Policy Recommendations for

Hawaii's Energy Future

Prepared by Rocky Mountain Institute for
State of Hawaii
Department of Business,
Economic Development & Tourism
Strategic Industries Division

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Rocky Mountain Institute

Rocky Mountain Institute 1820 Folsom Street Boulder, CO 80302 T 303.245.1003 www.rmi.org

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Department of Business, Economic Development & Tourism (DBEDT)
Theodore Liu, Director
Maurice H. Kaya, P.E., Chief Technology Officer and
Strategic Industries Division Administrator
John Tantlinger, Ed.D., Manager, Energy Planning and Policy Branch
Steven Alber, Energy Planner, HES Project Manager

Gary Greenly, Energy Emergency Preparedness Planner
Douglas Oshiro, Research Statistician
Elizabeth S. Raman, Ph.D., Energy Conservation Program Specialist
Carilyn O. Shon, Manager, Energy Efficiency Branch
Priscilla Thompson, Energy Analyst
Maria Tome, P.E., Alternate Energy Engineer

Rocky Mountain Institute
Joel Swisher, Managing Director
Katherine Wang, Principal, HES Project Manager
Kyle Datta, Senior Fellow

Nathan Glasgow, Senior Consultant
Lena Hansen, Consultant
Virginia Lacy, Analyst
Lionel Bony, Analyst
Natalie Mims, Fellow
Aaron Silverman, Fellow
Cameron Burns, Staff Editor
Cindy Cash, Editor
Robin Strelow, Art Director

Systematic Solutions, Inc. (ENERGY2020)
Jeff Amlin, President
Judy Silva, Project Manager

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Gary Hashiro, Director, Integrated Resource Planning, Hawaiian Electric Company, Inc.
Timothy Blume, Resource Planning Engineer, Kauai Island Utility Cooperative
Joseph McCawley, Manager, Regulatory Affairs, Kauai Island Utility Cooperative
Steven Golden, Vice President, External Affairs, The Gas Company

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Chapter 1 Introduction

1.1 The Hawaii Energy Strategy Program

1.1.1 State Energy Planning and Policy Development

Chapter 196, Hawaii Revised Statutes (HRS), assigns the Director of the Department of Business, Economic Development & Tourism (DBEDT) the duties of State Energy Resources Coordinator (ERC). The Director serves as cabinet-level energy coordinator and advisor to the Governor and all levels of government and industry. The Director is responsible for State energy planning and policy development. The Hawaii Energy Strategy (HES) program is the basic element of the planning and development process. HES planning is guided by the State Energy Objectives and Policies in Chapter 226-18, HRS.

1.1.2 State Energy Objectives and Policies

The HES program was designed to increase understanding of Hawaii's energy situation and produce recommendations to achieve the statutory energy objectives outlined in Section 226-18, Hawaii Revised Statutes (HRS), objectives and policies for facility systems – energy, which states:

1. *Planning for the State's facility systems with regard to energy shall be directed toward the achievement of the following objectives:*
    a. *Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;*
    b. *Increased self-sufficiency where the ratio of indigenous to imported energy use is increased;*
    c. *Greater energy security in the face of threats to Hawaii's energy supplies and systems; and*
    d. *Reduction, avoidance, or sequestration of greenhouse-gas emissions from energy supply and use.*
2. *To achieve the energy objectives, it shall be the policy of this State to ensure the provision of adequate, reasonably priced, and dependable energy services to accommodate demand.*
3. *To further achieve the energy objectives, it shall be the policy of this State to:*
    a. *Support research and development as well as promote the use of renewable energy sources;*
    b. *Ensure that the combination of energy supplies and energy-saving systems are sufficient to support the demands of growth;*
    c. *Base decisions of least-cost supply-side and demand-side energy resource options on a comparison of their total costs and benefits when a least cost is determined by a reasonably comprehensive, quantitative, and*

qualitative accounting of their long-term, direct and indirect economic, environmental, social, cultural, and public health costs and benefits;

d. *Promote all cost-effective conservation of power and fuel supplies through measures including:*
    i. *Development of cost-effective demand-side management programs;*
    ii. *Education; and*
    iii. *Adoption of energy-efficient practices and technologies;*
e. *Ensure to the extent that new supply-side resources are needed, the development or expansion of energy systems that utilize the least-cost energy supply option, and maximize efficient technologies;*
f. *Support research, development, and demonstration of energy efficiency, load management, and other demand-side management programs, practices, and technologies; and*
g. *Promote alternative fuels and energy efficiency by encouraging diversification of transportation modes and infrastructure;*
h. *Support actions that reduce, avoid or sequester greenhouse gases in utility, transportation, and industrial sector applications; and*
i. *Support actions that reduce, avoid or sequester Hawaii's greenhouse-gas emissions through agricultural and forestry initiatives.*

1.2 Purpose

The purpose of this report is to provide strategy and policy recommendations to Hawaii's 2007 Energy Strategy. The Hawaii Energy Strategy (HES) Program was initiated in 1992 under a Cooperative Agreement with the United States Department of Energy (USDOE). The purpose of this report is to assist State of Hawaii planners and policy makers, members of the Hawaii energy community, and residents to better understand the State's current energy situation, set a vision for their energy future, and outline necessary steps to achieve this vision under different scenarios in the future. This report is intended to support and help ensure achievement of the State Energy Objectives.

In the last few months, the State of Hawaii's energy initiatives and discussion have significantly changed with the signing of the Memorandum of Understanding between the State of Hawaii and the U.S. Department of Energy to initiate the Hawaii Clean Energy Initiative (HCEI). The HCEI targets 2030 for 70% or more of the State's energy needs from clean energy resources. The recommendations in this report were originally crafted as the Hawaii Energy Strategy (2007), but the rate of change of the plans and programs of the State and the advent of the Hawaii Clean Energy Initiative in partnership with the US Department of Energy necessitate shifting this report into a set of analysis and recommendations which will serve as a resource for further discussion.

1.3 Organization and Summary of the Report

This chapter (Chapter 1) provides an overall framework for developing a state energy strategy for Hawaii. It summarizes RMI's analytical modeling of Hawaii's energy system using the ENERGY2020 model under three different scenarios based on fuel supplies' availability, and primary energy prices. It also highlights the principal modeling insights and major implications of the energy system.

Chapter 2 provides a summary of policy and other recommendations which can assist policymakers and stakeholders with policy discussions and formulation. The chapter also compiles the sector-specific policies discussed later in this report. Each policy recommendation suggests a government entity, agency, or other stakeholder to champion the recommended policy's implementation. The intent is to provide a "stand-alone" implementation reference for Hawaii's decision makers on the energy strategy.

Chapter 3 examines the relationships between energy consumption, economic growth, and greenhouse-gas emissions, the primary cause of global climate change. Status, issues, and the potential climate change impacts of Hawaii's energy activities are discussed. Policies for reducing State greenhouse-gas emissions are recommended. Greenhouse gases are inextricably linked to Hawaii's energy system and its unique environment. Climate change policy can also spur the development of new industries in Hawaii and provide an additional boost to the local economy.

The demand for primary energy in Hawaii, supplies, global primary energy markets, and the implications of factors that influence primary energy markets and their impact on Hawaii are discussed in Chapter 4 . World oil, coal, natural gas and its derivative fuels, and renewable energy resources are also examined. The recent surge in demand, particularly from the United States, China, and India, and years of under-investment in supply, have resulted in higher average prices, and more volatile and risky primary fuels markets. This new landscape presents Hawaii with inherent price and supply risks that must be addressed through diversification away from fossil fuels.

Hawaii's electric power sector is examined in Chapter 5 . Status, issues, and activities around electricity consumption, supply, electrical efficiency and demand response, distributed generation, renewable energy, and the case against nuclear energy for Hawaii are discussed. Efficiency is the most cost-effective resource, with more than 1800 GWh of achievable potential per year, and its continued implementation should be among the State's highest priorities. Demand response and distributed generation —including combined heat and power—provide attractive and alternative engineering, financial, and operational benefits to large, centralized electric power stations. Use of renewable energy helps keep energy expenditures in-state, provides local jobs, increases energy security, and reduces environmental impact. These resources also provide electric services with greater cost-effectiveness and lower financial risk than fossil-fired generation. Barriers to greater adoption of these resources are identified and discussed. Policies for encouraging greater adoption of electric efficiency and demand response, distributed generation, and renewable energy are recommended.

Status, issues, and recommendations around reducing transportation oil dependence for cars, trucks and buses, as well as aviation and marine vessels are discussed in Chapter 6 . Approaches to improving the sustainability of Hawaii's transportation energy system include devoting greater attention to encouraging use of more efficient vehicles, expanding efficient modes of alternative transportation including alternatively fueled vehicles, as well as land-use planning and urban design. Ideally, the State should pursue policies that work through the market, drive innovation without prescribing specific technologies, have broad political appeal, and leverage alternative fuels and efficiency opportunities.

In Chapter 7 , the potential for expanding Hawaii's bioenergy sector is examined. To quickly summarize, Hawaii-grown bioenergy represents a multi-million dollar opportunity for import displacement in energy and agriculture. It can lead the State to a new level of economic, energy, and environmental security. However, developing a local bioenergy economy requires investments to be made across the entire bioenergy "value chain" by agricultural producers, fuel producers, fuel distributors, and end users. Risks associated with a bioenergy industry based in Hawaii can only be addressed through innovative partnerships between Hawaii's public and private sectors.

The final chapter describes energy emergency preparedness on Hawaii. Because of its geographical isolation from mainland United States and energy exporting nations, the State of Hawaii remains vulnerable to energy supply disruptions. Should an energy supply disruption occur, the resulting categorical energy shortages could significantly impact Hawaii's citizens, government operations, and the stability of the State's economy. The Energy Division of the Department of Business, Economic Development & Tourism (DBEDT) is responsible for the administration, implementation, monitoring, and sustained operation of the State of Hawaii Emergency Support Function #12—Energy. Chapter 8 delves into the status of energy emergency preparedness and suggests strategies for mitigating the impact of emergencies and for refining and strengthening preparedness moving forward.

Chapter 2 Policy Recommendations

2.1 Introduction

This chapter summarizes recommendations developed to accelerate the State's progress toward accomplishment of its energy objectives. The recommendations build upon those developed for HES 1995 and HES 2000, and generally complement policies enacted in 2006 as a result of the Governor's *Energy for Tomorrow* initiative. The recommendations compiled in this chapter are further discussed within related chapters of this report, with in-depth examination of relevant issues and barriers. Finally, this chapter is meant to provide Hawaii's energy stakeholders with a document that can be distributed independently from the full report to assist with discussion and formulation of new policies.

2.2 Overview of the Policy Framework

Hawaii's dependency on imported petroleum for nearly 90 percent of its energy needs, exposes the state to very real price and supply risks. This dependency is aggravated by escalating worldwide demand for oil and decreasing supplies, which have resulted in dramatically rising costs and price volatility.[1] In recent years, Hawaii has become increasingly dependent on foreign oil supplies from the Middle East. Modeling results in Appendix A show that Hawaii's energy system can be expected to shift to more diverse and clean energy supplies in the medium and long term in the absence of additional aggressive state energy policies. However, even in the high, long-term oil price scenario ("constrained supplies") as shown in (reference/table/chart), the state remains largely dependent on oil (77 percent total annual energy consumption) through 2025, though absolute oil consumption declines by about 10 percent.

Thus, Hawaii's energy, environmental and economic security all depend on the state's success in accelerating its transition away from dependence on fossil fuels. This transition requires two fundamental changes -- the increased use of energy efficient technologies, and policies to support the increased use of renewable energy resources. The efficiency with which fuels and electricity are used to provide energy services must be improved in order to limit total energy demand such that supply may be met increasingly by renewable energy sources. Development and integration of renewable energy supplies into the state's energy systems is the second needed change, to maximize the use of Hawaii's plentiful renewable energy resources.

The transition to clean energy supplies and efficient use is needed in both the transport sector and in the electric power sector. The combination of supply and demand-side possibilities in the transport and power sectors, is represented in Table 1, which shows the key opportunities for technology change in each area.

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[1] From 2002 to 2005, the price of imported crude oil increased 100 percent, costing the state's economy an estimated $1.1 billion. Source: United States Energy Information Administration (EIA), 2006. *World Crude Oil Prices*. Washington DC: EIA. (http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm), retrieved August 23, 2006.

Table 1. Key Opportunities for Technology Change to Meet State Energy Goals

	Transportation sector	Electric power sector
Demand-side opportunities	Introduce and accelerate to market fuel-efficient vehicles, and reduce total vehicle miles traveled	Energy efficient technology and peak load management in residential, commercial, industrial, agricultural uses
Supply-side opportunities	Biofuel or renewable electricity substitution for fossil fuels	Renewable electricity and distributed generation to substitute for fossil fuels

There are important opportunities on the supply and demand-side in each of the key sectors. A comprehensive vision of a future energy system that realizes the needed transition would include the following elements:

- Utilities that partner with customers, developers, and trade allies to minimize the net energy demand of new buildings, and improve energy efficiency in enough existing facilities to keep total demand constant or declining over time (electric power demand);

- Renewable energy from wind, solar, hydro, geothermal, biomass and possibly ocean energy sources are integrated into the power grid in a way that maximizes reliance on these clean, local resources, matches them to efficient, responsive loads, and enables the retirement of old oil-fired generation (electric power supply);

- A revitalized agricultural sector that produces feedstocks for efficient local production of renewable biofuels, mostly ethanol and biodiesel, which are used to displace fossil fuels in power plants and vehicles (transportation supply); and

- Highly energy-efficient vehicles gradually replace less efficient ones as personal vehicles and corporate fleets turn over. These include vehicles that can be fueled partially or entirely by ethanol, biodiesel, electricity, or possibly hydrogen (transportation demand).

Capturing these opportunities, such as by implementing the policies RMI recommends in this chapter, can help Hawaii make serious progress toward reducing oil dependence, CO2 emissions, and the environmental and economic insecurity caused by fossil fuel dependence. Some progress can be expected in response to energy prices, but RMI recommends targeted policy measures to achieve a comprehensive and lasting impact. The recommended next steps can be summarized as follows:

- Energy efficiency standards and financial incentives for the regulated utilities to benefit from capturing all cost-effective energy efficiency investments (electric power demand, discussed in Chapter 5);

- Introduction of policy instruments such as feebates to accelerate the introduction and market penetration of fuel-efficient, flexible-fuel, and plug-in hybrid vehicles in Hawaii (transportation demand, discussed in Chapter 6);

- A renewable fuel standard, a sliding-scale subsidy mechanism to insulate biofuel producers from some of the oil market's volatility, and removal of barriers to the production and distribution of ethanol and biodiesel (transportation supply, discussed in Chapter 5 and Chapter 7); and

- A more stringent renewable portfolio standard, exclusive of energy efficiency, to require an increased share of renewable generation integrated into the power grid (electric power supply).

Together, a package of such policy instruments can help move Hawaii toward an efficient, clean energy future. Policy is needed even in light of today's high energy prices, which in late 2007 exceeded the highest levels projected in the modeling scenarios that we set up in 2006. While high prices can exert pressure to reduce fossil fuel use, they are not enough. The price signal often gets muted before it becomes a stimulus for investment in clean energy technology, and economists have observed that energy demand is relatively inelastic, i.e., insensitive to price changes. Thus, policies and incentives, targeted toward specific outcomes, are needed ensure continuing investment in clean energy technologies.

In addition, policies are needed to protect against reverting to increased fossil fuel dependence if and when energy prices abate, as occurred in the 1980s. The success of energy efficiency and renewable sources is not only Hawaii's best defense against climate change, but nationally and globally it is the only thing that will drive oil and other energy prices downward. Even if energy or CO_2 taxes are imposed to maintain the incentive for clean energy, revenues from such taxes can be recycled in our economy, whereas the costs of imported fossil fuels mostly benefit foreign countries.

Energy prices and the policy environment are especially important to harnessing Hawaii's renewable energy resources. While geothermal and wind power are cost-effective against modest energy prices, the economic viability of biomass, solar, and ocean energy is sensitive to volatile oil prices. Thus, policies are needed to avoid stranding investments in these technologies.

Using a select package of the recommended policies, Hawaii can limit energy demand growth, conservatively cut oil dependence from nearly 90% to 77%. These policies thus begin to reduce absolute CO_2 emissions by 2025, assuming sustained high (but not as high as in 2007) oil prices. With a modest CO_2 emission tax, or equivalent CO2 cap-and-trade allowance price, E2020 modeling results indicate that the state can reduce energy use and CO2 emissions a further 10%. In the latter case, CO2 emissions in 2020 would be lower than 2000 emissions, but still above 1990 emissions.

Why can't the transition to clean energy be more complete or go faster? Given the broad consensus around implementing energy efficiency and harnessing renewable resources,

and the economic and environmental imperatives for moving to clean energy, it seems frustrating not to see this transition being more complete by 2020 or 2025. We were conservative in modeling the energy system, as explained below, and it is indeed possible that some changes could happen faster than we have assumed. However, it is important to recognize the many factors that must be overcome to achieve a clean energy transition in Hawaii.

One factor is the inertia of the status quo—an inefficient, oil-dominated energy economy. Hawaii has only recently begun to institute the needed policy mechanisms, and many are still missing, for example to provide incentives for utility energy efficiency programs and remove barriers to biofuel production. Moreover, energy conversion technology, such as power plants and fuel refineries, are long-lived assets. So are energy-using equipment such as vehicles, household appliances and air-conditioning equipment in buildings, and especially the buildings themselves. It can be difficult or impossible to improve energy efficiency or change energy supply sources once these assets are put in service.

Another factor stems from Hawaii's small size and remote location. Market demand from Hawaii is not sufficient to influence global oil prices, renewable energy technology costs, or the availability or rate of development of new products such as efficient, flexible-fuel vehicles. Rather, Hawaii is largely a price-taker and a technology-taker. In other words, the state has relatively little national or global influence on setting the selling price of goods or the manufacturing of more clean and efficient technologies on the market.

Likewise, Hawaii is essentially a policy-taker as well. Unlike Congress and the larger states, particularly California, Hawaii would have great difficulty imposing technology-forcing policies or even fiscal policies such as CO2 emission taxes or cap-and-trade in isolation. Instead, the state is more likely to conform to or adapt Federal policies or those of other states. Because Hawaii cannot move market prices or technology trends, and is limited in its policy options relative to other states, the state is limited in how fast it can accelerate the clean energy transition.

A factor that is unique to Hawaii is the prominent role that aviation plays in the state's economy, energy balance, and CO2 emission inventory. Unfortunately, there is little that can be done at the state level, or indeed even at the Federal level, to influence aviation energy and emissions, which are governed mostly under international agreements.

Finally, Hawaii is limited in its capability to accelerate the clean energy transition, both in terms of technology implementation and policy innovation. Much of the state's energy technology and expertise comes from the mainland or abroad and is not always adapted to Hawaii's situation and needs. In the policy arena, the key agencies such as the Public Utilities Commission, {other agencies}, and DBEDT itself will need more staff capacity to implement the needed policy initiatives. This capacity building should be treated as a necessary part of Hawaii's energy and environmental policy.

Market incentives to accelerate investments in efficiency, biofuels and renewable power should increase in-state technological capacity. However, it is also important to support the private sector with targeted R&D and training through cooperation between the state

agencies, universities, and the private sector. Also, policy mechanisms that generate state revenues can also be tapped to cover the cost of needed capacity building.

2.2.1 Modeling Scenarios and Results

Modeling results show that Hawaii's energy system will shift to more diverse and clean energy supplies in the medium and long term in absence of further aggressive state policies. However, even in the high, long-term oil prices scenario, the state remains largely dependent on oil (77 percent of total annual energy consumption) through 2025.

Details of energy system modeling in the state using Energy2020 are provided in Appendix A and are summarized in the following paragraphs. The modeling results reveal that oil, as a fraction of total energy consumed in the state, declines under all scenarios between 2005 and 2025. Electricity demand will be increasingly met with renewable sources, with Hawaii and Maui Counties contributing much of the renewable generation for the state (18-35 percent renewable generation capacity and 3-10 percent biodiesel substitution across the scenarios). In the transportation sector, vehicle technology is assumed to become more efficient under all scenarios, ranging from about 10 percent improvement under low to moderate oil prices ("adequate supplies") scenario to a high of 16 percent improvement in the high oil prices ("constrained supplies") scenario. However, *total* energy consumption is projected to rise by approximately 19 percent in the adequate supplies scenario and the cyclic scenario where prices initially rise then eventually fall below 2005 prices by 2018. However, if fuel supplies remain constrained over the long term, annual energy demand will only grow by 7 percent before leveling off around 2015.

The overall energy strategy for Hawaii should place first priority on demand-side energy efficiency. Energy efficiency is the most cost-effective energy resource, and numerous technology options in both electric power and vehicles are already available and can be deployed quickly. Damping total demand growth first through efficiency will help reduce pressures for building fossil-generation, and improve the economics of renewable resources and other distributed generation, which can then be satisfied with fewer capacities and at smaller scales.

As such, energy policy recommendations put forth for the state should create a conducive regulatory environment for utilities and other power suppliers to benefit from energy efficiency, encourage or mandate electrical efficiency in new and existing buildings, and accelerate efficient vehicle adoption. Additional policies can be introduced that develop substitutions for fossil electricity and transportation supply resources and reduce the risk in making biofuels and renewable energy investments. Finally, policies should create forward thinking solutions for greenhouse-gas producing sectors that may be federally regulated soon.

In terms of policies, six of the 37 policy recommendations for HES 2007 were quantitatively modeled, and are described in more detail in Appendix B.[2] For these and the remaining recommended policies, additional quantitative analyses may be needed to further clarify and refine their design and implementation. The results previously described include efficiency and renewable energy policy targets set forth in the current state renewable portfolio standard (RPS) as well as the stand-alone energy efficiency standard, which utilities are able to satisfy under all scenarios when biofuels substitution is also considered. The state's alternative fuel standard (AFS) is easily met in the high oil price (constrained supplies) case without additional policies such as a sliding scale ethanol subsidy. A sliding scale subsidy will be needed in the cyclic scenario until 2017 when ethanol can no longer be cost effectively supplied, and is not used in the adequate supplies scenario given inadequate demand under that case.[3] With a high carbon cost adder mechanism (e.g., either a carbon tax or market price set for carbon in a cap and trade system),[4] both oil and total energy consumption decline under all scenarios.[5] Feebates (see Summary of Recommendations below) for transportation are estimated to further reduce oil consumption by 7-9 percent across scenarios.

2.3 Previous HES Policy Recommendations

The set of integrated energy policies presented in this chapter build upon the successes achieved by the Hawaii Energy Strategy 2000 (HES 2000) and other efforts such as the Governor's *Energy for Tomorrow* initiative. Additional details on past recommendations that have been implemented and legislated since 2000 are provided in Appendix D.

2.3.1 Hawaii Energy Strategy 1995

The first HES (HES 1995), completed in October 1995, laid a foundation for future work. It included the following seven projects:

Project 1: Analytical Energy Forecasting Model for the State of Hawaii;

Project 2: Fossil Energy Review and Analysis;

Project 3: Renewable Energy Resource Assessment Development Program;

Project 4: Demand-Side Management Assessment;

Project 5: Transportation Energy Strategy;

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[2] RPS that requires 20 percent renewable resources by 2020; existing AFS goal of 10 percent of highway fuel in 2010, 15 percent in 2015, and 20 percent in 2020 to come from non-traditional fuels such as ethanol and biodiesel; Sliding scale subsidy for biofuels relative to oil price for alternative fuels; feebates for consumer vehicles, carbon cost adder on fuels (low and high levels); stand-alone energy efficiency standard of 20 percent by 2020.

[3] In other words, in the adequate supplies scenario the model does not forecast a sufficient number of flex-fueled vehicles to meet the AFS, even if the fuel were cost-effective.

[4] Specific mechanism not defined, but could be valued via trading or taxes. High adder assumes \$26/sht ton CO_2e in 2006 and escalating 5 percent annually.

[5] Under the adequate supplies scenario, for example, total consumption declines by 9 percent and fossil fuel consumption declines by 5 percent.

Project 6: Energy Vulnerability Assessment Report and Contingency Planning; and

Project 7: Energy Strategy Integration and Evaluation System.

The projects each involved significant consultant support and produced detailed documents in each subject area, as well as the first iteration of the ENERGY 2020 software, which modeled the energy system and economy of each of Hawaii's four counties.

Recommendations made within HES 1995 for the electric power sector included cost-effective energy efficiency and conservation that was generally geared to encouraging gas and electric utilities to consider demand-side management (DSM) in integrated resource planning. It called for mandating load control devices on air conditioning and water heating systems, adopting and improving compliance with the model energy code in Maui. For renewable energy, recommendations included improving power purchase contract terms, obtaining access to land for renewable energy projects, and developing a renewable energy implementation plan.

In the transportation sector, HES 1995 recommendations included encouraging oil refiners to upgrade capabilities to better respond to world oil market changes and the development of state programs on alternative fuels. It called for the adoption of more stringent fuel economy standards than the federal CAFE standard, improved efficiency of state fleets, and expanding the use of alternatively-fueled vehicles.

The first HES program produced valuable information for the DBEDT Energy Division staff to use. Project work and the preparation of final reports greatly increased staff expertise related to energy planning. An increased understanding of fossil energy in Hawaii was gained from Project 2 (fossil energy review and analysis), and information in the report developed under Project 3 was used in the HECO Supply-Side Advisory Group as well as the renewable energy docket. The work done on alternate fuels for Project 5 (transportation energy strategy) prompted Tenn-Ark and other potential developers to consider developing alternate fuel production facilities on the Big Island.

2.3.2 Hawaii Energy Strategy 2000

The Second HES, HES 2000, was completed in January 2000. It focused on the following specific objectives:

- Increase diversification of fuels and the supply sources of these fuels;
- Increase energy efficiency and conservation;
- Develop and implement regulated and non-regulated energy development strategies with the least possible overall cost to Hawaii's society;
- Enhance a system of comprehensive energy policy analysis, planning, and evaluation;

- Increase the use of indigenous renewable energy resources;
- Enhance contingency planning capabilities to effectively contend with energy supply disruptions; and
- Reduce greenhouse-gas emissions from energy supply and use.

The last objective was added out of a growing concern about a vital environmental issue: the potential effects on Hawaii of global climate change due to greenhouse gas emissions. *HES 2000* supplemented the work of the Hawaii Climate Change Action Program and provided a new focus on measures to more efficiently use energy or provide indigenous energy alternatives and thereby reduce greenhouse gas emissions.

HES 2000 again recommended that the electric power sector support cost-effective utility DSM programs, efficiency in state buildings, and the adoption of a model energy code in Maui. It also recommended improving the efficiency of electric power generation, pursuit of distributed generation technologies, implementing a renewable portfolio standard, continue support for solar water heating, and a public benefits charge or green pricing to increase renewable energy use. It encouraged state agencies such as DBEDT, DOH, and DLNR, as well as interested stakeholders, to set state greenhouse-gas reduction goals with public input.

Transportation sector recommendations included reducing aviation fuel consumption, such as maintaining high load factors while increasing overall overseas capacity by airlines, and for airlines to adopt operating measures to increase fuel efficiency and use newer, more efficient aircraft. It recommended incentives for owners of alternative fuel vehicles, and also that the State Department of Transportation and Land Use Commission improve the bicycle transportation system and use land use planning to reduce traffic congestion.

Hawaii has achieved many of the recommendations established in the Hawaii Energy Strategy of 2000 (HES 2000). Those that have been adopted are summarized in Table 2 and presented in more detail in Appendix D.

Table 2. Historical Achievements Since 2000

HES 2000 Recommendation	Policy Created	Date	Description
Encourage Production and sale of 10% Ethanol Blend Gasoline in Hawaii (4.6.2.2)	Title 15, Chapter 35 Hawaii Administrative Rules	Passed legislation 1994; Amended with administrative rule 2004	Regulation requiring that at least 85% of Hawaii's gasoline contain 10% ethanol.
Continue to Increase the Use of Solar Water Heating (8.5.3.1)	Act 240 (SLH 2006)	Passed 2005	The Public Utilities Commission is authorized to implement a Solar Water Heating Financing program.
Consider implementing a Renewable Portfolio	Renewable Portfolio Standard (HRS §269-91)	Passed 2001; Amended 2004, Amended 2006	Each electric utility is required to meet 20% of its net electricity sales from renewable resources by 2020.

Standard, a Public Benefits Charge, or Green Pricing to Increase Renewable Energy Use (8.5.3.3)			
Encourage purchase and use of fuel-efficient conventional vehicles and hybrid vehicles (4.5.1.3)	Not Applicable	Not Applicable	Hybrid vehicles have been sold in the state for several years.
Increase use of renewable energy for electricity generation in Hawaii (7.4.3.2)	Renewable Portfolio Standard (HRS §269-91)	Passed 2001; Amended 2004, Amended 2006	Each electric utility is required to meet 20% of its net electricity sales from renewable resources by 2020.
Continue to assess the need for state income tax credits for renewable energy beyond 2003	Act 240	Passed 2006	Eliminates the sunset date on the Renewable Energy Income Tax Credits.
Adopt Model Energy Code for Maui County and adopt Residential Building Model Energy Codes in all Counties (11.2.1.4)	Maui County Code Chapter 16.16 (Ordinance 3250 §3)	Adopted code 2005	Maui Model Energy Code adopted.
Increase efforts by State government to improve energy efficiency by meeting State goals for reduction of energy use in State facilities (11.2.4.1)	Act 96	Passed 2006	Energy efficiency standards for state facilities; requires agencies to design and construct buildings meeting green design standards.
Expand Hawaii State government energy Performance Contracting and alternative financing for projects (11.2.3.3)	§36-41	Amended 2000, amended 2004	2000 Amendment expanded energy performance contracting to retrofits by requiring that state agencies evaluate retrofitting buildings to save energy; energy savings from retrofits returned to agency. 2004 amendment expanded definition of energy performance contract and allows for water saving technology retrofits.

2.3.3 Energy for Tomorrow 2006

In June 2006 Governor Linda Lingle signed into law a comprehensive energy plan to encourage and support market-based development of reliable, cost-effective, and self-reliant energy for Hawaii. Three bills that were enacted, HB2175, SB2957, and SB3185, contain many of the Administration package's provisions on reducing oil consumption . They will help to reduce oil dependence through energy efficiency, renewables, and use of biofuels in Hawaii. Details about these bills are included in Table 3.

Table 3. Summary of Energy for Tomorrow Policies

Description	Law Passed
SECTION 24. Adds §103D- Relating to Biofuel preference, Act 240. Definition of biofuel: "from non-petroleum sources, such as natural vegetable oil, waste cooking oils, fats, greases, or grease trap waste."	SB2957 SD2 HD2 CD1 Section 4 (Act 240)
SECTION 25. Adds §286, A Energy efficient and alternative fuel vehicles. "Special license plate, exempt five years from registration fee."	
SECTION 26. Amends "§103D-412, Energy-efficient vehicles requirements for state fleets.	HB2175 HD2 SD2 CD1 Section 28 (Act 96)
SECTION 27. Amends §226-18, Objectives and policies for facility systems--energy. (10) Provide priority handling and processing, and expedite action on all state agency permits required for renewable energy projects; and (11) Support a renewable fuels standard of ten per cent of highway fuel demand to be provided by renewable fuels by 2010, fifteen per cent by 2015, and twenty per cent by 2020.	SB2957 SD2 HD2 CD1 Section 5 (Act 240)
SECTION 28. Amends Section 237-27.1, to repeal on December 31, 2009." (Extension of exemption of alcohol fuels from GET.)	
SECTION 29. Appropriates $200,000 for a statewide multi-fuel biofuels production assessment to be expended by DBEDT.	SB2957 SD2 HD2 CD1 Section 8 (Act 240)
SECTION 30. Adds " H.R.S. §226- Energy efficiency for state facilities and vehicles. Adds to H.R.S. §196- Energy efficiency and environmental standards for state facilities, motor vehicles, and transportation fuels. Requires agencies to design and construct buildings meeting the LEED Silver or Two Green Globes rating system, or another comparable system, unless standard conflicts with emergency shelter requirements. $500,000 or so much thereof as may be necessary for FY 2006-2007, to carry out energy efficiency for state facilities and equipment.	HB2175 HD2 SD2 CD1 Section 4 (Act 96) HB2175 HD2 SD2 CD1 Section 10 (Act 96) HB2175 HD2 SD2 CD1 Section 11 (Act 96)

The energy efficiency provisions include:

- Energy efficient vehicle requirements for state vehicle purchase;
- LEED Silver or Two Green Globes requirement for state building design and construction;
- Energy efficiency and environmental standards for motor vehicles, and transportation fuels;
- LEED building standards for county buildings[6];
- Pay-as-you-Save Solar hot water heater program;
- $5 million for school photovoltaic projects;

[6] Specifically, counties shall establish procedures for priority processing of private sector building permits incorporating LEED Silver or Two Green Globes ratings.

- Ability of the Public Utilities Commission to establish a Public Benefits Charge/Energy Efficiency utility; and
- Requirement that any automatic fuel rate adjustment clause be designed to fairly share the risk of fuel costs between the public utility and its customers.

The renewables provisions include:

- An increase in photovoltaic, solar thermal and wind renewable energy income tax credits;
- Elimination of the sunset date for renewable energy tax credits;
- Creation of a world class renewable hydrogen program; and
- Requirement that Public Utiltiies Commission establish a methodology to remove or significantly reduce any linkage between the price of fossil fuel and non-fossil-fuel-generated electricity.

The biofuels provisions include:

- Biofuel preference;
- Alternate fuel standard;
- $200,000 for a statewide multi-fuel biofuels production assessment;
- $150,000 for the State Department of Agriculture to provide assistance to the agricultural community in developing energy projects, especially for the production of biodiesel from energy crops and cellulosic ethanol from agricultural waste streams.

2.3.4 The 2007 Legislature

The 2007 legislative session was productive, with DBEDT testifying on and monitoring a total of 55 bills. Several of the bills introduced and passed resulted from Hawaii Energy Strategy 2007 discussions and proposed recommendations. Table 4 provides a summary of energy bills that were passed into law during the 24th Legislature Regular Session.

Table 4. Policies Implemented During the 2007 Legislative Session

Description	Bills Passed
Relating to Naptha, Act 103 - Adds definition of "power-generating facility" and amends provisions relating to the fuel tax. Clarifies that naphtha fuel, used in a power-generating facility, is subject to the fuel tax at a rate of 1 cent per gallon and retroactive back to the imposition of the tax on naphtha used in power generation facilities.	SB992 SD1 HD2 CD 1
Relating to Ethanol, Act 128 - Extends the tax credit for qualified ethanol production facilities for 5 years from January 1, 2012, to January 1, 2017.	HB506 HD1 SD1 CD1
Relating to Gasoline, Act 130 - Requires all distributors to report to the department of business, economic development, and tourism, in a format prescribed by the department, on the distribution and availability of gasoline that does not contain ethanol. Requires report to legislature.	HB 791 HD1 SD1 CD1

Relating to Energy Performance Contract, Act 157 - Replaces definition of "energy-savings performance contract" with "energy performance contract" with the addition of commissioning and retro-commissioning; extends the maximum term of an energy performance contract from fifteen to twenty years.	HB1787 HD1 SD2
Relating to Biofuels, Act 159 - Adds biofuel processing facilities and crops for bioenergy to the list of permitted uses in an agricultural district. Establishes an energy feedstock program. Requires report to legislature.	SB1943 SD2 HD2 CD1
Relating to Renwable Energy, Act 205 - Clarifies definition of "renewable energy producer" to include thermal energy sold to customers of district cooling systems, for purposes of leasing public lands. Allows a county to grant, sell or otherwise dispose of easements for chilled water and seawater distribution systems by negotiation without public auction. Establishes, as state and county policy, priority handling and processing of state and county permits for renewable energy projects.	SB987 SD1 HD2 CD1
Relating to Greenhouse Gas Emissions, Act 234 - Establishes as state policy statewide greenhouse gas emissions limits at or below the statewide greenhouse gas emissions levels in 1990 to be achieved by January 1, 2020. Requires the department of business, economic development, and tourism and the department of health to update the inventory of emission sources. Establishes greenhouse gas emissions reduction task force to prepare a work plan and regulatory scheme to achieve the statewide greenhouse gas emissions limits.	HB 226 HD2 SD2 CD1
Relating to HNEI Bioenergy, Act 253 - Establishes the Hawaii natural energy institute of the University of Hawaii and creates the energy systems development special fund for the development of renewable energy and energy efficient technologies. Requires department of business, economic development, and tourism to develop and prepare a bioenergy master plan to develop a bioenergy industry in Hawaii.	HB1003 HD3 SD2 CD1
Relating to Efficient Transportation Study, Act 254 - Appropriates funds to the University of Hawaii to conduct a study on energy-efficient transportation strategies.	HB869 HD1 SD2 CD1
Relating to Issuance of Special Purpose Revenue Bonds for Electrical Generation on the State of Maui, Act 261 - Authorizes special purpose revenue bonds to BlueEarth Maui Biodiesel, LLC, for construction of a biodiesel refinery on Maui.	SB1718 HD2 CD1
Relating to High Technology, Act 266 - Appropriates funds for the Center for Conservation Research and Training at UH to develop best practices consistent with comprehensive agricultural management strategies to facilitate sustainable production of crops through long-term enhancement of soil quality using ecologically responsible means.	HB1083 HD2 SD1 CD1

2.3.5 Summary of Recommendations

Aggressively encouraging the adoption of best-available end-use electric efficiency and renewable energy technologies, shifting vehicle fleets to more efficient types, and producing biofuels in the state are solutions that are within the State's control. By coordinating between sectors and thinking from an integrated, whole-system point of view, the State can create shifts that will help it become more sustainable in the long run.

Recommendations developed as part of HES 2007 have been grouped into four categories—electricity, buildings, transportation, and cross-sectoral recommendations. They are listed in Table 5. Each recommendation is described fully in the remainder of this chapter, and repeated in subsequent chapters.

Table 5. List of Recommendations

ELECTRICITY SECTOR	
1	Shift Away from Traditional Rate-of-Return Regulation
2	Seek Ratemaking Design and Ratemaking Policies to Encourage Greater DG Adoption
3	Conduct System Integration Studies for Intermittent Renewable Energy
4	Modify Renewable Portfolio Standard to Require Compliance Using Only Renewable Energy Generation
5	Create Energy-Efficiency Resource Standard
6	Encourage Biofuel Use for Electricity Generation
7	Conduct Additional Studies on Status and Strategies for Maximizing Distributed Generation (DG) and Combined Heat and Power (CHP)
TRANSPORTATION SECTOR	
1	Continue to Implement Existing State-Fleet Efficiency
2	Implement Feebates to Encourage Purchases of Efficient Vehicles
3	Coordinate Transportation System Development With Land Use
4	Develop State Incentives for Efficient Vehicle Use
5	Promote Adoption of Efficient Trucks
6	Create Incentives for Businesses to Promote Reduction of Petroleum Consumption
7	Improve Pedestrian and Bicycle Infrastructure
8	Implement Pay-As-You-Drive Insurance
9	Operate Honolulu's TheBus System on Alternative Fuel
10	Create a Biofuel Refueling Infrastructure Tax Credit
11	Create a Tax Credit to Encourage Purchase of Flex-Fuel Vehicles and Necessary Fueling Infrastructure
12	Create a Distribution Infrastructure Investment Tax Credit
BUILDINGS SECTOR	
1	Continue to Update Model Energy Code (MEC)
2	Develop "Whole-system" Comprehensive or Packaged Energy Efficiency Programs
3	Aggregate Green-Power Purchasing for State Facilities
4	Combine Resource Efficiency Programs (e.g., Combined Electricity, Gas, and Water Use

	Efficiency)
5	Extend Solar Water Heating Financing Program to Include Solar Photovoltaic
CROSS-SECTORAL RECOMMENDATIONS	
1	Clarify In-stream Flow Standards
2	Appropriate Research and Development Funding for Bioenergy
3	Streamline Permitting Process for Bioenergy Projects
4	Create a Sliding-scale Production Tax Credit for Biofuels
5	Create an Irrigation Infrastructure Investment Tax Credit
6	Promote the Creation of a Biofuels Logistics Master Plan
7	Create a Revolving Fund to Support Small-Scale Bioenergy Investments
8	Clarify the Use of State Land for Renewable Energy Producers
9	Allow Use of State Land for Infrastructure

The recommendations are organized to facilitate easy reference to the part of the report from which they were initially developed. The electricity sector and building sector recommendations, for example, were developed from the electric power chapter (Chapter 5). The transportation sector recommendations were developed from the transportation system chapter (Chapter 6). Almost all of the cross-sectoral recommendations were developed from the bioenergy chapter (Chapter 7). The last two cross-sectoral recommendations on greenhouse gas emissions and climate change are developed from the energy, the economy, and the environment chapter (Chapter 3).

2.4 Electric Utility Sector Recommendations

2.4.1 Shift Away from Traditional Rate-of-Return Regulation

At time of this writing, a number of policy proposals that would remove utility disincentives to invest in more energy efficiency programs are before the Public Utilities Commission for consideration.[7] These include lost margins, third-party administration, shareholder performance incentives, and decoupling. Decoupling, in combination with performance incentives, is arguably the best combination, as explained below.

Revenue Decoupling

Decoupling is a mechanism that breaks (or decouples) the dependence of a utility's recovery of fixed investment costs on its energy sales to its customers. One specific method is via a revenue adjustment mechanism that allows the utility to recover the distribution revenues that were "lost" due to energy efficiency measures. By minimizing the impact of customer energy savings on a utility's recovery of its fixed costs, decoupling also reduces a utility's incentive to support load growth.

Decoupling can be achieved without substantially changing the revenue stream recovered by the utility in the years between rate cases. There are a number of ways the mechanism

[7] Docket No. 05-0069, for approval and/or modification of demand-side and load management program and recovery of program costs and DSM utility incentives.

can be structured, but the basic principle is a true-up, or revenue balancing, mechanism applied to a utility's balance sheets once actual sales levels are known each year. A common form of decoupling, for example, allows the utility to earn its revenues based on the number of customers served, as opposed to the kilowatt-hours sold.

Several states have implemented a decoupling mechanism.[8] California Investor Owned Utilities have been implementing decoupling mechanisms since 2004. Additionally, Oregon has a well known example of gas decoupling and is the only state that has had the program in place long enough to have it formally evaluated. In 2005, an independent assessment of Northwest Natural Gas found that the company improved the performance of its high-efficiency furnace program, and had shifted resources towards marketing energy-efficiency programs.[9] Thus, the limited measurable experience of decoupling has shown that it is an effective way to break the link between utility profits and sales, allowing a utility to encourage robust energy-efficiency programs without detriment to its financial success.

Performance Incentives

Performance incentives offer utilities financial incentives for the successful implementation of energy-efficiency programs. When performance incentives are combined with a lost-revenue adjustment mechanism such as decoupling, negative impacts on the utility are reduced. Several methods allow a utility to receive a reward for good performance; some of the more common methods are:

- Rate of return on energy efficiency equal to supply-side and other capital investments (Wisconsin).
- Increased rate of return on energy efficiency (Nevada).
- Specific financial reward for meeting certain targets (Arizona, Connecticut, Massachusetts, New Hampshire, and Rhode Island).
- Incentive equal to some proportion of the overall net benefits the programs produce – a.k.a "shared savings" (Minnesota).

Recommendation: Hawaii's electric utilities should advocate that the PUC consider implementing performance incentives in conjunction with a utility revenue decoupling mechanism. These two policies, along with the Public Benefits Charge currently in place, can further enable the aggressive implementation of energy efficiency.

[8] California, Maryland, North Carolina, Oregon, New Jersey, Utah, Vermont, Arizona, Idaho, Indiana, and Ohio.

[9] Hansen, D.G. and S.D. Braithwait. 2005. *A review of Distribution Margin Normalization as Approved by the Oregon Public Utility Commission for Northwest Natural.* Evaluation report prepared for the Oregon Public Utility Commission. Madison, Wisconsin: Christensen Associated Energy Consulting. March 31.

2.4.2 Seek Ratemaking Design and Ratemaking Policies to Encourage Greater DG Adoption[10]

Encouraging greater DG adoption needs to be balanced with the design of equitable rates under a variety of arrangements between DG owners and electric utilities. The following is based upon HB2660 HD1,[11] which was considered by the 2002 Legislature but did not pass. The recommendations included the following elements:

- Ensure that standby charges are cost-based;
- Provide for equitable treatment of cost recovery for distribution service where customers provide for physical assurance;
- Consider equitable treatment of different levels of service such as supplemental power, backup service, and maintenance service;
- Ensure that supplemental power continues to be priced according to the customer's otherwise applicable tariff;
- Recognize cost differences between supplemental power and backup power needs by considering the value of diversity in standby reservation charges, since diversity reduces transmission and distribution infrastructure requirements;
- Recovery of public purpose costs from standby customers through a cost per kilowatt usage charge;
- Charges based on embedded, not incremental, costs of service consistent with the manner in which rates are calculated for other distribution services;
- Account for the benefits when DG reduces peak electricity demand at those times when the cost of delivering power are highest for the utility; and
- DG utilizing renewable energy resources shall not be subject to standby charges or customer recognition rates in consideration of the economic, environmental, and fuel diversity benefits of renewables.

Recommendation: In late 2006, the PUC issued a final decision regarding Docket 03-0371, Instituting a Proceeding to Investigate Distributed Generation in Hawaii. However, the PUC has opened two new dockets to address ongoing concerns about standby tariffs. In Dockets 06-0497 - HECO and 06-0498 - KIUC, independent power producers should advocate that the Public Utilities Commission reconsider the recommendations included in HB2660 HD1 (2002).

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[10] Global Energy Partners, LLC. (2004 July 29). *Creating Distributed Energy Opportunities for Hawaii*. Prepared for Energy, Resource and Technology Division, State of Hawaii Department of Business, Economic Development and Tourism (DBEDT).

[11] Electric Utility Charges and Discounts; Distributed Resources. State of Hawaii Legislature Archives. 2002. www.capitol.hawaii.gov/session2002/bills/hb2660_hd1_.htm.

2.4.3 Conduct System Integration Studies for Intermittent Renewable Energy

Intermittent renewable energy technologies, such as solar photovoltaics and wind, impose operational challenges to electric utility systems. Utilities around the country and in Europe have conducted studies regarding the technical and economic implications of the increasing penetration of intermittent renewables. However, the impacts of intermittent renewables are highly dependent on load shapes, system characteristics, and, in the case of wind, the wind regime in question. While existing studies from around the country may indicate the potential scale of the impact of intermittent renewables, they are not sufficient as a basis for decision-making by Hawaii's utilities specifically, due to Hawaii's unique situation as an isolated utility.[12]

What is needed is a system-specific analysis of the reliability impact of different penetrations of intermittent renewables, known as the Effective Load Carrying Capability (ELCC) of the resource. These studies also include estimations of the operational cost of renewable integration on several different time-scales, including seconds, minutes, hours, and seasons.

Recommendation: The PUC should consider directing HEI and KIUC to conduct (either internally or through an outside contractor) studies of intermittent renewable integration and operational impacts. These studies should include an analysis of the potential for "firming" intermittent renewables using geographical dispersion, combinations of renewables, or storage technologies. Once completed, the PUC should consider directing the utilities to implement the recommendations in the studies.

2.4.4 Modify Renewable Portfolio Standard to Apply Only to Renewable Energy

The Renewable Electrical Efficiency provision of the existing Renewable Portfolio Standard should be a stand alone standard to allow the RPS to become a renewable-energy-only standard. Separating the RPS goals into separate efficiency and renewable energy standards (see next recommendation), would provide greater transparency and accountability. If the PUC should determine that a non-utility entity should administer the DSM programs, than that entity would be accountable for these goals because of contractual obligations.

Recommendation: State Legislators should consider updating the Renewable Electrical Energy provision of the existing RPS to establish the RPS as a renewable energy-only standard. As discussed in the following recommendation, the Renewable Electrical Energy provision would be moved under the energy efficiency resource standard. The minimum renewable energy requirement would stay the same (20 percent by 2020).

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[12] Studies have been conducted by Xcel Energy, PacifiCorp, and the California Energy Commission, among others. In general, these studies have found a positive reliability contribution from wind (on the order of 10–20 percent), and an added operational cost of $1–5/MWh. However, this cost cannot be directly applied to Hawaii because mainland utilities are interconnected to regional grids that may affect (either positively or negatively) the operational impacts of wind.

2.4.5 Create an Energy-Efficiency Resource Standard

Energy efficiency is generally the most cost-effective means to increase energy sustainability in the State. An energy-efficiency resource standard (EERS) is "a simple, market-based mechanism to encourage more efficient generation, transmission, and use of electricity."[13] The EERS would require that the utility achieve reductions in demand through efficiency as a percentage reduction of gross electric sales, starting from a set baseline year. The DSM reductions would be quantified as megawatt-hours from the baseline year, using the Measurement & Evaluation (M&E) reports used for calculation of shareholder performance incentives. The gross electric sales would be the net electrical sales plus quantified DSM reductions.

HECO's recent IRP filing proposed an effective reduction of 0.6 percent of gross sales.[14] Therefore, based on its proposed IRP, HECO indicates that this level of DSM savings is achievable, assuming the programs are approved, and adequate funding is provided. As reported by American Council for an Energy Efficient Economy (ACEEE) in its 2006 study, independent, third-party administrators, such as Efficiency Vermont, as well as leading electric utilities, are achieving a one percent reduction in electrical sales each year.[8] Using 2006 as the baseline year, and a goal of a one percent reduction in electric sales per year for all utilities combined is a reasonable goal for energy efficiency.

A one percent reduction, using 2006 as a baseline, would result in a 20 percent reduction in electric utility companies' gross sales by 2026. This may be an achievable target for the utilities in Hawaii, based on current achievements of third-party administrators and leading electric utilities.[15] The Public Utilities Commissions in Texas, Nevada, Pennsylvania, and California have conducted rulemaking in 2004–2005 to create an EERS.

Recommendation: The State Administration should consider introducing a bill to the Legislature to establish an EERS with a goal of achieving a one percent reduction in kWh energy sales annually, using 2006 as a base year, for all utilities combined. The EERS would require a cumulative energy-efficiency goal of 20 percent by 2026, statewide.

2.4.6 Encourage Biofuel Use for Electricity Generation

While highway transportation biofuels are subject to a lower tax rate than highway fossil fuels,[16] fuel (either biofuel or fossil fuel) used for electricity production is only subject to

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[13] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations*. *March 2006 (ACEEE Report EO63*. Washington DC: ACEEE, 2006.

[14] Hawaiian Electric Company (HECO), 2005. *Integrated Resource Plan, 2006–2025*. Honolulu: Hawaiian Electric Company, Inc.

[8] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006*. *(ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[15] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006*. *(ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[16] H.R.S.§243-4 and §243-5

general excise tax. Therefore, biofuels for power are at a greater risk of not being cost-competitive with fossil fuels for power. Despite this, analysis indicates that biodiesel is always cost-competitive with No. 2 fuel oil (its substitute) for power production. Ethanol, however, is not always cost-competitive with naphtha (its substitute).

Current biofuel subsidies in Hawaii are focused almost exclusively on the ethanol production step. To support the development of the biofuels industry as a whole, new subsidies and incentives should support other parts of the ethanol value chain. For example, by ensuring the agricultural sector a market and profitable price for its products, agricultural subsidies would encourage and support the production of biofuels and biomass feedstock. At the same time, subsidies that shield end users—such as Hawaii's electric utilities—from pricing risks associated with uncertain oil prices would help create an increase in demand and, in turn, protect consumers from rate increases.

Because of the different cost structures for fuels in the transportation and electricity sectors, different incentives for biofuels are appropriate. As discussed in a later section, a sliding-scale production tax credit for transportation ethanol should be the most effective incentive. However, this type of policy is not necessarily the most effective for the electric power industry, partly due to the small number of market participants. Since Hawaii's electric utilities are regulated, the PUC should work with the utilities and other stakeholders to determine the most appropriate incentive mechanism.

Recommendation: Efforts underway by Hawaiian Electric Company in partnership with Blue Hawaii Biodiesel will likely result in the production of sufficient biodiesel to meet the three HEI companies' needs for diesel fuel. The PUC should consider examining the potential financial risks faced by the HECO and other Hawaii utilities regarding biofuels consumption, and what additional incentives may be appropriate to mitigate those risks.

2.4.7 Conduct Additional Studies on Status and Strategies for Maximizing Distributed Generation (DG) and Combined Heat and Power (CHP)

The Public Utilities Commission was recently assigned responsibility for collection and maintenance of data on fossil fuels.[17] The usefulness of the fuels database could be enhanced to allow tracking of the amount and type of fuel consumed for DG. The State has historically received detailed information primarily from the sugar industry concerning the electricity generated for the industry's own use, the electricity sold back to the utility, generation heat rates, and the quantities of each type of fuel consumed.

The State's ability to benchmark all existing non-utility electricity generation sources and evaluate potential policies and programs would be significantly enhanced if these data were available for all commercial and residential segments. Such a survey can better inform the potential for CHP and non- emergency backup DG capacity in the state. It would benefit energy service companies and independent power producers interested in

[17] State of Hawaii, 2006. *Hawaii Revised Statutes*, Chapter 486J, Petroleum Industry Information Reporting Act. Honolulu: State of Hawaii

doing more business in Hawaii with CHP. Utilities may also be able to incorporate this information into their integrated resource planning.

Recommendation: DBEDT should consider updating the distributed generation study completed in 2004 to provide new information on existing and future DG capacity and generation by application. The study should also distinguish between backup installations, CHP installations, and net-metering installations. DBEDT may want to consider soliciting assistance from energy service companies or independent power producers for conducting this study since they, too, would likely find it beneficial.

2.5 Transportation Sector Recommendations

2.5.1 Continue to Implement Existing State-Fleet Efficiency

In 2006 the State Legislature passed Act 96, which amended Chapter 196 and Chapter 103D, HRS to promote renewable energy and energy efficiency for State facilities, motor vehicles, and equipment. Implementation of these measures will reduce Hawaii's foreign oil dependence.

The primary intention of Chapter 196 is to reduce Hawaii's dependence on imported fossil fuels. Act 96 amended several parts of Chapter 196, including the State's fleet purchasing requirements. The major changes included requiring that all agencies purchase alternative fuel and fuel efficient vehicles, and that they purchase alternative fuels and ethanol-blended gasoline when available.

Act 96 also amended the vehicle procurement code, Chapter 103D-412, HRS. The major changes included requiring increasing percentages of fleet purchases of light vehicles to be energy efficient.[18] For the fiscal year beginning on July 1, 2006, at least 20 percent of light-duty vehicles for each fleet were to be energy-efficient; for the fiscal year beginning on July 1, 2007, 30 percent; and the fiscal year beginning on July 1, 2008, it is 40 percent. Subsequent fiscal year purchases are to increase by 5 percent per year until they reach 75 percent.

The Act also allows the procurement requirements to be offset by successfully demonstrating improvements in overall light-duty vehicle fleet fuel economy, as well as by biodiesel substitution.

Recommendation: All responsible agencies, including state motor vehicle fleet operators, should continue ongoing work to meet the new state vehicle and fuel procurement laws.

[18] Alternative-fueled vehicles, electric vehicles, hydrogen vehicles, hybrid electric vehicles, and efficient conventional vehicles (found on the list of "Most Energy-Efficient Vehicles" in its class or is in the top one-fifth of the most energy-efficient vehicles in its class available in Hawaii as shown by vehicle fuel efficiency lists, rankings, or reports maintained by the U.S. EPA) are all considered to be "energy-efficient" vehicles defined within the Act.

2.5.2 Implement Feebates to Encourage Efficient Vehicle Purchases

Feebates are intended to increase the number of efficient vehicles purchased in Hawaii by providing a continuing incentive to improve fuel economy. Feebates provide a financial incentive or assess a fee on each new vehicle upon registration depending on the gallons per mile the vehicle achieves. The feebate could help accelerate the sales of more energy-efficient vehicles because it affects the purchase cost of a vehicle while simultaneously preserving customer choice as to the type and class of vehicle. Modeling shows that feebates have the potential to reduce annual gasoline consumption in Hawaii by 30–60 million gallons by 2025, or cumulatively by 300–400 million gallons between 2006 and 2025.

The ideal feebate is revenue-neutral and size-neutral. This type of feebate would revolve around a fuel-economy benchmark called a "pivot point" for each size class of vehicle. The preferred pivot point metric is measured in gallons per mile (GPM). The pivot point would determine whether a vehicle received a rebate or was assessed a fee, thus it would also determine the revenue neutrality of the policy.

The size classes could coincide with the size classes that have already been established under CAFÉ, or could be new size classes that are based on the vehicle's rectangular shadow (calculated by multiplying the length of the vehicle by the width of the vehicle). Ideally, there would be new size classes designed that would be broader than current CAFÉ standards, thus creating fewer size classes. Fewer size classes are preferred because they are not as susceptible to manipulation because it is more difficult for manufacturers to move up to a different size class (that would have a different GPM pivot point).

Within a given size class, buyers of vehicles that exceed the pivot point would receive a rebate, while buyers of vehicles that are below the pivot point would pay a surcharge. A typical feebate design applies a $1,000 fee (or rebate) for each 0.01 (GPM) difference between a vehicle's fuel economy and the target fuel economy. The mathematical equation for this feebate design is as follows:

Fee or Rebate[19] = $1,000 x GPM (target) - GPM (efficient))/0.01

For example, in the midsize SUV class, a typical feebate might be $1,000 per 0.01 gallons per mile (GPM) with a target fuel economy of 23 miles per gallon. Thus, a Nissan *Pathfinder* getting 18 miles per gallon (1/18 mpg = 0.056 GPM) is 0.13 GPM worse than the target, so the *Pathfinder* incurs a $1,300 fee. Ford's new *Escape* hybrid SUV gets 36 mpg, or 0.028 GPM (0.015 GPM better than the target fuel economy), so it would earn a $1,500 rebate.

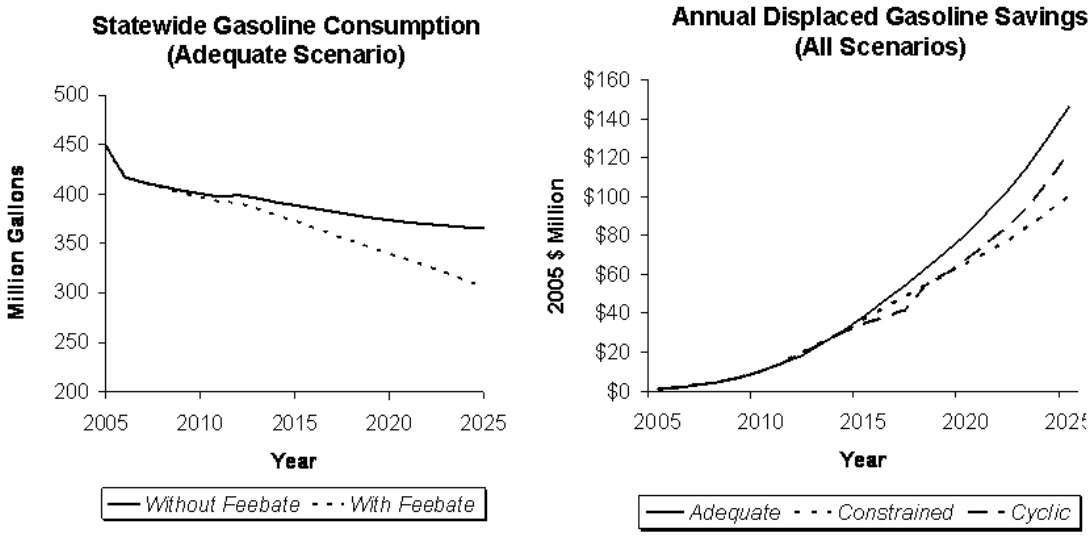
Based on our modeling in the constrained scenario with feebates, accelerating the sales of more efficient and ultra-efficient next-generation vehicles increases the average

[19] Greene, D.L., Patterson, P.D., Sing M., & Li, J. (2004). "Feebates, Rebates and Gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy," *Energy Policy*, vol. 33, no. 6, pp. 721-827.

efficiency of the vehicle stock from 30 mpg by 2025 to more than 40 mpg, and reduces gasoline consumption by 7 percent annually compared to the constrained scenario without feebates. This is in addition to the efficiency gains that will be encouraged by high fuel prices experienced under the constrained supplies scenario. Additional reductions in gasoline consumption are even greater under the adequate supplies and commodity cyclic scenarios, where—with feebate policies in place—consumption is estimated to decline by an additional 9 percent beyond the fuel price stimulus.

Figure 42 estimates the cost savings to consumers from reduced gasoline consumption, resulting from a feebate policy for light cars and trucks. By 2012, feebates are estimated to generate approximately $19 million annually in fuel cost savings for consumers. By 2025, these additional savings increase almost five-fold to $145 million under the adequate supplies scenario, $122 million under the commodities cyclic scenario, and $100 million under the constrained supplies scenario. The incremental savings under the constrained scenario are muted because high fuel prices under this scenario stimulate the adoption of more efficient and next-generation vehicles.

Figure 1. Annual Consumer Savings From Gasoline Reduction Due to Feebates



One problem in implementing the feebate is that the revenue-neutral, size-neutral feebate may be pre-empted by the Energy Policy and Conservation Act, which forbids states from adopting their own fuel economy standards. In 1992, Maryland passed a feebate that was based on the fuel economy rating of new vehicles sold, in addition to requiring that the savings/additional tax be recorded on the window label for consumer ease. This practice resulted in Maryland's feebate being struck down based on the labeling preemption under the Energy Policy and Conservation Act.[20]

[20] Chanin, Rachel, *California's Authority to Regulate Mobile Source Emissions.* NYU Annual Survey of American Law Vol 58:699:2003 p735.

However, the pre-emption challenge did not discuss the broader issue of whether the Maryland feebate was "related to" regulating fuel economy. Thus, in order to implement a feebate based on a pivot point determined by GPM, states will need to prove that feebates do not "relate to" fuel economy. Recent Supreme Court rulings indicate that the Court has been moving toward a more narrow interpretation of "related to."[21] This is significant because it shows the Court is leaning toward granting states more leeway to adopt policies, as long as the states' policies do not hamper federal policy goals. Also, the Court has begun taking into account the degree to which states' programs reflect traditional areas of state activity.

The National Highway Traffic Safety Administration (NHTSA) is responsible for establishing and amending fuel economy regulations. NHTSA is the agency that could grant exemptions from the Energy Policy and Conservation Act. Another option is to ask the Governor of Hawaii to request NHTSA to provide the State with an administrative exemption to the federal pre-emption in Title 49. Yet another option is to ask Hawaii's U.S. Congressional representatives to introduce federal legislation to create a national-level feebate.

A final option is to adopt a feebate that is not based on a GPM pivot point, and instead base the law on weight. This type of feebate structure was passed into law in Washington DC on December 7, 2004. Washington DC's City Council approved the Motor Vehicle Reform Act, which raised the excise tax on vehicles weighing more than 5,000 pounds and simultaneously eliminated the excise tax on clean-fuel and electric vehicles in the District of Columbia.[22] The Act also raised the registration fee on vehicles weighing more than 5,000 pounds and reduced the registration fee on clean-fuel and electric vehicles. No pre-emption challenges were raised. A similar feebate structure was introduced during the 2006 Hawaii legislative session, but it did not pass.

All four options present implementation challenges. The first option (getting NHTSA to grant an exemption from CAFE standards) requires passing legislation that may be pre-empted and potentially ignite a legal battle. This may be time-consuming and expensive. The second option, petitioning the Governor, may also be time-consuming and it may require the same legal arguments (i.e., that the feebate does not prohibit efficient and proper administration of the CAFE standard) be made to NHTSA. The third option, asking Hawaii's U.S. Congressional representatives to craft federal legislation, will require support from automobile manufacturers–which will also be time-consuming and difficult. The final option, adopting a feebate-like structure that will not be pre-empted, is a step in the right direction, but it does not contain the important characteristic of promoting consumer choice. Instead, it creates a preference for the purchase of small lightweight vehicles, which may reduce petroleum consumption rather than reward

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[21] The phrase "related to" was explained by the Court in *Morales v. Trans World Airlines,* 504 U.S. 374, 384 and cases cited (1992). Since *Morales,* the Court has shifted to a more narrow interpretation of what constitutes pre-emption, see *California Division of Labor Standards Enforcement v. Dillingham Construction*, 519 U.S. 316 (1997); *Engelhof v. Engelhof,* 532 U.S. 141 (2000).

[22] As determined by the United States Internal Revenue Service to be eligible for a federal tax deduction or credit pursuant to 26 U.S.C. §§ 30 and 179A.

customers for choosing the most efficient vehicle within the customer's desired vehicle class (passenger vehicles versus SUVs versus light trucks, for example).

Recommendation: The Administration should consider submitting a bill to the Legislature establishing a feebate based on a GPM pivot point. It will allow for the creation of a policy that has the ability to significantly reduce the state's dependence on oil for transportation purposes. Additionally, once current legal challenges around the nation have been worked out, and a path is chosen for feebate implementation, feebates should also be considered for medium and heavy trucks.

2.5.3 Coordinate Transportation System Development With Land Use

One of the most important recommendations that can be made in regard to transportation policy is to coordinate land development with the development of appropriate transportation infrastructure, including pedestrian and bicycle infrastructure, as well as public transit capability.

In Hawaii, each county has control over its land use laws and zoning.[23] It is crucial for the counties to consider transportation needs and infrastructure as development occurs. Without a coordinated development and transportation plan, a piecemeal strategy will emerge that may be more costly and will certainly be less effective in the long term.

Recommendation: When updating its General Plan, we recommend that each county's planning authority consider developing land and transportation infrastructure simultaneously in a cohesive manner.

2.5.4 Develop State Incentives for Efficient Vehicle Use

In the past, Hawaii offered incentives for electric vehicles, which were ultimately deployed only in small numbers. Currently, Hawaii does not offer incentives for the purchase of energy-efficient vehicles. Two incentives to consider for encouraging energy-efficient vehicles include allowing discounted or preferential parking for efficient vehicles, and allowing solo-operated energy-efficient vehicles to use the high-occupancy vehicle (HOV) lane.

Several major U.S. cities have begun offering free or discounted public parking to the owners of energy-efficient or alternative-fuel vehicles, particularly hybrid vehicles. It is

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[23] The Kauai General Plan was last updated in November 2000 and is available online at: www.kauai.gov/Default.aspx?tabid=130. Maui is in the process of updating its General Plan. On January 10, 2007, Maui County released a Draft Countywide Policy Plan. The Draft Countywide Policy Plan and the General Plan from 1990 are available online at: www.mauicounty.gov/departments/Planning/gp2030/info.htm. Oahu has a General Plan and Development/Sustainable Communities Plans. There are eight planning areas, each of which develops a Development/Sustainable Community Plan. The General Plan applies to the entire county. Together, these plans guide the population and land use growth over a 20-year time span. The Oahu General Plan is available online at: www.honoluludpp.org/Planning/OahuGenPlan.asp. The Development/Sustainable Community Plans are available online at: www.honoluludpp.org/planning/DevSustCommPlans.asp. The Hawaii County General Plan was last updated in February 2005 and is available online at: www.hawaii-county.com/la/gp/2005/main.html.

a useful tool for creating incentives for consumers to purchase more efficient vehicles. However, it is important when crafting the policy to establish a sunset date, which would occur when the projected number of efficient vehicles is too large to continue offering free parking.

An alternative to offering free parking to energy-efficient vehicle owners is to offer designated parking spots that still require payment. This means the counties do not lose parking revenue, and an incentive for people to purchase more efficient vehicles remains.

The State can also create incentives by changing laws to allow owners of efficient vehicles to use high-occupancy vehicle lanes, regardless of the number of people in the vehicle. Prior to August 10, 2005, federal law preempted potential changes in State law to allow hybrid vehicles with single occupants in the HOV lane. However, President Bush eliminated the provision forbidding efficient vehicles with solo occupants in HOV lanes when he signed the Transportation Equity Bill into law. Thus, the law currently allows states to regulate when and where hybrid vehicles are exempt from the HOV restrictions.

Recommendation: The Department of Transportation should consider conducting a study regarding the fiscal effects of allowing energy-efficient vehicles to use public parking for free or at a discount, and the feasibility of designating energy-efficient vehicle parking spaces. Additionally, the study may want to address the feasibility of allowing energy-efficient vehicles in HOV lanes, as well as the times at which the vehicles should be allowed to use the lanes.

2.5.5 Promote Adoption of Efficient Trucks

Among efficient technologies, hybrid trucks currently offer a substantial fuel savings opportunity. Today, a variety of models are entering the market. In diesel-electric hybrid trucks, the electric engine accelerates the vehicle and powers it at low speeds, and the diesel engine provides additional power needed to move the truck at high speeds. One advantage of hybrid trucks is that the diesel engine automatically turns off during loading, unloading, and waiting in line—all times when a conventional truck would normally be idling. Hauling distances in Hawaii are relatively short compared to the mainland, so trucks in Hawaii spend a greater percentage of their time idling during loading and unloading or in traffic than do many trucks on the mainland. This large reduction in idling time per trip means hybrid trucks could have a large impact on truck fuel consumption in Hawaii.

Recommendation: The Department of Health should evaluate and recommend program options to encourage the purchase and use of efficient trucks. Though hybrid trucks represent one of the most promising technologies, any legislative action should be performance-based, ensuring a focus on the efficiency objective without picking specific technologies as predetermined "winners." Potential policy options include a scrap-and-replace program, a low-interest loan program, or tax incentives or subsidies to encourage investment in efficient trucking technologies.

2.5.6 Create Incentives for Businesses to Promote Reduction of Petroleum Consumption

An option to reduce driving and the resulting congestion is to offer incentives to businesses that encourage their employees to telecommute, rideshare, use mass transit, and use alternative fuel in business vehicles. Businesses would be able to encourage employees to reduce transportation fuel use in many ways, including providing mass transit passes to employees. Hawaii could offer an income tax credit to businesses that reduces the total amount of petroleum transportation fuels used for commuting and business purposes by 20 percent (from an established baseline). The tax credit could be proportional to the petroleum savings achieved. The structure for the tax incentive would have to be developed in collaboration with the Department of Taxation to ensure that it would be within the State's budget.

Recommendation: The Department of Taxation should consider creating a Business Petroleum Reduction Tax Credit for proposal to the Legislature.

2.5.7 Improve Pedestrian and Bicycle Infrastructure

Creating pedestrian- and bicycle-friendly infrastructure is a simple way to encourage residents to walk or bike on shorter commutes. Many areas of the state do not have sufficient pedestrian- and bicycle-friendly infrastructure, such as pathways or bike lanes, thus residents do not feel safe walking or biking. Each county should take action in order to improve the pedestrian and bicycle infrastructure.

Recommendation: Counties should consider developing policies to support appropriate curb, sidewalk, crosswalk, and bike path infrastructure when planning new developments. We also recommend that this new infrastructure be integrated with any existing infrastructure to avoid the creation of piecemeal infrastructure that is ineffective in encouraging residents to walk or bike short distances.

2.5.8 Implement Pay-As-You-Drive Insurance

Typical automobile insurance rates are fixed, reflect poorly how many real-world miles a motorist drives, and fail to provide incentives for motorists to reduce the amount they drive. Usage-based automobile insurance, on the other hand, recognizes actual vehicle miles traveled (VMT) and reduces premiums for motorists who drive fewer miles. This type of insurance is also known as "pay-as-you-drive" insurance, and can be a powerful VMT-reduction tool as it offers a financial reward for eliminating unnecessary vehicle trips.

Various regions are taking steps to allow usage-based automotive insurance. Cities, states (Philadelphia, Oregon, Massachusetts, and Minnesota), and other countries (the United Kingdom, for example), realize the benefits of usage-based insurance. Studies show these benefits include a reduction in VMT by 10 percent, a 25 percent savings to motorists on their insurance premiums, and a 17 percent reduction in accidents.

Before a pay-as-you-drive insurance plan can be adopted, the State must grant insurers the authority to offer discounts based on miles traveled. This would allow companies

currently offering usage-based auto insurance, such as Progressive Insurance and GMAC Insurance, to offer voluntary pay-as-you-drive insurance plans in Hawaii. Other automotive insurers might then be encouraged, through competition, to develop and implement usage-based insurance as well. Ultimately, participating drivers will be able to keep more money in their pockets when they drive less.

Recommendation: The State Legislature should consider passing a bill that will allow Hawaii insurance providers to implement voluntary pay-as-you-drive insurance programs for the motoring public.

2.5.9 Operate Honolulu's TheBus System on Alternative Fuel

Currently, there are bus systems in all of Hawaii's counties, with Oahu's bus system having the largest fleet, most routes, and highest ridership. The County of Hawaii's bus infrastructure was expanded in January 2006 through the purchase of an additional ten buses, bringing the county's total to forty. Maui also expanded its system by adding an additional commuter route in October 2006. Oahu's bus fleet currently has ten hybrid-electric buses and transportation officials plan to purchase forty additional hybrid-electric buses.

While these are steps in the right direction, there are no buses in Hawaii that operate on biodiesel. Many cities in the United States have begun operating their buses on B5, a mixture of 95 percent diesel and 5 percent diesel from renewable resources. Any diesel engine may operate on B5 with no adverse affects to the engine.

Additionally, because the buses are centrally refueled, the counties would only need to install one biodiesel refueling station. The benefits of running the buses on biodiesel include reducing Hawaii's dependence on foreign oil and reducing emissions.

Recommendation: The counties should consider assessing the feasibility of running their buses on biodiesel by comparing the cost savings resulting from the diesel that would be displaced with the cost of installing biodiesel-refueling infrastructure.

2.5.10 Create a Biofuel Refueling Infrastructure Tax Credit

The State should support development of E85 and B100 retail service stations (as well as B100 marine fuel stations). The State can draw on the experience of other states in providing either 15 percent tax credits or outright grants for service station conversion and construction.[24]

[24] Several states offer tax credits for the installation of alternative fuel, refueling infrastructure. Florida offers a 75 percent tax credit on all capital, operation and maintenance, and research and development costs associated with the distribution of biodiesel and ethanol, with refueling station retrofits also qualifying for the credit. The Indiana Office of Energy and Defense Development administers a Biofuels Grant that offers funding for the installation of refueling infrastructure, with a fund-matching requirement of 50 percent.

Though in-depth cost analysis has not been performed on the cost of a distribution system, most estimates converge at around $10 million for the first 40 million gallons per year.

Recommendation: The Legislature should consider passing an alternative-transportation fueling infrastructure tax credit, including working with retail and wholesale distributors, and using successful past State tax credits and other states' experience to determine the exact credit.

2.5.11 Create a Tax Credit to Encourage Purchase of Flex-Fuel Vehicles and Necessary Fueling Infrastructure

Flex-fuel vehicles (FFV) can use varying mixes of up to 85 percent ethanol and 15 percent gasoline. Widespread use could significantly reduce oil use in the ground transportation sector. However, there is little use in purchasing this capability if the fueling infrastructure is not in place. This is often presented as a "which comes first, the chicken or the egg" problem. One way to address this is to simultaneously offer incentives for building fueling infrastructure to offer up to 85 percent ethanol blends and for purchase of FFVs.

First, a tax credit would be provided to FFV purchases on a first-come, first-served basis, with a maximum credit of $2,000 per vehicle. The FFV tax credit would be dependent on the presence of sufficient infrastructure, however. FFVs would receive a 50 percent credit when 10 percent of stations sell E85; that credit would increase linearly to 100 percent credit when 20 percent of stations sell E85.

Recommendation: Use vehicle choice modeling and vehicle sales data for Hawaii to quantify the effectiveness and cost of a vehicle purchase incentive. Making use of this information, State Representatives and Senators can work with the Department of Taxation to establish an effective Flex-Fuel Vehicle Tax Credit. Once the policy is in place, track its effectiveness.

2.5.12 Create a Distribution Infrastructure Investment Tax Credit

The delivery of biofuels to the end user is a crucial step in both the ethanol and biodiesel value chains, and it depends largely upon the availability of distribution infrastructure in Hawaii.[25]

Current biofuels subsidies in Hawaii are focused almost exclusively on the ethanol conversion process. Therefore, given the need for action by several distinct players, new subsidies and incentives should support the other parts of the bioenergy value chain. One of these incentives should be an investment tax credit for the transportation and storage of biofuels.

[25] Further detail on the distribution infrastructure subsidy is provided in the Hawaii Energy Policy Forum's report, developed in part by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195.

The main barriers to use of bioenergy at the distribution level is transportation from the location of the biofuel's production, as well as storage capacities for biofuels. There is a general geographic mismatch between the locations for optimal biofuel production on Maui, Kauai, and Hawaii and the demand for these fuels, primarily on Oahu. Ports on these islands are congested, and therefore the cost and ability to move biofuels through these facilities is unclear.

Hawaii should provide an investment tax credit for a portion of the building costs for biofuels storage facilities, pipelines, marine transport systems, and terminal infrastructure. These assets must be developed by the private sector, and an investment tax credit will reduce the investment risk considerably.

Recommendation: The State Legislature should consider creating an infrastructure investment tax credit for a portion of the cost of installing bioenergy storage, pipelines, marine transport, and terminal infrastructure.

2.6 Buildings Sector Recommendations

2.6.1 Continue to Update Model Energy Code (MEC)

The model energy code sets minimum requirements for the energy-efficient design of new buildings and provides methods for determining compliance with those requirements. It sets standards for electric power; lighting; building envelope; heating, ventilating, and air conditioning (HVAC) systems; water heating systems; and energy management. The current State model energy code was finalized more than a decade ago, in 1993.

Hawaii's MEC includes an energy code for commercial buildings adopted by Honolulu, Maui, and Kauai Counties that is based on ASHRAE 90.1 1999, a standard promulgated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and modified under a DBEDT contract to more closely match Hawaii's subtropical climate and building practices. Hawaii County's model energy code for commercial buildings is based on ASHRAE/IESNA 90.1 1998. Additionally, Honolulu and Maui County adopted the residential energy code that applies to new construction homes and additions of more than 100 square feet.

Recommendation: DBEDT is in the process of developing a Tropical Energy Code, which will draw heavily from ASHRAE 90.1-2004 and the Guam Energy Code. Hawaii is a home-rule state; thus, each county adopts building code provisions individually. However, it is recommended that County councils favorably consider the new MEC upon completion by DBEDT. DBEDT should consider developing presentations and written materials that make the benefits of the MEC clear.

2.6.2 Develop "Whole-Building" Comprehensive or Packaged Energy Efficiency Programs

The standard approach to energy conservation programs has been to target specific individual end uses. They typically involve reducing the electrical needs of individual

end-use equipment or providing incentives, typically in the form of rebates, for customers to replace existing technology with more efficient equipment.

However, single-measure efficiency programs have certain drawbacks. For example, single-measure efficiency programs tend to result in *cream skimming*, in which the most cost-effective measures are implemented first (for example lighting) and the more costly measures are never implemented at all.

The whole-building efficiency approach incorporates measures or materials that produce synergies and may not be intuitively obvious at first. In addition, the combination of measures may initially be more costly to implement. However, together they achieve a *multiplied* efficiency reduction that is greater than individual efficiency measures can achieve alone.[26] This "multiplier effect" of energy savings with a whole-building approach can increase the cost-effectiveness of the overall project more than a collection of measures treated as individual projects.

Recommendation: The Hawaii Public Utilities Commission is encouraged to require the Public Benefits Fund contractor to examine implementation of whole-building efficiency programs, particularly when the contractor is selected.

2.6.3 Aggregate Green-power Purchasing for State Facilities

In 2006, Act 96 was signed into law implementing the Governor's initiative for the State government to lead by example. There are many actions that the State is taking to implement this law, as discussed above. The State is already required to reduce energy consumption per gross square foot, but there are not any requirements that the State procure the energy that it uses from renewable energy sources. Requiring State facilities, such as offices, schools, and universities, to purchase all or a percentage of their power from renewable energy sources creates a stable market, and fosters widespread support for green electricity. In the past, the federal government, along with many local and state agencies, has purchased at least a certain percentage of their power from renewable sources. The initiative is a good way for Hawaii to support the development of renewables.

Recommendation: The Administration should consider issuing an executive order to the State Legislature that would establish a requirement for government agencies to procure a percentage of its energy from renewable energy sources, steadily increasing the percentage that must be procured until it reaches 100 percent. The percentage set and timeline should be determined through further analysis as this recommendation is pursued.

[26] For example, creating a package of efficiency measures such as better insulation, leak sealing, and efficient lighting or daylighting could reduce the cooling load enough to help improve the economics of an efficient air-conditioning system upgrade, by allowing for a reduction in the size of the HVAC system required, thereby significantly reducing capital costs in addition to operating costs.

2.6.4 Combine Resource Efficiency Programs (e.g., Combined Electricity, Gas, and Water Use Efficiency)

A whole-system approach to efficiency that is fuel-blind or resource-blind has advantages over measure-based or electricity-only approaches. Traditional efficiency programs typically limit electric utilities to electricity demand-side management programs, gas utilities to gas demand-side management programs, and water utilities to water use efficiency programs. Hawaii's gas utility, however, was exempted by the Public Utilities Commission from requirements to develop demand-side management programs due to overcapacity of their synthetic natural gas plant. The counties operate the principal water systems in the Islands, but they do not currently offer incentives for water use savings.

In combination with Hawaii's update of the Model Energy Code, the proposed adoption of the International Energy Code and the transition to a Public Benefits Fund (PBF) to manage electricity programs, it may be beneficial to consider encouraging the PBF Manager to develop programs combining electricity-, gas-, and water-savings incentives. This approach could take advantage of technical synergies and reduce program costs compared to three separate approaches.

Recommendation: The Public Utilities Commission may want to consider encouraging the PBF Manager to develop programs combining electricity-, gas-, and water-savings incentives. Hawaii's electric, gas, and water utilities may consider assisting the Public Benefits Fund contractor in the marketing and promotion of such programs with their customers.

2.6.5 Extend Solar Water Heating Financing Program to Include Solar Photovoltaic

In 2006, the State Legislature passed Act 240, which authorized the Hawaii Public Utilities Commission (PUC) to implement the Solar Water Heating Pay-As-You-Save Program® (SWH Financing Program). On October 24, 2006, the Hawaii Public Utilities Commission opened Docket No. 2006-0425, Instituting a Proceeding to Investigate the Issues and Requirements Raised by, and Contained in, Hawaii's Solar Water Heating Pay-As-You-Save® Program, Act 240, SLH 2006.

The financing program is designed to be a customer-financed market-based approach. It is designed to be self-funding as measures are paid back through the savings from the use of the efficient technology. This type of financing program removes the incentive barrier between building owners who do not pay the utility bill and the tenant who typically would not recover the cost of capital improvements.

The basic premise of the program is that the products adopted will save more money than they cost. The program can be used for any proven measure that is cost-effective based on retail rates (although incentives can be used in conjunction to make additional measures cost-effective). For cost-effective measures, assurance mechanisms can address consumer uncertainty. Certification of vendors and products, extended warranties for product reliability and savings, and effective disclosure requirements combine to eliminate consumer doubts. This mechanism is not applicable to unproven

technologies or to technologies that are known not to be cost-effective since there is no assurance the savings required to offset the monthly charges will be realized. PAYS cannot compete with steep incentives of 30–50 percent or greater for the cost of a measure. However, rebates can be used in conjunction with PAYS to ensure that measures are cost-effective.

The financing program removes the upfront payment requirement for the customer, because the conservation cost is repaid through a separate line item on the electric bill. The upfront capital for installation could be provided by a customer's utility, an energy supplier, a loan fund, or even a product vendor. Whoever supplies the capital is repaid (including financing costs) through the customer's monthly payment of the electricity charge. Since PAYS is typically structured so that vendors deliver the efficiency measure, the burden of program design and product marketing falls on the vendor, rather than the utility or public administrator.

Recommendation: DBEDT should consider introducing legislation to expand the Solar Hot Water Financing program to include solar photovoltaic, and it should explore expanding the program to encompass all cost-effective energy efficiency and renewable energy technologies. As the Hawaii Public Utilities Commission moves the Solar Hot Water Financing Docket forward, the Commissioners could expand the program into these other areas.

2.7 Cross-Sectoral Recommendations

2.7.1 Clarify In-stream Flow Standards

One of the major barriers to the large-scale development of a local biofuels industry is uncertainty regarding water rights. Landowners' and farmers' legal rights to water are currently in a state of flux. The manner in which they are resolved may have an important impact on the cost and availability of water for irrigation. Due to a combination of increased demand and recent drought conditions, a number of court cases have contested the use of water resources in Hawaii. These cases involve a variety of issues including surface water transfer, stream diversion, minimum in-stream flow standards, total maximum daily load standards, and claims of native Hawaiian rights.

The main issue is the quantity of water that can be diverted from Hawaii's streams for agricultural purposes. This amount is based on the quantity of water that must remain in the stream at all times, which is termed the in-stream flow standard. The Commission on Water Resource Management, within the Department of Land and Natural Resources, has the authority and obligation to create these in-stream flow standards for Hawaii's streams.[27] However, these standards have not been finalized, and the resulting uncertainty presents a significant risk to investors.

[27] The Commission on Water Resource Management website states, "The State, as trustee of water resources, has the constitutionally-mandated responsibility to set policies, protect resources, defines uses, establish priorities while assuring rights and uses, and establish regulatory procedures. The Commission on Water Resource Management is the

Recommendation: The Commission on Water Resource Management should consider revising the interim in-stream flow standards, and establish final in-stream flow standards as soon as possible.

2.7.2 Appropriate Research and Development Funding for Bioenergy

Substantial research and development (R&D) efforts are needed along the entire biofuels value chain.[28] This is especially important for Hawaii, since national biofuels value chain R&D efforts will likely not meet Hawaii's needs because of Hawaii's unique climate and dissimilarities with the United States mainland. Key R&D is needed at the agricultural level in the following areas:

- Viable biodiesel feedstocks such as oil palm or jatropha, as well as new crop cultivars and improved varieties of sugarcane, including drought-resistant plants;
- Mechanical harvesting techniques to increase productivity; and
- Options for byproduct utilization, such as animal feed or electricity production feedstocks.

A public fund could provide the necessary support for increased research efforts on these topics. The fund would act as a bridge until technologies have reached the proof-of-concept level and can be taken over by venture capital firms or large industry players.

A public source of funding makes all the more sense at the crop and farming level, as the spillover from biofuels/biomass research would affect the rest of the agricultural sector in the State.

Recommendation: The Administration should consider introducing a bill to the State Legislature to establish an R&D fund that can be accessed by Hawaii's various research organizations, as well as private sector entities interested in biofuels production (e.g., biofuels producers). Information from R&D efforts must be publicly available and widely shared.

2.7.3 Streamline Permitting Process

SCR 164 was adopted by 2007 Legislature. It requested the Department of Business, Economic Development and Tourism conduct a study on the feasibility of creating a one-stop permit shop to expedite permit processing for renewable energy projects and to recommend changes, if any, that are needed to establish this streamlined permit process; and to submit its recommendations and draft legislation, if necessary, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2008.

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responsible entity through the administration of the State Water Code." Available at: www.state.hi.us/dlnr.cwrm/cwrmrole

[28] Further detail on R&D funding is provided in the December 2006 report, *Biomass and Biofuels to Power,* that RMI developed for the Hawaii Energy Policy Forum.

Recommendation: DBEDT should work with the Legislature to consider adopt the recommendations of the Hawaii Integrated Energy Policy document[29] and the PUC Study, *Strategies to Facilitate the Development and Use of Renewable Energy Resources in the State of Hawaii,*[30] and should consider all types of renewable energy.

2.7.4 Create a Sliding-Scale Production Tax Credit for Biofuels

It is economically beneficial for Hawaii to ensure that in-state biofuels feedstocks are chosen over imports, and that in-state feedstocks can be grown in a cost-effective, environmentally sustainable manner. Biofuels production in Hawaii is at a competitive disadvantage to biofuels production in developing countries—such as Malaysia (a leading palm oil producer) and Brazil (a leading sugarcane and ethanol producer)—that are able to produce biofuels feedstocks at significantly lower costs due, in part, to cheap labor and land, as well as greater economies of scale.

Additionally, when looking at specific biofuels crops in the United States, sugarcane does not benefit from the large federal subsidies that corn receives.[31] Ethanol feedstock production requires large contiguous tracts of land. Moreover, if sugarcane or other similar crops are used, substantial water is required, also. The State agricultural infrastructure (particularly irrigation systems) needs substantial refurbishing and upgrading to become suitable for irrigating these crops.

Current ethanol subsidies in Hawaii are focused almost exclusively on the ethanol conversion process. New subsidies and incentives should support the other parts of the ethanol value chain if the state wants to develop the ethanol industry as a whole. For example, by ensuring the agricultural sector, a market and profitable prices for its products, agricultural subsidies would encourage and support the production of biofuels and biomass feedstock. At the same time, subsidies that shield end users, such as Hawaii's electric utilities, from pricing risks would help create a pull in demand and, in turn, protect consumers from rate increases.

The new bioenergy subsidies should be designed to support (1) the development of local, Hawaii-manufactured biofuels and biomass feedstocks that can ultimately become competitive internationally; and (2) the cost-effective adoption of biofuels by end users, particularly the power, marine, and transportation sectors.

The sliding-scale incentive achieves both of these goals. It is designed to stabilize biofuels pricing for both the agricultural and end-use sectors, and it has two components

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[29] Department of Business, Economic Development & Tourism (DBEDT), 1991. *Hawaii Integrated Energy Policy.* Honolulu: State of Hawaii DBEDT Energy Division.

[30] Public Utilities Commission (PUC), 1996b. Strategies to Facilitate the Development and Use of Renewable Energy Resources in the State of Hawaii. Honolulu: State of Hawaii Public Utilities Commission.

[31] From 1995 to 2002, federal subsides for corn totaled $42 billion. Environmental Working Group (2006). Farm Subsidy Database. Retrieved October 3, 2006, from: www.ewg.org/farm/findings.php.

or prongs.[32] The first component uses a broader definition of "alternative fuels" and links the current State detaxation of biofuels to in-state feedstock production. The second component creates a state-level sliding-scale subsidy that goes to zero when oil prices are high, and increases when oil prices drop, effectively creating a hedge for consumers and a price floor for producers.

Currently, "alternative fuels" are taxed at a lower rate than conventional fossil fuels. However, "alternative fuels" are defined as containing either a blend of at least 85 percent ethanol or at least 20 percent biodiesel (the blend benchmark).[33] This tax structure means that, for example, the ethanol used to create E10 (10 percent ethanol blend) receives none of the lower tax rate benefit. Therefore, the first component of the proposed sliding-scale subsidy would make the tax rate applicable to any alternative fuel blend below the blend benchmark. In addition, the State's current detaxation of biofuels (which accrues to the blender) would be linked to the percentage of biofuels produced with in-state feedstocks, once such feedstocks are available. The purpose of this incentive is to provide protection for Hawaii's farmers given the market risks for investing in growing biofuel feedstocks and to focus Hawaii taxpayer incentives on support for Hawaii-based businesses.[34]

The second component is a sliding-scale subsidy that protects producers and consumers against a drop in the price of oil while preventing biofuels producers from reaping windfall profits when biofuels are competitive on the market. First, the sliding scale addresses the difference between oil prices and the price of biofuels produced in Hawaii. Whenever the oil price sinks below the Hawaii biofuels price, the government pays a subsidy to the producer in order to ensure that his product stays competitive with fossil fuels in the end-use market. However, to avoid rewarding inefficiency, there is a "sliding-scale tool" that links statewide payout per gallon of ethanol to world commodity price benchmarks. By basing the credit on these world prices, the policy rewards efficiency because a production facility receives the same credit no matter its individual operating costs, which encourages the facility to minimize those costs.

This type of incentive is most appropriate for ethanol for transportation, and modeling indicates that biodiesel used for both transportation and power is cost-effective under each scenario and should therefore not require an additional incentive. Based on forecasted selling prices and production costs, Figure 52 shows the estimated dollar per gallon incentive necessary to make biofuels cost-effective under each scenario.

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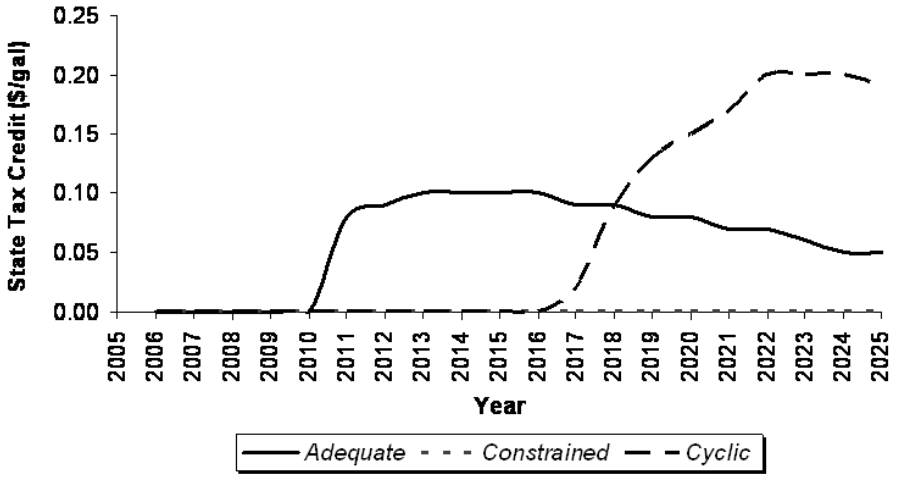
[32] Further detail on the sliding scale is provided in the Hawaii Energy Policy Forum's report, in part developed by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195.

[33] HRS §243-4, §243-5

[34] These risks include a long lead-time to market, which means that crops such as trees take several years to mature, and there is no guarantee that a market will exist for the product once it becomes available. In addition, a significant market risk exists that Third World countries will be able to produce biofuels feedstocks at a lower cost than in Hawaii, thereby potentially displacing Hawaii-produced feedstocks.

Figure 2. Sliding-Scale Production Tax Credit Example: Ethanol for Transportation



Recommendation: The State Legislature should consider developing a sliding-scale subsidy for biofuels producers that (1) links the current State detaxation of biofuels to in-state feedstock production and quantity of biofuel in the blended product, and (2) creates a state-level sliding-scale subsidy that goes to zero when oil prices are high, and increases when oil prices drop.

2.7.5 Create an Irrigation Infrastructure Investment Tax Credit

One of the most critical barriers to in-state feedstock production is the attendant need to invest in rehabilitating existing irrigation systems or building new ones. Rehabilitating or redesigning Hawaii's irrigation systems will significantly reduce the investment risk faced by potential fuel-crop producers.

Work has already been done on developing this type of tax credit by the Hawaii Department of Agriculture (HDOA). HDOA's September 14, 2005 draft "Incentives for Important Agricultural Lands" provides a good model and should be supported as it continues to be developed. In order to have a big impact on biofuels and biomass production in the state, the credit could be extended to all potential agricultural lands producing biomass feedstocks. If the final HDOA Important Agricultural Lands incentive is significantly different from the draft proposal, this recommendation should be reviewed and revised as appropriate.

Recommendation: The HDOA and the State Legislature should consider reviewing the irrigation infrastructure subsidy portion of the Important Agricultural Lands bill, making revisions as appropriate, and actively work to pass the bill as an omnibus package to derive the most benefits possible.

2.7.6 Promote the Creation of a Biofuels Logistics Master Plan

For a bioenergy industry to succeed, logistics must be coordinated across the value chain. The Legislature should allocate funding for state agencies or a contracted third party to research and develop a "Biofuels Logistics Master Plan" that will provide a clear

direction for Hawaii's bioenergy distribution network in cooperation with stakeholders. The findings of that master plan will indicate whether any additional distribution incentives are necessary.

Recommendation: The State Legislature should consider identifying and assigning a State agency or third party to be responsible for the creation of the Biofuels Logistics Master Plan. The State Legislature may want to consider appropriating monies to the agency to spend on the creation of the Master Plan.

2.7.7 Create a Revolving Fund to Support Small-Scale Bioenergy Investments

A revolving fund could be an important tool in jump-starting new biofuels and biomass industries in Hawaii because it would provide financing that might otherwise not be available.[35] A revolving fund is established for the purpose of carrying out a specific activity that, in turn, generates payments to the fund for use in carrying out more of the same activities.

Table 6. Assessment of possible size of actors across the biofuels/biomass value chain

	Biofuels		**Biomass**
	Ethanol	**Biodiesel**	**MSW, Ag Waste, Dedicated Ag**
Agriculture	Small/Large	Small/Large	Small/Large
Conversion	Large	Small/Large	Large
Storage/ Distribution	Large	Large	Large

The main barrier that small bioenergy entrepreneurs face is a lack of credit-worthiness. Small farmers might struggle to find the financing necessary to acquire the initial equipment. A revolving loan fund would provide a relatively affordable type of financing and, more importantly, it would lower the credit risk to other financiers who might then become interested in financing small-scale bioenergy development. Table 27 shows an assessment of the size of players in the bioenergy value chain.

Recommendation: The State Legislature should consider following up with its question about the feasibility of creating a revolving loan fund to support small-scale bioenergy investments. The Legislature may want to use the report submitted to Hawaii Energy Policy Forum on recommendations for HCR 195 as a guide for developing the fund.

[35] Further detail on the revolving fund is provided in the Hawaii Energy Policy Forum's report *Biomass- and Biofuels to Power*, in part developed by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195.

2.7.8 Clarify the Use of State Land for Renewable Energy Producers

Hawaii Revised Statutes (HRS) §171-95 allows the Department of Land and Natural Resources (DLNR) to lease public land to renewable energy producers for up to 65 years without public auction. However, it is unclear if bioenergy feedstock producers may benefit from this statute due to the ambiguity of the definition of renewable energy. HRS §171-95 allows DLNR to lease land to renewable energy *producers,* but there is some uncertainty as to whether a person growing a fuel crop would qualify as a renewable energy producer. This language should be clarified to specifically include feedstock producers.

Recommendation: DLNR may want to request that the State Legislature clarify its intent in HRS §171-95.

2.7.9 Allow Use of State Land for Infrastructure

The Department of Land and Natural Resources may lease public land to renewable energy producers without an auction (for details on HRS §171-95: Leasing of Public Lands to Renewable Energy Producers, see Appendix D). One option is to make State lands available for long-term leases at reasonable rates for the express purpose of building biofuels infrastructure, in addition to growing bioenergy feedstocks. This is of greater importance than providing State land for fuel crops, per se. The State has important parcels that have been cataloged by DLNR.[36]

Recommendation: The DLNR report could be used as a resource for identifying potential sites for infrastructure development in addition to renewable production. If additional public lands abut the catalogued land that is available for biofuel crops, the DLNR may want to request that the State Legislature allow the DLNR to give preference to the renewable energy producers who would lease the infrastructure and cropland parcels together.

[36] HRS §196-41 requires DLNR to develop and publish a catalog of potential sites for the development of renewable energy.

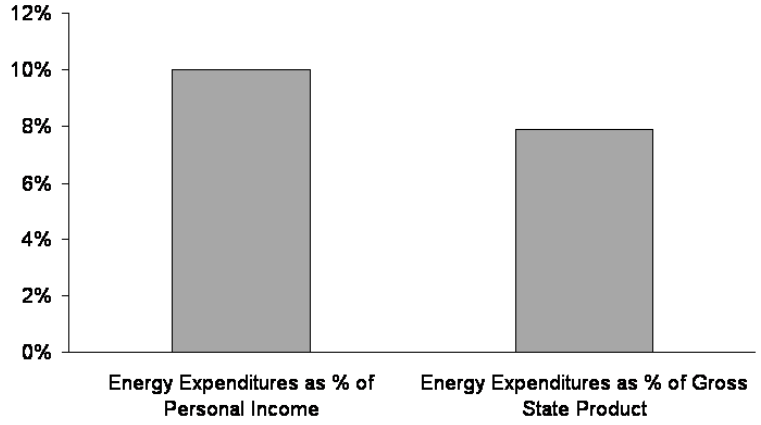
Chapter 3 Energy, the Economy, and the Environment

Hawaii's energy, economy, and environment are intricately connected. Both energy and the environment are essential to Hawaii's prosperity. Energy is essential to modern life. Individuals and industries depend on energy to provide essential services such as transportation, light, heat, and refrigeration. Hawaii's beautiful environment, meanwhile, is also a source of livelihood for many of its citizens and industries. For example, tourism is a major part of the State's economy. Additionally, Hawaii's diverse and unique natural resources support other local industries, such as fishing and other agricultural products, such as sugar. On the other hand, energy use also degrades air quality, threatens water and land resources, and results in emissions of greenhouse gases (GHGs) that cause global climate change. This section briefly examines the benefits of energy and the interrelationships between energy, the economy, and the environment.

3.1 Energy and Hawaii's Economy

Energy use by Hawaii's residents is a major component of economic activity, and energy-related companies make up a large segment of Hawaii's economy. Interestingly, however, Hawaii's people use less energy per capita than the citizens of most states, primarily because of Hawaii's comfortable climate and short driving distances. Hawaii's total energy use per capita ranked 45th of the states and District of Columbia in 2005.[37]

Figure 3. Hawaii Energy Costs as a Percentage of Personal Income and GSP for 2004[38,39,40]



[37] United States Energy Information Administration (EIA), 2004. *State Energy Consumption, Price and Expenditure Estimates (SEDS), 1970–2002, Hawaii. (*http://www.eia.doe.gov/emeu/states/_seds.html), retrieved July 23, 2006.

[38] Consumers in Hawaii paid an estimated total of $4.26 billion for energy in 2005. This is relative to personal income in the state altogether totaling $43.95 billion and a Gross State Product (GSP) of $53.71 billion (see sources below).

[39] Data on Energy Expenditures and Gross State Product from: State of Hawaii, DBEDT. 2006. Energy Resources Coordinator Annual Report. Retrieved January 12, 2007 from www.hawaii.gov/dbedt/info/energy/publications/.

[40] Data on personal income from: State of Hawaii, DBEDT. 2006. Quarterly Statistical Report. Retrieved January 12, 2007 from www.hawaii.gov/dbedt/info/economic/data_reports/qser/.

Due to its heavy dependence on imported fuels, however, Hawaii's current energy practices strain the State economy with high energy prices. Expensive energy and volatile petroleum markets create budgeting problems and unduly burden residents, businesses, and the government (see Figure 3). Furthermore, those funds leave the state and provide little employment or income for Hawaii's residents.

3.2 Links Between Hawaii's Energy Use, the Economy, and the Environment

Much of Hawaii's economy is based upon its beautiful environment. The challenge is to protect Hawaii's environment while meeting the energy needs of Hawaii's people for jobs, income, and a growing economy. Over the long term, energy use in Hawaii degrades air quality, poses risks of water and land pollution, and is Hawaii's major human-caused contribution to greenhouse gas emissions that contribute to global climate change.

3.2.1 Energy Use and Air Quality

Hawaii's air quality meets federal and state environmental health standards because Hawaii's trade winds and the lack of major polluting industries reduce the buildup of air pollution over the islands. Most emissions from energy use are highly regulated by Federal and State laws.

3.2.2 Energy Use and Water Quality

Other than the risk of oil spills, the main risk to water quality from energy uses is non-point source pollution. Recent implementation of higher standards for fuel storage tanks reduced the potential for leaks, but spills and leaks of small amounts of transportation fuels and lubricants onto pavement or earth can eventually find their way into bodies of water or into aquifers.

3.2.3 Energy Use and Land Impacts

Land use impacts of electric power facilities, transportation fueling facilities, and oil refineries are mitigated by a number of regulations and permit requirements. Aesthetic impacts can be reduced through a number of measures and are considered in the state's Environmental Impact Statement approval process. Transportation fueling facilities, oil refineries, oil terminals and pipelines, oil and coal storage facilities, and coal handling facilities also have significant land impacts.

3.3 Hawaii and Global Climate Change

Climate change is a global problem, and greenhouse gas (GHG) emissions generated at a local scale have global impacts. Hawaii's own contribution to global climate change is very small, and the state's reductions of GHG will not significantly lessen the threats that climate change poses to Hawaii's environment. However, taking action to reduce GHG emissions in Hawaii demonstrates support for more widespread and significant climate change mitigation efforts. It is this widespread action that is necessary to combat global

climate change and to protect Hawaii and in the rest of the world from potentially devastating effects.

The rest of this chapter delves deeper into the complex relationship between energy, the economy, and the environment, and focuses specifically on the implications of climate change. It focuses on how future climate change, as well as potential federal legislation relating to it, may affect Hawaii. The intention is to highlight future risks and opportunities so that the State can make plans to support economic growth while also maintaining energy security and protecting its natural capital.

The greenhouse gases (GHG) (primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs)) are implicated in the global warming of the earth's atmosphere. Naturally occurring GHGs in the atmosphere trap solar radiation and help maintain the Earth's temperature. Excess emissions resulting from fossil fuel combustion disrupt this balance, trapping more solar radiation and causing the Earth's atmosphere to warm even more. This increased heating not only raises the average temperature of the Earth but, in doing so, also causes glaciers to melt; sea levels to rise; precipitation, and wind, and ocean circulation, patterns to change. It can have permanent and potentially catastrophic effects on the global climate system.

The effects of global climate change in Hawaii will include higher temperatures, altered precipitation patterns, higher sea levels, and the possibility of more frequent extreme weather events. Such changes to Hawaii's climate may increase stresses on freshwater resources, and they may affect plant and animal life, both on land and in the ocean. Unexpected changes can also impact human health and economic activities. By taking a proactive role in managing its energy use and related emissions, Hawaii can lessen the risks and potential losses and damages that could result from global climate change.

Furthermore, Hawaii's economy could be seriously damaged if the combination of higher temperatures, changes in weather patterns, and sea-level rise make Hawaii difficult to live in, work in, and visit. Adapting to sea-level rise could be very expensive, as it may necessitate the protection or relocation of coastal structures to prevent their damage or destruction.

Programs to reduce GHG emissions from energy activities in other states may offer opportunities for Hawaii to profitably reduce its own emissions. In addition to actions taken by individual states to curb GHG emissions, several initiatives have also been proposed in Congress.[41] In the event that such legislation is passed, Hawaii needs to be prepared to comply with the new laws. Being aware of its own emissions profile currently and carefully cataloging activities that reduce GHG emissions can help reduce the eventual costs of complying with federal mandates.

Regardless of what path Hawaii decides to take along the road of climate change mitigation, potential actions should be viewed from a holistic perspective. Actions

[41] For more information on proposed GHG legislation at the federal level see Table 8 of this chapter, Congressional Proposals for Federal GHG Regulation

should be evaluated with respect to how they interact with Hawaii's economy, its energy systems, and the state's overall goals. By integrating climate change policy into energy planning, legislators can design policies that increase opportunities and reduce risk for the state.

3.3.1 Potential Effects of Climate Change in Hawaii

Although it is not certain to what extent climate change will affect Hawaii, hotter temperatures, higher sea levels, and altered precipitation patterns are fairly certain consequences. Global climate models predict that Hawaii could experience a 0.9 to 2.7 °F increase in average temperature by 2025 and a 4.5 to 6.3 °F increase by 2090–2099 (both figures relative to average temperatures in 1961–1991).[42]

Changing climate conditions are already evident in Hawaii. Over the past century, for instance, Honolulu has seen average temperatures increase 4.4 °F, rainfall decrease about 20 percent,[43] and the sea level rise approximately 6 to 14 inches.[4445] Sea-level rise in Hawaii is occurring at a rate ranging from 0.3 to 1.5 inches per decade. With increased warming of the oceans causing thermal expansion and more rapid melting of the ice caps, this rate of sea-level rise is likely to accelerate. NASA's latest study found that global temperatures are now within 2 °F of the warmest temperatures seen in three million years. When temperatures were so high, sea level is estimated to have been 80 feet above its current level.[46]

Estimates for future rainfall are highly uncertain because reliable projections are subject to seasonal and irregular effects, such as El Niño Southern Oscillation (ENSO). These factors make modeling future precipitation complex and difficult. Nonetheless, existing studies predict that many parts of Hawaii are likely to see more rain in the summer and less rain in the winter. Although it is not clear exactly what the effect will be, El Niño occurrences are also likely to be influenced by climate change.[47]

Meanwhile, the frequency of tropical cyclones or hurricanes, meanwhile, may increase with global warming. Tropical cyclones typically develop over ocean water that is

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[42] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

[43] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.*

[44] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change (available at www.usgcrp.gov).

[45] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.*.

[46] NASA. September 25, 2006. *Study Finds World Warmth Edging Ancient Levels*. Retrieved 1 November, 2006 from www.giss.nasa.gov/research/news/20060925. Note: NASA's discoveries seem to imply that, unless global warming is adequately addressed, there might be accelerated sea-level rise in the near future possibly due to entrenched warming.

[47] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

warmer than 82.4°F. Generally, the Eastern Pacific only reaches these temperatures during El Niño years. However, global climate change may expand the region of very warm ocean water and increase the frequency of hurricanes affecting Hawaii.[48]

3.3.1.1 Human Health

More frequent and severe heat waves could increase heat-related illnesses and deaths. Concentrations of harmful pollutants, such as local ozone, could increase due to higher average temperatures and stronger sunlight. Many disease-carrying insects breed in warm temperatures, which could lead to increased transmission of malaria and dengue fever. Warmer temperatures may also foster the growth of toxic algae and create algal blooms or "red tides" that, in turn, damage habitat and shellfish growth. These toxic blooms can be directly harmful to human health as they can carry cholera-like bacteria. As viruses and bacteria that multiply more rapidly in warmer waters, they could infect fish and shellfish and cause human illness when ingested. The destruction of wastewater treatment infrastructure from floods and other extreme weather events could also lead to unsanitary conditions in the State that enable the spread of disease.[49]

3.3.1.2 Water Resources

In Hawaii, fresh water is already a scarce and valuable resource. Like many island settings, surface water is limited and aquifers are small and fragile. These factors make Hawaii susceptible to prolonged droughts.

Since a warmer climate may disturb precipitation patterns and hotter temperatures would increase evaporation, fresh water supplies may suffer. More rainfall, on the other hand, could cause flooding and increase sediment and pollutant runoff that could affect marine and freshwater resources.

As discussed further in the following sections, reducing the quantity and quality of fresh water in Hawaii threatens economic activities such as agriculture and tourism, and it can also have serious repercussions on human health.

3.3.1.3 Agriculture

Agricultural production patterns are also likely to change along with warmer temperatures. Higher temperatures and reduced fresh water availability could alter the mix of crop and livestock production. Higher rates of evaporation due to increased

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[48] East-West Research Center. 2001. *The Pacific Island Regional Assessment of the Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

[49] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

temperatures would also reduce soil moisture. Farming would require more irrigation and thus further stress Hawaii's already contested freshwater resources.[50]

Some studies suggest that higher temperatures could increase yields of pineapple and sugarcane, Hawaii's major crops, by about 10 percent.[51] However, studies cannot fully predict the effect of changes in climate variability, water availability, crop pests, changes in air pollution, and costs of adaptation by farmers. Low-lying cropland could also be at risk from sea-level rise, floods, and saltwater intrusion.

3.3.1.4 Terrestrial Ecosystems

Species composition, geographic range, and health and productivity of trees and forest could also be altered as the climate warms. Since many non-native species are more resistant to weather fluctuations than indigenous plants, the local organisms are probably at greater risk and may be displaced by more resilient, invasive species. One such case is the Hawaii native 'ohi'a tree which appears to be very sensitive to both drought and heavy rain, and is already threatened by non-indigenous species. The 'ohi'a tree also provides an essential habitat for native Hawaiian birds, such as the endangered Hawaiian honeycreeper.

In addition, climate stress increases the vulnerability of forests to fungi and insect pests. Higher summer temperatures, meanwhile, increase the threat of forest fires caused by drying forest debris. Hawaii is also home to temperate cloud forests ecosystems, which, as their name suggests, are characterized by low-lying cloud cover. Because cloud forests depend on a constant layer of clouds providing moisture and reducing their exposure to sun, changes in temperature or precipitation can seriously affect these fragile ecosystems.[52]

Hawaii is home to a large variety of unique biological species. The survival of many of these indigenous plants and animals is already tenuous. In fact, the State has the highest number of endangered species per unit of area of any place on earth.[53] Habitat destruction, introduced diseases, and the effects of non-indigenous organisms constitute the greatest threats to the survival of Hawaii's rare species; changing climate may intensify these drivers of extinction.

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[50] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

[51] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.* Retrieved September 20, 2006 from www.epa.gov.

[52] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.* Retrieved September 20, 2006 from www.epa.gov.

[53] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.* Retrieved September 20, 2006 from www.epa.gov.

3.3.1.5 Marine Ecosystems and Coastal Areas

Reefs are important to Hawaii residents and help sustain important economic activities such as tourism and fishing. Healthy reefs are important both as habitats for marine life and for providing shoreline protection. Coral reefs are also the source of the white sand on Hawaii's world-renowned beaches and provide protection from erosion. Sources calculate that the State's reefs produce an estimated economic benefit of US$365 million per year and have a total valuation of $10 billion.[54]

Higher temperatures are likely to cause coral bleaching and threaten the survival of many marine organisms. As the sea level rises, increased water depth and the higher frequency of storms could also threaten the survival of Hawaii's reefs.

Warmer water temperatures may also alter fish populations and force changes in fishing practices. Specifically, fisheries may suffer from destruction of fish habitats and also from the displacement of commercially important stocks.[55]

Sea level has increased 6 to 14 inches in this century at Honolulu, Nawiliwili, and Hilo, and is likely to rise another 17 to 25 inches by 2100. The expected rise in sea level could cause loss of coastal wetlands, beach erosion, flooding of low-lying property during more frequent and intense coastal storms, saltwater contamination of drinking water, and damage to coastal roads and bridges.

With respect to coastal areas, adjusting to the effects of climate change is likely to be expensive and problematic. For instance, the EPA noted that the cumulative cost of sand replenishment to protect Hawaii from a 20-inch sea-level rise by 2100 could cost between $340 million and $6 billion.[56] Low-lying areas may need to be protected by constructing ditches and berms. Vulnerable buildings could also require relocation, which would also be expensive.

3.3.1.6 Infrastructure

Vital infrastructure is at risk from rising sea levels, flooding, and extreme weather events in Hawaii. Many power plants and essential services are located in coastal areas that face potential inundation. Petroleum and gas storage centers are also located just above sea level within commercial harbors. Communication networks, fire and police stations, and wastewater facilities are all vulnerable to disruption from large storms as well as from the gradual effects of sea-level rise. The potential effects of climate change on Hawaii's oil

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[54] Cesar, H. S. J. and Herman S. J. April, 2004. *Economic Valuation of the Coral Reefs of Hawai'i*. Pacific Science - Volume 58, Number 2, April 2004, pp. 231-242. Retrieved November 4, 2006 from www.hawaii.edu

[55] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.* Retrieved September 20, 2006 from www.epa.gov.

[56] U.S. Environmental Protection Agency (U.S. EPA). 1998. *Climate Change and Hawaii.* Retrieved September 20, 2006 from www.epa.gov.

and gas energy infrastructure and key public health and safety facilities could put Hawaii's citizens at risk.[57]

3.3.1.7 Insurance Costs

The insurance industry will bear the brunt of many climate-change-related losses. Recent increases in claims from weather-related events on the Mainland, for example, have begun to strain insurance funds. In response to more frequent weather-related damage, insurance companies have begun to increase their premiums for hurricane coverage while reducing the benefits of the coverage. Also, insurance companies are increasingly looking to governments to share the economic burden of natural disasters.

Insurance companies predict that rising carbon dioxide emissions are likely to add to their expenses. A report from the Association of British Insurers stated that rising GHG emissions could increase average annual losses caused by U.S. hurricanes by 70 to 75 percent (or $41 to $62 billion above current losses of $60–85 billion). Under a low-emissions scenario, losses were estimated to be one-fifth of losses under a high-emissions scenario.[58]

3.4 Inventory of Hawaii's Greenhouse Gas Emissions

3.4.1 Explanation of Units and Terminology

Emissions of greenhouse gases are often measured in terms of carbon dioxide equivalent or CO_2e. The term carbon dioxide equivalent is used as a metric for comparing the effect on global warming by the different types of greenhouse gases. The units are used because each greenhouse gas traps solar radiation in the atmosphere to a different degree, called global warming potential (GWP). Although carbon dioxide dominates global emissions, and cumulatively is the greatest contributor to global warming, other gases have significantly higher GWP[59] compared to carbon dioxide. For instance, one ton of methane is equivalent to 23 tons of carbon dioxide over a 100-year period (methane therefore has a GWP of 23 relative to carbon dioxide) and nitrous oxide is 296 times more potent than 1 ton of carbon dioxide over 100 years (GWP of 296 also relative to carbon dioxide).[60] In order to facilitate comparison between the effects of the different gases, emissions of all gases can be represented in terms of the tons of carbon dioxide

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[57] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

[58] Association of British Insurers. June, 2005. Financial Risks of Climate Change. Retrieved November 15, 2006 from www.abi.org.uk.

[59] East-West Research Center. 2001. *The Pacific Island Regional Assessment of The Consequences of Climate Change and Variability* for the U.S. Global Change Research Program as part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Retrieved October 5, 2006 from www2.eastwestcenter.org/climate/assessment/report.htm.

[60] Intergovernmental Panel on Climate Change (IPCC). 2001. *Third Assessment Report – Climate Change 2001*. Retrieved January 5, 2007 from www.ipcc.ch.

that have an equivalent global warming potential (i.e., carbon dioxide equivalent). Therefore, for the sake of GHG accounting, 1 ton of methane would be quantified as 23 tons of CO_2e and 1 ton of nitrous oxide would be quantified as 296 tons of CO_2e.

3.4.2 Hawaii's Interim 1990 Baseline GHG Emissions

An interim 1990 baseline was established as a benchmark for Hawaii's efforts to reduce greenhouse gas emissions. This is because under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), signed by the United States in November 1998, the United States should commit to reduce its emissions by 7 percent less than 1990 emissions by 2008–2010.[61] The Protocol was not ratified by Congress. As such, these numbers represent preliminary numbers, not developed to support regulatory measures. Per the requirements of Act 234 (SLH 2007), however, these numbers will be validated and refined in order for them to support regulatory measures as required by Act 234.

Table 7: Hawaii's GHG Emissions, 1990 (Tons CO2e)[62]

Sector	GHG Emissions (Tons CO_2e)	% Total GHG Emissions	% Energy GHG Emissions
Energy Sources:			
Residential Sector	94,804	0.5%	1%
Commercial Sector	282,412	1.5%	2%
Industrial Sector	837,599	4.5%	5%
Electricity Sector	7,652,966	40.7%	46%
Marine Transportation	155,599	0.8%	1%
Air Transportation	3,865,711	20.6%	23%
Ground Transportation	3,923,915	20.9%	23%
Subtotal	16,813,006	89.4%	100%
Non-Energy Sources:			
Oil-refining	5,214	0.03%	
Cement Production	109,274	0.6%	
MSW Management	1,366,464	7.3%	
Wastewater Treatment	22,594	0.1%	
Domestic Animals	294,096	1.6%	
Manure Management	133,232	0.7%	
Sugar Cane Burning	14,106	0.1%	
Fertilizer	52,920	0.3%	
Subtotal	1,997,900	10.6%	
Total	18,810,906	100.0%	

[61] A review of legislative proposals indicate that 1990 will not necessarily be referenced as a year for baseline emissions in the future (see Table 8 of this chapter, Congressional Proposals for Federal GHG Regulation). Future legislation is likely to use a year such as 2000 or later as a baseline or target for emissions reductions (for more information on proposed legislation. Thus, year 2000 emissions and current emissions should be well documented. Keeping an annual inventory of GHG emissions is highly important and is valuable on many fronts.

[62] State of Hawaii, DBEDT. 2000. *Hawaii Energy Strategy 2000.*

Hawaii's greenhouse-gas emissions for the 1990 baseline year were estimated at 16,961,453 tons of carbon dioxide, 75,717 tons of methane, and 680 tons of nitrous oxide—all together, 18,810,906 tons of carbon dioxide equivalent. This was 0.3 percent of total U.S. emissions in 1990. Table 7 shows the components of Hawaii's 1990 baseline GHG emissions by sector.[63]

Hawaii's energy use produced most of the carbon dioxide equivalent in the 1990 baseline year—an estimated 16.8 million tons of carbon dioxide equivalent or 89 percent of total emissions from all sources. Municipal solid waste (MSW) management and wastewater management together produced 7.4 percent of Hawaii's 1990 GHG emissions; agricultural activities emitted 2.7 percent; and industrial processes emitted the remaining 0.6 percent.

The emissions presented in Table 7 are from energy use in Hawaii only, and don't include overseas domestic flights and marine use. In accordance with the United Nations Framework Convention on Climate Change and U.S. EPA guidance, emissions from overseas international air and marine transportation fuel consumption in Hawaii were not counted. In addition, about 4 percent of the energy sold or distributed in Hawaii in 1990 was provided to the U.S. military. Because there are no data available concerning where this fuel was actually used, emissions from military energy use were not included in the estimate.[64]

3.4.3 Trends in Hawaii's Historic GHG Emissions

According to DBDET calculations, Hawaii's GHG emissions increased between 1990 and 2002, at an average rate of 0.8 percent per year. As Figure 4 shows, emissions increased by 11 percent from 2002 to 2003, primarily driven by increased emissions from stationary sources. According to the data, this is due to increases from the industrial sector in Honolulu. Growth in emissions was, again, essentially flat between 2003 and 2004, and declined by 3.5 percent between 2004 and 2005. This change was also driven by stationary sources and, again, particularly by a decrease in emissions from industrial activities in Honolulu. Future emissions projections have been modeled and are shown in the model outcomes in Appendix A.

Hawaii's carbon intensity (carbon emitted per dollar of gross state product) has been consistently lower than the average for the United States, as shown in Figure 5. However, this may be because Hawaii does not have many energy-intensive industries and Hawaii's high energy prices have encouraged greater efficiency. Furthermore coal, the most carbon-intensive fossil fuel, does not dominate electricity generation in Hawaii. In comparison, coal generates almost half of the nation's electricity.[65]

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[63] State of Hawaii, DBEDT. 2000. *Hawaii Energy Strategy 2000*

[64] State of Hawaii, DBEDT. 2000. *Hawaii Energy Strategy 2000*

[65] Energy Information Administration. 2005. *Electric Power Generation by Fuel Type* Retrieved December 18, 2006 from www.eia.doe.gov.

Figure 4: Hawaii Energy-Related GHG Emissions, 1990-2005[66]

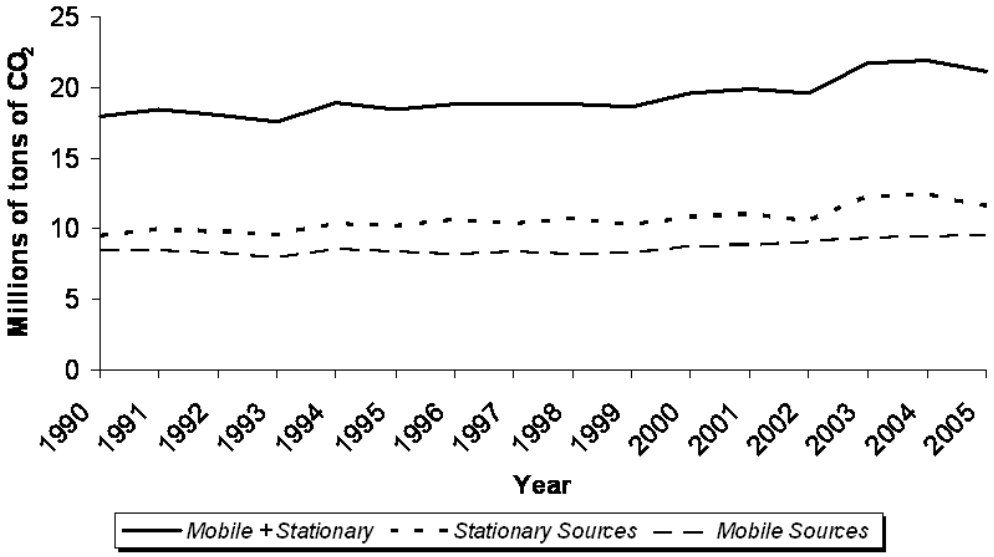
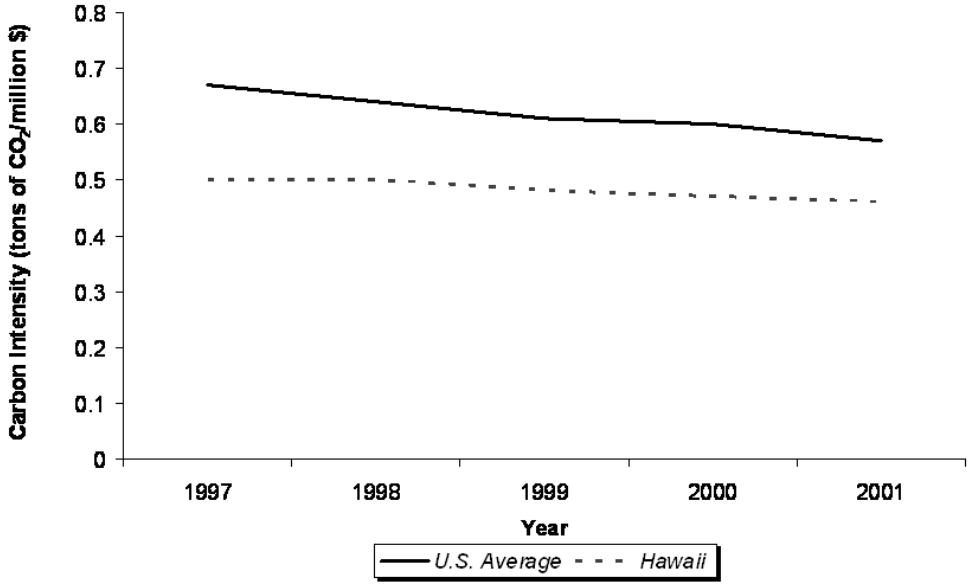


Figure 5: Energy-Related Carbon Intensity (CO_2e/thousand $) for Hawaii & U.S. Average, 1997-2001[67,68]



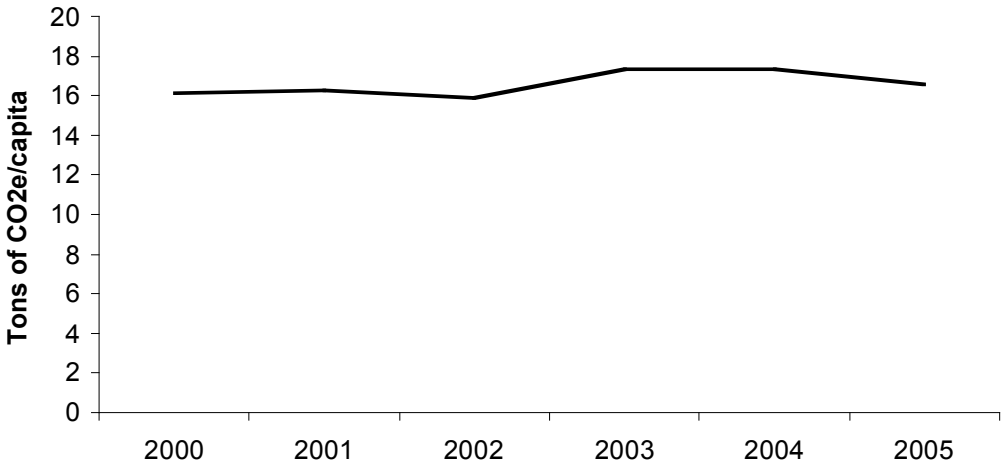
[66] State of Hawaii, DBEDT. 2006

[67] Emissions are energy-related CO_2 values from: Energy Information Agency (EIA), 2001. *State Energy-related Carbon Dioxide Emissions by Energy Sectors* Retrieved December 18, 2006 from www.eia.doe.gov

[68] National and state GDP from: Bureau of Economic Analysis (BEA). 2001. Retrieved December 18, 2006 www.bea.gov.

Per capita emissions for Hawaii were also consistently lower than the average for the nation. For instance, in 2001 Hawaii's emissions were about 16 metric tons of carbon dioxide equivalent per person, while the average for the United States was 20 tons per person.[69] As Figure 6 indicates, however, per-capita emissions for the state have increased since then.

Figure 6: GHG Emissions per Capita in Hawaii, 2000-2005[70,71]



3.4.4 Current Sources of Energy-related GHG Emissions

In 2005, Hawaii emitted approximately 25.8 million tons of carbon dioxide equivalent ($MMTCO_2e$) from energy-related activities.[72] As Figure 7 shows, the transportation and electrical sectors emitted the vast majority of energy-related GHG in Hawaii. All activities in the transportation sector (ground transportation, domestic aviation, overseas aviation, overseas marine, and domestic marine) accounted for 55.3 percent of Hawaii's GHG emissions in 2005, while the electricity sector produced 35.1 percent. Emissions from combustion activities (apart from electricity) related to the industrial and commercial sectors generated 9 percent of emissions, and direct energy use in the residential sector accounted for less than half a percent.[73]

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[69] Population data from: U.S. Census Bureau. 2005. Retrieved December 18, 2006 from www.census.gov/popest/states/tables/NST-EST2005-01.xls.

Emissions data from EIA (same as above).

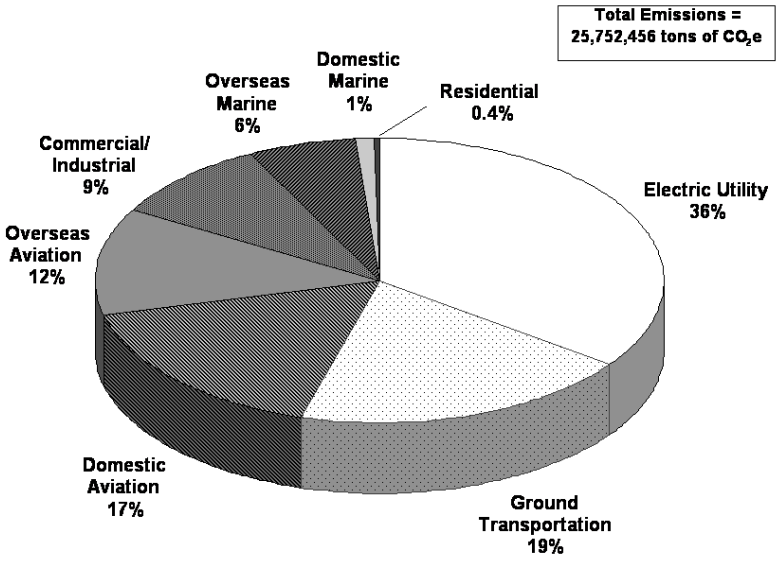
[70] Emissions data from: State of Hawaii, DBEDT. 2006.

[71] population data from U.S. Census Bureau, (same as above)

[72] State of Hawaii, DBEDT. 2006

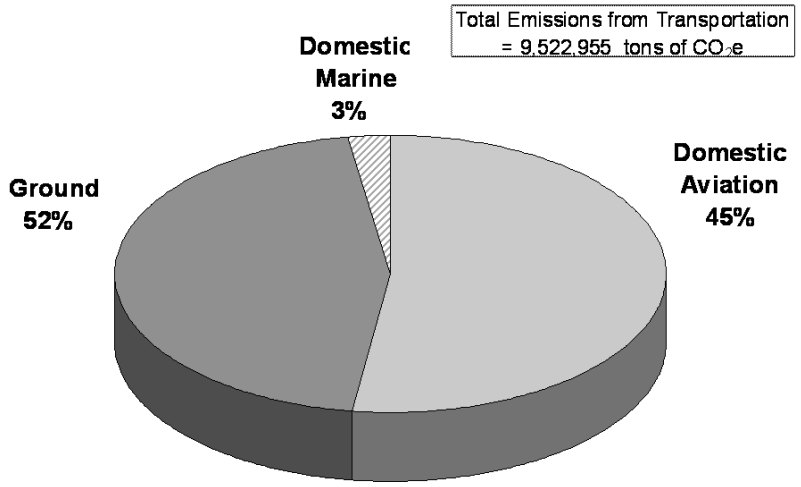
[73] State of Hawaii, DBEDT. 2006

Figure 7. Energy-Related GHG Emissions by Sector in Hawaii, 2005[74]



As mentioned above, emissions due to international transportation are not included in official inventories. Therefore, it is worth distinguishing between emissions due to domestic versus international travel. Thus, overseas aviation and overseas marine transportation are accounted separately and would not count towards Hawaii's official emissions inventory.

Figure 8. GHG Emissions from Domestic Transportation in Hawaii, 2005[75]



[74] State of Hawaii. DBEDT. 2006

[75] State of Hawaii, DBEDT. 2006

Figure 8 shows carbon dioxide emissions of domestic transportation in Hawaii. Within this sector, ground transportation was the single largest source of emissions, contributing 52 percent. Domestic aviation, in turn, emitted 45 percent and emissions from combustion activities related to the industrial and commercial sectors generated 3 percent of emissions.[76]

3.4.5 Hawaii's Projected GHG Emissions

By 2025, Hawaii's emissions are projected to grow about 14 percent to approximately 30 $MMTCO_2e$ under adequate energy supplies and cyclic commodities scenarios. In the constrained supplies scenario where energy prices are expected to be high, the state's GHG emissions are projected to decline 9 percent relative to 2005, to approximately 23.5 $MMTCO_2e$. Additional discussion of GHG emissions from modeling scenarios is provided in Appendix A to this report.

For purposes of comparison, 17.5 million tons $MMTCO_2e$ is 7 percent below the 1990 level of emissions from all sectors including energy. Hawaii thus faces major challenges in reducing its future greenhouse gas emissions. However, should the Protocol be ratified, it is not expected that individual States will have to meet Kyoto targets independently. Nevertheless, the target is useful for comparison with Hawaii's projected future emissions to evaluate scenarios designed to reduce greenhouse gas emissions.

3.5 Potential Climate Change Regulation and Strategies for In-State Action

Since greenhouse gases are both uniformly mixed in the atmosphere and are long-lived, the effects of GHG emissions are the same regardless of where the source is located and when the emissions occur. This means that reducing CO2 emissions by 1 ton has the same effect regardless of where the reduction happens. Therefore,, entities can implement reductions outside the state (where achieving reductions may be cheaper) that can count towards statewide reduction goals. As such, many states are implementing GHG emissions reduction programs, and at least some of these programs will allow for out-of-state emissions credits to be counted towards meeting their own reduction targets.[77] This means that Hawaii could reduce its emissions for the purpose of selling the credits for the reductions (offsets) and thus potentially get paid to reduce its own GHG emissions.

Furthermore, recent congressional activities indicate that some form of climate change legislation is likely to pass in the near future. For instance, during the 109th Congress (between 2005 and 2006), for instance, no less than 103 climate change-related

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[76] State of Hawaii, DBEDT. 2006

[77] Oregon is the only state that currently limits carbon emissions and allows for use of offsets to meet in-state reductions. California is also in the process of instituting what will most probably be a cap and trade program and states participating in The Regional Greenhouse Gas Initiative (NY, ME, NH, VT, MA, RI, CT, NJ, DE) will also be capping their emissions and allowing for out-of-state offset credits although the Initiative will likely limit the amount and type of qualifying offset activities. For more information, see Table 9 in this chapter, Summary of Regional GHG Regulatory Activities with Potential for Out-of-state Offset Opportunities

legislative proposals were introduced.[78] Many of the proposals indicated that a carbon trading system is a popular option. Some of the proposed federal GHG regulation are listed and described in Table 8.

Table 8: Congressional Proposals for Federal GHG Regulation[79]

Proponent	Type	Scope	Target	Price Cap	Offsets
McCain and Liberman	Cap and trade.	Electricity, transportation (refiners and importers) industry and large commercial facilities.	2000 levels by 2010.	N/A	Up to 15 %, including sequestration and international markets.
Bingaman	Intensity target with trading mechanisms.	Fuel producers; Manufacturers, importers and importers and emitters of non-fuel GHGs.	2.4% below business as usual emissions intensity.	US $7/ton + 5% annually	Domestic credits including sequestration. Up to 3% international credits.
Feinstein	Cap and trade.	Large stationary sources, including utilities, oil and gas and transportation facilities.	2006 levels in 2010 92.75 % of 2006 level in 2020.	N/A	25 % domestic and international including farming and afforestation.
Waxman	Cap and trade.	Large emitters.	Stabilization at 2000 levels, 2% annual reduction from 2010 to 2020.	N/A	

Hawaii should be prepared to participate in the political debate over climate change and ensure that it is well-situated to reduce its emissions in the event that Congress passes GHG legislation. Establishing a rigorous GHG inventory is one of the best ways for Hawaii to be prepared for federal climate change action.

It is worth noting that regardless of whether or not the federal government takes action, reducing Hawaii's contribution to climate change is a State energy objective in §226-18 (a), HRS, that requires "(4) Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use" be considered along with the other three objectives in planning state energy facilities. Reduction, avoidance, or sequestration of GHG emissions contributes to meeting other objectives and may result from actions taken under the other objectives. For instance, reduced dependence on imported fuels implies a reduction of GHG-emitting fossil fuels. Similarly, energy efficiency is likely to be economically beneficial and can reduce GHG emissions at a net zero or negative cost.

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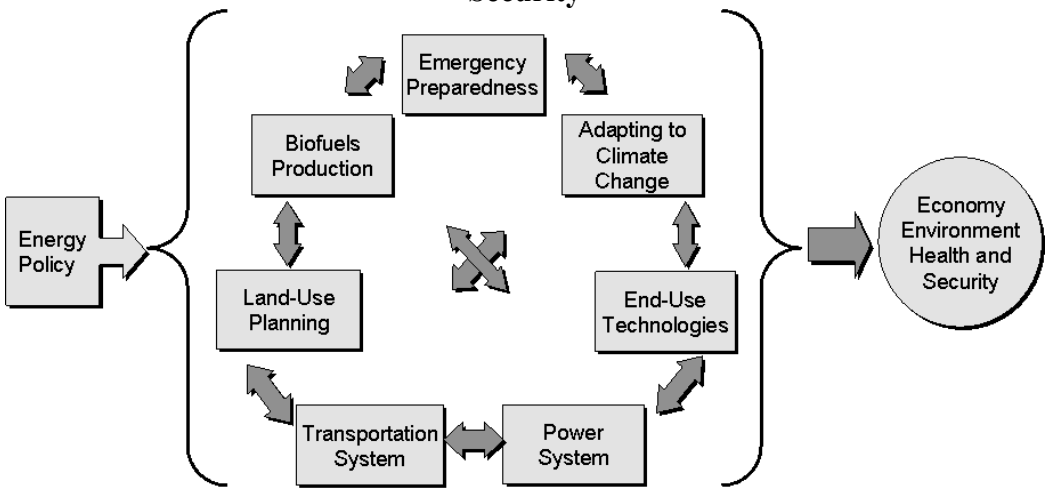
[78] Pew Center on Global Climate Change. 2005. *Legislation in the 109th Congress Related to Global Climate Change*, Retrieved January 5th, 2007 from www.pewclimate.org.

[79] PointCarbon. 2006, September 13. *Carbon trading in the US: The Hibernating Giant*. Carbon Market Analyst. Retrieved November 1, 2006 from www.pointcarbon.com.

Increased use of indigenous renewable energy, meanwhile, clearly supports the reduction or avoidance of emissions.

Figure 9. The Energy System and Hawaii's Economy, Environment, Health and Security



Regardless of what path Hawaii decides to take along the road of climate change mitigation, potential actions should be analyzed from a whole-system perspective, as Figure 9 illustrates. Actions should be evaluated with respect to how they interact with Hawaii's economy, its energy systems, and the State's overall goals. Appropriate climate change policy can have a synergistic relationship with biofuels, demand-side energy management, land-use planning, local emergency preparedness, and with the transportation and power systems as a whole. Improvements in the different energy systems and sectors, for instance, very often result in GHG emissions reductions. Overall, climate change policy within the state energy policy can benefit the State economy and also improve Hawaii's health, security, and environment.

Climate change policy can also spur the development of new industries in Hawaii and provide an additional boost to the local economy. For instance, climate change policy can help:

- Stimulate the economy by
  - Promoting new industries,[80]
  - Creating employment in new industries,[81]
  - Generating cash by selling offset credits,[82]

[80] According to the recently published *Stern Review on Economics of Climate Change*, the market for low carbon energy products could be worth at least $5000 billion per year by 2050. The same source also cites clean technology as the third largest category of venture capitalist investment in the US in 2006. HM Treasury. 2006. *The Stern Review on Economics of Climate Change*, retrieved November 20, 2006 from www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

[81] The Stern Review also projects global employment in the renewable energy products industry to grow from 1.7 million people in 2006 to 25 million people in 2050.

    - Saving money by promoting efficiency and locally-generated fuels alternatives, and
    - Reducing the dollar drain from purchasing imported fuels.
- Increase reliability and reduce risk by diversifying energy resources.
- Reduce costs from damages by implementing measures to adapt to climate change and encourage advanced preparation for emergencies.
- Improve health and environment by reducing pollution and waste generation.

While current actions and State goals provide a good basis for taking action to reduce GHG emissions, additional measures are required. The options explored below are for Hawaii to (1) update 1990 baseline inventory (2) conduct regular and rigorous emissions inventories; (3) establish an emissions target; (4) participate in carbon trading through a state cap-and-trade program and/or the sale of offset credits out of state; (5) establish emissions standards for energy facilities; and (6) update the Hawaii Climate Action Plan.

3.5.1.1 Conduct Regular and Rigorous Emissions Tracking:

Regardless of what form future GHG legislation will take, developing an accurate state emissions inventory is a key first step to any GHG-related activity. Hawaii conducted its first statewide GHG emissions inventory in 1998 and has since updated these estimates in 2007. Additionally in 2007, GHG emissions for 2005 were estimated. Continuing to conduct emissions inventory regularly can help Hawaii address future climate change regulation and also ensure that any early activities that help reduce emissions are adequately accounted and rewarded. Having a mechanism for emissions tracking helps qualify emissions credits from projects for sale to other markets participating in a cap-and-trade program, and assess whether entities are in compliance with GHG regulations.

Though DBEDT is the most likely entity to take responsibility for creating a GHG emissions tracking program, it need not start with a blank slate. National and international protocols for GHG emissions accounting exist, and a number of states have adapted them for their own GHG emissions tracking systems. For example, the Greenhouse Gas Protocol Initiative, created by the World Resources Institute (WRI), has developed a Corporate Accounting and Reporting Standard that provides step-by-step instructions for organizations to identify, calculate, and report their GHG footprint in a consistent, transparent, and credible manner. The information is available for free from the WRI.[83] Alternatively, Hawaii could join public emissions monitoring programs and registries such as the Eastern Climate Registry and the California Climate Action Registry, which are open to all states. The accounting protocol of California's Climate Change Action Registry is based on the WRI system. Such registries enable internationally recognized, standardized methods for quantification and registering of

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[82] A World Bank Report estimates that in 2006 the global carbon market will be worth $25-$30 billion, up from $10 billion in 2005. Although, for the most part, this market is not yet accessible to the Unites States, this will change as more states take action to cap carbon emissions or if there were to be a national cap and trade system. The World Bank. 2006. *State and Trends of the Carbon Market 2006*. Retrieved November 20, 2006 from http://carbonfinance.org/.

[83] For more information, see www.ghgprotocol.com.

reductions and may provide useful information and experience in anticipation of national GHG legislation.

Recommendation: The Legislature is encouraged to consider appropriating funds to DBEDT to create and maintain a voluntary GHG emissions tracking program for utilities, large agricultural businesses, and State facilities. Additionally, county facilities should be provided the option to voluntarily participate in the emissions tracking.

3.5.1.2 Participate in Carbon Trading Through a State Cap-and-Trade Program and/or the Sale of Offset Credits Out-of-State:

Cap and trade programs are generally considerParticied a cost-effective emissions reduction option. Analysis of the economic impacts of existing cap-and-trade programs indicate that such policies would have negligible or even positive impacts on regional economies. Cap-and-trade programs can provide incentives for trading emissions outside the geographic area of the program if outside entities can provide reductions as cheaply as or more cheaply than entities within the cap-and-trade systems can.

Hawaii could develop its own cap-and-trade program or consider reducing GHG emissions with the intent of participating in emerging U.S. GHG markets, such as Oregon's offset market, The Regional Greenhouse Gas Initiative (RGGI), or the California market.[84] Table 9 describes these and other U.S. markets and their emissions trading possibilities. On September 27, 2006, Governor Schwarzenegger signed AB 32, the Global Warming Solutions Act. The Act caps California's greenhouse-gas emissions (GHG) at 1990 levels by 2020. This legislation represents the first enforceable statewide program in the United States to cap all GHG emissions from major industries that includes penalties for non-compliance. It requires the State Air Resources Board to establish a program for statewide GHG reporting and to monitor and enforce compliance with this program.

Governor Schwarzenegger has advocated setting up a market system that would allow California companies unable to reduce their own emissions cost effectively to trade emissions credits with other entities that have reduced emissions. According to a press release from Governor Schwarzenegger's office dated October 16, 2006, Governor Schwarzenegger and New York Governor Pataki agreed to explore ways to link California's future greenhouse-gas emissions credit market and the Northeastern and Mid-Atlantic States' RGGI upcoming market in order to more efficiently reduce GHG emissions.

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[84] Through RGGI, nine Northeastern and Mid-Atlantic states have agreed to establish a cap-and-trade system to reduce carbon dioxide emissions from power plants in the region (with the possibility of reductions extending to other gases and sectors). For more details, see Table 9 in this chapter, Summary of Regional GHG Regulatory Activities with Potential for Out-of-state Offset Opportunities. RGGI is allowing for carbon offset credits in all of the U.S. to be eligible in the market. These offsets are subject to limitations and qualifications but they may still provide windfall profits and added incentives to perform GHG reductions. For more information on RGGI see www.rggi.org. In the case of California, it is not yet clear how the program will involve out-of-state participation but it is likely to provide some flexibility mechanisms allowing for out-of- state credits. Oregon is also instituting a cap-and-trade program that could potentially tie in with other initiatives.

Table 9: Summary of Regional GHG Regulatory Activities with Potential for Out-of-state Offset Opportunities[85]

Participating Region/States	Activity type	Regulated Parties	Potential for out-of-state offset
Regional Greenhouse Gas Initiative (RGGI)			
NY, ME,NH, VT, MA, RI, CT, NJ, DE. MD, PA,DC and the Eastern Canadian Provinces are observers.	Cap and Trade. 75% of allocations to be distributed for free at State's discretion. 20% allocations auctioned off, revenues used to promote EE and RE. 5% allocations to Climate Trust. Enforcement by individual state.	Power plants of 25MW or higher in participating states.	Up to 50% of compliance may be met by offset credits. Currently, offset credits must be from methane capture and combustion, afforestation, Sulfurhexaflouride (SF_6) capture and recycling and energy-efficiency improvement projects.[86] Preference is given to in-region offsets, but national and international offset credits may be allowed with certain restrictions.
Global Warming Solutions Act			
CA	Likely Cap-and-Trade System.	Multi-sectoral. Details TBD.	TBD. Out-of-state offsets are a possibility.
Oregon Carbon Dioxide Emissions Standard			
OR	Offset requirements of 17% of emissions for new power plants.	New OR energy facilities.	Plants may reduce emissions, run offset programs themselves or buy offsets through the Climate Trust. The Climate Trust can implement projects in the US and even internationally but currently most projects are based in the Northwestern U.S.
Voluntary Offsets Market			
Not restricted	Allows companies, individuals or any interested organizations to offset their emissions by purchasing carbon credits. This is a voluntary market with many organizations.	Voluntary program	Offset brokers can develop projects or purchase credit from wherever they choose. Each broker will usually have their own criteria for selecting or developing projects.

[85] As mentioned earlier in the chapter, because greenhouse gases are both uniformly mixed in the earth's atmosphere and long-lived, the effects of GHG emissions thus are the same regardless of where the source is located and when the emissions occur. Emission markets can be national or even global in scope. The markets created by cap-and-trade systems can provide incentives for sources outside the geographic area of the program to enter if they can provide reductions more cheaply than the market prices within the jurisdiction using the cap and trade system.

[86] PointCarbon, 2006, September 13. *Carbon trading in the US: The hibernating Giant*. Carbon Market Analyst. Retrieved November 1, 2006 from www.pointcarbon.com.

Results of these developments in other states could be similar for Hawaii if Hawaii adopts similar policies. In the case of the RGGI, the investment in energy-efficient technologies is expected to give a slight boost to local economy (only under a high-emissions scenario is RGGI expected to have a small negative impact on economic growth). Additionally, domestic electricity consumers are expected to benefit from RGGI. Specifically, improvements in end-use efficiency over time are projected to generate average household bill savings that more than compensate for increases in electricity prices due to the program.[87,88] Preliminary analysis in Oregon also indicates that the state's cap-and-trade program will likely benefit energy consumers.[89]

With respect to Hawaii's participation in regional carbon markets, Hawaii should consider the implications. It is important to carefully design the cap and trade system, specifically the cap itself and allocation of emissions allowances to participating entities, to encourage additional renewable energy deployments and more energy efficiency locally. The system should fully reward Hawaii entities that identify and pursue all cost-effective projects up to the clearing prices of credits in the markets in which they trade. The money realized from the sale of credits could subsidize additional renewable energy resources and energy-efficiency measures. This would lead to further diversifying Hawaii's energy system, a bolstering of the local economy, and protection of the environment.

Recommendation: DBEDT should consider investigating and making recommendations on direct emission measures, alternative compliance measures, and/or market-based compliance measures that can cost-effectively reduce emissions within the State.

3.5.1.3 Establish Emissions Standards for New Energy Facilities

Hawaii could proactively reduce its emissions by establishing minimum emissions standards for new energy facilities. Hawaii's carbon dioxide standards could be modeled after Oregon's emissions standards, which have been in place since 1997. California has also adopted a GHG performance standard for baseload power plants similar to Oregon's.[90] In order to guarantee significant reductions, standards would be set just *below* the emission rate of the most efficient low-carbon option. For Hawaii, the benchmark would likely be emissions from diesel electricity generation. Such a standard encourages construction of carbon-free renewable generation and fuel substitution using biodiesel and ethanol. The standard also forces energy facilities to start reducing their contributions to global warming.

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[87] RGGI analysis indicates that the effect of retail price increases to electricity bills in the region would be up to 3.2% increase under a high emissions scenario by 2015. As previously mentioned, however, end-user efficiency improvements will more than compensate for these price increases and result in net savings for consumers.

[88] Regional Greenhouse Gas Initiative. December 16, 2005. *Overview*. Retrieved October 15 from www.rggi.org.

[89] Zelljadt, Elizabeth. 2006, October 11. *Modeling Shows Cap and Trade to be Cheap in Oregon*, Carbon Market North America, Point Carbon. Retrieved October 11, 2006 from www.pointcarbon.com.

[90] California Public Utilities Commission. 2005 October 6. Policy Statement on Greenhouse Gas Performance Standards. Retrieved December 15, 2006 from www.cpuc.ca.gov/PUBLISHED/REPORT/50432.htm.

Facilities that fail to meet the standard would be required to offset their carbon dioxide emissions. Options for offsetting emissions could include facilities meeting reductions through their own projects, through projects implemented by a third party directly in a bilateral agreement, or for them to pay an established amount per ton of carbon dioxide emissions to an administrative entity that will use the funds to implement offset projects. Hawaii may require that offset projects be implemented within the state to support additional State energy goals of energy security and greater self-sufficiency.

Oregon's standards further require that all new energy facilities[91] there offset at least 17 percent of their baseline carbon dioxide emissions. Each regulated facility is subject to one of three protocols for calculating their emissions, based on some assumed rates of emissions per unit of fuel burned and hours of operation.

In Oregon, facilities may meet offset requirements either through their own reduction projects, projects implemented by a third party, or via a "monetary path." Offsets are defined as avoiding, sequestering, or displacing carbon dioxide emissions. Unlike Hawaii's recommended proposal, the Oregon Standard places no restrictions on type or geographic location for offset projects. Projects must meet the approval of the Oregon Facility Siting Council, which reviews projects directly. Generating facilities can also meet offset requirements via cogeneration.

The monetary path is relatively simple: facility applicants pay to meet the standard ($0.85 per short ton of carbon dioxide at the time of writing, plus selection and contracting funds to the qualifying organization that manages the offsets). This can be adjusted, but not by more than 50 percent in any two-year period. Offsets under the monetary path must be managed by a qualifying, non-profit organization. Currently, the only qualifying organization is the Climate Trust.[92]

The Climate Trust (formerly known as the Oregon Climate Trust) was originally formed to select and contract offset programs for facility applicants under the Oregon Standard. Now the organization functions as a buyer and seller of offset credits for other entities nationally. Although The Climate Trust is a non-profit organization with no regulatory nor enforcement authority per se, the organization currently supports the only true carbon dioxide compliance market in the United States.

The Climate Trust continues to be the sole third-party source through which regulated Oregon generators meet their offset requirements; however, it now provides a wide range of domestic and international offset credit options for meeting both voluntary and required reductions for corporations, utilities, and individuals. The Climate Trust's offset portfolio is diverse, is mostly Northwest U.S.-based, and includes energy, forestry, and

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[91] Specifically, base load gas plants, non base-load power plants, and non-generating energy facilities that emit CO_2. The most likely type of non-generating facility regulated under this standard is a compressor at an underground natural gas storage facility. Emissions for such facilities are expressed as a rate of emissions per horsepower hour, versus a set power plant standard of emissions per kWh.

[92] For more information see *Oregon Carbon Dioxide Emission Standards for New Energy Facilities* available at www.oregon.gov/ENERGY/SITING/docs/ccnewst.pdf.

non-carbon dioxide emissions. The quality of its verified offsets is high, employing conservative accounting methods, strict due diligence, and third-party verification standards.

Entities typically offset their emissions through the Climate Trust by making a tax-deductible donation. The donation is used to expand the Trust's offset portfolio by a specified number of tons, either through the expansion of existing projects, or by adding funds to new projects. The types of projects currently in the portfolio include energy efficiency, renewable energy, transportation efficiency, cogeneration, and reforestation.

Hawaii could create a local organization like Oregon's Climate Trust to manage its local offset projects. The organization could collect funding from utilities to promote efficiency or finance renewable energy within the state. Additionally, the payments for carbon offsets could be structured so that they also support the costs of the implementing organization. Alternatively, the state could explore the possibility having The Climate Trust help manage offset projects in Hawaii.

Recommendation: The PUC should set emissions standards for new energy facilities. The standard should apply to base-load plants, non-base-load power plants and non-generating energy facilities that emit carbon dioxide. The established rules should be divided into standards specifically applicable to each of these three kinds of facilities. Rules should also be set for how offsets can be quantified, verified, or purchased. The State should also establish or designate an organization to manage such offsets.

3.6 Conclusions

Reduction in oil use in particular offers the opportunity to reduce the environmental risks of energy production and use, and to reduce the costs of managing those risks. Oil supplies are finite and oil prices are subject to sudden, extreme fluctuations that could devastate Hawaii's economy. Oil use poses risks to Hawaii's environment and global climate.

Global climate change may threaten the quality of life and economic growth currently enjoyed by Hawaii citizens. Economic models indicate that, in the absence of significant action, the overall costs of climate change will be equivalent to losses between 5 and 20 percent of global GDP each year.[93] State residents, as well as people all over the world, are at risk of food shortages, droughts, coastal flooding, and extreme weather events.

How might energy needs, economic growth, and environmental protection be balanced? In general, efforts to improve energy efficiency can reduce energy costs and permit businesses and consumers to spend their money in ways more productive to the local economy. In addition, by investing in alternative energy resources within the state, expenses may not necessarily be reduced, but more of the money spent will remain in the State's economy and more jobs will be created.

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[93] HM Treasury. 2006. *The Stern Review on Economics of Climate Change*, retrieved November 20, 2006 from www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

Specifically, effective and economically efficient action requires a coordinated and dedicated global effort. Hawaii's actions alone will not significantly protect it from the consequences of global climate change. As such, the State must demonstrate support and exert pressure for widespread action to combat global warming. Hawaii must start with local measures and call for national efforts that will dramatically curb GHG emissions. Because GHGs are inextricably linked to our energy system and because they are so ineffectively considered in the current market, it is in the State of Hawaii's best interests to regulate these emissions through coordinated energy and climate change policies now.

Chapter 4 Primary Energy for Hawaii

Primary fuels include crude oil, coal, natural gas, and renewable energy. Since the last Hawaii Energy Strategy was published in 2000, global energy, technology, environmental, geopolitical, and societal trends coupled with regulatory shifts and infrastructure constraints have intersected to prompt fundamental shifts in primary energy markets. After fifteen years of relative stability, oil prices began to rise rapidly in 2000, as did U.S. natural gas prices. Even the normally inactive coal market has experienced price escalation, with coal prices on the spot market starting to rise in 2003. These markets have become far more volatile as well, with higher relative price spikes and price drops around the average versus the prior decade. Thus, primary fuel prices have risen to a new plateau, *and* they've become more unpredictable.

Hawaii has begun to feel the local impact of rapidly changing dynamics in the globally traded primary fuels markets. Since 2002, the state has experienced steep fuel price increases and faced an increasing number of risks in energy costs and security of supply. In order to meet Hawaii's goal of ensuring secure and reliable energy supplies for its citizens at minimal economic and environmental cost, the state must grapple with emerging strategic drivers that are shaping the primary energy markets and develop a strategic response both as a consumer and as a responsible global player. This section offers insights into the major trends underlying the global and regional primary fuel markets and the implications for Hawaii.

4.1 Primary Energy Demand in Hawaii

Hawaii's energy system employs a combination of fossil-fuel-based resources and renewable resources to meet its energy demands (see Figure 10). Hawaii relies on fossil fuels for more than 90 percent of its energy needs despite abundant and diverse renewable resources (see Figure 11). Since Hawaii has no indigenous fossil energy resources, it must import all of its coal, crude oil, and a selection of refined oil products, which raises energy security concerns. Biomass and other renewable sources total only 4 percent of the energy consumed in the state. Natural gas is consumed in very small amounts in the form of synthetic natural gas and liquefied petroleum gas.

A word about terminology

Commodity – Any homogeneous, traded good or service**.** Metals, agricultural products, and fuels are typically considered commodities.

Value chain – A progression of linked activities or industry sectors that work in cooperation to produce an end product.

Market power – The influence over prices or output that a market participant wields in the market.

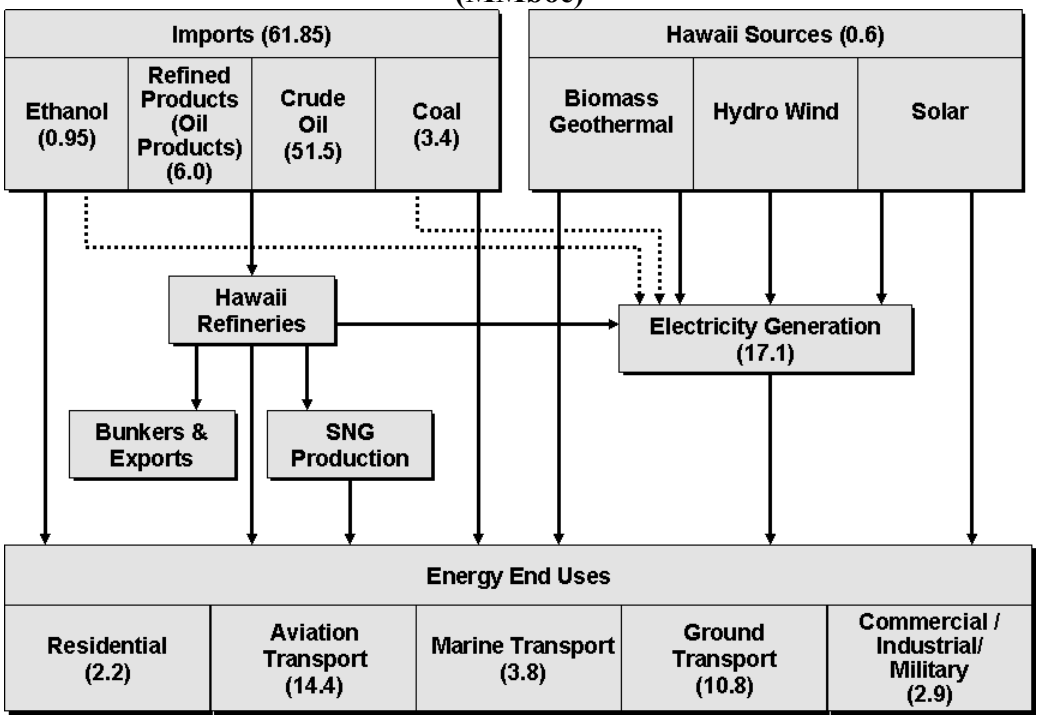
Price taker – A market participant who is too small to affect the overall market; therefore, the participant must "take the price" that is dictated by the market.

Futures contracts – An agreement to buy or sell a commodity, which will be delivered in the future, at a given price.

Risk premium – An additional amount affixed to an asset that represents a quantification of risk.

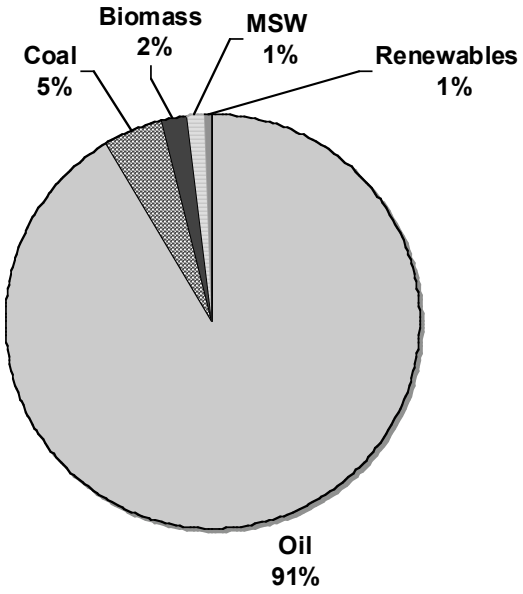
Convergence – In the context of energy markets, the tendency of the prices and demand of two markets or commodities to align and begin to move in sync.

Figure 10. 2005 Hawaii Primary Energy Use, Million Barrels of Oil Per Day (MMboe)



Source: RMI analysis and Hawaii Energy Strategy 2000.

Figure 11. Statewide Primary Energy Consumption by Fuel Type, 2005[94,95]



Hawaii's overwhelming dependence on imports directly and inextricably connects the state's economic vitality to the global commodities markets. Regionally, Hawaii's location in the middle of the Pacific Ocean links it most closely with the U.S. West Coast and Asia-Pacific markets, from which the majority of its fossil-fuel imports originate. As the world's appetite for energy continues to grow, driven in large part by China and India, Hawaii will feel the impact of emerging energy consumption and economic growth patterns not only as a participant in the global market, but also as a potential competitor for energy resources within the Asia-Pacific region.

4.2 Primary Energy Supplies

Primary fuels markets are both global and regional. Oil, liquefied natural gas (LNG), and coal are traded in global fuels markets as commodities, the prices of which are affected by global supply and demand. Natural gas and renewable energy, because of their more limited mobility, are traded in regional markets. Globally traded commodity markets enable convergence[96] between energy value chains, creating tighter interrelationships between the world's oil, gas, and coal markets (see Figure 12). For example, the creation of the oil futures and then the gas futures markets allowed these two energy value chains to converge during the 1980s. Nevertheless, these interrelationships are mediated by the storage, transmission, and delivery infrastructure of each of the energy sources, which depend on local energy infrastructure and constraints by region or country.

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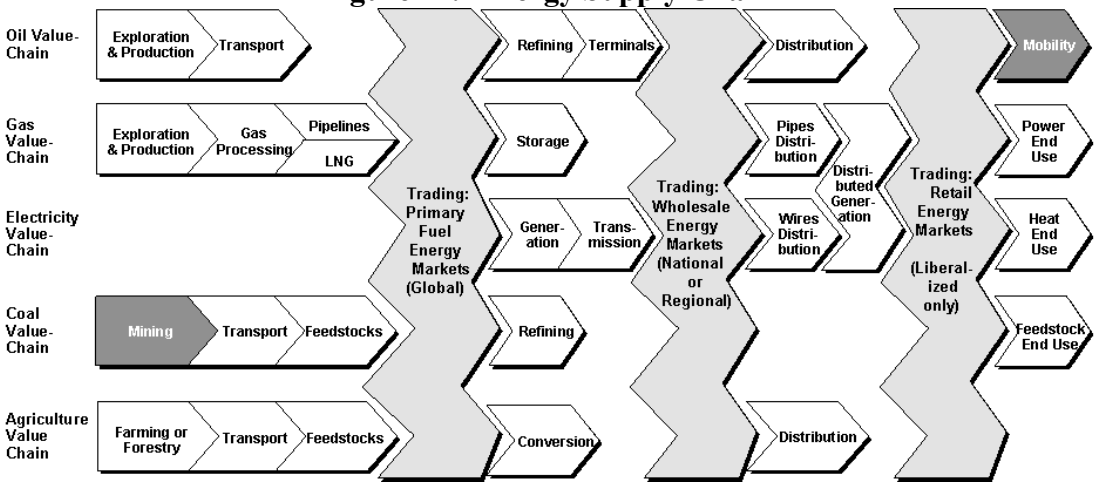
[94] Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections.*

[95] Hawaii, Public Utilities Commission, *Annual Report of the Gas Company* (Hawaii: PUC, 2005) 40.

[96] See "A Word About Terminology" on page 66.

Figure 12. Energy Supply Chain



All of the major world energy forecasts[97] project strong growth in worldwide energy demand through 2030. Global energy demand, which the U.S. Energy Information Administration (EIA) forecasts will grow by 37 percent by 2020 and 70 percent by 2030, is closely linked to world economic growth and driven by emerging markets in non-Organization for Economic Cooperation and Development (OECD) countries (see Figure 13). EIA projects that by 2030 energy consumption in non-OECD countries, lead by China and India, will surpass demand in OECD countries by 34 percent.[98]

Despite escalating prices in fossil fuels and advances in alternative energies, most major forecasts predict that fossil fuels will remain the dominant source of energy through 2030. Globally, EIA projects the world's energy mix will vary slightly (see Figure 14). Oil will remain the dominant source of fuel with a market share of 33 percent, a decline from 39 percent in 2003. Meanwhile, coal and natural gas are both forecasted to increase in market share from 24 to 27 percent and 24 to 26 percent, respectively. Domestically, EIA projects that oil, coal, and natural gas will still provide roughly the same 86 percent share of the total U.S. primary energy supply in 2030 that they did in 2005.[99] Although biofuels and other forms of renewable energy are expected to grow rapidly, their relative market share pales in comparison to fossil fuels.

[97] EIA International Energy Outlook 2006, BP Statistical Review of World Energy 2006, IEA World Energy Outlook 2006.

[98] Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

[99] Energy Information Administration (EIA). (2006). Annual Energy Outlook 2007 (early release). Washington DC: U.S. Government Printing Office.

Figure 13. World-Marketed Energy Use by Fuel Type 1980–2030[100]

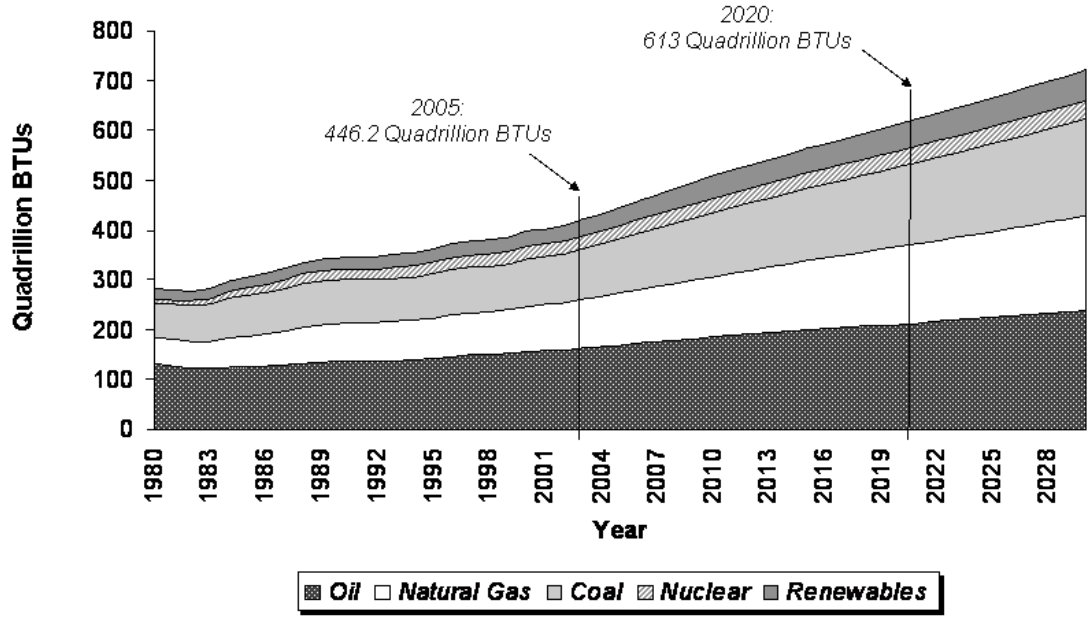
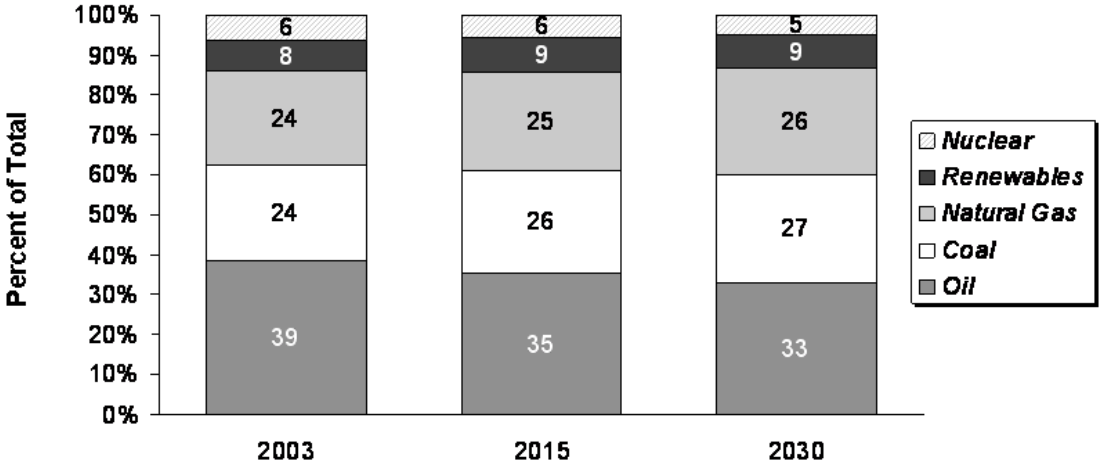


Figure 14. Fuel Shares of World Marketed Energy Use, 2003, 2015 and 2030[101]



4.2.1 Oil

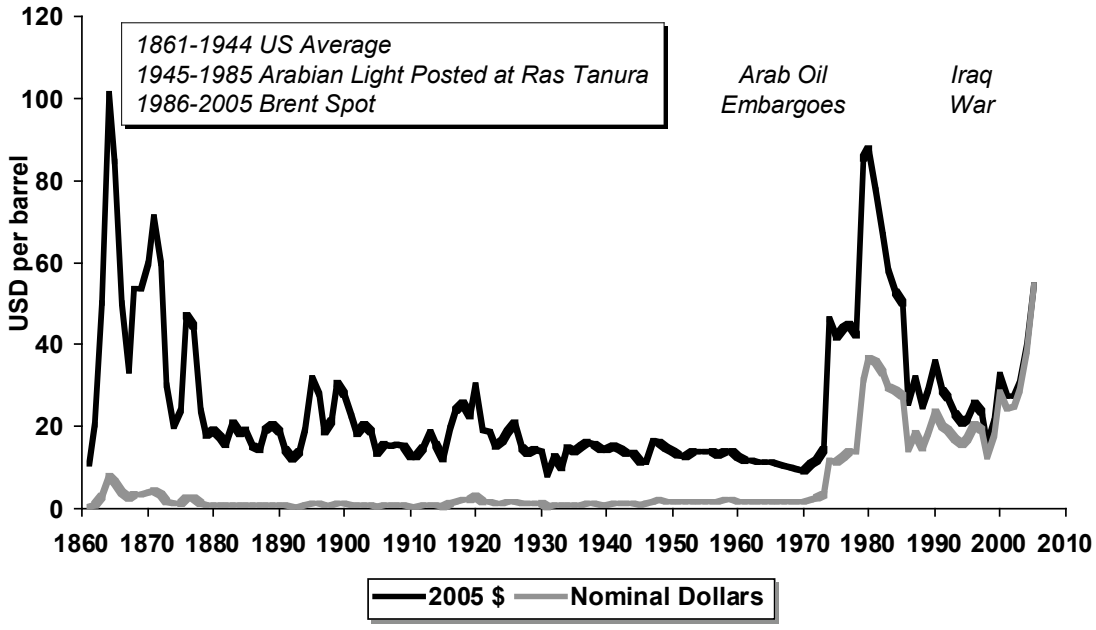
Escalating demand, volatile prices, and threatened supplies have put oil market dynamics at the forefront of public policy debates and on the front pages of newspapers worldwide. This is especially true in Hawaii, where the state depends on oil for more than 90 percent

[100] Source: Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

[101] Source: Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

of its energy needs. After decades of relatively low and stable prices, the real price of oil and its volatility have returned to the levels observed when it was first discovered (see Figure 15). From 1999 to 2005, the price of imported crude oil increased 198 percent.[102] As the price has increased, so too has price volatility. In recent years, the movements of the New York Mercantile Exchange (NYMEX) oil futures market have echoed price fluctuations in the oil spot market, reflecting "heightened uncertainty over supply" and they suggest "a lack of clarity about longer-term direction."[103] Although oil prices remain extremely uncertain, the IEA and the EIA have both adjusted their 2006 price forecasts upward on the expectation that geopolitical tensions or supply disruptions may keep prices high despite new supply capacity.

Figure 15. World Oil Price Movements 1890–2005[104]



The world oil market serves as a prime example of the emerging global trends discussed earlier in this chapter. The growing demands of the developing world, including China, India, and other parts of Asia, are already producing a tangible shift in global oil trading patterns, which ultimately affect prices and supplies. For example, according to the EIA, world oil consumption grew an average of approximately 1.5 percent per year from 1990 to 2004. However, that growth was not evenly distributed. According to the Asian Development Bank, oil consumption by the developing world (excluding former Soviet Union states) grew 79.2 percent from 1990 to 2004, while demand from G7 countries

[102] EIA World Crude Oil Prices, http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm, Accessed October 17, 2006.

[103] Asian Development Bank. (2006.) *Asian Development Outlook 2006 Update.* Hong Kong, China: Asian Development Bank.

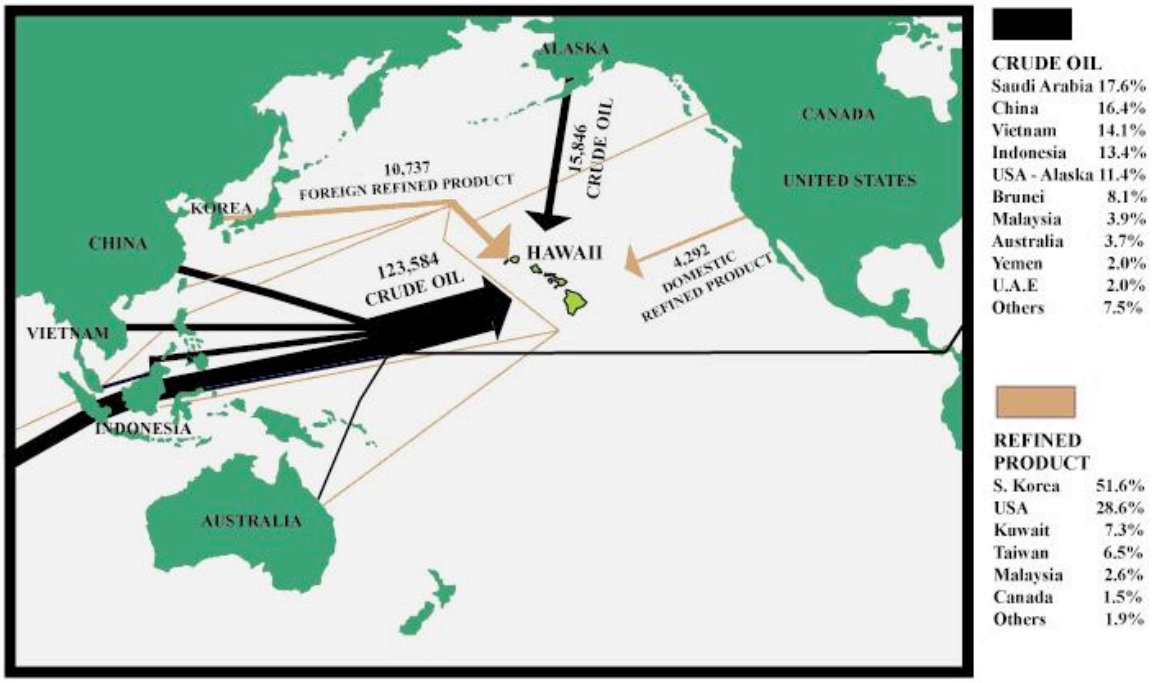
[104] Source: EIA, www.eia.doe.gov/emeu/international/petroleu_html#IntlPrices; BP Statistical Review of World Energy

grew only 12.5 percent.[105] To provide another example, during the same period, China's share of total world oil consumption grew from 3 to 8 percent, making it the second largest oil consumer.[106] These trends are not only expected to continue, but to accelerate. EIA expects China's petroleum imports to increase four-fold between 2003 and 2030.[107]

The change in oil trading patterns will not only affect Hawaii as a participant in the global oil market, but also as a competitor in the Asia-Pacific market, where most of the growth in oil demand is projected to occur. Concurrently, Hawaii will remain a price-taker with little market power, and Hawaii will face increasing competition over fuel supplies from some of the most powerful economies in the world, including China.

4.2.1.1 Crude Oil in Hawaii

Figure 16. Movement of Petroleum to Hawaii - 2005[108]



Oil is imported in Hawaii in the form of crude or refined oil products for use as jet fuel, gasoline, diesel fuel, LPG, and residual fuel oil. In 2005, Hawaii imported 50.9 million barrels of crude oil (see Figure 16), of which 88.6 percent came from foreign sources and 11.4 percent came from domestic sources, principally Alaska. In the same year, Hawaii

[105] Asian Development Bank. (2006.) Asian Development Oulook 2006 Update. Hong Kong, China: Asian Development Bank.

[106] EIA, International Energy Outlook 2004, Table 1.2: World Petroleum Consumption.

[107] Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

[108] Source: State of Hawaii Strategic Industries Division; and U.S. Energy Information Agency, 2006. Preliminary figures, April 2006.

imported 5.5 million barrels of refined oil products, of which 71.4 percent came from foreign refineries and 28.6 percent from domestic refineries.[109]

Hawaii's two refineries, Chevron USA and Tesoro Hawaii, refine all of the state's imported crude oil on Oahu. The Chevron refinery has a current capacity of about 20 million barrels per year,[110] while the Tesoro Hawaii refinery has a capacity of about 33 million barrels per year.[111] Both of Hawaii's refiners play a pivotal role in the unique structure of Hawaii's petroleum market by not only meeting the state's demand for various refined oil products, but also influencing that demand through their respective refining capabilities. As a result, Hawaii has a unique refined oil product slate that has been instrumental in shaping the state's petroleum market to date and it will continue have an impact in the future.

Figure 17. Typical Refined Oil Product Slate Produced by Hawaii's Refiners, Barrels Per Day (bpd)[112]

	Chevron	Tesoro	Supply	Demand	Exports
	bpd	bpd	bpd	bpd	bpd
Propane	1,500	1,500	3,000	3,000	-
Gasoline	14,000	14,000	28,000	28,000	-
Naphtha	6,000	7,000	13,000	7,000	6,000
Jet Fuel	13,000	26,000	39,000	45,000	(6,000)
Diesel	5,000	14,000	19,000	19,000	-
Fuel Oil*	14,000	23,000	37,000	37,000	-
Asphalt	500	500	>1,000	>1,000	-
	54,000	86,000	140,000	140,000	-

* Includes fuel oil consumed in the refinery: Chevron 1,000 bpd, Tesoro 2,000 bpd (estimated)

Figure 17 shows the typical refined oil product slate produced by Hawaii's refineries. Chevron maximizes gasoline production, while Tesoro maximizes the production of jet fuel and provides feedstock to The Gas Company's (TGC) synthetic natural gas (SNG) plant, which is used as utility gas on Oahu. Theoretically, it is possible for refiners to purchase an optimal crude slate and run their refineries to balance local supply and demand. In practice, it is rarely cost-effective to do so, and therefore it is common to see some trade to balance the market. Typically, Hawaii's refineries must import jet fuel in

[109] Data provided by DBEDT.

[110] Chevron. (2006, October 17). "Media Statement: Update on Restart of Chevron Refinery in Hawaii Following Earthquake." Retrieved on October 19, 2006 from www.chevron.com/news/press/2006/2006-10-17.asp.

[111] Yerton, Stewart, (2006, October 17). "Tesoro Corp. May Resume Gas Production as early as Today," *Honolulu Star Bulletin*. Retrieved from http://starbulletin.com/2006/10/17/business/story02.html.

[112] Source: Stillwater Associates. (August 2003). *Hawaii Ethanol Alternatives: Study Conducted for DBEDT, Strategic Industries Division, State of Hawaii.*

significant quantities to meet the state's demand while some surplus refinery products, such as naphtha, are routinely exported to the Asia-Pacific market.

Hawaii's unique product slate is partially attributable to the configuration of its refineries, which do not have the same technological capacity as those in competing markets in California and around the Pacific Rim. Specifically, modern refineries are designed to maximize the production of light oil products even when using heavy crude oil because lighter refined products are in higher demand and more valuable than heavier residual fuels. However, Hawaii's refiners do not have the capacity to refine heavier crudes into lighter products due to a lack of expensive retrofitting equipment, such as cokers, which are required for the process. Historically, Hawaii's refineries have not had to consider making such a capital-intensive investment due to the unique product slate that the Hawaii market can absorb. As illustrated in Figure 17, fuel oil accounts for approximately 30 percent of refinery production. Hawaii's electric utilities, which consumed 9.1 million barrels of residual (No. 6) fuel oil in 2005, help to create a market that provides little incentive to invest in the equipment necessary to produce lighter oil products and reduce the production of heavy fuel oil.

Furthermore, Hawaii's refineries also lack the infrastructure to reduce the sulfur content, which is often associated with heavier crude oils.[113] In contrast to modern refineries, which have the capability to remove sulfur from heavier, sour crudes via hydrodesulfurization, Hawaii's refineries are incapable of removing sulfur and, instead, must purchase light sweet crudes, which are naturally low in sulfur.

Federal regulation has only reinforced the necessity for importing lighter, sweeter crude oil. In 2001, the U.S. Environmental Protection Agency (USEPA) established ultra-low-sulfur diesel standards that required all on-road diesel fuel to have its sulfur content drastically reduced from a formerly mandated level of 500 parts per million (ppm) to 15 ppm in 2006. As of October 2006, at least 80 percent of the diesel available for trucks and buses in the United States had to meet this standard.[114] In an effort to avoid the "capital investment and permitting issues associated with installing desulfurization capacity, as well as the absence of a local sulfur market and the implied cost of exporting sulfur,"[115] Hawaii's refiners are meeting the lower-sulfur standards by purchasing higher quality crude with lower sulfur content.

Hawaii's reliance on lighter, sweeter crude oil has tangible impacts on prices and supply security. With regards to price, Hawaii's refineries already pay a premium for crude oil

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[113] The terms "heavy," "light," "sweet," and "sour" describe qualities of crude oil. "Heavy" and "light" refer to the viscosity or weight of crude oil, which is determined by the amount of wax contained in a type of crude. The more wax, the heavier and less viscous the oil. "Sour" and "sweet" refer to the amount of sulfur in crude oil. Generally, oil with more than 0.5% of sulfur is considered "sour" and less desirable due to low-sulfur emissions regulations.

[114] Barringer, Felicity. (2006 October 11). "Low-Sulfur Diesel Fuel Is Reaching Market," *New York Times*, Oct. 11, 2006. www.nytimes.com/2006/10/11/washington/11diesel.html?ex=1318219200&en=21bafbc36bd68d44&ei=5088&partner=rssnyt&emc=rss.

[115] Stillwater Associates, (2003 August 5.) Study of Fuel Prices and Legislative Initiatives for the State of Hawaii. State of Hawaii: Department of Business, Economic Development & Tourism (DBEDT).

over their counterparts on the U.S. West Coast and around the Pacific Rim. The 2003 fuels study commissioned by DBEDT empirically determined that Hawaii's refiners paid about $3 per barrel more than refiners on the West Coast, and $1 per barrel over other refineries in Pacific Rim countries.[116] Refiners in competing markets on the U.S. West Coast and in Pacific Rim countries retain purchasing leverage not only because of the availability of alternative crude supplies, but also because these refiners have the capability of processing a broad spectrum of crudes. Needless to say, since crude oil represents more than 80 to 90 percent of the cost of refining oil, Hawaii's gasoline and refined oil fuel prices are often at a premium compared to oil in neighboring markets on the U.S. West Coast.[117]

In terms of supply security and availability, the supplies of light sweet crude on which Hawaii's refineries depend are declining. On average, Hawaii refineries "need crude oils with an American Petroleum Institute (API) gravity of more than 30 and a sulfur content of less than 0.5 percent, a quality that even in 1981 was hard to find."[118] Globally, the world's nations are adopting lower-sulfur specifications for transportation fuels resulting in increased global demand for low-sulfur crude oil. As a result, the cost differential between lower-sulfur sweet crude relative to higher-sulfur sour crude has increased and will continue to widen. For example, the average difference between the cost of world oil, a weighted average of all crudes produced in the world, and West Texas Intermediate (WTI), a light, low-sulfur crude often used as a benchmark for sweet crude, was $3.01 per barrel in 2000. By 2005, the average differential of these two benchmarks was $7.00.[119] For Hawaii, this widening price spread will mean an even higher premium for the acquisition cost of crude than the $3 per barrel differential over the U.S. West Coast acquisition cost that was estimated in 2003.

4.2.2 Coal

As one of the world's most widely dispersed and available sources of energy, coal is less expensive and has relatively more secure supply sources than oil and gas. Historically, the price of coal has remained stable relative to the oil and gas markets. The capital intensity (US$ per million Btu) for coal production is one-fifth as much as oil and one-sixth as much as gas. Therefore, it is not surprising that coal is the second largest primary fuel,[120] currently meeting 24 percent of the world's energy demands, or that its market share is expected to grow to 27 percent by 2030, driven mainly by electricity generation.

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[116] Stillwater Associates, (2003 August 5.) Study of Fuel Prices and Legislative Initiatives for the State of Hawaii. State of Hawaii Department of Business, Economic Development & Tourism (DBEDT).

[117] Stillwater Associates, (2003 August 5.) Study of Fuel Prices and Legislative Initiatives for the State of Hawaii. State of Hawaii Department of Business, Economic Development & Tourism (DBEDT).

[118] Stillwater Associates, (2003 August 5.) Study of Fuel Prices and Legislative Initiatives for the State of Hawaii. State of Hawaii Department of Business, Economic Development & Tourism (DBEDT).

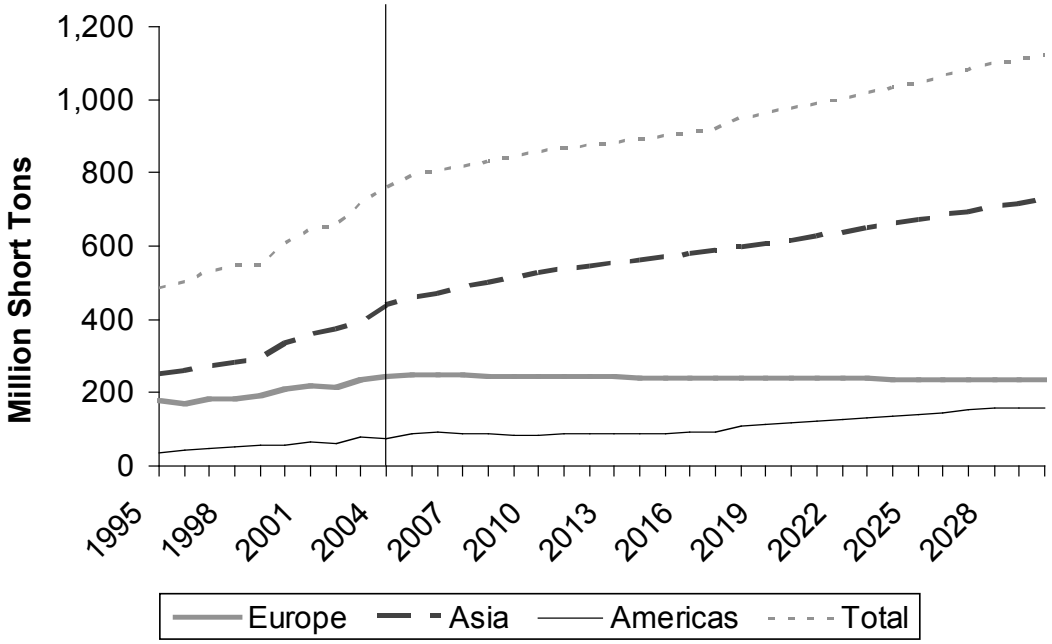
[119] RMI analysis based on EIA historical monthly prices of the "World Oil Average of All Countries Spot Price" and the "Average of Cushing, OK WTI Spot Price" in real 2004 US dollars.

[120] International Energy Agency (IEA). (2006). World Energy Outlook 2006. Paris: OECD/IEA.

The EIA forecasts world coal production will increase from 5.4 billion tons to 10.6 billion tons by 2030. Notably, 70 percent of the 5.2-billion-ton increase in use is expected in Asia, primarily in China and India (see Figure 18). In 2005, China was already the largest consumer of coal, accounting for 80 percent of global growth.[121] Elsewhere in Asia, Australia is projected to remain the world's largest exporter of coal, while coal exports from Indonesia, Hawaii's principal supplier of coal, are expected to double within 5 years.[122]

The United States is expected to shift from being a net exporter of coal to a net importer by 2030.[123] Although coal imports are projected to make up only 5 percent of overall U.S. consumption, the shift is profound for the country, which claims 27 percent of the world's coal reserves. The EIA expects declining domestic mining productivity, higher domestic production costs, and rising consumption of coal in the Southeast to make imported coal increasingly more cost-competitive with U.S. coal production.[124]

Figure 18. Coal Imports by Major Importing Regions, 1995–2030[125]



[121] British Petroleum, Ltd (BP). (2006). Statistical Review of World Energy 2006. London: BP.

[122] Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

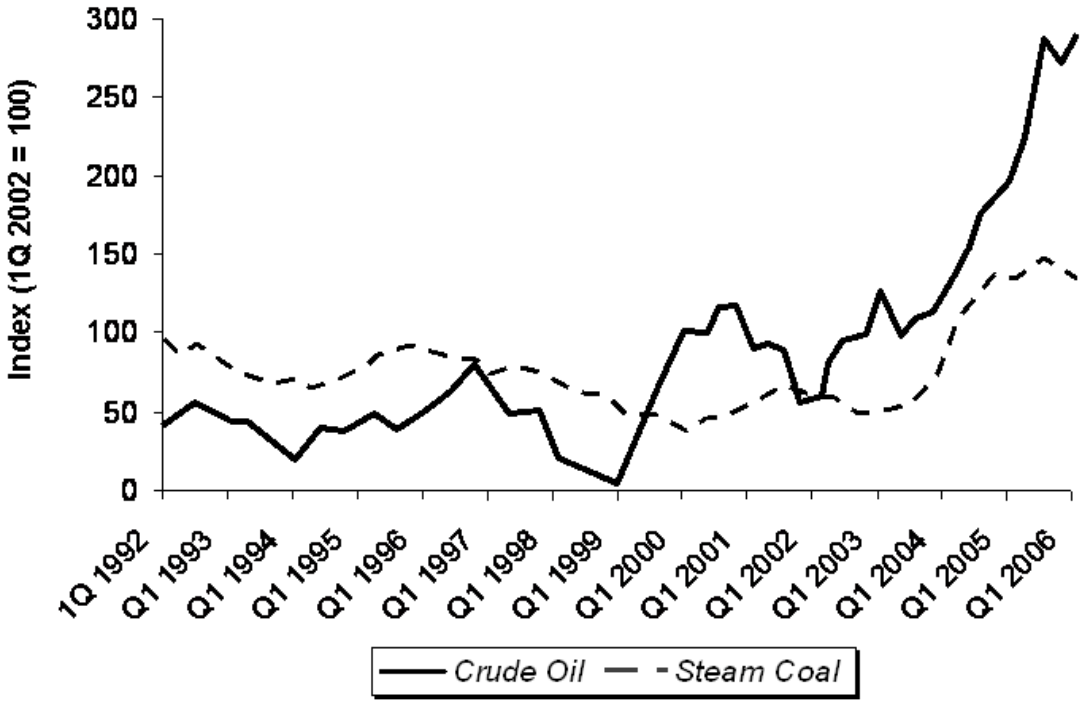
[123] Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

[124] Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

[125] Source: Energy Information Administration (EIA). (2006). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

Although coal prices have historically been more stable than oil and gas prices and remain so, coal has experienced bouts of increased volatility since 2000. Figure 19 charts the most recent 15-year trend in steam coal prices as compared against world crude oil prices. The average price for steam and coking coal paid by OECD countries increased in 2000 and 2001 before falling lower than those prices seen in the 1990s. By 2004, prices had risen drastically again before leveling off, then decreasing to roughly half of the average price during the previous ten years.[126] The price of OECD steam coal imports is assumed to fall back slightly from a peak of $62 per tonne in 2005 to around $55 in the next few years, and then to increase slowly to $60 by 2030.[127]

Figure 19. Average IEA Crude Oil and Import Coal Prices[128]



4.2.2.1 Coal in Hawaii

Coal was first introduced in Hawaii on a large scale in 1992 with the construction of the 180 MW AES Hawaii coal plant on Oahu. AES Hawaii imports low-sulfur coal under a long-term contract from Indonesia's Kaltim Prima mine. Since 2000, AES Hawaii's coal plant has contributed an average of 20 percent to HECO's electricity generation per year on Oahu and an average of 14 percent of the electricity generation across the entire state.[129]

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[126] International Energy Agency (IEA). (2006). World Energy Outlook 2006. Paris: OECD/IEA.

[127] International Energy Agency (IEA). (2006). World Energy Outlook 2006. Paris: OECD/IEA.

[128] Source: International Energy Agency (IEA). (2006). World Energy Outlook 2006. Paris: OECD/IEA.

[129] Based on annual generation figures reported annually to the Federal Energy Regulatory Commission (FERC) by HECO, MECO, HELCO and KIUC for 2000 through 2005.

The push for increased fuel diversity, security, and the high cost of oil-fired electricity generation is driving the potential expansion of coal-fired generation in Hawaii. HECO's most recent Draft Preferred Plan, presented in the utility's 2005 Integrated Resource Plan (IRP), proposes the installation of an additional 180 MW coal plant in 2022.[130] In the plan, the utility notes that as fuel prices rose in 2004, the IRP Advisory Group revised HECO's 2002 oil forecasts and, as a result, HECO determined that, "the larger difference between oil and coal prices makes a coal unit appear more economically attractive and the fuel savings from the coal unit would more than offset the incremental capital cost of installing the unit earlier." HECO further elaborated, "A coal unit was cost-effective and would be added to the plan at the earliest date feasible, even before firm capacity was required by HECO's capacity planning criteria." It is important to note that the IRP did not revise the coal price assumptions upward as it did with oil prices.[131]

The critical uncertainty facing coal demand and coal-related investment is not price or supply-related, but environmental policy. Coal-fired generation emits 25 percent more carbon dioxide per million Btu than oil-fired generation, assuming comparable heat rates.[132] The future of coal is therefore inextricably linked to carbon regulation in determining the future of coal demand and prices. The more stringent the regulatory requirements, the higher the potential cost of coal usage and coal plant investments, and the less competitive coal becomes in comparison to gas or other power sources.

It is possible that carbon taxes or other measures such as carbon trading could, in the future, raise the cost of using coal relative to oil and gas. However, while placing a high price on carbon could make coal a more expensive fuel for electricity generation relative to oil or gas in the short term, this may not always be the case due to the second order effects of price. That is, as the price of carbon increases, the demand for cleaner fuels such as natural gas will increase, driving up the price of natural gas. Therefore, in the long term, the carbon-adjusted price of generating baseload electricity with gas could converge with that of coal.

The same outcome could result in an alternative scenario in which the energy commodities markets take into account and adjust for the added cost of carbon dioxide. The scenario is similar to the recent developments occurring in the U.S. refining industry, in which low-sulfur "light, sweet" crude oil is priced at a premium compared to high-sulfur "sour" crude, which must be refined more extensively to meet new EPA standards for low-sulfur gasoline and diesel fuel.

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[130] Hawaiian Electric Company (HECO). (2005). Integrated Resource Plan, 2006-2025. Honolulu: Hawaiian Electric Company, Inc.

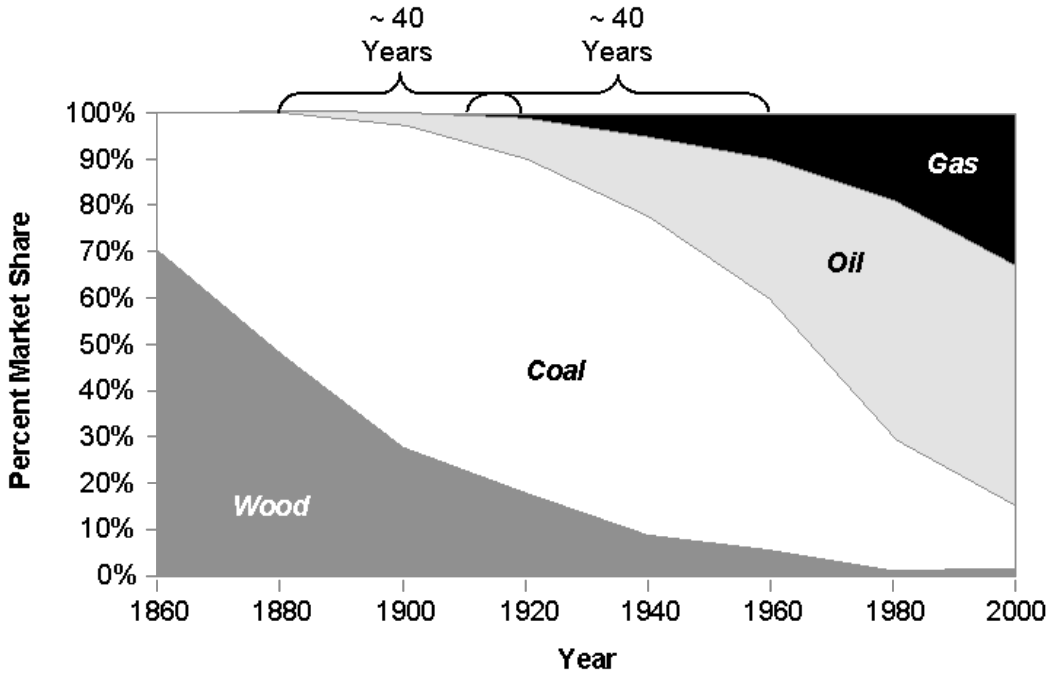
[131] Hawaiian Electric Company (HECO). (2005). Integrated Resource Plan, 2006–2025. Honolulu: Hawaiian Electric Company, Inc.

[132] On Oahu, HECO's coal-fired generation is even less efficient than its oil-fired steam generation, resulting in almost 50% greater carbon dioxide emissions. On the other hand, its coal plant is almost 60% more efficient than the average oil-fired combustion turbine, and as such emits 15% less carbon dioxide per million Btu consumed.

4.2.3 Natural Gas and LNG

Although global oil demand will continue to grow, the world is transitioning from the Age of Oil and entering the Age of Gases, as illustrated Figure 20. Gas is still largely consumed within regional markets, where more than 80 percent of natural gas produced is consumed in the country where it is produced. The reason is straightforward: gas is more difficult to transport than other fuels and gas infrastructure generally requires much larger investments than oil or coal infrastructure. In terms of international gas trade, 75 percent takes place through pipelines, with the United States and Western Europe as major consumers, and the remaining 25 percent is in the form of liquefied natural gas (LNG).

Figure 20. Global Market Share of Competing Carbon-Based Primary Fuels[133]



U.S. gas prices have risen dramatically in the last few years and they have become increasingly volatile. In April 2005, before Hurricanes Katrina and Rita devastated the Gulf of Mexico's gas supply infrastructure, the price of natural gas at Henry Hub had already risen to $7.40 per million Btu,[134] nearly twice its historical average. The summer of 2005 was 26 percent hotter than the previous one,[135] resulting in a 21 percent increase

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[133] Source: A. Lovins, D. Williams, "A Strategy for Hydrogen Transition." April 1999; International Institute for Applied Systems Analysis, 1979 (Marchetti C. and Nakicenovic).

[134] Federal Energy Regulatory Commission (FERC), (2005, October 12). Staff Report: Gulf Coast Storms Exacerbate Tight Natural Gas Supplies; Already High Prices Driven Higher. Retrieved from www.ferc.gov/eventcalendar/Files/20051020121515-Gaspricereport.pdf.

[135] Federal Energy Regulatory Commission (FERC), (2005, October 12). Staff Report: Gulf Coast Storms Exacerbate Tight Natural Gas Supplies; Already High Prices Driven Higher. Retrieved from www.ferc.gov/eventcalendar/Files/20051020121515-Gaspricereport.pdf.

in gas-fired electric generation. Thus, gas prices were already up to approximately $10 per million Btu in August 2005 *before* the hurricanes hit.[136] After the storms, gas prices at the Henry Hub shot up farther to $14 per million Btu due to both a cumulative 450-billion-cubic-foot reduction in production and anticipation of seasonal demand—despite the fact that gas storage inventories were above their five-year averages.[137] In 2006, gas prices have oscillated between $9 and $5 per million Btu, for an average price of $6.75 per million Btu for the year.[138]

Liquefying natural gas reduces the volume of natural gas, making it practical to transport and store. Thus, LNG is enabling gas to penetrate markets that would otherwise be inaccessible due to the great distances it must be transported to reach those markets.[139] LNG is expected to play an increasingly important role in the natural gas industry and global energy markets in the next several years. Hawaii could be a beneficiary of these global trends.

4.2.3.1 The Possibility of Importing Liquefied Natural Gas into Hawaii

The possibility of importing LNG into Hawaii has been studied for more than a decade. In 1993, DBEDT initiated a study with the East–West Center on the possibility of importing LNG for use as a fuel for electricity generation, utility gas applications, and ground transportation. The study concluded that demand on neighboring islands was too small to justify construction of receiving terminals. Furthermore, building the LNG infrastructure, including a liquefaction plant at the source of LNG export, a fleet of LNG tankers dedicated to moving the product to Oahu, and a receiving terminal on Oahu, would have cost $5.38 billion. The unit cost of delivered gas was estimated at 2.5 times the cost of residual fuel oil, which made the needed investments uneconomical. The system would not reduce its energy supply vulnerability due to the need to rely on a single supplier. Finally, LNG imports were also not recommended due to safety hazards faced by LNG carriers, regasification facilities at the receiving terminal, and pipelines.

By 1999, the regional LNG market in the Pacific Basin had developed a burgeoning spot market, the result of buyers backing out of long-term contracts. This development enabled LNG to be purchased in shipload increments using short-term contracts. In light of the altered market, Hawaii's gas utility, The Gas Company (TGC), reexamined the potential for importing LNG to replace synthetic natural gas (SNG) and utility propane on Oahu. Although buying LNG on the spot market could eliminate the need to invest directly in the supply and transport elements of the LNG chain, a receiving terminal

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[136] Federal Energy Regulatory Commission (FERC), (2005, October 12). Staff Report: Gulf Coast Storms Exacerbate Tight Natural Gas Supplies; Already High Prices Driven Higher. Retrieved from www.ferc.gov/eventcalendar/Files/20051020121515-Gaspricereport.pdf.

[137] Federal Energy Regulatory Commission (FERC), (2005, October 12). Staff Report: Gulf Coast Storms Exacerbate Tight Natural Gas Supplies; Already High Prices Driven Higher. Retrieved from www.ferc.gov/eventcalendar/Files/20051020121515-Gaspricereport.pdf.

[138] 2006 natural gas price at the Henry Hub accessed from the Wall Street Journal

[139] According to the EIA, "the economic crossover — the point at which transporting LNG via tanker is cheaper than transporting natural gas via pipelines — occurs at a distance of around 2,000 kilometers (1,250 miles) for offshore pipelines and around 3,800 kilometers (2,375 miles) for onshore pipelines."

would still be required. TGC saw the availability of a receiving facility site and related safety issues, pipeline requirements, and political issues as major obstacles. The study also concluded that it was not clear whether the LNG spot market would continue to be a long-term prospect or if it may disappear once the Asian economy stabilized.

Four years later, in 2003, the Hawaii Energy Policy Forum commissioned FACTS, Inc. to conduct a feasibility study on LNG in Hawaii. The study reported that although Hawaii's potential LNG demand is relatively small, increased gas demand from the U.S. West Coast, as well as in Asia, "puts Hawaii in a unique position as it is well placed between the two regional demand centers. LNG would only be economically viable if HECO purchased the fuel for its power requirements, displacing fuel oil. There is also the possibility of Hawaii acting as a midway point between the two regions and receiving LNG either on the way to the U.S. West Coast from Southeast Asia and Australia or during the backhaul." In this study, LNG was an attractive alternative to fuel oil because the costs of the LNG value chain, including commodity, gasification, transport, and regasification, were close to parity with fuel oil. FACTs estimated that the final price in Hawaii would likely fall between "the average and high cost category—in the range of $3.50–4.50 per million Btu."

In today's energy markets, the fundamental question is how LNG would be priced for Hawaii. From a supplier's perspective, LNG delivery to the U.S. West Coast is economically attractive because the near-term prices for natural gas far exceed the costs of LNG imports. Therefore, the risk to LNG suppliers is the long-run prices of U.S. natural gas. Further, capital costs in U.S. dollars for LNG facilities and transport vessels have risen 40 percent since 2003 due to the higher prices for steel, the decline of the dollar, and high demand for LNG facilities.

Unless there was a surplus of LNG capacity, we would expect that LNG suppliers would look to markets with the greatest profit potential, as measured by the netback, or net price back to producers after transportation. The California Energy Commission estimates that prices from the proposed Baja California facility could be in the range of $4.50 to $5.50 per million Btu[140] through 2015, assuming U.S. natural gas prices in the range of $3.75 to $5.25 per million Btu. However, if gas prices were higher than this, LNG producers would sell at market prices. Atlantic spot LNG contracts are already being linked to Henry Hub gas prices; thus, changes in the gas price in Houston are affecting consumers in, for example, Marseilles, France.

It is unlikely that producers would sell LNG to Hawaii at net prices that are lower than they can otherwise realize on the U.S. West Coast, nor would they price the LNG at the costs of production unless the markets were oversupplied. If Hawaii prices for LNG were tied to West Coast natural gas prices, Hawaii would experience greater volatility in primary fuel prices than it currently does for oil. If LNG prices are tied to a crude oil index, then Hawaii would experience primary fuels pricing comparable to today's

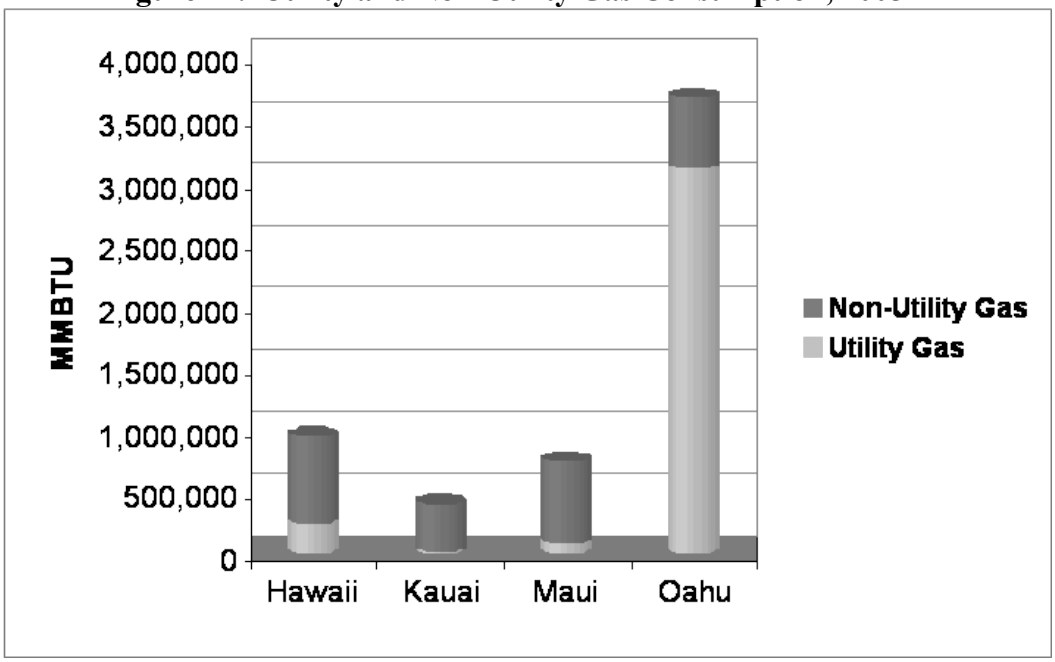
[140] Data provided by Pat Perez, California Energy Commission (CEC), from reference case forecast of CEC's 2005 Integrated Energy Policy Report.

pricing. Thus, in the near term, it is unlikely that LNG will provide a meaningful mechanism for diversifying or hedging Hawaii's primary fuel prices.

4.2.4 SNG/LPG

Synthetic natural gas (SNG) and propane (LPG) met 2 percent of Hawaii's energy needs in 2005. On Oahu, The Gas Company pipes SNG and LPG to its customers as part of its utility service. This is considered utility gas. On neighboring islands, this utility gas comprises only LPG. LPG is also delivered in the form of bottled, non-utility gas on all islands. As Figure 21 shows, Oahu consumed more utility and non-utility gas than all of its neighbors combined.

Figure 21. Utility and Non-Utility Gas Consumption, 2005[141]



4.2.5 Renewable Energy

There has been little change in the mix of resources in Hawaii's renewable energy portfolio during the last decade. Figure 22 illustrates the state's renewable energy mix in 2005. The two greatest sources of renewable energy in the islands remain geothermal and refuse or municipal solid waste (MSW).[142] Oahu's Honolulu Project of Waste Energy Recovery (H-Power) facility is responsible for the large share of electricity capacity produced from MSW. The facility began operating in 1990, and helped to offset reductions in biomass electricity production from the declining sugar industry. Meanwhile, 30 MW of geothermal came online on the Big Island in 1993 via the Puna Geothermal Energy Venture, an independent power producer.

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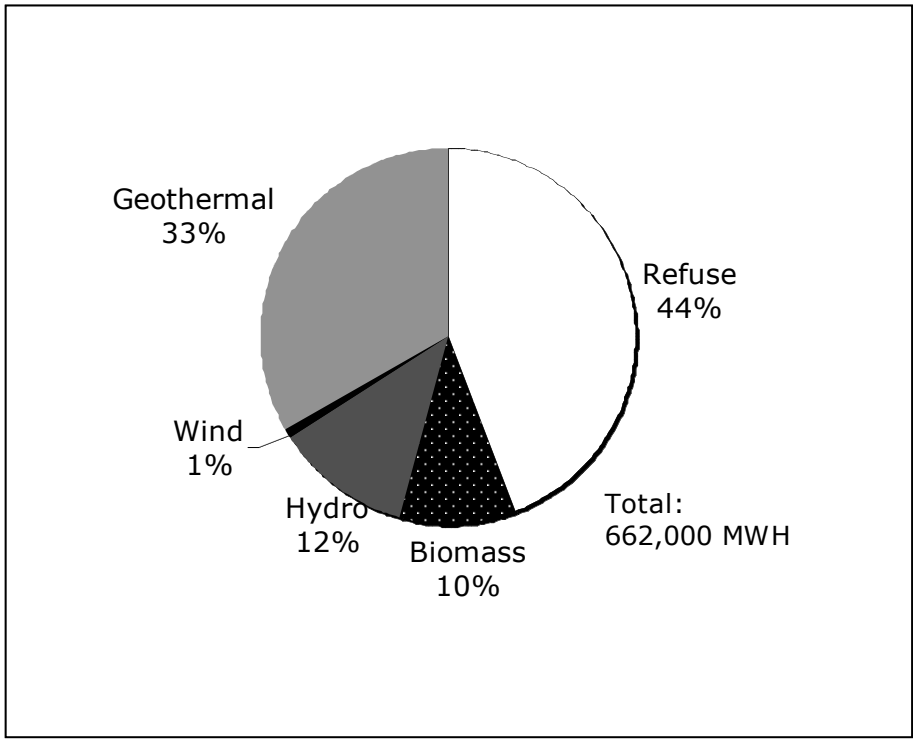
[141] Hawaii, Public Utilities Commission, *Annual Report of the Gas Company* (Hawaii: PUC, 2005) 40.

[142] Does not include 30 MW wind on Maui which went online in 2006.

Figure 22. Renewable Energy Generation Sources (MWh), 2005[143,144,145,146,147]



By and large, most of the non-oil diversity in Hawaii's fuel mix is the result of electricity purchased from independent power producers who are under contract to sell it to the utilities. In 2005, Hawaii's utility-owned capacity accounted for 78 percent of the state's 8.9 million MWh of oil-fired power generation, which included generators that burn #2 fuel oil, #6 fuel oil, naphtha, and refinery gas. In contrast, during the same year, independent power producers produced more than 98 percent of the 2.2 million MWh of non-oil-related generation, which included renewable energy sources and coal. Table 10 below illustrates the various types of fuels that non-utility generators contribute to Hawaii's electricity portfolio.

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[143] Hawaii, Public Utilities Commission, Annual Report of Hawaii Electric Light company (Hawaii: PUC, 1999–2004).

[144] Hawaii, Public Utilities Commission, Annual Report of Kauai Electric (Hawaii: PUC, 1999–2002); Annual Report of Kauai Island Utility Cooperative (Hawaii: PUC, 2002–2005).

[145] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999–2005).

[146] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999–2005).

[147] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

Table 10. 2005 Hawaii's Estimated Power Generation, MWh [148,149,150,151,152]

	Renewable Energy	Oil-fired[153]	Coal
HECO	0	4,721,429	0
HELCO	11,038	546,530	0
MECO	0	1,229,869	0
KIUC	4,429	427,807	0
HEI utilities + KIUC	15,467	6,925,635	0
Non-utility generators	647,507	1,987,855	1,567,228
Total	662,974	8,913,490	1,567,228

4.3 Primary Energy Market Trends

There are several important trends that are rapidly shaping the global and regional energy markets in which Hawaii operates:

Since 2000, primary fuels prices have risen substantially as the markets for these fuels have exhibited strong demand growth, tight supply conditions related to limited spare capacity and infrastructure constraints, and a significant risk premium[154] based on geopolitical uncertainties.[155] In several countries, gas prices have become more volatile than oil prices. Historically, coal prices have been comparatively stable. A comparison of the price trends of the major primary energy fuels in the United States is depicted in Figure 23.

[148] Hawaii, Public Utilities Commission, *Annual Report of Hawaii Electric Light Company* (Hawaii: PUC, 1999–2004).

[149] Hawaii, Public Utilities Commission, *Annual Report of Kauai Island Utility Cooperative* (Hawaii: PUC, 1999–2005)

[150] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999–2005).

[151] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999–2005).

[152] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

[153] Oil-fired generation includes #2 and #6 fuel oil, naphtha and refinery gas.

[154] See "A Word About Terminology" on page 66.

[155] Asian Development Bank. 2006. *Asian Development Outlook 2006 Update.* Hong Kong, China: Asian Development Bank.

Figure 23. U.S. Primary Fuels Price Comparison[156]

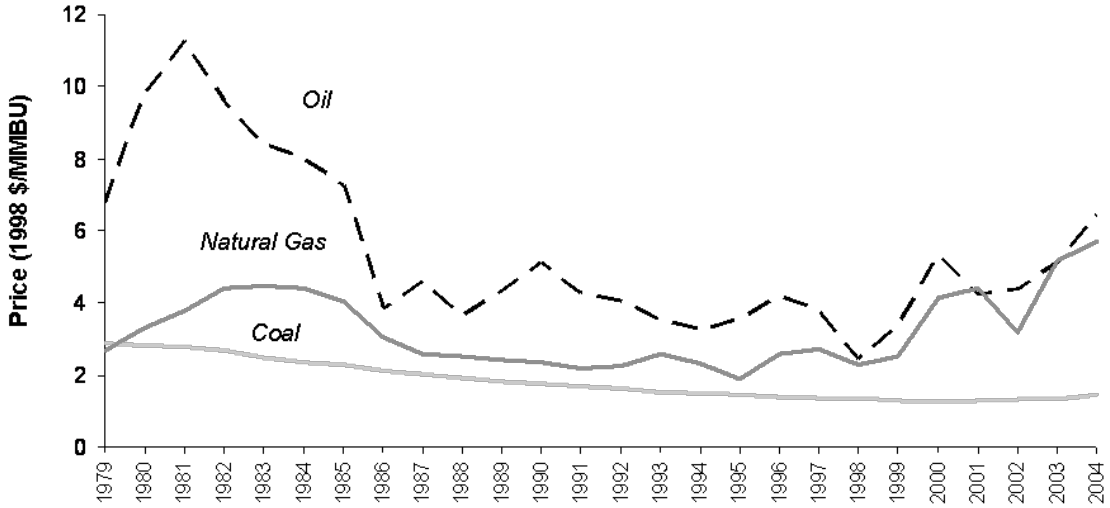
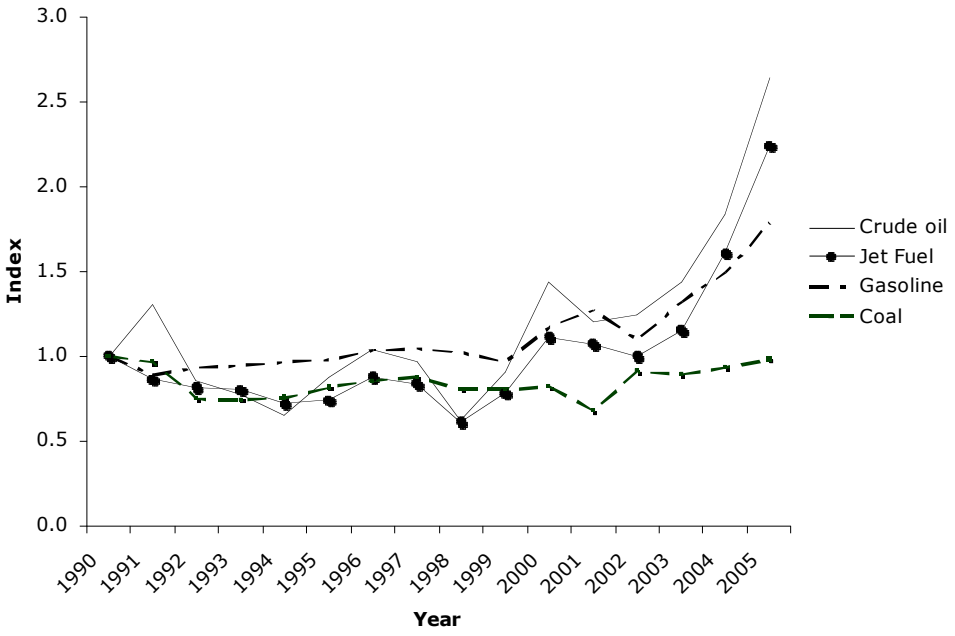


Figure 24. Statewide Historical Fuel Prices, 1990-2005[157,158,159]



[156] Source: US Energy Information Administration (EIA). (2006 December 21). Monthly Energy Review. Retrieved on January 10, 2007 at www.eia.doe.gov/emeu/mer/prices.html.

[157] U.S. Energy Information Administration, *State Energy Consumption, Price and Expenditure Estimates (SEDS),1970–2002, Hawaii.* www.eia.doe.gov/emeu/states/state.html?q_state_a=hi&q_state=HAWAII. Accessed July 23, 2006.

[158] U.S. Energy Information Administration, *World Crude Oil Prices*. http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm. Accessed August 23, 2006.

[159] Hawaiian Holdings, Inc., *Form 10-K: Annual Report to the Securities Exchange Commission* (Washington, DC: SEC, 1999–2005) 7.

Like the rest of the United States, Hawaii's economy benefited from low oil prices during the mid-1990s and up until 2001, and it suffered heavily when petroleum prices rose rapidly starting in 2002 (Figure 24). However, unlike states on the mainland, Hawaii's heavy reliance on petroleum has more pronounced impacts on the state as sharp increases in oil prices flow to every aspect of the islands' economy: transport of goods and tourists to the islands, local transportation, and electricity generation.

4.3.1 Energy Security Concerns Increasing

The most pressing issue in energy is the comparative insecurity of energy supply and delivery in the future. Over the next 30 years, fewer countries, Gulf State Organization of Petroleum Exporting Countries (OPEC) members (Saudi Arabia, Iran, Iraq), and Russia will provide an increasing share of the world's oil and gas, as production in OECD countries peaks and decreases.[160] Among the top 20 countries with the largest oil reserves, eight are OPEC-member countries, which collectively account for 65 percent of the world's total reserves.[161] The geopolitical implications of energy dependence on these countries have been identified as a national security concern by numerous government agencies and think tanks.

The geopolitical concern is the ability of a few countries to control the supply of oil and natural gas as a way to achieve political ends. Increased concentration of supply is likely to result in greater volatility in prices, particularly if excess capacity to produce oil and gas continues to remain at current historically low levels (see Appendix A). Under such conditions, the political actions of countries that are considered unfriendly to U.S. interests can cause prices to spike upwards.

The concentration of supply also creates attractive targets for terrorists, and Al Qaeda has already targeted key oil facilities in Saudi Arabia and the Straights of Hormuz and Singapore. This terrorist risk adds to the underlying future volatility of the oil and LNG markets.

The threat of energy security due to import concentration is already becoming a reality in Hawaii after a period of relative stability for Hawaii's energy markets. Before 2000, political or economic disruption in an OPEC state or affecting a Hawaii crude supplier had virtually no effect because of surplus world capacity. Thus, during the 1997 Asian economic crisis, the state experienced no oil and coal supply shortages, despite the considerable political and social unrest in Indonesia—the source of a third of Hawaii's oil imports during that time—because the economic crisis itself caused massive overcapacity in oil supply, collapsing oil prices to $14 a barrel.

However, in just a decade, Hawaii's fuels portfolio has undergone a dramatic transformation that could have profound consequences on the security of the state's fuel supplies in the future. In 1995, 45 percent of the state's imported crude oil originated in

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[160] Store, Jonas Gahr. (2006, December 16). Geopolitics of Energy Security: The Rise of Asia. Opening Address of the conference, "Geopolitics of Energy Security: The Rise of Asia," in New Delhi, India.

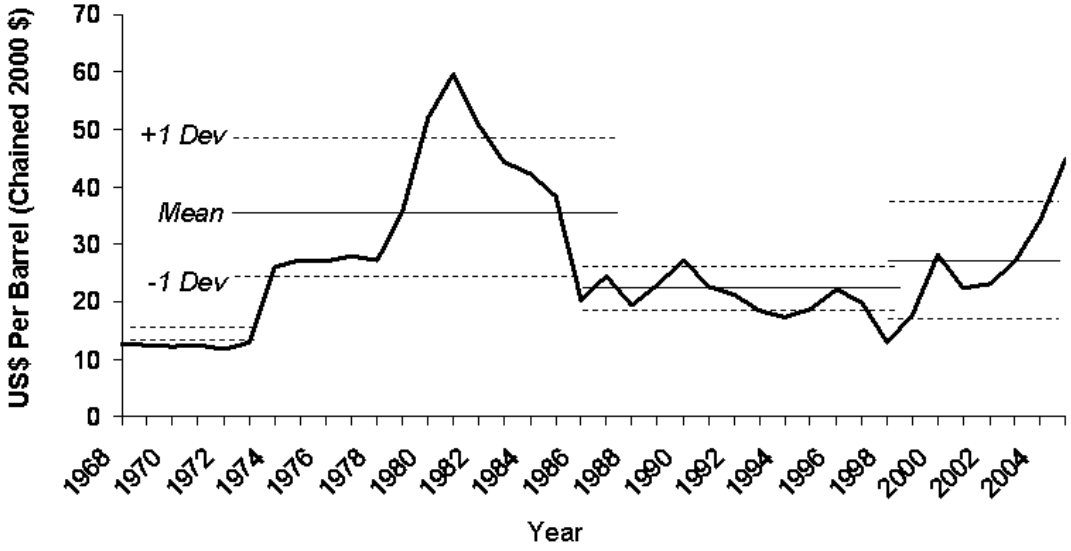
[161] EIA. (2006, June). International Energy Outlook 2006. Washington DC: U.S. Government Printing Office.

Alaska, while only 0.5 percent was imported from the Middle East. In contrast, by 2005, only 11.4 percent of the state's oil was imported from domestic sources in Alaska and 21.6 percent was imported from the Middle East. Even more alarming, more than 80 percent of the oil imported from the Middle East came from one source—Saudi Arabia.[162] Saudi Arabia is now the largest single source of Hawaii's oil, followed by China, which provides 16.4 percent of Hawaii's crude.[163] Including Australia, the Asia-Pacific region provides Hawaii with the largest total share of imported crude oil (59.6 percent). However, as Chinese demand grows, it is unlikely to remain a crude exporter, and increasingly more of Hawaii's oil will likely come from the Middle East. Thus, Hawaii will face a higher risk of supply disruptions because of its dependence on a few, unstable sources.

4.3.2 Tight Excess Production Capacity Increases Energy Price Volatility

Robust global demand coupled with supply constraints is driving increases in primary commodity prices. From 2001 to 2005, energy prices increased an average of 20.5 percent each year, driven by prices of oil and natural gas.[164] In general, commodity prices rise as excess capacity falls and vice versa. The relationship between crude oil prices and excess capacity, defined as a combination of excess production capacity, and inventories, is shown in Figure 25. When there is no excess capacity both man-made and natural disruptions have a disproportionate impact on oil prices. The relative price volatility of oil is correspondingly higher in periods of low excess capacity.

Figure 25. Price Volatility of Crude Oil Refiner Acquisition Costs 1968–2005[165]



[162] DBEDT, State of Hawaii Strategic Industries Division, and EIA.

[163] DBEDT, State of Hawaii Strategic Industries Division, and EIA.

[164] Asian Development Bank. 2006. *Asian Development Outlook 2006 Update.* Hong Kong, China: Asian Development Bank.

[165] Source: RMI Analysis conducted based on EIA's "Crude Oil Refiner Acquisition Costs" retrieved from www.eia.doe.gov/oil_gas/petroleum/info_glance/petroleum.html.

While tight capacity is an obvious influence on the oil markets, it also underlies the higher U.S. natural gas prices, which have also risen to a new higher plateau, and which will not be alleviated until significant new suppliers are brought in from the Arctic or demand is reduced. The U.S. gas market has even higher volatility than the U.S. oil market, and it has increased the volatility of U.S. electricity prices.

As a small user in the world market, Hawaii is a price-taker,[166] with little or no market power. Hawaii's dependence on fuel imports makes the state's economy profoundly vulnerable to fuel price volatility and economic turbulence. In 2005, the run up in oil prices cost the state an additional $1.23 billion dollars compared to 2002.[167] The impact on the average citizen is striking. The price rise cost each household in Hawaii nearly $2,900.[168] The effect was similar to a massive tax increase, except that the "revenues" did not remain in Hawaii as tax revenues would, but were instead exported out of state. Volatile oil prices threaten Hawaii's economic future by simultaneously lowering disposable income and reducing tourism.

4.3.3 New Demand Patterns and Players

Increasing energy demand from emerging economies will continue to shape the world's energy commodity markets. Over the last 30 years the commercial energy consumption in developing countries has grown three and a half times faster than that of developed countries. More than 70 percent of the increased energy demand through 2030 is projected to come from the developing world, particularly China and India.[169] This trend could have an effect on the availability and stability of the world's energy supply because it re-links energy demand to global GDP.

In developing Asia, China's economic growth has produced an insatiable appetite for natural resource commodities, especially energy**.** China's primary energy demand was responsible for 24 percent of the world's primary energy demand growth from 1980 through 2004.[170] In the 1990s, China moved from being a net exporter to being a net importer of energy.[171] Already, China's demand for steel and other commodities has contributed to 20-year highs in commodity prices. Increased energy demand by China underpins most forecasts of 2 to 3 percent per annum growth in energy commodity demand, and the concomitant support of energy commodity prices.

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[166] See "A Word About Terminology" on page 66.

[167] Includes only inter-island air transportation fuel costs.

[168] RMI analysis based on 2004 DBEDT data book estimation of number of households in Hawaii, refiners acquisition cost of oil increase from 2002 to 2005 according to EIA, excluding jet fuel except inter-island travel [calculations located in DBEDT_data_v16_v2.xls].

[169] International Energy Agency (IEA). (2006). World Energy Outlook 2006. Paris: OECD/IEA.

[170] Energy Information Administration (EIA). (2004). International Energy Outlook 2004. Washington DC: U.S. Government Printing Office.

[171] Energy Information Administration (EIA). (2004). International Energy Outlook 2004. Washington DC: U.S. Government Printing Office.

This has two implications for Hawaii. First, unless China, India, and the United States are able to successfully embark on energy productivity improvements, the demand for energy will continue to rise, keeping capacity tight and prices high and volatile. Second, Hawaii, like Japan, will be in direct competition with these countries for preferred access to primary fuels since Hawaii is in the same Asia-Pacific market region.

Several studies demonstrate the ability of developing countries to substantially and cost-effectively improve their energy productivity.[172] If energy productivity increases in reaction to higher oil prices, primary fuels prices could soften.

4.3.4 Decarbonization and Threat of Climate Change

Concerns over global climate change are growing, prompting many local, state, and national governments to explore or implement legislation to reduce net emissions of greenhouse gases. While the United States and Australia have yet to ratify the Kyoto Protocol, many countries, including those of the European Union and Japan, have imposed mandatory greenhouse-gas reductions. Concurrently, the world's energy systems are undergoing a steady decarbonization.[173] This trend has accelerated the push toward less carbon-intensive primary fuels, such as natural gas, particularly in electricity generation. This "dash for gas," as it's been called, for electrical generation increased natural gas demand, which has caused gas prices to rise substantially, particularly in the United States. As a result, gas is no longer the low-cost alternative for power production, and coal is beginning to make a comeback in the United States, despite its higher carbon content.

Globally, the growing scientific consensus on global warming means that energy policies will increasingly embrace less-carbon-intense technologies and fuels. Thus, gas and renewables will likely enjoy a bigger primary fuel market share due to both the fundamental economics of these fuels versus oil and coal, as well as expected policy incentives favoring these alternatives. The decarbonization trend also supports the development of biomass, biofuels, and renewable alternatives that are discussed in greater detail in Chapter 5 and Chapter 7 of this report. In Hawaii, this trend manifests itself in increasing interest in liquefied natural gas (LNG) as a possible alternative to oil for power generation and transportation, as well as policies supporting renewable power and fuels.

4.4 Conclusions

The fundamental questions in evaluating Hawaii's energy system include: how risky the energy system is, what creates those risks, who bears the risks, and how they can be mitigated. As this chapter outlined, the largest risk factors that underlie the state's energy system are the inherent price and supply risks linked to all traditional primary fuels—oil, gas, and coal. To be sure, the price and supply risks associated with traditional primary

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[172] McKinsey Global Institute. (November 2006). Productivity of Growing Energy Demand: A Microeconomic Perspective. www.mckinsey.com/mgi/publications/Global_Energy_Demand/index.asp.

[173] Decarbonisation is defined as the number of carbon molecules used to provide a unit of energy or economic product.

energy fuels are not new. Historically and by their nature, energy commodities have followed a boom and bust cycle that produces price spikes, recessions, and greater uncertainty in the marketplace. However, a number of factors reviewed in this chapter are influencing each other in such a way that the primary fuels markets are fundamentally shifting and will only grow more volatile in the near term until a new equilibrium is reached. For example, a recent surge in demand, particularly from the mainland United States, China, and India, combined with years of under-investment in supply, have made primary fuels and the markets in which they are traded more expensive and volatile. In addition, market-trading behavior has exacerbated the price volatility and reactions to sudden shifts in supply. Finally, carbon-intensive fuels, such as coal and oil, face additional price uncertainty in light of constraints posed by potential carbon regulation.

Given the price spikes in primary fuels markets, the most immediate concerns are the extent to which prices will rise and the extent to which Hawaii is exposed to these price increases. The second part of the question is fairly easy to answer. Hawaii's current energy system is overwhelmingly dependent on fossil fuel imports and is there fore heavily exposed to primary fuel price swings. The first part of the question, the extent to which prices will rise, is more difficult to answer because it depends on the market's position along the commodity cycle and the fundamental relationships between supply, demand, and price. While it is impossible to definitively forecast future prices and future market conditions, the increasing risk posed to Hawaii's energy security can be mitigated through increased diversification of its primary fuel mix and emphasis on local energy sources.

Chapter 5 Electric Power

Hawaii and its utilities face unique challenges in meeting the state's electricity needs. Since 1970, population growth, a growing economy, and increasing use of electric technologies has resulted in steady increases in total electricity consumption and peak demand in Hawaii. Though Hawaii has diversified its energy resource use since the late 1970's and non-oil production of electricity has increased, the use of new electric energy resources did not outpace demand growth over the past 15 years. As such, oil was still responsible for 80 percent of electricity generation in 2005.[174] While renewable energy represented 6 percent of electricity generation compared to the Nation's modest 2 percent, further diversification of Hawaii's electricity resource mix is necessary to reduce risks to Hawaii's environment, hedge the State's exposure to volatile primary fuels markets, keep money in-state, and provide greater levels of employment.

Fortunately, Hawaii has other energy resource alternatives available for diversifying its electricity mix. Energy efficiency, demand response, renewable energy, and distributed generation are resources that could make important contributions to increasing Hawaii's energy security. A conservative estimate of the State's maximum achievable energy-efficiency potential suggests Hawaii could save 1780 GWh of electricity, of which 60 percent could be implemented at less cost than generating it. Furthermore, the efficiency technologies than can be cost effectively implemented are readily available on the market.

Renewable energy also has the potential to make an even larger impact. Approximately 1100 MW of power could be supplied through Hawaii's indigenous renewable energy sources, such as wind, solar, and wave energy. As in the case of energy efficiency, most renewable energy technologies such as wind, biomass, and even solar are already cost-effective when Hawaii's high electricity prices are considered. Several more renewable technologies, such as ocean energy, could be cost-effective with strategically targeted tax incentives. This underscores the importance of thoughtfully designed and carefully executed state energy policies to further Hawaii's energy security goals. This chapter provides an overview of the potential for alternative energy resources in Hawaii and suggested policy initiatives to encourage their expanded implementation.

The State's primary goals are to ensure its citizens' need for secure and reliable electricity can continue to be met in a way that minimizes economic and environmental costs. These objectives require the increased use of local renewable fuels to displace oil-fired generation, a greater investment in efficiency and demand response measures, a more robust, resilient electric infrastructure, and greater use of distributed generation.

[174] State of Hawaii, DBEDT. 2006.

5.1 Improving Hawaii's Electric Utility Systems

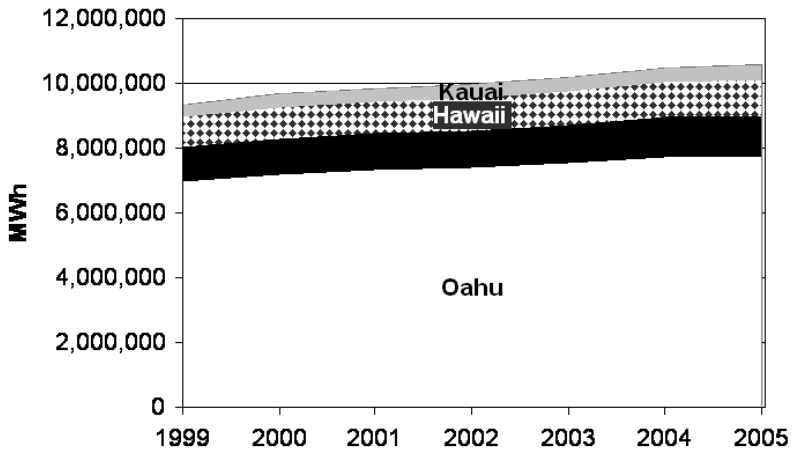
5.1.1 Electricity Consumption and Prices in Hawaii

During the past several years, electricity has become more expensive due in large part to the State's dependence on oil for the vast majority of its electricity production. Though the energy supply has diversified somewhat during since the late 1970s with the introduction of coal and renewable resources, oil was used for 80 percent of electricity generation in 2005. Furthermore, Hawaii's islands each require separate electricity grids, resulting in a need to maintain high reserve margins that also contribute to higher rates for consumers. Though renewables represented only 6 percent of electricity generation in 2005, the State's Renewable Portfolio Standard requires 20 percent of all electricity to come from renewable resources by 2020.

5.1.1.1 Electricity Sales

As Figure 26 illustrates, electricity consumption steadily increased at a compounded annual growth rate of 2.1 percent between 1999 and 2005. The fastest growth has occurred on the island of Hawaii, with consumption growing at rate of 3.3 percent per year.

Figure 26. Electric Utility Sales by County, 1999-2005[175,176,177,178,179]



[175] Hawaii, Public Utilities Commission, *Annual Report of Hawaii Electric Light Company* (Hawaii: PUC, 1999-2004) 36.

[176] Hawaii, Public Utilities Commission, *Annual Report of Kauai Island Utility Cooperative* (Hawaii: PUC, 1999-2005) 36.

[177] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999-2005) 304.

[178] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999-2005) 304.

[179] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005) 304.

Figure 27. Statewide Electricity Consumption by Sector, 2005

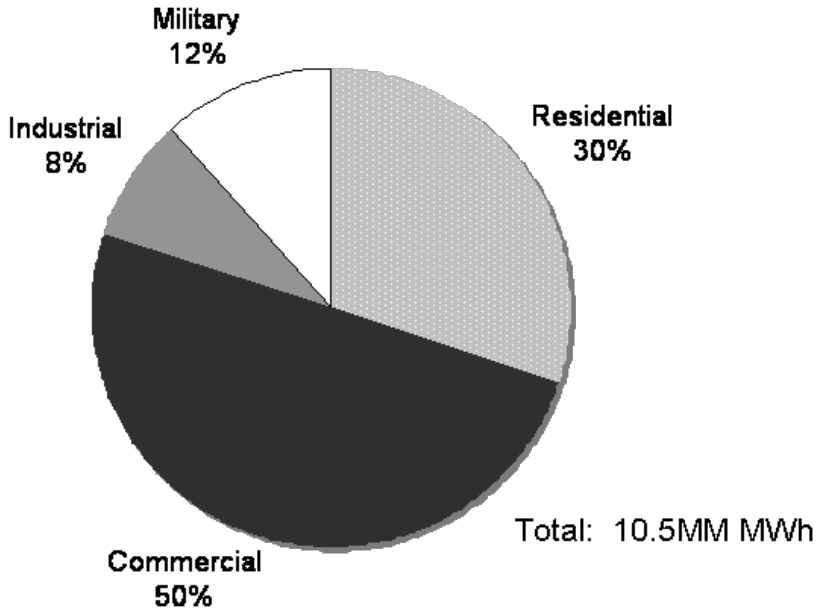
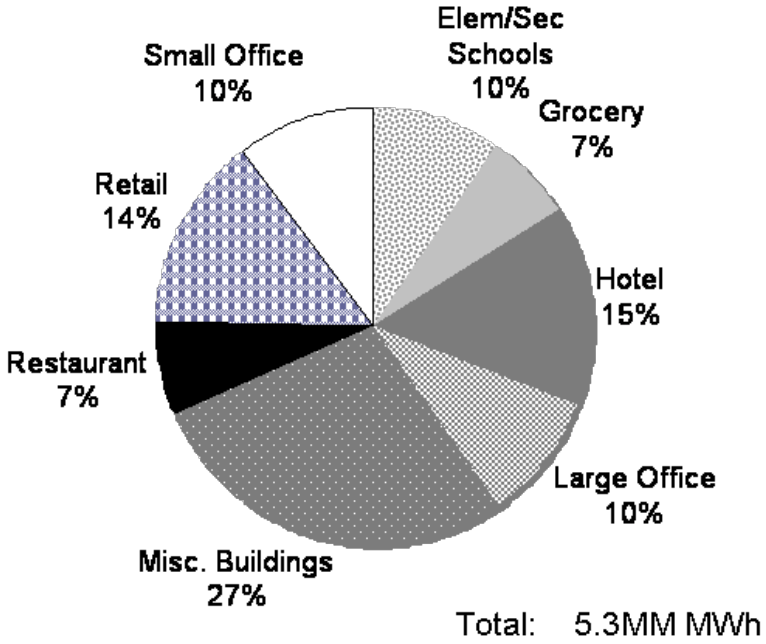


Figure 28. Commercial Electricity Consumption by Category, 2005[180,181]



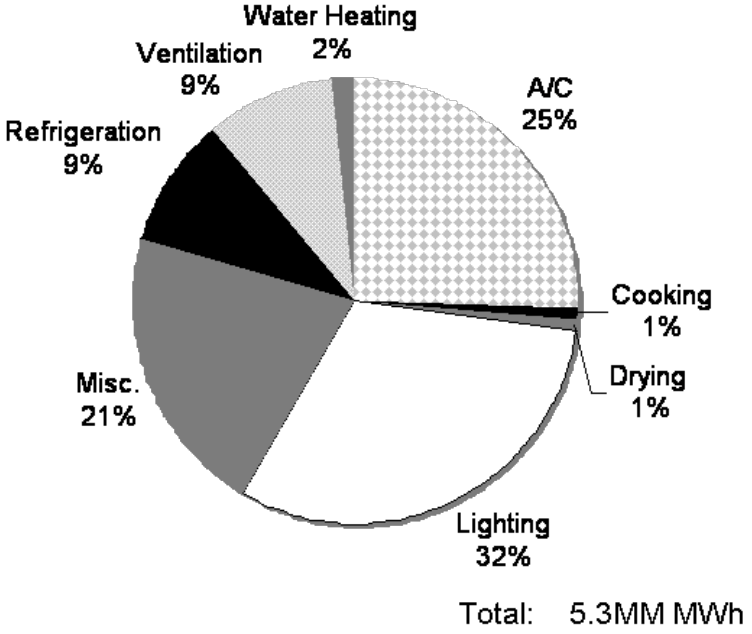
[180] KEMA, *Energy Efficiency Potential Study* (Oakland: KEMA, 2005), B-4.

[181] Global Energy Partners, *Assessment of Energy Efficiency and Demand Response Potential* (Lafayette, CA: Global Energy Partners, 2003).

A closer examination of consumption reveals that half of all electricity generated is consumed by the State's commercial sector (Figure 27). Figure 28 illustrates the share of commercial electricity consumption for the most common building categories. Of the 5.3 GWh of commercial consumption in 2005, 20 percent is consumed by offices, followed by hotels and resorts (15 percent), and retailers (14 percent).

Figure 29 describes commercial sector electricity consumption by end use. Offices, hotels, and retail establishments use most of their electricity to power lighting and air conditioning systems, and this fact is reflected in the overall end-use shares for the commercial sector. More than half of all commercial electricity powers lighting and air conditioning. Lighting, which consumes almost half of the electricity purchased by retailers, accounts for approximately one-third of total commercial electricity consumption.

Figure 29. Commercial Electricity Consumption by End Use, 2005[182,183]



Though commercial establishments use one-quarter of their electricity for air conditioning, residential buildings only require 11 percent of their electricity for this purpose. By contrast, refrigeration is the largest single end use for electricity in the residential sector, followed closely by lighting and water heating (Figure 30). However, it is likely that with continued economic growth, greater air conditioning saturation will lead to modest increases in the share of energy consumed by air conditioning. Solar thermal technologies have the potential to reduce the amount of electricity required for water heating.

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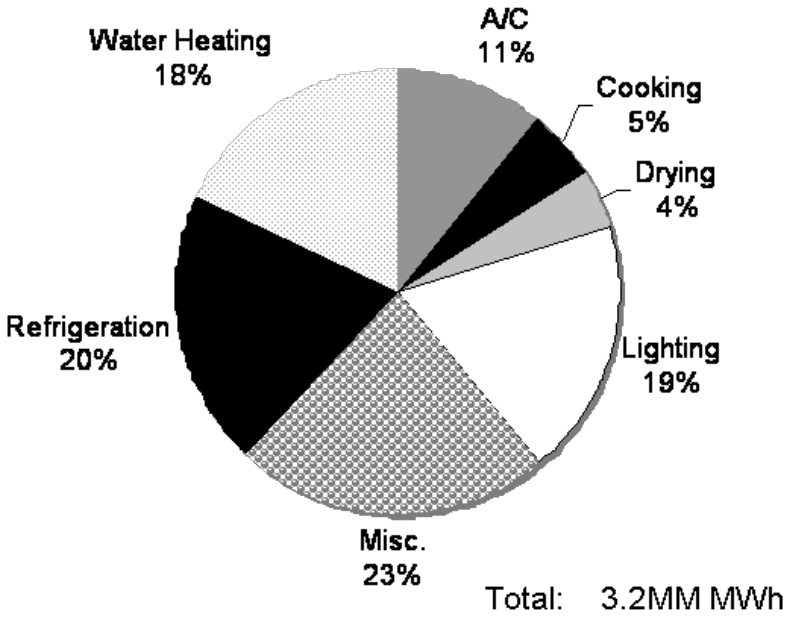
[182] KEMA, *Energy Efficiency Potential Study* (Oakland: KEMA, 2005), B-4.

[183] Global Energy Partners, *Assessment of Energy Efficiency and Demand Response Potential* (Lafayette, CA: Global Energy Partners, 2003).

Figure 30. Residential Electricity Consumption by End Use, 2005[184,185]



5.1.1.2 Hawaii's Electricity Prices

Hawaii's statewide average electricity revenues per kilowatt-hour for residential, commercial, and industrial ratepayers was 15.3 cents in 2004 and 17.8 cents in 2005, making it the highest average electricity price in the country. In contrast, the average revenue per kilowatt-hour on the mainland was 7.62 cents in 2004.[186]

Hawaii's elevated electricity rates are the result of several factors. Hawaii's electricity system consists of six physically separated systems on each of the major island-counties in the state. This isolation means there is a need to maintain excess generating capacity to ensure reliability. Greater reserve capacity requirements equate to extra costs and higher rates for cost recovery. Additionally, Hawaii's geographic isolation and its dependence on imported fuels and consumer goods translate to higher overall cost of living, which in turn affects the cost of producing electricity. While such isolation is unavoidable, Hawaii's heavy dependence on oil for electricity production further exacerbates electricity rates, which is reflected in the increasing disparity between U.S. Mainland rates and Hawaii's rates.

Table 11 provides a closer look at Hawaii's electricity prices for each of its counties. Oahu County consistently maintains the lowest electricity prices due to the relative size

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[184] KEMA, *Energy Efficiency Potential Study* (Oakland: KEMA, 2005), B-2.

[185] Global Energy Partners, *Assessment of Energy Efficiency and Demand Response Potential* (Lafayette, CA: Global Energy Partners, 2003).

[186] US Energy Information Administration, Electric Power Annual 2005. <http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html>, Accessed September 22, 2006.

of its population and the central role it plays as the state's hub for importing and refining oil, the primary source of fuel for the state's electricity. Kauai County consistently ranks among the highest in terms of electricity prices because of its remote location at the end of the island chain. In addition, Kauai has endured higher fixed costs due to system repairs, which were needed after the system was damaged during Hurricane Iniki in 1992.[187]

Table 11. Electricity Prices by County (nominal cents/ KWh), 1996-2005[188,189,190,191,192]

Year	Oahu	Maui	Hawaii	Kauai
1996	10.8	14.1	17.4	18.8
1997	11.1	14.7	17.9	21.3
1998	10.3	13.3	17.0	18.7
1999	10.4	14.7	17.2	19.7
2000	12.2	17.4	20.1	22.5
2001	12.1	18.0	20.1	22.8
2002	11.7	16.5	19.3	21.9
2003	12.8	17.7	20.4	22.6
2004	13.6	20.1	22.3	26.1
2005	15.6	24.1	26.1	29.3

From 1996 to 2005, Hawaii's electricity rates increased from 79 to 113 percent. While this absolute increase over the past decade is notable, the timing and magnitude of the price fluctuations are even more revealing when compared to crude oil prices during the same period. As Figure 31 shows, the electricity prices demanded by a heavily petroleum-dependent electric system not surprisingly fluctuated closely along with oil prices.

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[187] Gilman, Gail S. and Steven P. Golden, 1999. Letter, Re: Draft Hawaii Energy Strategy 2000, September 14, 1999. (Hawaii Statewide Manager, Regulatory Affairs and Manager, Government Affairs, respectively).

[188] Hawaii, Public Utilities Commission, *Annual Report of Hawaii Electric Light Company* (Hawaii: PUC, 1999-2004).

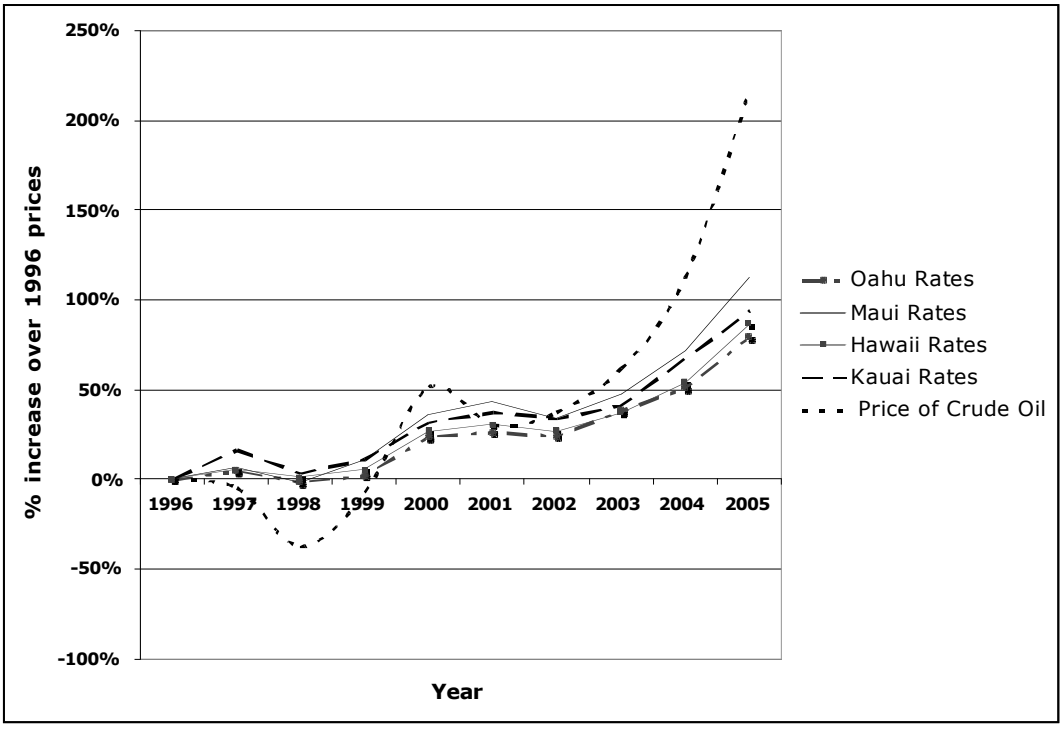
[189] Hawaii, Public Utilities Commission, *Annual Report of Kauai Island Utility Cooperative* (Hawaii: PUC, 1999-2005)

[190] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999-2005).

[191] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999-2005).

[192] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

Figure 31. Percentage Growth in Average Electricity Rates, 1996-2005[193,194,195,196,197]



The impact of volatile fuel oil costs on the State's electric rates and ratepayers is especially pronounced due to the disproportionate cost-sharing structure imbedded in Hawaii's rates. Under current law, Hawaii's utilities pass fuel costs (along with any changes in the costs over time) directly through to ratepayers through a fuel price adjustment mechanism known as the Energy Cost Adjustment Charge (ECAC). In 2004, thirty-three states had ECAC policies in effect; however, Hawaii is the only ECAC state whose electric utility system relies on oil for more than 80 percent of its power generation. The state with the next highest dependency on oil is Florida (17 percent), while the majority of other ECAC states use oil for less than 1 percent of their electricity needs.

5.1.2 Electric Energy Efficiency

Reducing energy consumption by using high-efficiency technologies is one of the best ways to meet the State's energy goals. In addition to being the most cost-effective energy resource, investments in efficiency provide greater planning flexibility and reduce

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[193] Hawaii, Public Utilities Commission, *Annual Report of Hawaii Electric Light Company* (Hawaii: PUC, 1999-2004).

[194] Hawaii, Public Utilities Commission, *Annual Report of Kauai Island Utility Cooperative* (Hawaii: PUC, 1999-2005)

[195] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999-2005).

[196] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999-2005).

[197] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

pressure on utilities to build additional electric generating capacity, which can be costly and financially risky. Efficiency projects can be implemented relatively quickly (with the exception of major new construction and renovation projects, typically one year or less) and therefore begin to accrue benefits almost immediately. Furthermore, efficiency is like renewable resources in that these measures can hedge against fuel price volatility. This is particularly significant for Hawaii, whose electricity rates are the highest in the nation due to the State's dependence on oil-fired power and the costs associated with delivering fuel to the outer islands.

5.1.2.1 Status

Hawaii's utilities have captured over 30 MW (>135,000 MWh) of electrical efficiency in the last decade via demand-side management programs. Both the Hawaii Public Utilities Commission and DBEDT have endorsed the recommendations described in the National Action Plan for Energy Efficiency (NAPEE), developed in conjunction with more than 50 leading organizations, including the U.S. Environmental Protection Agency. The Plan's primary goal, published in July 2006, is to create a sustainable, aggressive national commitment to energy efficiency by gas and electric utilities, utility regulators, and partner organizations. The Hawaii PUC is currently examining, as a high priority matter, energy efficiency issues relevant to the State of Hawaii within its ongoing Energy Efficiency Docket. This is an effort to increase and enhance the effectiveness of energy-efficiency programs in Hawaii. DBEDT is promising to support NAPEE commitments by implementing Governor Lingle's *Energy for Tomorrow* energy policy strategy.

Table 12. Achievable Energy Savings Potential for HECO, MECO, HELCO, and KIUC[198,199]

Energy (GWh)	2010	2015	2020	2025
HECO	437	948	1255	1327
MECO	65	149	213	245
HELCO	61	134	184	208
KIUC	25	35	45	52

Table 13. Achievable Demand Savings Potential for HECO, MECO, HELCO, and KIUC

Demand (MW)	2010	2015	2020	2025
HECO	80	167	220	235
MECO	12	26	38	43
HELCO	11	24	33	37
KIUC	4	6	7	8

[198] Global Energy Partners. (2003). *Assessment of Energy Efficiency and Demand Response Potential.* Lafayette, CA: Global Energy Partners.

[199] KEMA. (2005). *Energy Efficiency Potential Study.* Oakland: KEMA.

There is significant potential for increased efficiency in Hawaii, much of which can be achieved at a lower cost per kWh than building new generation capacity. According to a Global Energy Partners (GEP) study for Hawaiian Electric Industries,[200] the total achievable potential in Hawaii between HECO, MECO, and HELCO combined, totals approximately 1,780 GWh and 315 MW of energy and demand reduction by 2025.[201] These savings represent approximately 13 percent of projected baseline energy consumption (13.9 GWh) and demand (2400 MW) in 2025. KEMA's recent study for KIUC found that an additional 52 GWh per year and 8 MW (about 6 percent) could be saved on Kauai. These savings are summarized in Table 12 and Table 13.

Figure 32. Energy-Efficiency Supply Curve: Potential in 2015 for HECO, MECO, and HELCO[202]

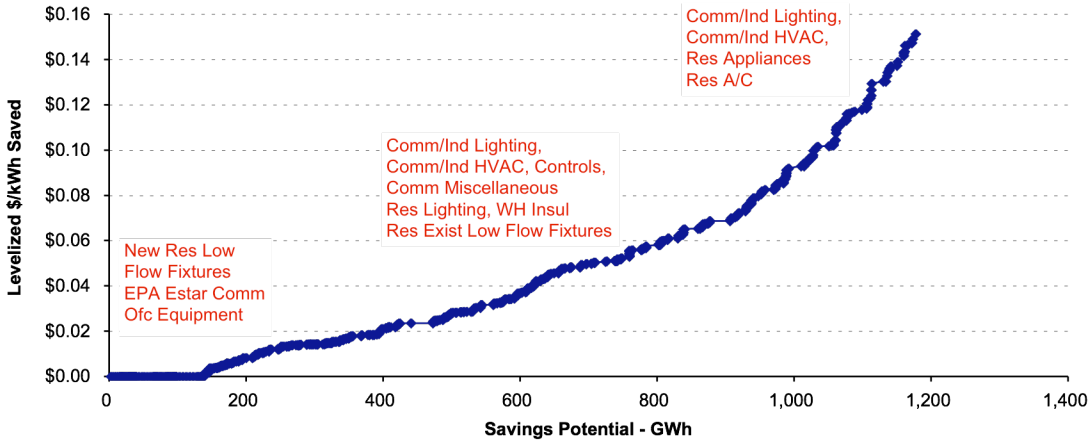

Figure 32 illustrates, more than two-thirds of the achievable potential for the HECO companies is cheaper than utility avoided energy costs. Utilities paid an average of 16 cents per kWh across the state to generate electricity in 2005.[203] As such, almost 70 percent of the estimated savings potential can be achieved a decade earlier in 2015 for less than it costs to produce electricity today. Furthermore, as the labels in Figure 32 shows, the efficiency measures that need to be implemented are readily available today on the market. If electricity prices continue to rise over time, more of the total efficiency potential will be cost effectively achievable. Additionally, the efficiency potential is

[200] Global Energy Partners. (2003). *Assessment of Energy Efficiency and Demand Response Potential.* Lafayette, CA: Global Energy Partners.

[201] Economic potential is significantly larger, at 3,121 GWh per year of energy reduction and 550 MW of demand reduction by 2025.

[202] Rocky Mountain Institute. (2004, November 24). *The Efficiency Prize.* Hawaii Energy Policy Forum. www.hawaiienergypolicy.hawaii.edu/papers/datta.pdf.

[203] Energy Information Administration (EIA). (2006). *Electric Sales, Revenue, and Average Price 2005.* Washington DC: EIA.

sustained, and possibly even grow, as new and even more efficient technologies enter the marketplace.

A note on the GEP efficiency study is that the estimated potential is conservative, for two reasons. First, he efficiency measures in the GEP report do not include other promising technologies such as commercial seawater air conditioning (SWAC). SWAC is a variation on commercial district cooling in which cold seawater is distributed around a cluster of buildings. Four projects are currently under development, with the first planned for completion in downtown Honolulu in 2009. Each project provides approximately 25,000 tons[204] of cooling and displaces 70–90 GWh of electric cooling on Oahu. If just two of the four projects are implemented, approximately 156 GWh would be saved annually by 2025 and cumulative energy savings are estimated to be 2400 GWh from 2006–2025.[205]

Second, the GEP efficiency study is based on the implementation of individual measures within a facility. This approach tends to underestimate total potential because it ignores any positive interactions between multiple measures implemented simultaneously as a "whole system," which can achieve efficiency reductions greater than the sum of a number of measures implemented individually in isolation.

In addition to the potential for greater electric reductions, the "whole-system" approach, when applied to new construction or major renovation, has several advantages over the single-measure, incremental approach. While the *marginal cost* of the last efficiency measure may exceed the utility's cost-effectiveness test, the *average cost* of the efficiency measures in combination may be lower due to system design synergies that reduce the overall capital cost. A whole-system approach thus increases the cost-effectiveness of the overall project in comparison to the cost-benefit of each measure as individual projects. The enhancing effect can be particularly pronounced for new construction, where integrated design can produce energy cost savings of 20–50 percent with an average cost premium of 2–7 percent over an average-efficiency building.[206]

For existing facilities, Hawaii utilities should consider delivering efficiency incentives on a "whole-building" basis, and examine efficiency opportunities (such as lighting, appliances, building envelope, water heating, and passive and mechanical space cooling) simultaneously in the residential sector. Commercial buildings include additional significant end uses such as ventilation, office equipment (to minimize internal heat gain), and process heating.

5.1.2.2 Challenges

Though Hawaii has significant potential to increase the efficiency of the electrical system and further incorporate renewable resources, the State has a role to play in ensuring this

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[204] 1 ton cooling = 12,000 btu/lb

[205] State of Hawaii, DBEDT. Energy modeling analysis 2006.

[206] 2003. Do Green Buildings Cost More to Build*? Building Design and Construction*. Vol. 44. no. 11. Journal supplement: White Paper on Sustainability. November. pp. 29–33.

potential is achieved. In the absence of appropriate regulations and legislation, the required investments may occur too slowly, if at all. For instance, investors may be hesitant to invest in alternative fuels given the high degree of uncertainty concerning future oil prices. The state's utilities are not properly encouraged to reduce demand, as their revenues are currently coupled to kilowatt-hours of energy sold. Furthermore, the intermittent nature of some renewables poses new challenges to incorporating this generation into the electricity transmission system.

The state's utilities and end users of electricity have implemented a number of programs to increase end-use efficiency. Nonetheless, if Hawaii is to achieve its efficiency potential, several critical barriers must be overcome. On the consumer side, information and financial constraints continue to limit investment in efficient technologies.

A wide variety of factors prevent consumers from investing in more efficient end-use technologies. Among these are perceptions of risks and uncertainties. Consumers often heavily discount future energy costs and the benefits of alternative investments. High implicit discount rates lead to unrealistic requirements for how quickly an investment must pay for itself. Residential customers will typically only invest in a product if the payback period is two years or less, and commercial customers three years or less.[207] At the same time, they are averse to adopting unfamiliar technology with uncertain performance. These factors further reduce a product's value and/or raise the perceived cost of a purchase in the eyes of a consumer.

Consumers often fail to invest in efficient technologies due to a lack of accurate or clear information. On the one hand, they may be unaware of the latest practices and technologies available to conserve energy (they may also be operating their electrical equipment incorrectly or wastefully). On the other hand, retailers and vendors, to whom consumers turn to for primary sources of information, do not or cannot provide accurate information concerning the technical features and economic benefits of efficient products.

However, even if consumers are aware that a certain measure or technology has a short payback time, they may not be able to pay the up-front capital costs. This particularly affects low-income customers, who are typically reluctant to incur additional debt in order to fund such purchases. Programs to improve the flow of information and provide targeted loans could help to remove some of these barriers. Nonetheless, one must recognize that consumers often act as problem avoiders, disinclined to take action unless they perceive a critical need, and then only doing what is necessary to make the need go away. It is therefore incumbent upon the State's leadership to impress upon the public the important security and environmental benefits of taking action to improve efficiency, and what those specific actions may be.

In addition to these consumer-related barriers, the current regulatory structure does not provide proper incentives for utilities to reduce demand. For example, electricity

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[207] Rocky Mountain Institute. (2004, February). *Hawaii's $3 Billion Efficiency Prize: Transportation and Electrical Efficiency Potential in the State of Hawaii Using Existing Technologies.* Hawaii Energy Policy Forum.

companies are legally defined as being responsible for supplying electricity only, and are required to make investments only in the power sector. This limits consideration of fuel substitution alternatives. Furthermore, legal accounting procedures impede utilities from considering investments in their customers' facilities as part of the utility investment, and therefore such investments cannot, for example, be taken into consideration when rates are calculated.

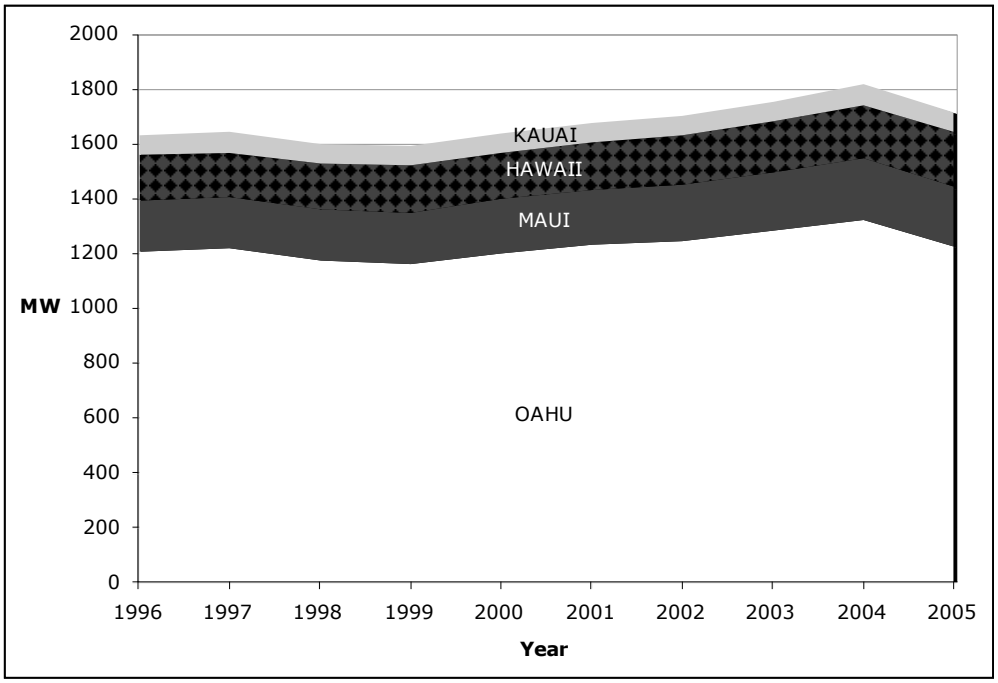
The current rate making process actually promotes greater electricity sales, which discourages conservation and demand-side management. For example, electricity rates are designed to cover average costs. As a result, very few consumers pay higher rates for on-peak service, even though the cost to the utility of providing this energy is substantially higher than providing non-peak power. Furthermore, the process of determining appropriate rates encourages utilities to sell more power, and penalizes them for selling less. This standard process of rate-setting ties revenues directly to electricity sales. Thus, if utilities sell less than they have forecasted, they will lose money. Likewise, extra sales boost the utility's profitability.

5.1.3 Demand Response

Demand response (DR) is another strategy that utilities and their customers can employ to shave peak demand. In addition to deferring new capacity construction, this strategy can also help maintain proper system voltage, and has the potential serve as a useful tool to enhance a utility's ability to incorporate intermittent renewables. Demand response, also known as load management, focuses on reducing electricity demand temporarily in response to a price signal or other type of incentive, particularly during the system's peak periods. End-user customers receive compensation (either through utility incentives or rate design) to reduce non-essential electricity use or to shift electric load to a different time, without necessarily reducing net usage.

When the utility offers customers payments for reduction of demand during specified periods, the program is called *load response*. *Price response* is another method, whereby customers voluntarily reduce their demand in response to forward market prices. Customers reduce load during those periods when the cost to reduce load is less than the cost to buy the energy. Load response and price response are designed to address emergencies and economic conditions that warrant reduced demand. *Reliability DR* is a form of load response used for system contingencies, as when customers reduce load to relieve generation and/or transmission or distribution capacity constraints. Economic programs offer customers incentives to reduce loads during non-emergency periods when utility cost of service exceeds some specified limit.

Figure 33. Peak Electricity Demand, 1996-2005[208,209,210,211,212]



5.1.3.1 Status

After a few years of relatively little growth—and even decline—in net peak demand in the late 1990s, Hawaii's peak demand followed the state's economic recovery and increased steadily after 1999 (see Figure 33). During the period 1999 to 2004, Hawaii's net peak demand grew from 1592 MW to 1821 MW, a 14 percent increase. In fact, the year 2004 was the highest net peak demand on record for each of the four utilities in Hawaii. In 2005, Hawaii's overall demand declined below 2003 levels largely due to Oahu's precipitous drop in peak demand of almost 100 MW or 7 percent. The other islands did not experience dramatic declines, and their electricity demands remained relatively steady. While Maui and Kauai's demand declined 2 percent and 1 percent, respectively, the Big Island's peak demand actually increased by 1 percent. Thus, despite the fall in peak demand in 2005, the overall trend is steady growth.

DR has several benefits. In the case of economic events, it is cheaper for utilities to buy DR from end users than to ramp up inefficient and costly peak reserves. Reliability-

[208] Hawaii, Public Utilities Commission, Annual Report of Hawaii Electric Light company (Hawaii: PUC, 1999-2004).

[209] Hawaii, Public Utilities Commission, Annual Report of Kauai Electric (Hawaii: PUC, 1999-2002); Annual Report of Kauai Island Utility Cooperative (Hawaii: PUC, 2002-2005).

[210] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999-2005).

[211] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999-2005).

[212] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

triggered DR can defer or eliminate the need for generation capacity additions and transmission and distribution upgrades. This on-call demand reduction is particularly beneficial to Hawaii, where the isolated electricity systems require high reserve margins. Furthermore, just as DR has the ability to respond to fluctuations in demand, it also has the potential to respond to the fluctuations in supply caused by intermittent renewables. Though further exploration is required, DR's potential as a "supply-side" resource could enhance the ability of Hawaii's utilities to incorporate intermittent renewables such as wind.

While utilities commonly operate energy-efficiency and demand response programs independently of one another, these two types of demand-side resources are not mutually exclusive. Efficiency and demand response fulfill different but complementary goals for utilities trying to serve customers cost effectively, while complying with environmental protection regulations. Demand response, by lowering peak power requirements and relieving transmission and distribution congestion, achieves temporary, short-term benefits. Efficiency, on the other hand, provides long-term energy reductions, which reduce harmful emissions and lower consumers' bills.

Utilities should couple demand response with efficiency programs as part of a demand-side resource package to leverage the different strengths of each for an optimum resource plan. Implementing a coordinated efficiency and DR program portfolio can help flatten the utility's system load curve, lower prices for power and gas considerably, and defer new plant construction with subsequent benefits to both the utility and its customers. From the customers' perspective, combining energy efficiency and DR may be necessary to create an adequate value package (e.g., efficient technology may be an effective means to mitigate customer comfort concerns about participating in DR efforts).

5.1.3.2 Challenges

Numerous concerns and uncertainties deter customers from participating in DR programs, but none is insurmountable. One of the greatest barriers is a lack of information. Many customers lack an understanding of how much and what types of loads are available for reduction during an event. They also may not know how to reduce loads when called upon to do so. Utilities or DR program sponsors must therefore assist customers in understanding their facility's loads, and provide financial and technical assistance to help customers achieve their peak load reduction potential.

For customers more familiar with their potential to reduce electricity demand, additional concerns may prevent them from participating. For instance, commercial customers may be concerned about the comfort of clients or tenants if air conditioning is curtailed to improve reliability. This is particularly relevant in Hawaii, given the multitude of hotels and resorts supporting the state's tourism-based economy.

An effective DR strategy for such establishments would target spaces that are not in use. Unoccupied hotel rooms and ancillary areas are prime candidates for DR, especially if their heating and cooling is controllable through a central energy management system (EMS). Conference rooms, convention space, and theaters are also good targets for DR.

Miscellaneous loads in common areas (such as elevators or escalators, fountains, outdoor signage, exhibits lighting, pool lighting, and pumps) can also be turned off. Two notable case studies have demonstrated that DR programs can be implemented successfully without sacrificing comfort. The Marriott Marquis in New York City leveraged its existing EMS systems to participate in a pilot real-time pricing program with Consolidated Edison and the Electric Power Research Institute. By linking its system to real-time hourly pricing information from the utility, the hotel was able to reduce peak load by 20 percent.[213] The Doubletree hotel in Sacramento, through its participation in California's Enhanced Automation campaign, installed new automated load controls to reduce its overall energy use by 11 percent while simultaneously participating in the Sacramento Municipal Utility District (SMUD) voluntary load curtailment program.[214]

The level of effort required to reduce load can also serve as a significant barrier to program participation. Many customers either lack EMS or other automated control technologies, or they lack sufficient training in their use. As a result, they often end up relying on manual strategies to reduce loads and therefore fail to fully achieve their DR potential. Manual load reduction strategies require customers to be on site at the time of a load reduction event. Such strategies can result in high transaction costs. Properly employed control technologies, on the other hand, can relieve the customer of this burden and provide more consistent load reduction. Policies should therefore be put in place to encourage investment in facilitating technology.

Additionally, the level of effort required to both administer and participate in a price response program using dynamic electricity rates can be much greater than for a load response program. The evidence is inconclusive as to whether dynamic pricing produces greater DR than load response facilitated by automated control technologies. Utilities need to invest in additional metering technology and acquire more sophisticated advanced notification and performance verification methods with price response. At the same time, few residential and commercial customers are willing to constantly monitor changing prices to reduce non-critical loads during only a handful of times per year.

5.1.4 Distributed Generation: Combined Heat and Power, Combined Cooling, Heating and Power

Distributed generation (DG) presents an attractive alternative to large, centralized electricity generation stations. DG is broadly defined as electricity produced on-site or close to a load center that is also interconnected with the electricity grid. DG technology includes engines and mini-turbines that run on diesel, natural gas, or renewable electric energy technologies such as solar photovoltaics (PV), and mini-turbines run on biogas from livestock and wastewater facilities.

Cogeneration, or combined heat and power (CHP), is the most efficient and cost effective form of DG, as it captures the waste heat from the DG exhaust stream for use in

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[213] Hirst, E., & Kirby, B. (2001, January). *Retail Load Participation in Competitive Wholesale Electricity Markets.* Prepared for Edison Electric Institute.

[214] California Energy Commission (CEC). (2004). *Final Report, Enhanced Automation Educational Campaign.*

commercial and industrial process heating. This also saves customers money and obviates the need for large customers to purchase additional fuel to meet process heat needs separately. CHP thus improves the economics of onsite DG and, if the project can displace enough high heating and high electricity costs, can make the project cost-effective.

With the exception of industrial facilities and certain types of commercial facilities, energy requirements for space and process heat is small relative to space cooling needs, particularly on Hawaii. Commercial buildings in particular tend to have space cooling needs year-round. Combined cooling, heating, and power (CCHP) uses waste heat from the electric generator to power absorption chilling for space cooling when heating energy needs are low. This additional flexibility of CCHP can prove economical in cases where heating needs are insignificant or intermittent.

5.1.4.1 Status

A survey conducted in 2004 estimates the total DG capacity in the state at 146 MW (Table 14). This existing capacity is estimated to be approximately 17 percent of DG's total technical potential of 824 MW.[215] Most on-site generation on Hawaii is currently limited to emergency backup. Emergency backup generators are installed in large commercial facilities and campuses, including resorts, offices, hospitals, military installations, universities, or industrial facilities, for use in meeting critical loads during power outages. Backup generators are limited in their annual hours of operation due to emissions concerns. The amount of existing CHP or CCHP in the State is unknown. On the other hand, the amount of biogas potential from agricultural livestock, landfills, and wastewater facilities is estimated to exceed 50 MW.

DG provides a number of benefits to the electricity system, including increasing the reliability of the grid. Like electric energy efficiency, it can also help defer the construction of large centralized generation plants. Central generation plants, as well as transmission and distribution (T&D) capacity, are "lumpy" investments, as they are built in large increments and can take years to complete. Often, a large unit is built to meet demand that is expected to exceed existing capacity by only a small amount. This leads to excess generation and distribution capacity that remains idle but still incurs costs. Smaller DG units can reduce the tendency to overbuild in order to meet expected but uncertain demand growth. The short construction lead-time of smaller DG units is thus an advantage in meeting incremental demand growth more precisely. In addition, smaller generation units can usually be ramped up faster than large central stations if new customers suddenly increase demand.[216]

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[215] Global Energy Partners, LLC. (2004 July 29). *Creating Distributed Energy Opportunities for Hawaii*. Prepared for Energy, Resource and Technology Division, State of Hawaii Department of Business, Economic Development and Tourism (DBEDT).

[216] On Hawaii, individual loads are smaller and average size of power plants are also smaller. "Utility-scale" plants on Hawaii in the range of 25-50MW is the equivalent of distributed-scale power plants on the Mainland. Thus distributed-scale generation projects on Hawaii are considered to be plants in the range of 25 MW or less.

Table 14. Existing DG Capacity (kW) by County[217]

Business Segment	Hawaii	Honolulu	Kauai	Maui	Total
Airports	0	0	0	0	0
Colleges and universities	0	0	0	0	0
Extended service restaurants	0	0	0	0	0
Food manufacturing	600	0	800	6,550	7,950
Hospitals	820	0	0	0	820
Hotels and resorts	3,428	0	3,225	0	6,653
K–12 education	2	18	0	2	22
Large retail stores	0	0	0	30	30
Military installation	0	21,000	4,390	0	25,390
Multi-unit housing	0	0	0	0	0
Municipal solid waste landfills	0	65	434	0	499
Nonmetallic mineral mining/quarrying	10,341	1,740	3,987	6,958	23,026
Office buildings	5	50	0	8	63
Petroleum products manufacturing	0	29,000	0	0	29,000
Wastewater treatment facilities	5,020	28,622	3,455	9,493	46,590
Water supply facilities	100	5,836	50	N.A.	5,986
Total	20,316	86,331	16,341	23,041	146,029

One advantage of DG that is particularly valuable in Hawaii is the opportunity to reduce reserve capacity. DG accomplishes this in two ways. First, distributed resources effectively reduce demand for power at the customer site, and thus eliminate the need to build additional capacity to serve as reserve margin for this demand. Second, the reserves that are required to cover the potential loss of the largest generation unit are greater in isolated systems than in interconnected ones due to the higher need for redundancy within isolated systems. It follows then that the amount of capacity needed to manage system reliability decreases with relative unit size. Generally, a system with a large number of small plants is more reliable than a system with a small number of large plants.[218]

[217] Global Energy Partners, LLC. (2004 July 29). *Creating Distributed Energy Opportunities for Hawaii*. Prepared for Energy, Resource and Technology Division, State of Hawaii Department of Business, Economic Development and Tourism (DBEDT).

[218] Rocky Mountain Institute. (2005, April). Distributed Generation Workshop: Valuation of Distribute Resources Contribution to Reliability. Presented to Hawaiian Electric Company.

DG can provide additional economic benefits to utilities and consumers. Siting generation closer to end users reduces the losses that would ordinarily be incurred when transmitting electricity from a remote central source. Furthermore, the potential for DG to be operated in "island" mode independently of the grid reduces a customer's vulnerability to faults in the electricity distribution system that can be caused by trees, animals, cars, etc., leading to improved reliability. Power outages can be particularly costly to Hawaii's businesses, especially those with data centers and other high-performance equipment that relies upon high-quality and uninterrupted power.

Because of all of these advantages, DG also contributes to mitigating the impacts of energy emergencies and disasters such as earthquakes and hurricanes. It gives critical infrastructure such as police and fire stations, and hospitals the opportunity to remain operational during times of crises and enables the grid and other essential services to get back on line faster. Additional information on energy emergency preparedness in Hawaii is provided in Chapter 8 .

5.1.4.2 Challenges

The PUC has a role to play in ensuring a climate that encourages the expansion of DG. More broadly, the PUC has historically played a conservative role with regard to sorting out the many issues related to DG. State utility commissions in Indiana, Texas, and Minnesota have taken a more active role, bringing together stakeholders for workshops and summits that address issues pertaining to interconnection, standby charges, and net metering.

The barriers to expansion of DG span a range of issues, including interconnection standards and permitting, utility tariffs, and current business models. Many of these challenges were highlighted in a Global Energy Partners study conducted for DBEDT in 2003.[219] Responding to these barriers will require the efforts of legislators, regulators, utilities, and consumers.

Utilities are rightfully concerned with maintaining the safety and reliability of the grid. However, these concerns can lead to inconsistent and unpredictable administrative and technical requirements imposed upon potential DG project owners. Better communication and more standardized interconnection requirements could facilitate greater adoption of DG.

The current utility tariff and fee structures can also serve as a barrier to DG investments. For example, in May 1999, the Public Utility Commission approved HECO's standard form contract for customer retention, which allows HECO to provide a rate option for customers who would otherwise reduce their energy use from HECO's system by using energy from a nonutility generator. Based on HECO's current rates, the standard form contract provides a 2.77 percent and an 11.27 percent discount on base energy rates for

[219] Global Energy Partners, LLC. (2004 July 29). *Creating Distributed Energy Opportunities for Hawaii*. Prepared for Energy, Resource and Technology Division, State of Hawaii Department of Business, Economic Development and Tourism (DBEDT).

qualifying "Large Power" and "General Service Demand" customers, respectively. In 2000, the Public Utility Commission approved a similar tariff for HELCO. These rates discourage investments by reducing the financial advantage of such systems. Customers may choose the smaller but certain financial benefit from taking no action and incurring no risk over the financing, construction, ownership, and operation of a project that offers a greater but somewhat less certain financial gain.

Standby charges (the option to purchase utility-generated power to supplement or support DG electricity) can also deter such investments. Customers with DG systems in Hawaii must still access the grid when their systems go offline due to maintenance or unplanned outages. Some complain that the standby charges they incur are too high and do not take into account the likelihood that a particular customer will require standby power during peak versus other hours.

All utilities in Hawaii submitted draft standby charges to the Hawaii Public Utility Commission in 2006 for Docket Number 03-0371, Instituting a Proceeding to Investigate Distributed Generation in Hawaii. The final decision and order (D&O) was issued in late 2006. However, the standby tariffs have caused a lot of concern so two new dockets were opened in early 2007 (06-0497 - HECO and 06-0498 - KIUC).

Additionally, customers may not be permitted to realize the full benefits of net metering, whereby excess electricity generated on site can be sold back to the utility. Net metering on Hawaii places a ceiling on the total amount of capacity that is eligible. This ceiling, which is 0.5 percent of each utility's peak demand, imposes a cap of approximately 10 MW for the state, again placing limits on the financial incentives to invest in DG. Finally, the utility rate structure rewards increased electricity consumption, as the price per kilowatt-hour increases as monthly consumption increases. As a result, the first kilowatt-hours avoided are the lowest priced.[220]

The permitting process, which can be costly, complex, and time-consuming, can also deter DG investments. Given that this process typically does not correspond to the size or complexity of the project, smaller DG systems are disproportionately affected. Though local concerns about emissions, noise, and aesthetics should be properly investigated, current codes are typically interpreted on a project-by-project basis, which can result in costly delays. A more standardized process for smaller, less complex DG systems therefore seems warranted, as it increases the likelihood that such projects will be economically feasible. Furthermore, increased use of DG will defer or prevent the even more complicated prospect of siting large central power plants, whose impact on local air quality, noise, and aesthetics would be of much greater concern to Hawaii's citizens than smaller DG units.

Utilities, by historically prioritizing efforts to minimize generation costs and not focusing as heavily on delivery costs, do not fully account for the benefits of siting DG closer to load centers. Customers have also failed to recognize the full benefits of DG; they have

[220] Global Energy Partners. (2003). *Creating Distributed Energy Opportunities for Hawaii.* Lafayette, CA: Global Energy Partners.

typically focused on reduced electricity costs and have ignored benefits such as increased reliability and power quality. They also tend to focus on the initial capital costs, rather than on life-cycle or long-term savings. Furthermore, commercial customers are primarily concerned with serving their customers and prioritize their time and investments accordingly. Many simply do not have time to think about energy issues.

Finally DG that is installed onsite must be extremely clean and quiet. Currently, onsite generation takes the form of backup generation that is used only few times a year. For DG to be operated more often during the year—for example, in combined heat and power (CHP) applications—stricter controls on emissions and noise are needed. On the Mainland, combined heat and power applications consume primarily natural gas, which is a relatively clean-burning fuel. Natural gas fuel is limited in Hawaii and is derived from liquid petroleum, while alternative technologies such as stationary fuel cells are not yet widely available or cost-effective. These issues thus retard the adoption of onsite DG in Hawaii.

5.1.5 Central (Utility Scale) Renewable Electricity

Hawaii's current use of renewable energy provides an important diversification of the state's energy supply, helps keep energy expenditures in the state, provides local jobs, and reduces environmental impact. Furthermore, renewable energy can be less costly than fossil-fuel resources as shown by the successful negotiation of power purchase agreements at or below utility avoided cost for municipal solid waste, geothermal, landfill methane, hydroelectric, and wind projects since 1989.

Hawaii's local sources of renewable energy complement efficiency as an important hedge against erratic world oil prices. In order to insulate the state's economy from additional oil price shocks and improve energy security, it will be important to continue to diversify fuel supply. Furthermore, the potential impacts of climate change necessitate additional aggressive investment in these renewable sources of energy, which can help stabilize greenhouse gas emissions. Bioenergy is also attractive, as it can be substituted for oil products such as diesel fuel and naphtha in existing generation plants. Though the process of burning bagasse from sugar cane produces carbon dioxide, growing sugar cane takes carbon dioxide out of the atmosphere, thereby making this fuel carbon neutral.

5.1.5.1 Status

In 2005, Hawaii's renewable energy resources contributed 6 percent of the total amount of electricity produced in the state. This compares favorably to the fraction of renewable electricity produced in the rest of the country, which is just 2 percent.[221] According to existing studies of renewable energy resources for electricity generation,[222,223,224,225]

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[221] United States Energy Information Administration (EIA), 2005. *Electric Power Annual 2005*. (www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html), accessed September 22, 2006.

[222] Bollmeier, Warren et al. (2003, November). *Interim Report on Renewables and Unconventional Energy in Hawaii*. Hawaii energy Policy Project, University of Hawai'i at Manoa.

Hawaii has approximately 1100 MW of renewable electricity potential that could be feasibly developed (Table 15). All of the technologies in Table 15 are assumed to be utility-scale, electricity generation projects. More recently, The Department of Land and Natural Resources has submitted its final catalogue on potential renewable energy sites for the state.[226]

Table 15. Estimate of Renewable Energy Potential for Electricity Generation

	Maui	Hawaii	Kauai	Oahu	Total
Hydro	7.8	8.2	4	0	20
Biomass	0	21	31	10	62
Refuse	15	35	9	40	99
Intermittent Wind	80	0	0	80	160
Geothermal	25	150	0	0	175
Solar Thermal	40	90	0	100	230
Firm Wind*	11.8	39.74	4.69	21.15	77.38
SolarPV	20	80	5	55	160
Wave	30	30	30	90	180
Totals	**217.8**	**414.2**	**79**	**375**	**1086**

*Assumes wind is firmed up to 60 percent capacity factor using hydro and battery energy storage, and that available wind resource is allocated in priority to develop firm wind, then non-firm (intermittent) wind.

Almost all of the utility-scale renewable electricity generation technologies reviewed have reached commercial levels where cost decreases have begun to make them competitive on the margin with fossil-fuel-based generation. Renewables have exhibited a 20 percent experience curve (20 percent cost reduction for each doubling of cumulative manufacturing experience),[227] which is similar to the improvements in gas turbine technology. Certain renewables, such as hydroelectricity, wind, and geothermal, are already mature technologies and cost competitive at less than 10 ¢/kWh (without subsidies).

Other technologies, particularly ocean technologies, have not yet reached widespread commercial adoption. Hawaii is well endowed with ocean energy resources and their potential remains largely untapped. Approximately 180 MW of wave capacity is

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[223] Francfort, James. (1996, September). *U.S. Hydropower Resource Assessment for Hawaii*. Idaho National Engineering Laboratory.

[224] Geothermex, Inc. (2005, September). *Assessment of Energy Reserves and Costs of Geothermal Resources in Hawaii*.

[225] DBEDT (2002, January). Feasibility of Developing Wave Power as a Renewable Energy Resource for Hawaii. State of Hawaii Department of Business, Economic Development and Tourism (DBEDT). Written in Response to House Resolution 8.

[226] State of Hawaii. Department of Land and Natural Resources. December 2006. *A Catalog of Potential Sites for Renewable Energy in Hawaii.*

[227] Rocky Mountain Institute analysis.

estimated to be feasible with an ultimate generation potential of about 570,000 MWh per year.[228] Hawaii is among the best locations in the world for wave energy, with sites available on all islands and the largest potential sites located near Oahu. Similarly, ocean thermal energy conversion (OTEC) could help further increase renewable electricity generation in Hawaii, although the large capital costs of demonstration-scale plants under study are prohibitive. Research and development efforts are ongoing, and continued improvements should be monitored.

The set of renewable electric technologies studied also includes both firm and non-firm generation. Firm renewable electricity, like firm fossil electricity, is considered such because there is great certainty that the energy and capacity can be generated to meet demand.[229] The firm renewable electric technologies examined in Table 15 include biomass, geothermal, and wind.

Intermittent renewable generators are, by definition, driven by the weather. The question is simply whether the weather patterns driving renewable resources are the same patterns driving load. Solar and tidal resources are perhaps most obviously correlated to distinct weather patterns. Insolation is driven by a well-known and regular weather pattern, the sun, and can be predicted fairly precisely on a daily, seasonal, and annual basis. The tides are driven by the most reliable weather pattern known, and the fluctuations in the tides can be predicted years into the future.

Wind energy intermittency is significantly more complicated. There are three primary wind regimes that affect Hawaii, (and most systems): trade, convection, and frontal. Trade winds are seasonal and highly reliable, but they are primarily driven by pressure, not temperature (which is a significant driver of power demand in many systems). Convection winds follow a daily cycle based on land and sea temperature differentials. Finally, frontal winds are driven by storms and are therefore erratic and unlikely to be able to support reliable wind generation in most places. A major consideration—besides whether the wind will be there—is, on a macro scale, whether it will be there when it is needed. Thus the challenge becomes identifying sites with good wind speeds that are temporally coincident with peak power demand.

For wind, it is possible to firm up the resource by integrating it with additional wind resources or other renewable resources. In this analysis, we assumed that almost 80 MW of the total available wind potential in the state can be "firmed" up to a 60 percent capacity factor through a combination of hydroelectric and battery storage technology at a cost of $4000/kW declining to $1800/kW over time.[230]

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[228] Personal communications. July 2006. Energetech Australia Pty Ltd, Ocean Power Delivery Ltd, and Wave Dragon.

[229] One should keep in mind however that all generators, have some probability of failure. The forced and unforced outages of conventional generators result from planned and unplanned mechanical failures,

[230] State of Hawaii, DBEDT. 2006. E2020 modeling analysis. Costs are estimated for Oahu. Cost of firming wind on other islands are higher, on the order of $9000/kW declining to $5000/kW over time.

5.1.5.2 Challenges

A key challenge in shifting renewable electricity market penetration from 3–5 percent to 20–30 percent is making currently intermittent renewables firm. Because these resources cannot be dispatched in the same manner that firm renewable electricity and fossil-fuel-based electricity can, there is considerable uncertainty as to the extent to which they can contribute to meeting demand, providing reserve margin, and contributing to the reliability of the grid. Specifically, the utility is required to ensure the system has the appropriate voltage and frequency at all times. The key for utilities will be blending such intermittent resources in ways that make the entire portfolio of renewables more predictable and more efficient.

Furthermore, utilities must overcome the traditional "not in my backyard" (NIMBY) concerns associated with siting new generation facilities. Despite their environmental benefits, renewable technologies, especially wind, may face local opposition due to aesthetic concerns or potential conflicts with the local natural environment. Especially in Hawaii, there may be opposition based on cultural and religious grounds, as was the case with geothermal development on the Island of Hawaii. The limited amount of available land area in Hawaii will only result in growing public scrutiny over siting new generation facilities. It will be increasingly important to consult with local communities early in the siting and development process to incorporate community concerns. The State could play a constructive role by working with counties and communities to create a master plan that would identify target areas for new facilities. This proactive approach has already been discussed in the context of growing Hawaii's biofuels industry and could be a positive step in addressing community concerns.

5.1.5.3 Renewable Energy and Transmission/Infrastructure

The current transmission system will likely require upgrades as development continues and as more renewable and distributed resources are connected to the grid. Specifically, additional infrastructure may be required to incorporate intermittent renewables and relieve transmission line congestion. Hawaii's geographic isolation also requires greater infrastructure redundancy due to an inability to connect to other power systems. However, increased use of distributed generation, efficiency, and a balanced portfolio of renewable resources can help to mitigate the need for such investments.

As additional generation sources are built, the utilities will need to build additional transmission lines to tie such resources into the grid. For instance, some of the proposed bioenergy-fueled generation sites are located in remote areas that would require significant transmission upgrades. Based on a preliminary analysis by Hawaiian Electric Industries, a potential 25 MW biomass generation facility in the Hana area on Maui would require that a minimum of two 69 kV lines be extended from Pukalani or Kanaha. Other proposed sites require only minor line extensions.

In addition, moment-to-moment operation of a power system with high levels of intermittent renewable generation is challenging because the system operator must balance generation and demand while maintaining power quality and low costs, and

without violating system constraints. Solar and tidal power are fairly straightforward to predict because both the sun and the tides have regular cycles. Wind energy, however, is much more complex to predict, although forecasting methods are improving. In order to compensate for this variability, utilities typically need to invest in generation units to "firm" wind, that can quickly be ramped up or ramped down to maintain power quality and meet demand and to store electricity generated when the wind is blowing and loads are not available.

Additional such units may be required in Hawaii, though research suggests that the right portfolio of renewable resources may reduce the need for such units. For instance, as the geographic spread of wind farms increases, the wind speeds become less positively correlated. In other words, one wind farm becomes more likely to generate electricity while another site is idle. This diversified portfolio represents a smoother generation resource than would be observed by analyzing any single component on its own, reducing the need to build additional infrastructure to maintain proper voltage.

Continued real-estate development and population growth have increased the demand for electricity far from central generation sources. This phenomenon is particularly salient on the Island of Hawaii, as construction of large developments continues to take place on the western side of the island, whereas most of the generation occurs on the eastern side. The land in between, furthermore, is subject to highly unpredictable volcanic activity. This has led to congested transmission lines and will likely require the construction of a new transmission line in the absence of other measures. However, as was discussed earlier in this chapter, distributed generation, sited close to load centers, can potentially defer such investments in distribution capacity. Installation of DG on a concentrated basis should be prioritized in order to avoid marginal distribution capacity costs and protect consumers from higher bills.

Given that Hawaii is an isolated archipelago, the state's electric utilities face unique challenges. Whereas utilities on the Mainland are interconnected, each island's system stands alone. As a result, each system must have built-in redundancies in case a particular part of the grid fails. Furthermore, the lack of interconnection makes it more difficult for utilities to match supply and demand effectively. This challenge is magnified when dealing with intermittent renewable resources, further underscoring the need to develop the right portfolio of resources to reduce the need for costly investments in infrastructure.

5.1.5.4 Investment Risk

A number of the renewable energy technologies that can tap Hawaii's local resources are in the early stages of development. Technologies that harness wave power, for instance, have yet to experience large-scale commercial adoption. Furthermore, some alternative fuels, such as those derived from bioenergy, require high oil prices and subsidies in order to be competitive. In the absence of targeted policies, oil price uncertainty therefore makes investment in such fuels risky. A full discussion of barriers to increasing the use of local bioenergy can be found in Chapter 7 , section 7.3 .

5.1.6 Small-Scale Renewable Electricity Systems

Small-scale renewable electricity systems also contribute to displacing fossil-fired generation. Solar electricity using PV has the additional advantage of potentially being coincident with system peak demand. For utilities such as HECO whose peak demand is becoming more driven by central air conditioning loads, solar PVs help relieve demands on the electric system during the hottest days, when solar output is also highest. The potential for local or distributed renewable electricity using small-scale solar PV (less than 1 MW) and solar water heating, which Hawaii considers an electric *displacement* technology, are small but significant. One estimate of the potential for these distributed generation technologies found that 17 MW, for small-scale solar PV, and about 30 MW for residential solar water heating by 2020,[231] could be available. The potential for solar water heating systems in the state is estimated to be 22 MW or 96,000 MWh through 2018.[232] A solar hot water financing mechanism that is before the Hawaii Public Utility Commission (see Recommendations section 5.2 , this chapter) represents an opportunity to significantly expand the use of energy efficiency and distributed renewables, particularly if the program is extended to solar photovoltaics.

5.1.7 Central (Utility Scale) Fossil-fired Electricity

Hawaii's electricity generation system is overwhelmingly dependent on oil (83 percent in 2005), a century-old phenomenon. Due to Hawaii's geographic isolation and lack of conventional electricity generation resources, the state's electric system infrastructure developed around petroleum, an easily imported fossil fuel that produced firm, reliable power. Between the 1960s and the 1980s, petroleum's share of Hawaii's electricity production hovered between 85 and 90 percent. In fact, even as oil prices rose in the 1970s, the proportion of Hawaii's electricity generated with oil increased to more than 90 percent.[233]

Hawaii's electricity is generated by the three regulated, investor-owned electric utilities, one cooperative, non-utility generators, the sugar industry, and distributed combined heat and power (CHP) generators. Most of this electricity is sold to consumers by via the utilities. Hawaiian Electric Company, Inc. (HECO) serves the City and County of Honolulu (Oahu); Hawaii Electric Light Company, Inc. (HELCO) serves Hawaii County; the Kauai Island Utility Cooperative (KIUC) serves Kauai County; and Maui Electric Company, Ltd. (MECO) serves Maui County and Kalawao County. MECO operates separate systems for Maui, Lanai, and Molokai.

Independent power producers (IPPs) include "non-utility generators" (NUGs) that have negotiated power purchase agreements to sell all the power they generate beyond their own plants' needs to the utilities. Cogenerators (CHP generators) are also IPPs that

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[231] Bollmeier, Warren et al. (2003, November). *Interim Report on Renewables and Unconventional Energy in Hawaii*. Hawaii energy Policy Project, University of Hawaii at Manoa.

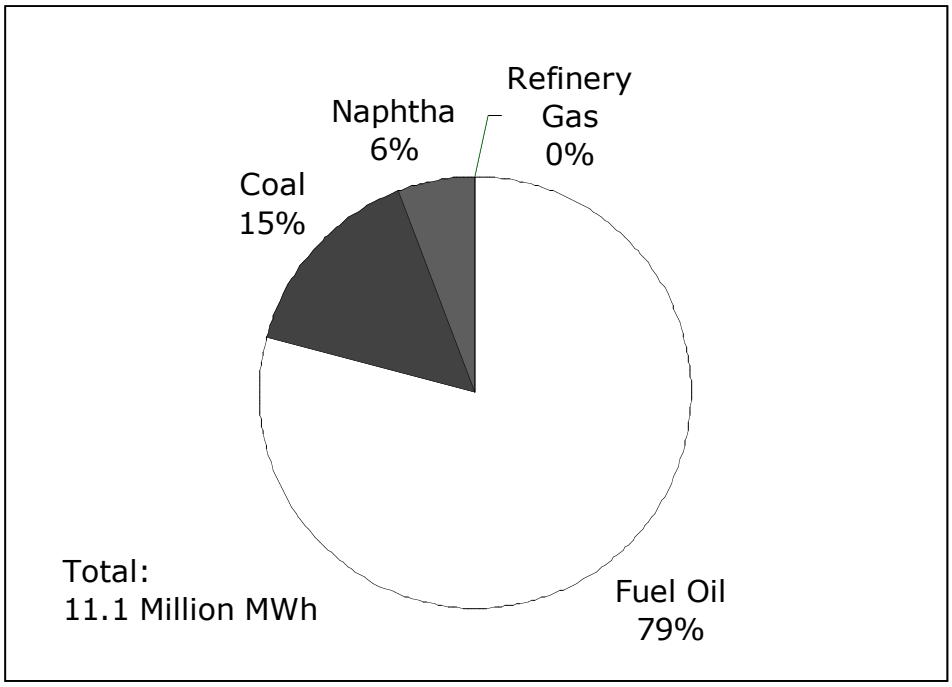
[232] *Ibid*.

[233] Hawaii, Department of Business Economic Development & Tourism, *Hawaii Energy Strategy 2000* (Hawaii: DBEDT, 2000) 3-6.

produce electric power and process heat for their own use and have contracts to sell surplus power to utilities.

Historically, Hawaii's sugar plantations co-generated electricity with sugar cane trash to power their operations and sell surplus electricity to their respective utility. High oil prices in the early 1980s led Hawaii to add renewable energy sources and related technologies: solar water heaters, some wind generation systems, and geothermal test wells. Together with hydro and biomass generation, these renewable energy sources accounted for 40 to 50 percent of the island's electricity in the early 1980s.[234]

Figure 34. Fossil-fired Electricity Generation Sources Statewide (MWh), 2005[235,236,237,238,239]



During the mid-80s, falling oil prices reduced incentives to offset oil use. Concurrently, Hawaii's sugar industry started to decline thus reducing the industry's contribution of largely biomass-fired and hydro-powered generation, the state's historical source of renewable energy and fuel diversity. In Kauai, for example, sugar-based energy made up

[234] Black and Veatch, *Renewable Energy Technology Assessments: Prepared for Kauai Island Utility Cooperative (Kansas: Black & Veatch, 2005).*

[235] Hawaii, Public Utilities Commission, Annual Report of Hawaii Electric Light company (Hawaii: PUC, 1999-2004).

[236] Hawaii, Public Utilities Commission, Annual Report of Kauai Electric (Hawaii: PUC, 1999-2002); Annual Report of Kauai Island Utility Cooperative (Hawaii: PUC, 2002-2005).

[237] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999-2005).

[238] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999-2005).

[239] United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005).

a substantial proportion of the island's historical electricity portfolio. With the closure of four sugar mills between 1985 and 2000, however, Kauai's renewable energy portfolio and fuel mix diversity declined and sugar operations closed entirely on the Big Island and Oahu. Thus, as recently as 1991, the portion of electricity generated by the utilities in Hawaii using oil once again increased to more than 92 percent.[240] Thus, the loss of agriculture in the state has resulted in an increased dependence on oil. Thus, revitalizing Hawaii's agriculture sector to include bioenergy production can result in triple-bottom-line benefits including local energy resources, more money kept within the state, and reduced CO2 emissions which contribute to global climate change.

During the last 15 years, new generation sources added to Hawaii's electricity system further reduced the state's petroleum dependence for electricity generation. Figure 34 provides an overview of electricity generation sources statewide in 2005, reflecting Hawaii's continuing efforts in electricity generation resource diversification.

Nevertheless, Hawaii remains largely dependent on imported fossil fuels, which now include coal. Coal initially made its introduction into Hawaii's energy mix as a supplement to biomass-fired generation in the sugar industry. However, the use of coal increased exponentially with the addition of a 180 MW coal plant on Oahu in 1994. As shown in Figure 34, by 2005 coal accounted for 15 percent of the state's electricity generation. Thus, in 2005, Hawaii generated 85 percent of its electricity from petroleum-based fuels. More than 94 percent of Hawaii's electricity was derived from fossil fuel resources.

5.1.8 Nuclear Power

No nuclear power exists or is planned in Hawaii. Historically, nuclear power has been considered infeasible in Hawaii due to public opposition, waste disposal concerns, and the mismatched scale of typical fission reactors to Hawaii's energy needs. The state's public opposition to nuclear power was formalized in 1978 with an amendment to the Hawaii State Constitution. Article XI states, "No nuclear fission power plant shall be constructed or radioactive material disposed of in the State without the prior approval by a two-thirds vote in each house of the legislature."

Even without a constitutional amendment constricting the use of nuclear reactors in Hawaii, nuclear power's fundamental economics and the underlying financial risk of nuclear power plants continue to pose major barriers for the technology. A 2004 Massachusetts Institute of Technology study, "The Future of Nuclear Power," found that nuclear power is uneconomic today compared with coal and natural gas plants, and pinned the future of nuclear power on major cost reductions and very high prices for carbon credits. Imposing a high price on carbon emissions ($100 per ton of carbon dioxide) could raise the nominal cost of new delivered coal power from $0.072 per kWh

[240] Hawaii, Department of Business Economic Development & Tourism, *Hawaii Energy Strategy 2000* (Hawaii: DBEDT, 2000) 7-7

to $0.17 per kWh (burning $1.33 per GJ coal), and that of new combined-cycle gas power from $0.067 to 0.086 per kWh to $0.13 to 0.15 per kWh.[241]

Additionally, of particular consequence to Hawaii, nuclear power plants fail with negative consequential effects during power outages and act as anti-peakers on the grid. When the grid is disturbed, nuclear power plants disconnect from the grid to ensure safe operations, which exacerbates the capacity and voltage support problems, accelerating the crash. Nuclear plants cannot resume full power until the grid is fully restored, extending the length of power blackouts. The recent blackout endured across Hawaii as a result of the earthquake on October 15, 2006 exemplifies the tenuous nature of each island's isolated grid systems.

Finally as discussed above in the distributed generation section 5.1.4 , a large central nuclear plant on a small and isolated system such as Hawaii could adversely affect reserve margin requirements. Remember that reserve capacity required to cover the potential loss of the largest generation unit is greater in isolated systems than in interconnected ones due to the higher need for redundancy within isolated systems. Building one nuclear plant would likely necessitate the construction of a second nuclear or other large central plant of similar size to backup the first. As noted previously, a system with a large number of small plants reduces reserve margin requirements and tends to be more reliable than a system with a small number of large plants.[242]

5.2 Recommendations for Achieving Greater Sustainability in Hawaii's Electricity Sector

The specific legislative, regulatory, and other actions taken by the state will be most effective if developed as part of a comprehensive strategy. This will increase the likelihood that these actions will support and not conflict each other. Several common themes are behind the vast majority of the barriers discussed earlier in this chapter. These include technological hurdles, regulatory roadblocks, pricing issues, and inadequate communication and awareness.

In order to overcome these barriers, the State should actively pursue the following strategies:

- Ensure utilities and customers are properly encouraged to make demand reduction their first priority by removing financial penalties for utility investments in efficiency;

- Ensure that utilities and customers are provided with useful and accurate information to plan, implement, and evaluate energy efficiency;

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[241] At a levelised gas price of $3.6-7.6 per J, equivalent to escalating those initial constant dollar gas prices at 5% per annum.

[242] Rocky Mountain Institute. (2005, April). Distributed Generation Workshop: Valuation of Distribute Resources Contribution to Reliability. Presented to Hawaiian Electric Company.

- Develop a portfolio of incentives to encourage investment in efficiency;
- Develop a portfolio of incentives to encourage investment in local renewable resources and distributed generation; and
- Support research and development in renewable energy and distributed generation solutions.

5.2.1.1 Shift Away From Traditional Rate of Return Regulation

At time of this writing, a number of policy proposals that would remove utility disincentives to invest in more energy efficiency are before the Public Utilities Commission for consideration.[243] These include lost margins, third-party administration, shareholder performance incentives and decoupling. Decoupling, in combination with performance incentives, is arguably the best combination, as explained below.

Revenue Decoupling

Decoupling is a mechanism that breaks (or decouples) the dependence of a utility's recovery of fixed investment costs on its energy sales to its customers. One specific method is via a revenue adjustment mechanism that allows the utility to recover the distribution revenues that were "lost" due to energy efficiency measures. By minimizing the impact of customer energy savings on a utility's recovery of its fixed costs, decoupling also reduces a utility's incentive to support load growth.

Decoupling can be achieved without substantially changing the revenue stream recovered by the utility in the years between rate cases. There are a number of ways the mechanism can be structured, but the basic principle is a true-up, or revenue balancing, mechanism applied to a utility's balance sheets once actual sales levels are known each year. A common form of decoupling, for example, allows the utility to earn its revenues based on the number of customers served, as opposed to the kilowatt-hours sold.

Several states have implemented a decoupling mechanism.[244] California Investor Owned Utilities have been implementing decoupling mechanisms since 2004. Additionally, Oregon has a well-known example of gas decoupling and is the only state that has had the program in place long enough to have it formally evaluated. In 2005, an independent assessment of Northwest Natural Gas found that the company improved the performance of its high-efficiency furnace program, and had shifted resources towards marketing energy-efficiency programs.[245] Thus, the limited measurable experience of decoupling has shown that it is an effective way to break the link between utility profits and sales,

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[243] Docket No. 05-0069, For approval and/or modification of demand-side and load management program and recovery of program costs and DSM utility incentives.

[244] California, Maryland, North Carolina, Oregon, New Jersey, Utah, Vermont, Arizona, Idaho, Indiana and Ohio.

[245] Hansen, D.G. and S.D. Braithwait. 2005. *A review of Distribution Margin Normalization as Approved by the Oregon Public Utility Commission for Northwest Natural.* Evaluation report prepared for the Oregon Public Utility Commission. Madison, Wisconsin: Christensen Associated Energy Consulting. March 31.

allowing the utility to encourage robust energy-efficiency programs without detriment to their financial success.

Performance Incentives

Performance incentives offer utilities financial incentives for the successful implementation of energy-efficiency programs. When performance incentives are combined with a lost-revenue adjustment mechanism such as decoupling, negative impacts on the utility are reduced. Several methods allow a utility to receive a reward for good performance; some of the more common methods are:

- Rate of return on energy efficiency equal to supply-side and other capital investments (Wisconsin).
- Increased rate of return on energy efficiency (Nevada).
- Specific financial reward for meeting certain targets (Arizona, Connecticut, Massachusetts, New Hampshire, and Rhode Island).
- Incentive equal to some proportion of the overall net benefits the programs produce –a.k.a "shared savings" (Minnesota).

Recommendation: Hawaii's electric utilities should advocate that the PUC consider removing barriers and establishing policies to encourage performance incentives in conjunction with a utility revenue decoupling mechanism. These two policies, along with the Public Benefits Charge currently in place, can further enable the aggressive implementation of energy efficiency.

5.2.1.2 Seek Ratemaking Design and Ratemaking Policies to Encourage Greater DG Adoption[246]

Encouraging greater DG adoption needs to be balanced with the design of equitable rates under a variety of arrangements between DG owners and electric utilities. The following is based upon HB2660 HD1,[247] which was considered by the 2002 Legislature but did not pass. The recommendations included the following elements:

- Ensure that standby charges are cost-based;
- Provide for equitable treatment of cost recovery for distribution service where customers provide for physical assurance;
- Consider equitable treatment of different levels of service such as supplemental power, backup service, and maintenance service;
- Ensure that supplemental power continues to be priced according to the customer's otherwise applicable tariff;

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[246] Global Energy Partners, LLC. (2004 July 29). *Creating Distributed Energy Opportunities for Hawaii*. Prepared for Energy, Resource and Technology Division, State of Hawaii Department of Business, Economic Development and Tourism (DBEDT).

[247] Electric Utility Charges and Discounts; Distributed Resources. State of Hawaii Legislature Archives. 2002 www.capitol.hawaii.gov/session2002/bills/hb2660_hd1_.htm.

- Recognize cost differences between supplemental power and backup power needs by considering the value of diversity in standby reservation charges, since diversity reduces T&D infrastructure requirements;
- Recovery of public purpose costs from standby customers through a cost per kilowatt usage charge;
- Charges based on embedded, not incremental, costs of service consistent with the manner in which rates are calculated for other distribution services;
- Account for the benefits when DG reduces peak electricity demand at those times when the cost of delivering power are highest for the utility; and
- DG utilizing renewable energy resources shall not be subject to standby charges or customer recognition rates in consideration of the economic, environmental, and fuel diversity benefits of renewables.

Recommendation: In late 2006, the PUC issued a final decision regarding Docket 03-0371, Instituting a Proceeding to Investigate Distributed Generation in Hawaii. However, the PUC has opened two new dockets to address ongoing concerns with standby tariffs. In Dockets 06-0497 - HECO and 06-0498 - KIUC, independent power producers should advocate that the Public Utilities Commission reconsider the recommendations included in HB2660 HD1 (2002).

5.2.1.3 Conduct System Integration Studies for Intermittent Renewable Energy

Intermittent renewable energy technologies, such as solar photovoltaics and wind, impose operational challenges to electric utility systems. Utilities around the country and in Europe have conducted studies regarding the technical and economic implications of the increasing penetration of intermittent renewables. However, the impacts of intermittent renewables are highly dependent on load shapes, system characteristics, and, in the case of wind, the wind regime in question. While existing studies from around the country may indicate the potential scale of the impact of intermittent renewables, they are not sufficient as a basis for decision-making by Hawaii's utilities specifically, due to Hawaii's unique situation as an isolated utility.[248]

What is needed is a system-specific analysis of the reliability impact of different penetrations of intermittent renewables, known as the Effective Load Carrying Capability (ELCC) of the resource. These studies also include estimations of the operational cost of renewable integration on several different time-scales, including seconds, minutes, hours, and seasons.

[248] Studies have been conducted by Xcel Energy, PacifiCorp, and the California Energy Commission, among others. In general, these studies have found a positive reliability contribution from wind (on the order of 10–20 percent), and an added operational cost of $1–5/MWh. However, this cost cannot be directly applied to Hawaii because mainland utilities are interconnected to regional grids that may affect (either positively or negatively) the operational impacts of wind.

Recommendation: The PUC should consider directing HEI and KIUC to conduct (either internally or through an outside contractor) studies of intermittent renewable integration and operational impacts. These studies should include an analysis of the potential for "firming" intermittent renewables using geographical dispersion, combinations of renewables, or storage technologies. Once completed, the PUC should consider directing the utilities to implement the recommendations in the studies.

5.2.1.4 Modify Renewable Portfolio Standard to Apply Only to Renewable Energy

The Renewable Electrical Efficiency provision of the existing Renewable Portfolio Standard should be a stand alone standard to allow the RPS to become a renewable-energy-only standard. Separating the RPS goals into separate efficiency and renewable energy standards (see next recommendation), would provide greater transparency and accountability. If the PUC should determine that a non-utility entity should administer the DSM programs, than that entity would be accountable for these goals because of contractual obligations.

Recommendation: State Legislators should consider updating the Renewable Electrical Energy provision of the existing RPS to establish the RPS as a renewable energy-only standard. As discussed in the following recommendation, the Renewable Electrical Energy provision would be moved under the energy efficiency resource standard. The minimum renewable energy requirement would stay the same (20 percent by 2020).

5.2.1.5 Create an Energy-Efficiency Resource Standard

Energy efficiency is generally the most cost-effective means to increase energy sustainability in the State. An energy-efficiency resource standard (EERS) is "a simple, market-based mechanism to encourage more efficient generation, transmission, and use of electricity."[249] The EERS would require that the utility achieve reductions in demand through efficiency as a percentage reduction of gross electric sales, starting from a set baseline year. The DSM reductions would be quantified as megawatt-hours from the baseline year, using the Measurement & Evaluation (M&E) reports used for calculation of shareholder performance incentives. The gross electric sales would be the net electrical sales plus quantified DSM reductions.

HECO's recent IRP filing proposed an effective reduction of 0.6 percent of gross sales.[250] Therefore, based on its proposed IRP, HECO indicates that this level of DSM savings is achievable, assuming the programs are approved, and adequate funding is provided. As reported by American Council for an Energy Efficient Economy (ACEEE) in its 2006 study, independent, third-party administrators, such as Efficiency Vermont, as well as leading electric utilities, are achieving a one percent reduction in electrical sales each

[249] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations*. *March 2006 (ACEEE Report EO63*. Washington DC: ACEEE, 2006.

[250] Hawaiian Electric Company (HECO), 2005. *Integrated Resource Plan, 2006–2025*. Honolulu: Hawaiian Electric Company, Inc.

year.[8] Using 2006 as the baseline year, and a goal of a one percent reduction in electric sales per year for all utilities combined is a reasonable goal for energy efficiency.

A one percent reduction, using 2006 as a baseline, would result in a 20 percent reduction in electric utility companies' gross sales by 2026. This may be an achievable target for the utilities in Hawaii, based on current achievements of third-party administrators and leading electric utilities.[251] The Public Utilities Commissions in Texas, Nevada, Pennsylvania, and California have conducted rulemaking in 2004–2005 to create an EERS.

Recommendation: The State Administration should consider introducing a bill to the Legislature to establish an EERS with a goal of achieving a one percent reduction in kWh energy sales annually, using 2006 as a base year, for all utilities combined. The EERS would require a cumulative energy-efficiency goal of 20 percent by 2020, statewide.

5.2.1.6 Encourage Bioenergy Use for Electricity Generation

While highway transportation biofuels are subject to a lower tax rate than highway fossil fuels,[252] fuel (either biofuel or fossil fuel) used for electricity production is only subject to general excise tax. Therefore, biofuels for power are at a greater risk of not being cost-competitive with fossil fuels for power. Despite this, analysis indicates that biodiesel is always cost-competitive with No. 2 fuel oil (its substitute) for power production. Ethanol, however, is not always cost-competitive with naphtha (its substitute).

Current biofuel subsidies in Hawaii are focused almost exclusively on the ethanol production step. To support the development of the biofuels industry as a whole, new subsidies and incentives should support other parts of the ethanol value chain. For example, by ensuring the agricultural sector a market and profitable price for its products, agricultural subsidies would encourage and support the production of biofuels and biomass feedstock. At the same time, subsidies that shield end users—such as Hawaii's electric utilities—from pricing risks associated with uncertain oil prices would help create an increase in demand and, in turn, protect consumers from rate increases.

Because of the different cost structures for fuels in the transportation and electricity sectors, different incentives for biofuels are appropriate. As discussed in section 7.4.1.4 , a sliding-scale production tax credit for transportation ethanol should be the most effective incentive. However, this type of policy is not necessarily the most effective for the electric power industry, partly due to the small number of market participants. Since Hawaii's electric utilities are regulated, the PUC should work with the utilities and other stakeholders to determine the most appropriate incentive mechanism.

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[8] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006. (ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[251] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006. (ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[252] H.R.S.§243-4 and §243-5

Recommendation: Efforts underway by Hawaiian Electric Company will likely result in the production of sufficient biodiesel to meet the three HEC companies' needs for diesel fuel. The PUC should consider examining the potential financial risks faced by the HECO and other Hawaii utilities regarding ethanol consumption, and what additional incentives may be appropriate to mitigate those risks.

5.2.1.7 Conduct Additional Studies on Status and Strategies for Maximizing Distributed Generation and Combined Heat and Power (CHP)

The Public Utilities Commission was recently assigned responsibility for collection and maintenance of data on fossil fuels.[253] The usefulness of the fuels database could be enhanced to allow tracking of the amount and type of fuel consumed for DG. The State has historically received detailed information primarily from the sugar industry concerning the electricity generated for the industry's own use, the electricity sold back to the utility, generation heat rates, and the quantities of each type of fuel consumed.

The State's ability to benchmark all existing non-utility electricity generation sources and evaluate potential policies and programs would be significantly enhanced if these data were available for all commercial and residential segments. Such a survey can better inform the potential for CHP and non- emergency backup DG capacity in the state. It would benefit energy service companies and independent power producers interested in doing more business in Hawaii with CHP. Utilities may also be able to incorporate this information into their integrated resource planning.

Recommendation: DBEDT should consider updating the distributed generation study completed in 2004 to provide new information on existing and forecasts of future DG capacity and generation by application. The study should also distinguish between backup installations, combined heat and power installations, and net-metering installations. DBEDT may want to consider soliciting assistance from energy service companies or independent power producers for conducting this study since they, too, would likely find it beneficial.

5.2.1.8 Continue to Update Model Energy Code (MEC)

The model energy code sets minimum requirements for the energy-efficient design of new buildings and provides methods for determining compliance with those requirements. It sets standards for electric power; lighting; building envelope; heating, ventilating, and air conditioning (HVAC) systems; water heating systems; and energy management. The current State model energy code was finalized more than a decade ago, in 1993.

Hawaii's MEC includes an energy code for commercial buildings adopted by Honolulu, Maui, and Kauai Counties that is based on ASHRAE 90.1 1999, a standard promulgated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers

[253] State of Hawaii, 2006. *Hawaii Revised Statutes*, Chapter 486J, Petroleum Industry Information Reporting Act. Honolulu: State of Hawaii

(ASHRAE) and modified under a DBEDT contract to more closely match Hawaii's subtropical climate and building practices. Hawaii County's model energy code for commercial buildings is based on ASHRAE/IESNA 90.1 1998. Additionally, Honolulu and Maui County adopted the residential energy code that applies to new construction homes and additions of more than 100 square feet.

Recommendation: DBEDT is in the process of developing a Tropical Energy Code, which will draw heavily from ASHRAE 90.1-2004 and the Guam Energy Code. Hawaii is a home-rule state; thus, each county adopts building code provisions individually. However, it is recommended that County councils favorably consider the new MEC upon completion by DBEDT. DBEDT should consider developing presentations and written materials that make the benefits of the MEC clear.

5.2.1.9 Develop "Whole-system" Comprehensive or Packaged Energy Efficiency Programs

The standard approach to energy conservation programs has been to target specific individual end uses. They typically involve reducing the electrical needs of individual end-use equipment or providing incentives, typically in the form of rebates, for customers to replace existing technology with more efficient equipment.

However, single-measure efficiency programs have certain drawbacks. For example, single-measure efficiency programs tend to result in *cream skimming*, in which the most cost-effective measures are implemented first (for example lighting) and the more costly measures are never implemented at all.

The whole-system efficiency approach incorporates measures or materials that produce synergies and may not be intuitively obvious at first. In addition, the combination of measures may initially be more costly to implement. However, together they achieve a *multiplied* efficiency reduction that is greater than individual efficiency measures can achieve alone.[254] This "multiplier effect" of energy savings with a whole-system approach can increase the cost-effectiveness of the overall project more than a collection of measures treated as individual projects.

Recommendation: The Hawaii Public Utilities Commission is encouraged to require the Public Benefits Fund contractor to examine implementation of whole-system efficiency programs, particularly when the contractor is selected.

5.2.1.10 Aggregate Green-power Purchasing for State Facilities

In 2006, Act 96 was signed into law and implemented the Governor's initiative for the State government to lead by example. There are many actions that the State is taking to

[254] For example, creating a package of efficiency measures such as better insulation, leak sealing, and efficient lighting or daylighting could reduce the cooling load enough to help improve the economics of an efficient air-conditioning system upgrade, by allowing for a reduction in the size of the HVAC system required, thereby significantly reducing capital costs in addition to operating costs.

implement this law, as discussed above. The State is already required to reduce energy consumption per gross square foot, but there are not any requirements that the State procure the energy that it uses from renewable energy sources. Requiring State facilities, such as offices, schools, and universities, to purchase all or a percentage of their power from renewable energy sources creates a stable market, and fosters widespread support for green electricity. In the past, the federal government, along with many local and state agencies, has purchased at least a certain percentage of their power from renewable sources. The initiative is a good way for Hawaii to support the development of renewables.

Recommendation: The Administration should consider issuing an executive order to the State Legislature that would establish a requirement for government agencies to procure a percentage of its energy from renewable energy sources, steadily increasing the percentage that must be procured until it reaches 100 percent. The percentage set and timeline should be determined through further analysis as this recommendation is pursued.

5.2.1.11 Combine Resource Efficiency Programs (e.g., Combined Electricity, Gas, and Water Use Efficiency)

A whole-system approach to efficiency that is fuel-blind or resource-blind has advantages over measure-based or electricity-only approaches. Traditional efficiency programs typically limit electric utilities to electricity demand-side management programs, gas utilities to gas demand-side management programs, and water utilities to water use efficiency programs. Hawaii's gas utility, however, was exempted by the Public Utilities Commission from requirements to develop demand-side management programs due to overcapacity of their synthetic natural gas plant. The counties operate the principal water systems in the Islands, but they do not currently offer incentives for water use savings.

In combination with Hawaii's update of the Model Energy Code, the proposed adoption of the International Energy Code and the transition to a Public Benefits Fund (PBF) to manage electricity programs, it may be beneficial to consider encouraging the PBF Manager to develop programs combining electricity-, gas-, and water-savings incentives. This approach could take advantage of technical synergies and reduce program costs compared to three separate approaches.

Recommendation: The Public Utilities Commission may want to consider encouraging the PBF Manager to develop programs combining electricity-, gas-, and water-savings incentives. Hawaii's electric, gas, and water utilities may consider assisting the Public Benefits Fund contractor in the marketing and promotion of such programs with their customers.

5.2.1.12 Extend Solar Water Heating Financing Program to Include Solar Photovoltaic

In 2006, the State Legislature passed Act 240, which authorized the Hawaii Public Utilities Commission (PUC) to implement the Solar Water Heating Pay-As-You-Save Program® (SWH Financing Program). On October 24, 2006, the Hawaii Public Utilities

Commission opened Docket No. 2006-0425, Instituting a Proceeding to Investigate the Issues and Requirements Raised by, and Contained in, Hawaii's Solar Water Heating Pay-As-You-Save® Program, Act 240, SLH 2006.

The financing program is designed to be a customer-financed market-based approach. It is designed to be self-funding as measures are paid back through the savings from the use of the efficient technology. This type of financing program removes the incentive barrier between building owners who do not pay the utility bill and the tenant who typically would not recover the cost of capital improvements.

The basic premise of the program is that the products adopted will save more money than they cost. The program can be used for any proven measure that is cost-effective based on retail rates (although incentives can be used in conjunction to make additional measures cost-effective). For cost-effective measures, assurance mechanisms can address consumer uncertainty. Certification of vendors and products, extended warranties for product reliability and savings, and effective disclosure requirements combine to eliminate consumer doubts. This mechanism is not applicable to unproven technologies or to technologies that are known not to be cost-effective since there is no assurance the savings required to offset the monthly charges will be realized. PAYS cannot compete with steep incentives of 30–50 percent or greater for the cost of a measure. However, rebates can be used in conjunction with PAYS to ensure that measures are cost-effective.

The financing program removes the upfront payment requirement for the customer, because the conservation cost is repaid through a separate line item on the electric bill. The upfront capital for installation could be provided by a customer's utility, an energy supplier, a loan fund, or even a product vendor. Whoever supplies the capital is repaid (including financing costs) through the customer's monthly payment of the electricity charge. Since PAYS is typically structured so that vendors deliver the efficiency measure, the burden of program design and product marketing falls on the vendor, rather than the utility or public administrator.

Recommendation: DBEDT should consider introducing legislation to expand the Solar Hot Water Financing program to include solar photovoltaic, and it should explore expanding the program to encompass all cost-effective energy efficiency and renewable energy technologies. As the Hawaii Public Utilities Commission moves the Solar Hot Water Financing Docket forward, the Commissioners could expand the program into these other areas.

5.3 Conclusions

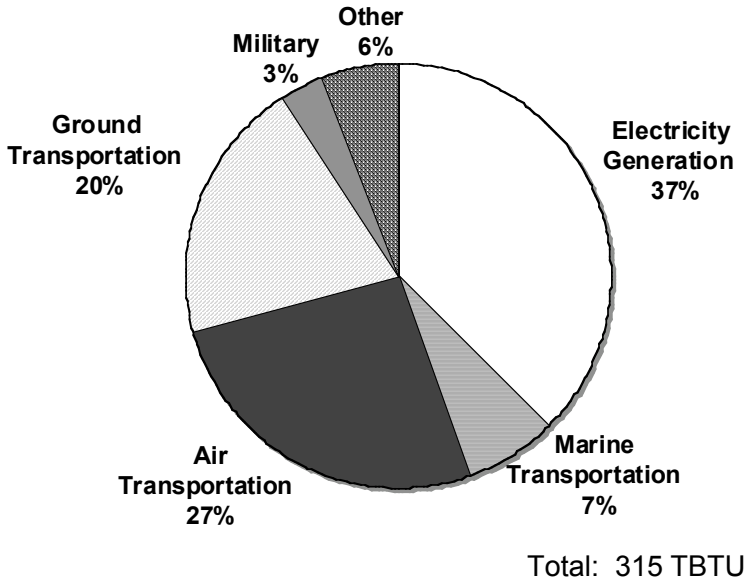
Hawaii has a track record of accomplishments in clean electricity generation. The state's renewable energy resources contributed 6 percent to total electricity produced in the state, higher than the national average of 2 percent. Hawaii's utilities have captured over 30 MW (>135,000 MWh) of electrical efficiciency in the last decade via demand side management programs. The state is a leader in solar water heating with over 70,000 residential and commercial systems installed statewide.

However, there is still more work to be done. Efficiency is the most cost effective resource with more than 1800 GWh of achievable potential per year, and its continued implementation should be among the state's highest priorities. Providing a regulatory environment conducive to greater efficiency is crucial to capturing the savings potential. Distributed generation including combined heat and power provide engineering, financial, and operational benefits and are attractive alternatives to large, centralized electricity generation stations. A main barrier to its greater adoption is standby rate design that must be properly resolved. Use of renewable energy also provides important diversification of the state's energy supply, helps keep energy expenditures in the state, provides local jobs, and reduces environmental impact. Providing a guaranteed market for renewable energy through aggregated green power purchasing for state facilities and allowing utilities to earn a premium through green pricing complement the existing renewable portfolio standard. All of these resources will need to be implemented in concert to displace oil and coal-fired electricity generation and hedge against fuel price increases and volatility.

Chapter 6 Transportation System

Hawaii's transportation sector includes ground, air, and marine transportation. Like most of the modern world, Hawaii's transportation energy comes almost entirely from oil. Ground transportation is dominated by passenger cars and light trucks, as there are no rail systems in the state. Although Oahu has an extensive public bus system, mass transportation is extremely limited on the other islands. The aviation sector provides a vital physical and economic link to the U.S. mainland and a host of Pacific Rim nations. It is also the primary means of commuting between the islands (despite a number of passenger boats connecting Maui to Lanai and Molokai). Rental vehicles—driven by tourists—comprise a significant part of the state's vehicle fleet. The shipping industry drives the demand for marine transportation fuels.

Figure 35. Statewide Primary Energy Consumption by Sector, 2005[255,256,257]



Though Hawaii currently has a small amount of locally produced biofuel, the state has no indigenous fossil-fuel resources, and all oil must be imported. Figure 35 shows primary energy that each sector directly consumed in 2005. Just over 50 percent of the state's primary energy is used for transportation. Almost 50 percent of the energy used within the transportation sector is jet fuel for planes, and 40 percent of the energy used for transportation goes to powering on-road vehicles.

Consumers are aware of oil price volatility in the transportation sector. Adjusting for

[255] Portion allocated to military sector represents only the primary fuels that is directly consumed. Purchased electricity for military is included as part of electricity generation.

[256] Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections.*

[257] Hawaii, Public Utilities Commission, *Annual Report of the Gas Company* (Hawaii: PUC, 2005) 40.

inflation, average Hawaii retail gasoline prices nearly doubled over a six-year period, from $1.20 per gallon in January 2000 to $2.30 per gallon in January 2006. This fuel price increase added approximately $500 to the annual cost of owning and operating a vehicle in Hawaii.[258]

Although Hawaii is unlikely to significantly influence federal legislation or the national transportation market, Hawaii can still reduce its dependence on oil for transportation by half or more. This can be achieved by promoting land use planning and alternative modes of transportation; promoting consumer purchase of the most fuel-efficient vehicles available; increasing the consumption of transportation biofuels; and providing incentives for the local production of biofuels.

More efficient technologies and innovative public policies exist to reduce Hawaii's dependence on transportation oil. Next-generation cars, trucks, and airplanes will offer the potential to save half of the transportation fuel Hawaii currently uses. If properly integrated with biofuels, efficient technologies offer Hawaii the opportunity to be a national example and become a leader in efficient transportation.

6.1 Improving the Sustainability of Hawaii's Transportation Energy System: Goals and Strategies

In 2005, 90 percent of on-road fuel use was gasoline and 10 percent was diesel. From 1999 to 2005, fuel use for ground transportation grew annually by 2.9 percent. Both the number of registered vehicles and the estimated vehicle-miles traveled in Hawaii grew at a compounded annual growth rate of 3.6 percent between 1999 and 2005. This exceeds the rate of population growth (0.8 percent), reflecting a rise in the number of vehicles per capita and vehicle-miles traveled per capita, both of which grew at a rate of 2.8 percent. As a result of the growing number of vehicles per capita, ground transportation represented the fastest growing transportation sector, with a compounded annual growth rate of 2.9 percent between 1999 and 2005. During the same period, gasoline and diesel consumption had compounded annual growth rates of 2.5 percent and 5.3 percent, respectively (see Figure 36).

Though demand for aviation fuels declined between 2000 and 2003, aviation fuels still account for half of all transportation fuel consumed in the state. Hawaii's jet fuel/aviation gas consumption totaled 84 TBTU in 2005 (see Figure 37). Highway transportation represents the second highest demand for fuel in the state. In 2005, gasoline consumption for highway vehicles totaled 56 TBTU, while diesel consumption totaled 6 TBTU.

Hawaii can reduce petroleum consumption in the transportation sector by applying energy-efficient technologies and transitioning to alternative fuels. Strategies to increase

[258] Figures represent 2006 dollars. Assuming annual vehicle-miles traveled (VMT) of 9,200 and vehicle fuel efficiency of 20 mpg, based on State of Hawaii Department of Business, Economic Development & Tourism (DBEDT). (2005). State of Hawaii Data Book. Retrieved December 26, 2006, from www.hawaii.gov/dbedt/info/economic/databook/db2005.

the efficiency of ground transportation sector are not limited to automobiles; urban design and mass transit are also important elements. A three-pronged approach that can reduce transportation fuel consumption should include: (1) the encouragement of the use of efficient and alternative-fueled vehicles. (2) the encouragement of efficient modes of alternative transportation, and (3) the implementation of land use planning and urban design measures that minimize vehicle-miles traveled.

Figure 36. Statewide Ground Transportation Fuel Consumption, 1999–2005[259]

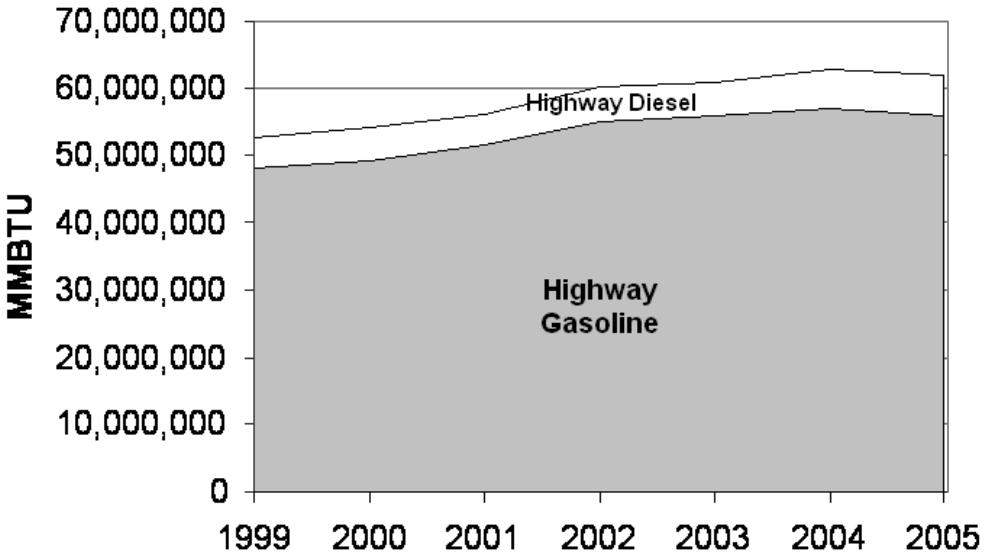
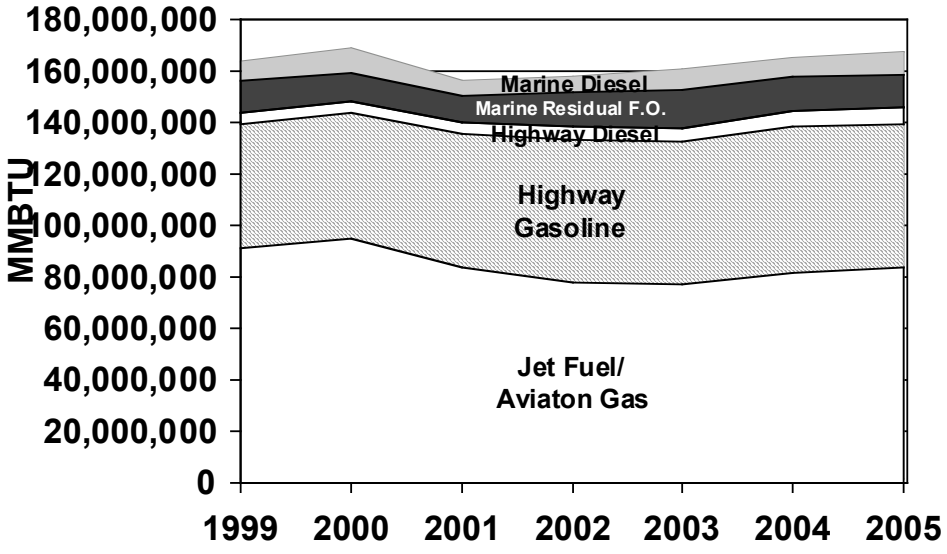


Figure 37. Statewide Transportation Fuel Consumption, 1999–2005[260]



[259] Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections.*

[260] Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections*.

6.1.1 Alternative Modes of Transportation

Using alternative modes of intra-island transportation, including car-pooling, buses, coastal ferry systems, rail systems, and bike lanes could reduce the amount of fuel consumed in Hawaii. For transportation between islands, fast and reliable ferries are a good alternative to airplanes. Similarly, encouraging the transportation of cargo by ship rather than by air can also save fuel.

Hawaii has an established public transportation infrastructure. Currently, there are bus systems in all of Hawaii's counties. TheBus in the City and County of Honolulu has the largest fleet, most routes, and the highest ridership in the State. On a per-capita basis, the City and County of Honolulu has the sixth highest transit ridership in the country and serves approximately 71 million passengers a year.[261] The system has over 80 different bus routes covering approximately 900 miles.[262] Oahu's bus fleet currently has ten hybrid-electric buses and transportation officials plan to purchase forty additional hybrid-electric buses.

The county of Hawaii's bus infrastructure was expanded in January 2006 through the purchase of ten additional buses, bringing the county's total to forty. Maui also expanded its system in October, 2006 by adding an additional commuter route. The Kauai Bus operates a fixed route bus service six days a week and provides paratransit services for the elderly and disabled.

While considering alternative modes of transportation in Hawaii, leaders may want to consider the interests of visitors in addition to residents, tradespersons, and freight carriers. Visitors to all counties contribute to statewide fuel use, but a well-planned transportation system that provides convenient access for visitors to popular destinations could significantly reduce the use of rental cars and the amount of fuel they consume. Mass transit systems, using light rail and/or buses, can accommodate residents in their everyday lives. The benefits of alternative modes of transportation go beyond that of convenience and time for residents; they are also important for reducing fossil fuel dependence in the state and for mitigating global climate change.[263]

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[261] TheBus. Oahu Transport Services, Inc. Retrieved 25 January 2007 from www.thebus.org/default.asp.

[262] American Public Transportation Association. *Bus Fixed Guideway Lane Miles*: Bus Directional Route Miles, 100 Largest Agencies, Fiscal Year 2004. Retrieved January 25, 2007 from www.apta.com/research/stats/bus/buslanemiles.cfm.

[263] On 2 November 2006, the Honolulu city council voted to make rail the mode of transportation for the future, but this decision has spurred opposition from taxpayers and made the improved public transportation system a hot topic in Honolulu. Regardless of the final outcome of the transportation debate, Honolulu is in the market for an improved transportation system that will reduce congestion and fuel use. Leidemann, Mike. (2006, November 3). "City Council Gives Rail Transit Big Thumbs-up." *The Honolulu Advertiser*. Retrieved December, 6 2006, from www.honoluluadvertiser.com.

6.1.2 Highway Vehicles

6.1.2.1 Efficient Cars and Light Trucks

Regardless of other alternatives and transportation policies, many people will still need to own and use light vehicles (including cars and light trucks). Policies and incentives (see Recommendations section below) that encourage vehicle owners to purchase fuel-efficient vehicles are needed to help reduce petroleum consumption. If put into operation, improved vehicle efficiency has the potential to reduce annual gasoline demand by 20 percent or more by 2025.[264,265]

The traditional vehicle has become significantly more efficient over time through improvements in the internal combustion engine (ICE), better drivetrain efficiency, the aerodynamic design and lightweighting of materials. Still, there is a marked disparity in efficiency among vehicles with traditional ICEs, even within each size class, and consumers should be encouraged to choose the most efficient models.

Over the past few years, hybrid-electric vehicles (HEVs) have become commercially available, offering significant leaps in efficiency over vehicles powered by conventional ICEs. HEVs use batteries and an electric motor along with the traditional ICE to supply motive power. Some HEVs use the ICE to charge batteries and power an electric motor or motors to drive the vehicle's wheels. Others use the motors to supplement power from the ICE. HEVs typically have very limited battery-only ranges and are charged only by the onboard ICE. Manufacturers continue to develop and introduce HEVs in all size classes.

Over the long term, large gains in vehicle fuel efficiency can be achieved through improvements to platform physics and advanced drivetrains. A fuel-efficient car has a lightweight, aerodynamic body, as well as minimal rolling resistance. More than 90 percent of a typical car's fuel is used in overcoming its weight. Fortunately, modern light-but-strong materials—light metals, special new steels, and advanced polymer composites—can slash the car's weight without compromising safety. For example, carbon-fiber composites can absorb 6–12 times as much energy per kilogram as conventional steel, and they can do so more smoothly. This more than offsets the composite car's weight disadvantage if it hits a steel vehicle. With such novel materials, cars can be big (comfortable and protective) but not heavy (hostile and inefficient), saving both oil and lives.

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[264] State of Hawaii Department of Business, Economic Development & Tourism (DBEDT). (2005). State of Hawaii Data Book. Retrieved December 26, 2006, from www.hawaii.gov/dbedt/info/economic/databook/db2005/.

[265] State of Hawaii, DBEDT. Energy modeling analysis 2006. Assumes gasoline only (does not include diesel), constrained supplies scenario with feebates policy. Without enabling policies such as feebates, high prices in the constrained supplies scenario stimulate enough efficient light vehicles adoption to reduce annual gasoline consumption by about 15 percent by 2025. See Appendix A for a description of modeling scenarios and modeling results.

New manufacturing techniques currently being developed can make advanced materials affordable, over the long term.[266] Some carbon-composite processes now show promise of having competitive cost per car at automotive volumes, meeting all requirements without compromise, and with valuable advantages: no fatigue or corrosion, color-in-the-mold (no paint), and bouncing undamaged from low-speed collisions. Such materials' extra cost per car can be offset by simpler automaking (the assembly plant becomes smaller and less capital-intensive), and by the smaller propulsion system. Thus the doubled efficiency of modern hybrid-electric cars can be nearly redoubled at little extra cost.

6.1.2.1.1 Challenge: Consumer Behavior

Consumer behavior in vehicle purchase and operation is the major factor in creating demand for gasoline in Hawaii. After a home, a vehicle is usually the second largest purchase a consumer makes. However, retail customers underestimate the true fuel economy benefits of a typical light vehicle over its 14-year average life by up to 60 percent. A 2003 U.S. Department of Energy survey found that the average consumer needed payback within 2.9 years to justify an investment in fuel economy.[267]

While consumers place a much higher value on short- versus long-term gasoline savings, society as a whole is indifferent: a gallon burned tomorrow will have the same societal effects as a gallon burned ten years from now. Because future fuel prices are discounted, high gasoline prices are not likely to significantly influence vehicle purchasing decisions. In a recent survey by Progressive Insurance, fuel efficiency and cost of insurance were listed as the two least important factors in new car purchasing decisions. Initial purchase price, make and model, safety, and performance were the most important factors cited in purchasing decisions.[268] Vehicle buyers are concerned about the economics of purchasing a car, but not what it costs to actually drive it. Policy decisions need to take this into account.

In addition to the capital and operating costs, buyers also value the convenience of private vehicles. Adding to this convenience benefits such as HOV lane access and reserved parking spaces for energy efficient cars can help to encourage consumers to buy efficient vehicles and to operate *all* cars in the most fuel-efficient ways.

Compared to individual consumers, fleet operators are more analytical in their vehicle-purchasing decisions. They tend to consider purchase and use from a business perspective rather than as personal statements. This means that fleet operators value fuel efficiency because it saves money. The main barrier to efficient trucks is a lack of

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[266] See, for example, www.fiberforge.com.

[267] Steiner, E. 2003. Consumer Views on Transportation and Energy. NREL/TP-620-34468. Golden, CO: National Renewable Energy Laboratory (August). www.nrel.gov/docs/fy03osti/34468.pdf.

[268] Progressive. (January 2006). *There's More To The Cost Of A Car Than Just The Purchase Price — But Don't Tell That To Shoppers!* Mayfield Village Ohio. Retrieved December 26, 2006, from . http://pressroom.progressive.com/releases/car_shopping_survey_06.asp.

coordination between buyers and sellers regarding opportunities to save petroleum through fuel substitution and more efficient use. For both fleet and consumer uses, stock turnover becomes a large issue in improving transportation efficiency. Light vehicles remain on the roads for an average of 14 years and trucks last for more than 20 years. Innovative policies, such as scrap-and-replace programs, can help speed up stock turnover.

6.1.2.2 Efficient Trucks

Trucks play an important role in Hawaii's transportation energy system, as truck shipments accounted for 55.5 percent of the total shipments originating in Hawaii in 2002.[269] Improving truck fuel efficiency will decrease statewide fuel consumption. Truck fuel efficiency can be improved by improving truck aerodynamics, reducing idling time, and by maintaining the correct tire pressure. Hybrid trucks will also vastly improve truck fuel economy.

6.1.2.3 Alternative Fuels

An additional course of action would be to replace gasoline and diesel with alternative fuels. Vehicles that are compatible with alternative fuels may run on biofuels (plant-derived biodiesel or bioethanol), electricity, or hydrogen. Biofuels are a particularly good option for Hawaii because there is considerable cropland available for growing them. Thus, the fuels could be produced locally, thereby reducing the amount of fuel consumed while transporting fuel, boosting agriculture in Hawaii, and decreasing dependency on imported petroleum. Additional discussion on the potential supply, demand, and benefits of bioenergy are included in section 7.1.1 of this report.

Hawaii currently consumes approximately 40 million gallons per year of ethanol (imported to meet Hawaii's E10 mandate).[270] Modeling results indicate approximately 38 million gallons of ethanol under the adequate supplies scenario[271], 215 million gallons under the constrained supplies scenario, and 60 million gallons under the commodity cyclic scenario could be cost effectively supplied for the transportation sector in the state.

All vehicles on the road today are capable of using blends of ethanol up to 10 percent. In order to use higher-percentage blends of alternative fuels, vehicles need to be equipped with flex-fuel technology. Flex-fueled vehicles (FFVs) are capable of running on blends that include up to 85 percent ethanol, or E85. At less than $200 per vehicle, this technology is inexpensive to install and offers an option for consumers to use renewable fuels.

In addition to ethanol, Hawaii currently consumes approximately 0.5 million gallons per

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[269] U.S. DOT Bureau of Transportation Statistics. *Freight in America: A New National Picture*. (January 2006). Retrieved 15 January 2007, from www.bts.gov

[270] Hawaii's E10 mandate, which took effect in April 2006, requires that 85 percent of all gasoline sold contain 10 percent ethanol.

[271] See Appendix A for a definition of modeling scenarios for HES 2007.

year of biodiesel (produced exclusively from waste vegetable oil). Although the potential market demand for biodiesel in Hawaii is ten times less than transportation ethanol, a substitute for gasoline, biodiesel production can likely be increased in the state by producing fuel from dedicated energy crops such as oil palm, kukui, or jatropha. However, significant research must be conducted into the costs and techniques of growing these crops.

All diesel engines are technically capable of using up to 100 percent biodiesel, though manufacturers have been slow to warranty the use of high-biodiesel blends. On pre-1996 vehicles, using greater than 20 percent biodiesel can cause problems with fuel lines and filters, and cars and light trucks running on high-biodiesel concentrations can have difficulties starting at low temperatures. Temperatures in Hawaii are generally not cold enough to cause problems with biodiesel vehicles.[272]

Nearly all diesel trucks and buses must run on a 5 percent biodiesel blend (B5) today in order to remain within the requirements of the vehicle warranty. However, European and U.S. truck manufacturers are testing engines to develop a standard for running on a 20 percent biodiesel blend (B20). It is expected that B20 certification will be granted within the next five years. Work is also on-going for an ASTM B20 standard, which could make it more likely that manufacturers will provide warranty coverage for vehicles running on B20.[273]

6.1.2.3.1 Flex-Fueled Vehicles: A Chicken-And-Egg Problem

Currently, more than four million flex-fuel vehicles are driven on America's roads. Most drivers of these vehicles in Hawaii don't know that their vehicles can burn E85, a type of fuel that contains 85 percent ethanol and 15 percent gasoline, by volume. Furthermore, many Hawaii drivers either do not have access to, or are unfamiliar with, local ethanol fueling stations. Indeed, a recent study confirmed that less than one percent of the fuel used in alternative-fuel-capable vehicles was E85.[274] Thus, there is a chicken-and-egg problem with biofuels: alternative-fueled vehicles need alternative-fuel infrastructure to operate, but alternative-fuel infrastructure needs a sufficient vehicle population to justify the necessary investment to make it available.

Hawaii can encourage the development of ethanol infrastructure through innovative policies, but influencing consumer behavior may be more difficult. The State of Hawaii has limited influence over the types of vehicles that manufacturers offer, which limits consumers' flex-fuel vehicle options. In 2005, Hawaii citizens purchased only 0.5

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[272] Note that this depends on the location and on the type of biodiesel.

[273] American Society for Testing and Materials (2006). WK7852 New Standard Specification for Diesel Fuel Oil, BIODIESEL Blend (B20)1. Retrieved September 22, 2006, from www.astm.org/cgi-bin/SoftCart.exe/STORE/filtrexx40.cgi?U+mystore+dfxj3488+-L+BIODIESEL+/usr6/htdocs/astm.org/DATABASE.CART/WORKITEMS/WK7852.htm.

[274] Office of Planning and Consumer Standards, & Office of Rulemaking. (August 2003). *Final Environmental Assessment of the Dual Fuel Vehicle CAFE Credit Incentive.* US DOT. Retrieved December 26, 2006, from http://dmses.dot.gov/docimages/pdf90/298455_web.pdf.

percent of the vehicles sold in the nation.[275]

Brazil's success in producing sugar cane-derived ethanol could offer some lessons for Hawaii. The Brazilian government provided three important initial drivers that encouraged changes in both infrastructure and consumer practices: (1) the Brazilian government guaranteed that the state-owned oil company, Petrobras, would purchase domestically produced ethanol; (2) the government provided low-interest loans for firms interested in investing in agro-industrial ethanol production; and (3) the government fixed fuel prices to ensure that the at-the-pump price of hydrous ethanol was 59 percent of the price of gasoline.[276]

6.1.2.4 Plug-in Hybrid-Electric Vehicles (PHEVs)

The plug-in hybrid-electric vehicle (PHEV) is a promising technology that is experiencing a high level of market interest. PHEVs are a close cousin of HEVs. As their name suggests, PHEVs are designed to be plugged into electric outlets for charging their battery packs, which have a greater capacity and which give them battery-only driving ranges of between 20 and 40 miles (or more). The onboard ICE is used to charge the batteries should a longer trip be necessary. Since the average vehicle trip is less than 14 miles,[277] PHEVs are capable of using electricity while reducing oil use for a sizable portion of their operation.

Typical PHEV operation involves charging the batteries at night for use in driving during the day. One implication is that a high market penetration of PHEVs would result in an increase in off-peak electric utility load. Estimates from transportation analyses and E2020 modeling suggest that 140,000 PHEVs on Oahu in 2025 would add approximately 190 GWh per year to the nighttime load under a constrained supplies scenario.

In addition, PHEVs have the potential to supply energy to the grid, which can supplement conventional utility electric generation capacity and provide electric system services such as peak reserve capacity. The ability of this vehicle technology to "cross-over" into the electricity supply sector could potentially transform the way suppliers provide power, through other promising applications such as firming intermittent renewable electric energy resources. Fully realizing the potential applications of PHEVs in the electricity generation sector, however, will require substantial infrastructure investment in the form of grid discharging stations, and communications and metering advancements for both the vehicle and the grid.

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[275] Polk Automotive Profiles (2006). Vehicle sales data for 2005 prepared for RMI. www.claritas.com/claritas/Default.jsp?ci=3&si=1&pn=polkauto.

[276] Goldemberg, J., Coelho, S.T., Nastari, P.M., & Lucon, O. (2004). Ethanol Learning Curve – the Brazilian Experience. *Biomass & Bioenergy*.

[277] US DOT. (2005). *Highway Statistics 2005*. Federal Highway Administration. Retrieved December 21, 2006, from www.fhwa.dot.gov/policy/ohim/hs05/index.htm.

6.1.2.4.1 Challenges

The viability of PHEVs hinges considerably upon the performance and cost of battery technology. Research and development of advanced battery technologies have been driven primarily by the increasing popularity during the last two decades of portable computing and digital electronic devices such as cell phones and cameras. The cost of PHEVs is high at present, in large part due to the cost of the batteries.

At present, the two types of batteries showing the greatest potential in electric-drive vehicle applications such as PHEVs are nickel-metal hydride (NiMH) and lithium-ion (Li-ion) batteries. With an energy density (about 60 watt-hours per kilogram) and a cycle life (about 600 full charge/discharge cycles and hundreds of thousands of partial discharge cycles) approximately twice that of conventional lead-acid (PbA) batteries, NiMH has been the technology of choice for advanced automotive powertrains. It is also the battery used in Toyota's HEV *Prius*. These parameters are critical for the automotive and industrial sectors, as safety, weight, volume, and cycle life are all key product drivers for profitability and market acceptance.

Lithium-ion batteries appear to be the next step forward in energy storage technology development. Li-ion batteries' high energy density and minimal weight make them extremely popular for use in personal electronic devices. Currently, there is a global race to bring to market a high-voltage, lithium-based energy storage solution for both mobile and stationary applications. The progress looks promising. In 2006, Tesla Motors introduced the fully electric Tesla Roadster, a sports car using lithium-ion batteries that is aimed at the luxury vehicle market.[278] Tesla plans to introduce a line of passenger cars comparable in price to high-end Lexus, Mercedes, and BMW products in 2008.

6.1.2.5 Hydrogen Vehicles

There has been great interest in using hydrogen to provide energy for both transportation and electricity generation in Hawaii. One of the fundamental barriers to the practical adoption of a hydrogen economy is that hydrogen by itself is not a fuel, but rather an energy carrier like electricity. As such, other fuel inputs, such as reformed natural gas and electrolyzed water, are needed to supply hydrogen for use in fuel cell vehicles as well as stationary fuel cells.

In Hawaii, a number of pathways have been examined as being feasible for producing hydrogen: electrolysis of water using renewable energy from geothermal or wind technology and gasification of biomass or liquefied natural gas (LNG) fuels.[279] Either of these pathways is less direct, and thus less efficient, than the direct conversion of fuel or renewable energy into electricity to power PHEVs, or the direct use of biomass or natural

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[278] This high-performance PHEV can accelerate from 0–60 mph in about 4 seconds and the vehicle body is based on the Lotus and costs about $80,000–$100,000.

[279] Hawaii Natural Energy Institute and Sentech, Inc. (2002). *Nurturing a Clean Energy Future in Hawaii: Assessing the Feasibility of Large Scale Utilization of Hydrogen and Fuel Cells in Hawaii*. Prepared for State of Hawaii Department of Business, Economic Development & Tourism (DBEDT). Final Report.

gas in vehicles.

Figure 38. Alternative Transportation Energy Pathways, Hydrogen versus Electric Battery[280]

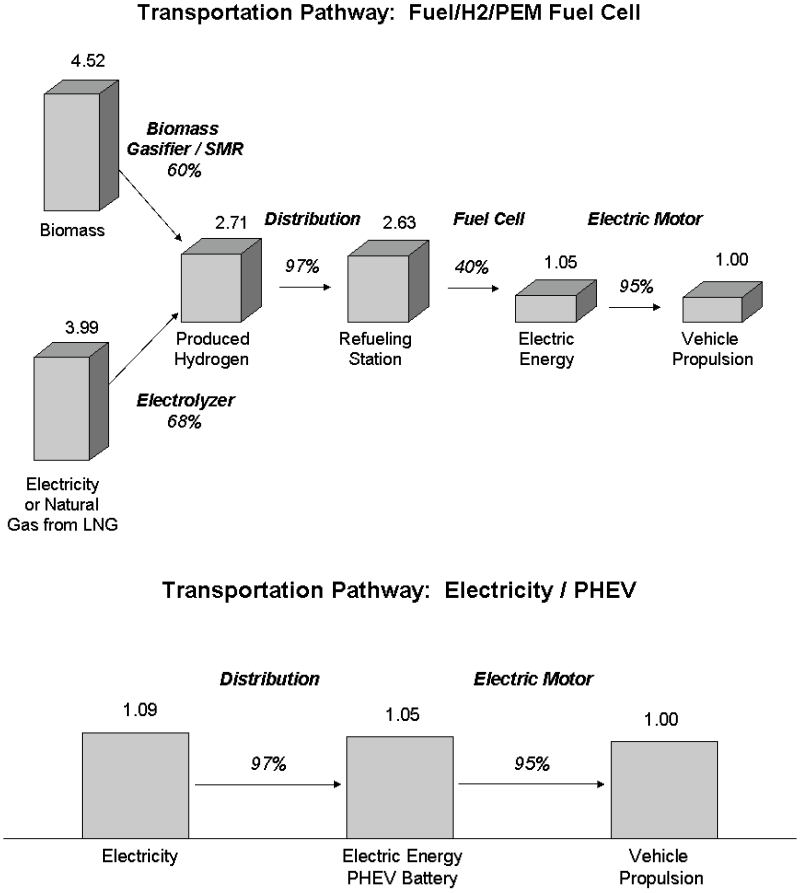


Figure 38 compares the energy pathways of fuel cell vehicles versus PHEVs. While a fuel cell is more efficient than a conventional internal combustion engine (ICE) that burns gasoline or diesel,[281] the electrolysis of water to produce hydrogen for fuel cells is much less efficient than the direct charging of batteries for PHEVs. A PHEV battery can be charged with 90 percent efficiency from electricity delivered via the grid, for an overall delivery pathway that is 80–88 percent efficient, including grid losses. A fuel cell, on the other hand, uses hydrogen made at 60–75 percent conversion efficiency in an electrolyzer from grid electricity delivered at 90–97 percent efficiency. Add to that a 40–50 percent efficiency in converting hydrogen *back* to electricity to power the vehicle's

[280] Hawaii Natural Energy Institute and Sentech, Inc. (2002). *Nurturing a Clean Energy Future in Hawaii: Assessing the Feasibility of Large Scale Utilization of Hydrogen and Fuel Cells in Hawaii*. Prepared for State of Hawaii Department of Business, Economic Development & Tourism (DBEDT).

[281] An ICE engine itself is about 20% efficient while a fuel cell is about 40% efficient. Source; Hawaii Natural Energy Institute and Sentech, Inc. (2002). *Nurturing a Clean Energy Future in Hawaii: Assessing the Feasibility of Large Scale Utilization of Hydrogen and Fuel Cells in Hawaii*. Prepared for State of Hawaii Department of Business, Economic Development & Tourism (DBEDT). Final Report. Appendix D.

electric motor and the result is an overall delivery pathway that is only about 25 percent efficient.

A second family of pathways studied for hydrogen includes the gasification of biomass and the use of reformed LNG. There are not enough indigenous biomass resources to produce both liquid biofuels and gasification for hydrogen production in the state. These two economic pathways for the state's biomass resources are thus mutually exclusive. The relative cost of developing a hydrogen economy compared to a biofuels economy depends on the relative cost of the distribution infrastructure for hydrogen compared to the distribution infrastructure for biofuels. The relative use of LNG reformation depends on the viability of the LNG market in Hawaii, as discussed in section 4.2.4 of this report.

The lower technical performance parameters of storing energy in the form of hydrogen for fuel cells in comparison to battery electric storage for PHEVs, the lack of widespread market adoption of fuel cells to date compared to the level of adoption of HEVs, and the imminent commercialization of PHEVs all suggest that PHEV technology is likely to be more viable than hydrogen technology for Hawaii in the foreseeable future.

6.1.3 Land Use Planning and Urban Design

In Hawaii, righteousness perpetuates the life of the land. Land use planning and urban design characterized by attention to environmental goals like preserving open spaces and critical habitats, and reducing greenhouse-gas (GHG) emissions and petroleum consumption can be a comprehensive and effective means of reducing vehicle-miles traveled. Additionally, it can support the preservation of Hawaii's unique natural environment. Smart land use planning makes particular sense for Hawaii because of the state's already limited land area. These benefits accrue not only to urban areas but suburban and rural areas as well. On islands neighboring Oahu in particular, inattention to land use planning has resulted in significant traffic congestion and unhappy residents over the last few years.[282]

Carefully planned land use development provides a strategy that encourages walking and biking, the redevelopment of brownfields, the reduction of urban sprawl, and the reduction of rainwater runoff through practical and intelligent design. No cookie-cutter approach exists for smart development, however many developers implement it by emphasizing in-filling of town centers and the integration of multiple building uses—such as combining commercial and residential space in the same area. If urban environments are well designed almost everything residents need (work, health care, education, shopping, restaurants, parks, entertainment, etc.) would be easily accessible without personal vehicles.

As the population soars, careful planning could also help preserve coastlines and other natural areas that might otherwise be lost to development. The State of Hawaii could create guidelines for growth management and provide funding incentives for local

[282] Pacific Business News, December 2007. *Neighbor Island seething not a surprise.*

governments that adopt land use planning for all new developments.

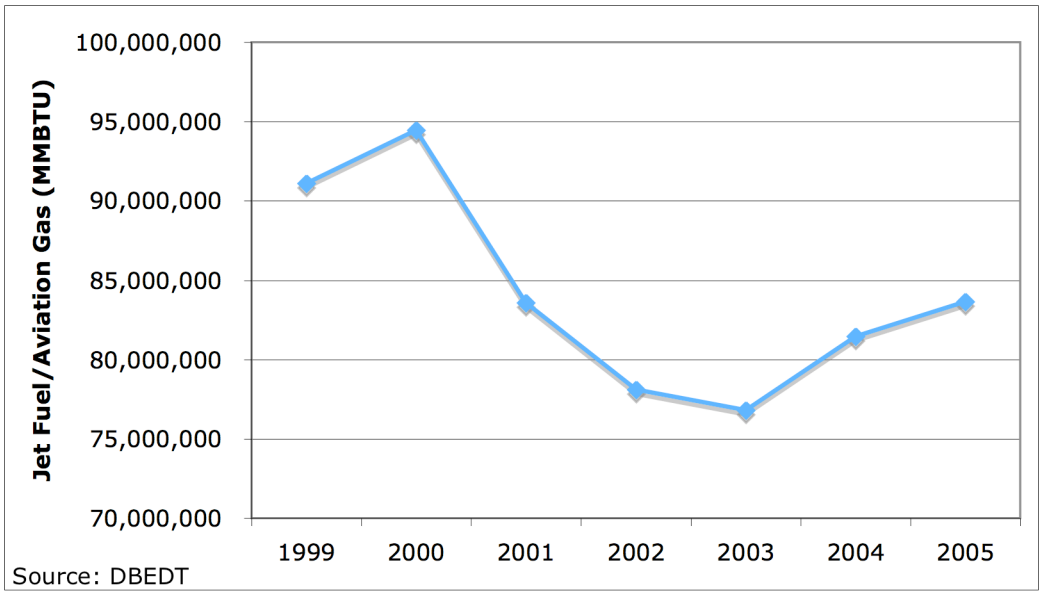
6.1.4 Aviation and Marine Vessels

Aviation makes up the largest share of transportation fuel consumed in Hawaii, and represents 50 percent of total transportation fuel demand in 2005. Improved aircraft efficiency could play a big role in reducing Hawaii's oil use, because nearly every person traveling to Hawaii from overseas and between the islands travels by air. Unfortunately, there is little that the State itself can do to materially improve the overall efficiency of airline operations, given that Hawaii represents an insignificant market for most airlines.

On the other hand, the airlines themselves have an inherent self-interest in greater efficiency. In 2005, Hawaiian Airlines reported that fuel accounted for 25 percent of its operating costs, up from 15 percent in 2003. The company noted that, "Further increases in jet fuel prices or disruptions in fuel supplies…could have a material adverse effect on our…operations, financial position or liquidity."[283]

In addition to the critical role of the aviation sector in connecting the islands to the mainland United States and international destinations, air travel is currently the most common way of commuting between the islands. In 2006, Mesa Air entered the inter-island market, joining Aloha Airlines, Hawaiian Airlines, and Island Air in providing regularly scheduled intrastate service. Between 1999 and 2005, aviation fuel consumption actually fell at a rate of -1.4 percent over this period, despite rebounding in 2004 and 2005, whereas marine fuel use grew at 1.4 percent.[284]

Figure 39. Statewide Air Transportation Fuel Consumption

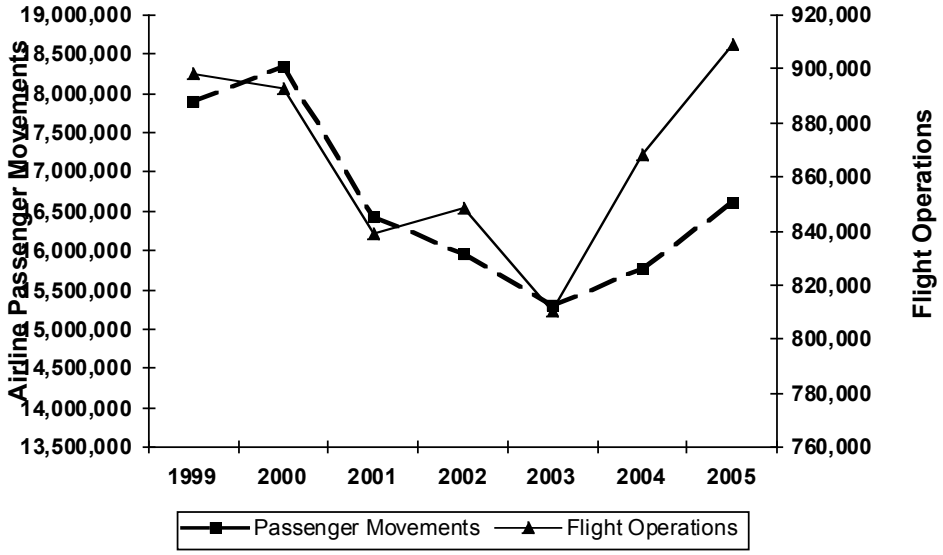


[283] Hawaiian Airlines. (2005). 2005 Annual Report.

[284] Compounded annual growth rates.

Furthermore, as Figure 39 indicates, demand for aviation fuel gradually declined between 2000 and 2003, and then experienced a recovery in 2004 and 2005. This mirrors the trends in passenger movements and flight operations as depicted in Figure 40.

Figure 40. Statewide Flight Operations and Airline Passenger Movements[285]



Efficient operations have consequently become a priority for airlines. Load factors have increased considerably. For instance, as of the writing of this report, Hawaiian Airlines was reporting an 89 percent load factor, and U.S. carriers were reporting a combined 79 percent load factor.[286] Additional load factor increases could possibly come at the expense of frequency and route options, and hence, competitiveness.

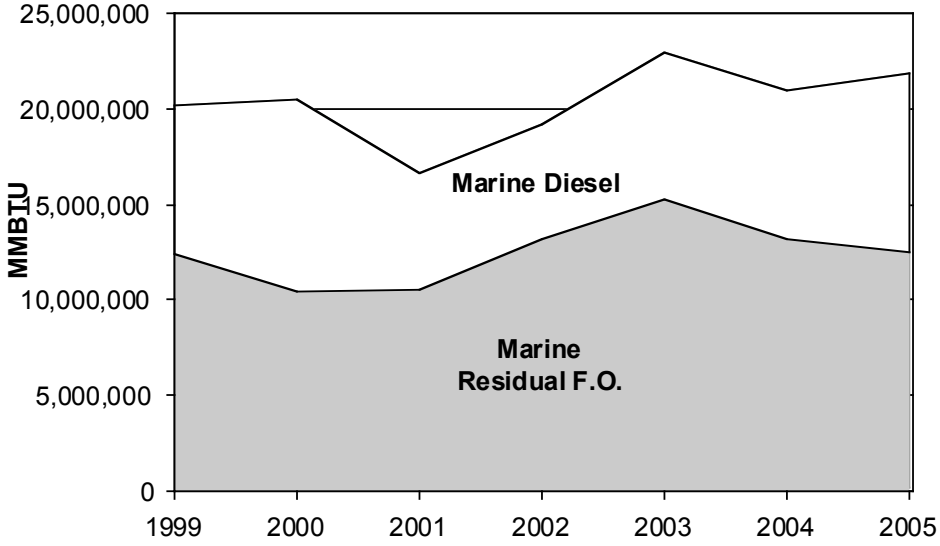
The purchase or leasing and use of more efficient aircraft represents a major opportunity to reduce fuel consumption. Here, limited opportunities may exist to encourage such investments through state-level policies. For instance, Hawaii could explore implementing differential landing fees based upon aircraft fuel efficiency.[287] However, the majority of policy options to encourage investment in newer, more efficient aircraft, such as dedicated financing for fleet restructuring, must take place at a national level.

[285] Hawaii, Department of Transportation. *State of Hawaii Airport Activity Statistics.*

[286] U.S. DOT Bureau of Transportation Statistics. *U.S. Air Carrier Traffic Statsitics*. U.S. Carrier data retrieved 17 January 2007 from www.bts.gov/xml/air_traffic/src/index.xml and represents the 12-month period ending in September 2006. Hawaiian Airlines data retrieved 17 January 2007 from www.transtats.bts.gov/carriers.asp and represents the 12-month period ending in October 2006.

[287] State of Hawaii. DBEDT. Hawaii Energy Strategy, 2000.

Figure 41. Statewide Marine Transportation Fuel Consumption



Inter-island marine shipping is analogous to interstate trucking on the mainland, pipelines, and railroads. Inter-island vessels, primarily towed by barges, transport most of Hawaii's cargo between islands. Transportation of cargo from the mainland and overseas is primarily by ship. The only alternative is air cargo, with its inherent cost and limits on weight and bulk. Air cargo is primarily used for high-value, time-sensitive, or perishable items. Figure 41 shows that marine fuel consumption has remained relatively stable, with some fluctuations. Between 1999 and 2005, the consumption of residual fuel oil grew at a compounded annual growth rate of 0.2 percent, and the consumption of diesel grew at 3.1 percent. Total marine fuel consumption grew at 1.4 percent.

Biofuels can also be used in certain instances to reduce petroleum use in the marine sector. Marine vessels refueling in Hawaii consume 65 million gallons of diesel every year.[288] Marine vessels that run on diesel fuel could be operated on biodiesel blends or converted to 100 percent biodiesel (B100) if the fuel is cost-competitive.

6.2 Recommendations for Achieving Greater Sustainability in Hawaii's Transportation Sector

To reduce the Hawaii's reliance upon oil for transportation, the State should implement policies that encourage efficiency and the substitution of oil with alternative fuels. For instance, enhanced public transit, smart growth, and incentives to reduce vehicle trips can help reduce total vehicle-miles traveled (VMT). Furthermore, policies can help guide consumers when purchasing new vehicles. As noted earlier, consumers tend to pay little attention to future fuel savings. Policies that help more strongly signal the benefits of future fuel savings by reducing the purchase price can encourage consumers to choose

[288] State of Hawaii Department of Business, Economic Development, and Tourism (DBEDT). (2005). State of Hawaii Data Book. Retrieved December 26, 2006, from www.hawaii.gov/dbedt/info/economic/databook/db2005/.

more efficient vehicles. To reduce diesel consumption, fleet operators, including the State, need policies that increase the demand for petroleum-saving technologies.

The State should pursue policies that:

- Work through the market;
- Are revenue neutral;
    - Policies that are not revenue neutral should:
        - Show clear links between the cost of the policy and the reduction in fuel consumption; and
        - Offer comparable reduction in other taxes so the net tax burden due to any tax increase is relatively unchanged;
- Drive innovation without prescribing technologies (e.g., performance targets for fleet operators);
- Have broad political appeal;
- Leverage alternative fuels and demand-reduction opportunities; and
- Provide a model for other states, and for federal action.

6.2.1.1 Continue to Implement Existing State Fleet Efficiency

In 2006 the State Legislature passed Act 96, which amended Chapter 196 and Chapter 103D, HRS to promote renewable energy and energy efficiency for State facilities, motor vehicles, and equipment. Implementation of these measures will reduce Hawaii's foreign oil dependence.

The primary intent of Chapter 196 is to reduce its dependence on imported fossil fuels. Act 96 amended several parts of Chapter 196, including the State's fleet purchasing requirements. The major changes included requiring that all agencies purchase alternative fuel and fuel efficient vehicles, and that they purchase alternative fuels and ethanol-blended gasoline when available.

Act 96 also amended the vehicle procurement code, Chapter 103D-412, HRS. The major changes included requiring increasing percentages of fleet purchases of light vehicles to be energy efficient.[289] For the fiscal year beginning on July 1, 2006, at least 20 percent of light-duty vehicles for each fleet were to be energy-efficient; for the fiscal year beginning on July 1, 2007, the percentage is 30; and the fiscal year beginning on July 1, 2008, it is 40 percent. Subsequent fiscal year purchases are to increase by 5 percent per year until they reach 75 percent.

The Act also allows the procurement requirements to be offset by successfully demonstrating improvements in overall light-duty vehicle fleet fuel economy, as well as by biodiesel substitution.

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[289] Alternative-fueled vehicles, electric vehicles, hydrogen vehicles, hybrid electric vehicles, and efficient conventional vehicles (found on the list of "Most Energy-Efficient Vehicles" in its class or is in the top one-fifth of the most energy-efficient vehicles in its class available in Hawaii as shown by vehicle fuel efficiency lists, rankings, or reports maintained by the U.S. EPA) are all considered to be "energy-efficient" vehicles defined within the Act.

Recommendation: All responsible agencies, including state motor vehicle fleet operators, should continue ongoing work to meet the new state vehicle and fuel procurement laws.

6.2.1.2 Implement Feebates to Encourage Purchases of Efficient Vehicles

Feebates are intended to increase the number of efficient vehicles purchased in Hawaii by providing a continuing incentive to improve fuel economy. Feebates provide a financial incentive or assess a fee on each new vehicle upon registration depending on the gallons per mile the vehicle achieves. The feebate could help accelerate the sales of more energy-efficient vehicles because it affects the purchase cost of a vehicle while simultaneously preserving customer choice as to the type and class of vehicle. Modeling shows that feebates have the potential to reduce annual gasoline consumption in Hawaii by 30–60 million gallons by 2025, or cumulatively by 300–400 million gallons between 2006 and 2025.

The ideal feebate is revenue-neutral and size-neutral. This type of feebate would revolve around a fuel-economy benchmark called a "pivot point" for each size class of vehicle. The preferred pivot point metric is measured in gallons per mile (GPM). The pivot point would determine whether a vehicle received a rebate or was assessed a fee, thus it would also determine the revenue neutrality of the policy.

The size classes could coincide with the size classes that have already been established under CAFÉ, or could be new size classes that are based on the vehicle's rectangular shadow (calculated by multiplying the length of the vehicle by the width of the vehicle). Ideally, there would be new size classes designed that would be broader than current CAFÉ standards, thus creating fewer size classes. Fewer size classes are preferred because they are not as susceptible to manipulation because it is more difficult for manufacturers to move up to a different size class (that would have a different GPM pivot point).

Within a given size class, buyers of vehicles that exceed the pivot point would receive a rebate, while buyers of vehicles that are below the pivot point would pay a surcharge. A typical feebate design applies a $1,000 fee (or rebate) for each 0.01 (GPM) difference between a vehicle's fuel economy and the target fuel economy. The mathematical equation for this feebate design is as follows:

Fee or Rebate[290] = $1,000 x GPM (target) - GPM (efficient))/0.01

For example, in the midsize SUV class, a typical feebate might be $1,000 per 0.01 gallons per mile (GPM) with a target fuel economy of 23 miles per gallon. Thus, a Nissan *Pathfinder* getting 18 miles per gallon (1/18 mpg = 0.056 GPM) is 0.13 GPM worse than the target, so the *Pathfinder* incurs a $1,300 fee. Ford's new *Escape* hybrid SUV gets 36 mpg, or 0.028 GPM (0.015 GPM better than the target fuel economy), so it would earn a $1,500 rebate.

[290] Greene, D.L., Patterson, P.D., Sing M., & Li, J. (2004). "Feebates, Rebates and Gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy," *Energy Policy*, vol. 33, no. 6, pp. 721-827.

Based on our modeling in the constrained scenario with feebates, accelerating the sales of more efficient and ultra-efficient next-generation vehicles increases the average efficiency of the vehicle stock from 30 mpg by 2025 to more than 40 mpg, and reduces gasoline consumption by 7 percent annually compared to the constrained scenario without feebates. This is in addition to the efficiency gains that will be encouraged by high fuel prices experienced under the constrained supplies scenario. Additional reductions in gasoline consumption are even greater under the adequate supplies and commodity cyclic scenarios, where—with feebate policies in place—consumption is estimated to decline by an additional 9 percent beyond the fuel price stimulus.

Figure 42. Annual Consumer Savings From Gasoline Reduction Due to Feebates

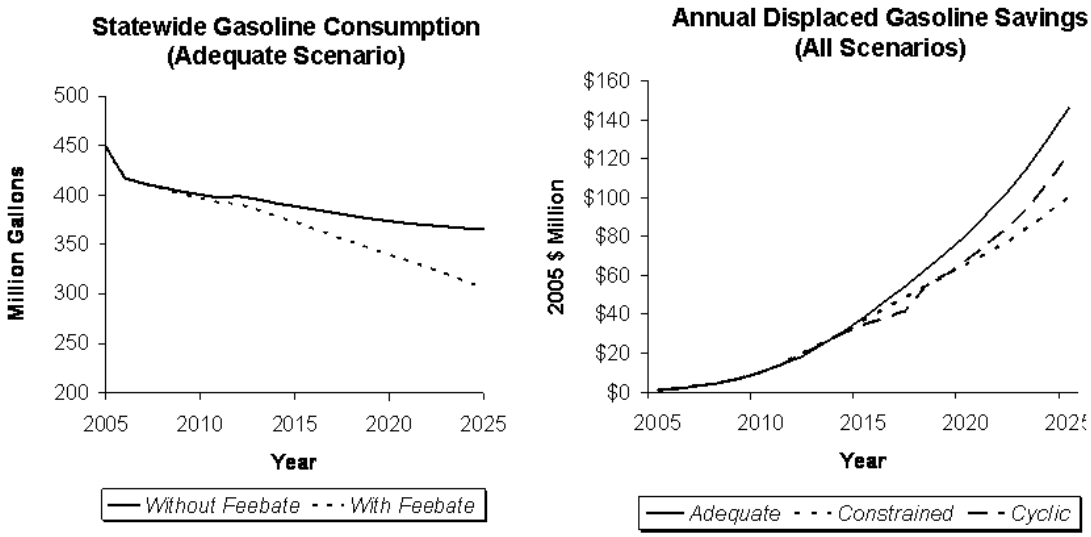

Figure 42 estimates the cost savings to consumers from reduced gasoline consumption, resulting from a feebate policy for light cars and trucks. By 2012, feebates are estimated to generate approximately $19 million annually in fuel cost savings for consumers. By 2025, these additional savings increase almost five-fold to $145 million under the adequate supplies scenario, $122 million under the commodities cyclic scenario, and $100 million under the constrained supplies scenario. The incremental savings under the constrained scenario are muted because high fuel prices under this scenario stimulate the adoption of more efficient and next-generation vehicles.

One problem in implementing the feebate is that the revenue-neutral, size-neutral feebate may be pre-empted by the Energy Policy and Conservation Act, which forbids states from adopting their own fuel economy standards. In 1992, Maryland passed a feebate that was based on the fuel economy rating of new vehicles sold, in addition to requiring that the savings/additional tax be recorded on the window label for consumer ease. This practice resulted in Maryland's feebate being struck down based on the labeling preemption under the Energy Policy and Conservation Act.[291]

[291] Chanin, Rachel, *California's Authority to Regulate Mobile Source Emissions.* NYU Annual Survey of American Law Vol 58:699:2003 p735.

However, the pre-emption challenge did not discuss the broader issue of whether the Maryland feebate was "related to" regulating fuel economy. Thus, in order to implement a feebate based on a pivot point determined by GPM, states will need to prove that feebates do not "relate to" fuel economy. Recent Supreme Court rulings indicate that the Court has been moving toward a more narrow interpretation of "related to."[292] This is significant because it shows the Court is leaning toward granting states more leeway to adopt policies, as long as the states' policies do not hamper federal policy goals. Also, the Court has begun taking into account the degree to which states' programs reflect traditional areas of state activity.

The National Highway Traffic Safety Administration (NHTSA) is responsible for establishing and amending fuel economy regulations. NHTSA is the agency that could grant exemptions from the Energy Policy and Conservation Act. Another option is to ask the Governor of Hawaii to request NHTSA to provide the State with an administrative exemption to the federal pre-emption in Title 49. Yet another option is to ask Hawaii's U.S. Congressional representatives to introduce federal legislation to create a national-level feebate.

A final option is to adopt a feebate that is not based on a GPM pivot point, and instead base the law on weight. This type of feebate structure was passed into law in Washington DC on 7 December 2004. Washington DC's City Council approved the Motor Vehicle Reform Act, which raised the excise tax on vehicles weighing more than 5,000 pounds and simultaneously eliminated the excise tax on clean-fuel and electric vehicles in the District of Columbia.[293] The Act also raised the registration fee on vehicles weighing more than 5,000 pounds and reduced the registration fee on clean-fuel and electric vehicles. No pre-emption challenges were raised. A similar feebate structure was introduced during the 2006 Hawaii legislative session, but it did not pass.

All four options present implementation challenges. The first option (getting NHTSA to grant an exemption from CAFE standards) requires passing legislation that may be pre-empted and potentially ignite a legal battle. This may be time-consuming and expensive. The second option, petitioning the Governor, may also be time-consuming and it may require the same legal arguments (i.e., that the feebate does not prohibit efficient and proper administration of the CAFE standard) be made to NHTSA. The third option, asking Hawaii's U.S. Congressional representatives to craft federal legislation, will require support from automobile manufacturers–which will also be time-consuming and difficult. The final option, adopting a feebate-like structure that will not be pre-empted, is a step in the right direction, but it does not contain the important characteristic of promoting consumer choice. Instead, it creates a preference for the purchase of small lightweight vehicles, which may reduce petroleum consumption rather than reward

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[292] The phrase "related to" was explained by the Court in *Morales v. Trans World Airlines,* 504 U.S. 374, 384 and cases cited (1992). Since *Morales,* the Court has shifted to a more narrow interpretation of what constitutes pre-emption, see *California Division of Labor Standards Enforcement v. Dillingham Construction*, 519 U.S. 316 (1997); *Engelhof v. Engelhof,* 532 U.S. 141 (2000).

[293] As determined by the United States Internal Revenue Service to be eligible for a federal tax deduction or credit pursuant to 26 U.S.C. §§ 30 and 179A.

customers for choosing the most efficient vehicle within the customer's desired vehicle class (passenger vehicles versus SUVs versus light trucks, for example).

Recommendation: The Administration should consider submitting a bill to the Legislature establishing a feebate based on a GPM pivot point. It will allow for the creation of a policy that has the ability to significantly reduce the state's dependence on oil for transportation purposes. Additionally, once current legal challenges around the nation have been worked out, and a path is chosen for feebate implementation, feebates should also be considered for medium and heavy trucks.

6.2.1.3 Coordinate Transportation System Development With Land Use

One of the most important recommendations that can be made in regard to transportation policy is to coordinate land development with the development of appropriate transportation infrastructure, including pedestrian and bicycle infrastructure, as well as public transit capability.

In Hawaii, each county has control over its land use laws and zoning.[294] It is crucial for the counties to consider transportation needs and infrastructure as development occurs. Without a coordinated development and transportation plan, a piecemeal strategy will emerge that may be more costly and will certainly be less effective in the long term.

Recommendation: When updating its General Plan, we recommend that each county's planning authority consider developing land and transportation infrastructure simultaneously in a cohesive manner.

6.2.1.4 Develop State Incentives for Efficient Vehicle Use

In the past, Hawaii offered incentives for electric vehicles, which were ultimately deployed only in small numbers. Currently, Hawaii does not offer incentives for the purchase of energy-efficient vehicles. Two incentives to consider for encouraging energy-efficient vehicles include allowing discounted or preferential parking for efficient vehicles, and allowing solo-operated energy-efficient vehicles to use the high-occupancy vehicle (HOV) lane.

Several major U.S. cities have begun offering free or discounted public parking to the owners of energy-efficient or alternative-fuel vehicles, particularly hybrid vehicles. It is

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[294] The Kauai General Plan was last updated in November 2000 and is available online at: www.kauai.gov/Default.aspx?tabid=130. Maui is in the process of updating its General Plan. On January 10, 2007, Maui County released a Draft Countywide Policy Plan. The Draft Countywide Policy Plan and the General Plan from 1990 are available online at: www.mauicounty.gov/departments/Planning/gp2030/info.htm. Oahu has a General Plan and Development/Sustainable Communities Plans. There are eight planning areas, each of which develops a Development/Sustainable Community Plan. The General Plan applies to the entire county. Together, these plans guide the population and land use growth over a 20-year time span. The Oahu General Plan is available online at: www.honoluludpp.org/Planning/OahuGenPlan.asp. The Development/Sustainable Community Plans are available online at: www.honoluludpp.org/planning/DevSustCommPlans.asp. The Hawaii County General Plan was last updated in February 2005 and is available online at: www.hawaii-county.com/la/gp/2005/main.html.

a useful tool for creating incentives for consumers to purchase more efficient vehicles. However, it is important when crafting the policy to establish a sunset date, which would occur when the projected number of efficient vehicles is too large to continue offering free parking.

An alternative to offering free parking to energy-efficient vehicle owners is to offer designated parking spots that still require payment. This means the counties do not lose parking revenue, and an incentive for people to purchase more efficient vehicles remains.

The State can also create incentives by changing laws to allow owners of efficient vehicles to use high-occupancy vehicle lanes, regardless of the number of people in the vehicle. Prior to 10 August 2005, federal law preempted potential changes in State law to allow hybrid vehicles with single occupants in the HOV lane. However, President Bush eliminated the provision forbidding efficient vehicles with solo occupants in HOV lanes when he signed the Transportation Equity Bill into law. Thus, the law currently allows states to regulate when and where hybrid vehicles are exempt from the HOV restrictions.

Recommendation: The Department of Transportation should consider conducting a study regarding the fiscal effects of allowing energy-efficient vehicles to use public parking for free or at a discount, and the feasibility of designating energy-efficient vehicle parking spaces. Additionally, the study may want to address the feasibility of allowing energy-efficient vehicles in HOV lanes, as well as the times at which the vehicles should be allowed to use the lanes.

6.2.1.5 Promote Adoption of Efficient Trucks

Among efficient technologies, hybrid trucks currently offer a substantial fuel savings opportunity. Today, a variety of models are entering the market. In diesel-electric hybrid trucks, the electric engine accelerates the vehicle and powers it at low speeds, and the diesel engine provides additional power needed to move the truck at high speeds. One advantage of hybrid trucks is that the diesel engine automatically turns off during loading, unloading, and waiting in line—all times when a conventional truck would normally be idling. Hauling distances in Hawaii are relatively short compared to the mainland, so trucks in Hawaii spend a greater percentage of their time idling during loading and unloading or in traffic than do many trucks on the mainland. This large reduction in idling time per trip means hybrid trucks could have a large impact on truck fuel consumption in Hawaii.

Recommendation: The Department of Health should evaluate and recommend program options to encourage the purchase and use of efficient trucks. Though hybrid trucks represent one of the most promising technologies, any legislative action should be performance-based, ensuring a focus on the efficiency objective without picking specific technologies as predetermined "winners." Potential policy options include a scrap-and-replace program, a low-interest loan program, or tax incentives or subsidies to encourage investment in efficient trucking technologies.

6.2.1.6 Create Incentives for Businesses to Promote Reduction of Petroleum Consumption

An option to reduce driving and the resulting congestion is to offer incentives to businesses that encourage their employees to telecommute, rideshare, use mass transit, and use alternative fuel in business vehicles. Businesses would be able to encourage employees to reduce transportation fuel use in many ways, including providing mass transit passes to employees. Hawaii could offer an income tax credit to businesses that reduces the total amount of petroleum transportation fuels used for commuting and business purposes by 20 percent (from an established baseline). The tax credit could be proportional to the petroleum savings achieved. The structure for the tax incentive would have to be developed in collaboration with the Department of Taxation to ensure that it would be within the State's budget.

Recommendation: The Department of Taxation should consider creating a Business Petroleum Reduction Tax Credit for proposal to the Legislature.

6.2.1.7 Improve Pedestrian and Bicycle Infrastructure

Creating pedestrian- and bicycle-friendly infrastructure is a simple way to encourage residents to walk or bike on shorter commutes. Many areas of the state do not have sufficient pedestrian- and bicycle-friendly infrastructure, such as pathways or bike lanes, thus residents do not feel safe walking or biking. Each county should take action in order to improve the pedestrian and bicycle infrastructure.

Recommendation: Counties should consider developing policies to support appropriate curb, sidewalk, crosswalk, and bike path infrastructure when planning new developments. We also recommend that this new infrastructure be integrated with any existing infrastructure to avoid the creation of piecemeal infrastructure that is ineffective in encouraging residents to walk or bike short distances.

6.2.1.8 Implement Pay-As-You-Drive Insurance

Typical automobile insurance rates are fixed, reflect poorly how many real-world miles a motorist drives, and fail to provide incentives for motorists to reduce the amount they drive. Usage-based automobile insurance, on the other hand, recognizes actual vehicle miles traveled (VMT) and reduces premiums for motorists who drive fewer miles. This type of insurance is also known as "pay-as-you-drive" insurance, and can be a powerful VMT-reduction tool as it offers a financial reward for eliminating unnecessary vehicle trips.

Various regions are taking steps to allow usage-based automotive insurance. Cities, states (Philadelphia, Oregon, Massachusetts, and Minnesota), and other countries (the United Kingdom, for example), realize the benefits of usage-based insurance. Studies show these benefits include a reduction in VMT by 10 percent, a 25 percent savings to motorists on their insurance premiums, and a 17 percent reduction in accidents.

Before a pay-as-you-drive insurance plan can be adopted, the State must grant insurers the authority to offer discounts based on miles traveled. This would allow companies currently offering usage-based auto insurance, such as Progressive Insurance and GMAC Insurance, to offer voluntary pay-as-you-drive insurance plans in Hawaii. Other automotive insurers might then be encouraged, through competition, to develop and implement usage-based insurance as well. Ultimately, participating drivers will be able to keep more money in their pockets when they drive less.

Recommendation: The State Legislature should consider passing a bill that will allow Hawaii insurance providers to implement voluntary pay-as-you-drive insurance programs for the motoring public.

6.2.1.9 Operate Honolulu's TheBus System on Alternative Fuel

Currently, there are bus systems in all of Hawaii's counties, with Oahu's bus system having the largest fleet, most routes, and highest ridership. The county of Hawaii's bus infrastructure was expanded in January 2006 through the purchase of an additional ten buses, bringing the county's total to forty. Maui also expanded its system by adding an additional commuter route in October 2006. Oahu's bus fleet currently has ten hybrid-electric buses and transportation officials plan to purchase forty additional hybrid-electric buses.

While these are steps in the right direction, there are no buses in Hawaii that operate on biodiesel. Many cities in the United States have begun operating their buses on B5, a mixture of 95 percent diesel and 5 percent diesel from renewable resources. Any diesel engine may operate on B5 with no adverse affects to the engine.

Additionally, because the buses are centrally refueled, the counties would only need to install one biodiesel refueling station. The benefits of running the buses on biodiesel include reducing Hawaii's dependence on foreign oil and reducing emissions.

Recommendation: The counties should consider assessing the feasibility of running their buses on biodiesel by comparing the cost savings resulting from the diesel that would be displaced with the cost of installing biodiesel-refueling infrastructure.

Energy efficiency is generally the most cost-effective means to increase energy sustainability in the State. An energy-efficiency resource standard (EERS) is "a simple, market-based mechanism to encourage more efficient generation, transmission, and use of electricity."[295] The EERS would require that the utility achieve reductions in demand through efficiency as a percentage reduction of gross electric sales, starting from a set baseline year. The DSM reductions would be quantified as megawatt-hours from the baseline year, using the Measurement & Evaluation (M&E) reports used for calculation of shareholder performance incentives. The gross electric sales would be the net electrical sales plus quantified DSM reductions.

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[295] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations*. *March 2006 (ACEEE Report EO63*. Washington DC: ACEEE, 2006.

HECO's recent IRP filing proposed an effective reduction of 0.6 percent of gross sales.[296] Therefore, based on its proposed IRP, HECO indicates that this level of DSM savings is achievable, assuming the programs are approved, and adequate funding is provided. As reported by American Council for an Energy Efficient Economy (ACEEE) in its 2006 study, independent, third-party administrators, such as Efficiency Vermont, as well as leading electric utilities, are achieving a one percent reduction in electrical sales each year.[8] Using 2006 as the baseline year, and a goal of a one percent reduction in electric sales per year for all utilities combined is a reasonable goal for energy efficiency.

A one percent reduction, using 2006 as a baseline, would result in a 20 percent reduction in electric utility companies' gross sales by 2026. This may be an achievable target for the utilities in Hawaii, based on current achievements of third-party administrators and leading electric utilities.[297] The Public Utilities Commissions in Texas, Nevada, Pennsylvania, and California have conducted rulemaking in 2004–2005 to create an EERS.

Recommendation: The State Administration should consider introducing a bill to the Legislature to establish an EERS with a goal of achieving a one percent reduction in energy sales annually, using 2006 as a base year, for all utilities combined. The EERS would require a cumulative energy-efficiency goal of 20 percent by 2020, statewide.

6.2.1.10 Create a Biofuel Refueling Infrastructure Tax Credit

The State should support development of E85 and B100 retail service stations (as well as B100 marine fuel stations). The State can draw on the experience of other states in providing either 15 percent tax credits or outright grants for service station conversion and construction.[298]

Though in-depth cost analysis has not been performed on the cost of a distribution system, most estimates converge at around $10 million for the first 40 million gallons per year.

Recommendation: The Legislature should consider passing an alternative-transportation fueling infrastructure tax credit, including working with retail and wholesale distributors, and using successful past State tax credits and other states' experience to determine the exact credit.

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[296] Hawaiian Electric Company (HECO), 2005. *Integrated Resource Plan, 2006–2025*. Honolulu: Hawaiian Electric Company, Inc.

[8] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006. (ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[297] Nadel, Steven. *Energy Efficiency Resource Standards: Experience and Recommendations. March 2006. (ACEEE Report EO63*. Washington, DC: ACEEE 2006.

[298] Several states offer tax credits for the installation of alternative fuel, refueling infrastructure. Florida offers a 75 percent tax credit on all capital, operation and maintenance, and research and development costs associated with the distribution of biodiesel and ethanol, with refueling station retrofits also qualifying for the credit. The Indiana Office of Energy and Defense Development administers a Biofuels Grant that offers funding for the installation of refueling infrastructure, with a fund-matching requirement of 50 percent.

6.2.1.11 Create a Tax Credit to Encourage Purchase of Flex-Fuel Vehicles and Necessary Fueling Infrastructure

Flex-fuel vehicles (FFV) can use varying mixes of up to 85 percent ethanol and 15 percent gasoline. Widespread use could significantly reduce oil use in the ground transportation sector. However, there is little use in purchasing this capability if the fueling infrastructure is not in place. This is often presented as a "which comes first, the chicken or the egg" problem. One way to address this is to simultaneously offer incentives for building fueling infrastructure to offer up to 85 percent ethanol blends and for purchase of FFVs.

First, a tax credit would be provided to FFV purchases on a first-come, first-served basis, with a maximum credit of $2,000 per vehicle. The FFV tax credit would be dependent on the presence of sufficient infrastructure, however. FFVs would receive a 50 percent credit when 10 percent of stations sell E85; that credit would increase linearly to 100 percent credit when 20 percent of stations sell E85.

Recommendation: Use vehicle choice modeling and vehicle sales data for Hawaii to quantify the effectiveness and cost of a vehicle purchase incentive. Making use of this information, State Representatives and Senators can work with the Department of Taxation to establish an effective Flex-Fuel Vehicle Tax Credit. Once the policy is in place, track its effectiveness.

6.2.1.12 Create a Distribution Infrastructure Investment Tax Credit

The delivery of biofuels to the end user is a crucial step in both the ethanol and biodiesel value chains, and it depends largely upon the availability of distribution infrastructure in Hawaii.[299]

Current biofuels subsidies in Hawaii are focused almost exclusively on the ethanol conversion process. Therefore, given the need for action by several distinct players, new subsidies and incentives should support the other parts of the bioenergy value chain. One of these incentives should be an investment tax credit for the transportation and storage of biofuels.

The main barriers to use of bioenergy at the distribution level is transportation from the location of the biofuel's production, as well as storage capacities for biofuels. There is a general geographic mismatch between the locations for optimal biofuel production on Maui, Kauai, and Hawaii and the demand for these fuels, primarily on Oahu. Ports on these islands are congested, and therefore the cost and ability to move biofuels through these facilities is unclear.

Hawaii should provide an investment tax credit for a portion of the building costs for biofuels storage facilities, pipelines, marine transport systems, and terminal

[299] Further detail on the distribution infrastructure subsidy is provided in the Hawaii Energy Policy Forum's report, developed in part by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195.

infrastructure. These assets must be developed by the private sector, and an investment tax credit will reduce the investment risk considerably.

Recommendation: The State Legislature should consider creating an infrastructure investment tax credit for a portion of the cost of installing bioenergy storage, pipelines, marine transport, and terminal infrastructure.

6.3 Conclusions

This chapter outlines steps that Hawaii can take to decrease transportation fuel consumption by using skillful planning, efficient technologies, and alternative fuels. Major recommendations include:

- Reduce the necessity for use of personal vehicles by installing mass transit and by using smart growth principles in new developments;
- Encourage consumers to purchase fuel-efficient personal vehicles including hybrid, PHEV, and electric models;
- Replace petroleum fuels with bio-derived alternative fuels like ethanol and biodiesel; and
- Improve the fuel economy of trucks.

As might be expected, there are barriers to implementing fuel-saving measures. Consumers do not accurately value fuel efficiency when purchasing new vehicles. Technology for PHEV and hydrogen-powered vehicles is not yet mature. Alternative fuels are not readily available, and manufacturers do not yet offer a wide variety of flex-fuel vehicles. Shipping companies do not have the capital to replace their inefficient truck, airplane, or ship fleets with more efficient models. These barriers need not impede progress; they are simply hurdles that Hawaii can overcome.

Prospects for reduced reliance upon oil in Hawaii's transportation sector are promising. The opportunities are not only technologically feasible, but they can also be readily implemented with the support of well-designed policy. The recommendations included in this chapter are designed to address the most significant barriers to reducing transportation-related fossil-fuel consumption. If Hawaii acts now, the state can become a leader and a model for efficiency and alternative fuels in transportation.

Chapter 7 Bioenergy for Electric Power and Transportation

The term "bioenergy" refers to useful energy derived from biomass and the energy products that can be made from it. Table 16 summarizes potential sources of bioenergy in the state, as well as the various biofuels and biogas products that can be derived from them. A robust bioenergy industry could offer significant economic benefits to Hawaii by helping to reduce the state's dependence on high-cost imported energy, supporting the agriculture industry, and improving energy security.

Table 16. Biomass Sources and Derived Products[300]

Biomass can be:		
Biomass crops—crops grown primarily for the production of energy	Agricultural and animal residues and wastes including bagasse, wood chips, macadamia nut shells, manure	Municipal solid waste (MSW) including trash and garbage, landfill contents, and waste cooking oils
Which can produce:		
Biofuels—liquid or gaseous fuels produced from biomass including ethanol, methanol, bio-oil, biodiesel, and hydrogen. Biofuels may be used for electricity production or as transportation fuels.		
Biogas—includes landfill and sewage-based digester gas that can be used for electricity production or for transportation fuel. Conversion technologies include gasification (biomass crops, agricultural and municipal wastes) and anaerobic digestion.		
Biomass power for electrical generation—direct combustion of biomass.		

In terms of transportation, Hawaii has enough available land to produce the biofuels required to meet the State's existing alternate fuel standard (AFS), based on our modeling results. However, demand for transportation ethanol is highly dependent on gasoline prices, which are high and very volatile. Consumers will generally not pay more for biofuel than for fossil fuel. Based on estimates of the cost of importing biofuel versus producing it in-state, Hawaii will not be able to cost-effectively meet the AFS without additional incentives under the modest ("adequate supplies") and cyclic oil price scenarios. In fact, the AFS targets are never met under the adequate supplies scenario, because there simply will not be enough alternatively fueled vehicles on the road to consume the amount of biofuels required by the goals. However, the AFS will be met under the constrained scenario through 2025 and cyclic scenario through 2018, due to higher fossil fuel prices.

In terms of electric power, biodiesel is more cost-effective than ethanol. Based on our modeling, biodiesel is always cost effective to import or produce in Hawaii and can be used for electric power generation, assuming that utilities co-fire existing power plants with up to 20 percent biodiesel. However, direct conversion of biomass for electricity generation is also likely to be a viable solution, assuming the appropriate power plants and infrastructure are available.

[300] RPS definitions relevant to biofuels, biomass, and biogas per Act 162, SLH 2006.

Whether Hawaii has sufficient water resources that can be reliably accessed to support biofuels production remains unclear. While rainfall may be adequate for some biofuels crops (particularly biodiesel and cellulosic crops) in some areas, irrigation will be required for economically viable sugar cane yields. Upgrades to existing irrigation infrastructure and new irrigation infrastructure are needed.

7.1 Expanding Bioenergy Supply in Hawaii

7.1.1 Benefits of Bioenergy to Hawaii's Economy

Due to Hawaii's isolation, expanding the bioenergy supply in Hawaii has increased significance and importance throughout the state. Importing or harvesting bioenergy grown within the state could increase the state's energy independence. It could also offer benefits to many sectors of the economy—including electricity generation, transportation, and agriculture—while increasing energy security and reducing negative impacts to the environment. These benefits and are discussed in more detail below.

7.1.1.1 Biofuels-to-Power

The two most common liquid biofuels, ethanol and biodiesel, can be used as substitutes for petroleum-based fuels in vehicle engines and oil-fired power generators. Ethanol can be used to replace naphtha in gas turbines and in combined-cycle units. A 10-million-gallon ethanol facility can potentially produce enough excess electricity to sell 1–2.5 MW[301] of renewable biomass power to the grid.[302] Therefore, ethanol can displace oil in power generation units in two ways—by serving as a substitute for diesel and naphtha, and by meeting demand for grid electricity through the on-site production of electricity via the burning of bagasse.[303]

Biodiesel can be readily blended with diesel in diesel-powered engines or boilers. The heat content and viscosity of biodiesel make it a suitable alternative for No. 2 diesel fuel. Maui Electric Company (MECO) currently uses biodiesel in its diesel engines to reduce particulate emissions during generator startup.

7.1.1.2 Biomass-to-Power

Sugarcane bagasse, used for the co-generation of heat and power, was Hawaii's primary renewable energy resource in 1980, contributing approximately 8 percent of the state's

[301] About 14,610 to 17,520 MWh, based on an 80 percent capacity factor.

[302] Assuming power is produced at a rate of ~300 kWh/ton of bagasse, and consumed at a rate of ~150 kWh/ton. The low end of this range is based on using sugarcane feedstocks, and the high end is based on using cellulosic feedstocks.

[303] Producing electricity from the burning of bagasse assumes that excess bagasse is not used to make ethanol through a cellulosic ethanol conversion process. Until cellulosic ethanol reaches commercialization, producing electricity is the most likely use of bagasse.

electricity generation. However, the supply of biomass power to the electric grid has declined with the closure of all but two sugar plantations.[304]

Biomass-fired power has low-to-zero net greenhouse-gas emissions and generally stable prices that can hedge volatile fossil-fuel prices. Additionally, biomass-fired power is firm.[305]

7.1.1.3 Municipal Solid Waste-to-Power

Municipal solid waste (MSW) and waste oils can be used for electricity generation. Furthermore, use of MSW and waste oils reduces the quantity and volume of solid waste that must be disposed of while simultaneously reducing the energy challenges facing all counties, including the City and County of Honolulu, where a H-Power waste-to-energy unit provides 46 MW of firm capacity generation to HECO. Waste oil is used in varying amounts on all of the major islands.

7.1.1.4 Biofuels in Transportation

Ground and marine transportation in the state accounts for almost 30 percent of all the energy consumed. Between 1995 and 2005, the estimated vehicle-miles traveled in Hawaii increased by 28 percent, exceeding the 7 percent rate of de facto population growth by a factor of four.[306,307] Expanding the use of biofuels such as ethanol and biodiesel could significantly reduce pressures on imported petroleum and, as in the electricity generation sector, reduce the state's exposure to rising and volatile petroleum energy prices.

7.1.1.5 Bioenergy Benefits to Agriculture

If Hawaii's bioenergy industry is based on locally grown crops, there are additional economic benefits, including the creation of jobs to grow, harvest, transport, and process the crops. Livestock manure can be converted to biogas,[308] with high-quality, low-cost organic fertilizer as a byproduct. Agricultural wastes, such as green trash and bagasse, can be converted into ethanol through a cellulosic ethanol conversion process. Byproducts from biodiesel feedstock processing and production such as glycerin and high-protein animal feed can create additional economic value. Additional byproducts include animal feed, which could also displace imported feed and support the expansion of the local livestock sector.

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[304] U.S. Department of Energy, Energy Efficiency and Renewable Energy (2006). *Biomass Program, Technology, Electrical Power Generation.* Washington DC. Retrieved November, 1, 2006, from www1.eere.energy.gov/biomass/electrical_power.html.

[305] Firm power is defined as electricity generation that is produced at a consistent and reliable rate.

[306] Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections.*

[307] Hawaii, Department of Business, Economic Development & Tourism, *State of Hawaii Data Book* (Hawaii: DBEDT, 1999-2005).

[308] Biogas is obtained from decomposing biological waste. It is usually composed of 50 to 60 percent methane.

7.1.1.6 Synergies in Security

Biodiesel processing systems can range in character from small, distributed, co-operative-based operations to large-scale, centralized facilities. This modularity can reduce risk and increase reliability of biodiesel production since processing systems can be diversified in ownership, feedstock source, and technology.

Building additional terminal capacity needed for biofuels will increase Hawaii's storage infrastructure, and additional production capability for ethanol will increase the quantity of indigenously sourced fuel. Both types of capacity allow the state to expand its fuel reserves in the event of a natural or man-made disaster that temporarily reduces petroleum supply. The use of both of these fuels, and related infrastructure development, will therefore enhance energy security.

Perhaps most significantly, the increased use of biomass for power generation and the production of biofuels from MSW, local agricultural and animal waste, and local dedicated crops will help reduce the state's reliance on imported fossil fuels.

7.1.1.7 Synergies in Protecting Environment

In addition to the benefits to air quality, including lower greenhouse-gas (GHG) and other pollutant emissions, biofuels are nontoxic and biodegradable, and can be used to enhance most parts of an ecosystem under certain conditions. For example, cellulosic ethanol could potentially be produced from less energy-intensive feedstocks such as fast-growing trees. Furthermore, many cellulosic crops, such as sugarcane and banagrass, are perennials, and therefore retain soil carbon and prevent soil erosion to a much greater extent than annual crops.[309]

Biofuels- and biomass-to-power processes can use waste resources such as paper, organic municipal waste, and used vegetable oil to produce energy, thereby reducing the quantity of material that must be landfilled. The use of biofuels and biomass for power production may improve air quality. Burning biomass emits less sulfur and less ash than burning coal, for example.[310]

The National Renewable Energy Laboratory (NREL) found that the use of B20 biodiesel reduced particulate matter emissions from diesel engines by an average of 25 percent compared over emissions produced from burning diesel fuel oil. However, nitrogen oxide emissions from biodiesel use are, on average, 3 percent greater than nitrogen oxide emissions from the use of diesel oil. For pure biodiesel, nitrogen oxide emissions were about 20 percent higher than diesel oil. Nonetheless, U.S. Environmental Protection Agency (EPA) analysis states that it may be possible to mitigate this increase, and

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[309] Downing, Mark, et al. Through Agriculture: Proceedings of a Conference. Center for Agriculture, Food and Environment, Tufts University. (November 1995). *Perennial Grasses for Energy and Conservation: Evaluating Some Ecological, Agricultural, and Economic Issues.*

[310] Bain, R., Kinoshita, C., Overend, R., & Turn, S. Journal of Energy Engineering. (December 1997). *Power Generation Potential of Biomass Gasification Systems.*

research is underway on strategies such as "using a lower-emitting base fuel for blending, adding acetane improver to the biodiesel blend, or determining what source or properties of biodiesel can be modified to lower nitrogen oxide emissions."[311]

7.1.2 Hawaii's Bioenergy Goals

The State of Hawaii's bioenergy policies, as reflected in statute, can enable the state to achieve a combination of energy, agriculture, environmental, and economic objectives:

- Energy: Reduce oil dependence, stabilize costs to consumers, and increase energy security through diversification of fuel sources and production of indigenous fuels;
- Agriculture: Preserve important agricultural lands, revitalize the rural economy, and contribute to economies of scale and infrastructure to support a variety of agricultural crops, including food crops;
- Environment: Protect the environment, foster sustainable agricultural production, and integrate biofuels and biomass and their byproducts into the agricultural sector; and
- Economy: Diversify the economic base and expand economic growth.

7.1.3 Hawaii's Bioenergy Objectives, Policies and Mandates, and Incentives

Hawaii is one of the nation's leaders in providing statutory objectives, policies, mandates and financial incentives for biomass and biofuels.

7.1.3.1 Objectives

As discussed in the introductory chapter to this Strategy, Hawaii has four primary objectives relating to energy, as established in Section 226-18, Hawaii Revised Statutes (HRS). The second of these four objectives, the most relevant to bioenergy, is increased energy self-sufficiency where the ratio of indigenous to imported energy is increased.

7.1.3.2 Policies and Mandates

Ethanol Mandate: In 1994, Act 199, Session Laws of Hawaii (SLH) 1994, set a 10 percent ethanol content requirement for gasoline. Following the creation of Administrative rules, which ultimately took effect in April 2006, it was required that at least 85 percent of the gasoline delivered to fleets and retail fuel stations in Hawaii contain include 10 percent ethanol.

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[311] Environmental Protection Agency. (October 2002). *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*. EPA420-P-02-001.

Alternative Fuel Standard: Act 240, SLH 2006, created an alternative-fuel standard (AFS) for the State, with a goal to provide 10 percent of highway fuel demand from alternative fuels by 2010, 15 percent by 2015, and 20 percent by 2020.

Renewable Portfolio Standard: Hawaii's Renewable Portfolio Standard (RPS), Chapter 196-41, HRS, requires that 20 percent of net electricity sales come from renewable energy by 2020, and includes biofuels as a renewable energy source. The RPS law also set milestones of 10 percent by 2010 and 15 percent by 2015. The requirement for electric utilities to meet the standard is expected to be an incentive to use biofuels for electricity generation.

7.1.3.3 State Incentives

The State of Hawaii offers a number of financial incentives to encourage biofuels production and use, including:

- Ethanol Facility Tax Credit: A tax credit is provided for the first 40 million gallons of ethanol production capacity in the state. Each qualified ethanol production facility between 500 thousand and 15 million gallons in capacity is eligible for up to 30 cents per gallon of nameplate capacity per year.[312]

- State and County Fuels Tax Reduction: State and county fuel taxes are reduced by a weighted average of $0.21/gal for ethanol and $0.26/gal for biodiesel.[313]

- State Biodiesel Procurement Preference: A $0.05/gal State government procurement preference is provided for biodiesel.[314]

- Business Investment Tax Credit: A high-technology business investment tax credit is provided for non-fossil-fuel energy research technologies.[315] The tax credit is for 100 percent of the equity investments in qualified high-technology business, over five years, up to a maximum of $2 million.

- Special Purpose Revenue Bonds (SPRB): The issuance of up to $50 million in SPRBs for a Kauai biomass-to-ethanol plant[316] and up to $59 million for a Maui biodiesel plant[317] are authorized.

[312] Up to a maximum of 100 percent of the investment. §235-110.3, HRS.

[313] §243-4, through 5, HRS.

[314] §103D-1012, HRS.

[315] §235-110.9, HRS, defines a high-technology business as: "A business, employing or owning capital or property, or maintaining an office, in this State; provided that (1) more than 50 percent of its total business activities are qualified research; and provided further that the business conducts more than 75 percent of its qualified research in this State; or (2) more than 75 percent of its gross income is derived from qualified research; and provided further that this income is received from products sold from, manufactured in, or produced in this State or services performed in this State."

[316] For issuance prior to June 30, 2009. Act 136, SLH 2000; extended by Act 139, SLH 2004.

[317] For issuance prior to June 30, 2012. Act 261, SLH 2007.

Based on feedback at the Hawaii Biofuels Summit,[318] these state incentives are necessary but not sufficient to address the market barriers to biofuels development in Hawaii.

7.1.3.4 Federal Incentives for Bioenergy

The federal Energy Policy Act of 2005 (EPACT 2005) created several tax credits for biofuels and biomass.

Federal Biofuels Tax Credit: Three major incentives for biofuels included in EPACT 2005 are, most notably, a $0.51/gal ethanol blender credit set to expire in 2010, a $1.00/gal agri-biodiesel credit that is set to expire in 2008, and a $0.10/gal production tax credit for small agri-biodiesel or ethanol producers, which will expire at the ends of 2008 and 2010, respectively.

Federal Biomass Tax Credit: EPACT 2005 also extended the renewable energy production credit, a per kilowatt-hour (kWh) tax credit for electricity generated with qualified energy resources. The credit applies to wind, closed-loop biomass, open-loop biomass, geothermal, small irrigation power (150 kW–5 MW), MSW,[319] landfill gas, refined coal, hydropower, and Indian coal.

Wind, closed-loop biomass, and geothermal are eligible for a 1.5-cents/kWh credit, adjusted annually for inflation, while open-loop biomass, small irrigation hydroelectric, landfill gas, MSW resources, and hydropower receive half of the annually adjusted amount. In 2005, the full credit was 1.9 cents/kWh and the half credit was 0.9 cents/kWh.[320] Finally, EPACT 2005 established a 20 percent investment credit for qualifying gasification projects in the taxable year in which the property is put into service.[321] Federal loan guarantees and grants are also available.

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[318] Rocky Mountain Institute. Prepared for State of Hawaii Department of Business, Economic Development, and Tourism. (September 2006). *Hawaii Biofuels Summit Technical Synopsis.*

[319] MSW is municipal solid waste. "Solid waste means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or an air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. Solid waste does not include solid or dissolved materials in domestic sewage, solid or dissolved materials in irrigation return flows, industrial discharges that are point sources subject to permit under 33 U.S.C. 1342, or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923)." Source: US Environmental Protection Agency (2006). *Summary of the EPA Solid Waste Program.* Washington D.C. Retrieved on November 1st, 2006, from: www.epa.gov/reg3wcmd/solidwastesummary.htm.

[320] As provided by the federal Energy Policy Act of 2005 (EPACT 2005), the credit period for open-loop biomass using agricultural livestock waste, geothermal, solar energy, small irrigation power, landfill gas, and trash combustion placed in service after August 08, 2005 is ten years. Generally, the owner of the facility is allowed the credit.

[321] EPACT 2005 explains that qualifying property includes the construction of a gasification project, and projects must employ gasification technology, which is defined as "any process [that] converts a solid or liquid product from coal, petroleum residue, biomass..." The aggregate amount of credits available is $350 million, after which the credit will expire unless more funding is appropriated. The application period for the first round of funding closed October 2, 2006. The 2007 funding application period began on October 3, 2006 and closes on October 1, 2007.

7.1.4 Potential Bioenergy Sources Available in Hawaii

7.1.4.1 Ethanol

Many studies have analyzed potential ethanol feedstocks in Hawaii, and most conclude that sugarcane is currently the most viable. It is easily fermentable, grows well in Hawaii's climate, and due to its long history in Hawaii, is a well-understood crop. Significantly, some sugarcane processing infrastructure and available acreage (see section 7.1.6) exists on most islands, even though sugarcane grown as an energy crop may require different growing and harvesting techniques.

Once cellulosic technology has been commercially demonstrated, other feedstocks, including agricultural residues, banagrass, and tree crops, can be used for ethanol production.[322] Banagrass was used as a representative cellulosic ethanol feedstock in modeling for this study.

7.1.4.2 Biodiesel

Currently, biodiesel in Hawaii is exclusively produced using waste vegetable oil collected from restaurants. However, expanded biodiesel production will require either the importation of oils or the use of dedicated agricultural crops. A recent survey by the Hawaii Agricultural Research Center[323] found significant potential in growing two oil crops: oil palm (*Elaeis guineensis*), "the best known source for vegetable oil in the world when considering oil content, site requirements, and available cultivars," and jatropha, which "can withstand less than optimal growing conditions, and can produce up to three harvestable crops per year with only minimal irrigation requirements." Oil palm trees and jatropha have expected yields of 760 and 300 gallons of oil per acre, respectively. Jatropha requires between two and three years to start producing oil, versus three to ten years for oil palm.

Other potential candidates include peanuts, castor beans (*Ricinus communis*), jojoba, Pongam trees (*Pongamia pinnata*), Ben-oil trees (*Moringa oleifera*) and microalgae.[324] For each of these plants, though, further research in controlled settings will be needed in order to assess yields, processes, and environmental impact.

7.1.4.3 Biomass combustion

As mentioned in section 7.2 , with oil prices at $45 per barrel or more, some biomass projects (e.g., MSW) are profitable with the current federal incentives and hence need no additional State subsidies. Dedicated biomass projects (i.e., with crops planted

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[322] BBI International Consulting (November 2003). *Economic Impact Assessment for Ethanol Production and Use in Hawaii.*

[323] Poteet, Michael D. (September 2006). *Biodiesel Crop Implementation in Hawaii*. Hawaii Agriculture Research Center.

specifically to produce biomass) are economic only when oil prices rise above $75 per barrel and may need additional State support.

Based on cost, biomass-to-power feedstocks should be sourced in the following order:

- Municipal Solid Waste: available for power production at minimal or no cost due to the tipping fees that are charged for waste disposal.
- Agricultural or forestry wastes: including sugarcane bagasse, wood chips and sawdust, and macadamia nut shells. These wastes are typically available for $25–40 per ton of biomass.
- Dedicated biomass crops (such as eucalyptus or banagrass): cost estimates range from $50–70 per ton.[325]

7.1.4.4 Biocarbons

Biocarbon is charcoal produced through the carbonization of biomass. According to the University of Hawaii at Manoa's Hawaii Natural Energy Institute,[326] potential feedstocks include:

- Woods, such as leucaena, eucalyptus, and oak;
- Agricultural byproducts, such as macadamia shells, corncobs, and pineapple chop;
- Cow manure;
- Wet green wastes, such as wood sawdust and Christmas tree chips; and
- Several invasive species, such as strawberry guava.

7.1.4.5 Biogas

Consisting mostly of carbon dioxide and methane, biogases are gases produced through the anaerobic fermentation or digestion of organic matter. Such matter includes MSW, wastewater sludge, manure, biodegradable waste, and any type of biodegradable feedstock.

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[325] Black & Veatch (November 2005). "Unit Information Form (UIF)." *MECO IRP-3*. MECO. And, Stillwater Associates (October 2003). *Hawaii Ethanol Alternatives: A Study Conducted for Department of Business, Economic Development & Tourism. (*DBEDT).

[326] University of Hawaii at Manoa, Hawaii Natural Energy Institute. *Biocarbons (charcoal).* Retrieved November 13, 2006 from www.hnei.hawaii.edu/bio.r3.asp.

7.1.4.6 Biomass

According to a study by the Hawaii Natural Energy Institute, the State of Hawaii generated the following amounts of biomass in 2002.[327] Any dedicated crop would be additional to these figures, shown in Table 17.

Table 17. Existing Biomass in Hawaii (2002)

	tons/yr	Hawaii	Maui	Kauai	Oahu	State Total
Manure	dry	410	540	180	9,860	10,990
Poultry	dry	1,520			4,830	6,350
Bagasse Fiber	dry		275,000	74,000		349000
Molasses	as received		80,000	15,000		95000
Cane Trash	dry		137,000	37,000		174000
Agricultural Wastes	dry	19,000	7,500			26500
MSW	as received	110,000	96,000	56,000	668,000	930,000
Food Waste	as received	24,000	15,000	5,800	90,000	134,800
Sewage Sludge	dry	183	3,352	246	16,576	20,357
Fats/Oil/Grease	dry	1,850	1,850	800	10,000	14,500

7.1.5 Bioenergy Needed to Meet Hawaii's Goals

Bioenergy can substitute for ground transportation fuels, marine transportation fuels, and power production fuels (either oil or coal). Potential demands for these various types of fuels are discussed in the following section.

7.1.5.1 Ground Transportation

Over the next twenty years, highway fuel requirements, and thus the requirement for biofuels for vehicles, will depend on both economic growth and fleet efficiency improvements. As discussed in Appendix A, an analysis of the impact of projected improved vehicle efficiency found that efficiency improvements have the potential to reduce absolute oil demand from current levels by 20 percent or more by 2020. Three oil price scenarios were evaluated. Under the adequate supplies scenario, the estimated efficiency of light vehicle stocks in Hawaii has been forecasted to improve from 21 miles per gallon (mpg) today to 25 mpg in 2025. Under the constrained supply scenario, efficiency will reach 26 mpg in 2025, and under the cyclic supply scenario, efficiency will improve to 25 mpg in 2025.[328]

[327] University of Hawaii at Manoa, Hawaii Natural Energy Institute. (December 2002). *Biomass and Bioenergy Resource Assessment*.

[328] The modest fuel economy improvements under the various oil price scenarios demonstrate that additional policies are needed to further raise fuel economy.

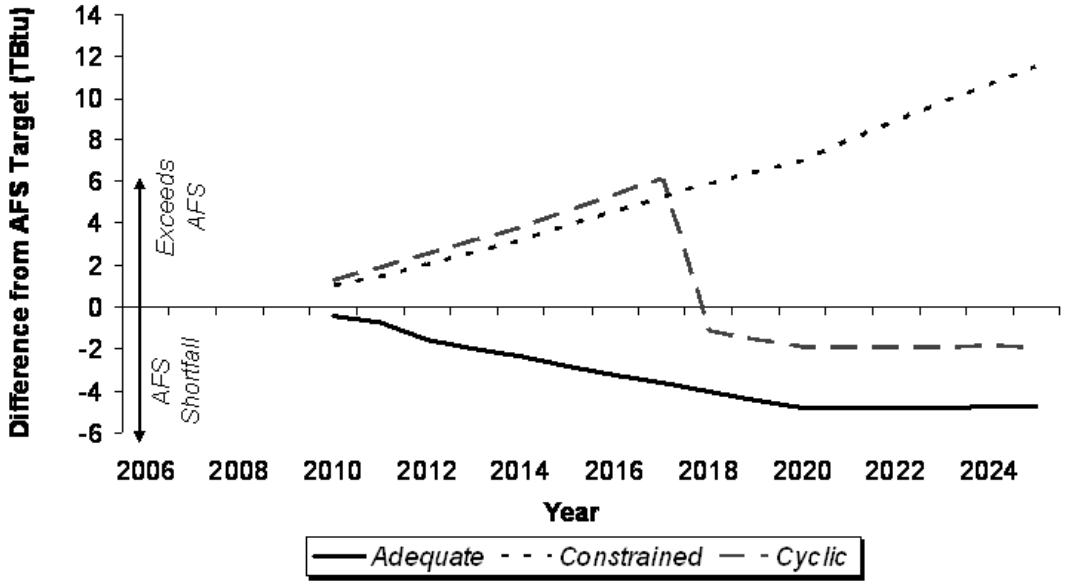
Minimum biofuels consumption for highway vehicles to meet the AFS are shown in Table 18. Since the AFS is a target not a mandate, the state's ability to meet the AFS may depend on market demand, and, accordingly, on the cost-effectiveness of biofuels supply, further discussed in section 7.2 of this chapter.

Table 18. Estimated Future Minimum Highway Biofuels Requirements to Meet AFS Goals

Ethanol (Millions of gallons)			
Scenario	**2010 (10%)**	**2015 (15%)**	**2020 (20%)**
Adequate	44.33	65.41	85.41
Constrained	44.50	64.81	82.67
Cyclic	44.50	64.90	85.35
Biodiesel (Millions of gallons)			
Scenario	**2010 (10%)**	**2015 (15%)**	**2020 (20%)**
Adequate	4.31	6.77	9.27
Constrained	4.29	6.47	8.50
Cyclic	4.29	6.48	8.89

Based on estimates of the cost of importing biofuel and of producing it in-state, Hawaii will not be able to meet its AFS targets without additional incentives under the adequate supplies and cyclic commodities scenarios. The shortfall under each scenario is shown in Figure 43.

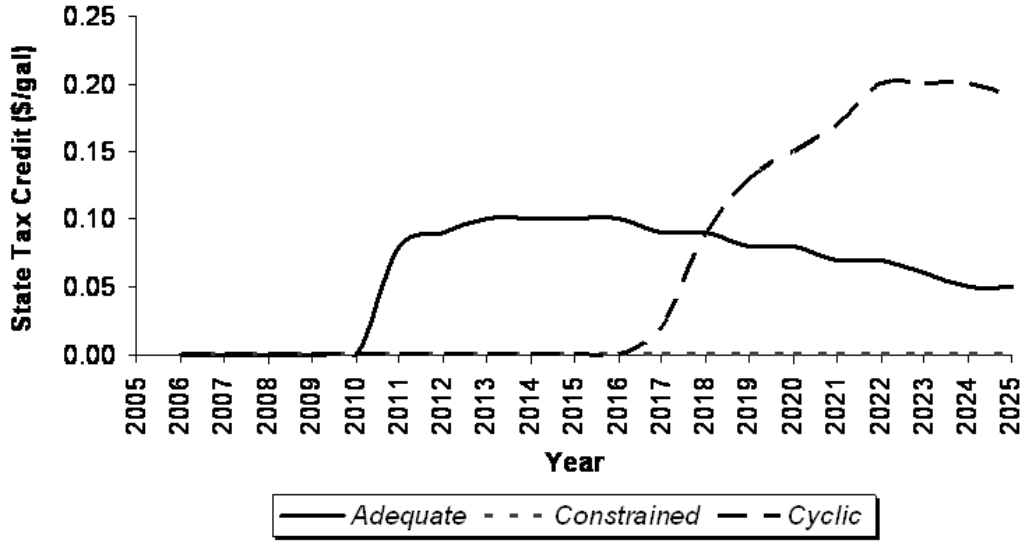
Figure 43. Ability to Meet Hawaii Alternative Fuel Standard



Hawaii easily meets, and in fact exceeds, the AFS targets under the constrained supplies scenario. However, the AFS targets are never met under the adequate supplies scenario, and stop being met in 2017 under the commodities cyclic scenario. While the production cost of biofuel is roughly the same under each scenario, the price at which that fuel can be sold differs significantly depending on the price of oil.

Based on the forecasted price of oil in each scenario, the additional cost of meeting the AFS has been estimated under each scenario. These values are based on the additional revenue per gallon necessary to make biofuels cost-effective, and are shown in Figure 44.

Figure 44. Additional Costs of Meeting Alternative Fuel Standard



In the ground transportation sector, the market for biofuels will also depend on consumer adoption of flex-fuel vehicles (FFVs) that can use a blend of up to 85 percent ethanol (E85), or that can run on the warranty-stipulated level of biodiesel in diesel vehicles.[329]

Currently, FFVs make up only 2.5 percent of Hawaii's vehicle fleet. Without specific incentives for consumers and fleet operators to purchase FFVs, as in the adequate supplies scenario, the FFV market penetration is forecasted to be limited to 6.5 percent of the market by 2020. Meanwhile, to meet the 20 percent AFS target, at least 14 percent of the vehicle stock would need to be FFVs.[330] However, under the constrained supplies and commodities cyclic scenarios, policies are assumed to be put in place to encourage the increased development of FFVs, leading to an FFV penetration of approximately 60 percent.

[329] The 20 percent AFS target is for the transportation sector as a whole. For illustrative purposes only, gasoline and diesel displacement are calculated.

[330] The necessary FFV penetration estimate is based on the total forecasted fuel demand in 2020 and therefore the AFS ethanol requirement. The quantity of ethanol consumed to produce E10 was estimated, and the remainder of the AFS ethanol requirement assumed to be met through E85. Based on average fuel efficiency and vehicle miles traveled, the number of FFVs required to consume that quantity of E85 was calculated.

Nearly all diesel trucks and buses are warrantied to run on a 5 percent biodiesel blend (B5) today. European and U.S. truck manufacturers are already developing engines that will be capable of running on a 20 percent biodiesel blend (B20) within the next five years, and work is on-going for an ASTM B20 standard.[331]

However, even if vehicle manufacturers widely adopt FFV technology, the lack of necessary fuel infrastructure may remain a major obstacle to the optimal use of ethanol. Because E85 cannot be transported through the same pipelines as gasoline, separate infrastructure to distribute E85 must be developed. This will require significant financial resources to develop E85 fueling stations, ethanol terminals, and storage tanks.

7.1.5.2 Marine Vessels

Marine vessels refueling in Hawaii consume 65 million gallons of diesel every year.[332] Marine fuel use is not regulated, but the marine transportation sector could be converted to 100 percent biodiesel (B100) if the fuel is cost-competitive. For more details on marine fuel consumption, refer to section 6.1.4 in this report. The environmental and technical benefits of using biodiesel in the marine sector could be important drivers of this shift (see text box: Benefits of Biodiesel Use in Marine and Power Sectors). Furthermore, the Environmental Protection Agency's ultra-low-sulfur diesel (ULSD) rule took effect in June 2006, requiring a reduction in diesel sulfur from 500 parts per million (ppm) to 15 ppm by 2010.[333] While there is uncertainty as to whether Hawaii's refineries will be able to convert to ultra-low-sulfur diesel fuel production, 2 percent biodiesel blends (B2) provide the lubricity needed once the sulfur is removed.[334]

Benefits of Biodiesel Use in Power and Marine Sectors

Environmental Benefits – Biodiesel-fueled engines emit less GHG and reduce emissions of particulate matter, unburned hydrocarbons, and sulfur dioxides. Additionally, biodiesel can smell better, is less irritating to the eyes, and biodegrades 2.5 times faster than diesel, which would reduce damage to fragile marine ecosystems in the event of a spill.

Technical Benefits – Biodiesel is well adapted to transportation, power generation, and marine use. It is compatible with most engines with few or no modifications, its lubricity properties reduce wear and tear on the engines, and it has a higher flash-point, so that it is defined as non-flammable by the NFPA.

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[331] American Society for Testing and Materials (2006). WK7852 New Standard Specification for Diesel Fuel Oil, BIODIESEL Blend (B20)1. Retrieved September 22, 2006, from www.astm.org/cgi-bin/SoftCart.exe/STORE/filtrexx40.cgi?U+mystore+dfxj3488+-L+BIODIESEL+/usr6/htdocs/astm.org/DATABASE.CART/WORKITEMS/WK7852.htm.

[332] DBEDT, 2006.

[333] 40 CFR Parts 69, 80, and 86.

[334] A 2000 final rulemaking by the EPA on Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements is aimed at decreasing NOx and particulates from engines and vehicles that use diesel fuel. As a consequence of this rule, new emissions standards will be implemented in 2007. ULSD greatly reduces particulate matter emissions, but it also results in lubricity losses. On the other hand, biodiesel reduces all pollutants but NOx (slight increase) while increasing lubricity. Energy Information Administration (2001). Special Report: *The Transition to Ultra-Low-Sulfur Diesel Fuel: Effects on Prices and Supply*. Retrieved on September 27, 2006, from: www.eia.doe.gov/oiaf/servicerpt/ulsd/preface.html.

7.1.5.3 Electric Power

Hawaii's potential demand for bioenergy for electric power generation has several key drivers:

1. The Integrated Resource Planning (IRP) process by which Hawaii's electric utilities develop their short- and long-term resource plans, including which types of energy resources will be built;

2. Hawaii's Renewable Portfolio Standard (RPS), which sets legally mandated targets for the production of renewable electricity statewide;

3. The current demand for biomass by existing biomass-fired power generation and the technical feasibility of integrating biofuels or biomass into existing oil- or coal-fired power generation facilities that make up Hawaii's electric utility system; and

4. The potential production capacity of the state's developing ethanol industry, which will contribute biomass co-generation.

In 2005, Hawaii's electric utility systems sold almost 11 million megawatt-hours (MWh) of electricity.[335,336] The magnitude of utility fuel demand establishes these companies as potential drivers of future bioenergy demand. A single 130 MW baseload power plant using biofuels would require as much biofuel as the entire AFS target for highway fuels.[337] Thus, Hawaii's electric utilities could play a major role in accelerating the growth of the state's biomass and biofuels industry.

7.1.5.4 Demand Identified by Current IRP Process

Two of the three Hawaiian Electric Industries' (HEI) utilities, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO), are in the final stages of completing their respective Integrated Resource Plans (IRP). Of MECO's two draft preferred plans, one includes the 2017 installation of a 25 MW biomass baseload combustion unit that would burn banagrass. Only one of the five plans that HELCO is considering includes a biomass-related facility—an 8 MW waste-to-energy unit to be installed in 2021. HECO completed its latest IRP in 2005, but it does not include biomass resources in its Final Draft Preferred Plan.

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[335] Hawaii, Public Utilities Commission (2005). *Annual Report of Kauai Island Utility Cooperative* Hawaii & United States, Federal Energy Regulatory Commission (2005). *FERC Form No. 1 of Hawaiian Electric Company*. Washington DC & United States, Federal Energy Regulatory Commission. (2005). *FERC Form No. 1 of Maui Electric Company*. Washington DC.

[336] Estimates provided by HI DBEDT show that to produce approximately 94 percent of that power, Hawaii's electric utilities and independent power producers consumed almost 600,000 tons of coal, 473 million gallons of residual fuel oil, 110 million gallons of number two diesel fuel oil and 44 million gallons of naphtha fuel.

[337] Either 72 million gallons of biodiesel or 111 million gallons of ethanol will produce 1,000 GWh/year.

Kauai Island Utility Cooperative (KIUC) is still in the process of developing its IRP and had already confirmed its intention to increase the amount of biomass it uses when it announced in April 2006 the selection of two biomass facilities and a waste-to-energy plant for a total of 17.3 MW of capacity.

7.1.5.5 Demand Driven by Hawaii's Renewable Portfolio Standard

Hawaii's Renewable Portfolio Standard (RPS), established by Act 272 (SLH 2001), and amended by Acts 95 (SLH 2004) and 162 (SLH 2006), requires that 20 percent of electricity sales be produced from renewable resources—including biomass and biofuels—by 2020. The RPS law also sets milestones of 10 percent by 2010 and 15 percent by 2015. Each of Hawaii's four electric utilities collectively contributes to meeting the State's RPS requirements. In 2005, Hawaii's utilities produced 715 GWh of renewable electricity for their customers, most of which was produced by independent power producers (IPPs).[338] To meet the 20 percent target by 2020, the utilities must generate an additional 1,100–1,300 GWh per year of renewable electricity.[339]

Under the current law, both energy efficiency and renewable energy count towards meeting the RPS.[340] However, should the standard be changed, as is currently within the purview of the Hawaii Public Utilities Commission (HI PUC), so that the standard must be met entirely with renewable energy,[341] the demand for biofuels and biomass could significantly increase. E2020 modeling indicates that the utilities will likely meet the majority of the RPS requirements primarily through the construction of renewable electricity generating facilities that rely on wind, MSW, geothermal energy, or other renewable energy.[342] However, to meet the entire 1,200 GWh/year demand for renewable electricity using only biofuels substitution, 75 million gallons of biodiesel, 115 million gallons of ethanol, or 600,000 tons of banagrass per year would be required.

7.1.5.6 Ability to Co-fire Biofuels and Biomass in Existing Power Plants

Oahu benefits from a 46 MW MSW facility, the Honolulu Project of Waste Energy Recovery (H-Power), which came online in 1990 and produces 300,000 MWh/year. The plant is owned and operated by an IPP under a power purchase agreement (PPA) with HECO. Co-firing existing generation with biomass can be even more cost-effective than building new generation capacity as it avoids the capital costs associated with building new capacity. The most common type of co-firing with biomass is the substitution of some percentage of coal with biomass in a coal-fired generator. The existing 180 MW coal-fired power plant on Oahu may offer this option.

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[338] Hawaiian Electric Company, *2005 Renewable Portfolio Standard Status Repor*t. Honolulu: Hawaiian Electric Company, filed with PUC on December 8, 2006 and Kauai Island Utility Cooperative. *2005 Renewable Portfolio Standard Status Report.* Lihue: Kauai Island Utility Cooperative, filed with PUC on March 30, 2006

[339] State of Hawaii, DBEDT energy modeling analysis 2006.

[340] For additional details on RPS definitions and a history of the RPS refer to Appendix D.

[341] See chapter 5, which recommends that the current RPS be modified to include only renewable energy and the creation of a dedicated energy efficiency resource standard.

[342] Hawaii Department of Business, Economic Development & Tourism (DBEDT), 2006.

Table 19. Summary of Potential Annual Future Biofuel Demand

Type	Utility	Capacity	Bioenergy Type and Quantity
IRP	MECO	25 MW biomass unit installed in 2017[343]	212,000 tons biomass[344]
	HELCO	8 MW of waste-to-energy installed in 2021[345]	110,000 tons MSW[346]
	KIUC	4.5 MW biomass direct-fired unit 7.5 MW biomass gasification unit 5.3 MW waste-to-energy unit	100,000tons biomass;[347] 73,000 tons MSW[348]
Existing units with bioenergy co-firing potential	HELCO	180 MW IPP-owned coal plant 117 MW of #2 diesel-fueled capacity	83,000 tons banagrass or bagasse 1.1 MMgal biodiesel
	MECO	220 MW of #2 diesel-fueled capacity	15 MMgal biodiesel
	HELCO	60 MW IPP-owned naphtha-fired plant 118 MW of #2 diesel-fueled capacity	3.7 MMgal biodiesel 8.4 MMgal ethanol
	KIUC	27.5 MW KIUC-owned naphtha-fired plant 97 MW of #2 diesel-fueled capacity	3.7 MMgal biodiesel 4.75 MMgal ethanol
Planned units with bioenergy co-firing potential	HECO	180 MW coal plant (2022) 100 MW single-cycle combustion turbine	83,000 tons banagrass or bagasse
	MECO	70.2MW of #2 diesel oil-fired generation (2006-2026) [349]. or 91.35 MW of #2 diesel oil-fired generation (2006-2026)[350].	10.4 MMgal biodiesel[351] or 12.1 MMgal biodiesel[352]
Ethanol co-cogeneration	MECO (HC&S)	16 MW	550,000 tons biomass

[343] Maui Electric Company, Limited (MECO), (2006). Integrated Resource Planning 2007–2026. MECO Presentations to IRP Advisory Group. *Draft Preferred Renewable Plan*. Kahului, Hawaii: Maui Electric Company, Inc.

[344] Estimates obtained from Black & Veatch. (November, 2005). Unit Information Form (UIF). *MECO IRP-3*. (581 tons per day at normal top load = 212,000 tons of biomass annually)

[345] Hawaii Electric Light Company (HELCO), (2006). Integrated Resource Planning 2007–2026. HELCO Presentations to IRP Advisory Group. *IRP-3 Finalist Plan 4: Renewable Energy Resource Flexibility Plan*. Hilo, Hawaii: Hawaii Electric Light Company, Inc.

[346] Black & Veatch (April, 2005). Unit Information Form (UIF). *HELCO IRP-3*. (300 tons per day at normal top load.)

[347] Biomass tonnage estimate for 12 MW of biomass capacity based on Black & Veatch's estimates for a 25 MW biomass combustion facility. B&V estimates 581 tons per day at normal top load for a 25 MW facility, which equates to 212,000 tons annually. Thus, 12 MW of biomass fired generation is estimated to need 100,000 tons of biomass annually.

[348] MSW tonnage estimate based on Black & Veatch's estimates for an 8 MW waste-to-energy facility of 110,000 tons per year, reduced for 5.3 MW of capacity. A 5.3 MW facility is approximately 66 percent the size of an 8 MW facility, requiring an estimated 73,000 tons of MSW.

[349] Maui Electric Company, Limited (MECO), (2006). ntegrated Resource Planning 2007–2026. MECO Presentations to IRP Advisory Group. *Draft Preferred Renewable Plan*. Kahului, Hawaii: Maui Electric Company, Inc.

[350] *Ibid.*

[351] *Ibid.*

[352] *Ibid.*

	KIUC (G&R)	4 MW	150,000 tons biomass
	Any 10 MMgal Ethanol Plant	2 MW	

All generation units that run on No. 2 diesel oil or naphtha are also potential candidates for co-firing biofuels. Hawaii's electric utility systems currently include of 552 MW of No. 2 diesel-oil-fired capacity, 80.5 MW of naphtha-fired capacity, and 180 MW of coal-fired capacity. In 2005, these units consumed more than 120 million gallons of diesel fuel, 43 million gallons of naphtha fuel, and 586,000 tons of coal.

While the co-firing of coal with biomass is a widely accepted practice, substituting ethanol and biodiesel in existing power generators is comparatively new and presents special challenges. The amount of co-firing potential for biofuels is limited by three factors: 1) the technical feasibility of biofuel substitution; 2) the impacts on original equipment manufacturer (OEM) warranties; and 3) the underlying economics of the fuel price differentials plus any conversion costs. HECO is examining the feasibility of running its 110 MW combustion turbine at Campbell Industrial Park on an ethanol–naphtha mix, and has had a plan approved by the Hawaii Public Utilities Commission to fuel the plant on 100 percent biofuel.[353]

7.1.5.7 Demand Driven by Co-generation of Heat and Power

In 2005, only two sugar facilities still sold power to Hawaii's electric system: Hawaii Commercial & Sugar (HC&S) on Maui, which supplied MECO with 16 MW of firm power, and Gay & Robinson on Kauai, which has a 4 MW generator, but only sells a small amount of as-available power to KIUC. In 2005, HC&S sold approximately 98,000 MWh of electricity, of which approximately 66 percent was derived from biomass combustion.[354] In the same year, Gay & Robinson sold approximately 3,000 MWh of electricity, all of which was generated with biomass.

The future contribution of biomass co-generation will depend on how much in-state ethanol production capacity will be developed from conventional or next-generation (cellulosic) ethanol facilities. Each 10-million-gallon conventional ethanol facility (likely using sugarcane feedstock) can potentially produce enough excess electricity to sell 1.5–2 MW of renewable biomass power to the grid.[355] A 10-million-gallon cellulosic ethanol plant could potentially sell 2–2.5 MW of power to the grid.

[353] Hawaiian Electric Company. (October 2007). *Campbell Industrial Park Generating Station Update.*

[354] State of Hawaii. DBEDT. 2006

[355] Assuming power is produced at a rate of ~300 kWh/ton from bagasse, and consumed at a rate of ~150 kWh/ton.

7.1.6 Land and Water Availability for Bioenergy Production

7.1.6.1 Land Availability

The amount of acreage available for bioenergy production has been estimated in several recent studies, including the 2003 *Hawaii Ethanol Alternatives* study by Stillwater Associates; the 2003 *Economic Impact Assessment for Ethanol Production and Use in Hawaii* study by BBI International Consulting; and the 1999 *Siting Evaluation for Biomass-Ethanol Production in Hawaii* study by the University of Hawaii at Manoa College of Tropical Agriculture and Human Resources.[356] All estimates concluded that Hawaii has enough land available to meet at least the state's 10 percent transportation ethanol mandate. For biomass-to-power generation, green waste and MSW sources are the least expensive and should be used first as they require no additional land. When dedicated crops are planted, they should be planted to use marginal agricultural land when possible so that they don't displace food crops.

Table 20 summarizes Hawaii's bioenergy production potential. The Stillwater/Kinoshita estimates are from the 1999 University of Hawaii siting evaluation study, which identified the best locations for biomass-for-ethanol production in the state. Because Kinoshita's study only identified sites that have ideal conditions for growing biofuel crops, this acreage, along with land already in sugarcane production, can be considered a low estimate of the amount of land available for biomass-for-biofuel production.

Table 20. Estimated Land Area for Bioenergy Production[357,358,359,360]

	Maui	Kauai	Oahu	Hawaii	Total
Stillwater/Kinoshita estimates	26,000	7,000	25,500	27,000	85,500
Land currently used for sugar production	36,700	11,100	0	0	47,800
Sub-total	**62,700**	**18,100**	**25,500**	**27,000**	**133,300**
Additional available prime farmland	0	35,500	15,300	30,000	80,800
Sub-total	**62,700**	**53,600**	**40,800**	**57,000**	**214,200**
Existing non-sugar agricultural production	9,300	3,000	17,300	11,800	41,400
Maximum potential (exclusive of land currently in agriculture (except sugar))	**53,400**	**50,600**	**23,500**	**45,200**	**172,800**

[356] Additional information is available in the following study, which was unavailable at the time of printing: University of Hawaii, December 2006. *Potential for Ethanol Production in Hawaii* Prepared for State of Hawaii Department of Business, Economic Development, and Tourism..

[357] The amount of acreage available has been estimated by several studies. RMI has estimated additional available acreage based on GIS analysis of a combination of Agriculture Land of Importance to the State of Hawaii (ALISH) agricultural designation, soil type, existing agricultural production, and parcel size.

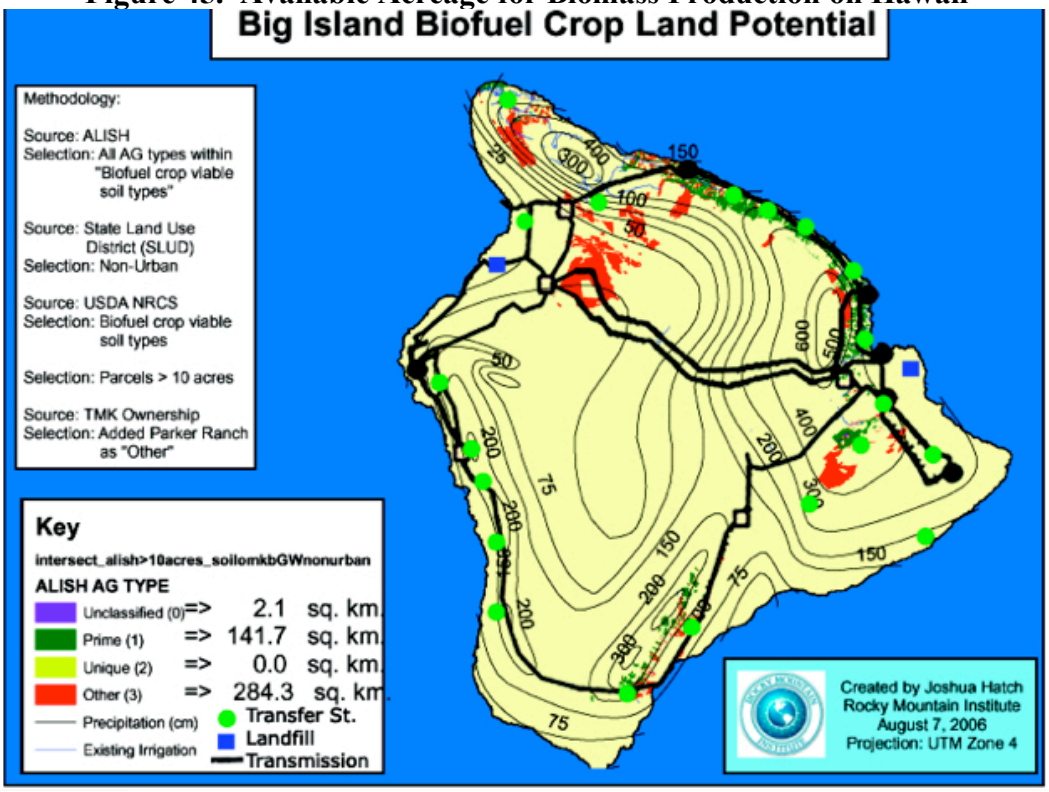
[358] Kinoshita, C. and Zhou, J., October 1999. *Siting Evaluation for Biomass-Ethanol Production in Hawaii.* Prepared for National Renewable Energy Laboratory

[359] BBI International Consulting, November 2003. *Economic Impact Assessment for Ethanol Production and Use in Hawaii* Prepared for State of Hawaii Department of Business, Economic Development and Tourism

[360] Stillwater Associates, October 2003. .*Hawaii Ethanol Alternatives* Prepared for State of Hawaii Department of Business, Economic Development and Tourism

The estimated additional available acreage is based on a combination of Agriculture Land of Importance to the State of Hawaii (ALISH) agricultural designation, soil type, existing agricultural production, and parcel size. Forestry land was included because of its potential for cellulosic feedstocks for ethanol production.[361] In addition, because of the State's desire to maintain a diverse agricultural sector, this estimate of maximum available acreage excludes land already in non-sugar crop production. Much of the remaining available acreage is not contiguous, and it is not likely to meet the minimum efficient scale necessary for economically viable sugarcane production. But it could be used for biodiesel crops, which have the potential to be economically produced on a smaller scale. Ownership of the majority of available acreage is concentrated among a handful of entities, including State and county government agencies, Kamehameha Schools Bishop Estate, Alexander & Baldwin, Maui Land & Pineapple, and the James Campbell Estate. Estimated acreage is shown on the following maps, and summarized in Table 20.

Figure 45. Available Acreage for Biomass Production on Hawaii



[361] To determine the viable acreage potential for Hawaii, GIS maps were created with the following overlays: ALISH agricultural designations, non-urban State Land Use Districts, USDA soil types conducive to biomass production, and parcel sizes greater than 10 acres. Land slope would also affect viability of biofuels production (slopes of more than 15 percent are generally unviable).

Figure 46. Available Acreage for Biomass Production on Maui

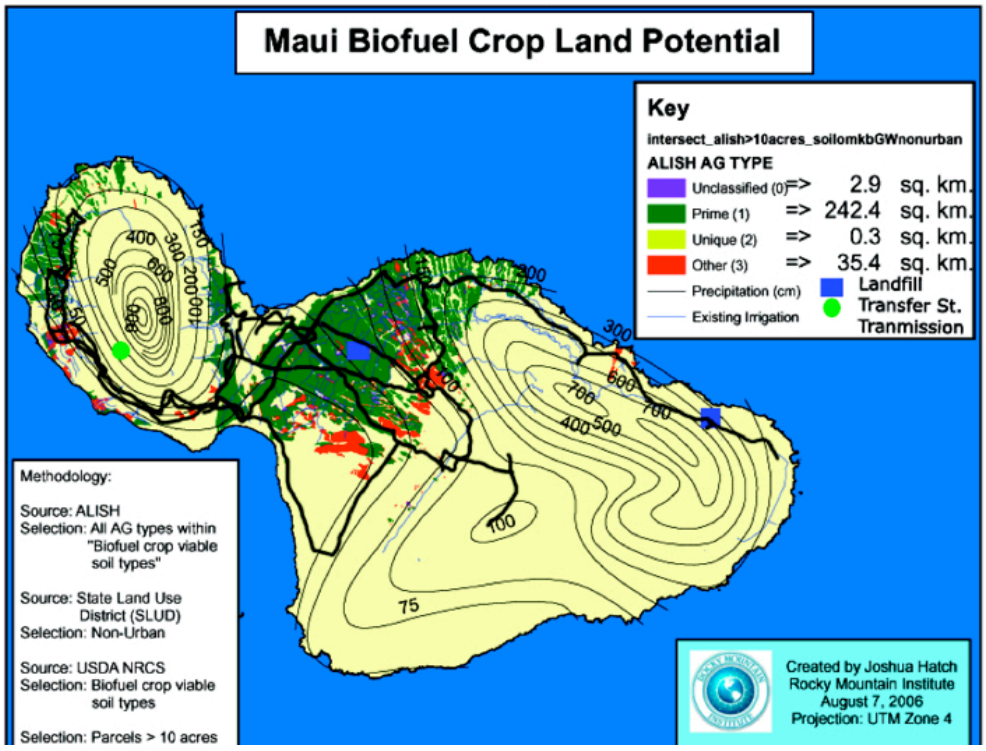


Figure 47. Available Acreage for Biomass Production on Oahu

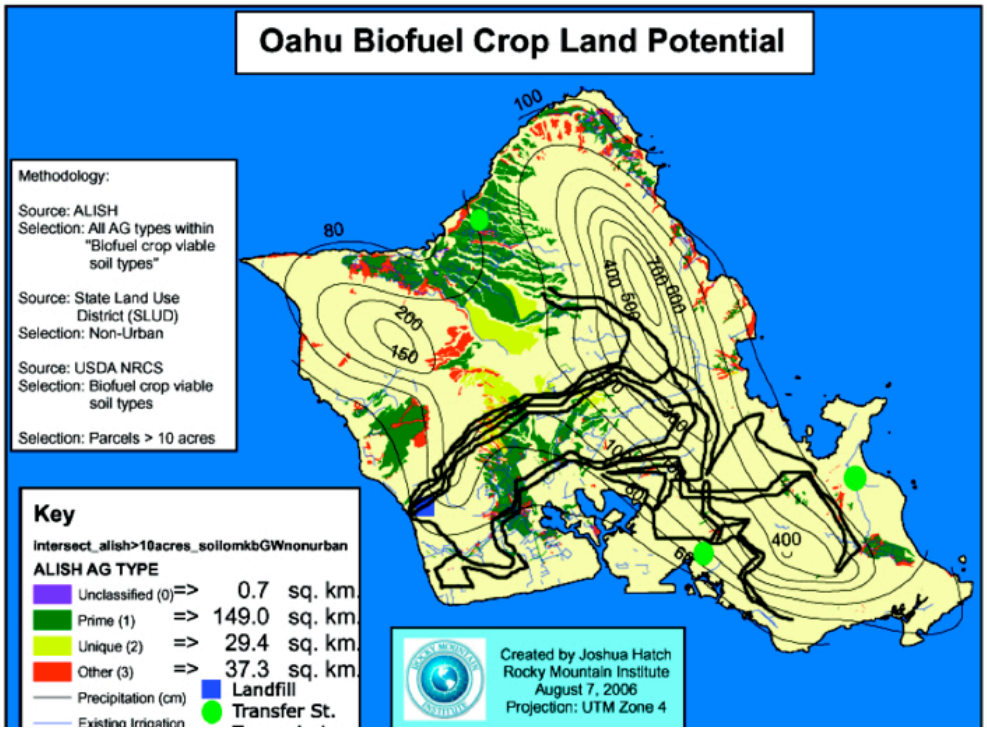
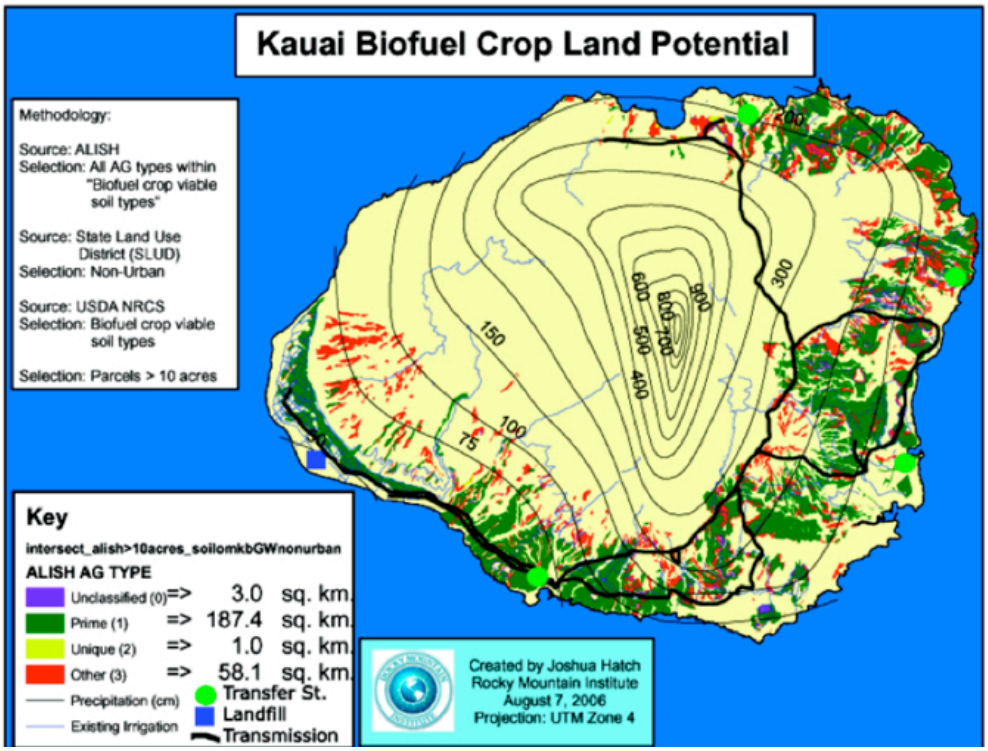


Figure 48. Available Acreage for Biomass Production on Kauai



Current sugarcane yields range from 10 to 21 dry tons of unburned cane per acre-year,[362] or 620 to 1,310 gallons of ethanol/acre, depending on the particular site's soil type, rainfall, and irrigation regime. Yields from a cellulosic crop such as banagrass range from 12 to 26 dry tons of biomass per acre-year, or 1,380 to 2,990 gallons of ethanol per acre.

Although large-scale oil seed production has not been attempted in Hawaii, estimates of annual oil seed production from row and tree crops suggest potential yields of 2,100–4,400 pounds of oil per acre for tree crops and 300–900 pounds of oil per acre for row crops, which could yield 300–600 gallons of biodiesel per acre and 50–130 gallons of biodiesel per acre, respectively.[363] Additionally, while still in the research phase, it is expected that microalgae could potentially produce 40 million gallons per year of biodiesel from an algal pond farm of perhaps 1,000 acres.[364]

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[362] Sugarcane yield is reported in dry tons of unburned cane harvested annually. Historically, Hawaii's sugar industry has reported burned cane harvested bi-annually. However, it is likely that harvesting practices for sugarcane grown as an energy crop would be modified.

[363] Poteet, Michael (July 2006). *Biodiesel Crop Implementation in Hawaii: Draft Report*. Hawaii Agricultural Research Center. Tree crops include oil palm (635 gal/acre), kukui (380 gal/acre), and jatropha (300 gal/acre). Row crops include soy beans (48 gal/acre) and rape seed (127 gal/acre).

[364] Poteet, Michael (July 2006). *Biodiesel Crop Implementation in Hawaii: Draft Report*. Hawaii Agricultural Research Center. Poteet reports that GreenFuel Technologies Inc., have estimated that a several hundred hectare-size algal pond farm could produce more than 40 million gallons of biodiesel.

Table 21. Estimated Required Acreage to Meet Future Biofuel Demand

Ethanol				
	2006	**2010**	**2015**	**2020**
Ethanol required for AFS (MMgal)	38.8	50.4	78.9	110
Potential production from existing sugar (MMgal)	51	51	51	51
Net additional ethanol required (MMgal)	0	0	28	59
Required land using conventional technology (Acres)	0	0	26,400	55,900
Required land using cellulosic technology (Acres)	0	0	11,200	23,600
Biodiesel				
	2006	**2010**	**2015**	**2020**
Biodiesel required for AFS (MMgal)	0	5.6	9.6	14.2
Existing and potential waste oil production (MMgal)	2.5	2.5	2.5	2.5
Net additional biodiesel required (MMgal)	0	3.1	7.1	11.7
Required land (Acres, high potential tree crops)	0	6,900	15,800	26,000

Based on these ranges, Table 21 provides a high-level estimate of the amount of acreage needed to meet Hawaii's future AFS-driven demand, assuming that *all* current sugar production was converted to ethanol, and that *all* available waste oil was converted to biodiesel.[365] Table 21 does not reflect RPS-driven biofuels demand.

Table 22. Public and Set Aside Land in Hawaii (1999)[366]

Type of land	Total (thousand acres)	Oahu (thousand acres)	Hawaii (thousand acres)	Kauai (thousand acres)
Public lands	397.9	19.5	296.9	38.0
Lands set aside and managed by other government agencies	758.0	42.9	525.1	96.6

Assuming existing sugarcane production is entirely converted for ethanol production,[367] an additional 50,000–83,000 acres of prime farmland would be needed to meet the AFS target for ethanol and biodiesel, which compares favorably to Kinoshita's conservative estimate of 85,500 acres of land suitable for sugarcane production.[368] If existing

[365] Potential production from existing sugarcane lands was estimated using total acreage currently in sugar production and a conversion yield of ~61 gal/dry ton. Existing and potential waste oil biodiesel was estimated based on existing production as reported by Pacific Biodiesel, and estimates of additional waste oil available extrapolated from: County of Hawaii, Department of Environmental Management. (December 2004). *Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii*. County of Hawaii.

[366] DEBDT. (2006). *State of Hawaii Data Book*. Retrieved on November 20, 2006, from www.hawaii.gov/dbedt/info/economic/databook/

[367] Existing sugarcane production is 36,700 acres on Maui (HC&S), and 11,100 acres on Kauai (G&R). United States Department of Agriculture. National Agricultural Statistical Service, 2002.

[368] Kinoshita, Charles, October 1999. *Siting Evaluation for Biomass-Ethanol Production in Hawaii*. University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources.

sugarcane is not entirely converted for ethanol production, or if lower yields are realized, then additional acreage will be necessary, as well as the use of more marginal lands and, potentially, cellulosic ethanol production technologies. A significant provider of land for bioenergy might be the State, through leases from the Department of Land and Natural Resources. Table 22 summarizes public land in the State of Hawaii.

7.1.6.2 Water Availability and Access

While rainfall may be adequate for some bioenergy crops (particularly biodiesel tree crops and some cellulosic crops) in some areas, irrigation will be required for economically viable sugarcane and some cellulosic crops in other areas. Crops used for fuel rather than for food may be irrigated with non-potable water.[369]

Due to increased demand and drought conditions during the past five years, Hawaii's water resources have been legally contested in a number of cases. These challenges, concerning landowners' and farmers' legal rights to access water, relate to issues of surface water transfers, stream diversion, minimum in-stream-flow standards, total maximum daily loads, and native Hawaiian rights, among other things. Further uncertainty with regard to water arises due to the lack of a comprehensive agricultural water development and use plan, and a lack of established in-stream-flow standards and data concerning water availability for biofuel production. As long as an in-stream-flow survey to determine the exact amount of water available has not been completed, the level of uncertainty may be too high for potential developers to start projects.

While there is extensive irrigation infrastructure throughout Hawaii, much of it has deteriorated significantly following sugarcane plantation closures in the 1980s and 1990s, and much of it is inefficient compared to modern systems.[370] The October 2006 earthquake also greatly damaged the Island of Hawaii's reservoir system.

Rehabilitating Hawaii's major irrigation systems or building new ones could require significant investment. The Hawaii Department of Agriculture's (HDOA) 2004 Agricultural Water Use and Development Plan states that "reliable irrigation systems give assurances to financial institutions providing agricultural financing and loans that there will be adequate water supply to grow crops which will generate revenues."[371] Recognizing this, HDOA is addressing the issue of irrigation infrastructure rehabilitation as part of the Important Agricultural Lands Initiative (Act 183, SLH 2005).

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[369] R-3 water (undisinfected secondary recycled water) may be used for surface, drip, subsurface irrigation of feed, foder, and fiber crops as well as seed crops not eaten by humans. Source: Hawaii State Department of Health Wastewater Branch. (May 2002). *Guidelines for the Treatment and Use of Recycled Water.* State of Hawaii.

[370] Hawaii Department of Agriculture (December, 2004). *Agricultural Water Use and Development Plan*.

[371] Hawaii Department of Agriculture (December, 2004). *Agricultural Water Use and Development Plan*.

Table 23. Estimated Costs for Rehabilitating Select Irrigation Systems to Support Sugar-Based Ethanol Production[372]

System	Total Cost	Potential Acres Served	Cost ($/gallon ethanol produced)
Kokee Ditch	$1,712,000	3,519	$0.05
Kekaha Ditch	$6,790,000	6,566	$0.10
Molokai	$16,776,000	9,885	$0.17
Waiahole Ditch	$10,668,000	6,270	$0.17
East Kauai	$10,387,000	5,922	$0.18
Lower Hamakua Ditch	$9,586,000	4,765	$0.20
ML&P/Pioneer Mill	$8,912,000	3,533	$0.25
Waimanalo	$5,492,000	1,601	$0.34
Upcountry Maui	$9,274,000	1,751	$0.53
Waimea	$20,963,000	1,367	$1.54

The most comprehensive study of the status of these irrigation systems was conducted by HDOA in 2004 and included ten irrigation systems. Many more irrigation systems are still in operation, although little data are available regarding their condition. Table 23 summarizes the estimated costs of rehabilitating the ten systems studied. The results indicate that some systems, especially those with costs above $0.25 per gallon, would be cost prohibitive to rehabilitate for sugarcane production.

7.2 Cost-Effectiveness of Bioenergy Production in Hawaii

Whether or not bioenergy resources can be cost-effectively produced in Hawaii is a key factor in determining the viability of a future bioenergy industry in the state. For the purposes of biofuels in this study, "cost-effective" was defined as being able to sell the fuel at a price that covered production costs plus a reasonable return on investment. Whether biofuels are cost-effective depends largely on oil prices, since consumers may not pay more for biofuel than they would for gasoline or diesel fuel. As such, the cost-effectiveness of biofuels was determined based on the three oil price scenarios—adequate supplies, constrained supplies, and commodities cyclic—used in this report.

Furthermore, the most common biofuels feedstocks—corn, sugar, soy, and palm—are globally traded market commodities. Locally grown biofuels will therefore only be economic in the long run if they can be produced at or below the import parity price[373] for both the feedstock and the finished fuel. Although it may not make economic sense to import biomass, biomass-to-power still needs to be competitive with fossil-fuel-based power.

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[372] Ibid.

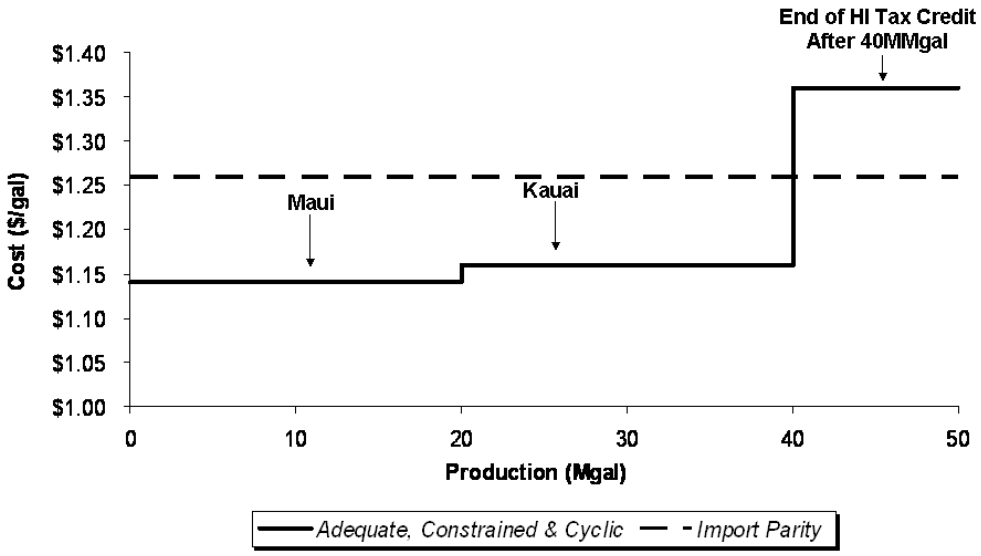
[373] The term "import parity price" is used to describe the price at which a particular biofuel could be imported into Hawaii. This price should serve as a ceiling price for biofuels produced in-state, since a consumer would likely not pay more for in-state supply.

7.2.1 Ethanol

It is estimated that, in the long run, ethanol could be imported into Hawaii at a price, before blender and fuel tax credits, of ~$2.00 per gallon for U.S. corn-based ethanol and ~$1.70 per gallon for Brazilian sugar-based ethanol, including tariffs.[374] Therefore, in-state supply will only be cost-effective if it can be produced for less.

To determine the quantity of ethanol available below this import parity price, the cost of production from sugarcane and from banagrass (as a representative cellulosic feedstock) on each county was modeled.[375] The results of this analysis for the adequate supplies, constrained supplies, and commodities cyclic scenarios are shown in the supply curves (Figure 49 and Figure 50). Total potential production is shown on the horizontal axis, and production cost (including incentives) is shown on the vertical axis. Import parity is represented as a dashed line. Based on this, all in-state production that is below the dashed line should be viable without additional financial incentives.

Figure 49. Sugarcane Ethanol Supply Curve (2010, All Scenarios)

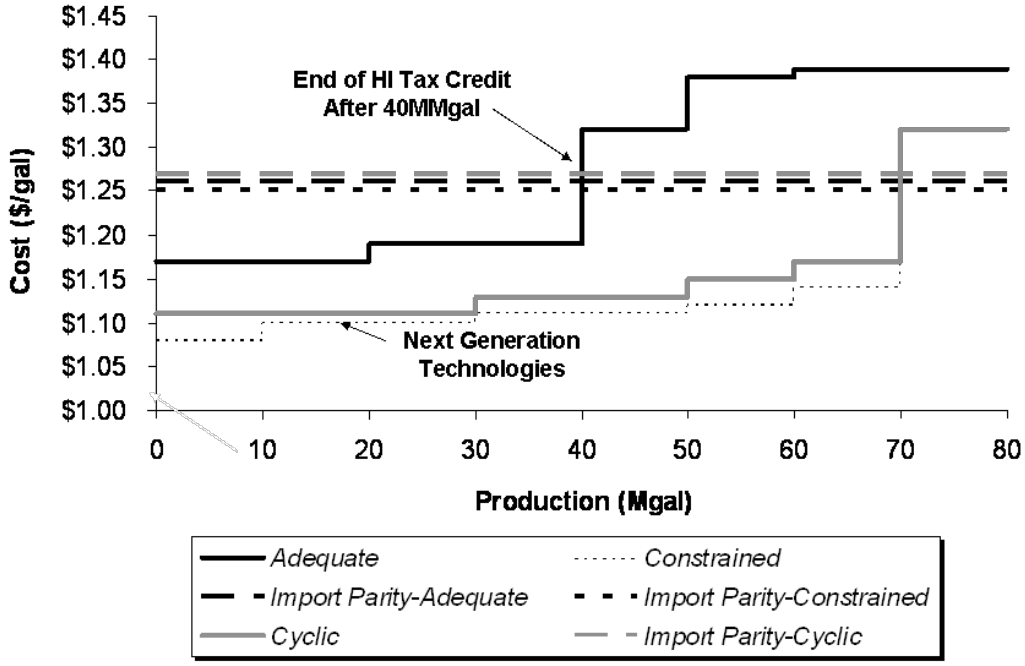


The differences in cost and production potential estimates between the scenarios reflect different oil price forecasts, and therefore different biofuels sale prices and different electricity prices. The differences in cost within a particular scenario reflect different production costs on the four major islands, driven primarily by expected yield.

[374] Corn-based ethanol import parity was calculated using the 2007 futures corn price, average conversion costs, and $0.22/gal transport and storage cost. Sugar-based ethanol import parity was calculated with OECD estimates of Brazilian production costs: $0.54/gal + 2.5 percent tariff and $0.29/gal transport and storage cost.

[375] These cost estimates are described in more detail in RMI's Hawaii Biofuels Summit Briefing Book, written for DBEDT in support of the August 22, 2006 Hawaii Biofuels Summit, and available at www.hawaii.gov/dbedt.

Figure 50. Sugarcane and Cellulosic Ethanol Supply Curve (2015, All Scenarios)



These cost differences also drive the location and timing of ethanol plant construction. Because of high soil quality and growing conditions, considerable available land, and existing sugar production, plants are expected to be established quickly on Maui and Kauai. Although Oahu has a similar cost structure, we anticipate that a lengthy siting process, due to limited land availability, could delay production from local feedstocks. However, a plant that uses imported feedstocks could be viable on Oahu in the short term. Finally, ethanol production in the County of Hawaii may start only when cellulosic technology is commercially available and if import parity prices for biofuels have increased due to higher demand—probably after 2015. This is largely due to low expected yields in the County of Hawaii and the viability of growing some types of cellulosic feedstocks on more marginal land.

Overall, under the adequate supplies scenario, the potential economic demand for ethanol, without regard to the AFS, could amount to 43 million gallons by 2010 (40 million gallons of in-state production supplemented by 3 million gallons of imported ethanol), and then drop to 40 million gallons by 2015 and remain at that level.[376]

[376] The minimum amount of ethanol used in the state in 2020 is 40 million gallons, which represents the quantity of ethanol required to meet the existing ethanol mandate.

Under the constrained supplies scenario, potential economic demand would be 58, 129, and 183 million gallons per year in 2010, 2015, and 2020, respectively (70 million gallons of in-state production, with the remainder of demand met by imported ethanol).

Table 24. Cost-Effective Ethanol Supply

Supply scenario	2010	2015	2020
Adequate (MMgal)	43	40	40
Constrained (MMgal)	58	129	183
Cyclic (MMgal)	62	122	66

7.2.2 Biodiesel

The import parity price for biodiesel produced from Malaysian palm oil is estimated at $1.14 per gallon, assuming $0.18 per pound for feedstock and $0.19 per gallon for transportation and storage.[377] In the absence of tariff increases, imported palm oil is cheaper than imported U.S. soy oil at $1.67 per gallon biodiesel, assuming $0.27 per pound soybean oil cost, plus $0.22 per gallon for transportation and storage.[378]

Hawaii's only commercial experience with biodiesel is production from waste oil by Pacific Biodiesel on Oahu and Maui. Currently, Pacific Biodiesel produces approximately 700,000 gallons per year. It is estimated that there is potentially enough waste cooking oil in Hawaii to produce 2–2.5 million gallons of biodiesel per year, with a cost largely depending on backhaul transportation.[379] Dedicated crop cost estimates for Hawaii are not available,[380] and further study on the technical and economic viability of oil crops in Hawaii must be conducted.

Under the adequate supplies scenario, the potential supply of biodiesel, based on cost-effectiveness is 24, 18, and 17 million gallons per year in 2010, 2015, and 2020, respectively. Due to the lack of production cost data for Hawaii, no assumption is made as to whether this supply is produced in-state or imported. Under the constrained supplies scenario, these figures increase to 25, 22, and 19 million gallons per year by 2010, 2015, and 2020, respectively. Under the commodities cyclic supplies scenario, the quantities are 25, 23, and 7 million gallons per year by 2010, 2015, and 2020 respectively. These results are summarized in Table 25.

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[377] Feedstock price based on 2007 futures price of palm oil. Transportation and storage costs based on Stillwater Associates.

[378] Feedstock price based on 2007 futures price of soy oil. Stillwater Associates. (August 2003). *Hawaii Ethanol Alternatives*. State of Hawaii.

[379] Turn, Scott. (December 2002). *Biomass and Bioenergy Resource Assessment.* State of Hawaii.; and Hawaii Natural Energy Institute; Solid Waste Division, County of Hawaii. (December 2004). *Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii;* and Accommodation and Foodservices: Hawaii. (2002). *U.S. Economic Census*. U.S. Census Bureau.

[380] Biodiesel can also be produced from animal renderings, and should be included in any analysis of biodiesel potential. In general, animal renderings can be expected to yield ~60 gallons biodiesel per ton of renderings. Lemley, Brad. (May 2003). Anything into Oil. *Discover Magazine.* 24(5).

Table 25. Cost-Effective Biodiesel Supply

Supply scenario	2010	2015	2020
Adequate (MMgal)	24	18	17
Constrained (MMgal)	25	22	19
Cyclic (MMgal)	25	23	7

The sharp decrease in cost-effective supply reflects the lower demand for diesel (both for transportation and power) in later years. In fact, this analysis indicates that biodiesel is always cost-competitive with diesel fuel. However, assuming that biodiesel will be used as a percentage of diesel fuel, as diesel demand decreases due to an increased amount of other types of power production, biodiesel demand will decrease as well. Despite this, the low import price of palm oil indicates that transitioning to biodiesel—converted from palm oil or from cost-competitive local feedstocks—will be the low cost option.

7.2.3 Biomass-to-power

Under the adequate supplies scenario, the levelized cost for biomass-fired power is estimated at $170.51/MWh in Oahu and $145.54/MWh on the Island of Hawaii in 2012, compared with $117.36/MWh for CC #2, and $89.73/MWh for coal. Electricity generation based on burning MSW is estimated at $70.14/MWh on Oahu, and $89.75/MWh on the Island of Hawaii.

Under the constrained supplies scenario, however, MSW becomes much cheaper ($68.5/MWh in Oahu and $88.1/MWh in Hawaii) than either CC #2 ($155.09/MWh) or Coal ($107.52/MWh), and biomass becomes more competitive ($167.20/MWh in Oahu, and $143.62/MWh in Hawaii).

7.2.4 Biogas for electricity generation

Although 60,000 tons of methane is emitted from landfills and wastewater treatment facilities in Hawaii each year, no methane is currently being used for electricity generation. This is a missed opportunity with significant GHG impact, which the state should leverage.

7.2.5 Potential Technological Shifts

7.2.5.1 Biomass Combustion

There are three ways in which biomass is used in electricity production: via dedicated biomass-fired power plants; via co-firing biomass or biofuels in an existing power plant furnace or industrial boiler; and via co-generation in industrial boilers in sugar mills and ethanol conversion plants. The most significant developments using biomass for electricity generation will occur in crop research and development to lower the cost of feedstock, and in increasing the technical feasibility of biofuels and biomass substitution.

7.2.5.2 Ethanol

This discussion has been based on the established sugarcane-to-ethanol production process and current cost estimates of a future banagrass-to-ethanol production process. However, there are three technological shifts that could potentially change the existing biofuels outlook: (1) improved agronomic and conversion approaches for sugarcane ethanol, (2) cellulosic ethanol, and (3) improved biofuels chemistry.

7.2.5.3 Improved Sugarcane Approaches

In recent years, significant research on sugarcane production and conversion has taken place in both the United States and Brazil. Full utilization of cane trash, improved high-fiber sugarcane cultivars, different harvesting procedures, and better distillation techniques, could, when combined, significantly improve the net yield of ethanol per acre. These advances may reduce the amount of land and water needed to produce biofuels, and the lower production costs may allow greater industry stability under cyclical fuel market conditions.

7.2.5.4 Cellulosic Ethanol[381]

While the conventional sugarcane-based ethanol production process may dominate Hawaii's ethanol production in the short term, technologies to convert cellulose-based crops, such as banagrass and eucalyptus, and cellulosic agriculture waste, such as sugarcane bagasse, to ethanol should reach commercial scale in five to ten years according to RMI and NREL analysis. Crops grown for cellulose can be selected for their ability to grow on marginal land and with smaller water requirements, thereby increasing the state's production capacity.

Cellulosic ethanol may be produced at lower cost than conventionally produced ethanol. Previous Hawaii-specific research into cellulosic crops indicates expected yields of 18 to 28 tons/acre-year,[382] depending on conditions such as insolation and water availability. These higher yields can result in lower feedstock production costs. The cost of ethanol, when converted via the enzymatic hydrolysis process, can be $1.15–1.20/gallon in the long run, based on RMI analysis. Key factors affecting the price of ethanol using this process are feedstock costs, the value of excess electricity, and enzyme price, as well as fixed costs such as pretreatment reactor price and project contingency requirements.[383]

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[381] There are currently three possible conversion pathways for cellulosic ethanol. The first, ethanol production from municipal solid waste (MSW) uses a strong acid hydrolysis process. The second process, enzymatic hydrolysis, is being promoted by Iogen Corporation, which plans to begin construction of the first commercial-scale plant in 2007, with full production in 2010. The third process, thermal gasification results in a syngas that can be converted into not only biofuels, but also a number of other commodities including hydrogen and methane.

[382] Low estimate from Kinoshita (1999) for unirrigated banagrass, high estimate from HARC (1996). *Demonstration of Grass Biomass Production on Molokai.* Hawaii Agricultural Research Center.

[383] Based on: National Renewable Energy Laboratory. Aden, A. et al. (June 2002). *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*. NREL/TP-510-32438.

7.2.5.5 Improved Biofuels Chemistry

European oil companies, notably Neste and British Petroleum, are actively researching improved production and chemistry approaches to biofuels. This type of research and development may lead to a fundamentally different set of biofuels molecules that will redefine industry standards. These companies, for example, are proposing butanol as a substitute for ethanol because it has a greater energy density and its use eliminates the need for a separate liquid fuels infrastructure. Additionally, they have suggested that hydrotreating vegetable oil produces a superior biodiesel molecule compared to transesterification.

7.2.5.6 Bio-oil and Biocarbons

Biomass can also be converted into bio-oil or biocarbons that can be readily stored and transported for direct use as fuels. Bio-oils are produced during pyrolysis, the heating of organic materials to achieve anaerobic decomposition. Biocarbons (e.g., charcoal) is produced during a similar process.

7.2.5.7 Biodiesel from Microalgae

While still largely in the experimental phase, microalgae have the potential to provide very high yielding biodiesel feedstock. Certain types of microalgae contain very high quantities of lipids, which can be used to produce biodiesel.

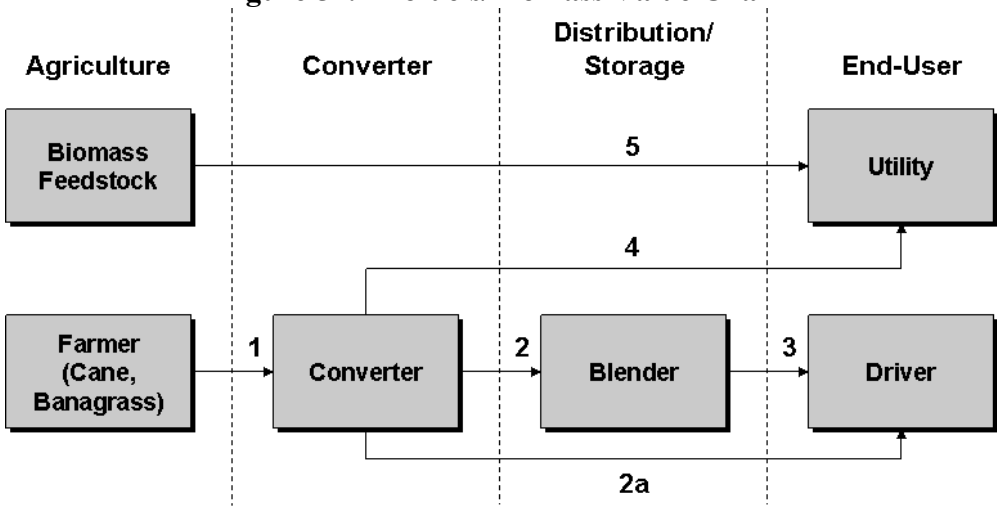
7.3 Barriers to Expanding Hawaii's Bioenergy Industry

As discussed earlier in this chapter, there is interest and demand for bioenergy resources in Hawaii. However, developing a fledgling bioenergy industry faces the same challenges as any new industrial cluster: actions and investment by agricultural producers, feedstock converters, fuel distributors, vehicle manufacturers, and electric utilities must all be synchronized so that supply and distribution capabilities are in place to meet demand. The development of a new industrial cluster entails risks across the spread of market participants, some of which can be offset by government actions.

Investments in biofuels and biomass face significant risks due to the spread between the price of feedstock they are made of and the price of fossil fuels they compete with. This risk is exacerbated by the fact that agricultural feedstocks and fossil fuels belong to markets that are independently volatile and uncorrelated to each other. While fossil fuels' prices can be hedged financially for up to five years, the agricultural commodities markets have cost-effective hedges of only 12–18 months. Neither is sufficient to cover the duration of power plant or biofuels facility debt. Thus, commodity risk spread from price volatility in both the energy and agricultural markets is the most critical risk facing all parties.

These barriers have been categorized according to where they fall in the biofuels and biomass value chains. Figure 51 presents an overview of the biofuels/biomass value chain.

Figure 51. Biofuels/Biomass Value Chain



Barriers that affect every step of the value chain include:[384]

- The short duration of federal tax credits and uncertainty regarding the permanence of supportive government policies towards bioenergy in general, and biofuels in particular;

- The need for both buyers and sellers to coordinate on supply, conversion, and infrastructure, each of which has a long independent lead-time. Large, credit-worthy "anchor tenant" buyers and sellers must be available to provide the financial security needed to invest capital;

- Both oil and agricultural commodities are independently volatile and impossible to hedge for meaningful periods of time, thus the economic risks beyond the next five years loom large across the entire industry;

- Research and development knowledge gaps, in areas ranging from increasing crop productivity to new crop cultivars (including drought-resistant genetically modified organisms (GMOs)) to mechanical harvesting techniques to developing next generation biofuels and biomass technology. An important source of funding for this R&D effort could come from the federal government;

- Logistical infrastructure bottlenecks, as the production, storage, and distribution of biodiesel and ethanol require dedicated systems and facilities; and

- Permit time and complexity. Speed to market is critically important. However, in Hawaii, the time it takes to acquire all the necessary State and local permits could cause participants to miss the market window of opportunity, and prevent the

[384] These barriers are discussed in more detail in RMI's summary of the August 22, 2006 Hawaii Biofuels Summit, available from DBEDT at www.hawaii.gov/dbedt.

industry from seizing the moment. For biomass specifically, the fact that power plant operating permits might need to be altered due to fuel change is a significant issue.

7.3.1 Agriculture

The most critical barriers in the agricultural sector appear to be availability of water and water rights, along with the attendant need to invest in rehabilitating irrigation systems or building new ones. Pressure from the real-estate market to convert land from large-scale agricultural operations to more profitable residential development is also a significant hurdle.

Since Hawaii-produced biofuels may not be export-competitive, there is considerable investment risk in Hawaii-based biofuels feedstock production compared to the use of imported feedstock or biofuel.

Feedstock quality is one of the primary barriers to the biomass-to-power industry because feedstock quality can be inconsistent, and poor-quality feedstock can damage generation equipment. MSW as a feedstock is difficult to manage due to the diversity of materials that fall under the umbrella of MSW. However, recent commercial proposals for modern waste-to-energy and waste gasification plants have demonstrated the industry's ability to manage separate materials, and therefore manage MSW effectively.[385]

The transportation of biomass feedstock is a critical issue given the limited road infrastructure and loss of the historic sugar infrastructure. A 25 MW biomass plant requires approximately 600 dry tons of feedstock per day to operate. Further, the fuel cost of transporting biomass increases significantly with distance.[386] If feedstock is going to be transported longer distances to power generating facilities, it should be appropriately packaged so that it is denser and costs less to transport. It may be beneficial to have distributed power generation, as suggested in HNEI's 2002 study,[387] to reduce transportation costs and road congestion.

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[385] Turn, S. et al. (December 2002). *Analysis of Hawaii Biomass Energy Resources for Distributed Energy Applications.* University of Hawaii, Hawaii Natural Energy Institute. This study found that high alkali levels (usually resulting from high levels of potassium in the feedstock) are the primary reason power generation facilities are damaged.

[385] *Ibid.* The HNEI study concluded that removal of elements such as potassium and chlorine prior to processing the biomass reduces the likelihood of fouling. If a variety of biomass crops are available as feedstock, power generation facilities may be able to blend different feedstocks, resulting in a more consistent fuel supply.

[386] Aden, A. et al. (June 2002). *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover.* National Renewable Energy Laboratory. NREL/TP-510-32438.

[387] Turn, S. et al. (December 2002). *Analysis of Hawaii Biomass Energy Resources for Distributed Energy Applications.* University of Hawaii, Hawaii Natural Energy Institute.

7.3.2 Biofuels Conversion

The conversion stage of the supply chain occurs only in the processing of biofuels and biogas. An important barrier in conversion is the uncertain viability of pre-commercial technologies, such as cellulosic ethanol production, which can utilize crops grown on marginal land. When these technologies will be available is unclear. Another barrier is the uncertainty of feedstock supply. Because plants are being used for twenty years or more, it is important to ensure feedstock will be available for that entire period. Finally, the market size and price for byproducts is another unknown.

7.3.3 Distribution

The main barrier to bioenergy at the distribution level is transportation, mainly from the place of production of the biofuel, as well as storage capacities for biofuels. There is a general geographic mismatch between optimal biofuel production sites on Maui, Kauai, and Hawaii, and the largest demand for these fuels, on Oahu. Ports on these islands are congested, and the cost and ability to move biofuels through these facilities is therefore unclear.

For the distribution of ethanol specifically, retail stations need to invest in dedicated ethanol pumps and infrastructure since E85 is not compatible with existing gasoline infrastructure.

7.3.4 End Use

Since a modified engine is required to burn more than 10 percent ethanol, the penetration of flex-fuel vehicles that can burn up to 85 percent ethanol largely dictates the potential demand for ethanol in the transportation sector.

A potential barrier for biomass-to-power systems is the need for a secure long-term supply of feedstock. Waste-to-energy facilities will be built based on either long-term public contracts that mandate minimum waste volumes or in strategic partnerships with the islands' major waste haulers, such as Pacific Waste.

Emissions permits may need to be altered. If a generating facility switches from a solid fuel to a liquid fuel, a permitting change under the federal Clean Air Act's New Source Review may be required. Additionally, older generating facilities that upgrade may be subject to stricter Best Available Control Technologies (BACT) regulations. Other permits from the Hawaii Department of Health may also need altering, depending on site specifications.

7.4 ***Recommendations for Expanding Bioenergy Supply in Hawaii***

7.4.1 Targeting Incentives Across the Value Chain

As discussed in 7.1.3 , the State of Hawaii already offers some incentives for the

conversion and sale of biofuels. These subsidies are in addition to substantial federal subsidies offered to biofuels converters.[388] Hawaii offers no subsidies for biomass-to-power systems.

Current subsidies are focused almost exclusively on the ethanol production process. Therefore, given the need for action throughout the bioenergy value chain, new subsidies and incentives should support the other parts of the value chain. For example, by ensuring the agricultural sector a market and profitable price for its products, agricultural subsidies would encourage and support the production of biofuels and biomass feedstock. At the same time, subsidies that shield end users, such as Hawaii's electric utilities, from pricing risks would help create a pull in demand and, in turn, diversify energy sources.

The incentives proposed target the value chain at the following points in Table 26:

Table 26. Incentives Along the Value Chain

Incentive	Targeted point in value chain
Sliding-scale incentive	Farmer/biomass producer and end user
Irrigation infrastructure subsidy	Farmer
Distribution infrastructure subsidy	Distributor
Research & development fund	Farmer/converter

There is no compelling reason for Hawaii's taxpayers to support foreign agricultural commodity producers. Therefore, biofuels subsidies should be designed to support (1) the development of local biofuels and biomass feedstocks that can ultimately become competitive internationally; and (2) the cost-effective adoption of biofuels by end users, particularly the power, marine, and transportation sectors.

7.4.1.1 Clarify In-stream Flow Standards

One of the major barriers to the large-scale development of a local biofuels industry is uncertainty regarding water rights. Landowners' and farmers' legal rights to water are currently in a state of flux. The manner in which they are resolved may have an important impact on the cost and availability of water for irrigation. Due to a combination of increased demand and recent drought conditions, a number of court cases have contested the use of water resources in Hawaii. These cases involve a variety of issues including surface water transfer, stream diversion, minimum in-stream flow standards, total maximum daily load standards, and claims of native Hawaiian rights.

[388] The federal Energy Policy Act of 2005 (EPAct 2005) created or extended three major incentives for biofuels, including a $0.51/gal ethanol blender credit set to expire in 2010, a $1.00/gal agri-biodiesel credit that is set to expire in 2008, and a $0.10/gal production tax credit for small agri-biodiesel or ethanol producers—set to expire at the end of 2008 and 2010, respectively. Non-agricultural biodiesel is eligible for a $0.50/gal credit for each gallon blended into traditional diesel fuel. Given that the ethanol blender credit is available for all ethanol marketed in the United States, Congress decided in 1980 to set a $0.54/gal import tariff on ethanol to offset the $0.51/gal for ethanol importers. An exception to this tariff exists for shipments of ethanol reprocessed in Caribbean Basin Initiative countries, however, the imports are capped at 7 percent of domestic demand. Since 2002, overall ethanol imports have not exceeded 5 percent of demand. Biofuels State fuel tax is also reduced.

The main issue is the quantity of water that can be diverted from Hawaii's streams for agricultural purposes. This amount is basedon the quantity of water that must remain in the stream at all times, which is termed the in-stream flow standard. The Commission on Water Resource Management, within the Department of Land and Natural Resources, has the authority and obligation to create these in-stream flow standards for Hawaii's streams.[389] However, these standards have not been finalized, and the resulting uncertainty presents a significant risk to investors.

Recommendation: The Commission on Water Resource Management should consider revising the interim in-stream flow standards, and establish final in-stream flow standards as soon as possible.

7.4.1.2 Appropriate Research and Development Funding for Bioenergy

Substantial research and development (R&D) efforts are needed along the entire biofuels value chain.[390] This is especially important for Hawaii, since national biofuels value chain R&D efforts will likely not meet Hawaii's needs because of Hawaii's unique climate and dissimilarities with the United States mainland. Key R&D is needed at the agricultural level in the following areas:

- Viable biodiesel feedstocks such as oil palm or jatropha, as well as new crop cultivars and improved varieties of sugarcane, including drought-resistant plants;
- Mechanical harvesting techniques to increase productivity; and
- Options for byproduct utilization, such as animal feed or electricity production feedstocks.

A public fund could provide the necessary support for increased research efforts on these topics. The fund would act as a bridge until technologies have reached the proof-of-concept level and can be taken over by venture capital firms or large industry players.

A public source of funding makes all the more sense at the crop and farming level, as the spillover from biofuels/biomass research would affect the rest of the agricultural sector in the State.

Recommendation: The Administration should consider introducing a bill to the State Legislature to establish an R&D fund that can be accessed by Hawaii's various research organizations, as well as private sector entities interested in biofuels production (e.g.,

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[389] The Commission on Water Resource Management website states, "The State, as trustee of water resources, has the constitutionally-mandated responsibility to set policies, protect resources, defines uses, establish priorities while assuring rights and uses, and establish regulatory procedures. The Commission on Water Resource Management is the responsible entity through the administration of the State Water Code." Available at: www.state.hi.us/dlnr.cwrm/cwrmrole

[390] Further detail on R&D funding is provided in the December 2006 report, *Biomass and Biofuels to Power, that* RMI developed for the Hawaii Energy Policy Forum.

biofuels producers). Information from R&D efforts must be publicly available and widely shared.

7.4.1.3 Streamline Permitting Process for Bioenergy Projects

SCR 164 was adopted by 2007 Legislature. It requested the Department of Business, Economic Development and Tourism conduct a study on the feasibility of creating a one-stop permit shop to expedite permit processing for renewable energy projects and to recommend changes, if any, that are needed to establish this streamlined permit process; and to submit its recommendations and draft legislation, if necessary, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2008.

Recommendation: DBEDT should consider adopting the recommendations of the Hawaii Integrated Energy Policy document[391] and the PUC Study, *Strategies to Facilitate the Development and Use of Renewable Energy Resources in the State of Hawaii,*[392] and should consider all types of renewable energy.

7.4.1.4 Create a Sliding-Scale Production Tax Credit for Biofuels

It is economically beneficial for Hawaii to ensure that in-state biofuels feedstocks are chosen over imports, and that in-state feedstocks can be grown in a cost-effective, environmentally sustainable manner. Biofuels production in Hawaii is at a competitive disadvantage to biofuels production in developing countries—such as Malaysia (a leading palm oil producer) and Brazil (a leading sugarcane and ethanol producer)—that are able to produce biofuels feedstocks at significantly lower costs due, in part, to cheap labor and land, as well as greater economies of scale.

Additionally, when looking at specific biofuels crops in the United States, sugarcane does not benefit from the large federal subsidies that corn receives.[393] Ethanol feedstock production requires large contiguous tracts of land. Moreover, if sugarcane or other similar crops are used, substantial water is required, also. The State agricultural infrastructure (particularly irrigation systems) needs substantial refurbishing and upgrading to become suitable for irrigating these crops.

Current ethanol subsidies in Hawaii are focused almost exclusively on the ethanol conversion process. New subsidies and incentives should support the other parts of the ethanol value chain if the state wants to develop the ethanol industry as a whole. For example, by ensuring the agricultural sector, a market and profitable prices for its products, agricultural subsidies would encourage and support the production of biofuels and biomass feedstock. At the same time, subsidies that shield end users, such as

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[391] Department of Business, Economic Development & Tourism (DBEDT), 1991. *Hawaii Integrated Energy Policy.* Honolulu: State of Hawaii DBEDT Energy Division.

[392] Public Utilities Commission (PUC), 1996b. Strategies to Facilitate the Development and Use of Renewable Energy Resources in the State of Hawaii. Honolulu: State of Hawaii Public Utilities Commission.

[393] From 1995 to 2002, federal subsides for corn totaled $42 billion. Environmental Working Group (2006). Farm Subsidy Database. Retrieved October 3, 2006, from: www.ewg.org/farm/findings.php.

Hawaii's electric utilities, from pricing risks would help create a pull in demand and, in turn, protect consumers from rate increases.

The new bioenergy subsidies should be designed to support (1) the development of local, Hawaii-manufactured biofuels and biomass feedstocks that can ultimately become competitive internationally; and (2) the cost-effective adoption of biofuels by end users, particularly the power and transportation sectors.

The sliding-scale incentive achieves both of these goals. It is designed to stabilize biofuels pricing for both the agricultural and end-use sectors, and it has two components or prongs.[394] The first component uses a broader definition of "alternative fuels" and links the current State detaxation of biofuels to in-state feedstock production. The second component creates a state-level sliding-scale subsidy that goes to zero when oil prices are high, and increases when oil prices drop, effectively creating a hedge for consumers and a price floor for producers.

Currently, "alternative fuels" are taxed at a lower rate than conventional fossil fuels. However, "alternative fuels" are defined as containing either a blend of at least 85 percent ethanol or at least 20 percent biodiesel (the blend benchmark).[395] This tax structure means that, for example, the ethanol used to create E10 (10 percent ethanol blend) receives none of the lower tax rate benefit. Therefore, the first component of the proposed sliding-scale subsidy would make the tax rate applicable to any alternative fuel blend below the blend benchmark. In addition, the State's current detaxation of biofuels (which accrues to the blender)) would be linked to the percentage of biofuels produced with in-state feedstocks, once such feedstocks are available. The purpose of this incentive is to provide protection for Hawaii's farmers given the market risks for investing in growing biofuel feedstocks and to focus Hawaii taxpayer incentives on support for Hawaii-based businesses.[396]

The second component is a sliding-scale subsidy that protects producers and consumers against a drop in the price of oil while preventing biofuels producers from reaping windfall profits when biofuels are competitive on the market. First, the sliding scale addresses the difference between oil prices and the price of biofuels produced in Hawaii. Whenever the oil price sinks below the Hawaii biofuels price, the government pays a subsidy to the producer in order to ensure that his product stays competitive with fossil fuels in the end-use market. However, to avoid rewarding inefficiency, there is a "sliding-scale tool" that links statewide payout per gallon of ethanol to world commodity price benchmarks. By basing the credit on these world prices, the policy rewards

[394] Further detail on the sliding scale is provided in the Hawaii Energy Policy Forum's report, in part developed by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195.

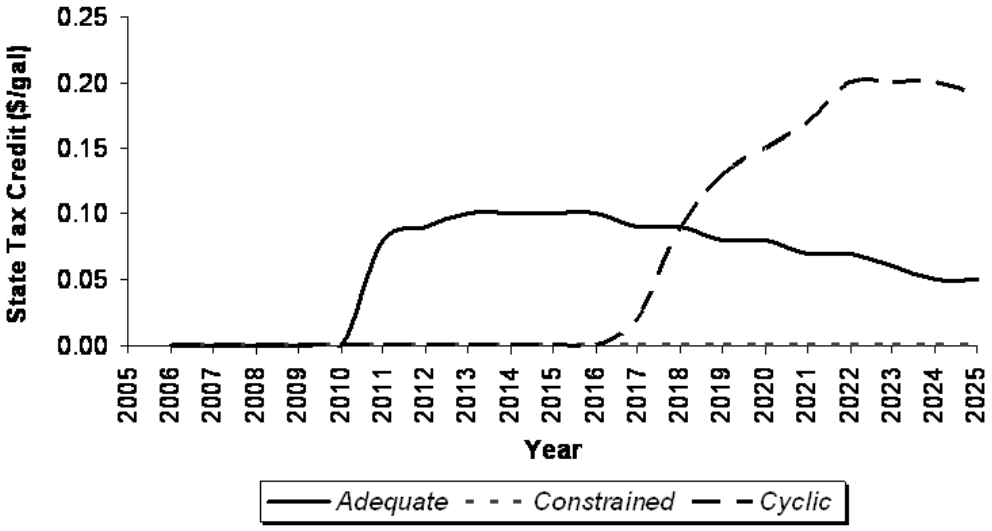
[395] HRS § 243-4, §243-5

[396] These risks include a long lead-time to market, which means that crops such as trees take several years to mature, and there is no guarantee that a market will exist for the product once it becomes available. In addition, a significant market risk exists that Third World countries will be able to produce biofuels feedstocks at a lower cost than in Hawaii, thereby potentially displacing Hawaii-produced feedstocks.

efficiency because a production facility receives the same credit no matter its individual operating costs, which encourages the facility to minimize those costs.

This type of incentive is most appropriate for ethanol for transportation, and modeling indicates that biodiesel used for both transportation and power is cost-effective under each scenario and should therefore not require an additional incentive. Based on forecasted selling prices and production costs, Figure 52 shows the estimated dollar per gallon incentive necessary to make biofuels cost-effective under each scenario.

Figure 52. Sliding-Scale Production Tax Credit Example: Ethanol for Transportation



Recommendation: The State Legislature should consider developing a sliding-scale subsidy for biofuels producers that (1) links the current State detaxation of biofuels to in-state feedstock production and quantity of biofuel in the blended product, and (2) creates a state-level sliding-scale subsidy that goes to zero when oil prices are high, and increases when oil prices drop.

7.4.1.5 Create an Irrigation Infrastructure Investment Tax Credit

One of the most critical barriers to in-state feedstock production is the attendant need to invest in rehabilitating existing irrigation systems or building new ones. Rehabilitating or redesigning Hawaii's irrigation systems will significantly reduce the investment risk faced by potential fuel-crop producers.

Work has already been done on developing this type of tax credit by the Hawaii Department of Agriculture (HDOA). HDOA's September 14, 2005draft "Incentives for Important Agricultural Lands" draft provides a good model and should be supported as it continues to be developed. In order to have a big impact on biofuels and biomass production in the state, the credit could be extended to all potential agricultural lands producing biomass feedstocks. If the final HDOA Important Agricultural Lands

incentive is significantly different from the draft proposal, this recommendation should be reviewed and revised as appropriate.

Recommendation: The HDOA and the State Legislature should consider reviewing the irrigation infrastructure subsidy portion of the Important Agricultural Lands bill, making revisions as appropriate, and actively work to pass the bill as an omnibus package to derive the most benefits possible.

7.4.1.6 Promote the Creation of a Biofuels Logistics Master Plan

For a bioenergy industry to succeed, logistics must be coordinated across the value chain. The Legislature should allocate funding for state agencies or a contracted third party to research and develop a "Biofuels Logistics Master Plan" that will provide a clear direction for Hawaii's bioenergy distribution network in cooperation with stakeholders. The findings of that master plan will indicate whether any additional distribution incentives are necessary.

Recommendation: The State Legislature should consider identifying and assigning a State agency or third-party entity to be responsible for the creation of the Biofuels Logistics Master Plan. The State Legislature may want to consider appropriating monies to the agency to spend on the creation of the Master Plan.

7.4.1.7 Create a Revolving Fund to Support Small-Scale Bioenergy Investments

A revolving fund could be an important tool in jump-starting new biofuels and biomass industries in Hawaii because it would provide financing that might otherwise not be available.[397] A revolving fund is established for the purpose of carrying out a specific activity that, in turn, generates payments to the fund for use in carrying out more of the same activities.

Table 27. Assessment of possible size of actors across the biofuels/biomass value chain

	Biofuels		Biomass
	Ethanol	**Biodiesel**	**MSW, Ag Waste, Dedicated Ag**
Agriculture	Small/Large	Small/Large	Small/Large
Conversion	Large	Small/Large	Large
Storage/ Distribution	Large	Large	Large

[397] Further detail on the revolving fund is provided in the Hawaii Energy Policy Forum's report, in part developed by RMI, to the Hawaii State Legislature regarding House Concurrent Resolution 195 of 2006.

The main barrier that small bioenergy entrepreneurs face is a lack of credit-worthiness. Small farmers might struggle to find the financing necessary to acquire the initial equipment. A revolving loan fund would provide a relatively affordable type of financing and, more importantly, it would lower the credit risk to other financiers who might then become interested in financing small-scale bioenergy development. Table 27 shows an assessment of the size of players in the bioenergy value chain.

Recommendation: The State Legislature should consider following up with its House Concurrent Resolution 195 (SLH 2006) question about the feasibility of creating a revolving loan fund. The Legislature may want to use the HCR 195 report as a guide for developing the fund.

7.4.1.8 Clarify the Use of State Land for Renewable Energy Producers

Hawaii Revised Statutes (HRS) § 171-95 allows the Department of Land and Natural Resources (DLNR) to lease public land to renewable energy producers for up to 65 years without public auction. However, it is unclear if bioenergy feedstock producers may benefit from this statute due to the ambiguity of the definition of renewable energy. HRS § 171-95 allows DLNR to lease land to renewable energy *producers,* but there is some uncertainty as to whether a person growing a fuel crop would qualify as a renewable energy producer. This language should be clarified to specifically include feedstock producers.

Recommendation: DLNR may want to request that the State Legislature clarify its intent in HRS §171-95.

7.4.1.9 Allow Use of State Land for Infrastructure

The Department of Land and Natural Resources may lease public land to renewable energy producers without an auction (for details on HRS §171-95: Leasing of Public Lands to Renewable Energy Producers, see Appendix **XX**). One option is to make State lands available for long-term leases at reasonable rates for the express purpose of building biofuels infrastructure, in addition to growing bioenergy feedstocks. This is of greater importance than providing State land for fuel crops, per se. The State has important parcels that have been cataloged by DLNR.[398]

Recommendation: The DLNR report could be used as a resource for identifying potential sites for infrastructure development in addition to renewable production. If additional public lands abut the catalogued land that is available for biofuel crops, the DLNR may want to request that the State Legislature allow the DLNR to give preference to the renewable energy producers who would lease the infrastructure and cropland parcels together.

[398] HRS §196-41 requires DLNR to develop and publish a catalog of potential sites for the development of renewable energy.

7.5 Conclusions

Hawaii-grown bioenergy represents a multi-million-dollar opportunity for the state to become independent of imported energy and agricultural products. This independence could lead the State to a new level of economic, energy, and environmental security. Millions of dollars of private-sector funds must be invested in the entire bioenergy value chain by agricultural producers, fuel producers, fuel distributors, and end users. Imported feedstocks and products are likely to be necessary as a transition strategy, but port and terminal access and cost could be bottlenecks. The comparatively long payback periods and the need for synchronized timing of investments mean that there are substantial risks and barriers associated with a state bioenergy industry. These risks can only be addressed through innovative partnerships between Hawaii's public and private sectors.

Chapter 8 Energy Emergency Preparedness

On a daily basis, Hawaii's energy infrastructure allows residents to travel to and from work, conduct business, prepare food, and keep their homes and offices illuminated and comfortable. Hawaii's energy infrastructure also hosts an active network of energy transactions, including the transportation and conversion of fuels into electricity, motive power, and heat. Damage to this infrastructure can seriously disrupt Hawaii's society and economy, causing financial loss, personal injury and even death. Thus, it is vitally important for the government and private sector to work together to reduce the risk of such disruptions, to ensure the impact of a disruption is minimized, and to plan and train teams to respond to emergencies effectively.

It is important to have a technical understanding of Hawaii's energy resources, markets, and systems for effective energy emergency planning and preparedness, mitigation, response, and recovery. For Hawaii, being prepared for energy emergencies requires state agencies, private sector stakeholders, and the public to develop and maintain the following:

1. A plan for managing energy shortages;
2. A plan for mitigating the impacts of natural disasters;
3. A plan for mitigating the impacts of manmade disasters;
4. A plan for maintaining continuity of government operations during energy emergencies; and
5. Regular exercise of emergency plans to ensure preparedness and readiness.

The State of Hawaii Department of Business, Economic Development and Tourism (DBEDT) is the central agency responsible for energy emergencies. When a disaster is declared, the State Civil Defense (SCD) is the lead agency. In an energy emergency, DBEDT is responsible for the coordinated planning, administration, implementation, situational monitoring, and sustained operation of any energy emergency response as detailed in State of Hawaii Emergency Support Function #12 (ESF-12), which is the energy portion of the overall State of Hawaii Emergency Plan. This entails developing succession charts to ensure continuity of government, selecting alternative command and control sites, and training employees to protect, restore, and maintain the welfare of co-workers and facilities during a disruption. Additionally, DBEDT is the primary agency responsible for keeping energy emergency plans updated and in compliance with national energy emergency preparedness requirements.

The legal authorities and references for the Hawaii Energy Emergency Preparedness Plan are summarized in Table 28:

Table 28. Legal Authorities and References

YEAR	STATUTE / ACT	APPLICABLE PROVISIONS
2003	**Homeland Security Presidential Directive: HSPD-5**	Establishes the National Incident Management System (NIMS). Requires Federal, State, and Local Emergency Plans to be consistent with NIMS standards and principles. Establishes the National Response Plan (NRP), and requires compliance with NIMS, to include compatible integration strategies with State Emergency Plans
2003	**Consolidated Appropriations Resolution, Public Law 108-7**	Provides expanded funding for Urban Area Security Initiative (UASI). Specifies Planning for State Level Continuity of Government Operations (COGO) as authorized program expenditure for Homeland Security Grant Program (HSGP).
2003	**Homeland Security Presidential Directive:** **HSPD-7**	Establishes the requirement for a National Infrastructure Protection Plan (NIPP). Energy facilities, both public and privately owned are inclusively defined as part of the Nation's "critical infrastructure and key resources."
2002	**Homeland Security Act**	Establishes the Department of Homeland Security. Defines "State and Local Government" entities, as well as "emergency response providers." Implicit in this Act is the requirement of the State of Hawaii and its response agencies to engage in adequate preparedness and response planning.
1993	**Hawaii Revised Statutes: §128-1**	Sets forth overall Civil Defense Policies for the State of Hawaii. Provides for parity with federal government emergency response functions as appropriate. Establishes the framework upon which DBEDT may implement ESF#12 at the State level.
1992	**Hawaii Revised**	Assigns responsibilities to the Director of DBEDT

	Statutes: §125C-31	for development and maintenance of a Biennial Energy Emergency Preparedness Plan. Requires a comprehensive planning and review process involving electric and gas utilities, and other energy providers as well as coordination with county governments. Also requires DBEDT to develop an Energy Emergency Communications Plan to ensure effective implementation of the Energy Emergency Preparedness Plan.
1992	**Hawaii Revised Statutes: §125C-32**	Requires all Counties in the State of Hawaii to prepare a County Energy Emergency Preparedness Plan that integrates with the State Energy Emergency Preparedness Plan. Updates are required every two years (even numbered years). Plans are to be submitted to the Director of DBEDT.
1990	**State Energy Efficiency Programs Improvement Act**	Amends the Energy Policy and Conservation Act of 1975. Requires submission of a State Energy Emergency Planning Program to U.S. DOE in order to remain eligible for federal grant funding. Also increases the Strategic Petroleum Reserves (SPR) to one billion barrels.
1987	**Hawaii Administrative Rules: Chapter 15-10**	Provides rules governing the procurement, control, distribution, and sales of petroleum products in the event of a fuel shortage as defined in Section 125C-2, Hawaii Revised Statutes, and in compliance with Sections 125C-4 & 125C-23 HRS. This Chapter addresses "Retail Fuel Sales and the State Set-Aside Program.
1985	**Hawaii Revised Statutes:** **§125C-1**	Empowers the Governor to declare an Energy Shortage Emergency. Also, to ensure that limited resources are monitored and distributed in an orderly manner and that conservation programs are implemented.

8.1 Hawaii's Energy Emergency Vulnerabilities

All energy systems have some ability to resist failure and endure small disruptions. Engineers and planners build redundancy and reserve capacity to allow for maintenance and downtime that can occur due to unforeseen events. Even so, energy systems have a threshold beyond which they cannot maintain service. This section describes aspects of Hawaii's geography and energy infrastructure that affect the state's ability to mitigate emergencies such as energy shortages and natural disasters.

8.1.1 Geography

Hawaii's geography is particularly susceptible to energy shortages and disasters for two main reasons: (1) the state is isolated and remote, which makes providing aid particularly difficult and (2) the state's geography as an archipelago.

Unlike states in the continental United States, Hawaii does not have any nearby land-contiguous neighbors with complementary resources. One of the main issues during a localized emergency is the integrity of surrounding areas. While the federal government can step in during major disasters, Hawaii's geographic isolation makes it unlikely that the state would receive immediate help from neighboring states. Because of its isolation, the state also has to be prepared to be relatively self-sufficient during adverse situations. Establishing a more resilient energy system would contribute to this self-sufficiency.

Additionally, parts of Hawaii are susceptible to natural disasters caused by earthquakes, tsunamis, hurricanes and floods, which can be both deadly and sudden. Hazards such as these have the potential to greatly disrupt Hawaii's energy system. As mentioned, disrupting energy services in times of calamity can make already bad situations significantly worse.

8.1.2 Energy Infrastructure

Energy infrastructure is also more vulnerable in island environments like Hawaii. Furthermore, the state as a whole is a relatively small system, making large central electric plants such as those built on the Mainland impractical. The high cost of interconnecting the various island grids makes ensuring electric reliability across all of Hawaii difficult. Each county must be able to provide the total capacity for peak loads, as well as capacity reserves and ancillary services, in isolation from the electric grids in other island counties.

Just as significant is Hawaii's lack of indigenous fossil-derived fuels and its overwhelming reliance on imported oil. However, Hawaii's continued oil dependency will only act to increase the state's exposure to the risk of supply disruption over the next several years. Thus, a diversification strategy that would lead Hawaii towards the greater use of energy efficiency and renewable resources is vital for mitigating the impacts of future supply shortages.

Hawaii lacks significant public transportation infrastructure, with the exception of the Honolulu-area system on Oahu and a (very limited) system on the Island of Hawaii. This

has resulted in the state having the highest percentage of essential automobile use in the nation. Vehicular mobility is essential to Hawaii's citizens and opportunities for curtailing driving in the event of a fuel shortage are limited. In the event of a fuel shortage or price spike, public transportation often serves as an alternative to private transportation, reducing cost and meeting any emergency transportation needs.

8.2 Historical Development of Hawaii State Emergency Preparedness and Planning Program

Emergency preparedness has become increasingly important as our built environment has expanded in capacity, increased in density, and grown in energy dependency. Overall, the goal of energy emergency management is to recover essential services as quickly as possible after a disruption. Each situation is unique, however, and plans must be prepared so that agencies are ready when emergencies occur.

The Hawaii State Legislature first mentioned Energy Emergency Preparedness Planning (EEPP) in 1974, when it granted the Governor broad powers that could be exercised in the event of an energy shortage. The legislature also established the position of the Energy Resource Coordinator (ERC) in the Office of the Governor (Chapter 196, HRS). A later amendment to Chapter 196, in 1978, specified that the Director of Business, Economic Development (DBED) "shall serve as Energy Resources Coordinator." The focus of the Energy Resource Coordinator was on managing energy shortage events.

After oil industry deregulation, the importance of organized responses to disruptions in energy supply was recognized, and other states also started to develop contingency plans. In 1991 following the first Gulf War, Hawaii revitalized its energy emergency plans with the completion of the State of Hawaii Energy Emergency Preparedness Plan and Reference Book. The Reference Book contains information on the relationships between different agencies and their functions, and detailed procedures and protocols for energy emergency responders. During the same period, Hawaii created the Governor's Energy Emergency Preparedness Advisory Committee (GEEPAC) to assist with EEP policy issues. The group assesses the adequacy of energy emergency contingency plans and measures. This group also advises the Governor during energy emergencies. The "advisory" nature of the GEEPAC provides the Governor and DBEDT with government, industry, and consumer feedback relative to the effectiveness of energy policies and programs implemented during an energy shortage.

In 1992, Hurricane Iniki devastated Kauai, causing major damage to Kauai's electricity system and leaving many customers without electricity for an extended period of time. DBEDT worked with State Civil Defense and key entities to prioritize repair and relief efforts. Among the "lessons learned" from Hurricane Iniki was the need for a government/industry coordinating body, which led to the creation of the Hawaii State Energy Council. The Hawaii State Energy Council (HSEC) is the lead agency to the State's Energy Emergency Preparedness Program. Chaired by the Strategic Industries Division (SID) Program Administrator, the HSEC coordinates information flow and facilitates response to any energy emergencies and disruptions in Hawaii. HSEC

members include all of Hawaii's major energy companies (electric and gas utilities, oil refiners, and major fuel distributors and terminal operators, including the airlines' jet fuel terminal consortium), specialized military units, and relevant federal, state, and county government agencies.

Another initiative implemented was the Emergency Generator Survey, which began in November 1999. The program was designed to inventory and locate generators in the state that would be available in the event of the emergency. This geographical information system database is available to energy emergency response organizations so they can utilize local diesel generators when responding to an energy emergency situation. Additionally, the program provides advice on improving generator reliability during operation and maintenance. In parallel, a database of emergency response facilities and their minimum power needs was compiled. This database will help determine where new generators would be best situated to maximize support resources and facility functionality in the event of power loss. One direct result of this work was the provision of two new 275 kW diesel generators to the Young Brothers inter-island barge company after they were deemed a resource critical to DBEDT's emergency responses.[399]

In the aftermath of September 11, 2001 terrorist attacks, the federal government responded with a new and vigorous focus on homeland security. Federal mandates now shape the manner in which state and local governments prepare for, respond to, and recover from, incidents of national significance, which includes energy emergencies. The federal mandates now require states to comply with the National Response Plan (NRP), the National Incident Management System (NIMS), and the National Infrastructure Protection Plan, which have significantly changed the nature of existing plans and protocols for the State of Hawaii. The Reference Book contains a "Compliance Matrix" that illustrates the current status of the State of Hawaii relative to these mandates. State Civil Defense, DBEDT, and all other State Agencies that have ESF responsibilities as set forth the State Emergency Plan must comply with National Standards and Directives as described above, as a condition of approval for all federal grants. Additional state activities following the September 11 event include:

- Critical Infrastructure Protection Guidelines adapted to State of Hawaii Homeland Security Advisory System (HSAS), now based on the Federal HSAS;
- Development of State of Hawaii Threat Protection Conditions & Measures, using color codes from white (normal), following progressively elevated threat conditions green, amber, and red, to black (event imminent or has occurred) as consistent with USDOD Force Protection conditions in the Federal HSAS;
- Formed join assessment teams (JAT) to develop specific criteria to conduct vulnerability assessments of critical infrastructure facilities statewide;

[399] Hawaii Energy Strategy. 2000.

- Development of security force deployment plans for industry, law enforcement, and other security forces (in accordance with federal) law) to protect critical infrastructure facilities at predetermined Threat Protection Conditions and/or respond in the event of terrorist attack;

- Development of *State of Hawaii Infrastructure Security Guidelines*, a table of security and protection measures for infrastructure facilities to use to guide development of company- and facility-specific security plans. Hawaii's *Infrastructure Security Guidelines* are base on the same criteria used by JAT in its security assessments.

The State of Hawaii underwent an update process in 2004, and unveiled a number of policies to promote the development of alternative energy research and development in 2006.[400] These actions further reinforced the State's ability to respond to future energy emergencies resulting from terrorist attacks.

8.2.1 Current Work on Emergency Preparedness

The State of Hawaii is continuously improving emergency response plans and programs overall. Every year, an emergency is simulated to gauge the performance of different organizations. This annual exercise is called Makani Pahili Statewide Hurricane Exercise. It offers government and private-sector companies a chance to identify potential improvements that can be made to procedures already in place. Its purpose is to provide an opportunity for agencies and organizations to work collectively with a common hurricane scenario, enhance disaster preparedness for government and private-sector agencies statewide, and provide a forum to enable agencies to identify areas for improvement.

After each exercise, a Hot Wash, (also known as an "After Action Review") is completed in order to identify areas for improvement. These areas for improvement must be integrated and tracked in order to ensure that preparedness improves with each exercise. The focus of the exercises each year is different. Conducting such exercises and implementing the lessons learned is instrumental in improving the skills and plans required for dealing with emergencies.

Also, this year the Energy Emergency Preparedness Plan and Reference Book were revised and updated. The Energy Emergency Preparedness Plan is the document that contains the current master plan for dealing with energy emergencies affecting the state. The Reference Book is a companion document that "illustrates organizational relationships components, and provides primary reference materials as a basis for policies, procedures, protocols, and actions taken in the Energy Emergency Preparedness Plan."[401] Currently, these documents are in draft form and under the final stages of review.

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[400] Energy Emergency Preparedness Reference Book. DBEDT. August 2006.

[401] State of Hawaii, DBEDT, Forthcoming January 2008. *The State of Hawaii Energy Emergency Preparedness Plan and Reference Book.* Energy Planning and Policy Branch, Strategic Industries Division.

An additional document, called the Action Plan, was also developed in 2006 and is also in the final stages of review. This document outlines issues that need to be addressed via legislation, policy changes, research/feasibility studies, and training sessions.

8.3 Organizational Structure and Response Mechanisms

Planning for and response to an energy emergency are assigned to a wide variety of cooperating organizations from private industry to the military to Hawaii government agencies. Each of these cooperating organizations may participate in the GEEPAC and/or the HSEC.

The Energy Division of the Department of Business, Economic Development and Tourism (DBEDT) is responsible for the administration, implementation, monitoring, and sustained operation of the State of Hawaii Emergency Support Function #12 to include the following specified actions as appropriate:

- Activation and sustained operation of appropriate components of the Hawaii Energy Emergency Plan pursuant to a Gubernatorial Proclamation of an Energy Emergency, or at the direction or request of Hawaii SCD;
- Activation and sustained operation of appropriate functions, activities, and programs that comprise the Shortage Management Center;
- Ensure intra/inter-agency coordination among all primary and supporting agencies and organizations pursuant to ESF #12; and
- Demobilization of personnel, facilities, and resources as required at the conclusion of the event or occurrence.

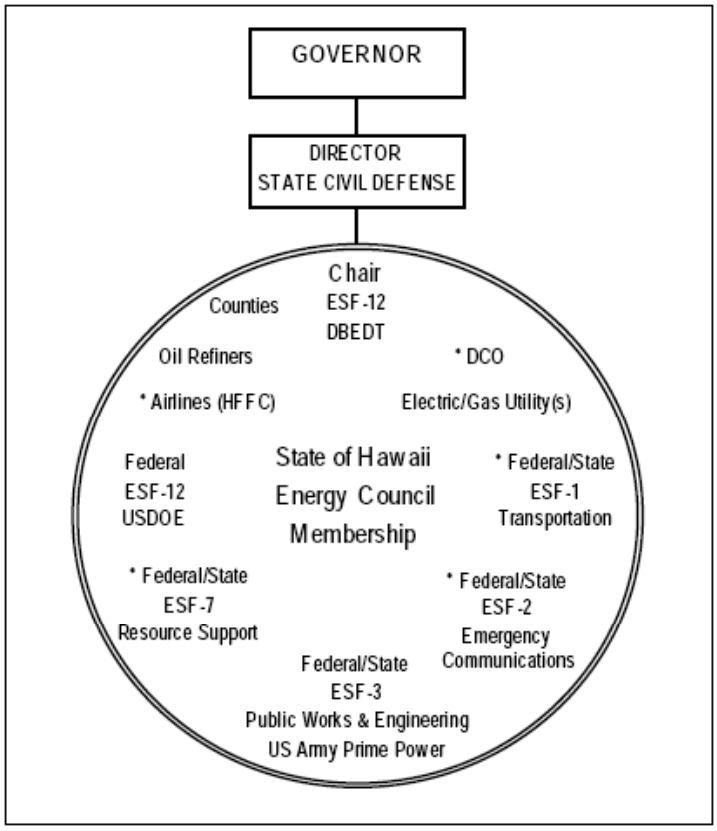
As noted above, the SID Program Administrator of DBEDT chairs the HSEC. The HSEC functions as a multi-agency, multi-organizational coordinating group, and assists DBEDT in energy emergency response. The HSEC integrates into and provides support for all activated Shortage Management Center functions, which include: member agency policy information and clarification, direct coordination augmentation to the operations function, critical situation and status information to the planning function, and material resources as appropriate in support of the logistics function. The primary responsibility of the HSEC is to coordinate activities necessary to facilitate:

- Safe, rapid restoration of the affected utilities' electricity grids;
- Emergency resource acquisition (e.g., temporary emergency generators to safely and rapidly provide and sustain electricity for essential and emergency facilities and services until commercial energy utility service can be restored);
- The availability and adequacy of fuel supplies, storage, and distribution; and

- The provision of energy-system situation reports to appropriate government and industry organizations, and to the community-at-large.

Represented on the HSEC are Hawaii's private-sector energy companies, and representatives from supporting agencies within the counties, State, and federal governments. The Director of DBEDT, or the Director's designee, hairs the EC and reports directly to the Director of Civil Defense, or his or her designee. The structure and membership of the HSEC are depicted in Figure 53.

Figure 53. State of Hawaii Energy Council Structure and Membership



8.3.1 Energy Emergency Phased Response Plan

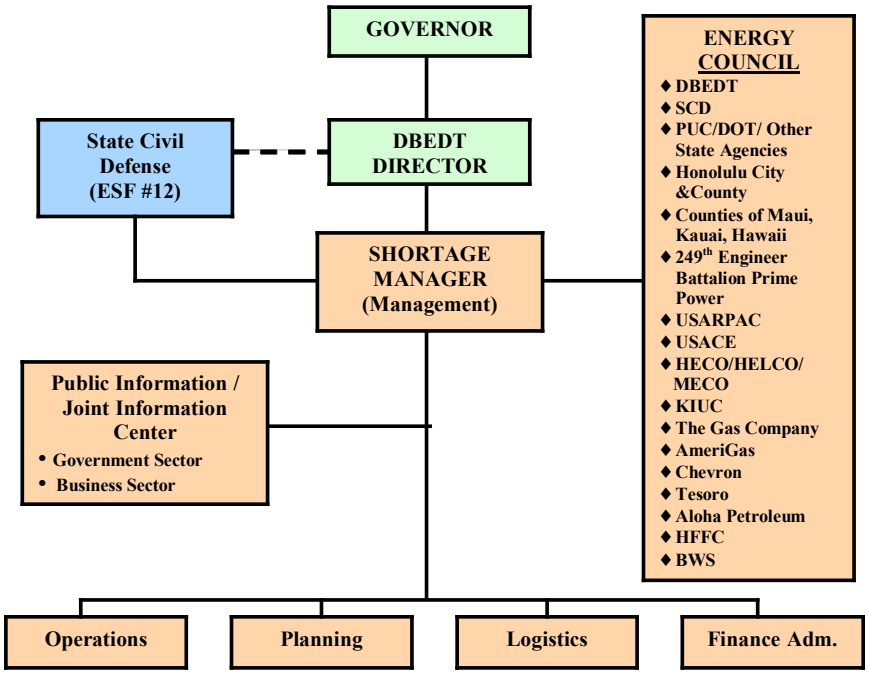
In the event of an energy emergency, DBEDT has a phased response plan.[402] The phases are "verification," "pre-shortage," "declared shortage," and "post-shortage and after-action." Each phase has specific actions to be taken, as well as activation criteria (except the final phase, which has de-activation criteria). The detailed procedures for this response plan are found in the State of Hawaii Energy Emergency Response Plan.

If an energy emergency enters phase three ("declared shortage"), DBEDT activates the

[402] State of Hawaii, DBEDT, Forthcoming January 2008. *The State of Hawaii Energy Emergency Preparedness Plan and Reference Book.* Energy Planning and Policy Branch, Strategic Industries Division.

Shortage Management Center and implements emergency fuel allocation and set-aside program while continuing coordination with SCD. The purpose of the Shortage Management Center (SMC) is to ensure centralized coordination of all ESF #12 activity pursuant to a "Declared Shortage." The scope of activities includes ESF #12 Operations as defined in the plan, information gathering and analysis, providing for logistical support for DBEDT personnel and facilities as that support relates to ESF #12 response operations, and ensuring accurate fiscal tracking of DBEDT expenditures pursuant to the activation of the SMC. Further, the Plan addresses key relationships with energy utilities, refiners, and other stakeholders at all levels of government. The Shortage Management Center functions as the DBEDT Department Operations Center (DOC) for ESF #12 and integrates with the State of Hawaii Emergency Operations Center, when activated. Its members and organization are shown in Figure 54.

Figure 54. Shortage Management Center Organization Chart[403]



The Emergency Fuel Allocation Program has three components: the Informal Allocation Process, the Fuel Set-Aside Program, and the Retail Service Station Sales Control Measures.[404] Descriptions of each program are provided below.

- ***Informal Allocation Process:***

[403] State of Hawaii, DBEDT, Forthcoming January 2008. *The State of Hawaii Energy Emergency Preparedness Plan and Reference Book.* Energy Planning and Policy Branch, Strategic Industries Division.

[404] State of Hawaii, DBEDT, Forthcoming January 2008. *The State of Hawaii Energy Emergency Preparedness Plan and Reference Book.* Energy Planning and Policy Branch, Strategic Industries Division.

- Used primarily for localized disaster support, at the request of SCD, or short duration market-related shortages.
- Voluntary cooperation of fuel companies to meet short-term fuel needs of emergency response agencies.
- Shortages are usually short-lived.
- Informal phone/e-mail request from designated DBEDT ESF# Staff, to fuel companies sets the allocation and delivery process in motion.

- ***Fuel Set-Aside Program:***

  - Used for prolonged energy supply disruptions.
  - Market forces are insufficient to offset a widespread petroleum shortage.
  - Fuel is unavailable at ANY price.
  - The FSAP is implemented when the Governor issues a disaster declaration or fuel shortage (Chapter 125C, HRS) and promulgates the Set-Aside Executive Order.

- ***Retail Service Station Sales Control Measures:***

  - Implemented during the Declared Shortage Phase.
  - Consists of the progressive implementation of the following procedures:
    - Uniform Flag System
    - Posted Hours of Operation
    - Odd-Even Fuel Purchase
    - Minimum/Maximum Fuel Purchases

8.4 Energy Strategies that Reduce the Impact of Emergencies

The energy strategies proposed in this section are basically the same as those proposed for the state energy strategy overall. While they cannot prevent energy emergencies from occurring, they contribute to improving preparedness by mitigating the impacts of energy emergencies. The strategies are described briefly here in the context of how they mitigate the impact of energy emergencies, and they are discussed in depth in sector-specific chapters throughout this report, including challenges to their greater adoption and policy recommendations for addressing those challenges.

In summary, reducing the consumption of imported fuels through efficiency and the development of local energy resources, including renewable energy, will help the state better manage energy shortages when they occur, mitigate the impacts of natural and manmade disasters, and facilitate the continuity of government operations during energy emergencies. Increasing the adoption of distributed generation will help reduce the state's vulnerability to natural disasters and intentional sabotage, which tend to affect the energy infrastructure. Diversifying energy resources away from imported fuels will also reduce the state's vulnerability to disruptions.

8.4.1 Using Efficiency to Reduce Demand

Reducing demand for, and thus dependence on, energy is one of the most effective means of minimizing the impact of energy shortages or other surprise disruptions (see in depth discussions section 5.1.2 and 6.1.2.1 in this report). Ultimately, efficiency allows for the same level of economic activity with less energy consumption, which benefits both the state and its consumers. Freeing up enough reserve capacity through electric and transportation efficiency in the system can enable utilities greater flexibility in scheduling plant maintenance, further reducing the risk of unforeseen downtime. More generally, efficiency can actively contribute positively to the local economy. For example, implementing natural ventilation and daylighting in buildings increases the comfort and productivity of residents and workers.[405] Similarly, transportation efficiency is improved through public transportation that reduces road congestion and thus the amount of time individuals spend in traffic (see section 6.1.1), which contribute to improved personal well-being.

8.4.2 Distributed Energy Resources

Large centralized power plants (greater than 150 MW in capacity) are more vulnerable to both natural and manmade disasters than smaller plants. Furthermore, when failure occurs with large generation facilities, they tend to negatively impact a large segment of the population. In contrast, smaller electric power plants are more modular, tend to be less complex in design, and hence tend to have lower failure rates, especially over the long term. Furthermore, localized, and geographically distributed sources of small-scale power are much more difficult to damage in a broad, systematic fashion. They cannot be easily targeted collectively, especially if they operate somewhat independently of one another.

Deploying generators onsite to reduce demand on the grid during critical times allows limited resources to be used for meeting the most essential needs. This would be especially strategic at facilities that would be important to carrying out energy emergency response programs, such as police and fire department facilities, hospitals, and communication centers. Additionally, distributed energy resources can help government with emergency operations when power is intermittent, unreliable or cut off entirely.

The ability to disconnect and operate independently from the grid (see further discussion section 5.1.4) would be a crucial advantage for facilities responsible for managing and responding to emergencies. The greater number of residences, commercial buildings, and other facilities that remain operational in light of an energy emergency, the greater the number of options and flexibility energy emergency coordinators will have in responding to the particular needs of a given populace. Some emergencies, such as Hurricane

[405] In one particularly well-designed energy-efficient building, worker productivity increased 6–16 percent, and considering that the operator of a typical office building pays about 100 times as much for labor as energy, a 1 percent increase in worker productivity would be as profitable as eliminating the entire energy bill. Source: Romm, J. and W. D. Browning. 1994. *Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design*. D94-27. Snowmass, CO: Rocky Mountain Institute. www.rmi.org/images/other/GDS-GBBL.pdf

Katrina, required a large facility—the Superdome—to provide refuge and safety for citizens. If energy service were disrupted, yet a facility similar in nature had its own power, it would quickly prove valuable. However, distributed generation also provides benefits more broadly, and its application should not be limited to the facilities mentioned above. Benefits can be realized on a continual, day-to-day basis for DER to reduce bottlenecks, peak demand, and total electricity consumption.

With the exception of diesel engines used for backup generation, most small-scale generators tend to be more expensive per MW of capacity to purchase and own. Although they are less expensive to operate due to less complex design and (except engines) higher efficiencies, most businesses do not have the expertise to operate generators onsite. A practical strategy is for utilities and independent power producers to include distributed resources into their electric supply planning and to provide resources to businesses and residents on the maintenance of on-site generation.

8.4.3 Local Energy Sources

Heavy reliance on imported fuels compounds the energy emergency risk. Local fuels, by contrast, are less prone to supply interruption by factors beyond the state's control. The development of local energy resources can contribute to local jobs creation and help keep more local dollars within Hawaii's economy.[406]

Hawaii has abundant renewable energy resources available to serve its electricity and transportation needs. Solar, wind, geothermal, biomass, biogas, and ocean energy are all resources that Hawaii can renewably exploit (see in depth discussions in section 5.1.5 and 5.1.6). They use "fuel" that is readily available and free, and is not subject to fuel price shocks, fuel price volatility, and fuel shipping interruptions. Additionally, Hawaii currently produces sugarcane, and could potentially produce crops such as banagrass, oil palm, or jatropha—crops that are ideal for cultivation and catalytic conversion to energy-dense, liquid biofuels such as ethanol, methanol, or biodiesel (see in depth discussions in Chapter 7). Minimizing dependence on imported fuels will also reduce risks as well as economic and energy system impacts should such imports be disrupted.

8.4.4 Diverse Energy Sources

Existing energy emergency plans currently rely heavily on diesel generators, which also produce petroleum-derived electricity. Diversification of Hawaii's energy fuels and technologies so that they include a greater amount of efficiency, renewable energy, and

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[406] For example, a dynamic macroeconomic model that simulated the net benefits to the Wisconsin economy of installing 750 MW of mixed renewable energy between 1995 and 2020 showed that the gross state product would increase by $3.1 billion, and real disposable income would increase by $1.6 billion (both in 1987 dollars), which is more than the benefits provided by 775 MW of coal- and gas-fired generation with the same annual electricity production. This is mainly because renewable energy, being more locally sourced, generated more than three times as many jobs and state economic benefits per GWh than the non-renewables. Source: Clemmer, S. 1995. "Fueling Wisconsin's Economy with Renewable Energy." Wisconsin Department of Administration, Energy Bureau. *Proceedings of the American Solar Energy Society's Soclar '95 Conference.* Minneapolis, MN, 15–20 July. Note that this source updates a longer 1994 state report by S. Clemmer and D. Wicher, *The Econoimcs Impacts of Renewable Energy use in Wisconsin*.

renewable fuels (as described above) would reduce the impact of energy emergencies. Diversification would also increase the options available for addressing energy emergencies. Diversification improves the robustness and resiliency of the energy system. For example, it may be worthwhile for critical facilities to minimize their electric consumption through efficient design and be powered by renewable and onsite electric resources. Additionally, it may be worthwhile for some or all emergency response vehicles, such as ambulances and fire trucks, to be highly fuel-efficient and/or able to run on alternative fuels to ensure they can be operational for as long as possible during disasters.

Hawaii's leaders should ensure that the policies and programs that are developed and implemented support the development of many different energy resources—not just the cheapest option. Furthermore, it has been shown that integrating renewable energy sources into the supply portfolio could reduce price shock risk without increasing the cost of electricity to the consumer.[407] Diversification ultimately means that Hawaii does not depend on any single technology or fuel in order to be able to continue government operations during emergency events.

8.4.5 Next Steps

Additional work is recommended for examining how efficiency, DER, local fuels, and increased diversification can fit within Hawaii emergency management responsibilities through the preparedness, response, recovery, and mitigation phases of an energy emergency. It is also worthwhile further examining whether and how:

- EEP plans need to be changed to incorporate energy mix changes during verification, pre-shortage, declared shortage, and post-shortage phases of an energy emergency;
- Operations, planning, logistics, and finance administration of the SMC may change to accommodate changes to Hawaii's energy mix; and
- Changes in Hawaii's energy systems and strategy have implications for the emergency fuel allocation program, and the mitigation and conservation programs.

8.5 Conclusions

As a result of its geographical isolation from the continental United States as well energy exporting nations, the State of Hawaii remains vulnerable to energy supply disruptions. Should a disruption in energy availability occur, the resultant energy shortages could significantly impact Hawaii's citizens, government operations, and the stability of Hawaii's economy in which energy plays an integral part.

[407] Awerbuch, S. "How to Value Renewable Energy: A Handbook for State Energy Officials" (draft edition 1.0, IREC, March 1996). Page 70.

The Strategic Industries Division of DBEDT has responsibilities encompassing promoting, attracting and facilitating statewide energy resource development, including energy efficiency and renewable energy resources. The DBEDT Director is the State Energy Resources Coordinator, who is also responsible for the coordinated planning, administration, implementation, situational monitoring, and sustained operation of any State energy emergency response. Hawaii has recently updated its Energy Emergency Preparedness Plan for responding to energy emergencies affecting the state.

DBEDT's responsibilities of promoting energy resource development and energy emergency preparedness are closely interrelated. In fact, encouraging energy efficiency and renewable energy development also emphasizes the development of local energy resources, improves emergency preparedness, and mitigates the impacts of energy emergencies. Reducing consumption of imported fuels through efficiency and the development of local energy resources help reduce the state's vulnerability to surprise energy disruptions. Increasing the adoption of distributed generation helps reduce the state's vulnerability to natural disasters and intentional sabotage, which tend to affect the energy infrastructure. Diversifying energy resources away from imported fuels will also reduce the state's vulnerability to surprise disruptions.

Appendix A: Modeling Hawaii's Energy System

This chapter presents the Energy2020 modeling results for Hawaii's energy system. The purpose of the modeling is to generate insights into Hawaii's energy system to better inform the development of a State energy strategy. This chapter also examines the energy system's projected behavior under various scenarios pertaining to future fuel prices and technological improvements. It is assumed the system will operate within an existing regulatory environment. The range of outcomes provides a sense of how the system's vulnerabilities will evolve in the absence of new policy intervention.

The energy modeling for this analysis takes a more probabilistic approach rather than a deterministic one as there are different routes leading to different energy futures. The analysis tries to capture the uncertainty around various assumptions about demand and fuel forecasts, fuel price volatility, and future regulatory compliance costs. As discussed in detail in the primary fuels Chapter 4 , the world's energy markets have become more volatile and risky, so that today one aspect of an energy strategy is a quantitative assessment of the ability of different solutions to manage the risks in the energy system. The solutions discussed in the rest of this report (heavily focused upon efficiency and the use of local renewable resources) are evaluated on their ability to hedge against costly risks.[408]

Developing Future Scenarios

Although the future of the world is wholly unpredictable, experience teaches us that the future will follow one of a relatively few, probable, and identifiable scenarios. While this analysis does not try to describe all the possible future states of the world at the extremes, the approach is to identify the boundary conditions, high and low, beyond which decision-making will change. The exercise of scenario analysis is not to predict exactly what the future will look like, but rather in to prepare for and shape it. The goal of a scenario analysis process is learning. Planning for Hawaii's energy future is primarily a matter of proactively identifying and managing against the various future risks and in gaining insight into how different pathways to identified future outcomes incur consequences that might otherwise be overlooked.

The scenarios themselves are hypotheses about how the future may unfold, and they are constructed so that they are internally consistent based on a logical set of assumptions. Developing scenarios involves blending factual, technical information with systemic observation of the playing field on which future events will occur, and the rules under which key actors will perform. Some of the keys include identifying the right questions to ask, identifying the most important elements of a system that will influence the way the system evolves, and identifying the solutions that will meet the requirements of economic growth, security, and environmental protection.

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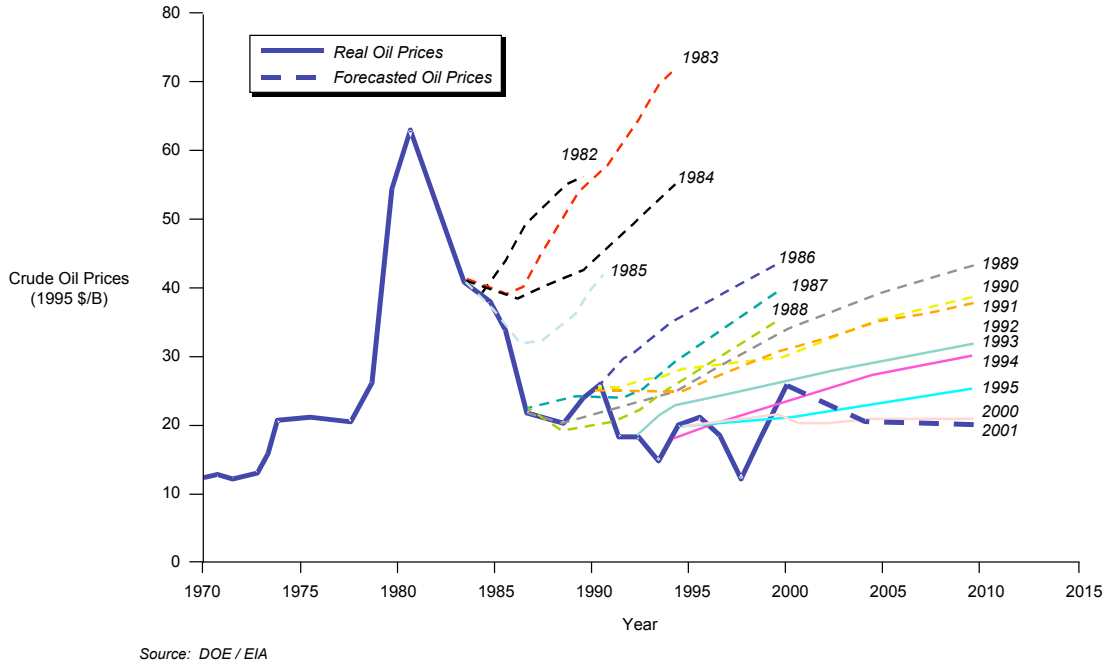
[408] Such strategies may present tradeoffs. For example, a resource mix with a larger degree of renewable power may have a larger expected cost but a narrower range of uncertainty compared with today's more conventional generation portfolio.

For HES2007 three scenarios, based on hypotheses of how the future will likely unfold, were created. These scenarios are driven primarily by fuel price projections, which affect and are affected by regional and global supply and demand. Additional elements of the scenarios included the impact of fuel prices on the pace of innovation and the market adoption of efficient and renewable technologies.

Forecasting: A Caveat

By its nature, forecasting, especially price forecasting, is an inaccurate science. A stark example is the chart below, illustrating the U.S. Energy Information Administration's (EIA) forecast for oil prices over the last two decades, and the actual oil price. As the chart reveals, the only consistency with energy price forecasts is that they tend to be wrong and that they tend to track current price levels.

Figure 55. EIA Price Forecasts versus Actual Oil Prices 1970–Current

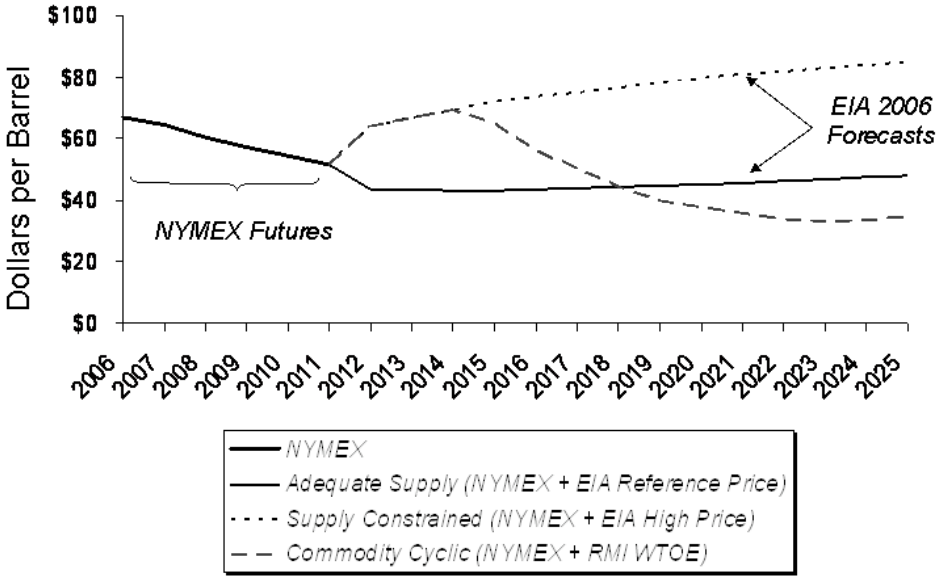


Source: DOE / EIA

The three scenarios constructed for HES2007 include the "adequate supplies" scenario, the "constrained supplies" scenario, and the "commodity cyclic" scenario. They are so named for the relative supply of oil and its products that are used in Hawaii's energy system. The "adequate supplies" scenario, as its name implies, assumes that oil supplies continue to expand in the future so that they comfortably keep up with demand growth. As a result, long-run fuel prices remain moderately low over the 20-year duration of the analysis, through 2025. Under this scenario, improvements in efficient and alternative technology are modest and incremental. In the "constrained supplies" scenario, diminishing reserves and declining oil production cannot keep up with demand, so energy markets are characterized by sustained high fuel prices. High fuel prices stimulate the pace of technology innovation and adoption in the energy system. The "commodity cyclic" scenario is relatively more dynamic, projecting a cyclical pattern of fuel prices

over the analysis time frame. The fuel price forecast for this scenario therefore varies, with a period of rising fuel prices between periods of modest and falling fuel prices. In this scenario, fuel prices and technology are assumed to interact. The initial high prices stimulate a shift to more efficient and alternative technology, which in turn lowers the demand for oil. The resulting reduction in demand causes fuel prices to fall, which in turn retards efficient technology adoption and stimulates demand growth once again.

Figure 56. Analysis World Crude Price Projections, 2006–2025[409]



The crude oil price projections for each scenario are included in Figure 56. Near-term price forecasts out to 2012, derived from the New York Mercantile Exchange (NYMEX) futures markets price forecast, are the same for all three scenarios. Beyond 2012, the adequate supplies price forecast was constructed using the? Energy Information Administration (EIA) reference case primary fuel price forecast. The constrained supplies fuel price forecast was based on the EIA high case primary fuel price forecast. The commodity cyclic forecast was based on a scenario developed by Rocky Mountain Institute in its book *Winning the Oil Endgame,*[410] whereby rising fuel prices stimulate technological innovation that in turn causes a decline in prices around the year 2018. For HES2007, the model assumes that fuel prices continue to fall below those prices reached in the adequate supplies scenario so that demand once again begins to grow.

Forecasts for diesel and gasoline were created in relation to crude oil price projections. They were then adjusted to Hawaii-specific prices after incorporating refiners'

[409] Forecast is based on NYMEX future forecast through 2012. Beyond 2012, the forecast is based on EIA reference and high scenario forecasts. Commodity cyclic forecast was developed by RMI based on *Winning the Oil Endgame* research.

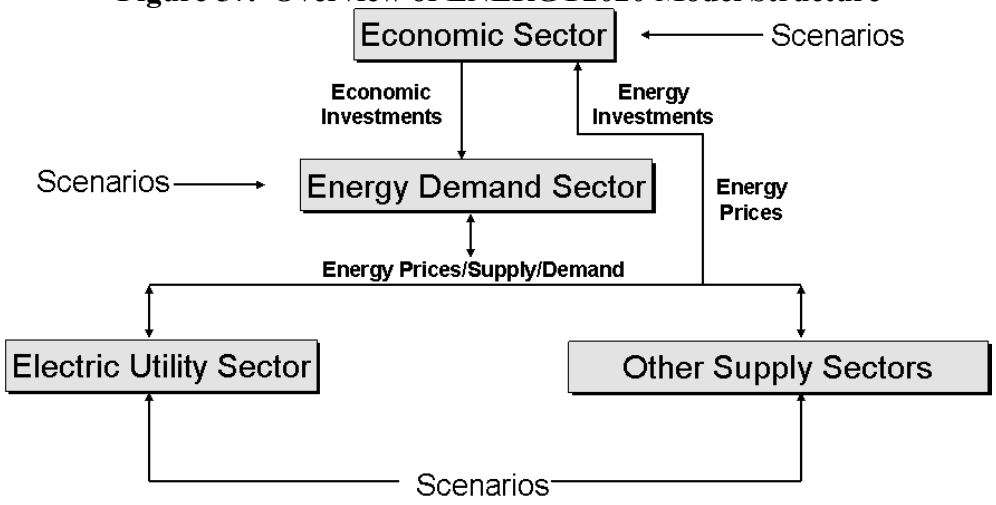
[410] Lovins, A. et. al. (2005) *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security.* Rocky Mountain Institute. www.oilendgame.com.

acquisition cost, and state and federal taxes. Coal and other electricity fuel price forecasts were based on price forecasts as reported by Hawaii's electric utilities.

Modeling Hawaii's Energy System

Much of the numerical analysis was done using the Energy2020 energy model. Energy2020 is a multi-sector energy model that simulates the decisions of both consumers and producers of energy. It allows the user to observe the likely affects of economic and price signals, energy policies, and other drivers affecting Hawaii's energy system through the year 2025. Integrated into Energy2020 is a macroeconomic model developed by Regional Economic Models, Inc. (REMI). REMI's model contains forward-looking macroeconomic data (elements such as gross state product, employment, income, population growth, etc.) specific to Hawaii that serves as the backdrop against which Hawaii's energy system behaves. One of the strengths of Energy2020 is that the model is flexible. It can be configured to operate at any level of detail, and it is limited only by the availability of data, budget, and time.

Figure 57. Overview of ENERGY2020 Model Structure



For HES 2007, the energy system was divided into a number of demand and supply sectors for each of the four counties in Hawaii (see Figure 57). The demand sectors consisted of: residential, commercial, industrial, military, marine, ground transportation, and aviation. The residential and commercial sectors were further broken down into sub-categories, such as single- and multi-family residences, hotels, offices, schools, hospitals, and other. The transportation sectors were further broken down into sub-categories, such as highway, bus, aviation, and marine.

The supply sectors included electric utility generators, independent power producers (IPP), and combined heat and power generation. External model enhancements to Energy2020 included light vehicle fuel economy and flex-fueled vehicle penetration, biofuels supply and demand for transportation, and electric utility supply sectors. These were modeled separately external to Energy2020, and the results were then incorporated into the Energy2020 simulation.

Historical Data Inputs and Sources

Energy2020 is tailored to Hawaii's energy system using historical demand and supply data provided for each energy sector by county from 1999 to 2005. The model was then calibrated against the state's utilities projections of future electricity demand, net of estimated energy-efficiency savings from utility efficiency programs. The following paragraphs provide a summary of the data types and sources used as historical inputs into Energy2020. For a detailed discussion of sources and methods used to derive these historical inputs, see Appendix B.

Historical demand sector inputs included historical consumption by fuel type and by end use. For each county, fuel consumption data for the electric demand sector included utility gas, bottled gas, refinery gas, solar hot water, electricity, #2 fuel oil, #6 fuel oil, coal, and biomass. Fuel consumption data for the transportation sector by county included gasoline and diesel, ethanol and biodiesel, marine fuels, and aviation fuels. Whenever possible, historical data were collected from publicly available documents, such as utilities' annual reports filed with the Federal Energy Regulatory Commission (FERC) and the Hawaii Public Utilities Commission (PUC), utility-sponsored demand-side management (DSM) studies, the Hawaii Department of Liquid Fuel Tax Base, and DBEDT public records.

Historical supply-side sector inputs included historical fuel prices, historical electric utility generation capacity, annual electricity generation, and utility financial data. Generation unit-level data were aggregated according to generation technology (steam, diesel, combustion turbine, hydro, etc.) for each county by utility and IPP. Historical data were collected from publicly available documents, including electric utilities' annual reports filed with the Federal Energy Regulatory Commission (FERC) and the Hawaii Public Utilities Commission (PUC). Gas utilities' data were collected from annual reports filed with each county. Historical fuel prices were collected from DBEDT databases and the U.S. Energy Information Administration.

Forecasted Data Inputs and Sources

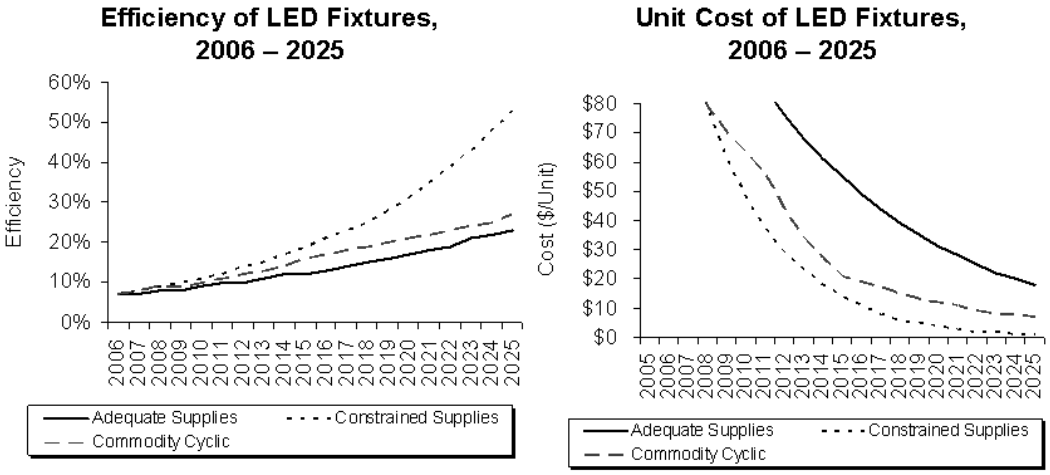
In addition to historical data inputs, Energy2020 also required a number of forward-looking data inputs, which were adjusted based on the specific scenario analyzed. These consisted of future fuel price projections, discussed above. Forward-looking data inputs relate to future technology costs and market potential. The data inputs included electricity generation technologies and electric end-use technologies (residential lighting and space cooling), as well as future technology performance information such as light car and truck efficiency, and residential lighting technology efficiency. Committed electric utility projected capacity additions in the near term were incorporated into Energy2020 for those generation projects approved by the PUC as of August 2006. The amount of cost-effective biofuels production under the three scenarios is discussed in Chapter 7 section 7.2 .

On the demand side, the device efficiency and unit prices of residential lighting (for example, incandescent lamps, compact fluorescent lamps (CFL), and light-emitting diode

(LED) lamps) were projected, along with residential central air conditioning and air source heat pumps. Residential central air conditioning and air source heat pumps are assumed to be relatively mature technologies, so that variations in efficiency and unit costs are marginal across the three scenarios.

Efficiency and the per-unit cost of incandescent lamps were assumed to remain relatively constant over the long term across all three scenarios (see Figure 58). LED technology is assumed to have a greater capacity for improvement than CFLs under the constrained scenario with higher fuel prices. LED efficiency increases from 7 to 50 percent between 2005 and 2025, compared to 11 to 18 percent for CFLs. Unit costs for LEDs are also assumed to decline at a faster rate than CFLs' unit costs. In the commodity cyclic scenario, efficiencies and unit costs for CFLs and LEDs are assumed to be better than, though similar to, those under the adequate scenario. Figure 58 compares the unit cost and efficiency improvements of residential lighting technology, using LEDs as an example.

Figure 58. Efficiency and Unit Cost of LED Fixtures, 2006–2025



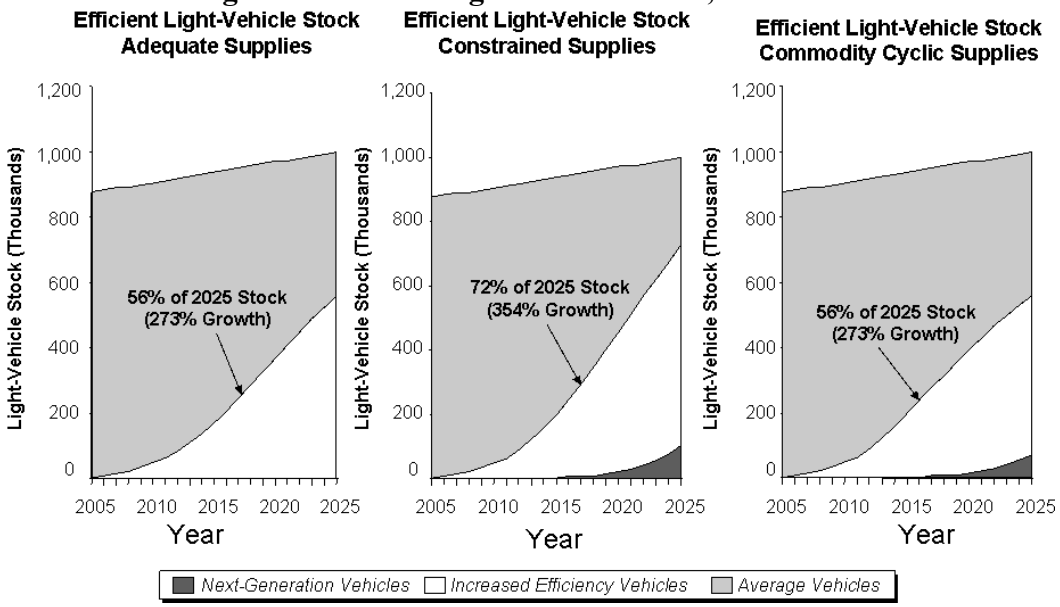
Fuel prices forecasted for the different scenarios also affect assumptions regarding the penetration of efficiency in the future automotive fleet, the penetration of flex-fuel vehicles in the market, and vehicle-miles traveled. Figure 59 offers a simplified view of the overall light-vehicle fleet predicted for each scenario. "Average vehicles" refers to the conventional vehicles on the road today. "Increased efficiency vehicles" refers to the most advanced vehicles currently available, such as hybrids. "Next-generation vehicles" include plug-in hybrids and ultra-lightweight vehicles that incorporate carbon fiber composite materials. Such vehicles could become commercially viable in the next fifteen years if oil prices remain high.

Increased efficiency and next-generation vehicles will experience the greatest penetration under the constrained scenario, making up more than 70 percent of the vehicle fleet by 2025. The adequate and cyclic scenarios will experience similar changes in the vehicle

population, though next-generation vehicles are expected to take a slim share in the cyclic scenario due to initially high fuel prices.

Flexible-fuel vehicles (FFVs) are assumed to be introduced under the constrained and commodity cyclic scenarios, where high fuel prices stimulate federal directives for manufacturers to introduce them to the market. FFVs are capable of running on 85 percent ethanol and 15 percent gasoline by volume (E85). In the absence of state-specific information, the penetration rate of flex-fuel vehicles is assumed to mirror national-level trends.[411] Flex-fuel vehicles are assumed to follow a standard technology diffusion s-curve, making up 32 percent of the vehicle stock in 2015 and reaching 80 percent of vehicle stock by 2025.

Figure 59. Mix of Light Vehicle Stock, 2005–2025



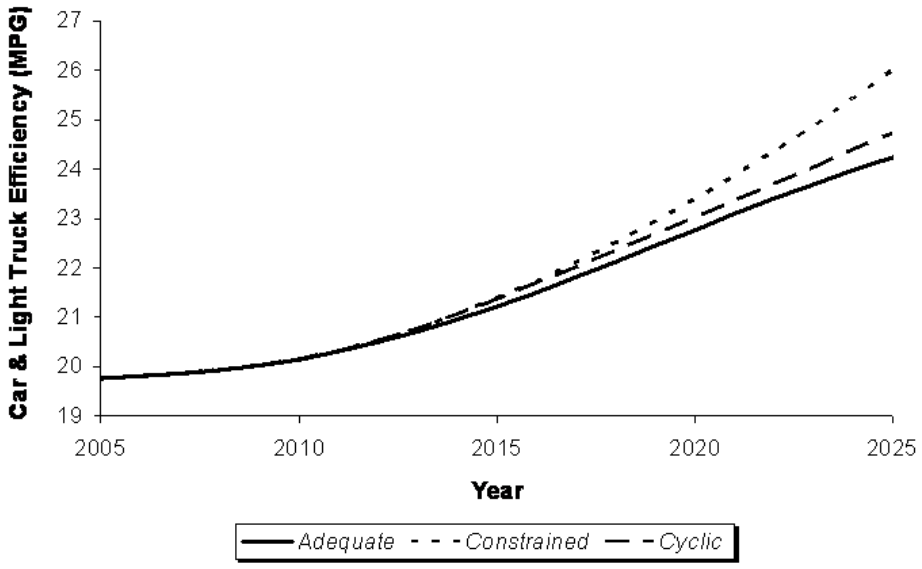
The impact of the changing fleet composition can be seen in Figure 60, which examines the efficiency gains under each scenario. With adequate supplies, the fuel economy of cars and light trucks improves only marginally to 24.2 miles per gallon by 2025. The increased penetration of more efficient and next-generation vehicles under the constrained scenario leads to an overall fleet efficiency of 26 miles per gallon in 2025. The cyclic scenario fleet mirrors the constrained supplies fleet through 2018, at which point falling fuel prices slow the pace of improvement. The average stock efficiency of cars and light trucks reaches 24.7 miles per gallon by 2025 under the cyclic scenario. Figure 60 does not show the relatively greater efficiency improvements in rental vehicles, which experience a higher rate of turnover than cars and light trucks. Rental vehicles experience a 20 percent improvement to 25 miles per gallon by 2025 under the adequate

[411] MacKenzie, Donald. 2006 August 30. Union of Concerned Scientists. Personal communication.

supplies scenario, a 35 percent improvement to 28 miles per gallon by 2025 under the commodity cyclic scenario, and a 49 percent improvement to 31 miles per gallon by 2025 under the constrained supplies scenario.

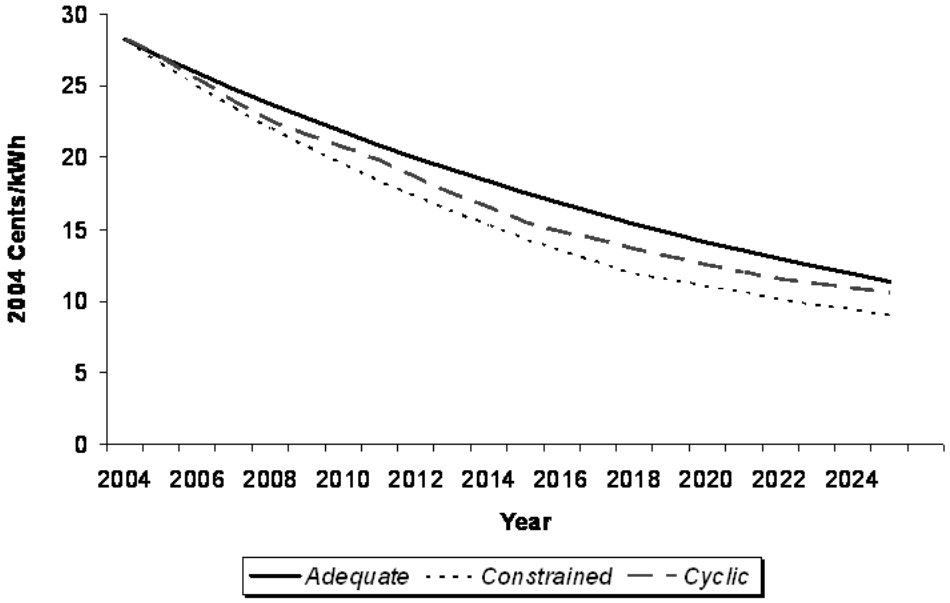
On the supply side, market adoption for renewable energy technology is assumed to take place under all scenarios, which results in declines in capital costs. Projections are based on the International Energy Administration's (IEA) World Energy Outook 2004. Under the adequate supplies scenario, wind is projected to grow at about 10 percent annually, solar at around 20 percent, and geothermal at 3.5 percent. Solar PV makes impressive gains even under the adequate supplies scenario, with high growth rates and learning rates.

Figure 60. Efficiency of Light Vehicle Stock, 2005–2025[412]



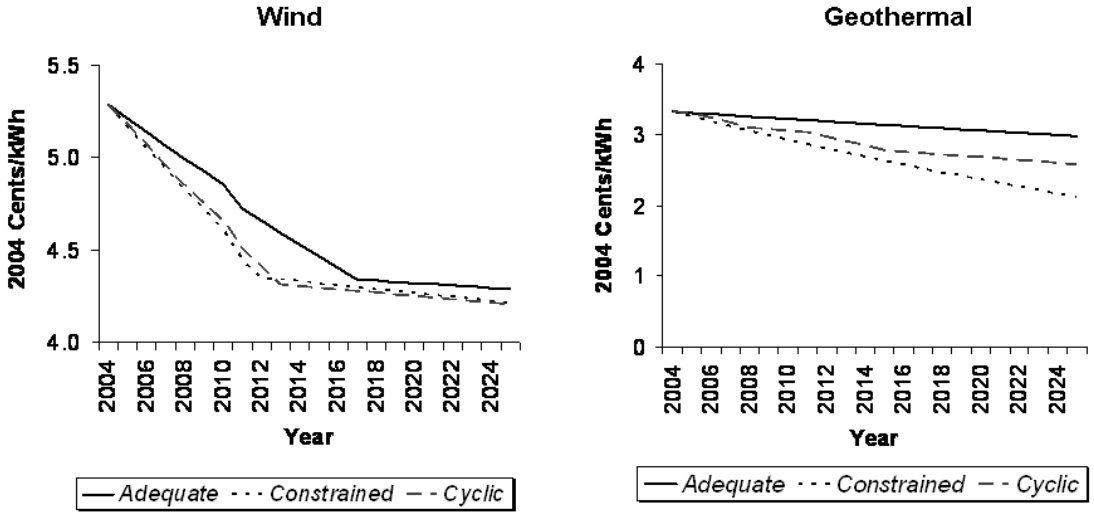
[412] Does not include rental vehicles, which—due to frequent turnover—are typically between 1 mpg and 3 mpg more efficient than the rest of the fleet.

Figure 61. Amortized Installed Cost of Solar PV, 2004–2025



Wind and geothermal energy are relatively mature, and are projected to experience only modest cost improvements. For instance, wind is expected to level off at approximately 4 cents per kilowatt-hour by 2013, regardless of the scenario. The cost of geothermal energy is slightly more sensitive to oil prices, possibly reaching 2 cents per kilowatt-hour by 2025 under the constrained scenario. Figure 62 illustrates these trends in renewable energy.

Figure 62. Amortized Installed Cost of Wind and Geothermal, 2004 – 2025

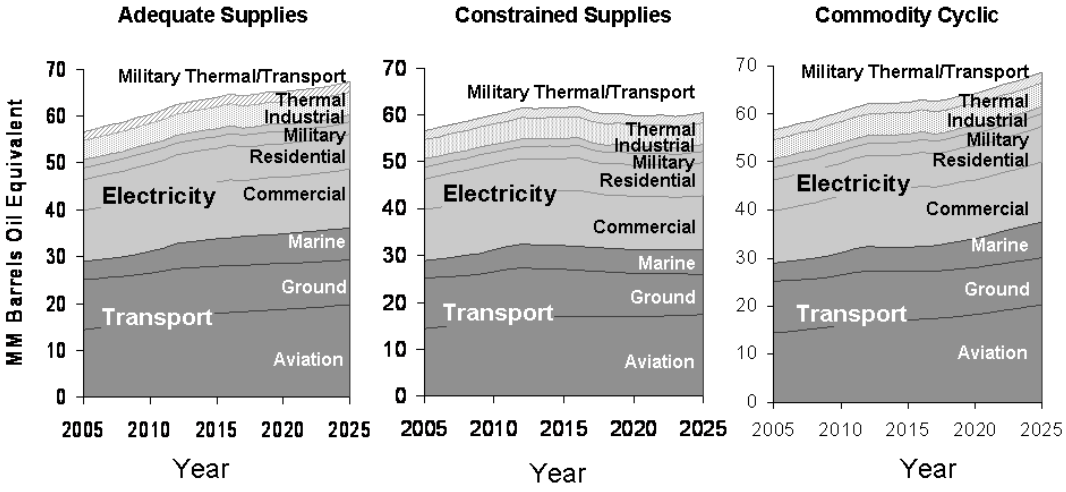


Projected Energy System Behavior

Projected energy demand by sector for each of the three scenarios is depicted in Figure 63. Energy2020 model projections show that if oil supply remains adequate and prices remain modest over the long term, Hawaii's total annual energy consumption will rise by 19 percent through 2025, to 67 million barrels of oil equivalent per year, statewide. This growth will be driven primarily by aviation and marine fuel demands, which are projected to increase by 37 percent and 81 percent, respectively, compared to 2005. Similarly, total energy demand under the commodity cyclic scenario reaches nearly 70 million barrels of annual crude oil equivalent by 2025 statewide, a 22 percent increase over 2005 levels, buoyed by low fuel prices later in the forecast period. However, if fuel supplies remain constrained over the long term, demand will grow by only 7 percent before leveling off around 2015. Transportation energy demand under the constrained supplies scenario actually begins to decline as more efficient vehicles are introduced to the market.

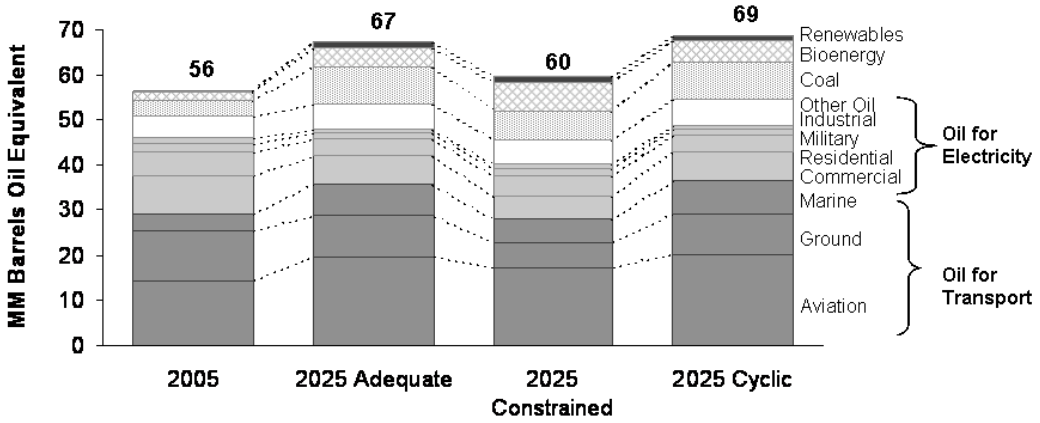
An examination of primary fuel consumption shows that oil's share of the total fuel supply is projected to drop under all scenarios. This reflects substitution bioenergy and other renewable resources, as well as coal consumption for electricity generation. As a result, oil is projected to supply between 77 and 80 percent of Hawaii's energy in 2025, as opposed to 90 percent today. However, absolute oil consumption will still rise by 5 and 7 percent under the adequate and cyclic scenarios, respectively. Figure 64 depicts primary fuel consumption by sector for each of the three modeled scenarios

Figure 63. Total Statewide Energy Demand, 2005 – 2025[413]



[413] Energy demand covers all fuels, including renewables. Total BTUs of energy have been converted to millions of barrels of crude oil equivalent using the heat content of crude.

Figure 64. Primary Fuel Consumption in 2005 and 2025

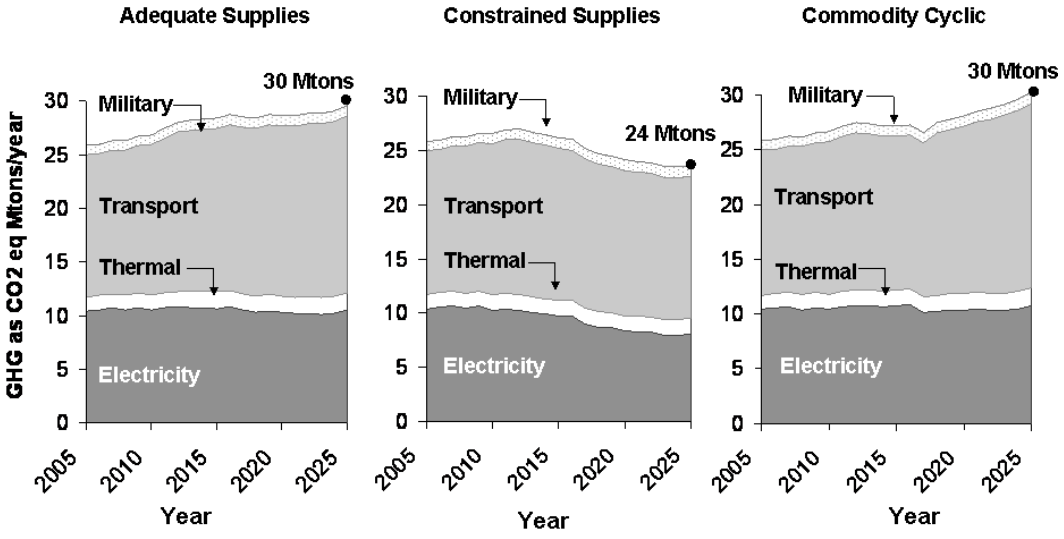


Oil Consumed (Mmboe/yr)	51	54	46	54
Oil Dependence	90%	80%	77%	79%

Trends in Hawaii's carbon dioxide emissions (Figure 65) are projected to be similar to trends in total energy demand for the three scenarios, though the growth will be dampened to the extent that renewable fuels are employed. Annual emissions are estimated to grow 14 percent between 2005 and 2025 under the adequate supplies scenario, driven primarily by the transportation sector, while emissions from electricity generation remains relatively constant at 10 million tons of carbon dioxide equivalent per year annually. Greenhouse-gas (GHG) emissions trends in the commodity cyclic scenario are projected to increase 17 percent between 2005 an 2025 as fuel prices fall below the levels experienced under the adequate supplies scenario beginning year 2018.

The constrained supplies scenario is the only scenario under which absolute oil consumption decreases, and this is reflected in the steady decline in emissions, starting in 2013. By 2025, with sustained high fuel prices under the constrained supplies scenario, annual emissions are projected to be 9 percent lower than in 2005. This decline will be driven by a leveling of demand growth in both the transportation and electricity sectors, as shown in Figure 63, as well as the greater adoption of efficient- and clean-vehicle and electric generation technologies. In the electricity sector, emissions are projected to fall by 23 percent compared to 2005 levels. A 180MW coal plant that is built on Oahu under the adequate supplies and commodity cyclic scenarios in 2025 is not built under the constrained supplies scenario as a result of slower demand growth, further reducing overall GHG emissions. Incremental demand growth on Oahu under the constrained scenario is met using solar thermal, refuse, and solar PV capacity.

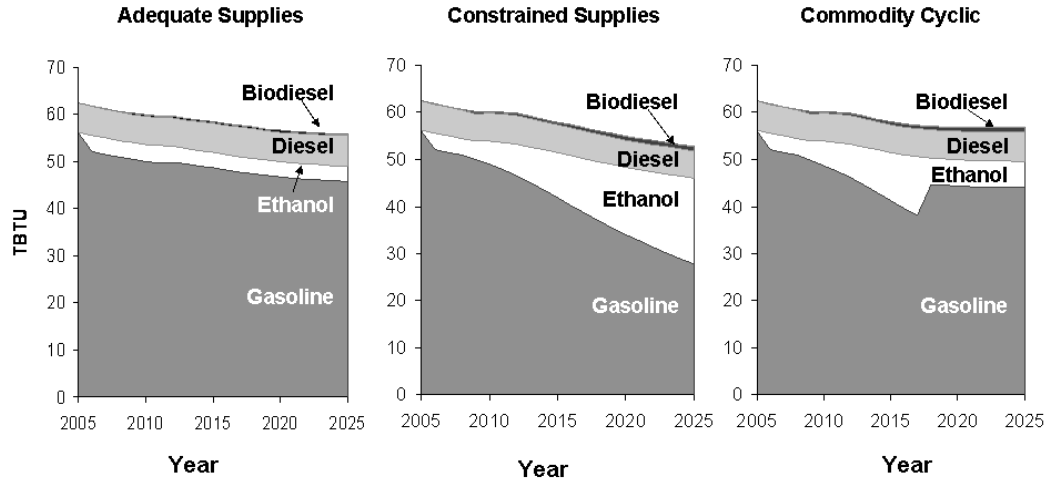
Figure 65. CO2 Emissions, 2005–2025



Ground Transportation Demand

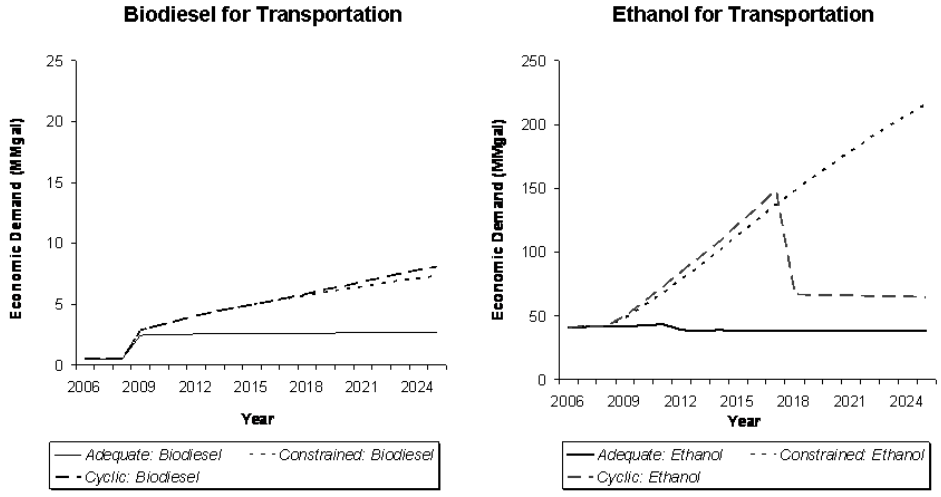
Vehicle technology is assumed to become more efficient under all scenarios, with differences in the magnitude and rate of efficiency improvement in response to gasoline and diesel prices under the different scenarios. If supplies remain adequate, annual ground transportation fuel demand in 2025 is projected to be 11 percent lower than in 2005. In terms of fuel consumed, this equates to 56 TBTUs in 2025 compared to 62 TBTUs in 2005. The commodity cyclic scenario shows a 9 percent reduction in annual consumption. Fewer next-generation vehicles are adopted under the market in the cyclic scenario compared to the constrained scenario, resulting in a lower vehicle stock efficiency. This is due to the lower fuel prices assumed in the cyclic scenario after 2018. As expected, the constrained scenario experiences the greatest decrease in annual demand—16 percent between 2005 and 2025. As discussed with regards to Figure 60, a 72 percent market penetration of efficient and next-generation vehicles results in the most efficient vehicle stock under the constrained scenario. Biofuels substitution, primarily ethanol, is also expected to occur under the constrained scenario, further reducing fuel demand over the long term. These trends are illustrated in Figure 66.

Figure 66. Ground Transportation Fuel Demand, 2005–2025



Biofuels are also expected to displace diesel and gasoline. The potential for ethanol substitution for transportation is much greater than for biodiesel (Figure 67), though the extent of this substitution will be highly dependent on the relative price of gasoline. Ethanol is always more cost-effective than gasoline under the constrained supplies scenario, and demand grows vigorously from 40 million gallons in 2006 to 215 million gallons by 2025. Under the cyclic scenario, customers with flex-fuel vehicles purchase E85 fuel in the near and medium term, but, as gasoline prices fall competitively below that of ethanol, they are expected to revert to using gasoline by 2018. With adequate supplies, low gasoline prices also out-compete ethanol, and the market demand for E85 is small given the limited number of FFVs on the market. However, ethanol is still used to meet the existing E10 mandate for gasoline.

Figure 67. Ground Transportation Biofuels Demand, 2006–2025

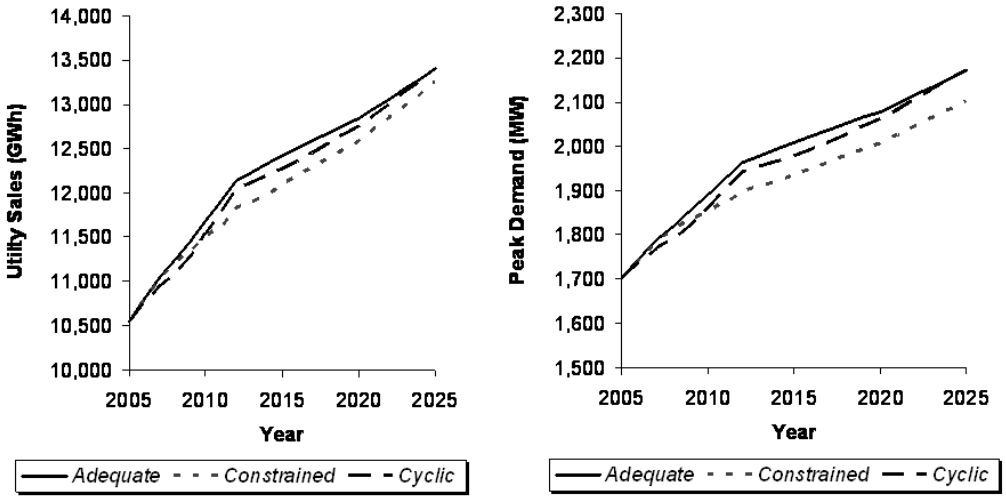


Biodiesel is expected to be cost-competitive regardless of the scenario, with production derived from imported palm oil. However, the opportunities to substitute this fuel in the transportation sector are limited due to the relatively small number of diesel engines and constraints imposed by manufacturer vehicle warranties. As such, it is conservatively assumed that diesel engines will consume no more than 20 percent biodiesel by volume (B20) over the long term.

Electricity

Statewide utility electricity sales and peak demand are depicted in Figure 68. Each is expected to grow at a compounded annual rate of 1.2 percent under both the adequate supplies and the cyclic scenarios. Initially, electricity sales and peak demand under the adequate supplies scenario grow more quickly than under the cyclic scenario. However, demand growth under the cyclic scenario accelerates as prices fall, ultimately catching up to demand under the adequate supplies scenario by 2025. Growth is slightly slower under the constrained supplies scenario, at compounded annual rate of 1.1 percent for both sales and peak demand.

Figure 68. Electricity Sales and Peak Demand, 2005–2025[414]

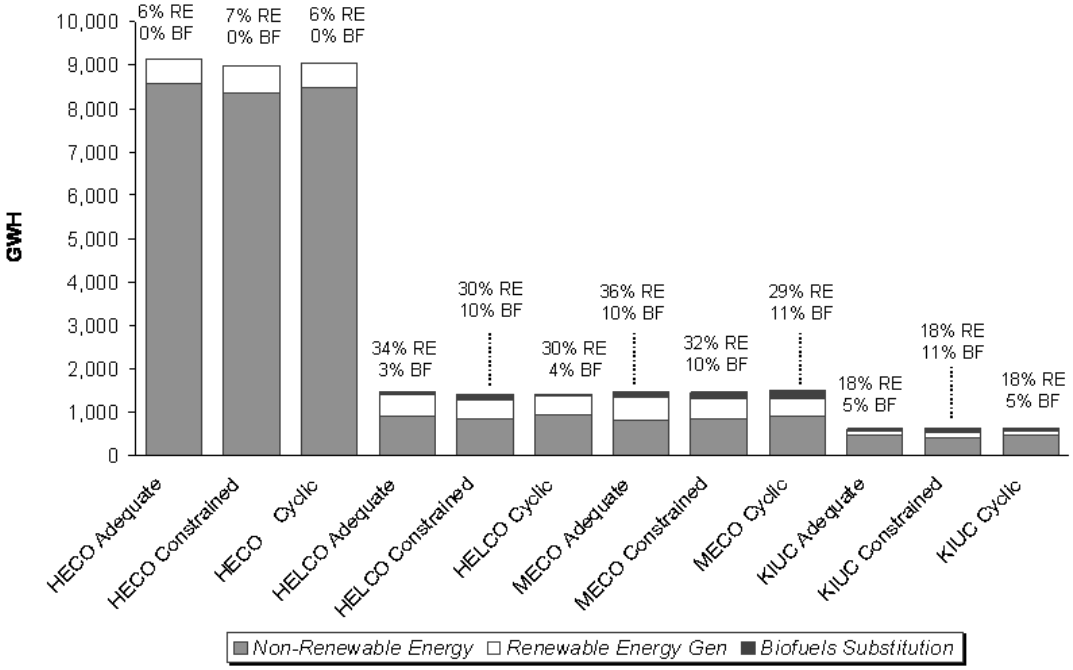


As technologies develop and new capacity additions are needed, the state's growing electricity demand will increasingly be met with renewable resources. For instance, Hawaii is projected to add a total of 50 MW of geothermal, and Oahu is projected to add a total of 60 MW of solar thermal. The Energy 2020 model also projects that additional wind will be developed in all counties except Kauai. By the year 2015, and again in 2020, HEI and KIUC are projected to meet the renewable energy generation requirement

[414] Statewide peak demand has been estimated by adding the individual peaks of each electricity system.

in the State's renewable portfolio standard (RPS).[415] Figure 69 is a snapshot of renewable energy's (including biofuels') contribution to each utility's projected generation in the year 2015. Note that HEI as a whole met the minimum renewable energy required by the existing renewable portfolio standard, which is based on the combined performance of HECO, MECO, and HELCO.

Figure 69. Electric Utility Energy Mix (GWh) in 2015[416]



**Biofuels Substitution (BF) refers to biodiesel and ethanol substituted in diesel and naphtha-fired plants. Other bioenergy such as refuse and biomass are included in Renewable Energy (RE).*

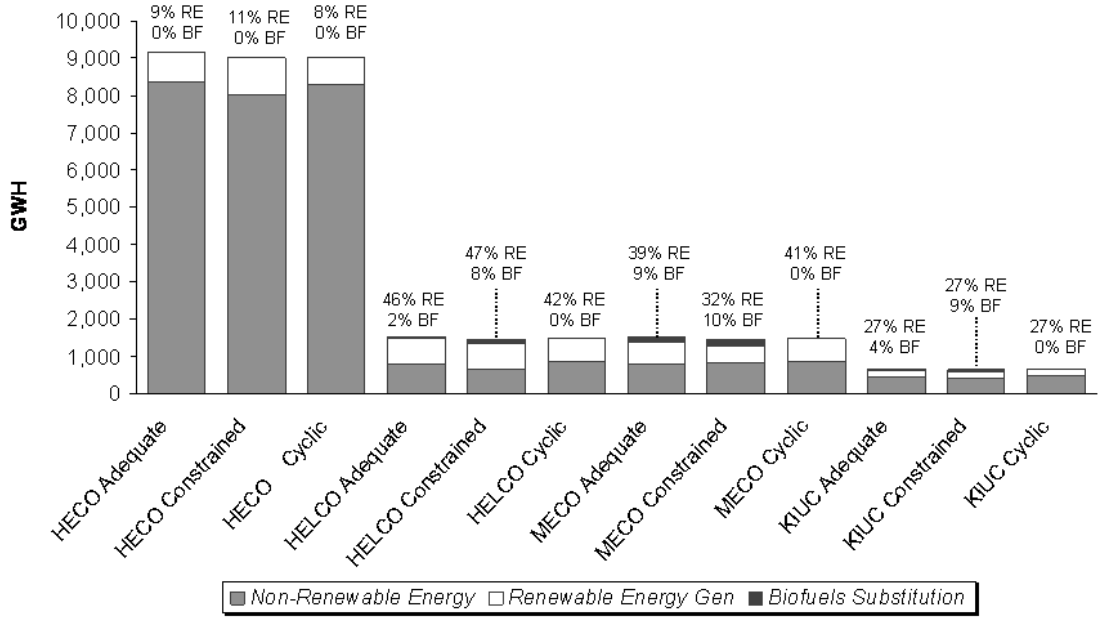
It is interesting to note that for MECO and HELCO in 2015, the percentage of renewable energy (excluding biofuels) is actually higher under the adequate supplies scenario than under the constrained scenario. This is because under the constrained scenario, electricity demand grows more slowly. As a result, renewable energy capacity additions have been deferred. For example, Energy2020 selects a 10 MW refuse plant for construction on Maui in 2013 under the adequate supplies scenario. That same 10 MW plant under the constrained supplies scenario is not built until 2017 as a result of projected slower demand growth. The earlier addition of the refuse plant under the adequate supplies scenario results in a greater renewable energy contribution in 2015 for MECO.

[415] The State's RPS requires 15% "renewable energy" by 2015. Of this 15%, at least half must come from actual renewable energy generation. The other half may come from any combination of renewable resources, energy efficiency, or electric displacement technologies, such as solar water heating or seawater air conditioning. By 2020, the standard increases to 20%, with at least half coming from actual renewable energy generation.

[416] Biofuels substitution (BF) refers to biodiesel and ethanol substituted in diesel and naphtha-fired plants. Other bioenergy, such as refuse and biomass, are included in Renewable Energy (RE).

As can be seen in Figure 70, renewables are projected to account for a large share of total generation by 2020. On the Island of Hawaii, Energy2020 estimates that renewable energy, including biofuels, will produce more than half of the county's electricity needs under the constrained scenario and nearly half if supplies remain adequate. Renewables will also play a significant role on Maui, helping HEI meet the RPS renewable generation requirements across its three systems. On Kauai, renewables are expected to meet at least a quarter of the county's electricity needs.

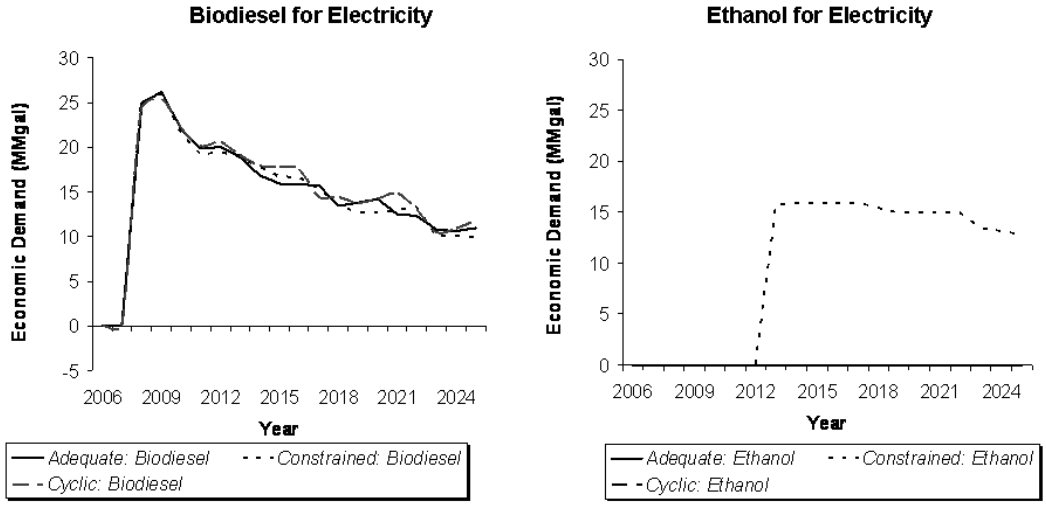
Figure 70. Electric Utility Energy Mix (GWh) in 2020



Biofuels substitution has been highlighted separately from other forms of renewable energy because biofuels can substituted for fossil fuels in existing oil-fired facilities. Biodiesel and ethanol can be substituted in diesel- and naphtha-fired plants, respectively, offering considerable flexibility for utilities to meet their RPS requirements. At the time of data collection, HECO had not yet secured all of the necessary permits for the planned Campbell Industrial Park project. As a result, the model projections do not include biofuels substitution on Oahu.

Figure 71 depicts quantities of biodiesel and ethanol projected to displace diesel and naphtha for electricity generation. Biodiesel is expected to be a cost-effective alternative to #2 diesel fuel under all scenarios. It is assumed that the utilities will be able to co-fire up to 20 percent biodiesel in their diesel generators. Though the model projects that counties will rapidly ramp up their biodiesel consumption, the quantity consumed will steadily decline thereafter, as other renewable energy systems displace the diesel plants. Ethanol is not expected to play as significant a role as biodiesel for the electricity sector. It will serve as a cost-effective alternative to naphtha starting in the year 2013 only under the constrained supplies scenario.

Figure 71. Biofuels Consumed for Electricity Generation, 2006–2025



Conclusions

This chapter introduced the Energy2020 model and presented results of modeling Hawaii's energy future under three plausible scenarios. The Energy2020 model is a multi-sector energy model that simulates the decisions of both consumers and producers of energy, providing a means to observe the likely impact of economic and price signals, policies, and other drivers affecting Hawaii's energy system through the year 2025. Energy2020 is tailored to Hawaii's energy system using primarily publicly available historical demand and supply data provided for each energy sector by county from 1999 to 2005. The model was then calibrated against the state's utilities projections for future electricity demand, net of estimated energy-efficiency savings from utility efficiency programs.

The results paint a picture of gradual shifts towards renewable energy and more efficient technologies. The constrained supplies scenario shows the largest relative shift away from oil, as slower demand growth along with greater adoption of more efficient electric and transportation technologies stabilize total demand at approximately 60 million barrels of crude equivalent annually by 2025. Furthermore, renewable energy, including biofuels substitution, is expected to make up 15 percent of all fuel by 2025 statewide; renewable energy accounted for 4 percent of all fuel statewide in 2005. The transportation fleet becomes modestly more efficient, reducing total fuel demand by 11 percent of 2005 levels by the year 2025.

A closer look at the constrained scenario reveals that 22 percent of the state's electricity will be generated from renewable energy by 2020. As demand growth slows, construction of some plants is deferred or eliminated. For instance, a 180 MW coal plant on Oahu is built under the adequate and cyclic scenarios, but it is eliminated in a world with constrained supplies, due to lower demand. Firm and non-firm renewable energy, such as solar thermal and intermittent wind, are added to displace oil-fired generation and are sufficient to satisfy the slower demand growth. The combination of utility efficiency

programs, renewable energy, and biofuels substitution for electricity allows utilities to exceed the mandated RPS targets in 2015 and 2025 as modeled by Energy2020. In the transportation sector, the vehicle fleet becomes more efficient and fuel flexible, though these improvements are slow to develop until after the year 2015. Absolute annual oil consumption will decline by 5 percent by 2025 as the total energy system becomes more diverse. However, oil would still supply 77 percent of energy consumed under the constrained supplies scenario.

The adequate and cyclic scenarios show Hawaii's current energy vulnerabilities magnified by 2025. Annual energy consumption under both scenarios is expected to increase by 20 percent by 2025. Though renewables will account for 8 percent of all fuel consumed, oil demand will also grow, with annual consumption 5 percent higher in 2025 than it is today. The combination of utility efficiency programs, renewable energy, and biofuels substitution for electricity allows utilities to satisfy the mandated RPS targets in 2015 and 2025 as modeled by Energy2020. On the other hand, under both scenarios the total energy system would remain largely dependent on oil, leaving Hawaii's economy vulnerable to oil price spikes and potential supply disruptions.

Additional smart policies can help accelerate the state's transition to a more secure, reliable, and environmentally benign energy future. In the following chapters, additional policies modeled by Energy2020, along with the transportation and biofuels model enhancements, are presented and their relative impacts estimated. Other potential policies for further shifting Hawaii's energy system are qualitatively discussed and specific recommendations for action provided.

Appendix B: E2020 Data Collection and Sources, Analysis of Selected Policies

Demand Data Collection and Sources

In order to properly simulate the choices made by energy consumers, the Energy 2020 model requires detailed information on historical energy consumption by fuel type, by economic category (building type or industry), and by end use. In most instances, the model requires that these data be reported for each county. For comparison across fuels, all energy consumption was reported in BTUs. RMI collected historical data across the energy system for the years 1999–2005.

Fuel types included utility gas, bottled gas, solar, electricity, #2 fuel, #6 fuel, coal, and biomass. Economic categories included single-family residential housing, multi-family residential housing, hotels, small offices, large offices, retail stores, grocery stores, elementary/secondary schools, restaurants, "miscellaneous" commercial buildings, the sugar industry, other food/agriculture industries, oil refineries, water pumping and sewage facilities, and "other" industrial sectors. End uses included refrigeration, lighting, water heating, cooking, drying, air conditioning, ventilation, motors, process heat, and miscellaneous. The model requires consumption by fuel type for each end use within each economic category. For instance, RMI provided SSI with total BTUs of electricity consumed for lighting in hotels on Oahu.

The Energy 2020 model also requires total BTUs of fuel consumed for ground transportation for each county. Distinctions are made for highway vehicles versus buses and for residential use versus local tourism. Marine and aviation fuels are modeled strictly at the state level.

Electricity

The following sources were used to calculate electricity consumption:

Global Energy Partners, *Assessment of Energy Efficiency and Demand Response Potential* (Lafayette, CA: Global Energy Partners, 2003).

Hawaii, Public Utilities Commission, *Annual Report of Hawaii Electric Light Company* (Hawaii: PUC, 1999–2004) 36.

Hawaii, Public Utilities Commission, *Annual Report of Kauai Island Utility Cooperative* (Hawaii: PUC, 1999–2005) 36.

KEMA, *Energy Efficiency Potential Study* (Oakland: KEMA, 2005), B-4.

United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaii Electric Light Company* (Washington: DOE, 2005) 304.

United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Hawaiian Electric Company* (Washington: DOE, 1999–2005) 304.

United States, Federal Energy Regulatory Commission, *FERC Form No. 1 of Maui Electric Company* (Washington: DOE, 1999–2005) 304.

First, RMI determined the proportion of total electricity in each county that was consumed by each economic category and the proportion devoted to each end use within each economic category. RMI developed these percentage "splits" using the Global Energy Partners (GEP) and KEMA reports. From the GEP report, the data are available in appendices C (Residential), D (Commercial), and E (Industrial) of volumes II (HECO), III (MECO), and IV (HELCO). From the KEMA report, appendix B provided the data for KIUC.

Next, RMI estimated historical demand for the Residential, Commercial, and Industrial sectors using historical sales by rate class. Residential included Residential Sales and Electric Service for Employees (if applicable). The utilities provided sales to the military through a separate data request. These military sales were subtracted from the non-Residential sales to determine total Commercial and Industrial sales.

RMI multiplied the demand for each sector by the share for each economic category and the share for each end use. In limited instances, actual data for a particular economic category were available, such as for the sugar and refinery industries. For economic categories with CHP/DER (see separate discussion of CHP and DER), RMI added generation figures to electricity purchases for each economic category before applying the end-use splits.

Oil for Water Heating and Process Heat

RMI did not use any public sources to determine oil consumed for water heating and process heat. DBEDT provided all necessary data, using its internal fuel sales database.

Diesel Oil. DBEDT provided RMI with the total fuel sold to the Commercial and Industrial sectors. RMI subtracted CHP/DER fuel inputs by county (see separate discussion of CHP and DER) from the total diesel sales by county to determine "excess fuel." Excess Commercial fuel was allocated to the water heating end use. Excess Industrial fuel was allocated to the process heat end use. RMI then split the excess fuel by economic category using each category's share of electricity consumption. For the sugar industry, fuel inputs for process heat were calculated separately, based on fuel consumption and electricity generation data provided by DBEDT (see separate discussion of CHP and DER).

Residual Fuel Oil. DBEDT provided RMI with total fuel sold data. RMI allocated all residual fuel oil sales to the Industrial sector and to the process heat end use. DBEDT data were not reported separately for each county. RMI therefore allocated fuel sales by county using the 1998 county proportions in the historical Energy 2020 model outputs. RMI then allocated fuel by economic category using each category's share of electricity consumption. For the sugar industry, fuel inputs for process heat were calculated

separately based on fuel consumption and electricity generation data provided by DBEDT (see separate discussion of CHP and DER).

Refinery Gas. Direct data on use of refinery gas for process heat (steam) were unavailable. This figure was developed using an RMI estimate of fuel inputs (MMBTU) per barrel produced. The fuel demand per barrel was multiplied by total refinery output to determine total fuel inputs for process heat.

Utility Gas and Bottled Gas

DBEDT provided bottled gas data using its internal fuel sales database. Utility gas data were provided by the following sources:

Hawaii, Public Utilities Commission, *Annual Report of the Hawaii Gas District of the Gas Company* (Hawaii: PUC, 1999–2005) 40.

Hawaii, Public Utilities Commission, *Annual Report of the Kauai Gas District of the Gas Company* (Hawaii: PUC, 1999–2005) 40.

Hawaii, Public Utilities Commission, *Annual Report of the Maui Gas District of the Gas Company* (Hawaii: PUC, 1999–2005) 40.

Hawaii, Public Utilities Commission, *Annual Report of the Molokai Gas District of the Gas Company* (Hawaii: PUC, 1999–2005) 40.

Hawaii, Public Utilities Commission, *Annual Report of the Oahu Gas District of the Gas Company* (Hawaii: PUC, 1999–2005) 40.

Utility Gas. RMI determined historical demand for the Residential and Commercial sectors using historical sales by rate class (utility gas was assumed to have no Industrial applications).

Single-family residential included Residential Sales and Residential Employee Sales (if applicable). Multi-family residential was determined using Multi-Unit Housing Sales (if applicable). The remainder of the sales was assigned to the Commercial sector.

Bottled Gas. DBEDT provided Residential and Commercial bottled gas sales data directly to SSI.

Solar Hot Water

The following sources were used to calculate solar hot water consumption:

Hawaii, Department of Business, Economic Development and Tourism (DBEDT), *State of Hawaii Data Book* (Hawaii: DBEDT, 2005).

Warren Bollmeier, Personal interviews, July–August 2006.

First, RMI determined the total number of solar hot water systems in operation each year using the DBEDT estimate of total statewide solar hot water heaters underlying table 17.05 in the State of Hawaii Data Book. KIUC (via Warren Bollmeier) provided the number of systems on Kauai in 2005, and this value was subtracted from the state total to determine the total number of systems on the remaining counties. RMI calculated the historical number of systems on Kauai using the 2005 proportion of Kauai systems to the statewide total. The total for the remaining islands was allocated by county based on the proportion of new systems installed from 1996 to 2005 (data provided by HEI via Warren Bollmeier). This proportion was held constant for every year.

Once the annual number of systems in operation in each county was determined, RMI multiplied the number of systems by the annual unit demand reduction (kWh) from the Update of DSMIS Unit Savings Values Based on the 2001–2003 Impact Evaluation Study. All solar hot water consumption was allocated to Residential Single Family housing.

Transportation

DBEDT provided statewide marine and aviation fuel data using its internal fuel sales database. DBEDT also provided data on fuel consumed annually by The Bus on Oahu. Other ground transportation fuel consumption was calculated using following source:

Hawaii, Department of Taxation, *Liquid Fuel Tax Base & Tax Collections*.

Fuel consumption data inputs for this sector included highway gas and diesel, bus gas and diesel, marine fuels, and aviation fuels. There was also a minimal amount of historical biodiesel consumption. Ethanol consumption for transportation fuels was assumed to be negligible for the time period 1999-2005.

RMI extracted annual gasoline, diesel, and biodiesel sales by county from the Department of Taxation's Liquid Fuel Tax Base. DBEDT provided total sales of aviation gas, jet fuel, marine diesel, and marine residual fuel oil directly to SSI. The Energy 2020 model required marine and aviation data only at the state level.

CHP and DER

Calculations for the sugar and refinery industries were based on data provided by DBEDT. CHP and DER fuel inputs and electricity generation for other industries were calculated based on data in the following source:

Global Energy Partners, *Creating Distributed Energy Opportunities for Hawaii* (Lafayette, CA: Global Energy Partners, 2003).

Sugar Industry. DBEDT received total electricity generation and fuel consumption by fuel type from the sugar companies and provided these data to RMI. RMI then used historical sugar industry heat rates to estimate fuel inputs used specifically for electricity

generation. The remainder of the fuel consumption was allocated to the process heat end use.

Refinery Industry. DBEDT received total electricity generated, purchased, and consumed from the refineries. No additional calculations were necessary.

Other Industries. RMI extracted total generation capacity by industry sector from the Global Energy Partners report. RMI then estimated annual generation and fuel inputs by assuming capacity factors and heat rates by technology type (e.g., diesel engine versus gas turbine) and application (e.g., hospital versus office building).

Supply Data Collection and Sources

Historical Electricity Supply Data

With DBEDT's assistance, RMI provided annual historical electricity supply data for years 1999 to 2005 to the E2020 model. These data can be divided into two major categories: generation data and financial data. Generation data include quantifiable information related to the energy supplied by Hawaii's electric utilities to meet the demands of Hawaii's residential, commercial, and industrial sectors. Examples include generator unit capacity, heat rates, total electricity generated annually, and the fuel sources of electricity production. Financial data include information typically found in publicly disclosed annual reports that reflect the financial health of public utilities. This information includes current and accrued assets, capital, debt, operating income, and power production expenses, sales, and taxes.

All electricity supply data were collected from publicly available utility information sources. Due to their generation size, the Hawaiian Electric Company, Inc. (HECO) and the Maui Electric Company, Ltd. (MECO) each file an annual FERC Form No. 1 with the Federal Energy Regulatory Commission (FERC). Meanwhile, the Kauai Island Utility Cooperative (KIUC) files an annual report with the Hawaii Public Utilities Commission (HI PUC). Similarly, the Hawaii Electric Light Company (HELCO) filed an annual report with the HI PUC until 2005, when the utility filed its first FERC Form No. 1 with FERC. These reports cover one year of respective data; therefore, multiple reports were collected to compile a complete data set for 1999 through 2005.

Regardless of the type of annual report filed by each utility, the generation and financial data in each report are structured similarly. However, each utility maintains some discretion as to how it presents aspects of these data. Thus, depending upon the method the utility uses in aggregating or disaggregating the information, the data are not always comparable. For example, HECO provides historical generation data for each of its plants by generation type (e.g., steam, combustion turbine peak, or internal combustion diesel units). By contrast, MECO provides historical generation data for each of its plants by location, regardless of the generation type of the units at each location. Meanwhile, KIUC and HELCO only provide a list of station locations that includes the total number of units, the types of units and a rated capacity for each location. This collection of mixed data sometimes makes it difficult to compare information provided

by different sources and often necessitates the estimation of missing data points based on the information provided.

In addition to annual reports, RMI extracted information from each utility's Integrated Resource Plan (IRP). IRPs are energy resource plans that Hawaii's utilities produce approximately every three years according to the State PUC's directive. A finalized IRP outlines the resources that the utility intends to employ to meet the area's short-term (five years) and long-term (twenty years) energy needs. RMI used IRPs for a wide variety of information, including details about planned and existing generation units.

In instances of incomparable or missing data, the HES research team attempted to locate the information needed via another source that originated from the respective utility. In the absence of utility information, the team tried to cull data from other reliable sources, such as the U.S. Energy Information Administration (EIA) or the U.S. Environmental Protection Agency (EPA). Lacking these sources, the research team used the best information available (e.g., standard engineering estimates for similar generation units) to make realistic estimates. In cases of data inconsistencies across years or between sources, RMI strived to reconcile discrepancies whenever possible by consulting with DBEDT or the utilities themselves. The HES team submitted a formal data request to the Hawaii Electric Industry, Inc. (HEI) via DBEDT to provide information for HECO, MECO, and HELCO for several missing data elements, including generating unit heat rates, generation, scheduled outage rates, unscheduled outage rates, and non-fuel operation and maintenance costs. The information was not provided. **To ensure the most accurate and robust data set possible, all compiled electricity supply data were provided to each utility for review.**

A. Historical Generation Data Sources

As discussed above, data were collected by year (1999–2005) and aggregated by generation unit type for each utility. The following sources were used:

Black & Veatch, (2005, April 21). Unit Information Forms for Hawaii Electric Light Company (HELCO) IRP-3 Integrated Resource Planning.

Black & Veatch, (2004, April 21). Unit Information Forms for Hawaiian Electric Company (HECO) IRP-3 Integrated Resource Planning.

Black & Veatch, (2005, November 21). Unit Information Forms for Maui Electric Company (MECO) IRP-3 Integrated Resource Planning.

Energy Information Administration. (2004) Form EIA-860 Database Annual Electric Generator Report. Retrieved May 30, 2006, from www.eia.doe.gov/cneaf/electricity/page/eia860.html.

Hawaii Electric Light Company (HELCO). (1999 through 2004). Annual Report to the Public Utilities Commission, State of Hawaii. Hilo: Hawaii Electric Light Company.

Hawaii Electric Light Company (HELCO). (2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Hilo: Hawaii Electric Light Company.

Hawaii Electric Light Company (HELCO). (2006). Integrated Resource Planning 2007-2026. HELCO Presentations to IRP Advisory Group. Hilo, Hawaii: Hawaii Electric Light Company, Inc.

Hawaii Electric Light Company (HELCO). (2004). Integrated Resource Plan, 1999-2018: 2004 Evaluation Report. Hilo, Hawaii: Hawaii Electric Light Company, Inc.

Hawaiian Electric Company (HECO). (1999 through 2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Honolulu: Hawaiian Electric Company.

Hawaiian Electric Company (HECO). (2005). Integrated Resource Plan, 2006-2025. Honolulu: Hawaiian Electric Company, Inc.

Hawaiian Electric Industries, Inc. (HEI). (2005). Form 10-K Annual Report for the Fiscal Year Ended December 31, 2005. Honolulu: Hawaiian Electric Industries, Inc.

Kauai Electric Company (KE). (1999 through 2002). Annual Report to the Public Utilities Commission, State of Hawaii. Lihue, Hawaii: Kauai Electric Company.

Kauai Island Utility Cooperative (KIUC). (2003 through 2005). Annual Report to the Public Utilities Commission, State of Hawaii. Lihue, Hawaii: Kauai Island Utility Cooperative.

Maui Electric Company (MECO). (1999 through 2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Kahului, Hawaii: Maui Electric Company.

Maui Electric Company, Limited (MECO), (2000). Integrated Resource Plan, 2000-2020. Kahului, Hawaii: Maui Electric Company, Inc.

Maui Electric Company, Limited (MECO), (2005). Integrated Resource Plan, 2000-2020. 2005 Evaluation Report. Kahului, Hawaii: Maui Electric Company, Inc.

Maui Electric Company, Limited (MECO), (2006). Integrated Resource Planning 2007-2026. MECO Presentations to IRP Advisory Group. Kahului, Hawaii: Maui Electric Company, Inc.

State of Hawaii. Department of Business, Economic Development and Tourism (DBEDT). 2006.

B. Electric Utility Financial Data Sources

The following sources were used to collect financial information for each utility:

Hawaii Electric Light Company (HELCO). (1999 through 2004). Annual Report to the Public Utilities Commission, State of Hawaii. Hilo: Hawaii Electric Light Company.

Hawaii Electric Light Company (HELCO). (2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Hilo: Hawaii Electric Light Company.

Hawaiian Electric Company (HECO). (1999 through 2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Honolulu: Hawaiian Electric Company.

Kauai Electric Company (KE). (1999 through 2002). Annual Report to the Public Utilities Commission, State of Hawaii. Lihue, Hawaii: Kauai Electric Company.

Kauai Island Utility Cooperative (KIUC). (2003 through 2005). Annual Report to the Public Utilities Commission, State of Hawaii. Lihue, Hawaii: Kauai Island Utility Cooperative.

Maui Electric Company (MECO). (1999 through 2005). FERC Form No. 1: Annual Report of Major Electric Utilities, Licensees and Others. Kahului, Hawaii: Maui Electric Company.

Historical Gas Supply Data

The protocol for culling historical gas supply data was similar to that of the electricity supply data. Two types of data were supplied to the E2020 model: gas sales data and gas utility financial data. Wherever possible, the HES team extracted all gas sales and company financial data from publicly available information that the gas utility is required to file by law with the HI PUC.

A. Gas Utility Data Sources

The Gas Company (TGC). (2000 through 2005.) Annual Report of the Hilo Gas District of Citizens Utility Company DBA The Gas Company to the Public Utilities Commission State of Hawaii, Honolulu: TGC.

The Gas Company (TGC). (2000 through 2005.) Annual Report of the Kauai Gas District of Citizens Utility Company DBA The Gas Company to the Public Utilities Commission State of Hawaii, Honolulu: TGC.

The Gas Company (TGC). (2000 through 2005.) Annual Report of the Maui Gas District of Citizens Utility Company DBA The Gas Company to the Public Utilities Commission State of Hawaii, Honolulu: TGC.

The Gas Company (TGC). (2000 through 2005.) Annual Report of the Molokai Gas District of Citizens Utility Company DBA The Gas Company to the Public Utilities Commission State of Hawaii, Honolulu: TGC.

The Gas Company (TGC). (2000 through 2005.) Annual Report of the Oahu Gas District of Citizens Utility Company DBA The Gas Company to the Public Utilities Commission State of Hawaii, Honolulu: TGC.

Historical Fuel Price Data

RMI supplied historical primary and secondary fuels prices from 1999 to 2005 to the E2020 model to calibrate the model. The following tables describe the type of fuel tracked and the source for that price data. In rare instances of incomparable or missing data, the HES research team used the historical trends and statistical analysis to extrapolate realistic estimates. For example, at the time of the data collection, the most recent State Energy Consumption Price and Expenditure Estimates (SEDS) released by the EIA were limited to 2002. Where possible, price data for 2003 through 2005 were extracted from other equally reliable and comparable sources. In the event other sources did not exist, values were extrapolated. These instances are noted in the source column for each fuel.

Table 29. Primary Fuels Prices

Data	Source
Crude Oil	EIA, Annual Energy Review, Crude Oil Refiner Acquisition Costs, Composite (Imports & Exports), Table 5.21, www.eia.doe.gov/emeu/aer/petro.html, Accessed May 14, 2006.
Coal	EIA, Annual Energy Review, Table 7.8: Coal Prices, 1949–2004, www.eia.doe.gov/emeu/aer/coal.html, Accessed May 14, 2006. [417]
Natural Gas	EIA, Annual Energy Review, Table 6.7, Natural Gas Wellhead, City Gate, and Imports Prices, Selected Years, 1949–2004, www.eia.doe.gov/emeu/aer/natgas.html, Accessed May 14, 2006.

[417] Prices are free-on-board (f.o.b.) rail/barge prices, which are the f.o.b. prices of coal at the point of first sale, excluding freight or shipping and insurance costs.

Table 30. Secondary Fuels Prices

Data	Source
Electric Utility Petroleum Fuels	
HELCO • Diesel oil 0.4% sulfur • Medium sulfur fuel oil	Hawaiian Electric Industries, Inc. (HEI) fuels division via DBEDT
MECO • Diesel oil 0.4% sulfur • Medium sulfur fuel oil	Hawaiian Electric Industries, Inc. (HEI) fuels division via DBEDT
HECO • Diesel oil 0.4% sulfur • Low sulfur fuel oil	Hawaiian Electric Industries, Inc. (HEI) fuels division via DBEDT
KIUC • Diesel oil 0.4% sulfur • Naphtha	1999–2004 data provided by DBEDT (obtained from KIUC); 2005 data obtained from KIUC)
Other Electric Utility Fuels	
Refuse/ Municipal Solid Waste	County tipping fees extracted from State of Hawaii Auditor, "Audit of the Department of Health's Administration of A Statewide Solid Waste Program and Assessment of Related Land Use Policies," Report No. 04-01 January 2004. 2005 data for Oahu's H-Power per personal correspondence with H-Power staff on June 21, 2006.
Biomass	"Biomass," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 6. Electric Power Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. 2003–2005 data based on 2002 value held constant.
Coal	"Coal," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 6. Electric Power Sector Price and Expenditure Estimates, 1970–2002, Hawaii. 2003–2005 data based on 2002 value held constant to reflect a long-term contract.

Gas Utility Fuels	
Residential Bottled Gas (Statewide average)	"LPG," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 2. Residential Sector Energy Price and Expenditure Estimates, Selected Years 1970–2002, Hawaii. 2003–2005 data based on growth rate of Gas Utility LPG price for same period.
Commercial and Industrial Bottled Gas (Statewide average)	"LPG," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 4. Industrial Sector Energy Price and Expenditure Estimates, Selected Years 1970–2002, Hawaii. 2003–2005 data based on growth rate of Gas Utility LPG price for same period.
Commercial & Industrial Fuels	
Coal	"Steam Coal," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 4. Industrial Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. 2003-2005 data based on regression of 1995–2002 data.
Biomass	"Biomass," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 4. Industrial Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. 2003–2005 data based on 2002 value held constant.
Transportation Fuels	
Jet Fuel	Hawaiian Airlines, 1999–2005, Form 10-K Annual Report for the Fiscal Year. Honolulu: Hawaiian Airlines.
Low-Sulfur-Diesel Fuel	"Distillate Fuel," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 5. Transportation Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. 2004–2005 data sourced from "U.S. & Hawaii Diesel Prices, January 1, 2004 to June 25, 2006," Daily Fuel Gauge Report, American Automobile Association (AAA), located on DBEDT website at www.hawaii.gov/dbedt/info/energy/transportation/gasoline/data/. 2003 data extrapolated based on EIA and AAA data.
Residual Fuel Oil (Marine Transportation)	"Residual Fuel," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 5. Transportation Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. Price data for years 2003-2005 were extrapolated based on growth rate of residual fuel oil prices supplied by Hawaiian Electric Industries, Inc. (HEI) during same period.
Gasoline	"Motor Gasoline," EIA State Energy Consumption Price and Expenditure Estimates (SEDS), Table 5. Transportation Sector Energy Price and Expenditure Estimates, 1970–2002, Hawaii. 2003-2005 data extrapolated by following methodology used by EIA SEDS for gasoline: EIA Petroleum Marketing Annuals prices plus state taxes.

Fuel Price Forecasts

In previous iterations of the Hawaii Energy Strategy (HES), primary fuel forecasts were adopted from EIA's primary fuels forecasts published annually in EIA's Annual Energy Outlook. Following EIA's methodology, the HES considered two scenarios in evaluating the possible future of Hawaii's energy system: a base case and a high case. In both scenarios, prices generally follow a steady trajectory from current prices.

However, these steady trajectories do not reflect the cyclical nature of energy commodity prices observed historically. Over the last several years, as deliverable primary fuels capacity has declined and demand has increased—resulting in higher prices and increased volatility—the discrepancy between EIA's forecasts and prices observed in the market has widened. Hawaii's selected strategy and policy recommendations should be robust in both high- and low-price primary fuel markets. Thus, to more accurately reflect the nature of primary and refined fuels markets, a third future scenario and integrated market prices were added into all primary fuel forecasts. The three scenarios are:

I. Adequate Supplies: Moderate Long-Run Prices

- Fuel prices decline after the current period of relatively high prices then follow a steady moderate price trajectory.
- Displays a monotonic range of variance based on relative stability.

II. Constrained Supplies: High Long-Run Fuel Prices

- Fuel prices remain at current high levels and follow a steady but high price trajectory.
- Displays a higher variance reflecting constrained capacity that creates price volatility.

III. Commodity Cycle: Cyclical Fuel Prices

- High fuel prices followed by low fuel prices, which most accurately reflects the cyclical nature of oil and gas prices.
- Displays a higher variance reflecting higher volatility during times of constrained capacity and lower variance when capacity catches up with demand and creates more stability.

Primary Fuels Forecasts Methodologies

The primary and secondary fuels forecasts are twenty-year forecasts for the period 2006 through 2025. RMI designed primary fuels forecasts using a hybrid of market prices derived from futures contract prices and EIA's primary fuel forecasts. Table 31 depicts the formulas used in deriving the primary fuel forecasts in more detail.

A. Crude Oil Forecasts

For the first five years (2006–2011) of each oil forecast, market prices were derived from the average price for one-, two-, three-, four- and five-year future contracts on the New York Mercantile Exchange (NYMEX) during a 90-day period from May 4, 2006 to August 3, 2006. To account for the difference in crude oil quality between the West Texas Intermediate (WTI) oil on which NYMEX futures contracts are based, and the weighted average mix of world oil on which EIA's imported crude oil forecasts[418] are based, RMI adjusted the NYMEX price stream downward by the average cost differential of WTI quality crude versus EIA's world oil over the last ten years.[419] For the remaining years (2012-2025), the adequate supplies scenario and constrained supplies scenario employed EIA's base and high case, respectively, from the AEO 2006 forecast. For the cyclic commodities scenario, from 2012 to 2014, prices follow the trajectory of the EIA AEO 2006 High Case. From 2015 to 2023, prices fall to a low of $33.16 per barrel (2004$), after which they hover at approximately the $35 per barrel (2004$) level.

Table 31. Statewide Primary Fuels Forecasts

Data	Source
Crude Oil Adequate Supply Scenario	Prices for years 2006 through 2011 are NYMEX 5-Year Futures Contracts (90 day average - May 4, 2006–Aug 3, 2006) deflated to 2004$ and adjusted to "World Oil." From 2012 to 2025, prices are EIA's AEO 2006 Reference Case in 2004$.
Crude Oil Constrained Supply Scenario	Prices for years 2006-2011 are NYMEX 5-Year Futures Contracts (90 day average - May 4, 2006–Aug 3, 2006) deflated to 2004$ and adjusted to "World Oil." From 2012 to 2025, prices are EIA AEO 2006 High Case (years 2012–2025) in 2004$.
Crude Oil	Prices for years 2006-2011 are NYMEX 5-Year Futures Contracts (90 day average - May 4, 2006–Aug 3, 2006) deflated to 2004$ and adjusted to "World

[418] As of the 2006 AEO, EIA revised its methodology for calculating world oil: "In previous AEOs, the world crude oil price was defined on the basis of the average imported refiner acquisition cost of crude oil to the United States (IRAC), which represented the weighted average of all imported crude oil. Historically, the IRAC price has tended to be a few dollars less than the widely cited prices of premium crudes, such as West Texas Intermediate (WTI) and Brent, which refiners generally prefer for their low viscosity and sulfur content. In the past 2 years, the price difference between premium crudes and IRAC has widened—in particular, the price spread between premium crudes and heavier, high-sulfur crudes. In an effort to provide a crude oil price that is more consistent with those generally reported in the media, AEO2006 uses the average price of imported low-sulfur crude oil to U.S. refiners." However, EIA still calculates a price forecast based on the previous methodology (IRAC) and includes it in EIA's tables as "Imported Crude Oil Price." Since Hawaiian Electric, Inc. (HEI) calculates its fuel price forecasts using EIA's former "world oil" numbers because it does not need as high of a grade of crude as WTI or Brent, RMI used the forecast for the "Imported Crude Oil Price" for the crude oil forecasts.

[419] The average differential between WTI and world oil was $3.93 (2004$) from 1997 through July 2006.

Cyclical Supply Scenario	Oil." From 2012 to 2014, prices follow the trajectory of the EIA AEO 2006 High Case. From 2015 to 2023, prices fall to a low of $33.16 per barrel (2004$), after which they hover at approximately the $35 per barrel (2004$) level.
Coal Adequate Supply Scenario	HELCO's 2005 "Reference" Coal Forecast obtained from HELCO [(2004 base price (based on two importers' prices) x (EIA AEO 2006 Export Coal escalation rate)] in 2004$.
Coal Constrained Supply Scenario	Years 2006-2008: HELCO's 2005 "High" Coal Forecast Base Price x (NYMEX Central Appalachian Coal (CAPP) Futures escalation rate); Years 2009-2030: HELCO's 2005 "High" Coal Forecast Base Price x (EIA AEO 2006 Export Coal "High Case" escalation rate) x Oil Ratio [1 + EIA AEO 2006 Imported Crude "High Case"/EIA AEO 2006 Imported Crude Reference Case * 50%] in 2004$.
Coal Cyclical Supply Scenario	Uses the Coal Constrained Supply Scenario adjusted to the Oil Cyclical Supply Scenario escalation rate.

B. Coal Price Forecasts

For the coal price forecasts, RMI established a distinct methodology for each future scenario to coincide with market conditions in each case. Under the adequate supplies scenario, the forecast was anchored to an empirically derived estimate for delivered coal based on two Hawaii importers' long-term contract prices for coal imported from Indonesia.[420] This base price was scaled upward based on the escalation rate the EIA AEO 2006 Export Coal forecast. For the constrained scenario, RMI used a higher base price[421] and established a conservative link to the crude oil forecast to reflect the recent escalation of relative prices of all energy commodities and better model the market reality faced in Hawaii.[422] The NYMEX Central Appalachian (CAPP) Coal Futures Index was applied to estimate the market escalation of coal prices through 2008. After 2008, prices were estimated by first, applying the EIA Export Coal escalation rate for the high case and, second, applying an oil price ratio of EIA's imported crude oil forecast in the high case to EIA's imported crude oil forecast in the reference case, then reduced by 50 percent. The cyclical scenario used the coal forecast for the constrained supply scenario

[420] This estimate was obtained from Hawaii Electric Light Company (HELCO), which also used the same base estimate in its own forecasting.

[421] This estimate was obtained from Hawaii Electric Light Company (HELCO), which also used the same base estimate in its own forecasting.

[422] Although coal prices have generally not been correlated to oil prices over the last two decades, the recent energy demand from China and India has driven the upward trend in all commodity prices, particularly Pacific Basin coal (including Australia and Indonesia) and global oil. Refer to the Primary Fuels chapter for more detail.

and adjusted it to the escalation rate of the crude oil forecast under the cyclical supply scenario.

Secondary Fuel Forecast Methodologies

Secondary fuels, or refined oil fuels forecasts, are linked to the crude oil fuels forecasts to reflect the market reality that the price for refined fuels prices are overwhelming dependent upon the price of crude oil, which accounts for 80 to 90 percent of the cost of secondary fuels prices.[423]

Table 32. Statewide Transportation Fuels Forecasts

Area	Fuel Type	Forecast Methodology
Hawaii State	Gasoline	Crude Oil Forecast Price + Average Price Differential Between U.S. Crude Refiners Acquisition Cost and HI Total Gas Retail Sales (Before Gas Cap: Jan 1994–August 2005) + Average Price Premium of U.S. Refiners Acquisition Costs over World Oil (1997–2005) + HI State Sales Tax + Federal Gasoline Tax + HI State Gasoline Tax + HI State Environmental Response Tax + Volume Weighted Average County Gasoline Tax.
Hawaii State	Diesel	Crude Oil Forecast Price + Average Price Differential Between U.S. Crude Refiners Acquisition Cost and HI Diesel Retail Sales (2004-August 2005, i.e., pre-Gas Cap) + Average Price Premium of U.S. Refiners Acquisition Costs over World Oil (1997–2005) + HI State Sales Tax + Federal Diesel Tax + HI State Diesel Tax + HI State Environmental Response Tax + Volume Weighted Average County Diesel Tax.

A. Statewide Transportation Fuels Forecasts

For statewide transportation fuel forecasts, RMI deduced the underlying relationship between the price of crude oil and the price of gasoline and diesel to determine the crack spread[424] for these fuels. The crack spread for gasoline was determined by averaging the price differential between EIA's retail gas sales price for Hawaii[425] and EIA's U.S. Crude Refiners Acquisition Costs from January 1994 and August 2005.[426] Similarly, the crack spread for diesel fuel was determined by averaging the price differential between the retail gas sales price for Hawaii and EIA's U.S. Crude Refiners Acquisition Costs from

[423] Refer to the Primary Fuels chapter for more detail.

[424] The crack spread is the cost differential between the cost of the barrel of crude and its products.

[425] Without taxes.

[426] Hawaii's gas cap legislation was implemented in September 2005, after which an abrupt increase in the crack spread occurred. RMI eliminated this anomaly from the data set to avoid artificially inflating the price differential.

2004 and August 2005.[427] The resulting gasoline and diesel forecasts add the respective crack spread to the crude oil forecast price plus the sales-weighted average of federal, state, and county taxes to determine forecasted gasoline and diesel prices.

B. Statewide Biofuels for Transportation Fuel Forecasts

To succeed in entering the transportation fuels market, biofuels must be cost-competitive with conventional petroleum fuels, gasoline, and diesel. To reflect this market reality for E2020, the fuel price forecast for both ethanol and biodiesel were priced at a 10 percent discount to the gasoline and diesel forecasts.

Table 33. Statewide Biofuels Price Forecasts

Hawaii State	E85	Gasoline Forecast - 10% (on MBTU basis)
Hawaii State	Biodiesel	Diesel Forecast - 10% (on MBTU basis)

C. Island-Specific Electric Utility Fuel Forecasts

For county-specific electric utility fuel forecasts, RMI used a linear regression analysis to deduce the underlying relationship between the price of crude oil and the price of the refined product. Whenever available, RMI used each utility's own fuel oil linear regression analysis forecast, which is noted in the table below. For each secondary fuel forecast, the price established by the crude oil forecast was used as the independent variable for each scenario.

Table 34. Island-Specific Electric Utility Fuel Forecasts

Area	Fuel Type	Forecast Methodology
Hawaii	#6 Fuel Oil	Y = 5.051 + 0.8152X (from HECO Fuels Division for HELCO), where X is crude oil price. Note: This fuel is MSFO, a lower grade fuel than LSFO, which is used on Oahu by HECO.
Maui	#6 Fuel Oil	[(HELCO's forecast (Y = 5.051 + 0.8152X), where X is crude oil price)]. Average historical price differential between HELCO and MECO (2004 $). Note: This fuel is MSFO, a lower grade fuel than LSFO, which is used on Oahu by HECO.
Oahu	#6 Fuel Oil	Y = 1.2307236X + .07419141, where X is crude oil price. [Linear regression on historical world oil prices and HECO's

[427] Since Hawaii's on-highway diesel prices are not readily available from EIA, RMI used retail "at the pump" diesel prices tracked by DBEDT at www.hawaii.gov/dbedt/info/energy/transportation/gasoline/data/ . RMI deducted the sales-weighted average federal, state, and county taxes from the "at the pump" diesel price. The data set is considerably smaller, spanning 2004 through June 2006, than that which was used for gasoline.

		historical LSFO prices (1990-2005)].
Hawaii	#2 Diesel Oil	Y = 10.421 + 1.2065X, where X is crude oil price (from HECO Fuels Division for HELCO).
Maui	#2 Diesel Oil	[(HELCO's forecast (Y = 5.051 + 0.8152X), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between HELCO and MECO (2004 $)].
Oahu	#2 Diesel Oil	[(HELCO's forecast (Y = 5.051 + 0.8152X), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between HELCO and HECO (2004 $)].
Kauai	#2 Diesel Oil	[(HELCO's forecast (Y = 5.051 + 0.8152X), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between HELCO and KIUC (2004 $)].
Hawaii	Naphtha	[(KIUC's forecast (Y = 0.843X + 21.069), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between KIUC and HELCO (2004 $)].
Maui	Naphtha	[(KIUC's forecast (Y = 0.843X + 21.069), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between KIUC and MECO (2004 $)].
Oahu	Naphtha	[(KIUC's forecast (Y = 0.843X + 21.069), where X is crude oil price) - (average historical price differential for #2 Diesel Oil between KIUC and HELCO (2004 $)].
Kauai	Naphtha	Y = 0.843X + 21.069, where X is crude oil price. [Linear regression on historical world oil prices and KIUC's historical naphtha prices (2004–2006)].

D. Island-Specific Biofuels for Electric Utility Generation Forecasts

Hawaii's utilities are in the process of evaluating the use of two major biofuels—ethanol and biodiesel—as substitutes for conventionally refined fossil fuels commonly used for electricity generation. Two factors are necessary for biofuels to be used on a broad scale: technical feasibility and cost-competitiveness. First, although ethanol and biodiesel have been technically proven to be substitutable fuels for naphtha and no. 2 diesel in a variety of applications, there are no industry standards or guidelines for their use in large-scale electricity generation. As part of a multi-stage process to quantify their potential demand for biofuels, the Hawaiian Electric Company (HECO) has partnered with the Electric Power Research Institute (EPRI) to determine the technical feasibility of biofuel substitution. HECO is also consulting with original equipment manufacturer (OEM) to determine the effect of using biofuels on generator warranties. Second, to be used on a broad scale by the utilities, biofuels must meet or beat the cost of their fossil fuel counterparts, including the fuel price differentials plus any conversion costs (including impacts to operating and maintenance costs).

The following steps were taken to account for the technical feasibility and cost considerations in the forecast modeling process. First, parameters within the E2020 model were set to limit the maximum quantity of biofuels that could be substituted for electricity generation.

Ethanol (substitute for naphtha)

- New generators: 50 percent maximum capacity
- Existing generators: 20 percent maximum capacity

Biodiesel (substitute for no. 2 diesel fuel oil):

- New generator, includes internal combustion units, combustion turbines, combined cycle units: 20 percent maximum capacity
- Existing generators, includes internal combustion units, combustion turbines, combined cycle units: 20 percent maximum capacity

Table 35. Island-Specific Biofuels for Electric Utility Generation Forecasts

Hawaii	Utility Ethanol	Utility Naphtha Forecast - 1% (on MBTU basis)
Maui	Utility Ethanol	Utility Naphtha Forecast - 1% (on MBTU basis)
Oahu	Utility Ethanol	Utility Naphtha Forecast - 1% (on MBTU basis)
Kauai	Utility Ethanol	Utility Naphtha Forecast - 1% (on MBTU basis)
Hawaii	Utility Biodiesel	Utility #2 Diesel Oil Forecast - 1% (on MBTU basis)
Maui	Utility Biodiesel	Utility #2 Diesel Oil Forecast - 1% (on MBTU basis)
Oahu	Utility Biodiesel	Utility #2 Diesel Oil Forecast - 1% (on MBTU basis)
Kauai	Utility Biodiesel	Utility #2 Diesel Oil Forecast - 1% (on MBTU basis)

Second, in order for the E2020 model to select biofuels instead of their petroleum fuel counterparts, biofuels must have a cost advantage just as they would in a realistic marketplace. Thus, the county-specific forecasts for ethanol and biodiesel for electricity generation were derived by subtracting 1 percent of the price of the comparative fossil fuel for which ethanol and biodiesel could be used as a substitute on a heat content (MBTU) basis.

Quantitative Evaluation of Select Policy Recommendations

In addition to examining the energy system under various oil price scenarios, a number of policies were quantitatively evaluated for their impacts on Hawaii's various energy sectors and, where possible, estimates of costs to the government. Not all policies evaluated for recommendation in HES 2007 were amenable to quantitative analysis. The number of policies analyzed quantitatively was also limited by budgetary constraints.

Identifying a select subset of policies for evaluation began with an initial review of policy recommended in other state research reports, new research, and discussions with DBEDT staff. The following existing reports relating to policy recommendations for Hawaii were reviewed:

- Recommendations from HES 2000 and 1995;
- Governor's Energy for Tomorrow plan;
- Recent and past Hawaii Energy Policy Forum recommendations;
- Results of Hawaii biofuels summit August 2006; and
- Utility Integrated Resource Plan (IRP) filings with the public utilities commission.

Following document review and additional consultations with DBEDT staff, the following policies were identified as both valuable and capable of additional quantitative evaluation:

- Existing state renewable portfolio standard (RPS) that requires 20 percent renewable resource by 2020;
- Stand-alone energy efficiency standard of cumulative 20 percent achieved by 2020;
- Carbon cost adder on fuels (high and low levels);
- Existing alternative transportation fuel standard (AFS): 10 percent of highway fuel by 2010, 15 percent by 2015, and 20 percent by 2020;
- Sliding scale subsidy for alternative fuels relative to oil price; and
- Feebates for consumer vehicles.

All of the policies quantitatively evaluated were either captured in ENERGY2020 or analyzed using biofuel and transportation model enhancements with results either input into ENERGY2020 or derived from ENERGY 2020 outputs. Both the biofuels and transportation model enhancements were provided to DBEDT along with personal meetings with key DBEDT personnel introducing the models. Specifically, the existing

state RPS and energy efficiency standard are captured in ENERGY2020 scenario runs. Model results show that utilities meet RPS requirements for renewable energy in all scenarios. Electricity demand forecasted by ENERGY2020 in adequate supplies scenario was initially calibrated against utility IRP forecasts with energy efficiency achievements from programs included. The low and high carbon cost adder policies were evaluated as separate policy scenarios in ENERGY2020.

The AFS policy was examined using the biofuels model developed as an enhancement to ENERGY2020. The quantity of cost effective ethanol and biodiesel for transportation was determined using the model enhancement, then the results were fed into ENERGY2020 as inputs to the scenarios. We assumed flex fueled vehicles were capable of operating on 5 to 20 percent biodiesel by volume when blended with diesel or up to 85 percent ethanol by volume when blended with gasoline, depending on the scenario. Non-flex fueled vehicles were assumed to be capable of running up to 10 percent ethanol by volume. For the adequate and commodity cyclic scenarios where cost effective ethanol production was less than the state AFS goal, the gasoline price projections for those scenarios were used to determine the additional incentives needed to make ethanol cost effective under a sliding scale production tax credit. Diesel price forecasts from ENERGY2020 were also examined, and biodiesel was determined to be always cost effective in all scenarios.

Similarly, the transportation model enhancement developed for HES 2007 was used to analyze the transportation feebate policy. The model was used to determine the incremental percentage fuel savings with feebates for each energy scenario. The percentage savings resulting from feebates were then applied to the total gasoline fuel consumption outputs from ENERGY2020 for each scenario to quantify fuel savings resulting from feebates. Finally, the gasoline savings calculated were multiplied by gasoline price projections in each scenario to estimate cost savings to consumers as a result of feebates.

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Appendix D: Summary of Past HES Recommendations

This appendix discusses historical policies passed since 2000. These historical policies are divided into two sections. The first section discusses recommendations that were introduced in the Hawaii Energy Strategy of 2000 (HES 2000) and achieved; and the second section discusses other relevant policies that were introduced from various sources.

Hawaii Energy Strategy 2000 Achieved Recommendations

Hawaii has achieved many of the recommendations established in the Hawaii Energy Strategy of 2000 (HES 2000). The recommendations that have been adopted are elaborated below and summarized in Table 2.

E10 mandate

In September 2004, new administrative rules were signed by the Governor to implement the ethanol mandate that was created in 1994.[428] Effectuve in April 2006, Hawaii's mandate requires 85 percent of Hawaii's gasoline to contain 10 percent ethanol.

Solar Water Heating

In 2006, the State Legislature passed Act 240, which authorized the Hawaii Public Utilities Commission (PUC) to implement a Solar Water Heating Pay As You Save® Program (SWH Financing Program). Act 240 requires that each electric utility implement a Pay As You Save® model system tariff for residential customers by June 2007, and provide at least six months prior notice of its proposed tariff to the PUC.

On October 24, 2006, the Hawaii PUC opened Docket No. 2006-0425, Instituting a Proceeding to Investigate the Issues and Requirements Raised by, and Contained in, Hawaii's Solar Water Heating Pay As You Save® Program, Act 240, Session Laws of Hawaii (2006). Act 240 requires the PUC to:

- Determine the time frame of the Solar Water Heating Financing Program pilot program;
- Gather and analyze information to evaluate the pilot program;
- Review, and if necessary, modify the proposed tariffs submitted by each electric utility; and

[428]The mandate requiring the blending of ten percent ethanol in motor fuel in the State was originally introduced in 1994 through Act 199. The ethanol mandate language in Act 199 became part of chapter 486E, HRS. Chapter 486E was replaced in 1997 by chapter 487J, HRS. On September 20, 2004, the Governor signed administrative rules to implement the ethanol mandate (Title 15, Chapter 35 Hawaii Administrative Rules).

- Examine the issues and requirements necessary to implement the SWH Financing Program.

Table 36. Historical Achievements Since 2000

HES 2000 Recommendation	Policy Created	Date	Description
Encourage production and sale of 10% Ethanol-blend gasoline in Hawaii (4.6.2.2)	Title 15, Chapter 35 Hawaii Administrative Rules	Passed legislation 1994; Amended with administrative rule 2004	Regulation requiring that at least 85% of Hawaii's gasoline contain 10% ethanol.
Continue to increase the use of solar water heating (8.5.3.1)	Act 240 (SLH 2006)	Passed 2005	The Public Utilities Commission is authorized to implement a Solar Water Heating Financing program.
Consider implementing a Renewable Portfolio Standard, a Public Benefits Charge, or green pricing to increase renewable energy use (8.5.3.3)	Renewable Portfolio Standard (HRS §269-91)	Passed 2001, Amended 2004, Amended 2006	Each electric utility is required to meet 20% of its net electricity sales from renewable resources by 2020.
Encourage purchase and use of fuel-efficient conventional vehicles and hybrid vehicles (4.5.1.3)	Not Applicable	Not Applicable	Hybrid vehicles have been sold in the State for several years.
Increase use of renewable energy for electricity generation in Hawaii (7.4.3.2)	Renewable Portfolio Standard (HRS §269-91)	Passed 2001, Amended 2004, Amended 2006	Each electric utility is required to meet 20% of its net electricity sales from renewable resources by 2020.
Continue to assess the need for state income tax credits for renewable energy beyond 2003	Act 240	Passed 2006	Eliminates the sunset date on the Renewable Energy Income Tax Credits.
Adopt Model Energy Code for Maui County and adopt esidential Building Model Energy Codes in all counties (11.2.1.4)	Maui County Code Chapter 16.16 (Ordinance 3250 §3)	Adopted code 2005	Maui Model Energy Code adopted.

Increase efforts by State government to improve energy efficiency by meeting State goals for reduction of energy use in State facilities (11.2.4.1)	Act 96	Passed 2006	Energy efficiency standards for State facilities; requires agencies to design and construct buildings meeting green design standards.
Expand Hawaii State government energy Performance Contracting and alternative financing for projects (11.2.3.3)	§36-41	Amended 2000, Amended 2004	2000 Amendment expanded energy performance contracting to retrofits by requiring that State agencies evaluate retrofitting buildings to save energy; energy savings from retrofits returned to agency. 2004 amendment expanded definition of energy performance contract and allows for water-saving technology retrofits.

Renewable Portfolio Standard (RPS)

In 2004, the State Legislature passed Act 95, the Hawaii Renewable Portfolio Standard. The RPS was amended in the 2006 legislative session.

The RPS requires that each electric utility company that sells electricity for consumption in the State to generate or purchase set percentages of renewable energy. The standards are:

- 10 percent of net electricity sales by December 31, 2010;
- 15 percent of net electricity sales by December 31, 2015; and
- 20 percent of net electricity sales by December 31, 2020.

Renewable energy is defined in the RPS as:

> *Energy generated or produced utilizing the following sources: wind; the sun; falling water; biogas, including landfill and sewage-based digester gas; geothermal; ocean water, currents, and waves; biomass, including biomass crops, agricultural and animal residues and wastes, and municipal solid waste; biofuels; and hydrogen produced from renewable energy sources.*

The definition of "renewable energy" was amended in 2006 to exclude energy efficiency measures and renewable energy displacement technologies. In addition to amending the definition of "renewable energy," a new definition, "renewable electrical energy" was added. The definition of renewable electrical energy includes renewable energy displacement technologies and energy efficiency.[429] The definition of the "renewable

[429] Renewable electrical energy is defined as, "Electrical energy generated using renewable energy as the source; electrical energy savings brought about by the use of renewable displacement or off-set technologies, including solar

portfolio standard" was also amended in 2006 to allow renewable electrical energy to meet the RPS, as opposed to only renewable energy. These three definition changes still allows the RPS to be satisfied with energy efficiency and renewable energy displacement technologies as opposed to only renewable energy. Creating a definition specifically to renewable energy, however, is another step towards reducing State oil dependence.

Act 95 also requires the PUC to develop and implement a utility ratemaking structure to provide incentives that encourage Hawaii's electric utility companies to use cost effective renewable resources in the State by December 31, 2007.

Other amendments made to the RPS in 2006 include the inclusion of penalties and the ability of the PUC to establish the standard for each utility that prescribes what portion of the RPS will be met with renewable energy (as opposed to renewable electrical energy). The penalty provision, as amended in 2006, requires the PUC to establish penalties for non-compliance, and allows the PUC to determine whether an electric utility company failed to meet the RPS. The penalty clause also offers exemptions for non-compliance due to events or circumstances outside of an electric utility company's reasonable control, such as weather-related damage or mechanical failure. The PUC is permitted to prescribe what portion of the RPS shall be met by specific renewable electrical energy resources, provided that at least fifty percent of the RPS be met by renewable energy (as amended in 2006).

Renewable Energy Income Tax Credits

In 2006, Act 96 (SLH 2006) was passed, extending the Renewable Energy Income Tax Credits that were established in 2003. The tax credit is for solar thermal, wind, and photovoltaic energy systems, with different tax credits for residential, multifamily residential, and commercial systems. The credit is the lesser of the percent of total cost or the set dollar amount. Table 37 summarizes the current tax credits.

Table 37. Renewable Energy Income Tax Credits

Technology	Single-Family Residential	Multi-Family Residential	Commercial
Solar Thermal	35% or $2250	35% or $350/unit	35% or $250,000
Wind	20% or $1500	20% or $200/unit	20% or $500,000
Photovoltaic	35% or $5000	35% or $350/unit	35% or $350,000

Model Energy Code (MEC)

The Model Energy Code sets minimum requirements for the energy-efficient design of new buildings, provides criteria for energy-efficient design and methods for determining compliance. It also set standards for electric power; lighting; building envelope; heating,

water heating, seawater air-conditioning district cooling systems, solar air-conditioning, and customer-sited, grid-connected renewable energy systems; or electrical energy savings brought about by the use of energy efficiency technologies, including heat pump water heating, ice storage, ratepayer-funded energy efficiency programs, and use of rejected heat from co-generation and combined heat and power systems, excluding fossil-fueled qualifying facilities that sell electricity to electric utility companies and central station power projects." Act 162 SLH 2006.

ventilating, and air-conditioning systems and equipment (HVAC); water-heating systems and equipment; and energy management. The State code was finalized in 1993. Since the HES 2000, all counties have adopted a commercial energy code and Honolulu and Maui Counties have adopted a residential energy code.

Energy Efficiency in State Facilities

There have been two major laws passed since the HES 2000—Act 77 (SLH 2002) and Act 96—(SLH 2005) that require energy efficiency in State facilities. Act 77, passed in 2002, was a broad, multi-part law that established a gasoline price cap in Part I and required improved energy efficiency in state facilities in Part II. The goal of Act 77 Part II was to significantly improve State energy management in state facilities to save taxpayer money and reduce emissions that contribute to air pollution and climate change.

In 2006, Act 96 was passed that replaced and amended major portions of Act 77. The goal of Act 96 is to lead the State by example with energy efficiency and environmental standards for state facilities, motor vehicles, and transportation fuel. The details of the amendments are explained below.

Act 96 amended four major portions of Act 77:

- *Energy-efficient products.* Act 96 replaced mandates for energy-efficient criteria for all guide and project specification developed for new construction and renovation; ENERGY STAR building criteria; sustainable design principles; implementation of energy reduction systems; and use of off-grid energy generation systems with a goal of achieving LEED Silver or Two Green Globes standards for building design and construction.

- *Energy-efficiency policy review and evaluation.* Act 77 required that the energy resources coordinator ensure that a review and evaluation, comparable to the 2002 Energy-Efficiency Policy Task Force's Report to the State Legislature, would be conducted by January 2007. Act 96 repealed these requirements.

- *Greenhouse gases reduction goal*. Act 77 required that each State agency reduce its greenhouse gas (GHG) emissions due to energy use by thirty percent by 2012. Act 96 repealed this goal.

- *Energy-efficiency improvement goals*. Act 77 required that each State agency reduce energy consumption per gross square foot by twenty percent by 2007 and thirty percent by 2012, with 1990 as the baseline year. Act 96 repealed this goal.

- *Annual reports*. Additionally, Act 77 required that each agency submit annual reports on its progress towards meeting these goals and mandates. The Act also called for facility energy audits, maximizing agency's ability to use alternative financing mechanisms, and use of energy efficient products. Act 96 repealed all of these requirements.

Act 96 also introduced many new energy efficiency policies for the State, including:

- An appropriation of $5 million was made for net-metered PV systems at schools.
- Fifty million dollars was appropriated for energy efficiency retrofits in school buildings to be administered by DOE.
- Funds were appropriated for an energy efficiency coordinator for the Department of Education.
- Fifty million dollars was appropriated for energy efficiency retrofits in state buildings to be administered by DAGS.
- Funds were appropriated for two energy efficiency positions in DBEDT and programs to enhance energy efficiency in State facilities and equipment.
- Motor vehicles purchased by the State must meet minimum Federal and State alternate fuel requirements, efficiency, and use alternate fuels such as ethanol blends and biodiesel.
- County agencies must establish a priority permitting process for building-, construction-, or development-related permits that incorporate energy and environmental design building standards into their project design.

Energy Conservation and Alternate Energy Retrofitting §36-41

In 2000, the State Legislature passed Act 158, which mandated that all agencies evaluate and identify for implementation energy-efficiency retrofitting through performance contracting. The Act also allows agencies that achieve energy efficiency savings through retrofitting to keep the savings resulting from the baseline and the energy efficiency.

Other Historical Relevant Policies

Many of the goals set forth in the HES 2000 have been achieved. In addition to those goals, much legislation has been passed that is complimentary to the HES 2000, although not explicitly mentioned as a recommended action. These policies are explained below and summarized in **Table 38**. Legislation passed specifically in 2006 were part of the Governor's Energy for Tomorrow Initiative.

Wind Farm Incentive

In 1986, the State Legislature recognized that certain areas of the state need particular attention to help attract private sector investment, and subsequently created Enterprise Zones to stimulate business and industrial growth in those areas.[430] Under the Enterprise Zone law, a "qualified business" is exempt from the general excise tax for seven years on the gross proceeds from the manufacturing or selling of personal property, or engaging in

[430] H.R.S. §209E-1, Purpose.

a service business, and the use tax does not apply to purchases by a qualified business.[431] Additionally, a "qualified business" is eligible for a tax credit for a percentage of the unemployment tax paid, and a seven-year declining state income tax credit.[432]

In 2000, the State Legislature expanded the definition of a "qualified business" to include wind farms producing electric power from wind energy for sale to a public utility company that resells the electric power to the public. Unfortunately, a wind farm may not receive the general excise tax exemption or the use tax exemption because electricity production does not qualify as manufacturing or selling of tangible personal property or engaging in a service business. Instead, the wind energy producer will pay a reduced general excise tax rate[433] (0.5 percent instead of 4.166 percent) and receive the unemployment tax credit and state income tax credit.

Net Metering

Hawaii's first net metering law was passed in 2001, allowing for the flow of electricity both to and from the customer. Residential and small commercial customers with solar, wind, biomass or hydroelectric systems less than 10 kW were allowed to net meter their electricity to produce their own energy, although the law did not allow customers to carry over their excess generation from month to month. Customers may enroll in this program on a first-come first-serve basis until the net-metered capacity equals 0.5 percent of each utility's peak demand. In 2004, the law was expanded to allow systems up to 50 kW to participate in the net-metering program. The law was expanded again in 2005 to remove the ability of the utilities to place additional requirements on net-metered systems; permit the PUC to increase individual system limits above 50kW and raise the net metering limit; and to allow customers to carry their excess generation forward from month to month. At the end of the year, all excess generation is automatically granted to the utility without customer compensation, unless the customer has entered into a power purchase agreement with the utility.

Duties of the Consumer Advocate

The Division of Consumer Advocacy (DCA) protects and advances the interests of Hawaii's consumers regarding regulated public utilities and transportation services. In 2004, the DCA's duties were expanded to include considering the long-term benefits of renewable resources in its role as a consumer advocate.[434] This change in duties is significant because the DCA is party to all utility dockets, and when preparing its position, the DCA must now consider the long-term implications of investing in renewables.

[431] H.R.S. §209E-11, State general excise exemptions.

[432] H.R.S. §209E-10, State business tax credit.

[433] H.R.S. 237-13.5, Relating to the sale of electric power to the public utility.

[434] H.R.S. §269-54, General powers; duties.

Solar Devices for Condos and Townhomes

The State Legislature passed a solar access law in 1992 that prohibited any form of rule that would prevent the owner of a single-family residential dwelling or townhouse from installing a solar energy device on their home. In 2005, the law was strengthened by adding a provision that requires all homeowner, community, and condominium associations and cooperatives to adopt rules that provide for the placement of solar energy devices by December 31, 2006.[435]

Energy Cost Adjustment Clause Modification

In 2006, the State Legislature passed Act 162, which requires that any automatic fuel rate adjustment charge requested by a utility be designed to fairly share the risk of fuel cost charges between the utility and customers. Prior to Act 162, utilities were able to pass the entire cost of fuel along to their customers.

Leasing Public Lands to Renewable Energy Producers

In 2002, the State Legislature passed a law that allows the Department of Land and Natural Resources (DLNR) to lease public land to renewable energy producers for up to 65 years without public auction.[436] This law has the potential to be an effective incentive for renewable energy, but there is some ambiguity regarding the definition of a renewable energy produce; the law allows DLNR to lease land to renewable energy *producers,* but does not clarify whether a person growing a fuel crop would qualify as a renewable energy producer.

De-linking the Price of Renewable Energy from the Cost of Oil

In 2006, the State Legislature passed Act 162, which addresses the problem of renewable power producers receiving the equivalent of utility-avoided costs for energy generated based on the floating price of oil. This is a problem because when the oil price is high, the cost is passed on to ratepayers through the purchased power agreement element of the utilities rates. Therefore, neither the utility nor the consumers enjoy any direct economic benefits from renewable power, nor will they benefit economically from future renewable power under the RPS.

Act 162 mitigated this problem by requiring the Public Utilities Commission to establish a methodology that removes or significantly reduces any linkage between the price of fossil fuel and the rate for the non-fossil fuel generated electricity. The intent is for utilities and customers share in the fuel costs savings resulting from renewable generated electricity.

Alternative Fuel Tax Rates

[435] H.R.S. §196-7, Placement of solar energy devices.

[436] HRS § 171-95

In 2004 the State Legislature reduced the fuel tax by fifty percent on ethanol, methanol, biodiesel, and other alternative fuels to encourage fuel diversity and reduce the State's dependence on imported fossil fuels.

Ethanol Facility Incentive

In 2000, the State Legislature created an investment tax credit for ethanol equal to 30 percent of nameplate capacity per year for the first 40 million gallons. The plant must be placed in service before January 1, 2012 and produce between 500k and 15 million gallons of ethanol a year.[437] The maximum tax credit is $4.5 million per facility per year, for facilities that produce over 15 million gallons per year, and less for smaller facilities. The credit may be taken for up to eight years, if the investment in the facility (exclusive of land costs) is less than $50 million; if the total investment in the facility is over $50 million, the credit may be taken for up to 10 years. If the credit exceeds the taxpayer's income tax liability, the excess shall be refunded to the taxpayer (i.e., the taxpayer shall receive a payment).

In 2004, the investment tax credit was changed to an ethanol facility tax credit. The tax credit amounts did not change, although the amendments did limit the amount of the tax credit to 100 percent of the investment, bar other credits from being claimed if the ethanol facility tax credit is claimed, and only allow facilities operating at 75 percent nameplate capacity to receive the credit.

Alternative Fuel Standard

In 2006, the State Legislature passed Act 240 (SLH 2006), creating an alternate fuel standard (AFS) for the State. The AFS goal is to provide 10 percent of the highway fuel demand from alternate fuels by 2010; 15 percent by 2015; and 20 percent by 2020. The AFS will achieve diversification of transportation fuel sources and development of local fuel supply, thereby creating jobs. The AFS will also provide a ready market for farmers growing ethanol-rich crops. A 2003 study by Stillwater Associates projected that Hawaii has a ethanol industry capable of producing 90 million gallons a year, which "could add as much as $300 million to Hawaii's economy in direct and indirect value." While Hawaii-grown ethanol will have to compete with the global market, the current tariffs on imported ethanol, the long transportation distance, infrastructure constraints, and state procurement preferences for locally-produced fuels collectively provide more than adequate price coverage to support Hawaii-grown ethanol.

State Procurement Preference

In 2006, the State Legislature passed Act 162, which included a purchase preference for biodiesel when awarding contracts for the purchase of diesel fuel or boiler fuel when these fuels are produced in Hawaii.

Biofuels Funding

[437] H.R.S. §235-110.3

In 2006, the State Legislature passed Act 240, which included $200,000 for a statewide multi-fuel biofuels production assessment of potential feedstocks and technologies, and $150,000 to provide assistance to the agricultural community interested in developing energy projects, especially for the production of biodiesel from energy crops and cellulosic ethanol from agricultural waste streams.

State Vehicle Acquisition Requirements

As mentioned above, the State Legislature passed Act 96 in 2006,. The goal of Act 96 is to lead the State by example with energy efficiency and environmental standards for state facilities, motor vehicles, and transportation fuel. Act 96 requires increasing percentages of state fleet vehicles purchased to be energy-efficient vehicles, which includes vehicles capable of operating on alternative fuel, electricity, hydrogen, or are on the list of "Most Energy Efficient Vehicles" in their class, as ranked by the EPA. In 2006, 20 percent of fleet vehicles purchased must be energy efficient, 30 percent in 2007, 40 percent in 2008, increasing by five percent a year to a maximum of 75 percent. Agencies may offset the vehicle purchase requirements at the rate of one vehicle for every 450 gallons of neat biodiesel used.

Table 38. Legislation of significance passed since HES 2000

Policy	Date	Description
Power		
Wind Farm Incentive (HRS §209E-9)	Amended 2000	Expanded definition of a "qualified business" under the State enterprise zones to include wind farms.
Net Metering (HRS §269-101)	Passed 2001, Amended 2004, Amended 2005	Net-metering enacted 2001, 2004 amendment increased eligible capacity limit of net-metered systems from 10kW to 50kW. 2005 amendment allowed PUC to increase allowable percentage of peak demand that is produced from eligible customer generators.
Duties of the CA (HRS §269-54)	Amended 2003	Requires that the CA, as part of it's role, consider the long-term benefits of renewable resources.
Renewable Energy Income Tax Credits (REITC; repeat from achieved goals)	Passed 2003, Amended 2004, Amended 2006	Created renewable energy tax credits for solar thermal, wind, and PV energy systems. The 2006 amendment increased selected credits and repealed the expiration date on the credit.
Solar devices for condos and townhomes (HRS §196-7, §514A-89, Act 164 SLH2004)	Passed 2005	Prohibits any declaration, bylaws, restrictions, deeds, or lease terms that prevent the installation of a solar energy device on single family or townhome dwellings.
Energy Cost Adjustment Clause (ECAC) modification (Act 162, SLH 2006)	Passed 2006	Requires the PUC to study whether the utility should share some of the risks associated with fuel costs, rather than allowing 100% pass through of fuel costs.
Bioenergy		
Leasing public lands to renewable energy producers (HRS §171-95)	Passed 2002	Allows DLNR to lease public lands to renewable energy producers without public auction, for up to 65 years.
Alternative Fuel tax rates (HRS §243-4,5)	Passed 2001, Amended 2004, Amended 2006	Adjusts transportation fuel tax rates to reflect energy content of fuel; removes disincentives from alternative fuels by lowering tax rate.
Ethanol Facility Incentive (HRS §235-110.3)	Passed 2000, Amended 2004	Investment tax credit for ethanol equal to 30% of nameplate capacity per year for the first 40 million gallons.
Alternative Fuel Standard (Act 240)	Passed 2006	Goal that 20% of state highway fuel demand will be met with renewable fuels by 2020.
State Procurement Preference	Passed 2006	$0.05/gal State government procurement preference

(Act 240)		for biodiesel.
State Vehicle Acquisition Requirements (Act 96)	Passed 2006	After all State and Federal vehicle procurement requirements have been met, each agency shall purchase energy-efficient vehicles. Agencies shall also purchase alternative fuels and ethanol-blended gasoline when available.
Biofuels Funding (Act 240)	Passed 2006	$200,000 in funding is provided for DBEDT to conduct a statewide multi-fuel biofuels assessment. $150,000 in funding is provided to the Department of Agriculture to assist farmers with developing energy projects, especially involving production of biodiesel from energy crops and cellulosic ethanol from waste streams and in seeking funding from Federal and private sector sources.
Delinking the price of renewable energy from the price of oil (Act 162)	Passed 2006	Requires the PUC to establish a methodology that removes or significantly reduces any linkage between the price of fossil fuel and the rate for the nonfossil-fuel-generated electricity.