich water. OTEC can provide this water as part of its process;

- Agriculture: OTEC can support chilled-soil agriculture. Cold seawater flowing through underground pipes can chills the surrounding soil. This process would allow plants better suited to temperate environments to be grown. NELHA has a demonstration garden near its OTEC plant with more than 100 different fruits and vegetables that would not normally survive in Hawai‘i;

- Air-conditioning and refrigeration. Cold ocean water can be used as a chiller fluid in air-conditioning and refrigeration systems. Space cooling is an economically valuable use of deep cold seawater that is available immediately.

Disadvantages of OTEC

Disadvantages of OTEC are as follows:[218, 219]

- Low efficiency. Electrical energy conversion efficiency of OTEC is less than 3 percent. By contrast, an oil- or coal-fired steam plants, have efficiencies around 30 to 35 percent. The raw material for OTEC (ocean water) is essentially unlimited and free, as opposed to a fossil fuel plant which must purchase the fuel source. However, due to its very low conversion efficiency, OTEC plants require very large volumes of water. A 100-megawatt (MW) OTEC plant would need approximately 3,400,000 gallons per minute of seawater, or the rough equivalent of the Colorado River flow into the Pacific Ocean.[220] This water must all be pumped, which is energy intensive. Pumping costs would represent as much as 30% of operating costs. Discarded cold sea water also must be re-injected into the ocean, which may damage aquatic ecosystems if not performed properly due to water temperature differences. This can dramatically alter local ecosystems and is a significant adverse environmental impact.

- High capital costs. Construction of an OTEC plant would require significant capital investment. The primary capital cost (~75%) would be for the deep seawater pipeline. For a 100 MW plant, a minimum pipe diameter of 10 meter would be required and would be constructed of fiberglass-reinforced-plastic or reinforced concrete pipe, both of which are expensive materials.

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[218] OTEC technology is discussed at http://www.oceansatlas.org/unatlas/uses/EnergyResources/Background/OTEC/OTEC2.html

[219] OTEC technology is discussed at http://www.otecnews.org/articles/vega/02_tech_limitations.html

[220] Ibid.

Current Funding For Ocean Energy Technology
The federal government currently provides no funding for research and development or for the production of energy from ocean renewables.[221] However, several pieces of federal-level legislation may benefit ocean technologies:[222]

- the House of Representatives passed H.R. 3221 and the Senate passed S.6, both of which contained core Research and Development provisions introduced by H.R. 2036 and S. 1511. Aimed at R&D for marine energy systems and technologies, these bills provide funding of $50 million per year over five years.
- Oregon Congresswoman Darlene Hooley introduced a marine renewable energy research and development bill;
- West Virginia Congressman Nick Rahall has introduced a broad energy package that includes ocean renewable energy;
- Washington Senator Maria Cantwell introduced a broad tax bill offering credits "to ensure more investment and innovation in clean energy technologies";
- Oregon Senators Gordon Smith and Ron Wyden introduced a bill that would extend production tax credits to marine renewable projects.
- the House of Representatives passed the energy tax bill H.R. 2776, which would extend Production Tax Credits (PTCs) through 2012, including ocean energy for the first time.

County Response
OTEC provides a genuine potential as a significant energy source for Hawai‘i in the medium- to long-term. None of its several disadvantages are insurmountable and there are many significant by-products that would be beneficial to the Hawai‘i County economy and community. However, OTEC would not provide a solution to Hawai‘i County's efforts to reduce its dependence on imported oil in the near-term. Additionally, the development of this technology is beyond the means of Hawai‘i County, both financially and technologically. The private sector, responding to market indicators and in conjunction with large public authorities, is the appropriate source for development and funding for this technology. As such, the County should not expend funds that could be used for other programs that would have a more immediate effect on reducing imported fuel dependence.

However, the County should be aware of the potential of OTEC to provide energy on the Island. As part of its future energy-needs solution, the County should encourage and advocate for the increased research and development of this technology. OTEC is also a technology that is ideally suited to Hawai‘i Island. Hawai‘i County should be receptive to large research projects that seek to develop OTEC. The County Planning department would be involved to an extent in that it is responsible for local zoning and has some

[221] Funding discussion is a summary of article "How Does the U.S. Ocean Energy Industry Compare with the Rest of the World?" by C. Elefant and S O'Neill, available at http://www.renewableenergyaccess.com/rea/news/ate/story?id=49103
[222] Ibid.

responsibility for coastal management. Similarly, the Building department would have jurisdiction over building permits. These agencies in particular, and County government agencies in general, should arrange that outside researchers are able to use Hawaiʻi as a laboratory for OTEC in a mutually beneficial way. At such time that OTEC is an economically viable energy resource, the County would be well-placed to benefit fully.

Wave Energy

The power and size of ocean waves depend on the distance, length of time, and speed at which wind blows across the water's surface. A clean and renewable, albeit intermittent, resource, waves contain tremendous amounts of energy. The wave systems throughout the Hawaiian Islands are among the best and most consistent in the world, making wave energy particularly attractive for the islands.

A 1992 report prepared for the Hawaiʻi Department of Business, Economic Development, and Tourism estimates that capturing just 5-10% of the total available offshore wave energy Hawaiʻi Island could meet the total electricity demand in 1992.[223] Although growth in electricity demand over the past 15 years changes these figures, the underlying idea remains valid: the energy contained in the waves around the island is theoretically capable of supplying all or most of Hawaiʻi County's total electricity demand.

A wide variety of technologies are being developed to capture the mechanical energy contained in the surface-level wave action and below surface pressure fluctuations associated with ocean waves. Working together, private companies and government bodies have developed several forms of wave energy converters, including both onshore and offshore systems. Onshore wave technologies rely on the energy contained within breaking waves while offshore technologies make use of open ocean wave action. Several examples of onshore and offshore systems are presented here, though the following do not constitute an exhaustive list of the wave energy technologies under development at present.

Fixed Wave Energy Technology

Fixed (unmoving, generally onshore) wave energy technologies include the oscillating water column and tapered channel (tapchan).

Oscillating water column: The most well studied and developed wave energy technology, the oscillating water column is a partially submerged structure made of steel or concrete. The open-ended bottom of the oscillating water column is fully submerged below the waterline, and encloses a column of air above a column of water.[224] As the water column rises and falls due to waves entering the air column, the air column compresses and

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[223] SeaSun Power Systems, "Wave Energy Resource and Economic Assessment for the State of Hawaii", Final Report, Virginia: June 1992, iii. Available: http://www.hawaii.gov/dbedt/info/energy/renewable/wave

[224] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Ocean Wave Power" Available: http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50009. Accessed: June 2007.

depressurizes; as the wave retreats, the pressure draws air back through the turbine. The movement of air within the column spins a turbine that in turn powers a generator to produce electricity.

Significant infrastructure requirements and environmental conditions are necessary for an oscillating water column system. Built along the shoreline, construction demands a "dry" site, a condition generally achieved through the use of a costly barrier wall protecting the site from incoming ocean water.[225] The ideal locations for siting oscillating water columns are often inaccessible by heavy equipment or conflict with zoning or environmental protection measures. Since 2000, a 500 kW ocean energy system that makes use of oscillating water column technology has been operating on the island of Islay, Scotland and successfully produces power for the national grid.

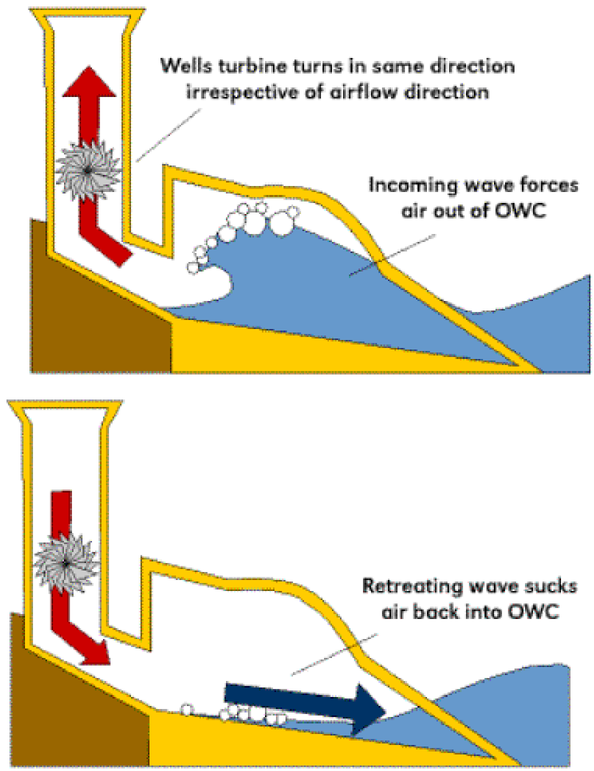

Figure 5.4. Conceptual diagram of oscillating water column technology[226]

Tapchan: An abbreviation of tapered channel, a tapchan is an ocean-facing concrete structure built into the side of a cliff. The water enters at a slight grade into a wide mouth entrance that gradually tapers as it approaches the reservoir on land, causing the incoming waves to increase in height and spill over the concrete walls.[227,228] Mimicking many

[225] Kelly J. Kimball, "Embedded Shoreline Devices and Uses as Power Generation Sources", Oregon State University, 2003.
[226] Research Institute for Sustainable Energy (RISE), "Wave Resources", Accessed: August 2007, Available: http://www.rise.org.au/info/Res/wave/index.html
[227] Ibid.
[228] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Ocean Wave Power".

hydroelectric power plants, the reservoir water feeds through a turbine that spins to produce electricity. A major benefit of the tapchan technology is its capacity to store electricity generated.[229]

Like the oscillating water column, tapchan systems are difficult to site. First, few coastal locations are suitable for this technology and promising locations may be off limits for zoning and/or environmental reasons.

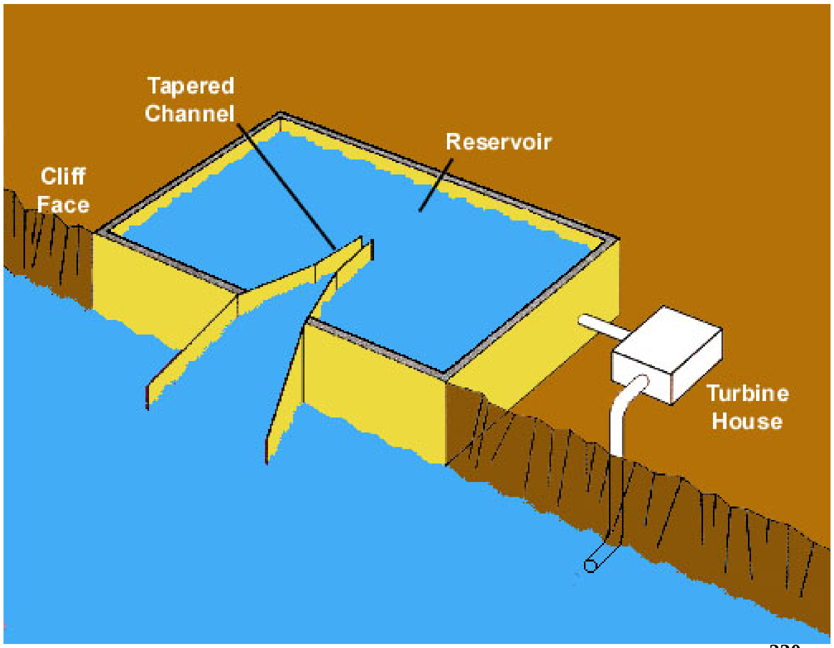

Figure 5.5 Conceptual diagram of tapchan technology[230]

Offshore Wave Energy Technology

Two promising offshore technologies include the Pelamis Wave Energy Converter and Wave Dragon Wave Energy Converter.[231]

Pelamis: The Pelamis consists of cylindrical segments connected by hinged joints that mimic the movement of waves driving electrical generators to produce electricity. Seabed cables transfer power to shore and a single cable is capable of supporting the power input of several Pelamis devices. Each device has a maximum rated capacity of 0.75 MW. A Pelamis wave farm is envisioned to produce up to 30MW (at least 40 devices) over a square kilometer area.[232] The Pelamis technology will be tested at large-scale facilities in Portugal, which plans to introduce 22.5MW of Pelamis generation

[229] RISE, August 2007.
[230] RISE, August 2007, http://www.rise.org.au/info/Tech/wave/index.html.
[231] World Energy Council, "Survey of Energy Resources, Wave Energy" Available: http://www.worldenergy.org/wec-geis/publications/reports/ser/wave/wave.asp, Accessed: June 2007
[232] Ocean Power Delivery Ltd, "The Pelamis Wave Energy Converter", Available: http://www.oceanpd.com/Pelamis/default.html, Accessed: June 2007

capacity to the national grid.[233] The European Marine Energy Centre in Orkney, Scotland, will test a 3MW small-scale version of the Pelamis wave farm.[234]

Figure 5.6. Pelamis Wave Energy Converter (single device)[235]

Wave Dragon: Developed in collaboration with six European nations, the Wave Dragon functions similarly to the tapchan apart from being moored in deep water as opposed to built into a cliff face. Overtopping waves enter the water holding area and are funneled through a turbine-generator system to produce electricity. A grid-connected 7 MW Wave Dragon system is planned for the coast of Wales with operation to begin in 2008.[236] Benefits of the Wave Dragon include its use of mature, existing technologies, the capacity to scale up electricity production, and low operating and maintenance costs.[237]

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[233] Rich Bowden, “Portugal Announces New Wave Energy Project” October 12, 2006, Worldpress.org, Available: http://www.renewableenergyaccess.com/rea/news/story?id=46206
[234] Ocean Power Delivery, Ltd, “UK’s First Wave Farm Project Announced”, Accessed: August 2007, Available”, http://www.oceanpd.com/default.html
[235] Pelamis Wave Energy Converter, Available: http://www.oceanpd.com/default.html
[236] Wave Dragon, “Wave Dragon Submit Environmental Impact Assessment Statement and Offshore Consents”, April 27, 2007, Accessed: August 2007, Available: http://www.wavedragon.net/index.php?option=com_content&task=view&id=42&Itemid=67
[237] Wave Dragon, “Technology”, Available: http://www.wavedragon.net/index.php?option=com_content&task=view&id=4&Itemid=35, Accessed: July 2007.

Figure 5.7. Wave Dragon Wave Energy Converter[238]

Wave Energy Capacity in Hawai‘i County

In an island-by-island comparison, Hawai‘i Island has the greatest potential wave energy resource of the five islands studied (Figure 5.8). The 1992 wave energy assessment conducted for DBEDT examined 7 wave segments in Hawai‘i County to assess the theoretic potential of the wave resources around the island. The sites included a total of 86.9 miles (140 km) of coastline and found that the areas of Hawai‘i-2 or Kukuihaele to Laupahoehoe Point (36 km) and Hawai‘i-7 or 3 km Northwest of Kaloli Point to Cape Kumukahi (16 km) may have the best wave energy resources (see Figures 5.9 and 5.10).[239] At least three locations- North Kohala, Honokaa, and Pepeekeo- offer technical generation capacity of several megawatts.[240]

These sites do not overlap with the majority of marine protected sites, which are primarily located along the Kona coastline (see Figure 5.11). It is unlikely that wave energy technology could be placed in these areas, which diminishes the potential for the technology to serve the growing West side (Kailua-Kona) demand without relying on inefficient cross-island transmission. Figure 5.11 does not detail recreational and commercial vessel patterns or harbors, or protected and fragile land areas, which are likely to impose additional constraints on the siting of potential onshore or offshore wave power facilities.

[238] Wave Dragon Photos, Accessed: August 2007, Available: http://www.wavedragon.net/index.php?option=com_docman&task=cat_view&gid=15&Itemid=28
[239] Ibid.
[240] Hawaii DBEDT, *Feasibility of Developing Wave Power as a Renewable Energy Resource for Hawaii*, Honolulu: January 2002, 41. Available: www.hawaii.gov/dbedt/info/energy/renewable/wave

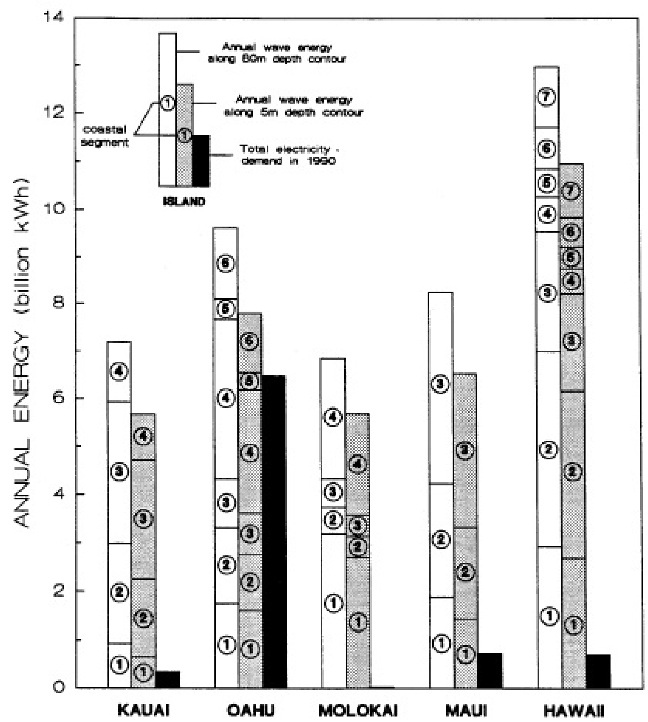
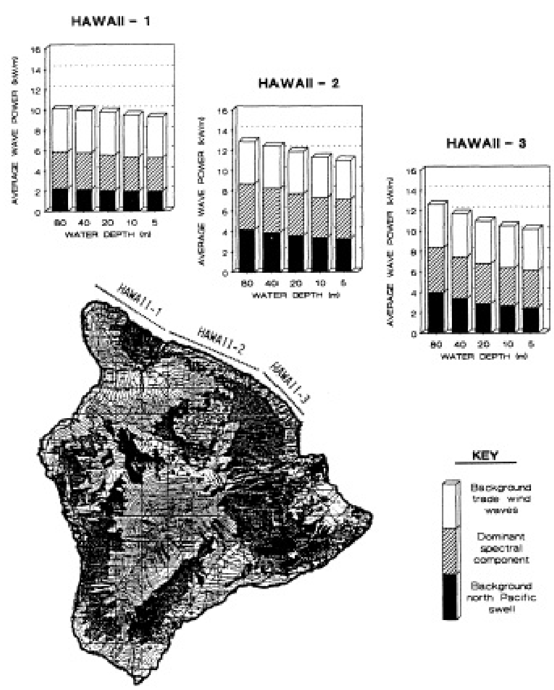


Figure 5.8: Annual wave energy resource by island, compared with 1990 electricity demand[241]



[241] Hawaii DBEDT, *Feasibility of Developing Wave Power as a Renewable Energy Resource for Hawaii*, 7.

Figure 5.9 Wave power distribution at Hawai‘i-1, Hawai‘i-2, and Hawai‘i-3 sites[242]

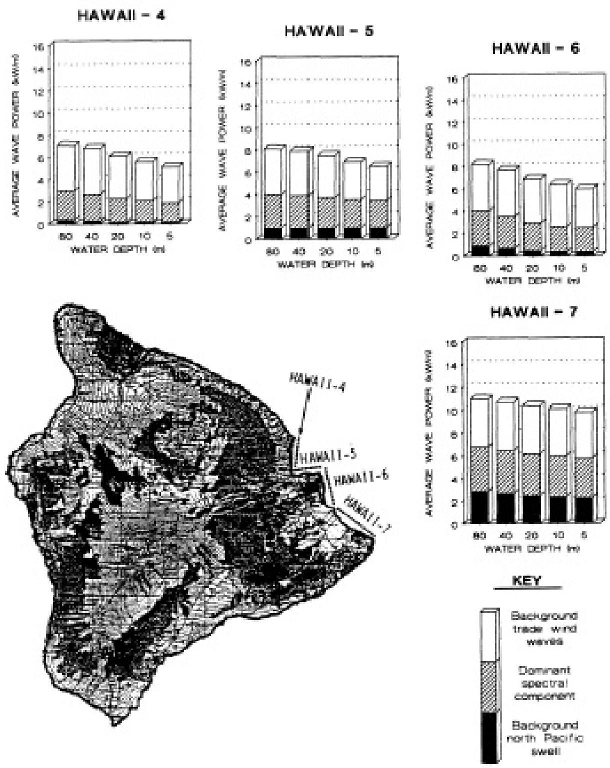


Figure 5.10: Wave power distribution at Hawai‘i-4, Hawai‘i-5, Hawai‘i-6, & Hawai‘i-7[243]

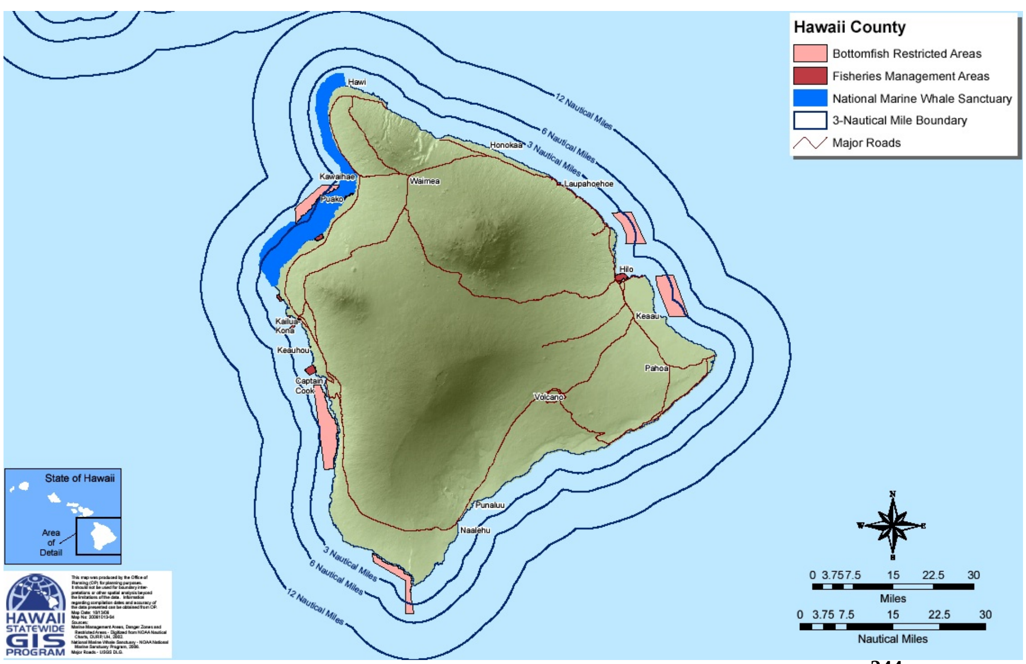


Figure 5.11 Marine Restricted Areas of Hawai‘i Island[244]

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[242] SeaSun Systems, 1990, 2-36.
[243] SeaSun Systems, 1990, 2-37.

County Response
At present, wave energy is not a viable grid-based energy resource for Hawaiʻi County for two primary reasons: the technologies are unproven under grid conditions and would likely conflict with onshore and offshore environmental and recreational use of the ocean area surrounding the island. As Hawaiʻi Island has many other renewable options available beyond wave power, unlike some of European nations for which wave power is particularly promising, the County should actively pursue additional installations of proven renewables like wind, solar, and even geothermal. Advancements in wave power technology should be monitored for potential future addition to the grid system in the event that the inclusion of wave technologies becomes a logical step for Hawaiʻi Island.

Grid connection
Although several prototype and experimental projects in wave energy exist in countries as diverse as Portugal, Scotland, the United Kingdom, and the United States, these technologies have not yet demonstrated successful large-scale integration with an electricity grid. Wave energy, like turbine-based power, is subject to intermittency issues associated with many renewable energy technologies.

Advances in the development of a wide range of wave technologies will likely resolve or ameliorate these concerns in the near future. Portugal's planned 22.5MW installation is among the promising examples of grid-integrated wave power, as the government expects to fully incorporate the electricity production capacity into the national system. In the interim, however, Hawaiʻi Island has many other renewable alternatives available and should maximize its use of these options while the wave energy field continues to develop.

Environmental restrictions & potential marine use conflicts
The potential environmental impacts of wave energy technologies vary considerably. A 1992 report analyzing wave energy potential for the Hawaiian Islands found that coastal wave heights would be reduced by about 3-5% as a result of tapping into 5-10% of the energy contained in offshore waves.[245]

Wave energy facilities may also face strict limitations due to the multiple marine protected areas and substantial commercial and recreational use of the coastal and ocean areas around Hawaiʻi Island.

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[244] DBEDT, *Summary of Permits Which May Apply to Wave Power Projects in the State of Hawaii*, Draft, October 19, 2006. Available: www.hawaii.gov/dbedt/info/energy/renewable/wave
[245] SeaSun Power Systems, iii. Available: http://www.hawaii.gov/dbedt/info/energy/renewable/wave

6. DEMAND – BUILDING EFFICIENCY

6.1 DEMAND – BUILDING EFFICIENCY: Residential Housing

Residential Building Efficiency

Recommendation 6.1: Implement both specific regulatory and market mechanisms (details below) aimed at mandating certain energy efficiency measures and providing rewards to those that implement additional measures.

Hawai‘i County consumed a total of 1.148 billion kWh of electricity in 2006.[246] Electricity use accounted for 21% the County's total final energy and 44% of the primary energy used on the Island. Thirty-nine percent of total electricity was used for residential housing needs (see Figure 6.1).[247] Thus, residential electricity provided by HELCO required approximately 5,500 billion Btu of primary energy in 2006.

Whereas there are many end users of electricity, **residential housing is by far the largest single consumer of electricity**. It is clear that an effective demand-side energy efficiency program must focus on how to reduce residential electrical demand. This section of the report will focus on residential electricity consumption.

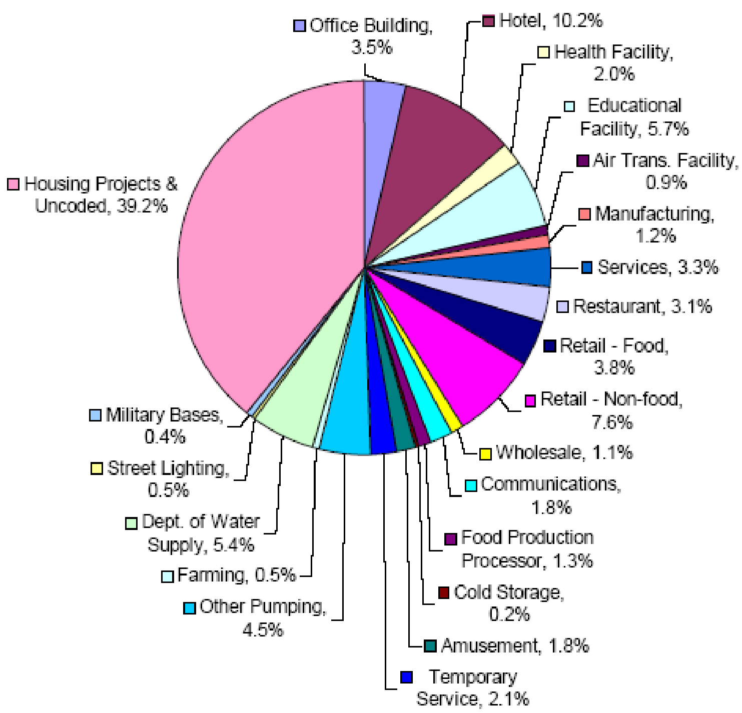

Figure 6.1: Electricity use by sector

[246] Robert Arrigoni, Hawaii County Research and Development, personal communication, 2007. From the HELCO rate increase docket.
[247] Johnson, J, D. Leistra, J. Opton-Himmel,,M. Smith,, "Hawaii County Baseline Energy Analysis" Report for The Kohala Center, 2006.

Using data from HELCO, the County, and the U.S. Census, an estimate of average use and attributes of a "typical house" on Hawai'i Island was developed for the purposes of this study: average monthly residential electricity use is 591 kWh per month.[248] In 2005, 45,237 of the 59,470 occupied residences in Hawai'i County were single-family unattached units,[249] representing 76% of the current housing stock.

Houses were assumed to be approximately 1,200 square feet.[250] Figure 6.2 below shows the breakdown of a "typical" U.S. home.[251] Hawai'i's subtropical climate means that very little energy is used for heating; over 74% of residences use no supplied heating fuel to heat their homes.[252] In Hawai'i, space cooling and water heating dominate residential energy needs, so it is to these two areas that efforts initially should be focused. For homes with no central air conditioning, water heating is the largest energy use.

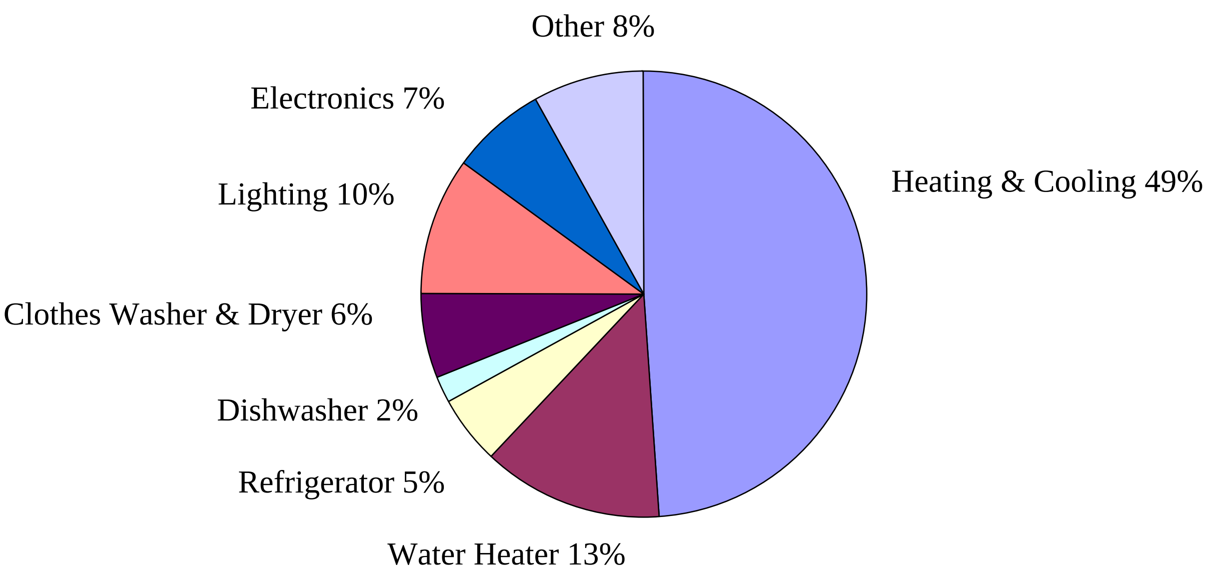

Figure 6.2: Energy end use in a typical U.S. home

[248] Robert Arrigoni, Hawaii County Research and Development, personal communication, April 2007.. From the HELCO rate increase docket.
[249] U.S. Census Bureau, Hawaii County, Hawaii Selected Housing Characteristics: 2005. Available at http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=05000US15001&-qr_name=ACS_2005_EST_G00_DP4&-ds_name=ACS_2005_EST_G00_&-_lang=en&-_sse=on
[250] Based on study home in Department of Business, Economic Development & Tourism "Data Collection and Analysis of the Heat Mitigating, Passive Design Strategies at the Waianae Model Demonstration House" Submitted by Honolulu Chapter American Institute of Architects Committee on the Environment, September 2002.
[251] Derived from EnergyStar website http://www.EnergyStar.gov/index.cfm?c=products.pr_pie)
[252] U.S. Census Bureau, Hawaii County, Hawaii Selected Housing Characteristics: 2005. Available at http://factfinder.census.gov

Hawai‘i's climate is unique as compared to the rest of the U.S. It is characterized by a relatively narrow range of annual temperatures (64 to 83°F) and moderate fluctuations in precipitation and wind conditions.[253] This constancy makes it easier to design structures that can take full advantage of local conditions. Technologies and building techniques only need to contend with a relatively narrow range of temperatures and weather conditions.

Despite a genuine need for residential housing built with energy efficiency in mind, there is little initiative on the part of builders in considering energy efficiency. Builders have very little market incentive to improve the energy performance of a building. Despite potential cost savings through energy efficiency, builders are chiefly concerned with capital (upfront) costs. *There are minimal regulatory and market incentives effectively implemented to build energy efficient buildings in Hawai‘i County.*

The message above should be of particular concern as residential housing construction continues to rise due to increased population growth and the growth of the second home market. The State of Hawai‘i has seen population increase by 6.1% between the years 2000 and 2006.[254] At the same time, Hawai‘i County has had a 15.1% increase in its population, while the period of 1990 to 2000 saw an increase of over 23%.[255] The population of Hawai‘i County is rising faster than that of the other Islands, with much of the new growth being retirees moving to the County from the mainland.[256] The number of annual applications for permits for new single-family residences (which represent over 76% of residential units on the Island) has risen sharply in the last decade, as shown in Figure 6.3.[257]

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[253] Department of Business, Economic Development & Tourism "Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes." Submitted by Honolulu Chapter American Institute of Architects, July 2001.
[254] From Hawaii DBEDT databook. Available at http://www.Hawaii.gov/dbedt/info/census/popestimate/06state_pop_Hawaii/NST-EST2006-02.xls).
[255] From County of Hawaii databook, available at http://Hawaii-County.com/info/bp/sc.htm).
[256] Hawaii County permits website: accessed through http://co.Hawaii.hi.us/
[257] DBEDT Data Book, accessed through http://www.Hawaii.gov/dbedt/info/economic/databook/

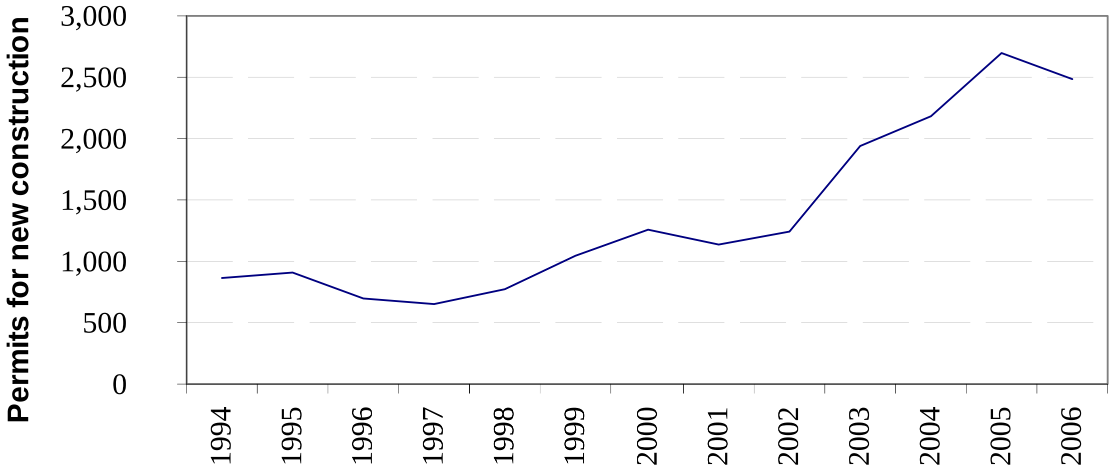

Figure 6.3: Permits issued for new residential construction

Figure 6.4 presents projections on both population and housing stock increases,[258] demonstrating the expectation of sustained and strong population growth in the coming decades.

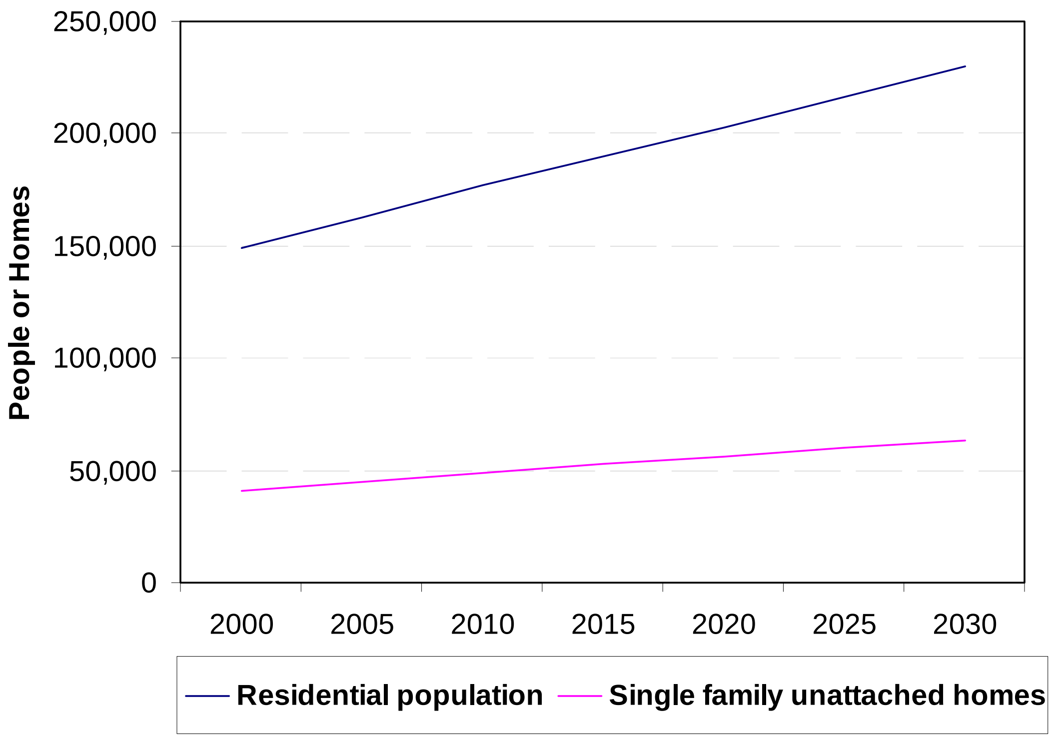

Figure 6.4: Increase in population and housing stock

[258] Increase in housing stock was calculated assuming 76% of residents in single-family detached units and 2.75 occupancy rate. Assumption per U.S. census. Original data from Hawaii County data book.

The spatial distribution of housing construction varies with housing prices. Until the mid-1990s, Puna had the majority of new construction. In recent years, the majority of new residential construction shifted to the Kona-Kohala coast, and in particular to the North Kona district. Figure 6.5 summarizes construction patterns in the districts with greatest residential growth on Hawai‘i Island (i.e., Puna, South Hilo, South Kohala, and North Kona). Starting in 2002, the amount of construction of Puna has rebounded and has nearly equaled that of the Kona coast. Permit numbers for 2004 to 2006 indicate that the cheaper Puna area has again surpassed Kona in the volume of new construction permits,[259] [260] likely due to the rising prices in Kona district.

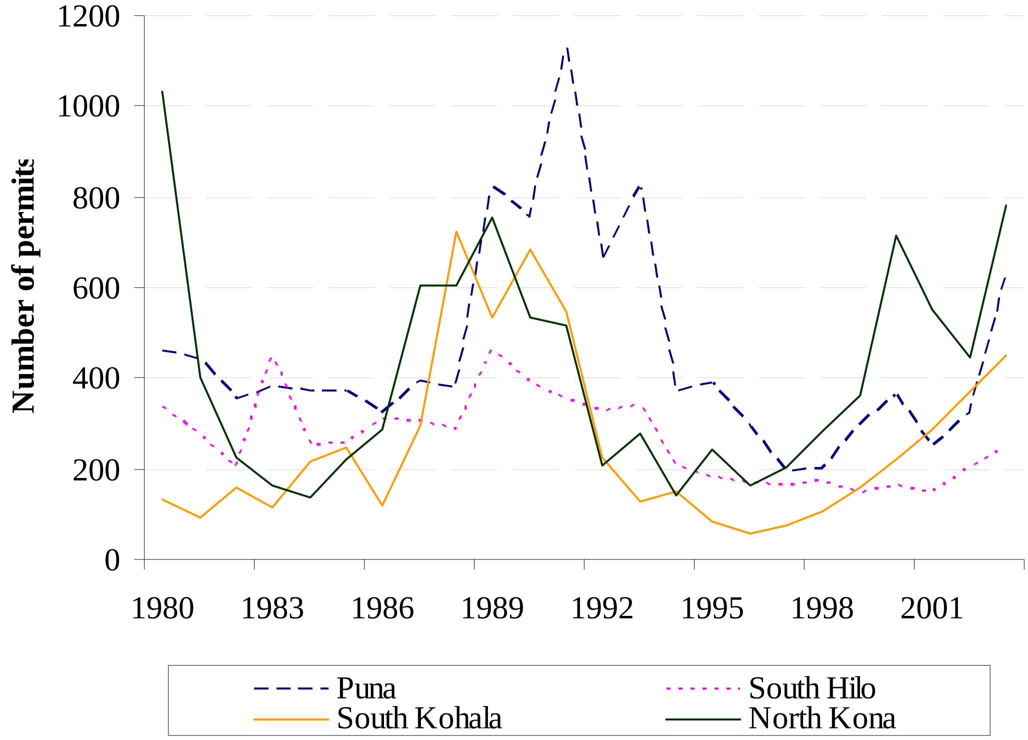

Figure 6.5: Location of new construction

Recommendation 6.2: Institute specific updates to the current building code. The current Model Energy Code is out of date and does not encourage energy efficiency.

The key regulatory instrument at the County’s disposal is the building code. Whereas a strictly regulatory approach to energy efficiency in the built environment would not be fully effective, the County can correct the most important omissions relating to energy performance of new construction from the current code. The current Model Energy Code is not effective with respect to energy efficiency.

[259]From Hawaii County website, available at http://www.Hawaii-County.com/info/bp/uc.htm
[260]From Hawaii County website, available at http://www.Hawaii-County.com/databook_current/section16.htm

Problems with the current Model Energy Code include:

1. The Model Energy Code has not been updated since 1995;
2. It is voluntary for many residential dwellings. Single family dwellings with no central air conditioning are exempt from the code requirements;[261]
3. The only provisions for energy efficiency include R-19 insulation in roofs and R-11 insulation in walls, and this is *only* required for buildings with central air conditioning;
4. Residential structures with fewer than four stories are rated as residential regardless of square footage. This applies to both hotels (R-1) and apartments and condominiums (R-2). In contrast, buildings four stories or greater are subject to commercial requirements under the code;[262]
5. The Model Energy Code is not compliant with International Energy Conservation Codes (IECC),[263] which is the basis for many of the federal programs for energy efficiency.

The effect of this weak Model Energy Code has been the construction of residences with poor energy performance and builders with neither responsibility nor incentives to improve energy performance. It has also provided builders with an incentive to build multi-family residences a maximum of three stories tall to circumvent the stricter requirements for commercial buildings. A review of 2006 permit applications reveals that all permits for new proposed construction for multi-family dwellings are three stories or less.[264]

Recommended specific changes to the current Model Energy Code: As a first step in meeting the County's goals of increased energy efficiency, the County should change the requirements for what buildings must comply with the County residential code.

1. The County should end exemption status for new residential buildings.

2. The County should institute a provision that single-structure residential developments that are 6,000 square feet in aggregate are subject to commercial requirements of the Model Energy Code. This would include most apartment, condominium blocks and very large houses that frequently serve as a second home for part time residents.

The second set of recommended measures focuses on the building envelope (i.e., outer walls; fenestration; roofing and insulation). This is not without precedent in Hawai'i: the City and County of Honolulu has implemented measures that resemble this approach.[265]

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[261] Hawaii County Code Chapter 5, Section 5-2.2.3.
[262] Howard Wiig, Hawaii DBEDT Energy Supervisor, personal communication, March 2007.
[263] From the Building Codes Assistance Project (BCAP). Available at http://bcap-energy.org/state_status.php?state_ab=HI
[264] County of Hawaii, Department of Public Works: 2006 Building Permits. Available at www.Hawaii-County.com
[265] City and County of Honolulu, Revised Ordinances of Honolulu, Chapter 32, Section 32-14.2

The code should be changed to incorporate the energy saving requirements listed below.

1. Roof heat gain: Minimum requirements for roof insulation should be R-19 or equivalent.

   Better insulation provides resistance to heat flow; it reduces the amount of heat entering a structure. There are many types of insulation, including fiberglass, cellulose, rigid foam, spray foam, and blown-in icynene (discussed at greater length below). Technologies such as ridge vents and vent fans also work well in conjunction with insulation.[266]

2. Wall insulation: R-12 insulation should be used in all walls, with credit given for use of solar-reflective surfaces.

3. Low-emissivity windows and doors: Low-e windows with maximum residential solar heat gain (RSHG) of 0.40 should be employed. These block out 99.9% of ultraviolet and 70% of infrared radiation, but still allow 65% of visible light. Low-e windows only work on those windows that receive direct sunlight.

   Two parameters (U-Factor and Solar Heat Gain Coefficient) measure a window's energy efficiency. U-Factor is a measure of the window's ability to prevent heat transfer either in or out of the building. The Solar Heat Gain Coefficient measures how well a window reflects heat with a lower SHGC number corresponding with less solar heat entering the home.[267]

4. Passive envelope cooling techniques: Heat gain should be controlled through radiant barriers, overhangs, reflective roofing, passive ventilation techniques, and shades, particularly on the west side of the structure.

5. New air conditioning units: New air conditioning units should have a minimum Seasonal Energy Efficiency Ratio (SEER) rating of 16. Ducts unions and joints should be sealed with mastic and fibrous tape.

6. Require that all additions and alterations conform to the new code: Alterations and additions to existing residences should be subject to the updated codes effective immediately. It is assumed that existing housing would be grandfathered, and therefore not subject to new code requirements.

[266] DBEDT Brochure, "Ceiling Insulation for Your Home"
[267] Department of Business, Economic Development & Tourism "Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes." Submitted by Honolulu Chapter American Institute of Architects, July 2001.

Recommendation 6.3: Expand existing and new market incentives to builders of new homes who employ energy efficiency measures. This would create a market environment that rewards those actors who use energy efficient measures in the housing market.

There are currently numerous County, State, and federal rebates, tax credits, and other financial incentives for both builders (and homeowners) encouraging energy efficiency in a number of areas.[268] These are presented and discussed below. However, in the absence of clear encouragement from the County, market inertia will hinder the implementation of these mechanisms. Market mechanisms should be directed primarily at the building community for two main reasons: (1) it is more effective to implement whole building approaches as part of new construction as opposed to after a house is built, and (2) it is easier to educate and influence a smaller group (builders) than the wider population of home owners.

With clearly signaled incentives in place, builders would implement new approaches more quickly because their initial costs would be partially offset and they would be able to increase market share by offering a more attractive product to customers. Homeowners would use them due to the cost savings accrued over time.

To this end, the County should:

- Encourage the Hawai‘i BuiltGreen, EnergyStar, and LEED programs;
- Encourage the use of the many County, state, and federal financial incentives that are available to implement efficiencies (details below);
- Take steps to facilitate the use of these incentives;
- Demonstrate to builders that they can increase market share by offering savings to potential buyers in the form of energy savings. These savings have been realized by established builders.

As a first step, the County should adopt and actively support existing programs that encourage energy efficient construction. The first such program is the Hawai‘i BuiltGreen program. This program was developed by a group consisting of builders, trade groups, researchers and academics, and Hawai‘i State government agencies. It is administered by the Building Industry Association of Hawai‘i, which is a professional trade organization affiliated with the National Association of Home Builders (NAHB).[269]

Hawai‘i BuiltGreen is a self-certification program designed for industry professionals. Approximately 250 potential design elements across a range of environmental impact areas are suggested and outlined under the program. Each element, if incorporated into a development project, is worth a point value. The program awards a rating based on the number of point accrued. Ratings are 1-Star Level, 2-Star Level, and 3-Star Level. Builders implement as many of the elements as they choose. The goal is to assist home builders implement “green” design elements into their development projects. The

[268] Database of State Incentives for Renewable and Efficiency. Available at http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=HI&RE=1&EE=1

[269] Information on the organizations activities can be found at http://www.bia-hawaii.com/.

Hawai'i BuiltGreen User Guide for Home Builder Checklist is an accompanying document that itemizes specific steps a home builder can take to improve a development's environmental performance.[270]

A potential area of concern with the BuiltGreen program lies in that it is a self-certification system and therefore may lack rigor. However, there are many areas of quality control in the construction industry that rely on the certification of a Professional Engineer.

Whereas this program does not focus exclusively on energy efficient, improved energy performance is a key component considered in the various impact areas. Environmental categories of concern under the GreenBuilt program include the following:[271]

- Design choices;
- Job site operations;
- Outdoor water conservation;
- Air conditioning features;
- Water heating;
- Electric lighting;
- Appliances;
- Interior design;
- Insulation;
- Fenestration.

The incentive for builders to implement this program is founded on the increased market share a builder would acquire by offering a more efficient product. As stated in the *Hawai'i BuiltGreen User Guide*, the program offers a customer improved quality of construction and increased affordability as energy efficient homes lower utility bills and life cycle costs. These are incentives a home builder can offer potential buyers.

A critical aspect of the Hawai'i BuiltGreen Program is that it was developed by Hawai'i based building organizations. There are many excellent energy efficiency programs currently being implemented in many markets throughout the country by industry and trade groups, as well as by government agencies.[272] BuiltGreen, however, is designed by builders and groups based in Hawai'i who are knowledgeable about conditions in Hawai'i. This is important because the environmental and market conditions in Hawai'i are unique. A local initiative with homegrown knowledge is far more likely to be successful because it responds to local needs and conditions. Hawai'i BuiltGreen is also an industry initiative and is therefore more likely than mandated solutions to be readily adopted by industry professionals. These are key reasons favoring the County's support of this venture,

[270] *Hawai'i BuiltGreen User Guide for Home Builder Checklist* guidance document is available at www.HawaiiBuiltGreen.com.
[271] Summarizes from the Hawai'i GreenBuilt Home Builder Checklist available at http://www.bia-hawaii.com/.
[272] The Greenbiz.com website is one of many online resources that provides links to organizations providing tools for energy efficiency, available at http://www.greenbiz.com/resources/energy/.

Hawai‘i BuiltGreen is increasingly being implemented on the Island of Oahu. Both the City and County of Honolulu and Maui County have active local builders' associations that are affiliated with the NAHB. It should be noted that the NAHB is taking positive steps to implement market-drive green building techniques on both a national and local scale. As a first order point of business, the County should encourage builders on the Island to tap into the momentum generated by their neighbor Island counterparts.

Another important initiative that the County should encourage is the EnergyStar program established by the federal government. This program offers an extensive list of guidelines, programs, and labels relating to energy efficiency. EnergyStar labels that relate to the energy performance of a building also provide the basis and criteria for many federal incentives. There are several advantages to this:

- Most federal rebates and tax credits are directly linked to EnergyStar criteria;
- EnergyStar is rigorous and requires third-party certification to receive benefits;
- EnergyStar focuses on energy efficiency;
- EnergyStar is a performance based standard.

The current Model Energy Code used by the County requires certain actions by the builder with respect to materials compliance but the energy performance requirements are very low. A key advantage of EnergyStar is its reliance on demonstrated performance of a building before it is labeled as efficient.[273]

LEED is a widely used and recognized system for implementing sustainable design. Energy is a key component in LEED and is an effective tool for encouraging whole-building and energy efficient design. LEED requires many other criteria not related to energy be met in order to receive one of the four LEED ratings.[274] The program does not target energy efficiencies specifically. However, LEED is a widely recognized and respected system and is an effective means of advertising the commitment of a builder or property owner to sustainable building. For instance, a requirement that all new County buildings be certified LEED Silver would convey an important message as to the County's intent with respect to green design. A feature of LEED, however, is the rigorous reporting and third-party verification requirements for achieving LEED certification. Lack of institutional knowledge is an impediment to the implementation of the LEED program. It is essential that developers and County agencies be familiar not only with energy efficient and sustainable building practices, but also with the stringent reporting requirements of utilizing LEED. LEED is an excellent program, but those new to energy efficient design may wish to consider alternatives until their familiarity with sustainable building has improved.

[273] Bases on EnergyStar Home Energy Rating System, details available at www.EnergyStar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS
[274] The four LEED ratings are Certified, Silver, Gold, and Platinum.

There are currently available a large number of utility, state, and federal financial incentives for implementing energy efficiency.[275]

Utility (HELCO):

- HELCO Energy Solutions Solar Water Heater Rebate:

  Solar water heater rebate offers $1,000 for retrofits or systems installed on new construction in the service territory of HELCO.

County

- Priority Permit Processing for Green Buildings:

  Hawaiʻi County agencies that issue building-related permits must establish a procedure at no extra cost for priority processing of permit applications for construction projects incorporating energy and environmental design building standards.

State:

- Residential Solar and Wind Energy Credit:

  Tax Credits allow individuals or corporations to claim an income tax credit of 20% of the cost of equipment and installation of a wind system and 35% of the cost of equipment and installation of a solar thermal or photovoltaic system.

Federal:

- New Energy Efficient Home Tax Credit for Builders

  Site-built homes qualify for a $2,000 credit if they are certified by a RESNet[276] Home Energy Rater to reduce energy consumption by 50% relative to the International Energy Conservation Code standard.

- Residential Solar and Fuel Cell Tax Credit

  This credit provides a 30% tax credit (up to $2,000) for the purchase and installation of residential solar electric and solar water heating property. An individual can take both a 30% credit up to the $2,000 cap for a photovoltaic system and a 30% credit up to a separate $2,000 cap for a water heating system.

- EnergyStar Building Option Packages

  Building Option Packages represent a set of construction specifications for a specific climate zone that would enable a home's energy performance to qualify

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[275] Database of State Incentives for Renewable and Efficiency. Available at http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=HI&RE=1&EE=1

[276] Residential Energy Services Network (RESNet) Home Energy Raters are certified under EnergyStar, hence the recommendation to adopt standard EnergyStar practices.

for the EnergyStar labels. This is especially useful as it allows builders in Hawaiʻi to take advantage of opportunities from the unique climate to lower energy consumption. In this way a building can be eligible for the Energy Efficient Tax Credit listed above. Building Option Packages qualify for tax credits once verified by a third party inspector.

- EnergyStar Sample Protocol

  This is a program whereby a builder with a demonstrated record of building energy efficient homes can be eligible for a reduction in the number of homes that must be independently verified as energy efficient per EnergyStar requirements. This can lead to significant reductions in transaction costs for builders.

Using the above incentives and variations thereof, the County can take specific steps to strengthen their utility to a prospective home builder. Recommended new incentives and improvements to existing ones are presented below.

- <u>Establish an environmental labeling system for homes.</u>

  Adopt the Hawaiʻi BuiltGreen and/or EnergyStar qualified homes labels. EnergyStar labeled homes are 15% more energy efficient than homes built to International Residential Code 2004 Standards, which are based on International Energy Conservation Code standards. There are also other thresholds at 30% and 50% above these standards that entitle the builder or homeowner to various additional awards and incentives. Different energy performances directly relate to different financial benefits.

- <u>Use labeling to entitle builders and home buyers to benefits.</u>

  One such benefit could be offering premium permit processing for buildings that reach a 30-40% energy reduction threshold described above. A builder could reduce construction costs through this mechanism and homeowners could make home improvements more quickly. Entitlements to builders could include expediting permit processing and reducing permitting fees.

- <u>Assist builders with paying for certifications:</u>

  Builders who have a demonstrated track record of building energy efficient homes to an established energy standard(s) should have the costs for certifying their homes as energy efficient partially offset with public funds. The cost of this could be offset with the use of Public Benefit Funds (see below).

- <u>Expedite the streamlined permitting process for energy efficient buildings:</u>

  Hawaiʻi Revised Statute §46-19.6 requires all County agencies to place a "priority on processing of permit applications for construction projects incorporating energy and environmental design building standards. The priority processing would be provided at no additional cost."

- Make EnergyStar Building Option Packages and Energy Efficiency Third-Party Verified:

  Building Option Packages and the Energy Efficient criteria are both federal programs currently administered by HELCO. This is a free service that they provide. In order to reduce backlog, a third-party verifier who is a qualified RESNet rater should be employed.
- Establish a County Energy Efficient tax credit:

  There are currently no County funds or credits that target overall efficiency. A credit that emulates the federal New Energy Efficient Home Tax Credit for Builders could be implemented, with credit indexed to the 30% EnergyStar threshold or one of the Hawai‘i BuiltGreen ratings. New homes should be performance tested in order to receive tax credits. This credit allows builders latitude to implement the most economically efficient means by which they achieve the required energy savings, encouraging innovation.

- Public Benefit Fund:

  On February 13, 2007, the PUC issued its Final Decision and Order No. 23258 in Energy Efficiency Docket No. 05-0069. The PUC ordered that "[a]ll of HECO Companies' Energy Efficiency DSM programs shall transition from the HECO companies to the Non-Utility Market Structure by January 2009…"[277] The docket also established that a Public Benefit Fund would be established for future demand side management programs. The County should work with the future third-party public benefit fund to secure financing of the various credits and incentives listed above as part of a new demand side management program. Elements of this new program would require a separate and more detailed study.

Recommendation 6.4: Develop innovative pricing and loan mechanisms that encourage homeowners to improve the energy efficiency of their current home.

It is important also to direct incentives to homeowners who wish to retrofit their homes for greater energy efficiency. Many of the incentives listed above are available to homeowners for retrofits. One of the key impediments to significant energy use reductions via new construction is due to the significant lag time in change in existing stock. As noted above, the majority of existing housing stock was built before 2000.

Homeowners are reluctant to invest in significant capital costs even when there are demonstrated long term savings. This is especially acute in Hawai‘i where the cost of living is high, land prices are high, but the median income is relatively low.

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[277] *Draft Integrated Resource Plan 2007-2026, Draft Executive Summary*. Docket No. 04-0046, March 4, 2007.

Homeowners generally wish to include any energy improvements in the cost of the mortgage (i.e., when they buy a new home). In addition, there is often reluctance on the part of homeowners to commence home improvement projects the details and technologies about which they may know very little. The challenge for home retrofits, therefore, is to overcome price concerns and lack of knowledge of the homeowner.

An innovative program that incorporates affordable pricing mechanisms therefore is necessary. One such strategy is the Home Performance with EnergyStar (HPwES) as modified and implemented in the State of Oregon.[278] As described below, Hawai‘i County should consider a variation of this system.

<u>Methodology:</u> HPwES is an existing home energy efficiency initiative that uses standards set by the EnergyStar program. It aims to use a market driven approach to identify and address areas of poor energy performance in a residence. For interested homeowners, contractors who are trained and certified by the County work with homeowners to review the energy performance of a residence and identify measures to yield cost savings through energy efficiency measures. Program elements include:

- County-approved contractors come to interested homeowners residences and perform an energy audit.
- The contractor provides an assessment of the home energy performance, a list of improvements, and a financial analysis of approximate payback time. It is then in the interest of the contractor to provide these services.
- Low interest loans are made available to the homeowner. Other mechanisms, such as performance contracting also could be made available.
- Homeowners still should be eligible for all County, state, and federal incentives listed above.
- This is market driven in that contractors would seek out and develop demand.
- A key advantage is it is one-stop shopping for the homeowner.

Recommendation 6.5: Publicize to builders techniques and practices known to improve energy efficiency. This should include introduction to Hawai‘i BuiltGreen, LEED, and EnergyStar Programs. Emphasizing a whole building approach to energy efficiency is essential for both new and existing structures.

The County should actively engage local builders to introduce them to techniques that reduce energy requirements of buildings. The efficiency measures and standards presented above would require a whole-building approach in order to qualify for incentives and benefits. As such, no single efficiency measure would be sufficient to substantially reduce building energy consumption.

Many of the efficiencies could be realized, and the resulting incentives gained, through relatively low cost changes to the way buildings are constructed as opposed to significant investment in new materials. Undoubtedly there would be costs involved for builders

[278] Energy Trust of Oregon, Inc. Details at http://www.energytrust.org/index.html

changing elements of their business practices. However, businesses constantly evolve to meet changing markets and incentive structures.

There are many building practices, materials, and techniques available for builders. It is not recommended that the County (or any government agency) instruct builders how to build energy efficient homes. The County should use market mechanisms described above to send price signals to builders and homeowners. It is useful, however, to review some of the technologies and techniques available. It is important to stress that none of these measures is a ‘silver bullet’: a whole-building approach must be employed.[279] Following is a summary of the most effective methods to reduce energy consumption given Hawai‘i’s climate. Techniques can be grouped broadly into three areas; building envelope, air conditioning, and other energy uses.[280]

Envelope. This refers to the building’s shell, which includes the roof, ceiling, outer walls, and doors and windows. From an energy efficiency perspective, the key objective in better envelope design is to reduce or even eliminate the need for air conditioning. Air conditioning is the single largest use of electricity in Hawai‘i County homes that employ an air conditioning system. Effective methods are presented in Table 6.1. Each of these technologies can lower the temperature inside the house up to 4°F and allow occupants to feel up to 9°F cooler.[281]

Table 6.1: Temperature Regulating Measures[282]

Type	Description
Light-colored roof[283]	Using more reflective (lighter) colors
Insulation	R-19 insulation on roof or ceiling, cellulosic/fiberglass or foam board types
Radiant barrier	Thermal barrier on inside of roof or ceiling. These work particularly well in warm climates like Hawai‘i.
Passive ventilation	House construction that maximizes natural ventilation. Effective use of prevailing winds and vertical ventilation techniques can eliminate the need for air conditioning altogether.[284]
Baffled roof ridge	Vent that allows attic air to vent
Solar powered roof ventilator	Vent with a solar fan that removes attic air

[279] An excellent resource that discusses the subjects presented below is the *Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes* developed for DBEDT. Builders trying to gain get energy credits to apply to the various incentives should use this resource.
[280] “Residential Home-Performance Programs National Summary.” Consortium for Energy Efficiency, August 2005. Available from www.cee1.org.
[281] DBEDT Brochure, “Ceiling Insulation for Your Home”
[282] Ibid.
[283] As an example, titanium embedded metal roofs come in numerous light and dark colors, and all reflect solar radiation.
[284] Macdonald, Virginia. *Heating and Cooling Your Building Naturally*, Solar Architectural Solutions, 2005, p.1. Discussion of passive solar ventilation.

- Shading: Shading is a low cost option for reducing heat gain in the house, which can reduce solar heat gain 80% more effectively than unshaded plate glass. Exterior horizontal overhangs are best utilized on north- and south- facing windows. Interior vertical shades, such as blinds, are best for east- and west-facing windows that experience lower angle sunlight.

- Low-emissivity windows: Low-e windows are a technique, in addition to shading, that lowers the heat gain (measured as solar heat gain coefficient). Whereas not as efficient as shading, it can be advantageous in that it does not have additional space requirements. For additional effectiveness, non-metal window frames that are less conducting (such as vinyl) should be used.

Air conditioning: Of homes in Hawai‘i with an air conditioning system, air conditioning represents the single largest expenditure in electricity. Depending on whether the system is a window mounted unit or central air conditioning system, the percentage of an air-conditioned home's total energy use which is consumed by air conditioning can range from 25% to 45% or higher. The methods listed below are proven to lower the temperature of a home and therefore reduce the need for an air conditioning unit.

- Use a minimum SEER 16 air conditioning unit

- Use a programmable thermostat

- Seal duct unions and joints with mastic and fibrous tape.

Other energy efficiencies:

- Hot water: Hot water can account for as much as 40% of a household's electricity bill, especially in those homes that are serviced by the electrical grid and that do not have central air conditioning. Passive or active solar water heaters or on-demand water heaters should be a standard application in all new homes. Details about solar water heaters are presented in Section 4.1.

- Lighting: The most effective means of reducing energy use is to minimize lighting requirements. Passive lighting systems effectively exploit Hawai'i County's excellent solar resources. Identifying opportunities for passive lighting while still avoiding heat gain should be a first step for builders.

  For those spaces that need electrical lighting, compact fluorescent light bulbs can significantly reduce the energy required to light a home and come in many sizes appropriate for a variety of uses. With greatly reduced energy use (a 13-watt compact fluorescent light bulb produces the same lumens as a 60-watt incandescent bulb) and greatly increased bulb longevity (10,000 hours versus 750 hours[285]), compact fluorescent light bulbs are one of the most cost effective means of reducing energy use. Prices are rapidly dropping; a 12-pack of GE Energy Smart CFL Light Bulbs 13 Watt sells for $23.22, or $1.93 per bulb,[286] and the payback period can be months. Details are discussed in Recommendation 6.10.

- Appliances: While appliances may represent as much as 15% of total house energy, each individual component is only a fraction of this amount. However, appliance use is increasing as people consume more electronic goods. Buying EnergyStar appliances can reduce their energy use by 15% to 40%, depending on the appliance.[287] Details are discussed below in Recommendations 6.7 to 6.9.

Recommendation 6.6: Interact directly with builders at seminars, their places of business, and building associations to detail the market benefits possible from energy efficiency.

A common reason cited by builders for not employing energy efficient measures (and green design in general) is due to the perceived cost of implementation. A survey of California builders taken in 2001 indicated their belief that green building techniques cost 10% to 15% more than conventional buildings.[288] This sentiment is echoed amongst those reluctant to use energy efficiency measures. Exacerbating this is a lack of data about the actual cost premiums of installing energy efficient measures. It is also difficult to compare cost and energy savings between homes with and without energy saving features due to the wide range of personal consumption habits amongst different homeowners.

In actuality, however, available data indicate that actual cost premiums between conventional and energy efficient homes are far lower than widely believed. A study performed in California of 33 LEED projects found that the average cost of the building was 1.84% higher than that of conventional buildings.[289]

A better gauge is from interviews with a home-building company based in Oahu.[290] This company is currently building homes that utilize many of the measures described above. It should be noted that this company is expanding and that 80% of its new business is

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[285] Department of Business, Economic Development & Tourism "Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes." Submitted by Honolulu Chapter American Institute of Architects, July 2001.
[286] Wal-Mart, GE Energy Smart CFL Light Bulbs 13 Watt, Accessed April 15, 2007, http://www.walmart.com/catalog/product.do?product_id=5650617; price for 12-pk of GE Energy Smart CFL Light Bulbs 13 Watt (60 Watt equivalent) includes $19.76 list price, 13% HI shipping cost, and 4% HI sales tax.
[287] Information from EnergyStar websites. Accessible at www.EnergyStar.gov.
[288] Kats, G (principal author), "The Costs and Financial Benefits of Green Buildings. A Report to California's Sustainable Building Task Force." October 2003.

[289] Ibid.
[290] Robert Kayser, Director Gentry Homes Construction (www.gentryHawaii.com), personal communication, March 2007.

from referrals. They take full advantage of the various County, State, and Federal incentive plans. Financial incentives they are not allowed to keep are passed on to the customer as cost savings, as described below.

This builder's costs for constructing an energy efficient home were only about 3 to 4% above that of a conventional residence. Table 6.2 presents some of the implemented measures and associated costs.

Table 6.2: Possible measures implemented for energy efficiency[291]

Measure Implemented	Details	Cost
Insulation in walls and roof	Icynene blown-in insulation	$5,000 total for installation in ceilings, walls
Solar water heater	Operating costs ~10% of conventional heater[292]	$2,500[293]
SEER 16 AC	High-efficiency two-stage units	$800 additional to upgrade from SEER 12 to 16
EnergyStar appliances	Electric ranges and dishwasher	Varies
Low-e windows	Double glazed, SHGC 0.29	$2,800
Vinyl window frames	Less conductive than normal metal	$2,000
Dimmable compact fluorescent light bulbs	As standard	Negligible[294]

The builder puts a total of approximately $11,000 worth of capital improvements into a home. Some of this is returned in the form of tax credits and incentives. The federally financed New Energy-Efficient Home Tax Credit for Builders offers $2,000 for each home that attains a 50% reduction over International Energy Conservation Code 2004 energy standards and this builder is currently attaining those standards. The development that is currently under construction contains 307 homes, which will yield $614,000 in federal tax credits for the builder.

However, the real incentive to the builder is the additional market share they were able to gain through ***offering homeowners the immediate benefits and cost savings of a reduction of 60% in their utility bill***. An average homeowner in Hawaiʻi consumes approximately 600 kWh of electricity per month, leading to bills of nearly $200 per

[291] Robert "McKibbin" Mist, Head of Procurement, Gentry Builders, personal communication (except where otherwise noted), April 2007.
[292] Department of Business, Economic Development & Tourism "Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes." Submitted by Honolulu Chapter American Institute of Architects, July 2001
[293] This is cost to the builder for a new unit and rebates are passed on to the consumer. Costs of installation to a homeowner for a 120-gallon solar water heater are identified in Recommendation 4.1.
[294] Refer to Recommendations 6.11 and 6.12 of this report for additional information regarding compact fluorescent light bulbs

month. If energy efficiency measures reduce electricity consumption by 60%, the homeowners would save $1,400 per year in energy costs.

The homeowner would also benefit from one-time solar water heater credits as follows:

- Utility rebates of $1,000 rebates and tax credits.
- State tax credits of 35% total a maximum of $2,250
- Federal tax credits of 30% to a maximum of $2,000

This is a truly win-win situation accomplished through the use of the existing market and minimal regulatory control.

Reduced energy demand for Hawaiʻi County. A hypothetical situation was envisioned to assess the potential impact of these efficiencies. If every new single-family detached home built in Hawaiʻi County in 2006 were built to the same standard as the example from Oahu provided above, there would have been 12 million kWh saved in total electricity use in 2006.[295] This represents an approximately 3.4% reduction in electricity use compared to the case where energy efficiency measures were not incorporated in new construction. Assuming approximately 26% efficiency of a HELCO power plant[296], this is equivalent to approximately 26,200 barrels of oil equivalent saved for this hypothetical first year.

Table 6.3 below presents the scenario described above. It shows estimated energy savings in the first year after energy efficiency measures are applied to all new single-family unattached housing stock. Values presented assume 2005 as a base year and that all new subsequent housing is 60% more energy efficient.

[295] This represents first-year energy savings. This calculation assumes that all new construction is built per Gentry Builders specs and attain 60% reductions in energy use, and assumes that all existing housing will continue to consume 591 kWh per month. This calculation only examines single-family unattached housing.
[296] Power generation average efficiencies obtained from U.S. Energy Information Administration. Accessible at http://www.eia.doe.gov/

Table 6.3: Comparative Energy Use Single Family Unattached Housing[297]

Uses	Without energy efficiencies	With energy efficiencies
Monthly avg use/residence for existing houses (kWh)	591	591
Housing in stock	45,237	45,237
Monthly use for in stock housing (kWh)	26,700,000	26,700,000
Annual use for in stock housing (kWh)	321,000,000	321,000,000
Projected number of new homes for 2006	2,698	2,698
Electricity use for new homes	591	236
Annual Use for New Housing	19,100,000	7,650,000
ANNUAL TOTAL USE (kWh)	340,000,000	328,000,000
Energy Savings (kWh):		**12,000,000**
Import savings (boe):		**26,200**

As more energy efficient houses are built over time, energy savings would increase. Figure 6.6 shows these savings graphically over time until 2030.[298]

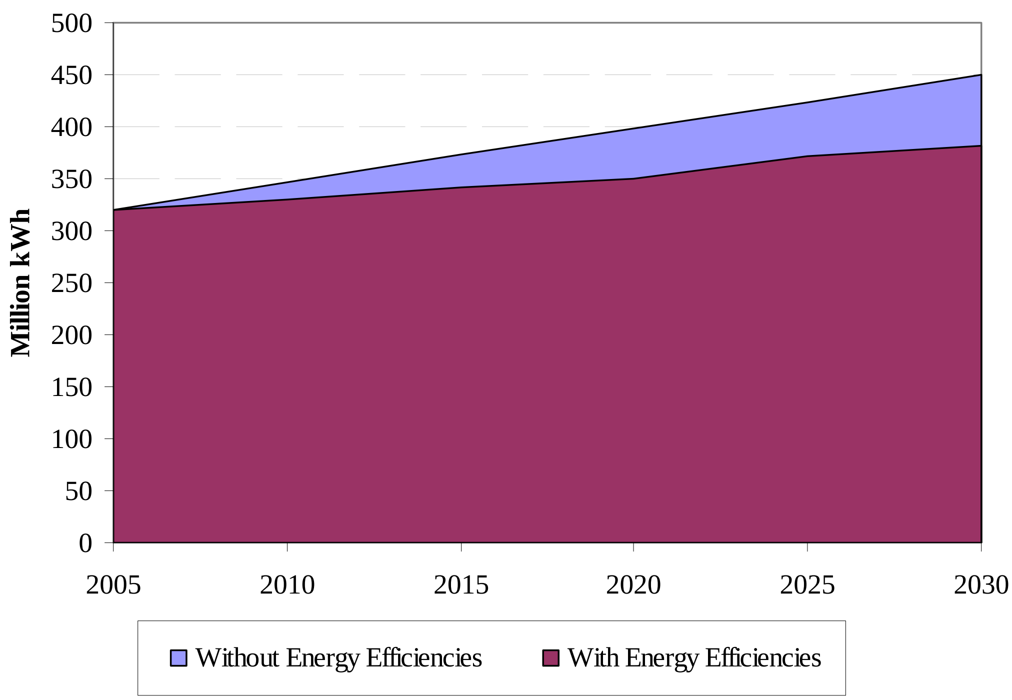

Figure 6.6: Island-wide energy savings due to efficient home design

[297] Assumes the monthly residential average electricity use for 2005; assumes all new housing stock with 60% energy savings efficient, and housing construction projections from DBEDT's Hawaii Data Book, 2005; only compares single family unattached housing. 236 kWh energy use for future homes calculated by 40% of 591, i.e. 60% energy savings.

[298] Figure 6 based on the same assumptions as those for Table 6.3. Derived from State of Hawaii DBEDT databook

Table 6.4 shows the potential savings over time in terms of barrels of oil equivalent. The table shows projected increase in single family homes in Hawaiʻi County and the increase in oil consumption both with and without energy efficiency measures implemented into new homes.

Table 6.4: Projected savings from energy efficient homes (barrels of oil equivalent)

Year	Number of single family homes	BOE without energy efficiencies	BOE with energy efficiencies	BOE savings
2005	45,047	730,000	730,000	0
2010	48,847	791,000	754,000	37,000
2015	52,592	852,000	779,000	73,000
2020	56,116	909,000	801,000	108,000
2025	59,736	968,000	849,000	119,000
2030	63,481	1,028,000	873,000	155,000

Point of Sale Incentives and Information for Efficient Appliances and Lighting

Effective point of sale incentives and information distribution for energy efficient appliances and lighting could result in significant changes in energy demand across existing households. Recommendations 6.7 to 6.10 present suggestions for how to achieve changes in the appliance and lighting market, the combined effect of which could reduce total electricity demand as much as 4.5% below 2005 levels (see Table 6.5).

Table 6.5: Potential energy savings with appliance and lighting point of sale incentives[299]

End use	Annual electricity savings (kWh)	Maximum electricity savings across all households (kWh)	Savings as percent of residential electricity demand	Savings as percent of total electricity demand
Lighting, compact fluorescents	795	33,100,000	7.80%	2.96%
Air conditioning	483	8,580,000	2.02%	0.77%
Refrigerator	72	1,780,000	0.42%	0.16%
Clothes Washer with 50% cold wash	414	7,870,000	1.85%	0.70%
Dishwasher	72	888,000	0.18%	0.07%
TOTAL	**1,762**	**52,200,000**	**12.3%**	**4.67%**

[299] Assumptions: 1. Household appliance penetration in Hawaii County: dishwasher (50%), clothes washer (77%), refrigerator (100%), A/C unit (72%), lighting (100%, average of 30 bulbs per house). 2. Existing market penetration of EnergyStar: 59% for appliances and 30% for light bulbs. 3. Take back effect from improved energy efficiency is 10% of savings. 4. Clothes washer run on cold water 50% of time, and cold water washing consumes 10% of energy needed for regular washing. 5. Electricity rate of $0.327 in Hawaii County. References: EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov

Recommendation 6.7: Create point-of-sale incentives that eliminate the price premium of energy efficient air conditioning units, refrigerators, dishwashers, and clothes washers.

Although lifetime energy savings associated with energy efficient appliances far outweigh the initial price premium (see Table 6.6), residential consumers often make purchasing decisions based on sticker price alone because they rely on a subjective discount rate.[300] Although most investments in energy efficient appliances are associated with financial benefits in the long run, consumers using a "subjective discount rate" may omit the long-run cost savings of efficiency investments.[301] An example of the effect of a subjective discount rate can be seen when a consumer calculates the cost of buying a particular appliance; in this calculation, the consumer may not factor in the cost of the energy and water needed to run the appliance, concentrating instead on the sticker price (upfront cost) of the model. Subjective discount rates are a common barrier to the marketing of energy efficient appliances, which tend to have higher upfront costs but much lower energy and water requirements than their conventional counterparts.

Table 6.6: Cost savings and price premiums for select EnergyStar appliances[302]

Appliance	Annual savings	Lifecycle savings	EnergyStar price premium
Dishwasher	$27	$170	$50
Clothes Washer	$123	$694	$300
Refrigerator	$23	$205	$30
Air conditioner	$158	$1,453	$30

Point of sale incentives that eliminate the upfront price difference between conventional and energy efficient models offer a simple solution to the problem of subjective discount rates. Hawai‘i County could reduce barriers to the purchase of energy efficient models as well as enhance the cost savings associated with these models by eliminating the additional upfront cost of efficient appliances (see Table 6.7), possibly using revenue from the Public Benefit Fund.

[300] Discount rate: the process of determining the present value of a quantity of money at some future date. Bhattacharjee, V.,C. Cicchetti, and W. F. Rankin, "Energy Utilities, Conservation, and Economic Efficiency", *Contemporary Policy Issues*,11(1), Jan 1993: 69-75.
[301] Net present value: a method of measuring cash flows that takes into account the price of financing an investment. NPV is used as a measurement of the financial payoff of making a particular investment. (Ibid.)
[302] Electricity rate of $0.327, EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov

Table 6.7: Payback period in Hawai‘i County with and without point of sale incentives[303]

Appliance	Conventional cost	EnergyStar cost	Cost difference Per unit	Simple payback period of additional cost (yrs)	Simple payback period of additional cost (yrs)
				Hawai‘i	*Hawai‘i w/ incentive*
Dishwasher	$450	$500	$50	1.8	0
Clothes Washer	$450	$750	$300	2.4	0
Refrigerator	$1070	$1100	$30	1.3	0
AC Unit	$470	$500	$30	0.2	0

The program cost of point of sale incentives and potential energy savings of varies considerably across appliances. With limited funding availability, the appliances have been ranked in order of cost of incentive relative to kilowatt hour savings: compact fluorescent light bulbs, air conditioner units, refrigerators, dishwashers, and clothes washer (see Table 6.8).

Table 6.8: Ranking of cost of point of sale incentives by appliance[304]

Ranking	Cost of point of sale incentive per unit	Total cost per kWh saved	Total cost
1. Compact fluorescent lighting	$1	$0.05	$1,670,000
2. Air conditioning	$30	$0.06	$533,000
3. Refrigerator	$30	$0.42	$740,000
4. Dishwasher	$50	$1.67	$617,000
5. Clothes Washer	$300	$2.43	$5,700,000

Recommendation 6.8: Promote the significant utility bill savings associated with energy efficient appliances by providing customers with appliance energy use data based on Hawai‘i County electricity rates at point-of-sale.

Since Hawai‘i County's electricity costs are much higher than the national average, using energy efficient appliances in Hawai‘i results in much better utility bill savings as well. However, the savings calculations for energy efficient models distributed with these appliances tend to reflect the lower electricity prices for the U.S. mainland, and thus do not accurately represent the savings in Hawai‘i County. For example, advertisements on

[303] Electricity rate of $0.327, EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov
[304] Ibid.

EnergyStar appliances include the EnergyGuide, an example of which is show in Figure 6.7.

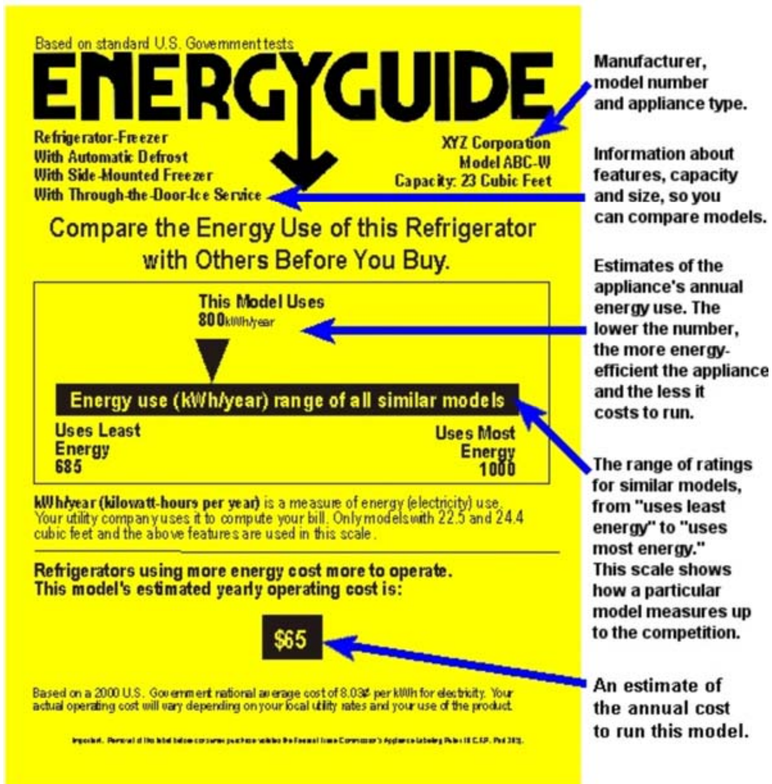

Figure 6.7: EnergyGuide for 800 kWh/year refrigerator-freezer unit at $0.08/kWh

With the current average electricity costs on the mainland at about $0.10/kWh, the average annual electricity cost of running this refrigerator is about $80. For Hawai‘i, average operating costs for the same model would be about $262. Over a 10 years, the cost to operate this refrigerator would be about $2600 in Hawai‘i versus about $800 in the mainland. Hawai‘i County’s higher electricity rates have the effect of amplifying the cost burden of energy inefficient appliances and the positive effect of energy efficient appliances. Consider the range of models offered in the EnergyGuide label depicted in Figure 6.7 (see Table 6.9).

Table 6.9: Effect of Hawai‘i County’s higher electricity rates on cost savings from energy efficient appliances

Refrigerator Model	Energy Demand per year in kWh	Annual Energy Cost on Mainland	Annual Energy Cost in Hawai‘i County
A- most efficient	685	$69	$224
B- medium efficient	800	$80	$261
C- least efficient	1000	$100	$327

Table 6.9 illustrates the significant differences in cost associated with running the same appliance in Hawai‘i and the mainland United States. In areas with lower electricity

rates, the yearly differences between operating the most and least efficient model is about $30; in Hawai‘i the difference is $100 per year.

Perhaps more striking, however, is the comparison between mainland electricity rates (represented by Energy Guide labels) and Hawai‘i County rates (not represented by Energy Guide labels). Although not their original purpose, Energy Guide labels for Hawai‘i County would serve to increase consumer awareness of the effect of individual purchasing decisions on monthly and annual expenses.

Table 6.10 demonstrates several examples of the cost savings associated with EnergyStar appliances for Hawai‘i County residents compared with the U.S. Mainland.

Table 6.10: Cost savings of EnergyStar appliances in Hawai‘i and U.S. mainland[305]

Appliance	Annual savings	Annual savings	Lifecycle savings	Lifecycle savings
	Hawai‘i	*U.S. Average*	*Hawai‘i*	*Mainland*
Dishwasher	$27	$11	$170	$88
Clothes washer	$123	$55	$694	$147
Refrigerator	$23	$7	$205	$42
Air conditioner	$158	$48	$1,453	$424

In addition to eliminating the price difference between efficient and conventional appliances, energy use data specific for Hawai‘i County customers should be used in marketing energy efficient appliances, since purchasing decisions for appliances can dramatically affect household electricity demand. Although the EnergyGuide specifically states that its calculations are based on an electricity rate of $0.084 per kilowatt hour, Hawai‘i County customers should not be expected to calculate the cost savings for their residential rate of $0.327 per kilo-watt hour. An effective and easily implemented marketing tool (e.g., a “Hawai‘i County EnergyGuide”) would advertise these additional cost savings from higher electricity rates on the appliances themselves.

Recommendation 6.9: Provide residential customers with information on cold water washing. Deliver information at point-of-sale and to existing customers.

Since approximately 90% of the energy used for washing clothes is required for water heating, washing clothes using lower water temperatures (warm instead of hot, cold instead of warm) can yield significant electricity savings and reduce the utility bills for residential customers.[306] The County should promote the use of cold water washing in energy efficient and conventional washing machine models. Residential customers

[305] Electricity rate of $0.327, EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov

[306] Department of Energy, Energy Efficiency and Renewable Energy, “Energy Savers: Tips on Saving Energy and Money at Home”, Accessed: April 2007, http://www1.eere.energy.gov/consumer/tips/laundry.html

should be assured that cold water washing would not affect the cleanliness of their clothing, as there is no minimum temperature required for optimum cleaning within a clothes washer.[307]

The Environmental Protection Agency's EnergyStar program estimates that the average annual energy consumption for a clothes washer is 531 kWh/year for conventional models and 234 kWh/year for EnergyStar models. Assuming that washing on cold water cycles saves 90% of the energy consumption and that clothes can be washed on cold water cycles 50% of the time, annual energy consumption could be reduced to 292 kWh for conventional models and 129 kWh for EnergyStar models. An EnergyStar model run on cold water cycles 50% of the time could save Hawai'i County's residential consumers $132 annually compared with costs for conventional models run on regular wash cycles (see Table 6.11). It is important to note that these calculations assume that an electric water heater is being used. The benefit of cold water washing would greatly decrease if the home had a solar water heater.

Table 6.11: Cost savings from electricity with cold water clothes washing[308]

Wash cycle	Conventional models		EnergyStar models	
	Annual Energy Demand (kWh)	*Annual Electricity Cost*	*Annual Energy Demand (kWh)*	*Annual Electricity Cost*
100% regular cycle	531	$174	234	$77
25% cold cycle	412	$135	181	$59
50% cold cycle	292	$96	129	$42
75% cold cycle	173	$56	76	$25
100% cold cycle	53	$17	23	$8

Water savings represent another facet of product differentiation between conventional and EnergyStar units. As the previous table indicates, the difference in electricity cost savings for conventional and EnergyStar models run exclusively on cold water cycles is small ($17 vs. $8 annual electricity cost). Assuming that consumers would not be willing to wash exclusively on cold water cycles – 50% of the time may be a best case scenario – this difference may increase to $54. However, this table does not show the difference in water costs associated with both models, which greatly favors the use of EnergyStar clothes washers: a typical conventional washer uses 13,494 gallons of water per year compared with an EnergyStar washer that uses 7,886 gallons per year. The water costs for a conventional model remain much higher than those with an EnergyStar model since the quantity of water used per wash cycle does not vary with temperature.

[307] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Reduce Hot Water Use for Energy Savings" Accessed: May 1, 2007.
http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13050
[308] Electricity rate of $0.327, EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov

Recommendation 6.10: Distribute information on payback time and cost savings associated with compact fluorescent light bulbs and expand Hawaiian Electric Company's incentive coupon program to HELCO customers.

Representing approximately 10% of total demand, residential lighting is another important component of household electricity use. Replacing conventional (incandescent) bulbs with compact fluorescents would save residential customers hundreds of dollars annually. The energy benefits of compact fluorescents are widely recognized and a demand side management incentive program run by HELCO parent company Hawaiian Electric Co (HECO) began in 2006. The HECO program enhances the significant cost savings associated with exchanging incandescent bulbs for compact fluorescents (see Table 6.12).

Table 6.12: Cost savings from avoided electricity with compact fluorescent light bulbs[309]

Compact fluorescent bulb rating (watt equivalent)	Hawai'i cost savings		Oahu customers cost savings with HECO coupon	
	Annual	*Lifetime*	*Annual*	*Lifetime*
One 60 w-e bulb	$11	$39	$13	$46
One 100 w-e bulb	$9	$30	$14	$48

HECO's program offers three compact fluorescent light bulb coupons for General Electric bulbs: $1.00 off for GE Spiral CFL single pack, $2.00 off for GE Spiral CFL double pack, and $3.00 off for GE Spiral Specialty CFL. A similar program should be adopted in Hawai'i County to encourage the purchase of CFLs, and could be run by HELCO or the County.

Additionally, the County should encourage retailers to promote CFLs in order to expand their use. WalMart introduced a compact fluorescent light bulb campaign this year in which the company intends to sell 100 million bulbs between January 1 and December 31, 2007. A 12-pack of GE Energy Smart CFL Light Bulbs 13 watt (60 watt equivalent) would sell for approximately $23.22, or $1.93 per bulb on Hawai'i Island, which has WalMart stores in Hilo and Kailua-Kona.[310]

At Hawai'i's 2007 electricity prices, the payback period on a single 60 watt equivalent compact fluorescent light bulb is about two months. Annual savings over a 12 pack of 60

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[309] EnergyStar CFL Savings Calculator, accessed: May 2007. www.EnergyStar.gov. Assumptions: for Hawaii, assumed average lighting hours per day of 1.045 (CFL 60) and 0.75 (CFL 100), electricity rate of $0.327, and CFL prices of $1.93 (CFL 60) and $2.52 (CFL 100). Prices based on 12-pack price for CFL 60 and CFL 100 from WalMart.

[310] WalMart, GE Energy Smart CFL Light Bulbs 13 Watt, Accessed April 15, 2007, http://www.walmart.com/catalog/product.do?product_id=5650617; price for 12-pk of GE Energy Smart CFL Light Bulbs 13 Watt (60 Watt equivalent) includes $19.76 list price, 13% HI shipping cost, and 4% HI sales tax.

watt equivalent compact fluorescent light bulbs is about $109 in Hawaiʻi compared with a U.S. average of $76.[311] These savings can be enormous for residential customers. A typical household in Hawaiʻi County could save as much as $380 annually by simply replacing thirty 60 watt incandescent light bulbs with 60 watt equivalent compact fluorescents (see Table 6.13).

Table 6.13: Compact fluorescent light bulb cost savings per package[312]

Packs	Bulbs per pack	Bulbs in use	Annual savings	Lifecycle savings
1 pack	12	10	$127	$127
2 pack	24	20	$253	$891
3 pack	36	30	$380	$1,337

[311] All calculation based on Hawaii electricity rate of $.327 per kWh and mainland electricity rate of $.10 per kWh. The hours per day using lights are less than on the mainland.
[312] Electricity rate of $0.327, EnergyStar Appliance Calculators, Accessed: April 2007, www.EnergyStar.gov

6.2 DEMAND – BUILDING EFFICIENCY: Commercial Buildings

Recommendation 6.11: Implement a combination of regulatory mandates and market incentives to improve commercial building energy performance.

Commercial electricity use accounts for approximately 41% of total HELCO electricity sales.[313] Unlike the residential housing sector that has a largely uniform pattern of energy use, commercial buildings vary widely in their energy use both in terms of processes requiring energy and time of day use. Due to the broad range of end users, it is difficult to implement commercial energy efficiency measures that are applicable to all. Figure 6.8 shows samples of different energy uses for different commercial spaces in Hawai‘i.[314]

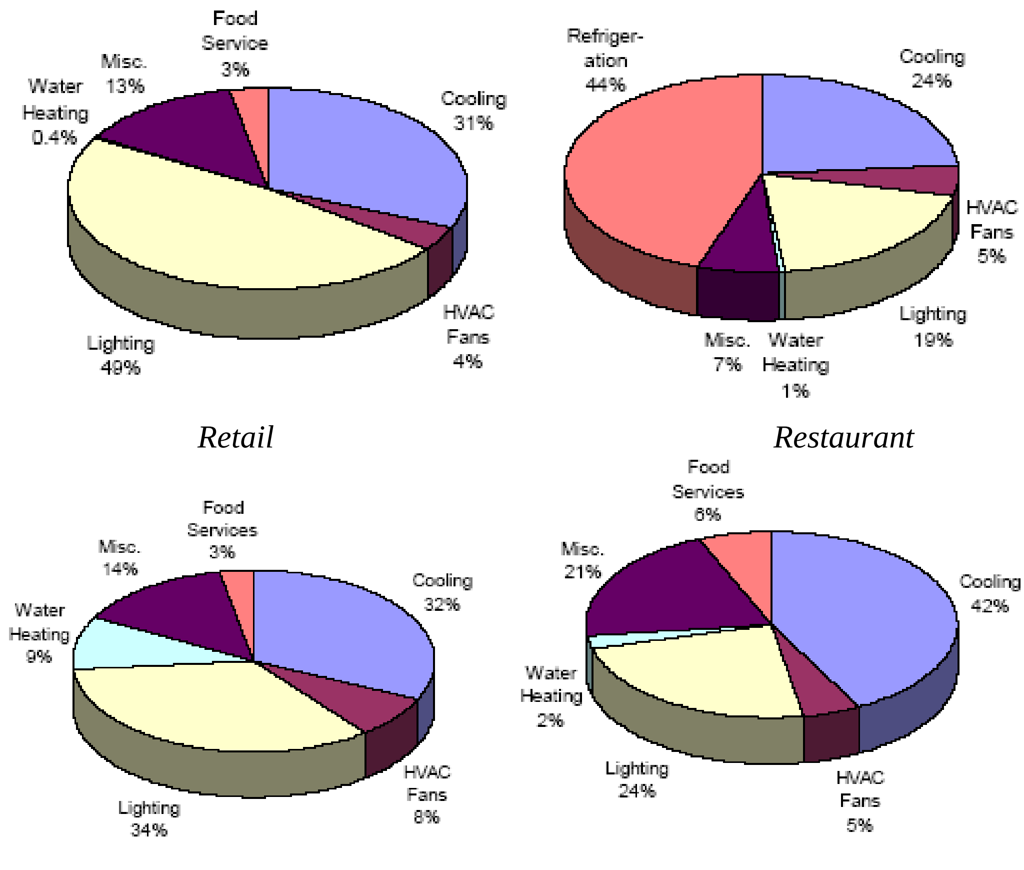

Figure 6.8: Energy use of different commercial spaces in Hawai‘i

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313 County of Hawaii Data Book Section 13: Utilities and Communications: available at http://www.Hawaii-County.com/databook_2004/section13.htm

314 Department of Business, Economic Development & Tourism. “Hawaii Commercial Building Guidelines for Energy Efficiency.” 2004. Document available at www.Hawaii.gov/dbedt/ert/cbg

Whereas air conditioning is still an important component to energy use, lighting use and miscellaneous (usually office equipment) become more of an issue as compared to residences.

Implications of the above are as follows:

1. Performance based standards for buildings are required for energy efficiency as opposed to a specific set of technologies and measures;
2. Operations of commercial buildings require more active management than that of residences.

Current impediments to change include:

- Lack of regulatory control (outdated codes);
- Incomplete understanding of potential cost savings (life cycle costing);
- Lack of building commissioning;
- Incomplete knowledge of available energy saving technologies and measures.

County efforts to reduce energy use in commercial buildings should seek to redress the inertia created by the above factors. As was the case with residential structures, the County should affect change with a mix of regulatory and market mechanisms.

Recommendation 6.12: Update requirements of the current commercial code in addition to adopting ASHRAE/IESNA 90.1-2004 as the basis for the energy code.

Hawai‘i County uses ASHRAE/IESNA 90.1-1989 for commercial buildings. While this is an improvement over its residential code, it is still one of the oldest codes in the nation. Only five other states use this code; 36 states have stricter commercial building codes and both Maui and Oahu use the more recent 90.1-1999 standards.[315] The result is commercial buildings are not required to implement available energy saving measures.

The County should implement the following:

1. As a first order of business, adopt ASHRAE 90.1-2004 standards for new commercial building construction.

   In adopting this code, the County would place itself at the forefront of energy efficiency for this sector.

2. Mandate cool roofs for all new commercial construction.

   Roofs are a primary means of heat transfer into the building interior. Whereas the County should avoid mandating specific technologies as a rule, roofs are common to all commercial buildings. Large energy savings are possible with relatively little additional expense. This system has been implemented to good effect in California and the County should consider adopting wholesale or with

[315] From the Building Codes Assistance Project (BCAP). Available at http://bcap-energy.org/state_status.php?state_ab=HI

modifications the California nonresidential building requirements regarding roof emittance and reflectivity.[316]

3. Require a rain-watering harvesting evaluation for new construction.

   With the exception of various catchment systems and a single reservoir system in Waimea, most of the water in Hawai‘i is obtained from pumped groundwater. Pumping water is energy intensive and expensive. As part of the permitting process, commercial building developers should be required to evaluate the possibility of installing rain-water harvesting techniques that can be used for such non-potable uses as watering lawns and flushing toilets. Rain-water harvesting techniques could include:
   - Synthetic tanks that collect storm water from roof drains;
   - Roof-top tanks for flushing toilets;
   - Piping that directs stormwater directly to surrounding lawns and gardens;
   - Permeable pavements for parking lots with a collection system (higher cost).

4. Require life cycle costing for large projects.

   As a condition of obtaining permits, large commercial construction projects should be required to perform a life-cycle costing analysis that compares project design with one that meets the “Energy Efficiency” threshold of EnergyStar. The intent of such a requirement would be to familiarize building owners with the long-term costs and benefits of implementing energy efficiency measures.

Recommendation 6.13: Provide incentives to builders of commercial structures that encourage energy efficient construction. Advertise potential cost savings builders can offer commercial building tenants and owners as a means of attracting market share.

As with residential savings, the real benefit of energy efficiency is increased market share by demonstrating cost savings to the customer. If the building owner occupies the building, savings can go directly to their bottom line. If building owners leases space, favorable energy performance would be an effective marketing strategy. For office buildings, electricity purchases can correspond to 19% of total building/office space expenditures,[317] and the energy bill reduction is a direct financial savings. Improvements in efficiency can be made through retrofits or, more effectively, during construction of a new building.

There are numerous County, State, and federal incentives available to builders and to owners to reduce energy consumption, many of which resemble or are the same as those available to residential housing builders and owners. As was the case with residential construction, through implementation of the more stringent code (which would

[316] 2005 Building Energy Efficiency Standards - Nonresidential Compliance Manual, Section 3-4
[317] Commercial Building Performance – Office Building Sector Fact Sheet. www.cee1.org

incorporate use of the new ASHRAE standard) and other energy savings rewarded with the various incentives, builders would improve the energy efficiency of buildings.

To this end, additional steps the County should take are as follows:

1. Establish a labeling system that corresponds to energy efficiencies.

   In the same manner as for residential housing, such a labeling system would in effect provide a measure of energy performance and goal for builders to reach. Labels would also provide the mechanism by which builders and building operators access the various financial entitlements, expedited permitting, and advertising to potential tenants that the building is energy efficient. EnergyStar, LEED, and Hawai‘i GreenBuilt all provide labeling and certifications systems that could provide a basis for this.

   A set of tools that provide energy efficiency assessment and performance tracking are available from EnergyStar. The “Portfolio Manager” is a benchmarking tool that collects a building’s energy and water data, tracks key consumption, performance, and cost information, and provides information to improve buildings performance during normal operation.[318] A similar tool is the “Target Finder” which helps architects, builders, and prospective clients set realistic goals with respect to a building’s energy performance. This is an important exercise to be implemented before a building is constructed.

2. Establish a financial incentive for building performance that emulates the federal Energy Efficient Commercial Buildings Tax Deduction.

   This deduction provides financial rewards and labeling to buildings that demonstrate 50% reduction in energy use over ASHRAE 901-2001 standards.[319] By prescribing a performance-based approach, the architect and builder are able to determine the appropriate mix of measures to achieve efficiencies and provide for different commercial needs as opposed to simply meeting regulatory and code requirements.

3. Require commissioning agents for all new large commercial construction projects.

   In the same manner as a RESNet rater for residences, a commissioning agent would provide documentation that building systems function in compliance with code criteria. Such a system would verify goals have been met. The agent could also verify that criteria for incentives had been met. The costs for this function could be paid for initially by the Public Benefits Fund. The commissioning agent could also serve as a resource for more energy efficient design, but it is essential

[318] Additional information for EnergyStar Portfolio Manager is available at http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager.
[319] Database of State Incentives for Renewable and Efficiency. Available at http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=HI&RE=1&EE=1

that the agent remain an objective party that does not stand to gain from design decision.

4. Provide rewards for certifying building engineers as Building Operators.

   Virtually all commercial buildings have facilities engineers. Building owners and managers should be rewarded for having building operators specifically certified in maximizing building electrical, air conditioning, and energy efficiencies. Such certifications exist.[320] The position would pay for itself by saving money for companies by improving energy efficiency. The County could reward companies through expedited permitting. Cost of training could be borne through the Public Benefits Fund.

The benefits of more efficient buildings are similar to those of the residential sector. The construction cost study noted earlier that reviewed costs of LEED implementation versus standard construction found a range of 0.66% to 6.5% additional capital costs required to get LEED certification for commercial buildings.[321] In terms of benefits, simply improving management of the air conditioning system can yield energy savings of up to 15%.[322] Energy performance modeling predicts that 30% savings in energy costs for an office space equates to an increase of 4% in net operating income.[323]

[320] Building Operator Certification, www.theboc.info
[321] Kats, G (principal author), "The Costs and Financial Benefits of Green Buildings. A Report to California's Sustainable Building Task Force." October 2003.
[322] "Commercial Building Performance – Office Building Sector Fact Sheet." Available at www.cee1.org
[323] Ibid.

6.3: DEMAND – BUILDING EFFICIENCY: Public Sector

Recommendation 6.14: Require that all new County buildings, buildings built on County land, and buildings using some share of County funds, meet or exceed LEED or EnergyStar certification.

Public facilities are among the largest users of electricity on Hawai‘i Island. Major consumers include the Department of Water Supply, the airports, schools, hospitals, and government office buildings. The County has been a pioneer in implementing building efficiency projects, having already retrofitted many County office buildings. The State has also taken an active approach, through its “Lead by Example” initiative. This initiative directs agencies to improve energy, water, and resource efficiency in State buildings, as well as improve efficiency or use alternative fuels in State vehicles.[324]

When examining the life cycle costs of a building, many energy efficiency measures pay for themselves in reduced energy costs. By requiring high standards for County building design, the County would reduce the total energy demand of future buildings while giving contractors invaluable experience in implementing state-of-the-art efficient construction. Useful tools designed to assess and improve energy performance in buildings, such as the EnergyStar “Portfolio Manager” and “Target Finder,” should be used by the County where applicable. Every new County building or facility built on County lands or with County funds should be required to meet or exceed one of the recognized standards, such as EnergyStar labels, LEED certification, or the Hawai‘i BuiltGreen standards. If attaining such certification is not possible, the project must obtain a waiver to bypass this performance standard.

[324] Department of Business, Economic Development & Tourism, “Lead by Example: State of Hawaii Agencies’ Energy Initiatives” report for fiscal year 2005-2006.

7.1: DEMAND – DEPARTMENT OF WATER SUPPLY: Leak Detection and Repair

Recommendation 7.1: Support the ongoing Department of Water Supply's Island-wide program to identify and repair water distribution leaks.

Pumping water is the single largest annual energy expenditure of any County agency. The County's Department of Water Supply (DWS) is one of the largest single customers of HELCO. Hawaiʻi County relies almost exclusively on pumped water for its drinking water needs and pumping groundwater is one of the most expensive and energy intensive ways of delivering water to consumers. DWS used 54.4 million kWh of electricity in 2006 at a cost of $14.8 million for the purpose of pumping groundwater.[325] This represents approximately 5% of total Island electricity use. DWS operates more than 60 deep extraction wells and delivers water to 38,000 residential, commercial, and industrial accounts. Approximately 192 extraction and booster pumps transmit water to various holding tanks and, ultimately, to consumers. With the assumption that pumping shall remain the significant means of water delivery, it is essential that DWS work to make the system as effective as possible, thereby maximizing energy efficiency

Given the high cost and energy intensity of pumping water, minimizing pumped-water losses during transmission is a priority. Much of the existing transmission infrastructure is old, degraded, and prone to leakage. More water must be pumped than is needed to meet demand, resulting in greater energy costs and usage, as well as water wastage. In 1999, DWS established an Island-wide program to identify system leaks and perform studies to estimate costs of repairs.[326] The purpose of the program was two-fold: (1) to repair existing leaks and (2) to provide continuous system maintenance in order to minimize the need for leak repairs. This ongoing program has resulted in successful leak repair and subsequent energy savings.

The leak studies revealed that leaks in the water extraction, transmission, and distribution system were especially acute on the East Side of the Island near Hilo where the system is older than in other districts of the County. As recently as 2005-2006, 44% of water in the Hilo distribution system was lost in transmission and distribution. Table 7.1 shows total daily production and loss of water for each of the districts in 2005.

[325] DWS Summary of 2005/2006 Energy Use Comparison/Year End Projection, compiled by Process Energy Services, LLC
[326] Ibid.

Table 7.1: Water losses in 2005[327]

District	System use (gpd)	Well production (gpd)	Percent unaccounted
Puna	1,399,000	1,633,000	14.3%
Hilo	5,970,000	10,709,000	44.3%
Hamakua	720,000	823,000	12.5%
North Kohala	569,000	581,000	2.1%
South Kohala	5,431,000	6,223,000	12.7%
North Kona	9,758,000	10,261,000	4.9%
South Kona	1,252,000	1,562,000	19.9%
Kau	617,000	705,000	12.5%
Total	**25,715,000**	**32,496,000**	**23.3%**

Phase 1 of the DWS' leak detection and repair program focused on the Hilo area. Included in the Hilo area are the Piihonua well and booster pump systems. The Piihonua well system consists of three wells and is one of the two biggest well systems on the Island. A total of 27 leaks were identified in the Piihonua system,[328] accounting for 66% of the water losses in the Hilo District.[329]

DWS has made significant progress in identifying and repairing leaks in the Hilo District. Water tracking units were installed in the transmission system to assist in identifying leaks. Costs of repairs were estimated at $1,000 per leak.[330] The payback time for each repair was calculated at between 1 month and 8 years, with the median simple payback period being approximately 10.5 months.[331] Phase 1 of this program has since been completed and unaccounted for (lost) water in the Hilo district has reduced from >44% to 19%. The recently completed 2005-2006 DWS fiscal audit revealed that repairing leaks in Hilo saved DWS approximately $715,000 in annual energy costs.[332] Phase 2 of this program was recently implemented and seeks to address leaks in the South Kohala area. Phase 3, which will address leaks along the Kona coast, is scheduled to commence in late 2007.

Clearly this is a program that should be encouraged. The leak repair portion of this program has resulted in Island-wide losses in pumped groundwater decreasing from 23% in 2005 to 12% in 2007. The American Water Works Association, a non-profit scientific organization dedicated to water supply issues, considers 10% system loss an acceptable threshold

[327] "Total Percent Unaccounted" calculated by using a weighted average.
[328] Groundwater is pumped from deep wells to the surface. Booster pumps subsequently push water uphill to a series of holding tanks from where they are delivered to customers.
[329] "Economic Analysis Report for the City of Hilo Non-Revenue Water Loss Identification and Repairs", July 2006, prepared by Process Energy Services, LLC
[330] Ibid.
[331] Ibid.
[332] Email exchange with Bettina Arrigoni and Earl Fukunaga from DWS.

In addition to energy and cost savings from better system operations, the Department may also take advantage of the HELCO Rider M Program. Rider M offers a reduced rate if a consumer can reduce demand during the peak 5-9 p.m. period. Currently, DWS has a number of pump systems on Rider M, saving hundreds of thousands in electricity costs per year. Improvement in system efficiencies and increases in storage capacity could allow the Rider M program to expand even more.

7.2: DEMAND – DEPARTMENT OF WATER SUPPLY: Distributed Generation with Microturbines and Photovoltaics

Recommendation 7.2: Install generating pressure reducing valves on water transmission lines to reduce grid demand from pumping.

The Department of Water Supply has the opportunity to install renewable generation to lessen their demand from the grid. Through the installation of microturbines (generating pressure reducing valves), potential energy due to elevation changes in water transmission can be captured in the form of generated electricity. Microturbines have been installed in Hawai‘i County, but there is considerable opportunity for additional generation. DWS is currently installing two microturbines in Kona. A 40 kW installed system costing $550,000 is expected to pay for itself in four to five years.[333] Each installed unit will save the County hundreds of thousands of dollars throughout its lifetime. The Department of Water Supply plans to maximize the installation of microturbines on its system.

Recommendation 7.3: Install photovoltaic modules on water transmission lines to reduce grid demand from pumping, possibly at Lalamilo pumping area.

In addition to micro-hydro generation, the Department could also generate electricity through dedicated photovoltaic modules or concentrated solar power. The Lalamilo pumping area has been noted as a potential site for photovoltaic generation. Third-party installations would have the most financial benefit.

[333] Robert Arrigoni, Hawaii County Research and Development, personal communication, March 2007.

7.3: DEMAND – DEPARTMENT OF WATER SUPPLY: Conservation Strategy

Recommendation 7.4: The Department of Water Supply should develop a County-wide conservation policy that reduces the demand for pumped groundwater.

There are numerous potential measures for water demand that may yield significant energy and cost savings and that this report did not fully explore. Such programs would have the dual benefits of reducing total energy demand and also allowing the Department of Water Supply to fully exploit cost savings from Rider M rates. This would make available additional funds for infrastructure improvements and energy efficiency programs. Specific areas of study should include:

- Rainwater harvesting on large commercial/industrial properties and resorts for the purposes of landscaping and flushing toilets.
- Installing water reuse infrastructure as a means of reducing the need for pumped water and preventing the expansion of service areas.
- Creating a progressive pricing scheme for water that considers total use, energy use, and reuse.
- Developing incentives for large users to reduce dependence on pumped water. This is especially applicable to those areas that use private water supplies.
- Creating point-of-sale incentives for water efficient clothes washers, low-flow toilets, and showerheads.

8. DEMAND – TRANSPORTATION

8.1 DEMAND – TRANSPORTATION: Public Sector

Mass Transit and Rideshare

Recommendation 8.1: Increase use of public transit system by funding additional bus runs, late shift runs, and adding a Kona International Airport bus route.

The County of Hawai‘i faces a unique set of challenges when it comes to implementing a mass transit program due to the Island's dispersed population and long commuting distances. Bus transit benefits all Island residents by reducing pollution, cutting energy use, and easing traffic congestion. Increased busing also makes roads safer by allowing tired drivers to ride the bus rather than commute two hours each way across the Island. A diverse cross-section of Hawai‘i residents use the public bus system, including hotel workers, teachers, hospital workers, and many others. These riders save money on commuting costs (fuel alone costs approximately $24 per day for a roundtrip cross-Island commute) and, as long as empty seats are available, commuters are able to work, sleep, or relax for the duration of their commute.

Hawai‘i Mass Transit has recently implemented changes that are having dramatic effects on the quality and convenience of the Island's transportation system. Bus ridership has increased 25-40% each year since Hawai‘i Mass Transit implemented the free bus policy in October 2005 (see Table 8.1). With buses already reaching 85-98% capacity on the majority of their runs, Hawai‘i Mass Transit is planning to expand the current bus service by bringing ten more buses onto the Island in the summer of 2007.[334] The five additional large buses, which have 49 seats each as well as standing room if needed, would provide: 1) more frequent service, such as more than the six cross-Island runs that now run between 3:30 and 5:20 AM, and 2) expanded daily service, such as more late-shift runs. These needs were identified through public requests and rider surveys. The three to five small buses that will join the fleet in summer 2007 will provide improved services for the Island's disabled population.[335]

Hawai‘i Mass Transit's plan to add more runs and destinations is a positive step. County residents and visitors would benefit even more if trips to Kona International Airport were included in the expansion plans. Such expanded service would aim to increase the number of passenger trips by 20% per year until 2015 and 5% per year from 2015-2030. By comparison, from 2005 to 2006 February trips increased 46%, and from 2006 to 2007 trips in February increased 28% (Table 8.1).

If additional bus runs increase ridership by 20% per year and the proportion of long to short rides (80%-20%) remains the same, the total fuel savings would be approximately 5.5 million gallons of gasoline annually by 2014, as shown in Figure 8.1. The fuel cost savings would be worth more than $15 million, and over 800,000 tons of CO_2 emissions would be avoided. These cost savings are realized in two ways: 1) Busing uses less fuel per passenger mile than driving, and 2) the County pays less per gallon of diesel ($2.37-

[334] Tom Brown, March 2007 meeting.
[335] Ibid.

$2.78 per gallon) than the consumer pays per gallon of gasoline (over $3.00 per gallon) because the County does not pay tax on its fuel purchases.

Table 8.1: Bus trips per month

Date	Number of trips	Percent increase
February 2005	22,500	--
February 2006	33,000	46%
February 2007	41,420	28%

In addition to these fuel cost savings, the County police department is likely to save resources by investigating fewer accidents as a result of fewer miles driven. While the police department does not currently track these statistics, data collection efforts by the highway department or police department would allow the County to accurately quantify its savings. In aggregate, the estimated cost savings for society from avoided fuel use, avoided accidents, and avoided fatalities would be nearly $18 million (Figure 8.2).

Public bus service makes Hawai‘i’s roads safer, saves money for the County and private citizens, provides an important service for people from a variety of socioeconomic backgrounds, reduces pollution, and reduces oil imports. Extensive free bus service not only saves money and energy, but also improves the quality of life on Hawai‘i.

Recommendation 8.2: Create and stimulate use of a Hawai‘i Island rideshare system, in part by supporting the marketing efforts of the University of Hawai‘i at Hilo.

One way to reduce gasoline and diesel consumption is to encourage Hawai‘i residents to share rides. In addition to simply reducing fuel consumption, ridesharing reduces commuting costs, eases traffic congestion, and can provide benefits like safer roads and building community.

Hawai‘i Mass Transit is rolling out an Island-wide rideshare program in late 2007. The rideshare program will be an inexpensive program the County can promote to provide commuter alternatives, especially for cross-island trips.

It is important to have a visible, public launch of the program since its success depends on public awareness and adoption of the program. The County has developed a partnership with a University of Hawai‘i at Hilo marketing class to educate citizens about the upcoming program launch and is providing funds for publications and postage. The County should track the advertising campaign closely and continue to support the effort if it is successful.

To further increase awareness of and participation in the program, the County should introduce incentives for government employees to carpool to work or use some other alternative means of transportation, such as busing or biking. One funding mechanism for rideshare advertising and incentives could come from dedicating a portion of County Fair Share Assessments or Impact Fees to these programs.

Another important piece would be the park and ride facilities that Hawai‘i Mass Transit is planning to build. Such facilities are crucial for increased participation in bus and rideshare systems so that residents can enjoy hassle-free access to alternative transportation options.

Figure 8.1 shows the amount of fuel used by Hawai‘i vehicles if ridership in buses and rideshare remain the same (Baseline), if bus ridership increase 20% per year as a result of the expanded bus service (20% Bus Growth), and if ridershare is adopted by Hawai‘i residents for 3% of their trips (20% Bus Growth + Rideshare). The least fuel is used when both the bus and the rideshare programs are in place (black line).

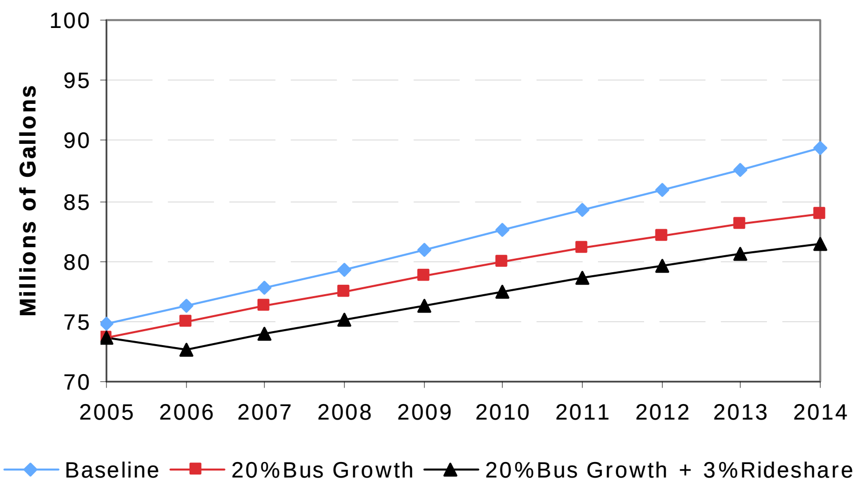

Figure 8.1: Potential reduction in transportation fuel use with increased bus ridership and rideshare.

Figure 8.2 shows the cost if no changes are made (Baseline), if bus ridership increases 20% per year (20% Bus Growth), and if rideshare is adopted by Hawai‘i residents for 3% of their trips (20% Bus Growth + 3% Rideshare).

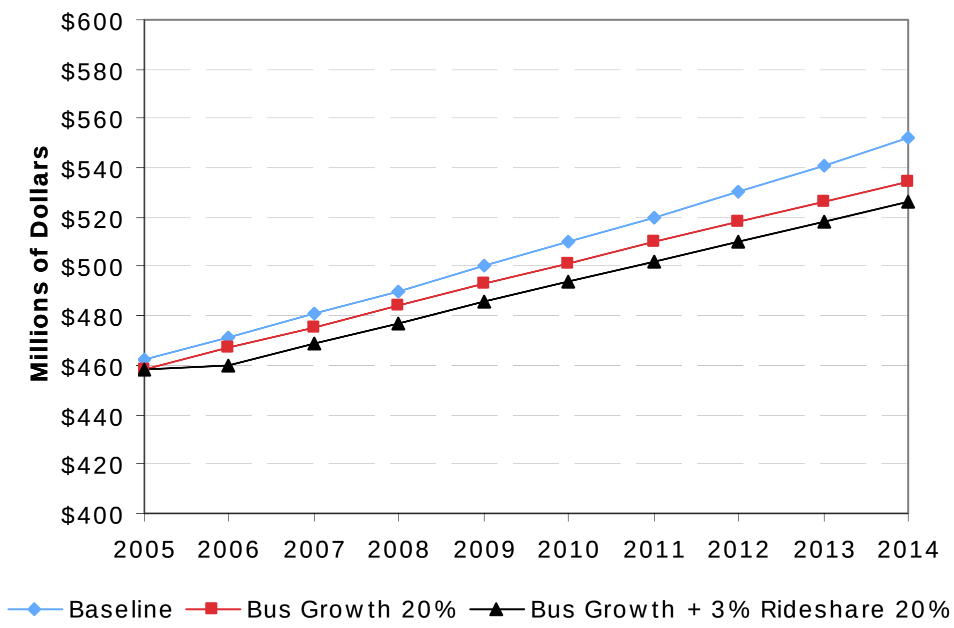

Figure 8.2: Total cost of vehicle transportation on Hawai‘i, including fuel, accidents, and fatalities.

Recommendation 8.3: Maximize efficiency of public school transportation through a survey of parents and school administrators to find out what proportion of children are driven to school, walk, bike, or take the bus.

Hawai‘i’s generally hospitable climate should cater well to walking, riding, and busing to school. Busing reduces pollution, reduces gasoline costs for parents, and alleviates traffic congestion on roads near schools. Buses are also one of the safest ways for children to get to school. Walking and biking are good exercise for children, but many of the Island’s schoolchildren may live too far from school to walk or bike.

Anecdotal reports reflect that children are increasingly being driven to school rather than walking or taking the bus, a trend that is not just limited to Hawai‘i. A survey could provide important information about the barriers to using less energy-intensive school transportation like walking, biking, and busing. Once these trends are identified, school and County officials can work together to reduce the energy footprint of school commutes. For example, if the barriers are related to inconvenient bus routes, administrators and parents can work together to design more user-friendly bus routes. If there are information barriers, a bus campaign, possibly administered through the University of Hawai‘i at Hilo marketing class, could be initiated and administered. The first step is identifying the trends in school transportation and understanding the barriers to realize more efficient school transportation.

Idling

Recommendation 8.4: Enforce the State prohibition on engine idling while the vehicle is stationary

The State of Hawai‘i technically has a law that prohibits vehicle idling for more than three minutes, but the law has not been enforced.[336] Hawai‘i County should take this opportunity to enforce the State idling prohibition for a number of reasons. First, idling wastes fuel; an idling bus uses half a gallon of diesel per hour. Second, idling contributes to local air pollution and greenhouse gas emissions; a bus idling for one hour releases 11 pounds of CO_2. There are a number of strategies that the County can employ to spur compliance with the idling law. It is recommended that the County advertise the idling prohibition and follow this public awareness campaign with a handful of warnings and fines for buses idling longer than three minutes. Specific targets might include private hotel buses and rental car company buses, which tend to idle rather than turn off their engines while they are waiting for passengers at each end of their loop. Warnings can be issued to both the driver and the managing company, and fines can be split between both parties. Some states structure their idling laws so that bus drivers pay a small amount and the company pays the bulk of the fine.

The County should post anti-idling signs near school parking lots and ask school officials to advertise the idling prohibition for school buses. A Connecticut study found that school bus idling near schools is damaging to children's health and the State is now launching an education campaign to have drivers turn off their school buses to reduce air pollution and protect children.[337] Hawai‘i may be able to get some federal assistance to support a school bus education campaign; the federal Energy Efficiency Promotion Act authorized $5 million per year for 2007-2013 for the Departments of Energy and Education to help schools and local governments reduce school bus idling and educate citizens about the benefits of such actions.[338]

If Hawai‘i wants to take an additional step against idling, the County could recommend that the State strengthen the State idling law along the lines of Environmental Protection Agency's (EPA's) model idle reduction law.[339] The set of rules requires that bus companies that need to idle for passenger comfort adopt idle reduction technologies and specifies fines of $150 to $500 for violating drivers and the registered vehicle owner, respectively. The EPA also outlines a financial assistance system for buying idle reduction technologies, which each cost between five and ten thousand dollars. (This is

[336] Compilation of State, County, and Local Anti-Idling Regulations. US Environmental Protection Agency, April 2006. http://www.epa.gov/smartway/documents/420b06004.pdf. Last accessed April 2007.
[337] Anti-Idling Efforts in Connecticut. http://www.ct.gov/dep/cwp/view.asp?a=2684&q=322086. Last accessed April 2007.
[338] Energy Efficiency Promotion Act. http://209.85.165.104/search?q=cache:PtEc3mZ4YfoJ:energy.senate.gov/public/_files/EnergyEfficiencyPromotionActOnepager.doc. Last Accessed April 2007.
[339] State Idle Reduction Model Law with Discussion Comments. http://www.ct.gov/dep/lib/dep/air/diesel/docs/stateidlelaw.pdf. Last Accessed April 2007.

1-2% the cost of a large 49-person bus.[340]) A number of states, such as California and Pennsylvania, have developed financial assistance programs for pollution prevention devices on commercial vehicles.

County Vehicle Fleet

Recommendation 8.5: For vehicles purchased for the County fleet, require that an increasing share of new light duty vehicles meet energy efficient vehicle standards set by HRS §103D-412 and that new and existing heavy duty vehicles meet alternative fuel targets established by Hawai'i State law ("Alternative Fuel Standard").[341] Additionally, the County should support ongoing incremental increases to the Alternative Fuel Standard.

Numerous County governments throughout the Western United States have instituted vehicle purchasing policies that introduce energy efficient vehicles (hybrid, alternative fuel, electric) and fuels (biodiesel, lower sulfur diesel, ethanol blends) into their fleets. Hawai'i County should require the purchase of energy efficient vehicles for its light duty fleet and require the use of biodiesel blends for its heavy duty fleet.

For light duty vehicles, the County should at least meet the energy efficiency[342] standards established under Hawai'i Revised Statute §103D-412 for State vehicle fleets (note that the County should develop its own time frame for implementation): [343]

1) In the fiscal year beginning July, 2007, at least thirty per cent of newly purchased light-duty vehicles shall be energy efficient vehicles;
2) In the fiscal year beginning July 1, 2008, at least forty percent of newly purchased light duty vehicles acquired by each covered fleet shall be energy-efficient vehicles;
3) For each subsequent fiscal year, the percentage of energy-efficient vehicles newly purchased shall be five percentage points higher than the previous year, until at least seventy-five per cent of each covered fleet's newly purchased, light duty vehicles are energy- efficient vehicles.

Since the goal for the Island is reduced fuel consumption, the County should consider a version of the State statute that mandates an increasing share of light duty vehicle purchases meet the energy efficiency standards established under HRS §103D-412. This

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[340] Tom Brown, Department of Mass Transit, personal communication, March 2007.

[341] The State of Hawaii's Alternative Fuel Standard establishes that alternative fuels must comprise 10% by 2010, 15% by 2015, and 20% by 2020 of total highway fuels, U.S. Department of Energy, Energy Efficiency and Renewable Energy, Hawaii Incentives and Laws, Accessed: April 2007. http://www.eere.energy.gov/afdc/progs/ind_state_incentive.cgi?HI

[342] Under this statue, "energy efficient vehicles" are defined as those capable of using an alternative fuel, those powered primarily through an electric battery or battery pack, those propelled by power derived from one or more cells converting chemical energy directly into electricity, those drawing propulsion energy from onboard sources of stored energy generated from an internal combustion or heat engine, or those on the list of "Most Energy Efficient Vehicles" in its class.

[343] HRS §103D-412 will have limited impact in Hawaii County, as there were just 4 vehicles were registered to the state government. Hawaii DBEDT, Hawaii Databook 2005,Table 18.09 Vehicle Registration, By Taxation Status, By County: 2005, *Transportation Section*, 13.

would accelerate the penetration of higher efficiency vehicles into the County fleet and improve overall fuel savings associated with the program. Additional fuel savings may be achieved by requiring the County's heavy-duty vehicles to comply with the Hawai'i Alternative Fuel Standard established by the State of Hawai'i. As all of the County's heavy-duty vehicles are diesel powered[344], most should be able to convert to a biofuel blend of at least B20.[345]

Potential fuel savings for the County fleet range from modest to significant depending on the new vehicle procurement policy selected (see Figure 8.3).[346] In the scenarios, the baseline refers to fuel demand for the existing County fleet, assuming that current trends in vehicle fleet growth remain constant. "HRS Scenarios" refers to the annual percentage increases established by Hawai'i Revised Statute §103D-412 and "All Efficient" refers to a more aggressive procurement policy requiring that 100% of new light duty vehicles meet the HRS §103D-412 standards. "MPG30" and "MPG56" refer to average fuel economy ratings in miles per gallon for the new vehicles. In both HRS and All Efficient scenarios, the heavy duty vehicles meet the Alternative Fuel Standard using biodiesel blends of B20 and B90.[347]

A seemingly more aggressive Alternative Fuel Standard for heavy-duty vehicles may not result in significant fuel demand differences in the long term (see Figure 8.4, "Most Biofuels" scenario) because of constraints on the use of high biofuel content fuels in certain vehicles. It is unclear how many of these vehicles could use biofuel blends higher than B20 or equivalent. For existing vehicles, a cost effective retrofitting process could increase the expected energy demand reductions associated with high biofuel content fuel blends (for instance, B90) in the County fleet. However, a conservative assumption holds that certain vehicles will remain incapable of running on biofuel blends.

Rather than devoting resources to the development of its own Alternative Fuel Standard, the County should focus its efforts in lobbying for an increase to the statewide Alternative Fuel Standard. Keeping in line with the incremental increases of the current Alternative Fuel Standard, alternative fuels should represent 30% of highway fuels by 2030.

[344] Randy Riley, Head of Hawaii County Department of Public Works, Automotive Division, personal communication, May 2007.

[345] Biodiesel blends of 20% or less, such as B20 or B5, can be used with almost any diesel-powered engine and require few or no modifications. National Renewable Energy Laboratory, "Biodiesel Fact Sheet", Clean Cities Program, April 2005, Available: www.eere.energy.gov/cleancities/blends/pdfs/37136.pdf

[346] For all scenarios, assumptions are as follows: vehicle scrappage rate of 1.72% annually (compared with 3.45% for private fleet), total vehicle growth rate of 2% annually, with total new vehicle purchases a sum of scrappage rate and total growth rate.

[347] The Alternative Fuel Standard requires 20% of highway fuel to be met by alternative fuels in 2020 with interim goals of 10% in 2010 and 15% in 2015. For this model, it was assumed that the Alternative Fuel Standard would be extended with a goal of 30% alternative fuel by 2030 and that the County Fleet did not impose Alternative Fuel Standard standards on its light duty vehicles.

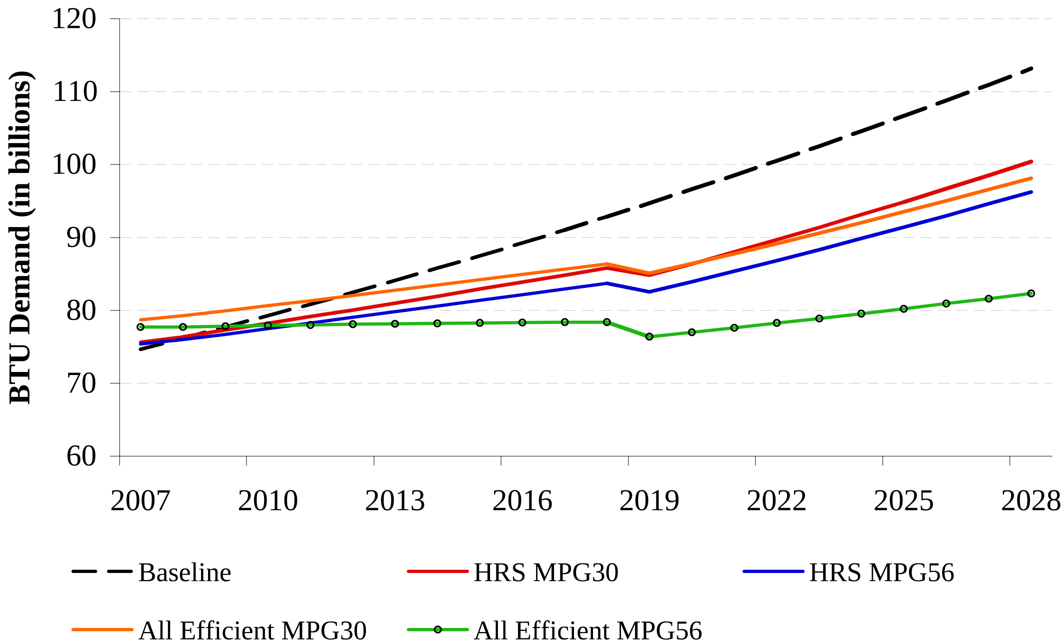

Figure 8.3: Fossil fuel demand reductions for County fleet, 2008-2030[348]

[348] Model assumptions: 1. County fleet is 65% light duty vehicles with an average fuel economy of 23 mpg and 35% heavy duty vehicles (all diesel burning) with an average fuel economy of 7 mpg, total annual miles of 10043 per vehicle, annual vehicle scrappage rate of 1.7% and rate of new vehicles added per year of 2%, conversion factors of fuel to Btu of 109000 Btu per gallon of gasoline and 120000 Btu per gallon of biodiesel.

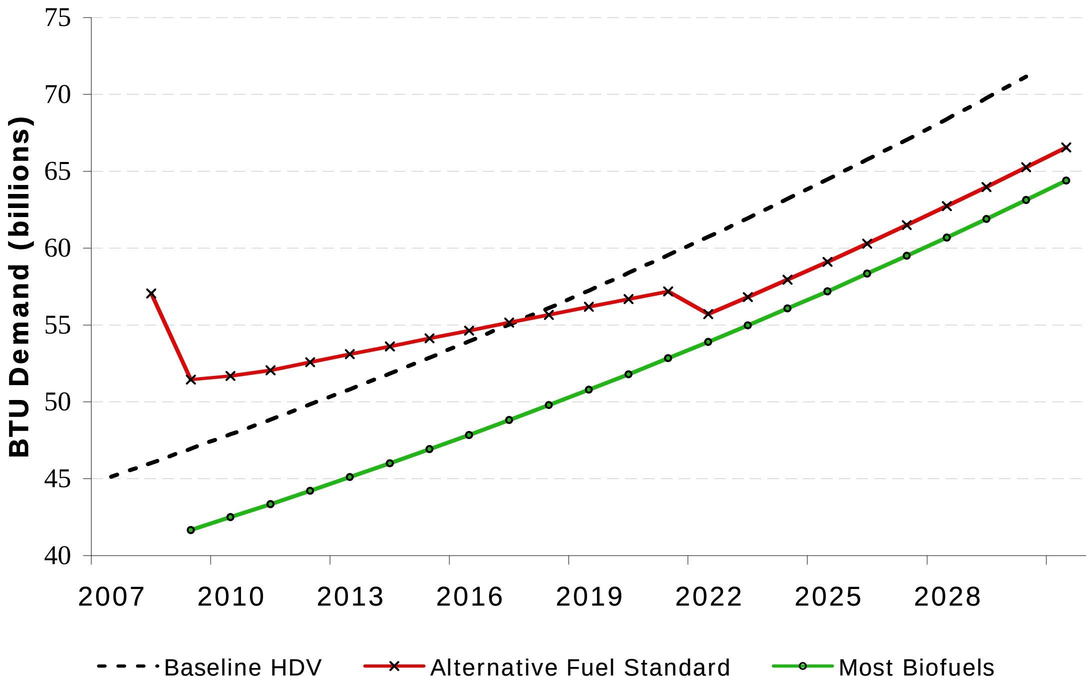

Figure 8.4: Fossil fuel energy demand under alternative fuel scenarios for heavy duty vehicles[349]

[349] Model assumptions: 1. County fleet heavy duty vehicles (all diesel burning) have an average fuel economy of 7 mpg, total annual miles of 10,043 per vehicle, annual vehicle scrappage rate of 1.7% and rate of new vehicles added per year of 2%, conversion factors of biodiesel to Btu of 130,000 Btu per gallon; 2. Alternative Fuel Standard and All efficient fleet Scenarios: assume that the County fleet is capable of supporting a maximum of 20% B100 vehicles and 10% of vehicles that cannot be converted to biodiesel engines. The Alternative Fuel Standard scenarios remains within these boundaries and complies with the targets set by the statewide standard.

Transportation Lighting

Recommendation 8.6: Replace all incandescent bulbs installed in traffic signals lights and airport lights, as safety standards and community standards allow, with LED bulbs. Encourage the Department of Public Works to pursue solar street lights in applicable locations using proven solar lighting technology.

LED bulbs use one-sixth the energy of traditional incandescent light bulbs to provide the equivalent lumen output. A successful and nearly complete transition from incandescent bulbs to LED bulbs in traffic signals across Hawaiʻi County illustrates the cost effectiveness of energy-saving LED bulbs. Hawaiʻi County should take advantage of the opportunity to save money and reduce energy use by switching to LED bulbs wherever applicable.

Traffic Signals

Starting in 2002, Hawaiʻi County began installing EnergyStar-certified LED bulbs in all traffic signals.[350,351] The motivation for the switch was threefold: 1) the LED bulbs provide brighter, better quality traffic signals, 2) LED bulbs use less energy, resulting in lower costs and improved efficiency, and 3) LED bulbs require less maintenance, reducing costs. As of April 2007, all traffic lights on County roads had been converted. Of the 30 lights on the State roads, all the reds and greens have been converted.[352,353]

While LEDs have higher upfront costs, they consume only 15 to 25% the energy (Table 8.2) and last about five times longer than their conventional counterparts. These characteristics translate into more predictable and less frequent replacement, which saves the County on maintenance fees. The maintenance savings are accrued in two ways: 1) less frequent bulb changes, and 2) routine changes instead of emergency maintenance. Because LED bulbs contain many small diodes, the lights dim over time and do not burn out all at once. Incandescent bulbs burn out abruptly and have to be replaced immediately to maintain road safety, but multiple LED lights can be replaced at the same time on a set schedule because they dim gradually. This reduces the need to assemble costly emergency maintenance teams.[354] Because LED lights dim over time, the County prefers to replace them every five years (compared with the rated ten year lifespan) to maintain desirable brightness.

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[350] EnergyStar Program Requirements for LED Traffic Signals: Eligibility Criteria. http://www.EnergyStar.gov/ia/partners/product_specs/eligibility/traffic_elig.pdf. Last accessed April 2007.
[351] The County Department of Public Works paid for all of the traffic light bulb conversions despite the fact that the State pays for the electricity bills that accrue on its traffic lights. A County request for State funds for bulb conversions on State highways was denied.
[352] Ron Thiel, Head of Traffic Division of Department of Public Works, personal communication, April 2007.
[353] The County changes yellow lights last because they are on for much less time than reds and greens, so they have a longer payback time. The yellows will be converted soon.
[354] Ibid.

Hawai‘i County roads have 51 intersections, for which the County pays all electricity bills.[355] Although a precise breakdown of quantity and type of light per intersection was not available, it is assumed for these calculations that each intersection has approximately 19 bulbs of which red/green each account for 7 bulbs and yellow accounts for 5 bulbs .[356] As such, the County pays for approximately 988 traffic light bulbs throughout Hawai‘i County[357]: 364 each of red and green, and 260 yellow.

Based on this approximation, the County pays about $15,400 for 988 red, green and yellow LED bulbs. In comparison the County would pay about $128,000 per year to run its traffic lights if all 988 lights on County roads used incandescent bulbs. For further comparison, over a five-year period the average intersection would cost $13,700 to power using incandescent bulbs and just $3,000 using LEDs.[358] Over their five-year lifetime, LED lights save the County about $10,700 per intersection.[359]

Table 8.2: Energy cost of LED and incandescent traffic lights in Hawai‘i County[360]

	Color	kWh per year per bulb	Cost per year per bulb	Total Energy Cost per year (all bulbs)
LED	Red	62.4	$20.41	$7,429
	Yellow	6.6	$2.15	$559
	Green	62.4	$20.41	$7,429
Incandescent	Red	520.1	$170.08	$61,909
	Yellow	54.8	$17.90	$4,655
	Green	520.1	$170.08	$61,909

In addition to the savings illustrated in Table 8.2, the County also benefits from avoiding yearly maintenance costs associated with emergency bulb changes, a common problem with incandescent bulbs, whose sudden burnouts darken traffic signals. In contrast, LED bulbs are made up of many diodes, which burn out periodically and cause the light to slowly dim over time. The routine maintenance costs associated with LEDs are much

355 Wendy Tuliao, Hawaii County Department of Public Works Traffic Division, personal communication, July 2007.
356 Based on estimates that the minimum number of bulbs per intersection is 11 and the maximum number of bulbs per intersection is 28 due to lights used exclusively for turn lanes and lighting in multiple lanes.
357 This figure includes one additional intersection within the jurisdiction of the Department of Hawaiian Homelands, for which the County pays the electricity bill. Tuliao, July 2007.
358 Based on a typical 19-bulb intersection with 7 reds, 7 greens, and 5 yellows. The figure accounts for the upfront cost of each type of bulb.
359 Transportation Lighting. http://www.lrc.rpi.edu/programs/transportation/LED/survey03.asp?section=2.3.
360 Assumptions: 1. Red and Green traffic lights are on for 11.4 hours per day, Yellow lights are on for 1.2 hours per day, Ron Thiel, Head of Traffic Division of Department of Public Works, personal communication, April 2007; 2. LED bulbs use 15 Watts (Red and Green use 0.171 kWh/day, Yellow use 0.018 kWh/day) and incandescent bulbs use 125 Watts (Red and Green use 1.43 kWh/day, Yellow use 0.15 kWh/day), 3. There are approximately 2,733 each of Red, Yellow, and Green lights in Hawai‘i County traffic signals for a total 8,200 lights, 4. Electricity Rate is $0.327/kWh, 5. Lights run 24 hours per day, 7 days per week, 365 days per year.

lower than those required for incandescent bulbs, although the savings is difficult to isolate due to the Department of Public Works' aggregate expense reporting.

Airport Lighting

Hawai'i's airports have also initiated the process of replacing conventional incandescent lights with LED lights, where safety regulations permit. The retrofit is complete at Hilo International Airport and is underway at the other three district airstrips on the Island, Waimea-Kohala, Upolu, and Kona International.

At 7.5 Watts, airport LEDs use just one-sixth of the energy of the 45-Watt incandescent bulbs that are traditionally used for airport taxiway and obstruction lights. Airports can save considerable amounts of energy and money by switching light bulbs. With prices at the commercial rate of approximately 30 cents per kWh, airports would save over $650 per LED bulb over its lifetime. With 382 bulbs, the Hilo Taxiway would save over $124,000 over 5 years with its LED bulbs (Table 8.4).[361]

The next step in this process would be to install photovoltaic systems with battery energy storage on site at airports to power their LED lights and satisfy additional energy needs. As of April 2007, the Federal Aviation Administration is reviewing the use of solar powered LED lights for runway illumination and is in the process of approving solar LEDs for various airports.

[361] David Hein, Engineer for Department of Transportation Airports Division, personal communication, April 2007.

Table 8.3: LED traffic light lifecycle cost savings

	Color	kWh per year per bulb	Energy cost per year per bulb	Cost per bulb	Lifecycle cost per bulb	Savings per bulb
LED	Red/Green	62.4	$20.41	($80.00)	$262.05	$678.36
LED	Yellow	6.6	$2.15	($80.00)	$170.74	$8.78
Incandescent	Red/Green	520.1	$170.08	($9.00)	$940.40	$0
Incandescent	Yellow	54.8	$17.90	($9.00)	$179.52	$0

Table 8.4: LED airport light cost savings

Incandescent Consumption	LED Consumption	LED Lifetime (hrs)	Savings in kWh	Price per kWh	Savings at the meter	5 Incan. Bulbs @ $1.00 each	1 LED @ $30.00	Savings on bulbs	Total Savings
45 W	7.5 W	60,000	2,250	$0.20	$450	$5.00	$30	($25)	$425
45 W	7.5 W	60,000	2,250	$0.25	$563	$5.00	$30	($25)	$538
45 W	7.5 W	60,000	2,250	$0.30	$675	$5.00	$30	($25)	$650
45 W	7.5 W	60,000	2,250	$0.35	$788	$5.00	$30	($25)	$763

Street lights

The Department of Public Works has also considered new street light technology. The County currently uses low-pressure sodium chloride bulbs because they cause minimal interference with the astronomical observatories on Mauna Kea. The County pays for the electricity bills associated with about 9,000 streetlights on Hawai‘i, most of which are on County property. While the State pays the energy bill for their lights, the County maintains all 9,000 lights. The lights are a mix of 55-watt (for residential applications), 90-watt (intersections), and 180-watt (main roads and commercial areas).

The observatory has resisted the installation of LED bulbs because of their bright white light, however, this obstacle may be eliminated by a new cutoff light fixture (also called a fully shielded fixture) that directs light down to the road. The County has been replacing conventional streetlights with cutoff fixtures to shield people's homes from the light and to improve conditions for the observatory.

Solar powered street lights could be a very useful for the County of Hawai‘i. Although perhaps not ideal for all highway areas in case of extended periods of cloudiness, solar powered street lights could be used for non essential areas such as parking lots and parks. Solar powered lights are particularly cost effective in the context of a built environment because of the additional cost to remove and replace pavement (i.e. in an already constructed parking area). Areas located far from the grid are also candidates for solar powered lights, which do not require expensive trenching and wiring.

The mayor suggested that the Department of Public Works try solar powered streetlights, but an unsuccessful pilot project at the Hilo Bayfront Beach Park has thus far hindered additional use. The selected solar technology proved to be unreliable, requiring extensive attention from County maintenance personnel.

Unfortunately, the problems with the solar powered street light installation could have been avoided with better solar technology. In accepting the lowest bid for the solar street light pilot project, the Department of Public Works allowed for the installation of an inferior PV system. The selected bid system has just 3 days of storage for cloudy days, is unable to match the daily load requirements in the winter months, is vulnerable to vandalism because of the placement of its panels and wiring, uses polycarbonate lens that will take on a green hue in less than 2 years of operation, and has significant risk of battery failure.[362] In contrast, technologies offered in competing bids offered 8 days of storage, used tempered glass for the lens, resisted vandalism through placement of important wires, and were capable of meeting the wintertime daily load requirements and preserving battery life.[363]

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[362] Steve Burns, "Comments and qualifications relating to the alternate bid (SEPCO solar lighting system) for County of Hawaii Hilo Bayfront Beach Park Pedestrian Walkway Improvements (photovoltaic lighting system)",

[363] *Ibid.*

Apart from solar powered bulbs, the County has not yet found a lower energy alternative to low-pressure sodium bulbs for streetlights. Provided that alternative solar technology is suitable to replace existing streetlights, the County should aggressively fund such initiatives as well as encourage the replacement of conventional lights by LED bulbs and cutoff light fixtures.

Recommendation 8.7: Set up a photovoltaic installation to power the County's streetlights and traffic lights.

The County pays $1 million for traffic and street lighting per year, accounting for 25% of the Department of Public Work's traffic budget. Each streetlight costs the County $100 per year even though each bulb is on for less than half the day.[364] The County pays the retail electricity rate, which was 32.7 cents per kWh as of April 2007. Lighting offers the County one of the best efficiency opportunities going forward if a shift occurs in the current regulatory environment.

The Traffic Division undertook a comprehensive feasibility study on installing a 2 MW solar system to generate enough power to offset the power needs for street and signal lighting. The report estimated a $5 million installation could provide all the energy needs for streetlights and traffic lights, with a five-year payback at current electricity prices. With net metering, a 2 MW solar installation would reduce the Department of Public Work's energy bill to zero.[365]

Unfortunately, under current regulations, such a scenario is not possible. In order to go forward, two actions need to happen: 1) the Public Utility Commission needs to permit wheeling of electricity. Wheeling refers to the process of purchasing electricity from a non-utility provider using utility transmission lines and is not currently permitted. The PUC opened an investigative docket in July 2007 to examine the possibility of allowing state and local government facilities to purchase electricity through wheeling;[366] and 2) The County would need to pursue a PUC exemption to allow a Net Metering project greater than the current maximum allowance of 50 kW.

It is recommended the County support the current Wheeling Docket and pursue this and other similar projects if the ruling is favorable.

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[364] Streetlights are unmetered, so for HELCO billing purposes the County assumes that each streetlight burns for 11.4 hours per day.

[365] Assuming 16% PV efficiency

[366] Linda Lingle, Office of the Governor of Hawaii, "Hawai'i PUC to Investigate Potential of State Purchase of Electricity from Renewable Sources", July 6, 2007, Available: http://www.hawaii.gov/gov/news/releases/Folder.2007-01-31.1527/News_Item.2007-07-06.1657

Aviation and the Superferry

The island nature of Hawai'i, coupled with the strong tourism industry, leads to high use of aviation fuel. It was estimated that in 2005, 17% of final energy used in Hawai'i County was in the form of aviation fuel.[367] When discussing options for alternative fuels to replace the import dependence on petroleum-based aviation fuel, synthetic kerosene from biomass is seen by some as the most attractive option in the near-term[368] and, in Brazil, the use of ethanol has been approved for small aircraft such as crop dusters.[369] Current research aims to make the use of liquid hydrogen supported aviation (i.e., cryoplanes) a viable option in the future.[370] Virgin Atlantic, Boeing, and General Electric plan to test an aviation biofuel in 2008 and if successful, may represent a new trend in the aviation industry.[371]

Despite the high use of aviation fuel, there is no recommended course of action at this time to switch energy sources or decrease number of flights. Tourism is too important to the Island's economy and the relatively small market power of Hawai'i County is unlikely to shift global aviation practices. Airlines can minimize the energy waste by following best practices and ensuring that high occupancy rates of their flights.

Recommendation 8.8: Explore the technical feasibility of using biodiesel on the Superferry and consider a renewable fuel standard mandating the use of a sustainably-generated biodiesel blend.

In 2009, ferry transport between Hawai'i Island and Oahu will begin. This new method of inter-island transportation will affect the total energy use, with an estimated quantification as follows: based on one trip per day, the Superferry between Hawai'i Island and Oahu will consume 6.1 million gallons of diesel annually.[372] Since it is assumed that fueling would occur at both ports, one can estimate the diesel fuel used on Hawai'i Island by the Superferry to be 3.1 million gallons per year, which would represent a 15% increase in the use of diesel fuel, as compared to 2005 use rates. This

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[367] Johnson, J, Leistra, D, Opton-Himmel, J, Smith, M, "Hawaii County Baseline Energy Analysis" Report for The Kohala Center, 2006.

[368] Haglind, F, Hasselrot, A, Singh, R, "Potential of reducing the environmental impact of aviation by using hydrogen - Part I: Background, prospects and challenges" *Aeronautical Journal*, 2006, 110 (1110): 533-540.

[369] Renewable Energy Access, "Ethanol Fueled Cropduster Certified in Brazil" October 28, 2004.

[370] Ponater, M, Pechtl, S, Sausen, R, Schumann, U, Huttig, G, "Potential of the cryoplane technology to reduce aircraft climate impact: A state-of-the-art assessment" *Atmospheric Environment*, 2006, 40 (36): 6928-6944.

[371] Fight Global Warming.com, "Virgin/Boeing/GE near biofuel selection for test", August 13, 2007, Available: http://www.flightglobal.com/articles/2007/08/13/216015/virginboeingge-near-biofuel-selection-for-test.html

[372] Based on a personal communication with T. O'Halloran, Director Business Development for Hawaii Superferry, December 2006, in which he stated that the ferry will consume 1,981 gallons of diesel per hour and the trip length is expected to be 4.25 hours.

corresponds to 2% of the total final energy used on the Island from all fuel sources in 2005 (400 billion Btu[373] out of 18,500 billion Btu[374]).

It would be inaccurate to say, however, that Hawai‘i Superferry would increase final energy use by 2% due to the potential reduction of inter-island aviation with the option for travel by ferry. While the actual displacement will not be known until the ferry begins operation, the potential effects can be estimated. Using a ferry capacity of 110 vehicles and 400 passengers, estimations were made based on the following scenarios:

1. The ferry would be operating at 30% capacity and 50% of the riders would have taken a Kona-Honolulu flight while the other 50% would not have traveled. This would displace approximately 31 billion Btu[375], offsetting 8% of the energy used by the Superferry.
2. The ferry would be operating at 80% capacity and 50% of the riders would have taken a Kona-Honolulu flight while the other 50% would not have traveled. This would displace approximately 82 billion Btu, offsetting 20% of the energy used by the Superferry.
3. The ferry would be operating at 100% capacity and 100% of the riders would have taken a Kona-Honolulu flight. This would displace approximately 200 billion Btu, offsetting half of the energy used by the Superferry. While this scenario is unlikely, it does show the upper-bounds for aviation fuel displacement.

It is difficult to make a direct comparison regarding the energy used per passenger trip due to the fact that the ferry will also be providing the service of vehicle transfer between

[373] Using a lower heating value of 128,400 Btu/gallon of diesel.
[374] Johnson, J., D. Leistra, J. Opton-Himmel, M. Smith, “Hawaii County Baseline Energy Analysis” Report for The Kohala Center, 2006.
[375] For short haul flights, an estimate of 1.04 kg fuel/passenger-kilometer was made, based on data from Penner, J., D. Lister, D. Griggs, D. Dokken, M. McFarland, “Aviation and the Global Atmosphere” report for the Intergovermental Panel on Climate Change, Cambridge: Cambridge University Press, 1999. A lower heating value of 46.6 MJ/kg was used. The flight distance was estimated to be 300 kilometers.

the islands. Given the expected use of energy by Hawai‘i Superferry and the potential range of aviation energy displaced by its use, it can be expected that the ferry’s operations would increase total energy use on Hawai‘i Island by one to two percent.

8.2 DEMAND – TRANSPORTATION: Private Sector

In 2005, over 165,000 passenger vehicles were registered in Hawai‘i County – one car for every resident.[376] Gasoline and diesel fuel use for ground transportation account for 54% of total final energy demand in all forms in Hawai‘i County.[377] The high fuel demand and vehicle to person ratio reflect a dispersed population, commuter culture, and large rental car fleet. Although a newly implemented and successful public bus system started targeting commuters between Hilo and Kona, private vehicles will continue to dominate the ground transportation fleet.

Reducing fuel consumption requires focusing on demand from the private vehicle fleet. A suite of policies aimed at decreasing fuel demand must be put in place because no single measure is capable of realizing the demand reductions necessary for this sector.

Plug-in Hybrid Electric Vehicles

Recommendation 8.9: Promote plug-in hybrid electric vehicle technology complemented by a time-of-day pricing scheme.

Plug-in hybrid vehicles are an emerging vehicle technology capable of operating as an electric vehicle (on an electric charge), as a typical fossil-fuel engine (on motor fuel), or as a hybrid electric vehicle (on a combination of electricity and motor fuel). When charged electrically, these cars simply “plug-in” to a wall outlet like another appliance. General Motors recently announced its intention to produce plug-in hybrid passenger car and SUV models starting in 2010 and the U.S. Department of Energy unveiled a research and development plan for plug-in hybrids.[378] It seems likely that the technology will soon be available to American consumers.

Potential to decrease gasoline consumption in Hawai‘i County through use of plug-in hybrids varies considerably depending on the penetration of the technology, the fuel source used to power the electricity charge, and the timing of the charge (see Table 8.5).

The current fuel mix for HELCO’s electric grid generation puts the plug-in hybrid electric operation at approximately 41 miles per gallon of gasoline equivalent (i.e., the fossil fuel use in power plants). Suggested improvements to the fuel mix in the Energy Sustainability Plan scenario (see Section 3) would increase this value to over 70 miles per gallon of gasoline equivalent by 2030. Figure 8.5 shows the net reduction in fossil fuel

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[376] Johnson, J., D. Leistra, J. Opton-Himmel, M. Smith, “Hawaii County Baseline Energy Analysis” Report for The Kohala Center, 2006.
[377] *Ibid*.
[378] Environmental and Energy Study Institute, “GM Targets 2010 for Volt Production” and “DOE Announces Draft Plug-in Hybrid Electric Vehicle R&D Plan”, *Clean Motion*, March 2007. Available: www.eesi.org/publications/Newsletters/CleanMotion/CleanMotion_March2007.pdf

use under nine plug-in hybrid scenarios taking grid power under the Energy Sustainability Plan scenario. The number of plug-in hybrids listed for each scenario is the fleet size achieved by 2030. Under a strong time-of-day pricing scheme, it is assumed that 74% of the miles driven are relying on electric power, while under a weak or non-existent time-of-day pricing scheme, it is assumed that 95% of miles driven are using electric power.

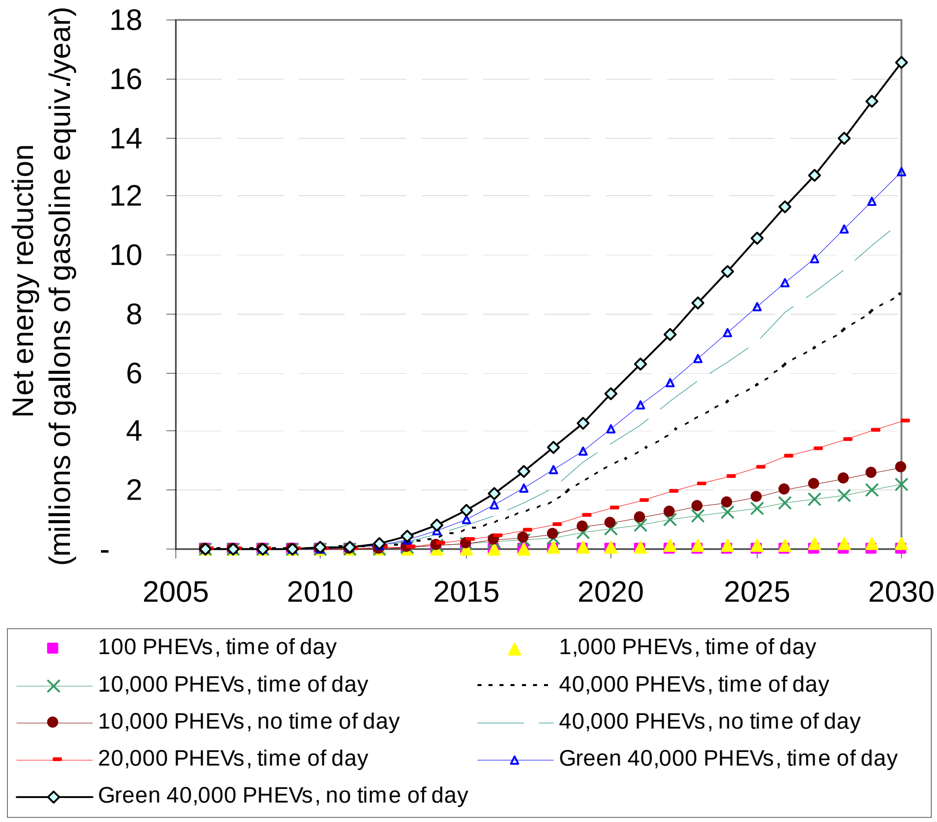

Figure 8.5: Effect of anticipated fuel mix changes on fuel demand in PHEV scenarios[379]

Another potential benefit of plug-in hybrids is their potential to flatten the electricity load curves when used in conjunction with time-of-day pricing schemes. Time-of-day pricing is an electricity pricing structure that seeks to create greater efficiency in electricity demand. A time-of-day rate structure reflects hourly changes in the supply/demand

[379] Assumptions: The Green PHEV ("Green fleet") assumes that electricity generation for the PHEV vehicles comes entirely from renewable sources, which require no input of fossil fuels (e.g., uses off-peak geothermal generation). As such, all Green Fleet scenarios represent a maximum upper threshold of potential fuel demand reduction associated with plug-in hybrid use. The other scenarios assume that plug-in hybrids' electricity demand comes from the electricity grid, and calculations of fuel demand reductions account for the take back effect associated with electricity generation.

balance, thus sending customers better price signals of when to consume electricity.[380] In addition to the economic efficiency gains associated with time-of-day pricing, another attractive feature of these price structures is their potential to flatten load curves by encouraging the distribution of electricity demand over lowest demand hours, which typically occur in the late evening and early morning hours.

Although the best fuel savings for plug-in hybrids are those associated with no time-of-day pricing (due to the potential for multiple charges per day), load curve benefits from plug-in loads would not be realized in the absence of time-of-day pricing (see Figure 8.6 and 8.7).[381]

If a plug-in hybrid fleet of 40,000 vehicles was charged entirely by a fuel-less energy source (geothermal, solar), the maximum theoretical fuel demand reductions would be 17 million gallons of gasoline equivalent in 2030 (see Table 8.5).[382] A scenario of 40,000 cars charging on the standard electric grid with time-of-day pricing could lead to a net reduction of fossil fuel use by 8.7 million gallons.

To meet its goals for fuel conservation, the County should actively pursue introducing plug-in hybrid technology in combination with more renewable generation on the grid and a time-of-day pricing structure to achieve dual ends of reduced energy demand and more consistent daily load curves. The Island grid and vehicle fleet could realistically support at least 40,000 vehicles, assuming proper management of when they are charged.

[380] Severin Borenstein, The Long-Run Effects of Real-Time Electricity Pricing, Center for the Study of Energy Markets, CSEM WP 133, 2004, 2.

[381] Ideally, the use of PHEVs should avoid adding significantly to peak demand, as this necessitates construction of additional supply capacity and contradicts many of the goals outlined in this report. As such, PHEVs must be introduced with strict TOD pricing structures that curtail peak demand. However, these problems may not be an issue in the future with “smart meters” for PHEVs. A smart meter will allow the PHEV to be plugged in during high demand hours and serve as a storage battery through which the grid can exchange electric charge.

[382] As cars would likely be charged on the standard grid, this is an unrealistic scenario intended to establish an upper limit on the theoretical fuel demand savings that could result from the use of 40,000 PHEVs.

Table 8.5: Plug-in hybrid impact on transportation sector and final energy demand in Hawai‘i County in 2025

Number of plug-in hybrids in 2030	Strong time-of-day pricing?	Dedicated renewable electricity source?	Avoided gasoline use in 2030 (gallons/yr)	Fossil fuel used in electricity production in 2030 (gallons of gas equiv/yr)	Net fossil fuel energy savings (gallons of gasoline equiv/yr)
100	Yes	No	32,000	10,000	22,000
1,000	Yes	No	320,000	100,000	220,000
10,000	Yes	No	3,200,000	1,000,000	2,200,000
40,000	Yes	No	13,000,000	4,200,000	8,700,000
10,000	No	No	4,100,000	1,300,000	2,800,000
40,000	No	No	17,000,000	5,400,000	11,000,000
20,000	Yes	No	6,400,000	2,100,000	4,300,000
40,000	Yes	Yes	13,000,000	0	13,000,000
40,000	No	Yes	17,000,000	0	17,000,000

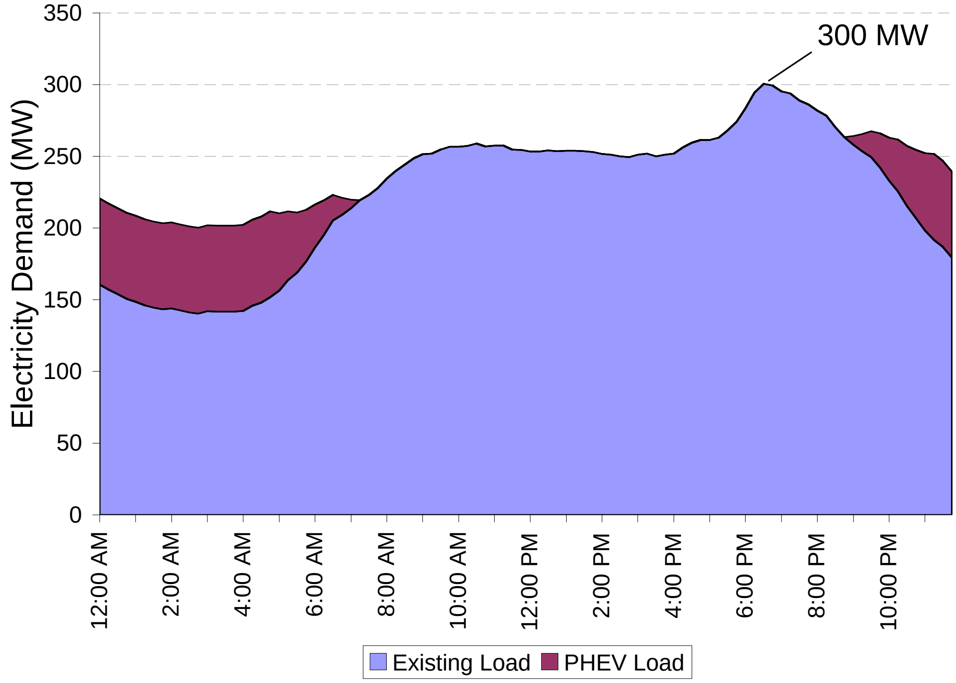

Figure 8.6: Grid demand of 40,000 plug-in hybrids with strong time-of-day pricing - Dec 2025

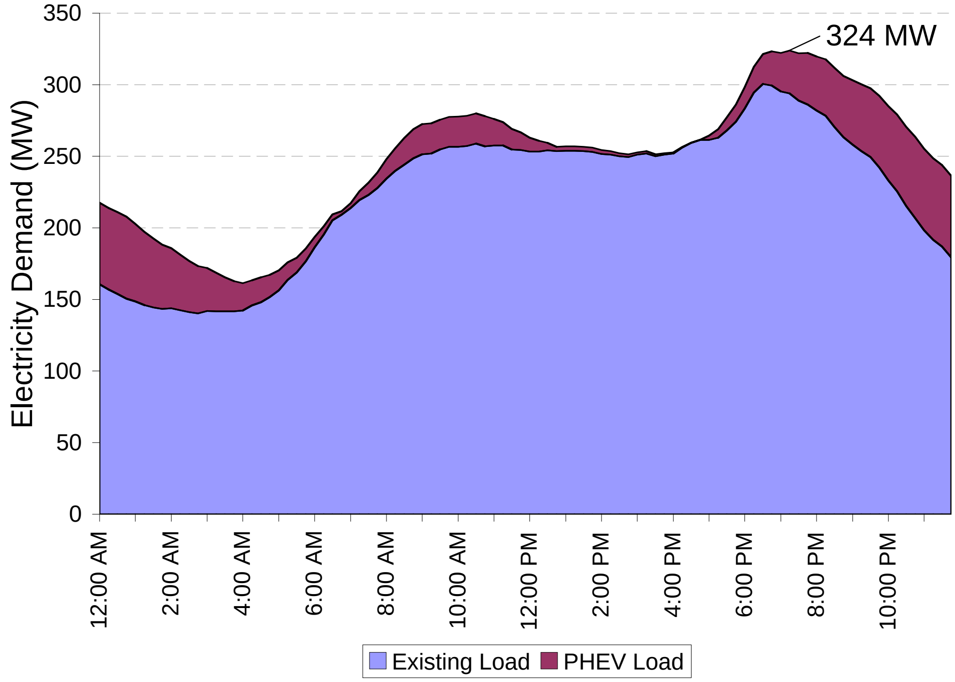

Figure 8.7: Grid demand of 40,000 plug-in hybrids without strong time-of-day pricing - Dec 2025

Private Automobile Fuel Efficiency

Recommendation 8.10: Institute a vehicle feebate with a dual pivot point starting at 23 mpg for trucks and 28 mpg for cars, with a rate of $1000 per 0.01 gallons per mile. The pivot points should increase in tandem with proposed increases to the CAFE standards to 35 mpg in 2020[383] and then increase 2% per year until 2030.

A feebate is a policy tool designed "to strengthen the market for environmentally preferable vehicles by charging a fee or paying a rebate to purchasers".[384] Feebates target fuel consumption by pegging the fee/rebate to the quantity of fuel consumed per mile driven in miles per gallon. They typically have a two-part structure: the rate, in dollars per gallons per mile, and the pivot point, which separates the vehicles that earn fees from those that earn rebates.

Improved vehicle fleet energy efficiency and reduced fuel consumption are intersecting goals of a feebate program. In general, feebates may be designed to target vehicle manufacturers or consumers and at the federal level, a strong case can be made for both strategies. In Hawai‘i County, however, implementing a feebate would serve several purposes: increase consumer awareness of the externalized costs associated with operating a less efficient vehicle, incentivize the purchase of vehicles with higher fuel economy, and reduce the current price premium on many fuel efficient models.

At the same time, there are several barriers to implementing a feebate program in Hawai‘i County. First, the County has no direct influence on the availability of fuel-efficient vehicles. Second, a feebate does not mandate purchasing behavior either by prohibiting the purchase of fuel inefficient vehicles or requiring the purchase of fuel-efficient models. Third, the County cannot require that vehicles sold meet a certain mpg requirement, as does the federal government through its CAFE standards. Fourth, the structure of the Hawai‘i State government inhibits Hawai‘i County from introducing a feebate program without the approval of the State.

Recognizing these limitations, the County should take action to influence the State to create a feebate system.

Structure for a sample feebate program in Hawai‘i County:

1. *Rate*: an appropriately aggressive feebate rate is $1000 per 0.01 gallons per mile, as shown in Table 8.6.

2. *Pivot point*: set a dual pivot point starting at 28 mpg for cars and 23 mpg for light duty trucks and SUVs, scaling up to 35 mpg for both by 2020 and by 2% in

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[383] In June 2007, the United States Senate passed energy legislation that included significant increases of the Corporate Average Fuel Economy (CAFE) standards applied to vehicles sold in the United States. If approved, the CAFE standards will increase from an average of 24.6 mpg to an average of 35 mpg by 2020.

[384] "Chapter 21", *Winning the Oil Endgame*, Rocky Mountain Institute, 2.

each of the following years (2021-2030).[385] This feebate reflects increases to the Corporate Average Fuel Economy standards proposed in June 2007 and its effect on fuel economy and fuel demand can be seen in Figure 8.8 and 8.9 under the scenario "CAFEplus".

3. *Program coverage*: the feebates would be collected or issued each time the car is sold, both new and used, but no more than once every three years. Vehicles shipped in from other islands or out-of-state would be assessed according to the feebate at the time of registration and whenever sold thereafter, but no more than once every three years.

4. *Complementary policy measures*: a buyback program for older model, inefficient vehicles which serves the dual purpose of reducing the quantity of older vehicles on the road, since the feebate explicitly avoids targeting these vehicles, as well as reducing the financial pressure of these policies on lower-income households.

For example, the city of Kelowna, British Columbia introduced a program called "Cash for Clunkers" that offers up to $750 towards the purchase of a new vehicle with a fuel consumption rating of at least 39 miles per gallon.[386] Funding for this rebate is $500 from Cash for Clunkers and $250 from the participating auto dealership. The County should consider implementing a similar program, however, the cost of such a program for the County cannot be estimated without detailed data of the model years for the Island vehicle fleet.

5. *Revenue neutral or positive:* Although a feebate program would likely be intended to be revenue neutral, it is unlikely that this would be realized during the first years following its implementation. There are several contributing explanations including, the learning curve among consumers; that consumer choice does not change instantaneously; the feebate rate is not so high as to overwhelmingly discourage purchases of inefficient vehicles or encourage purchases of efficient vehicles; and the current vehicle supply has a much lower overall fuel economy than those to be released in future years. Calculations suggest that if a feebate was implemented in Hawaiʻi County in 2007, the program would be revenue positive and potentially generate as much as $5 million in its first year.

[385] In its publication "Winning the Oil Endgame", the Rocky Mountain Institute recommends structuring feebates by auto class, of which there are 17 different classes. This recommendation distinguishes between two vehicle types, "cars" which refers to passenger vehicles of the following EPA classes: two-seaters, sedans (minicompact, subcompact, compact, mid-size, large), and "trucks" which refers to vehicles under 8,500 pounds Gross Vehicle Weight Rating (GVWR) of the following EPA classes: pickup trucks (small, standard), vans (passenger, cargo), minivans, sport utility vehicles (SUVs), and special purpose vehicles.
[386] Cash for Clunkers Clean Air Awards Program, Accessed: April 2007, http://www.city.kelowna.bc.ca/CM/Page464.aspx.

While the feebate program should ultimately aim for revenue neutrality, there are several benefits to a revenue-generating program in the initial years. For example, a positive gain of $5 million in the first year could allow the program to double its rebate for top fuel-efficient vehicles. For example, doubling the rebate given to the Top 10 vehicles in 2007 would decrease the surplus by about $1 million. At the same time, increasing the positive incentives to purchase a fuel efficient vehicle would help consumers overcome the sticker price gap that currently prices hybrids and other efficient models well above their conventional counterparts.

Additionally, this surplus can be used to fund an aggressive Cash for Clunkers program that targets highly inefficient, older model vehicles, often driven by the most economically vulnerable segment of the population (which has the unfortunate and unintended consequence of locking such vehicle owners into expensive fueling requirements). Assume for this example that a “Clunker” is defined by both the age of the vehicle and its mile per gallon rating, recognizing that older vehicles may not be equipped with standard tail-pipe emissions controls and lose their original fuel economy rating with age. If 20% of the vehicles on Hawai‘i County roads could qualify as Clunkers based on age (1995 or earlier) and 75% based on fuel economy (lower than the pivot points established for the feebate), than a full 15% of vehicles, or about 27,500 cars and trucks, on the Island may qualify for the Clunkers program. In the absence of detailed data on the nameplate and model year breakdown of vehicles in Hawai‘i County, consider a simple example of a potential Clunkers buyback program administered using funds generated by a feebate. With a surplus of about $3.5 million, the program could afford to buyback the worst 2% of these vehicles (about 550 per year) with a payout of $5400 per vehicle to be applied towards the purchase of a qualifying new or used vehicle (must be at or above the pivot point).

Table 8.6: Feebate rates with $1000 per 0.01 gallon per mile for dual pivot point of 28mpg (cars) and 23mpg (light duty trucks and SUVs)[387]

Class	Example	Best MPG	Feebate- Dual Pivot Point, $1000 per 0.01 Gallon per Mile
PHEV	Chevy Volt	53.0	$1,685
hybrid	Toyota Prius	48.0	$1,488
SUV, 2WD	Ford Escape Hybrid	33.5	$1,363
car, midsize	Camry Hybrid/Altima Hybrid	39.0	$1,007
car, subcompact	VW Beetle	38.0	$940
minicompact car	Mini Cooper	36.0	$794
car, compact	Toyota Corolla	35.3	$739
wagon, small	Honda Fit	34.7	$690
wagon, midsize	Ford Focus	31.3	$377
car, midsize luxury	Mercedes E320	30.0	$238
SUV, 4WD	Subaru Outback Wagon	24.0	$181
truck, 2WD	Toyota Tacoma	24.0	$181
car, subcompact luxury	Acura RSX	28.0	$0
wagon, small luxury	Audi A3	28.0	$0
minivan	Honda Odyssey	23.0	$0
truck, 4WD	Chevy Colorado	22.5	-$97
car, compact luxury	Audi A4	27.0	-$132
car, large	Honda Sonata	27.0	-$132
SUV, luxury	Lexus RX 330 2WD	22.0	-$198
two seaters	Mazda MX-5 Miata	26.0	-$275
car, large luxury	Hyundai Sonata	27.5	-$303
wagon, midsize luxury	Volvo V70	24.0	-$595

Five feebate scenarios were considered to assess the best mpg ramp-up structure for Hawai‘i County. The baseline for all scenarios was the current Island fleet fuel efficiency average of 23 mpg. In all scenarios, consumers were expected to purchase new vehicles with an average fuel economy rating equivalent to the pivot point; in practice, the effect of a feebate program may result in average fuel economy ratings higher or lower than the pivot point depending on consumer preference and sensitivity to price.

Feebate Scenarios:

Baseline: The baseline assumes that all cars and trucks purchased between 2008 and 2030 remain at the current fleet mile per gallon rating of 23.

Feebate CAFE: The CAFE feebate is pegged directly to national standards set under the Corporate Average Fuel Economy (CAFE) standard. Under expected increases to the CAFE standards, manufacturers will be required to increase the fuel economy of their

[387] Model Assumptions: 1. Pivot point of 30 mpg (single) and rated at $1000 per 0.01 gallons per mile.

American vehicle fleets to 35 mpg for both cars and trucks/SUVs by 2020. Reflecting these increases, the dual pivot point would start at 28 mpg for cars and 23 mpg for trucks/SUVs and scale up by 4% annually. The fuel economy of the fleet would increase to 28.9 mpg in 2030.

Feebate CAFEplus: This feebate offers a slightly more aggressive structure than its counterpart *Feebate CAFE*, extending the annual increases from 2021-2030 at a rate of 2% per year. Under this scenario, fuel economy of the fleet increases to 30.2 mpg in 2030.

Feebate Best Available Technology: The BAT scenario is designed to identify a theoretic lower boundary for fuel economy gains associated with the feebate. This scenario assumes a revenue neutral feebate with dual pivot points equal to the Best Available Technology of 2007, an average of 48.3 mpg for cars and an average of 27.3 mpg for trucks and SUVs. BAT does not attempt to account for improvements in vehicle technology over the period 2008-2030. The fuel economy in 2030 under this program is 37.3 mpg.

Feebate Constant Pivot Point: This feebate assumes that the original dual pivot points of 23 for trucks and SUVs and 28 for cars remain unchanged across the period. It is intended to illustrate the need for progressive scaling up of the pivot points ensure that the feebate remains viable as the program matures. In the absence of progressive increases to the feebate, the fuel economy in 2030 rises to just 25.8 mpg.

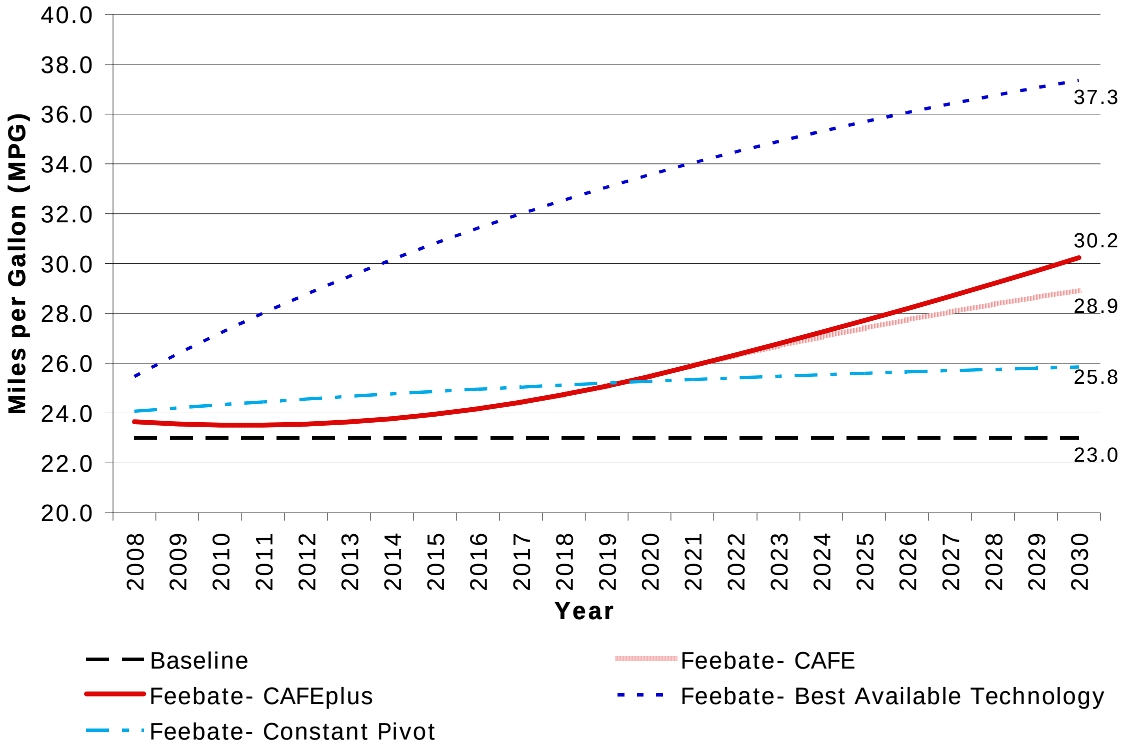

Figure 8.8: Automobile efficiency improvements under feebates, 2008-2030[388]

The greatest reductions in total fuel demand are realized under the Feebate Best Available Technology and Feebate CAFEplus scenarios, which also deliver the best miles per gallon ratings improvements across the Island fleet. Although offering slightly lower final mpg ratings across the Island fleet, CAFEplus is favored because it involves achievable ramping-up of the pivot point over time. In contrast, Best Available Technology sets the pivot point at an average mpg of 48.3 for cars and 27.3 for trucks and SUVs, and expects consumers to choose these vehicles in the absence of an increasing pivot point (i.e., pivot point remains 30 mpg throughout the 2008-2030 period). As Hawai‘i County should underpin the market effects of the feebate with solid regulatory requirements, a ramp-up of the pivot point from 28 to 43.3 mpg for cars and 23 to 40.4 mpg for trucks and SUVs is preferable to a program that starts high and does not adjust over time (Best Available Technology). It is important to note that the consumer purchasing response modeled in Best Available Technology represents a highly unlikely real-life scenario; benefits from the feebate would likely level off long before the fleet mpg rating reached its maximum potential of 37.3.[389] A State-level feebate policy

[388] Model Assumptions: 1. Annual population growth rate of 2.4% annually with mortality rate of 0.008; 2. Vehicle to person ratio of 0.966, scrappage rate of 2% annually, average fuel efficiency take back effect of 10%, average mpg rating of current island fleet is 23.

[389] “Chapter 21, Technical Annex”, *Winning the Oil Endgame*, Rocky Mountain Institute, 1.

that relies on consumer choice can only advance so far in the absence of complementary national policies.

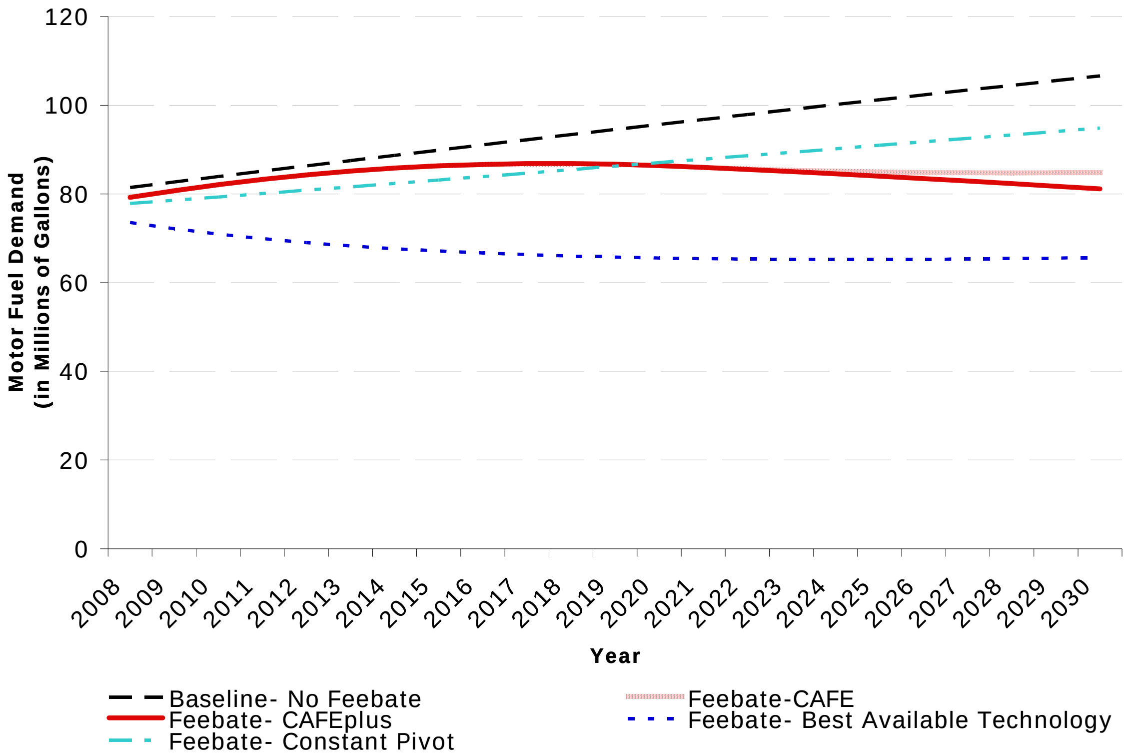

Figure 8.9: County-wide transportation fuel use with feebate programs, 2008-2030[390]

The fuel demand reductions associated with improved fuel economy in the Feebate CAFEplus would have among the greatest impact of any recommendation in this report towards the County goals of conservation. At present, average fuel economy of the privately owned vehicle fleet in Hawai‘i County is about 23 mpg. A fleet-wide increase of 7.2 miles per gallon by 2030 (to 30.2 mpg from 23 mpg) would save approximately 25.5 million gallons of gasoline in the year 2030. To give a sense of scale, 25.5 million gallons of motor oil is about 35% of total gasoline imports in 2005 and about 14% of all Hawai‘i County’s imported fuel oils in the year 2005.[391]

Much improved fuel economy standards can be achieved by replacing low efficiency vehicles with efficient vehicles that are already available and the many more that will

[390] Model Assumptions: 1. Annual population growth rate of 2.4% annually with mortality rate of 0.008; 2. Vehicle to person ratio of 0.966, scrappage rate of 2% annually, average fuel efficiency take back effect of 10%, average mpg rating of current island fleet is 23; 3. Gallon of gasoline to Btu conversion of 125,000 Btu per gallon.
[391] HELCO Electricity Production Summary, EIA Database, DBEDT’’s State of Hawaii Databook.

soon be available on the international automobile market. Consumers need to be aware that their vehicle purchasing decisions are not arbitrary and have a real, tangible impact on the degree to which Hawaiʻi County remains dependent on potentially unstable foreign oil resources. As more and more fuel efficient vehicle models enter the market in coming years as a result of increased CAFE standards, technological improvements, the influence of green business, and other forces, the availability of top-of-the-line hybrids, improved internal combustion engines, plug-in electrics, and alternative fuel vehicles would increase while their prices drop.

Recommendation 8.11: Disseminate information on available federal funds for private sector buyers of hybrids and alternative fuel vehicles to new vehicle buyers through mailing campaigns, newspaper advertisements, and at dealerships across the Island. A commercial tax credit rewarding sales of qualifying hybrid and alternative fuel vehicles should be used to stimulate dealership participation in improving fleet efficiency.

The *Federal Energy Policy Act of 2005* established several incentives for the purchase of specific energy efficient vehicles including hybrids. Hybrid vehicles placed into service after December 31, 2005 may be eligible for a federal income tax credit of up to $3,400. For example, these incentives range from $250 for a GMC Sierra Hybrid to $3,150 for a Toyota Prius.[392] The tax credit is based on the quantity of fuel the car saves over 120,000 miles and is phased out after the manufacturer sells 60,000 of a particular model.

Alternative fuel vehicle credits vary depending on manufacturing year: vehicles placed into service before January 1, 2005 may be eligible for a $2,000 clean-fuel vehicle tax deduction while those placed into service between January 1, 2005 and December 31, 2010 may be eligible for a federal income tax credit of up to $4,000.[393]

The federal tax credits for hybrid and alternative fuel vehicles are specific to certain models. This information should be made available to customers at auto dealerships, included in the calculation of the sticker price listed on these vehicles in the holding lots at the dealerships, and listed in advertisements for the vehicles.

Additionally, the County could create a tax incentive program that benefits dealerships by rewarding them for sales of vehicles with miles per gallon ratings above 30. A possible model is to provide commercial tax credits for one-eighth of the vehicle tax credit distributed by the federal government. This translates into a maximum total tax credit per vehicle of $425 for hybrid vehicles and $500 for alternative fuel models. Assuming that 50% of all new vehicles are sold at dealerships and that all of these vehicles qualify for a matching commercial tax credit at the maximum amount of $500 per vehicle, total

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[392] Prius Tax Credit has since been phased down to $787, reflecting increased sales of this model. U.S. Department of Energy, "New Energy Tax Credit for Hybrids, Alternative Fuel Vehicles", Fuel Efficient Vehicle Tax Incentives, Accessed: March 2007. http://www.fueleconomy.gov

[393] U.S. Department of Energy, "New Energy Tax Credit for Hybrids, Alternative Fuel Vehicles", http://www.fueleconomy.gov/feg/tax_hybrid.shtml

theoretical program costs average $2.7 million per year in tax credits between 2008 and 2030.[394]

Recommendation 8.12: Provide additional tax incentives for qualifying[395] hybrids (plug-in and traditional) and alternative fuel vehicles with a mile per gallon rating above the feebate pivot point. Encourage the State to waive the GET tax for qualifying vehicles.

Tax credits and *deductions* are the most common methods of delivering incentives for the purchase and use of hybrid and alternative fuel vehicles. For individual and corporate consumers, Massachusetts and Oregon offer examples of progressive tax-based policies.

In Massachusetts, owners of hybrids or alternative fuel vehicles with a placard are entitled to an income tax deduction of $2,000 while corporations with fleets of more than 50 vehicles, when at least 10% of which are alternative fuel vehicles, are eligible for tax credits for half of the difference in price between the alternative fuel vehicles and conventional models.

In Oregon, the Residential Tax Credit provides individuals with up to $1,500 towards the purchase of qualifying hybrid or dual-fuel vehicles. The Business Energy Tax Credit can be applied towards the purchase of qualifying hybrid and dual-fuel vehicles, cost of conversion to operate on alternative fuel, and cost of establishing alternative fuel fueling stations. This tax credit is 35% of incremental cost and taken over five years.
Tax holidays can also be used to promote the sale of hybrids and alternative fuel vehicles. Hawai‘i County should encourage the State government to exempt qualifying vehicles from the State GET tax.

Recommendation 8.13: Eliminate the County motor vehicle weight tax for energy efficient vehicles. Encourage the State to eliminate the motor vehicle weight tax and registration fee for energy efficient vehicles.

Vehicle owners in Hawai‘i County must pay an annual vehicle registration fee of $25 to the State,[396] and annual motor vehicle weight taxes to both the State and the County. Hawai‘i County vehicle weight taxes for 0.50¢ per pound for passenger cars and 1.00¢ per pound for commercial vehicles.[397] State weight taxes are levied on graduated scale, as follows:[398]

- 0.75¢ per lb. for vehicles weighing up to 4,000 pounds

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[394] Model Assumptions: Vehicle to person ratio of 0.966 and scrappage rate of 2% annually.
[395] Qualifying hybrids and alternative fuel vehicles should be expected to meet the current pivot point standards of the feebate scenario, or the HRS §103D-412 outlined in Recommendation 8.7, whichever is higher.
[396] Hawaii Revised Statutes §249-31
[397] Tax Foundation of Hawaii, http://www.tfHawaii.org/taxes/weight.html
[398] Hawaii Revised Statutes §249-33

- 1.00¢ per lb. for vehicles weighing over 4,000 to 7,000 pounds
- 1.25¢ per lb. for vehicles weighing over 7,000 lbs. to 10,000 pounds
- $150 for vehicles weighing over 10,000 pounds

The owner of a 3,500 pound automobile would therefore pay the $25.00 State registration fee and $26.25 to the State and $17.50 to the County in vehicle weight taxes. It is recommended that the County eliminates its tax for five years for energy efficient vehicles and advocate that the State to does the same for its registration fee and motor vehicle weight tax. Energy efficient vehicles should be defined as those which meet one of the characteristics described in Hawaiʻi Revised Statutes §103D-412. These actions would save the owner of the vehicle approximately $70 per year and create an added incentive to purchase efficient or alternative fuel vehicles.

Recommendation 8.14: Require improved fuel efficiency of the rental car fleet, including heavy construction equipment. Rental car companies should be included under a feebate of 30 mpg scaled up to 50 mpg by 2030 with a rate of $1000 per 0.01 gallons per mile.

All but one of the rental companies on the Island are owned by large corporations that source exclusively, or nearly so, from American automakers whose fleet fuel economy is notably low. At the same time, the rental car industry contributes significantly to the number of vehicles and total transportation fuel consumed in Hawaiʻi County: 50% of all new cars are rental vehicles.[399] This combination of factors contributes to an abundance of low efficiency vehicles within the Island fleet.

Although hybrid and alternative fuel vehicles options are becoming increasingly available through American carmakers, there is a "tradeoff effect" that applies to several models, whereby automakers use the energy saved with a hybrid engine to increase horsepower instead of fuel efficiency. Because of this, the County should base its incentives structure on miles per gallon ratings rather than on the hybrid or alternative fuel status of a particular vehicle.

[399] Kyle Datta, "The Efficiency Prize", *Rocky Mountain Institute*, PowerPoint presentation, November 24, 2003, slide 20.

9. POTENTIAL CUMULATIVE EFFECTS OF RECOMMENDATIONS

Analysis and Recommendations for the Hawai'i County Energy Sustainability Plan offers dozens of recommendations that aim to meet the County's goals of increasing energy efficiency, replacing fossil fuels with renewable energy, and increasing the energy security of the Island. There is not one isolated action that can be taken to solve the County's energy problems – it would be the sum of many actions, each leading to modest increases in energy efficiency or renewable generation, that bring Hawai'i Island to a more sustainable energy future. Princeton University's Pacala and Socolow published a research paper detailing the use of "stabilization wedges" to limit atmospheric CO_2 releases over the next fifty years.[400] Each wedge represented the potential for an existing technology or action to reduce emissions and, when various combinations of these wedges were added together, the overall effect is a stabilization of atmospheric CO_2 below double pre-industrial concentrations.

An approach similar to this Princeton study was employed to understand the cumulative benefits of the recommendations in the Hawai'i County Energy Sustainability Plan. Figure 9.1 shows a potential future scenario where no additional actions are taken, whereas Figure 9.2 shows a future scenario with aggressive energy efficiency and renewable generation actions.[401] The shades of grey represent fossil fuel use, blues and purples are renewable energy generation, and greens and yellows are energy efficiency measures.

When creating the scenario for Figure 9.1, it was assumed that electricity production would increase by 2.4% per year through 2030[402] and transportation fuel use (both ground and aviation) would increase by 1.5% per year. Figure 9.2 is an optimistic scenario that includes fourteen categories of actions, with Table 9.1 summarizing the underlying assumptions for each category. Table 9.2 provides details how primary energy demands are met in 2030. Figure 9.3 simplifies the results of this scenario, grouping together the demand reductions (energy efficiency) and supply production (renewable generation).

[400] Pacala, S. and R. Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies" *Science* 2004, 305, p. 968-972.
[401] Primary energy is the energy contained in the fuel source. For example, the primary energy of electricity generated from fossil fuels is the energy content of the fossil fuels, not of the distributed electricity.
[402] In HELCO's IRP-3 model, it is assumed that electricity demand increases 2.4% per year through 2010, followed by 1.6% annual increases due to a maturation of the economy. This model assumes 2.4% percent annual increases, before additional demand side management activities, through 2030.

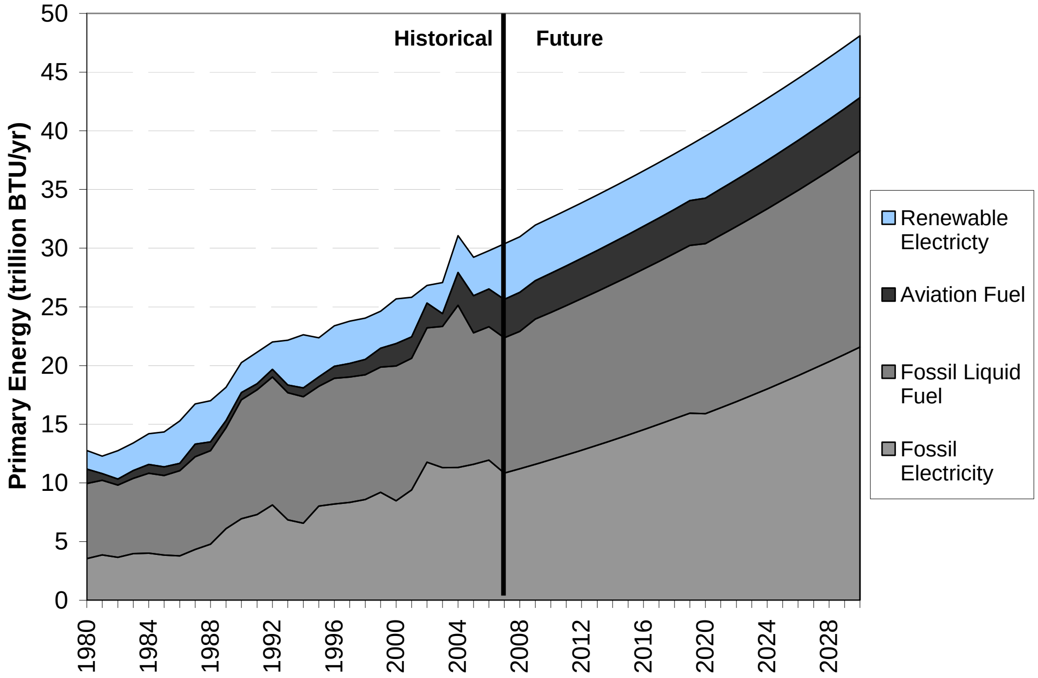

Figure 9.1: Primary energy use in Hawai‘i County without future energy efficiency and renewable energy actions

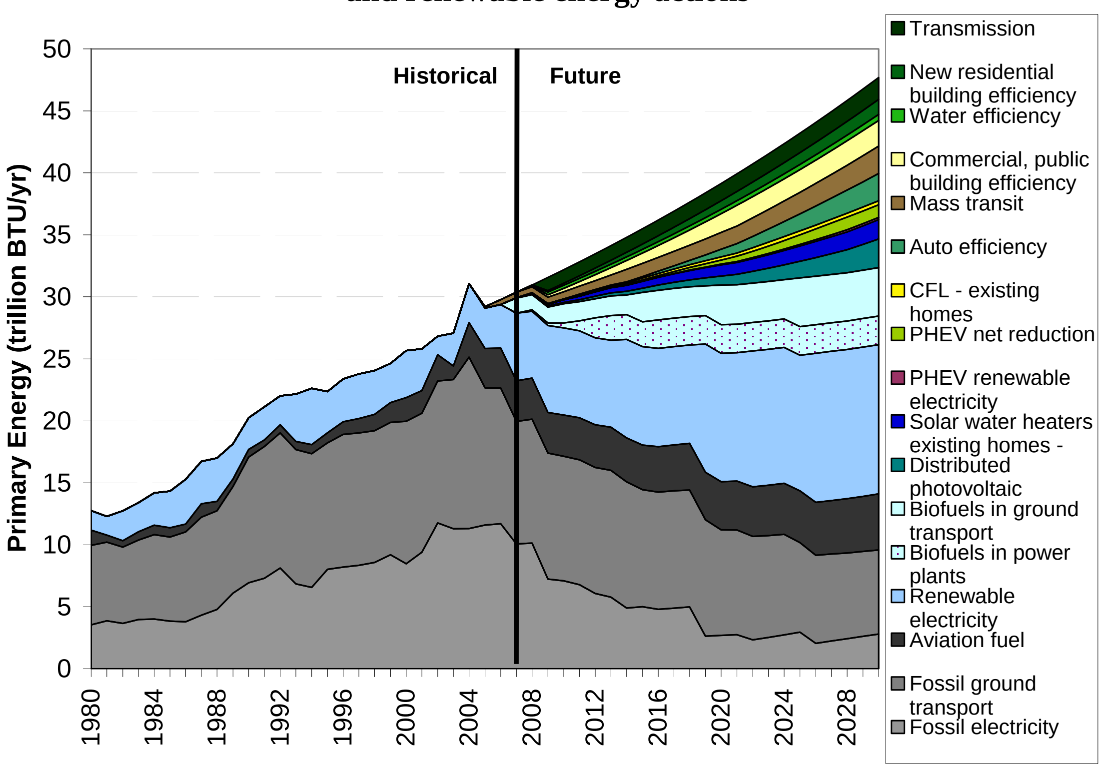

Figure 9.2: Primary energy use in Hawai‘i County with aggressive future energy efficiency and renewable energy actions

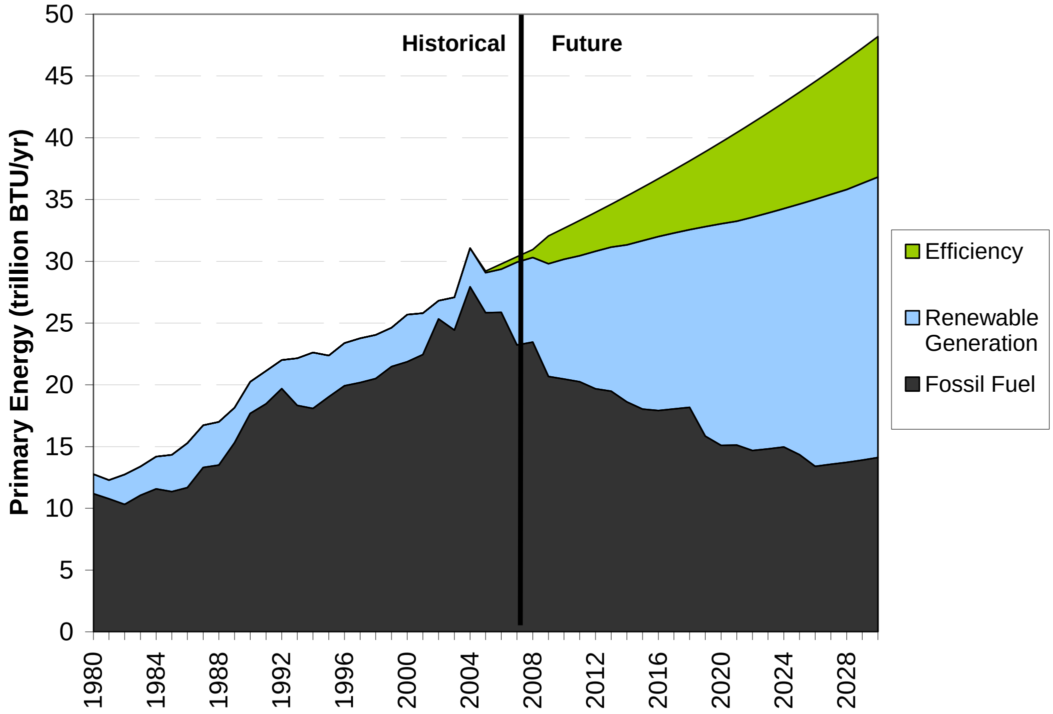

Figure 9.3: Primary energy use in Hawai‘i County with aggressive future energy action, as segmented by efficiency and renewable energy

Table 9.1: Assumptions for aggressive efficiency and renewable energy scenario

Category	Assumptions
Transmission improvements	Line losses are reduced by 1.8% of total generation.
New residential building efficiency	Each year, 1,000 new homes are constructed which utilize 240 kWh/month of electricity as compared to the current average home which utilizes 591 kWh/month.
Water use efficiency	Leaks in the Hilo water transmission and distribution system are repaired, saving approximately 5 million kWh/year in pumping energy. A water conservation strategy reduces water use by 20%. Two microturbines (0.04 MW) are added per year until 2030, which achieve 75% utilization.
Commercial & public building efficiency	Electricity use by these sectors is 36% of total demand and efficiency measures reduce demand by 1.5% per year until a 21% reduction is met.
Mass transit and rideshare	Current growth trajectories, which are very high, are reduced to annual increases of 20% through 2015, followed by 5% annual growth between 2015 and 2030, resulting in 310,000 trips in 2030.
Automobile efficiency	The average passenger vehicle efficiency is increased from 23 mpg to 30.2 mpg in 2030 using a graduated feebate strategy (i.e., CAFEplus)
CFL use in existing homes	Each year, 2,000 homes change to compact fluorescent lights, saving 65 kWh/month, increasing until 32,000 new homes have made the change.
Plug-in hybrid electric automobiles	Beginning in 2010 with a small pilot program, the sales of plug-in hybrids would grow to a green fleet of approximately 40,000 vehicles by 2030. Under time-of-day pricing, the automobiles use electric power for 74% of the miles driven and a 12 kWh charge provides 40 miles of driving.
Solar water heaters for existing homes	Of the roughly 65,000 residences, approximately 10% currently have solar water heaters. Three and a half percent of existing homes add this technology each year (2,300 units), saving 190 kWh/month. Solar water heaters on new homes are included in new building efficiency.
Distributed photovoltaic power	Starting at 1.5 MW in 2007, an additional 110% of capacity is added each year. In 2030 a total of 130 MW of photovoltaics are online with 13 MW installed in 2030 alone.
Biofuels in transportation	Biofuel use in transportation is assumed to meet the Renewable Fuel Standard with 8.5% of ground transportation fuel being met by biofuel until 2010; 10% for 2010 to 2014; 15% for 2015 to 2020; 20% for 2020 to 2025; and 25% 2025-2030. The Superferry would use biodiesel and have one trip per day starting in 2009.
Biofuels in power plants	Biodiesel is used to replace diesel and/or cellulosic ethanol is used to replace naphtha in existing power plants, increasing until reaching 2.3 trillion Btu in 2016.
Renewable electricity on grid	Geothermal capacity increases by 20 MW in 2009 and 10 MW in 2014. In 2019, 40 MW of wind coupled with 30 MW of pumped hydro storage goes online. In 2022, 10 MW of intermittent renewable generation goes online, followed by 20 MW of firm renewable in 2026.

Table 9.2: Contributions to primary energy in 2030 under an aggressive energy efficiency and renewable energy scenario

Category	trillion Btu	% of primary energy
Fossil fuel total	14.7	30.5%
Fossil fuels for electricity	*2.8*	*5.8%*
Fossil fuels for highway, off-highway	*7.4*	*15.4%*
Fossil fuels for aviation	*4.5*	*9.4%*
Energy efficiency total	11.3	23.4%
Transmission improvements†	*1.8*	*3.7%*
New residential building efficiency†	*1.2*	*2.5%*
Water use efficiency†	*0.5*	*1.0%*
Commercial, public building efficiency†	*2.1*	*4.3%*
Mass transit and rideshare	*2.2*	*4.6%*
Automobile efficiency	*2.2*	*4.6%*
CFL use in existing homes	*0.3*	*0.6%*
Plug-in hybrid net energy reduction	*1.0*	*2.1%*
Renewable generation	22.1	45.9%
Solar water heaters for existing homes†	*1.6*	*3.3%*
Distributed photovoltaics†	*2.3*	*4.8%*
Biofuels in transportation	*3.7*	*7.7%*
Biofuels in power plants†	*2.3*	*4.8%*
Renewable electricity on grid†‡	*12.2*	*25.3%*
Total primary energy	**48.2**	**100%**

†For the categories that displace fossil fuel electricity production, the primary energy listed here represents the amount of primary fossil fuel energy displaced.

‡Including geothermal, wind, hydro, and utility-photovoltaic. Excluding biofuel-based electricity generation.

Under this aggressive scenario, in 2030, 31% of the primary energy is still met using fossil fuels. The largest sector is ground transportation, followed by aviation and the power sector. As viable renewable options emerge for aviation, this wedge may be reduced further.

Energy efficiency measures reduce the primary energy demand by 23%, with the most substantial savings in the transportation sector. Improving automobile efficiency, increasing the use of mass transit, and introducing plug-in hybrid vehicles reduces primary energy use by 11%. Improved energy performance of buildings and appliances totaled 7.4% of primary energy use, while reduction in line losses saved 3.7%.

Renewable energy generation constitutes 46% of the primary energy use in this scenario. By far, the largest contributions are from utility-based production, totaling 25%, and composed of existing operations plus additional geothermal and wind power operations. Biofuels contributes a total of 12.5% of the primary energy, with a larger share going to transportation fuel over power plant use. If the biofuel of choice was biodiesel, approximately 46 million gallons per year would need to be produced,[403] requiring 115,000 acres of agricultural land with yields of 400 gallons per acre. Such a yield may be representative of kukui as the energy crop of choice, with higher yields attainable by palm oil and algae.[404] There are currently over 1.2 million acres of land available for agriculture in Hawai‘i County.[405] If ethanol was utilized, 58 million gallons would be needed to meet the energy requirement.[406] The amount of land needed to produce this much ethanol is highly dependent on the type of energy crop chosen (e.g., cellulosic or sugar) and the yields that would be determined through the pilot plot study. Likely, to meet the total demand for biofuel, some combination biodiesel and ethanol would be produced, determined by market conditions and the ability for the agricultural production and processing to reduce costs and maximize efficiencies.

Solar energy contributes approximately 8% of the primary energy, with a larger share from new installed capacity from distributed PV generation. Additional solar water heaters are also included in the "new residential building efficiency" wedge as well. To achieve this total level of photovoltaic performance, an estimated 580,000 square meters (143 acres) of modules would need to be employed.[407]

There are several other potential renewable energy and energy efficiency options that were not included in the scenario. While hydrogen is not a renewable energy source, many view it as a promising energy storage means for renewable energy, with the potential to utilize off-peak generation capacity. Hawai‘i Island is poised to become a leader in the U.S. in hydrogen research and development. Because widespread hydrogen

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[403] Assuming 2.3 trillion Btu of biodiesel for power plants and 28 million gallons for transportation use, at a lower heating value 130,000 Btu/gallon.

[404] M. Poteet, "Biodiesel Crop Implementation in Hawaii" Hawaii Agriculture Research Center, September 2006.

[405] Ibid.

[406] Assuming 2.3 trillion Btu of ethanol for power plants and 28 million gallons for transportation use, at a lower heating value 77,000 Btu/gallon.

[407] Assuming 2% annual efficiency improvements of the modules and an average incoming solar radiation of 210 W/m^2.

deployment is uncertain at this time and because hydrogen is not an energy source but a means of storage, it has not been included in this scenario.

The potential use of biofuel as a replacement for aviation fuel was not examined, nor was efficiency improvements in existing residential homes beyond the addition of solar water heaters and compact fluorescent light bulbs. Landfill gas was not included, but was estimated to contribute up to 1% of total primary energy.[408] Due to their experimental status, ocean thermal energy conversion (OTEC) and wave power were not included. These additional improvements could increase the gains met by energy efficiency and renewable energy.

[408] This estimation, which is very approximate, is based on the U.S. Environmental Protection Agency's LandGem program. As discussed in Section 10: Future Research, more study is needed to truly assess the potential of this energy resource.

10. FUTURE RESEARCH AND TOPICS FOR STUDY

While this study aimed to be comprehensive, there are several technologies and options that were not discussed. The following suggestions are offered for a continuation of this research.

Global Warming Solutions Act of 2007

Link the wedge scenario (Figure 9.2) to greenhouse gas emissions and discuss the potential for meeting the goals of the Global Warming Solutions Act of 2007

The Global Warming Solutions Act of 2007 passed the State Legislature by a wide margin and was signed into law by Governor Lingle. This act will require a decrease in greenhouse gas emission to 1990 levels. By explicitly linking the scenario presented in Section 9 to greenhouse gases, it would be more useful in the implementation of this act.

Landfill Gas

Examine the potential of capturing landfill and wastewater methane and identify end users for this energy

When waste is placed in a landfill, it undergoes anaerobic digestion or fermentation, producing methane-rich landfill gas. Using the Environmental Protection Agency's LandGEM program to get an order of magnitude estimation of landfill gas in County landfills, an optimistic (and very rough) assessment lead to an Island-wide collection rate of 500 billion Btu of methane per year. This is around 1% of the total primary energy expected be used in 2030. Further study is needed to refine this estimation, in addition to identifying potential end users for the gas.

Green Purchase Power Option

Determine the feasibility of creating a green purchase option for electricity and use the funds to subsidize the installation of photovoltaics or landfill gas capture

A Green Purchase Power Option would allow consumers to contribute to pay a premium on their monthly electricity bill with the goal of fostering renewable generation. It is unclear how many participants could be expected due to the high current rates.

Waste Heat Utilization

Determine the feasibility of utilizing waste heat from power generation

In the production of electricity, there is much energy lost in the form of heat. Capturing this energy for re-use in other industries (for example, in a fish farm) would help spur economic development and a higher utilization efficiency of the energy.

Land Use Strategies and Planning

Determine the feasibility and necessary action in the implementation of land use policies that lead to decreased vehicular travel

By living near your work and having the option to walk to commercial districts, the need to drive can be reduced. This should be addressed in the Community Development Plan process.

Expand Systems Purview to include Energy and Material Flows

Investigate the trade-offs, trends, and linkages between the energy systems and material flows.

In 2005, The Kohala Center and Yale University completed baseline reports on energy and materials. Further study could examine the linkages of these energy and material flows from a systems perspective to assess the net environmental impact, the potential for increased local production, and the opportunities for industrial symbiosis.

Tourism Industry

Work with resorts to identify common and cost efficient energy savings technologies and programs.

The tourism industry is a key component of the Hawai‘i Island economy. In 2005, Hawai‘i Island received more than 1.5 million visitors, an 18.8% increase over 2004, and the number of tourists visiting the Island is expected to continue increasing in the coming decade.[409]

As a core component of the tourism industry, the hotel and accommodations subsector also represents a major source of energy demand on the Island and about 10% of HELCO’s annual sales.[410] Despite the vast differences between hotel accommodations, common features such as water heating, lighting, and heating, ventilation and air conditioning (HVAC) dominate their energy use profiles. The potential gains from lowering hotel sector energy use are high; depending on their size, Hawai‘i County’s major resorts may use as much as 1-3 MW of electricity each, which is significant compared against the 2005 Island-wide peak of 196 MW.

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[409] State of Hawaii Department of Business, Economic Development & Tourism, Table 2: Summary of Visitor Characteristics: 2005 vs. 2004 (arrivals by air), *2005 Annual Visitor Research Report*, 8.
[410] Johnson, J., D. Leistra, J. Opton-Himmel, M. Smith, “Hawaii County Baseline Energy Analysis” Report for The Kohala Center, 2006, p.18.

Water Supply and Use

There are numerous potential measures for water demand that may yield significant energy and cost savings that this report did not fully explore. Such programs would have the dual benefits of reducing total energy demand and allow DWS to fully exploit cost savings from Rider M rates. This would make available additional funds for infrastructure improvements and energy efficiency programs. Potential recommendations to investigate include:

- Encourage rainwater harvesting on large commercial and industrial properties and resorts for use in landscaping and flushing toilets. This would offset the need for pumped groundwater.

- Research water reuse infrastructure as a means of reducing the need for pumped water and preventing the expansion of service areas.

- Create a progressive pricing scheme for water that considers total use, energy use, and reuse. Such a scheme would place incentives for water reduction, especially among high volume users.

- Developing incentives for large users to reduce dependence on pumped water. Such a scheme should be specially targeted at areas that use private water supplies where DWS policies and incentives do not apply.

- Develop point-of-sale incentives for water efficient clothes washers, low-flow toilets, and showerheads.

Demand Side Management Programs

In 2009, a third party will take over the demand side management program. Approximately 60% of the demand side management fund currently is paid to the utility for lost margins and shareholder incentives. The future third-party administrator will be limited to 10% for overhead and expenses, freeing up considerable capital to expand the demand side management program.

The County should develop programs that target energy efficiency before the 2009 transfer date. The programs that should be funded are as follows:

- New construction energy efficiency
- Existing structures retrofits for improved energy efficiency
- Transportation programs
- Land use changes that aim to reduce transportation times
- Commercial energy efficiency
- Improving promotion of Pay As You Save (PAYS) programs
- Improving promotion of solar water heater rebates.

APPENDIX A: THE SUPPLY-SIDE MODEL

This report develops a supply-side model to evaluate the effects of different future supply scenarios on electricity generation costs and peak and minimum capacity. The model begins by developing projections of generation costs per kWh for diesel and MSFO-based generation. To calculate fuel-specific generation costs, current fuel costs per kWh, HELCO operations and maintenance (O&M) costs per kWh, and profit proportional to the ratio of generation costs to total costs are summed for each year from 1990-2005 for each fuel type. Avoided cost payments to independent power producers are estimated for cases where avoided cost and fuel cost are linked (e.g. the status quo) and unlinked. Past data on fuel costs per kWh, O&M costs per kWh, and HELCO profit were provided by DBEDT,[411] while avoided cost data for independent power producers are from HELCO.[412]

Future energy generation costs from 2005-2025 are projected as a function of changing crude oil prices, with O&M and profit components of generation costs held constant at their average value over the period 2000-2005.[413] Both diesel and MSFO fuel prices are estimated by multiplying 2005 fuel cost by the ratio between crude oil prices for a given year and the price in 2005. Crude oil price estimates are taken from the EIA 2025 projections[414] and the NYMEX price projections developed by the advisory group in the run-up to HELCO's IRP-3.[415] EIA projections are used as the baseline for most cost projections, as they provide a reasonably conservative lower bound for potential future oil prices.

Future linked avoided costs are also modeled as directly proportional to crude oil prices, following a clear past trend.[416] Unlinked avoided costs (ACU) for any given year *t* are calculated by the equation $ACU_t = ACL_t * ({Fuel_{1990}}/{Fuel_t}) * 2/3 + ACL_t * 1/3$ such that unlinked avoided costs are held roughly constant at 1990 values, increasing slightly with the price of fuel due to overall increases in fuel-related costs (e.g. O&M, component costs, shipping costs, etc.). Figure A1 shows the 1990-2025 generation costs per kWh for diesel, MSFO, linked IPP, and unlinked IPP for both EIA and NYMEX crude oil price projections. For the purpose of later calculations, avoided costs paid to oil-based IPP generation (e.g. naphtha) is always considered linked to crude oil prices even if other avoided costs are delinked.

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[411] DBEDT datasheet on HELCO's operations, 2006.
[412] Pat Moore, HELCO, personal communication, 2007.
[413] O&M and profit data from DBEDT datasheet on HELCO's operations, 2006.
[414] U.S. Department of Energy, Energy Information Agency. 2007. *AEO Crude Oil Price Projections*. Available: http://www.eia.doe.gov/oiaf/forecasting.html
[415] Pat Moore, HELCO, personal communication, 2007. NYMEX oil price projections used in the IRP-3.
[416] See figure 3.16, for example.

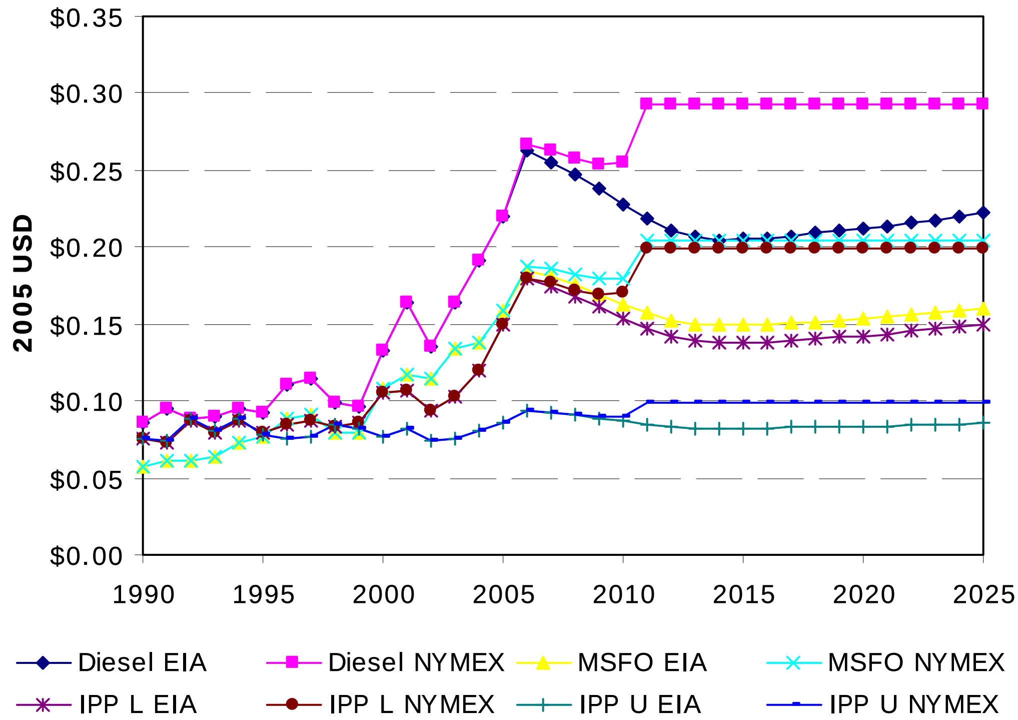

Figure A1: Generation costs per kWh by generation type and crude oil forecast

To determine future electricity demand (D) in Hawai‘i, the model uses the projections developed by HELCO in the IRP-3, where electricity demand increases by 2.4% per year from 2005 to 2010, and 1.5% a year thereafter till 2025.[417] Actual generation (G) requirements per year are calculated by dividing projected demand by the percent of energy not lost to transmission losses or in-use losses (L) via the equation: $G = D/(1-L)$. The value of L 1990-2005 is taken from DBEDT.[418] L from 2006-2009 is estimated based on the average L value over the period 2000-2005. Finally, L for 2010-2025 is estimated to be roughly 6.7 percent, based on the effects of line upgrades outlined in the IRP-3.[419] The effects of future installed capacity on transmission losses are not included in this model due to lack of specific data. Figure A2 shows estimated electricity demand and system losses over time, with required generation shown as the sum of both. Under these assumptions, total energy generation increases roughly 40 percent, from around 1200 GWh in 2005 to 1700 GWh in 2025.

[417] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.
[418] DBEDT datasheet on HELCO’s operations, 2006.
[419] HELCO. 2007. *Third Integrated Resource Plan* (IRP-3), Draft Report.

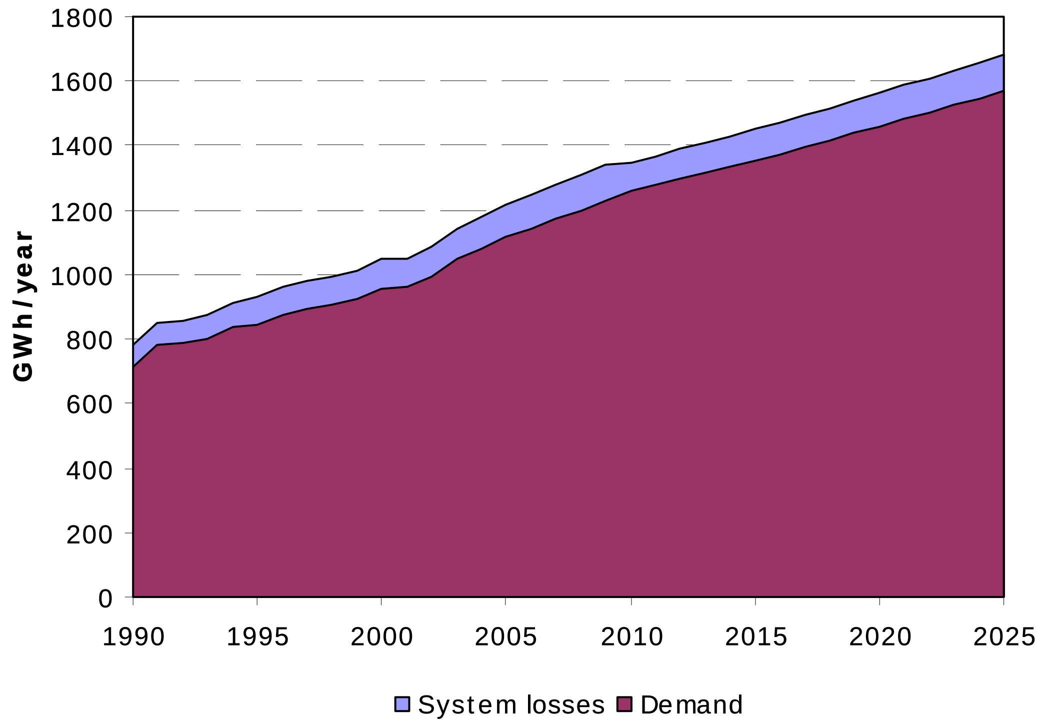

Figure A2: Projected generation as a function of system losses and demand

Given both future generation cost and demand projections, the model can effectively calculate total generation costs (and costs per kWh) for any supply scenario that includes data on annual generation by fuel type. To develop these generation projections for different supply models, estimates of GWh generation by fuel type by year were created for the following four scenarios, outlined in section 3.1:

- Baseline scenario
    - 10 MW Wind, 2020
    - 26.7 MW Coal, 2022
- Max renewable scenario
    - 1 MW Photovoltaic, 2012
    - 40 MW Wind/30 MW Pumped Storage Hydro system, 2014
    - 1 MW Photovoltaic, 2016
    - 1 MW Photovoltaic, 2021
    - 12.5 MW Geothermal, 2025
- HELCO IRP-3 scenario
    - 37 GWh/year intermittent source, 2016 (10 MW Wind equivalent)
    - 25 MW Firm renewable source in 2022
- Energy Sustainability Plan scenario
    - Retire the 14.1 MW Puna baseload plant, 2009
    - Retire the 14.4 MW Shipman intermediate plant, 2009
    - 20 MW Geothermal, 2009

- 10 MW Geothermal, 2014
- 40 MW Wind/30 MW pumped storage hydro system, 2019
- 37 GWh/year renewable source, 2022

Figures A3 and A4 show installed capacity and projected generation by scenario. The projected generation calculations are based on the assumption that new installed capacity offsets the more expensive diesel units first, when possible. The minimum amount of diesel generation allowed in the model is 100 GWh per year. This pattern of new generation displacing diesel generation can be seen in the past, particularly when the HEP naphtha plant reduced diesel generation from 264 GWh in 2000 to 74 GWh in 2001.[420] Note that the only time diesel generation is actually reduced close to the minimum allowed by the model is after the installation of a pumped storage hydro system, which provides the same peaking, cycling, and regulating services as the diesel generation it would displace.

Likewise, when demand for electricity increases predictably, that demand is first met by increasing output of the cheaper MSFO run units, up to 400 GWh/year, at which point additional demand is met by running the diesels longer.[421] New wind units in Hawai‘i are estimated to generate 55 percent of their rated capacity,[422] solar units 27 percent of their rated capacity,[423] geothermal units 85 percent, and coal units 90 percent.[424] For each scenario, total generation must meet total projected demand, with the choice of scenarios having no impact on the demand trajectory (e.g. demand is exogenous to the model).

Figure A5 shows installed capacity function by scenario, and is divided into intermittent, peaking, cycling, renewable baseload, and fuel baseload. For the purpose of this analysis,

[420] DBEDT datasheet on HELCO’s operations, 2006.
[421] Note that the Energy Group scenario has MSFO use capped at 225 GWh/year due to the retirements of the Puna and Shipman MSFO plants.
[422] Global Energy Concepts. 2004. *Select Hawaii Renewable Energy Project Cost and Performance Estimates*. Renewable Energy Resource Assessment and Development Program.
[423] Ibid.
[424] Geothermal and coal coefficients derived from historical performance in Hawaii.

pumped storage hydro systems are considered peaking units. The maximum potential firm peak capacity for any given year can be calculated by subtracting intermittent sources from the cumulative installed capacity, as intermittent sources cannot be relied upon for meeting peak demand. Likewise, the minimum load that can not be curtailed can be found by adding together fuel baseload, renewable baseload, and intermittent sources. Figure 3.4 in Section 3.1 shows a comparison of peak and minimum load potentials by scenario.

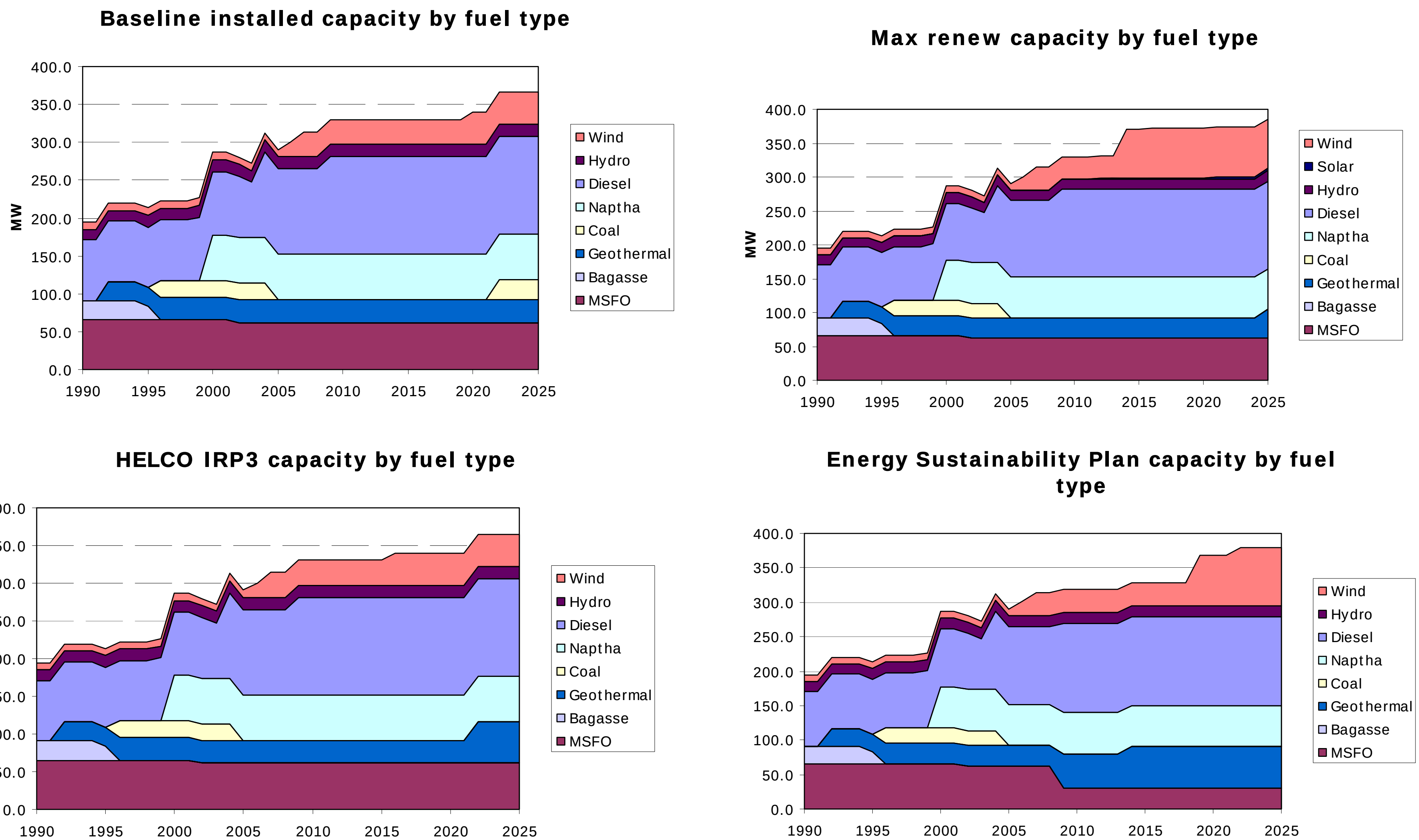

Figure A3: Installed capacity by scenario, 1990-2025

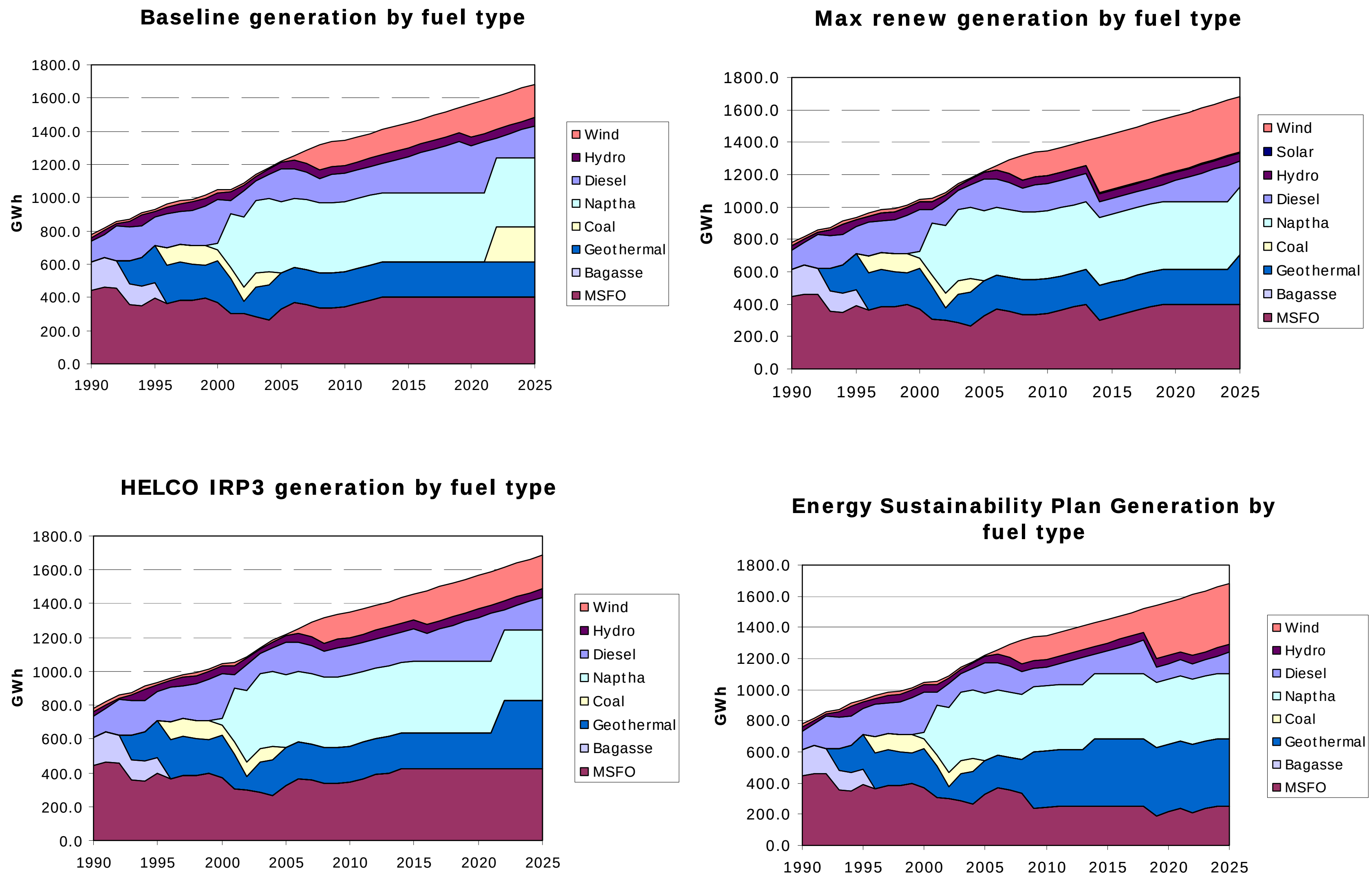

Figure A4: Generation by scenario, 1990-2025

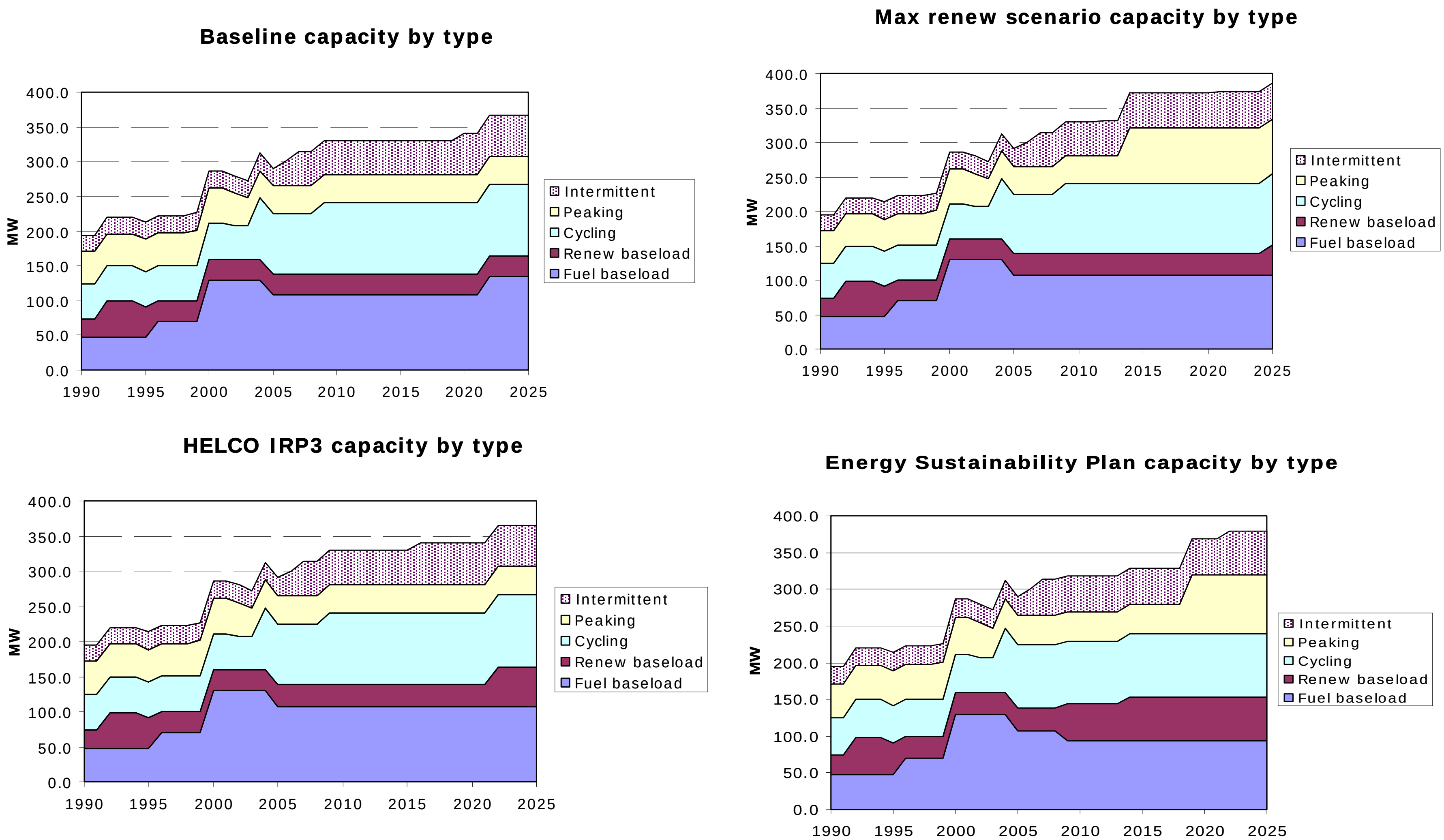

Figure A5: Installed capacity function by scenario, 1990-2025

In this analysis, it is assumed that the costs for constructing new renewable facilities would be borne by independent power producers. Hence for the purpose of cost calculations, any future installed capacity would be priced at avoided cost. Connection and transmission costs are assumed to be borne by HELCO, and storage systems costs are paid for either by HELCO or public financing (e.g. though a municipal bond). As all costs borne by HELCO or the government are expected to be passed through to consumers in the electricity rates set or taxes paid, these are directly weighed against the potential benefit of any scenario. This can be seen in Figure A6, below, reproduced from Section 3.1. In this model, pumped storage hydro costs are estimated to be $86.4 million, based on the calculations by HELCO (2004). Note that the pumped storage hydro costs are smaller in the HEISI scenario than the Max Renewable scenario because the installation occurs later and are subject to greater discounting.

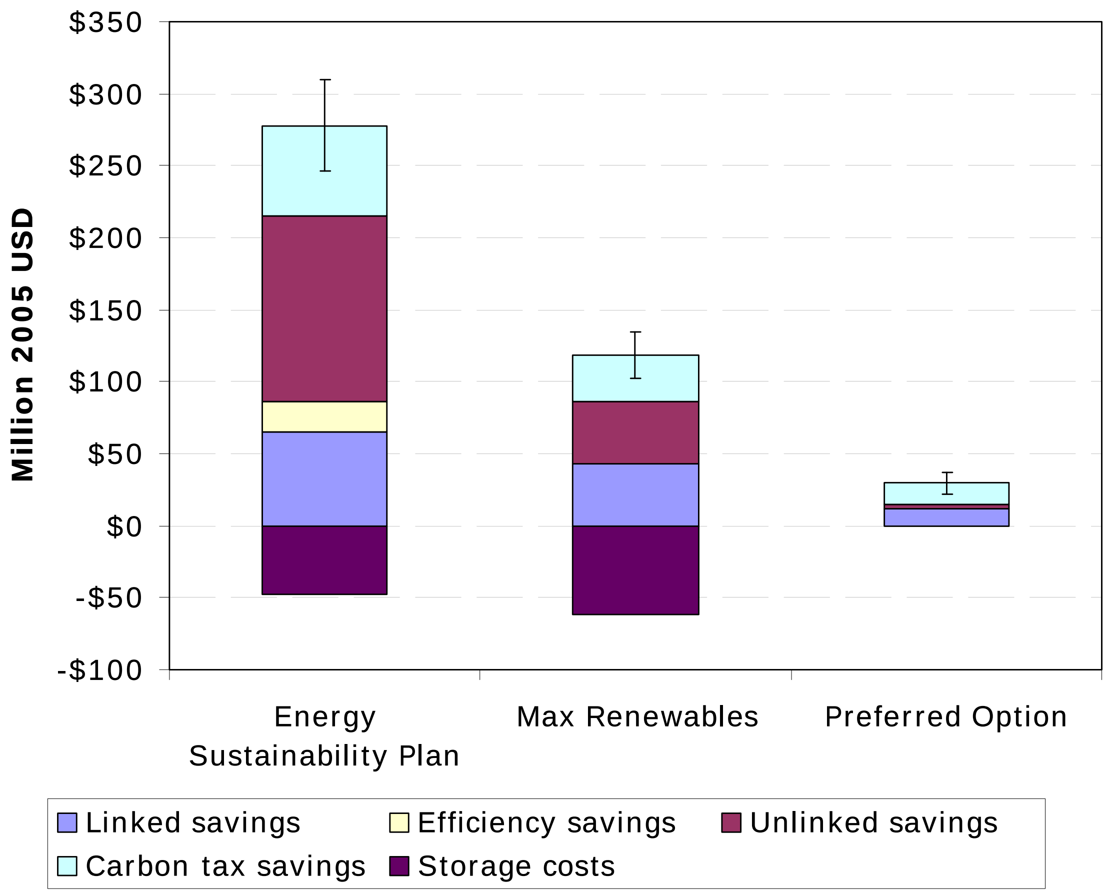

Figure A6: Net present value of savings relative to baseline, 5% discount rate, 2007-2025

Linked cost savings are calculated relative to the baseline scenario and are based on the difference between linked IPP generation costs and the generation costs of the fuel-based generation displaced. Unlinked cost savings are calculated similarly, using the unlinked IPP cost projections developed above. Efficiency cost savings come from scenario-specific plant retirements that increase the overall average efficiency of remaining fuel-based plants and lower the average cost of generation. In the Energy Sustainability Plan scenario, the efficiency of MSFO-based generation is increased by roughly 6 percent after the retirement of the Shipman and Puna MSFO units. Carbon tax savings are estimated based on data from DBEDT on greenhouse gas emissions per MMBtu of different fuel types (diesel, MSFO, naphtha, and coal).[425] Marginal emissions per MMBtu for fuel are held as exogenous and fixed in the model. A carbon tax ranging from $10 per ton to $30 per ton (see the error bars in Figure A6) is assumed to be imposed in 2010. This range of values is in line with current congressional proposals[426] and is lower than the $50 to $100 per ton that the recent IPCC report calculated as necessary to stabilize atmospheric concentrations below a potential dangerous level (IPCC 2007b).[427] The carbon tax-specific cost savings are calculated by multiplying the annual difference in emissions between the scenario in question and the baseline scenario by the price of carbon.

[425] DBEDT datasheet on HELCO's operations, 2006.
[426] Citigroup Global Markets. 2006. *Carbon Limits are Coming*.
[427] Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007: Mitigation of Climate Change*. Summary for Policymakers, Working Group Three.

APPENDIX B: RESOURCES

Following is a list of useful resources and web-links that relate to energy efficiency, renewable energy, and traditional energy. Many of these websites were used in the report. This list, however, does not constitute a complete reference list for the report. The websites' inclusion in this list does not imply the authors' endorsement of their content.

Public Education and Outreach

www.hawaii-County.com/la/gp/2005/main.html: Provides information General Plan as issued by the Hawaiʻi County Council. This document presents long-term development plans for the County.

www.capitol.hawaii.gov/: Website for the State of Hawaiʻi Legislature.

www.capitol.hawaii.gov/hrscurrent/: Complete listing of current State of Hawaiʻi statutes.

www.hawaii.gov/dbedt/info/energy/publications/: Website from the Hawaiʻi Department of Business, Economic Development, and Tourism (DBEDT) with a series of publications and studies relating to energy use and supply in the State.

www.paysamerica.org/: Non-profit organization dedicated to disseminating information about the PAY-AS-YOU-SAVE program.

factfinder.census.gov/: U.S. government census website with links to County demographic, economic, housing, and related information.

www.hawaii.gov/dbedt/info/: Resource for Hawaiʻi State and County information regarding population, energy use, demographics, economic activity, income, and related census information.

www.hawaii-County.com/databook_current/dbooktoc.htm: Hawaiʻi County Databook with links to information on County income, economic activity, geography, land use, demographics, and many other important data relating to the County.

www.greenbiz.com: Information resource on how to align energy efficiency and renewables with business success. Contains many links to external websites.

Energy Supply

www.eia.doe.gov: Energy statistics for all sectors as compiled by the U.S. government Department of Energy (DOE).

www.eia.doe.gov/oiaf/forecasting.html: Energy forecasts for future use and supply, compiled by the DOE.

www.ferc.gov/: Homepage of the Federal Energy Regulatory Commission, an independent agency that regulates the interstate transmission of electricity, natural gas, and oil.

www.renewableenergyaccess.com: Weekly newsletter covering all aspects of renewable energy technology and projects planned or ongoing internationally.

www.nrel.gov/: Website for the National Renewable Energy Laboratory. NREL is the DOE-funded laboratory for renewable energy and energy efficiency research and development. Various links accessing information on different renewable energies and efficiencies, and reviewing projects undertaken by NREL.

Energy Efficiency: Built Environment

www.hawaii.gov/dbedt/info/energy/efficiency/fieldguide: The *Field Guide for Energy Performance, Comfort, and Value in Hawaii Homes* was developed by DBEDT as a guide for builders to reduce energy use and maximize home efficiency. Topics include effectively utilizing Hawaii's climate, insulation, air conditioning, lighting, appliances, and water use.

www.archenergy.com/library/general/hawaiigl/: The *Hawaii Commercial Buildings Guidelines for Energy Efficiency* is a Green Building guide specifically for commercial buildings developed for DBEDT. Topics include whole building design, natural ventilation, lighting, HVAC, fenestration, insulation, and other subjects.

www.hawaii.gov/dbedt/info/energy/efficiency/: DBEDTs homepage for energy efficiency. Provides links and information for both the built environment and transportation efficiencies.

www.cee1.org: The Consortium for Energy Efficiency is a national non-profit dedicated to improving energy efficiency in the residential, commercial, industrial, and public sectors. Links are available to consumer information, studies, and resource libraries.

www.energystar.gov: Information on energy efficient products (appliances, heating & cooling, home electronics, lighting, office equipment), buildings (energy management, design, green building), and residential buildings (home energy audits, improvements for existing homes, locating green builders).

www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager: Presents EnergyStar "Portfolio Manager" which helps assess, track, and improve the water and energy performance of a building.

www.dsireusa.org: Database of State Incentives for Renewables & Efficiency, offers information for each state on incentives provided for renewable generation. Hawaii's database includes information on Personal and Corporate Tax Credits for solar and wind, Green Building Incentives, utility rebate programs, lists of codes, rules, and regulations.

www.eere.energy.gov: U.S. Department of Energy website with extensive coverage of Energy Efficiency and Renewable Energy topics such as building technologies, geothermal, hydrogen & fuel cells, solar energy, wind & hydropower, and ocean energy.

www.bcap-energy.org/: The Building Codes Assistance Project (BCAP) provides information on the current status of building codes for all states and counties in the U.S. The project aims to assist states and local jurisdictions in the adoption, implementation, and advancement of building energy codes.

www.HawaiiBuiltGreen.com: The Building Industry Association of Hawaii's "BuiltGreen" is a program for green building on Hawaii developed by local builders. The website provides links to the self-certification checklist and to the self-help guide.
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Energy Efficiency: Transportation

www.fueleconomy.gov: Includes information such as EPA's fuel economy ratings for specific vehicles, lists of available tax incentives for hybrids and alternative fuel vehicles, tips for maximizing fuel economy, explanations of different vehicle technologies

www.rechargeIT.org; www.calcars.org: Information on research & development, energy efficiency associated with Plug-in Hybrid Electric Vehicles (PHEVs)

www.greencarcongress.com: Covers technology, products, developments, issues and policies related to sustainable transportation options

www.hybridcars.com: News source, information clearinghouse, and research organization focusing specifically on hybrid vehicles. Includes vehicle reviews, comparisons, editorials on the market, fuels, fuel economy, and the environment, as well as coverage of laws and incentives related to hybrids.

www.htdc.org/hcatt/: The Hawaii Center for Advanced Transportation Technologies is a project of the High Technology Development Corporation, an agency of the State of Hawaii. Its mission is to research transportation alternatives for the military and commercial sector with the aim of improving economic efficiency. HCATT looks at numerous electric vehicles, low emission, and mass transportation options.