Hawaii Energy Strategy 2000

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State of Hawaii
Department of Business, Economic Development & Tourism
Energy, Resources, and Technology Division

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GLOSSARY

AFBC	Atmospheric Fluidized-Bed Combustion, a type of coal plant.
AFV	Alternative Fuel Vehicle -- a vehicle which runs on a fuel other than gasoline or diesel. Fuels include methanol, ethanol, biodiesel, electricity, hydrogen, natural gas, synthetic natural gas, and liquefied petroleum gas.
AGC	Automatic generation control
alternate energy	Energy sources which reduce dependence on imported petroleum. Hawaii's alternate energy supplies include coal, landfill gas, geothermal, hydropower, municipal solid waste, solar, and wind energy.
alternative fuel vehicle	A vehicle which runs on a fuel other than gasoline or diesel
alternative fuels	Vehicle fuels that displace gasoline or diesel. They include methanol, ethanol, biodiesel, electricity, hydrogen, natural gas, synthetic natural gas, and liquefied petroleum gas.
ANS	Alaska North Slope -- the current oil-producing area of Alaska.
ANSI/ASCE7	American National Standards Institute/American Society of Civil Engineers wind loading standard
ANSI-7	American National Standards Institute wind loading standard
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
bagasse	The crushed fibers that remain after the sugar has been removed from the sugarcane in processing. Used as a boiler fuel.
barrel	A volumetric unit of measure for crude oil and petroleum products equivalent to 42 U.S. gallons.
baseload capacity	The generating equipment normally operated to serve loads on an around-the-clock basis.
baseload plant	An electric power plant which is normally operated to take all or part of the minimum load of a system, and which consequently produces electricity at an essentially constant rate and runs continuously. These units are operated to maximize system mechanical and thermal efficiency and minimize system-operating costs.
bbl	The abbreviation for barrel -- a volumetric unit of measure for crude oil and petroleum products equivalent to 42 U.S. gallons.
BEA	Bureau of Economic Analysis
biomass fuels	Wood, agricultural wastes such as bagasse, garbage or municipal solid waste, and alcohol fuels are primary examples. Biomass energy sources are essentially unprocessed; they are burned as received to produce thermal energy. Examples are wood, bagasse, and garbage. Biofuels result from the processing of biomass energy sources. In general, biofuels have a greater energy density and are more easily transported and used. Examples are wood chips, pellets, briquettes, alcohol fuels, and refuse-derived fuel.
BLS	Bureau of Labor Statistics
Btu	British Thermal Unit - a standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit.
CAFE	Corporate Average Fuel Efficiency

capacity	The full-load continuous rating of a generator, prime mover, or other electric equipment under specified conditions as designated by the manufacturer.
carbon dioxide (CO_2)	The greenhouse gas whose concentration is being most affected directly by human activities. CO_2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalents). The major source of CO_2 emissions is fossil fuel combustion. CO_2 emissions are also a product of forest clearing, biomass burning, and non-energy production processes such as cement production. Atmospheric concentrations of CO_2 have been increasing at a rate of about 0.5% per year and are now about 30% above pre-industrial levels.
carbon dioxide equivalent (CDE).	A measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)" or "million short tons of carbon dioxide equivalents (MSTCDE)" he carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP.
CCAP	Climate Change Action Plan -- an international effort to reduce the emissions of greenhouse gases believed to cause global warming.
CH_4	Methane, a greenhouse gas
CIA	Central Intelligence Agency's
climate	The average weather (usually taken over a 30-year time period) for a particular region and time period. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail storms, and other measures of the weather.
climate change	A change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods
CO	Carbon monoxide
CO_2	Carbon dioxide
coal	A black or brownish-black solid combustible substance formed by the partial decomposition of vegetable matter without access to air.
cost	The amount paid to acquire resources, such as plant and equipment, fuel, or labor services.
crude oil	A mixture of hydrocarbons that existed in liquid phase in underground reservoirs and that remains liquid at atmospheric pressure after passing through surface separating facilities.
CT	Combustion turbine
DBEDT	State of Hawaii Department of Business, Economic Development & Tourism
DC	Direct current
defacto population	Sum of resident population and visitor census, less residents living elsewhere.
demand (electricity)	The rate at which electric energy is delivered to or by a system, part of a system, or piece of equipment, at a given instant or averaged over any designated period of time.
demand-side management (DSM)	Utility activities aimed at modifying the customer's use of energy to produce desired changes in energy demand.
DLNR	State of Hawaii Department of Land and Natural Resources

DOE	United States Department of Energy
DOH	State of Hawaii Department of Health
DSM	demand-side management
Dual-Train Combined Cycle (DTCC)	Dual-Train Combined Cycle. An oil-fired power plant consisting of two gas turbines each driving a generator which are connected to a steam recovery unit. The steam recovery unit uses the exhaust heat of the gas turbines to make steam to drive a third generator.
E10	Fuel Blend of 10% Ethanol and 90% Gasoline
E85	Fuel Blend of 85% Ethanol and 15% Gasoline
EAG	Externalities Advisory Group
EEP	Energy Emergency Preparedness
EIA	U.S. Department of Energy's Energy Information Administration
EIIS	Environmental Impact Information Sheet
electric utility	An enterprise engaged in the generation, transmission, or distribution of electric energy primarily for use by the public and that is the major power supplier within a designated service area.
electricity generation	The process of producing electric energy or transforming other forms of energy into electric energy. Also the amount of electric energy produced or expressed in Watthours (Wh).
emissions	The release of pollutants and greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.
energy	The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatt-hours, while heat energy is usually measured in British thermal units.
ENERGY 2020	A multi-sector energy analysis computer model for energy forecasting and policy assessment. ENERGY 2020 simulates the major departments of regulated electric and gas utilities, other supply sources, and the major components of energy demand, including transportation demand, in a single comprehensive framework connected by several important feedback responses.
Energy Emergency Preparedness (EEP) Program	A program that prepares Hawaii to be prepared to effectively manage energy emergencies and threats to its energy security.
energy source	The primary source that provides the power that is converted to electricity through chemical, mechanical, or other means. Energy sources include coal, petroleum and petroleum products, gas, water, uranium, wind, sunlight, geothermal, and other sources.
energy supply	Consists of domestic and foreign sources of crude oil, refineries, coal, renewable energy supplies, and alternate energy supplies.
EPA	Environmental Protection Agency
EPACT	National Energy Policy Act of 1992

ERC	State of Hawaii Energy Resources Coordinator (a duty assigned to the Director of the DBEDT)
ERTD	Energy, Resources, and Technology Division, State of Hawaii Department of Business, Economic Development & Tourism
ethanol	An alcohol transportation fuel produced on the Mainland primarily from corn. In Hawaii, ethanol could be made from sugarcane molasses, and several companies are also considering producing ethanol from yard and wood wastes or mixed waste paper.
EV	Electric Vehicle
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission **--** The federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within the Department of Energy.
fossil fuel	Any naturally occurring organic fuel, such as petroleum, coal, and natural gas.
fossil fuel plant	A power plant using coal, petroleum, or gas as its source of energy.
fuel	Any substance that can be burned to produce heat; also, materials that can be fissioned in a chain reaction to produce heat.
gasohol	A blend of finished motor gasoline and alcohol (generally ethanol, but sometimes methanol) limited to ten percent by volume of alcohol.
generation (electricity)	The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in Watthours (Wh).
generator	A machine that converts mechanical energy into electrical energy.
generator capacity	The full-load continuous rating of a generator, prime mover, or other electric power production equipment under specific conditions as designated by the manufacturer.
geothermal energy	Geothermal energy is the natural heat of the earth stored deep below the earth's surface. It can be in the form of steam, hot liquid, or hot dry rock. Wells drilled deep into the ground bring steam and hot water to the surface. The steam, or steam produced by the fluids in a heat exchange process, is used to drive a turbine generator to make electricity. Modern technology allows spent geothermal fluids and non-condensable gases to be reinjected back into the ground, eliminating surface disposal and air pollution
geothermal plant	A plant in which the prime mover is a steam turbine driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the earth’s surface.
Gigawatt (GW)	One billion Watts
Gigawatthour (GWh)	One billion Watthours
global warming	An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases. The IPCC recently concluded that increased concentrations of greenhouse gases are causing an increase in the Earth's surface temperature.

global warming potential (GWP)	The index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram of a greenhouse gas to that from emission of one kilogram of carbon dioxide over a period of time (usually 100 years). Based upon a recent reevaluation, the GWP for CO_2 is 1, for CH_4 it is 24.5, and for N_2O it is 320.
greenhouse effect	The effect produced as greenhouse gases allow incoming solar radiation to pass through the Earth's atmosphere, but prevent most of the outgoing infrared radiation from the surface and lower atmosphere from escaping into outer space. This process occurs naturally and has kept the Earth's temperature about 59 degrees F warmer than it would otherwise be. Current life on Earth could not be sustained without the natural greenhouse effect.
greenhouse gas	Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).
Gross State Product	An economic measure of the value of all the goods and services produced in a state in a year.
GSP	Gross State Product
GW	Gigawatt - one billion Watts.
GWh	Gigawatt Hour - one billion Watt-hours.
GWP	Global warming potential
Hawaii Climate Change Action Plan	Phase II of the Program for Developing, Implementing, and Evaluating a Greenhouse Gas Reduction Strategy for the State of Hawaii, the first iteration of a *Hawaii Climate Change Action Plan* was completed in November 1998. The plan does not set specific goals. It is intended to be a catalyst for discussions by Hawaii's people about their involvement in future efforts to reduce emissions and to adapt to climate change. The major recommendation of the first plan is to develop consensus as to Hawaii's goals for greenhouse gas emission reductions.
Hawaii Energy Strategy Program	The Hawaii Energy Strategy (HES) program was initiated on March 2, 1992 under a Cooperative Agreement with the United States Department of Energy (USDOE). The program was designed to increase understanding of Hawaii's energy situation and to produce recommendations to achieve the state energy objectives of dependable, efficient, and economical state-wide energy systems capable of supporting the needs of the people, and increased energy self-sufficiency.
HC&S	Hawaiian Commercial & Sugar Company
HCPC	Hilo Coast Power Company
HECO	Hawaiian Electric Company, Inc. -- the electric utility serving Oahu.
HEI	Hawaiian Electric Industries, Inc. -- the holding company which owns HECO, HELCO, and MECO.
HELCO	Hawaiian Electric Light Company, Inc. - the electric utility serving the Island of Hawaii.
HES	Hawaii Energy Strategy
HES 1995	Hawaii Energy Strategy 1995
HEVDP	Hawaii Electric Vehicle Demonstration Program

HNEI	University of Hawaii's Hawaii Natural Energy Institute
H-POWER	Honolulu Project of Waste Energy Recovery - a waste-to-energy power plant producing 46 MW of electricity for sale to HECO at Barbers Point, Oahu.
HRS	Hawaii Revised Statutes
HRS	Heat recovery system – a system designed to make use of waste heat from combustion
HSFO	High-Sulfur Fuel Oil. Has a sulfur content greater than 5%.
hydroelectric plant	A plant in which turbine generators are driven by falling water.
hydropower	In the simplest form of hydropower, flowing water turns a turbine, which then turns a generator, which produces electricity. The available power depends on the amount of water flowing, and also the pressure, or "head", of the water. Head can be increased by building dams or selecting sites with steep terrain. Pumped storage hydropower plants pump water back up from a lower reservoir to an upper reservoir where it is stored and then released when needed to provide power. This is mostly used for short periods to meet peak power demands.
independent power producer (IPP)	A cogenerator which produces and sells firm power under contract to the utilities.
Integrated Resource Planning (IRP)	An approach to regulated utility planning to meet consumer energy needs in an efficient and reliable manner at the lowest reasonable cost by evaluating all potential energy options as well as the social, environmental and economic costs of these options.
Intergovernment-al Panel on Climate Change (IPCC)	A panel of international climate scientists jointly established by the World Meteorological Organization and the United Nations Environment Program in 1988 to (i) assess available information on climate change, (ii) assess the environmental and socio-economic impacts of climate change, and (iii) formulate response strategies.
internal combustion power plant	A plant in which the prime mover is an internal combustion engine. An internal combustion engine has one or more cylinders in which the process of combustion takes place, converting energy released from the rapid burning of a fuel-air mixture into mechanical energy. Diesel or gas-fired engines are the principal types used in electric plants.
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer -- A cogenerator which produces and sells firm power under contract to the utilities.
IRP	Integrated Resource Planning
ISO	Independent System Operator
KE	Kauai Electric Division of Citizens Utilities -- the electric utility serving Kauai. A cogenerator which produces and sells firm power under contract to the utilities.
KGP	Kapaa Generating Partners
Ktherms	kilotherms -- one thousand therms
kW	kilowatts -- one thousand Watts
kWh	kilowatt hours -- one thousand Watt hours

Kyoto Protocol	A Protocol to the United Nations Framework Convention on Climate Change agreed by participants at the Kyoto Summit (Conference of Parties 3) in December 1997. It commits industrialized countries to firm reductions in greenhouse gas emissions. The United States is to reduce emissions by 7% below 1990 levels by the years 2008-2010. The U.S. signed the Protocol in November 1998, but it has not been submitted by the Administration to Congress for ratification due to Congressional concerns about the lack of requirements for emission reductions by developing nations.
landfill methane	Methane created by the decomposition of municipal solid waste in landfills. At Kapaa Landfill on Oahu, landfill methane is collected and piped to a combustion turbine generator at Kapaa Quarry for use as a fuel.
LF	Landfill (methane)
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas (propane)
LSC	Load service capability
LSFO	Low-sulfur fuel oil (residual fuel oil with a sulfur content of <0.5%)
M85	A fuel blend of 85% methanol and 15% gasoline.
mb/d	thousand barrels per day
MECO	Maui Electric Company, Inc. -- the electric utility serving the islands of Maui, Molokai, and Lanai (Maui County).
methane (CH_4)	A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 24.5. Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and oil, coal production, and incomplete fossil fuel combustion. The atmospheric concentration of methane has been shown to be increasing at a rate of about 0.6% per year and the concentration of about 1.7 parts per million by volume (ppmv) is more than twice its preindustrial value. However, the rate of increase of methane in the atmosphere may be stabilizing.
Model Energy Code	Design requirements for minimally efficient energy use in new and renovated buildings. The Code is meant to reduce energy use and costs. It was developed by the DBEDT ERT Division for adoption by Hawaii's four counties.
mpg	Miles per gallon – a measure of vehicle fuel efficiency
MSFO	Medium-sulfur fuel oil (residual fuel with a sulfur content >0.5% but <5%)
MSW	Municipal Solid Waste -- refuse burned as a fuel for electricity generation and to reduce land fill volume.
MW	megawatt - a million Watts
MWh	Megawatt Hour -- a million Watthours
N_2O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards

National Energy Policy Act of 1992 (EPACT)	Signed by President Bush on October 24, 1992, EPACT includes provisions related to state and county energy management, including model energy code, home energy efficiency ratings and energy efficient mortgages, efficient government buildings, integrated resource planning, tax provisions, renewable energy, alternative fueled vehicles, and climate change action plan.
natural gas	A naturally occurring mixture of hydrocarbon and nonhydrocarbon gases found in porous geological formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane.
NELHA	Natural Energy Laboratory of Hawaii Authority
nitrous oxide (N_2O)	A powerful greenhouse gas with a global warming potential of 320. Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.
non-utility gas	Propane or propane-based LPG distributed by delivery trucks to the consumer's tank or the consumer brings his or her tank to a refueling station. Not regulated by the Public Utilities Commission.
NREL	National Renewable Energy Laboratory
NUG	Non-Utility Generator
ocean thermal energy conversion (OTEC)	The technology for generating electricity from different ocean temperatures. OTEC makes use of the difference in temperature between the warm surface water of the ocean and the cold water in depths below 2,000 feet to generate electricity. As long as a sufficient temperature difference (about 40 degrees Fahrenheit) exists between the warm upper layer of water and the cold deep water, net power can be generated.
OFS	Oil-fired steam – uses oil beneath a boiler to produce steam to power a generator
OPEC	Organization of Petroleum Exporting Countries
OTEC	Ocean Thermal Energy Conversion
peak demand	The maximum load during a specified period of time.
petroleum	A mixture of hydrocarbons existing in the liquid state found in natural underground reservoirs, often associated with gas. Petroleum includes asphalt, fuel oil No. 2, No. 4, No. 5, No. 6; topped crude; kerosene; jet fuel; naphtha, LPG, and other products.
PGV	Puna Geothermal Venture -- operator of the geothermal power plant on the Island of Hawaii.
photovoltaics (PV)	A renewable energy technology that converts the sun's light, not its heat, directly into electricity. Sunlight shining on specially treated cells or film produces direct-current (DC) electricity. The solar cells are made of thin layers of material, usually silicon. The layers, after treatment with special compounds, have either too many or too few electrons. When light strikes a sandwich of the different layers, electrons start flowing, and an electric current is produced.
PICHTR	Pacific International Center for High Technology Research
PM_{10}	Particles less than 10 microns in diameter in emissions from power plants
PRB	Performance-based rate making
psig	Pounds per square inch (gauge)
PUC	Public Utilities Commission

pumped-storage hydroelectric plant	A plant that usually generates electric energy during peak-load periods by using water previously pumped into an elevated storage reservoir during off-peak periods when excess generating capacity is available to do so. When additional generating capacity is needed, the water can be released from the reservoir through a conduit to turbine generators located in a power plant at a lower level.
PURPA	Public Utilities Regulatory Policies Act of 1978
PV	Photovoltaics
PVUSA	Photovoltaics for Utility-Scale Applications
RD&D	Research, Development, and Demonstration
READ	Research and Economic Analysis Division
Regional Economic Models, Inc. (REMI)	A macroeconomic model composed of five sectors or “linkages”: output, demand, supply, market share and wage.
REMI	Regional Economic Models, Inc.
resource supply curve (RSC)	A computer model that provides the means to compare different generating options with each other, given similar economic assumptions and evaluation methodologies.
RFP	Request for Proposals
RPS	renewable portfolio standard
sales, electricity	The amount of kilowatt-hours sold in a given period of time; usually grouped by classes of service, such as residential, commercial, industrial, and other. Other sales include public street and highway lighting, other sales to public authorities and railways, and interdepartmental sales.
sector, commercial	Includes a variety of business facilities such as hotels, resorts, large and small offices, restaurants, hospitals, warehouses, schools, and others.
sector, energy	A system of classifying energy use divided into residential, commercial, industrial, and transportation sectors. These sectors are also grouped into regulated and non-regulated energy sectors.
sector, industrial	Includes oil refining, agriculture and irrigation pumping, food processing and miscellaneous.
sector, residential	Includes all household energy use in single- and multi-family homes.
sector, transportation	Includes air, marine, and ground transportation.
short ton	Common measurement for a ton in the United States. A short ton is equal to 2,000 lbs. or 0.907 metric tons.
SLH	Session Laws of Hawaii
SNG	Synthetic Natural Gas
solar thermal energy	Solar thermal energy is heat energy obtained by exposing a collecting device to the rays of the sun. A solar thermal system makes use of the warmth absorbed by the collector to heat water or another working fluid, or to make steam. Hot water is used in homes or commercial buildings and for industrial processes. Steam is used for process heat or for operating a turbine generator to produce electricity or industrial power.
SRG	Steam recovery generator
sulfur	One of the elements present in varying quantities in fossil fuels which contributes to environmental degradation when fossil fuels are burned.

system (electric)	Physically connected generation, transmission, and distribution facilities operated as an integrated unit.
T&D	Transmission and distribution
TBtu	Tera Btu -- trillion Btu (10^{12})
TCM	Transportation control measure
TGC	The Gas Company. Hawaii's only gas utility.
transmission system (electricity)	An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers.
TRC	Total resource cost
turbine	A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas).
U.S. Strategic Petroleum Reserve	The Strategic Petroleum Reserve (SPR) is the nation's first line of defense against an interruption in petroleum supplies. It is an emergency supply of crude oil stored in huge underground salt caverns along the coastline of the Gulf of Mexico. In 1998, Hawaii was granted priority access to enhance the State's energy security.
UH	University of Hawaii
UNFCC	United Nations Framework Convention on Climate Change
United Nations Framework Convention on Climate Change	The UNFCC was adopted at the Rio Environmental Summit in 1992. It was to serve as a basis for future efforts to achieve, through the work of the Conference of the Parties, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This was to be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable sustainable economic development.
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VMT	Vehicle miles traveled
Watt	The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.
Watt-hour (Wh)	An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric steadily for 1 hour.
wind power	Harnessing the wind with turbines to produce mechanical power or electricity. The wind turns the blades of a windmill-like machine. The rotating blades turn the shaft to which they are attached. The turning shaft typically can either power a pump or turn a generator, which produces electricity. For producing large amounts of electricity, many machines can be grouped together to form a "wind farm".
ZEV	Zero Emission Vehicle

CHAPTER 1 STATE ENERGY OBJECTIVES AND THE HAWAII ENERGY STRATEGY

1.1 State of Hawaii Energy Program

1.1.1 The State Energy Resources Coordinator

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 program is the basic element of the planning and development process.

1.1.2 State Energy Policy Objectives

The Hawaii Energy Strategy 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, as amended by Act 96, Session Laws of Hawaii 1994, of:

a) Planning for the State's facility systems with regard to energy shall be directed towards the achievement of the following objectives:

    (1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;

    (2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased; [and]

    (3) Greater energy security in the face of threats to Hawaii's energy supplies and systems.

(b) 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.

(c) To further achieve the energy objectives, it shall be the policy of this State to:

    (1) Support research and development as well as promote the use of renewable energy sources;

    (2) Ensure that the combination of energy supplies and energy-saving systems are sufficient to support the demands of growth;

    (3) 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;

(4) Promote all cost-effective conservation of power and fuel supplies through measures including:

(A) Development of cost-effective demand-side management programs;

(B) Education; and

(C) Adoption of energy-efficient practices and technologies;

(5) Ensure to the extent that new supply-side resources are needed, the development or expansion of energy systems utilizes the least-cost energy supply option, and maximizes efficient technologies;

(6) Support research, development, and demonstration of energy efficiency, load management, and other demand-side management programs, practices, and technologies; and

(7) Promote alternate fuels and energy efficiency by encouraging diversification of transportation modes and infrastructure.

1.1.3 Hawaii Energy Strategy Background

The Hawaii Energy Strategy (HES) program was initiated March 2, 1992 under a Cooperative Agreement with the United States Department of Energy (USDOE). The first HES was completed in October 1995. Throughout this document, the original HES will be referred to as *HES 1995*. It consisted of the following seven projects:

- Project 1: Develop an 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;
- 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, comprehensive documents in each subject area as well as the first iteration of the ENERGY 2020 software, which provided a model of the energy system and economy of each of Hawaii's four counties. The recommendations of *HES 1995* and their results are reviewed in Appendix D of this report.

1.2 Hawaii Energy Strategy 2000, Purpose and Objectives

The purpose of *HES 2000* is to assist State of Hawaii planners and policy makers, members of the Hawaii energy community, and Hawaii's people to better understand Hawaii's current energy situation. It develops and analyzes possible future energy scenarios and suggests a preferred energy future for Hawaii.

HES 2000 is intended to support achievement of the State Energy Objectives and has the following specific objectives:

- Increase diversification of fuels and the sources of supply 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; and
- Enhance contingency planning capabilities to effectively contend with energy supply disruptions.

It should be noted that "cost" as defined above in (c)(3) of the State energy policies is derived through a reasonably comprehensive quantitative and qualitative accounting of an option's long-term direct and indirect economic, environmental, social, cultural, and public health costs and benefits. Out of a growing concern about a vital environmental issue, the potential effects on Hawaii of global climate change due to greenhouse gas emissions (see Section 1.3.5), *HES 2000* supplements the work of the Hawaii Climate Change Action Program. This involves a new focus on measures that seek to more efficiently use energy or provide indigenous energy alternatives and thereby reduce greenhouse gas emissions. Accordingly, the following objective was added to those cited above for *HES 2000*:

- Reduce greenhouse gas emissions from energy supply and use.

HES 2000 incorporates the Hawaii Climate Change Action Program, which is discussed below in greater detail.

1.3 Hawaii Climate Change Action Program

1.3.1 Hawaii and Climate Change

The State of Hawaii initiated its Hawaii Climate Change Action Program in 1996, in recognition of the fact that Hawaii faces many potential negative consequences from global warming and climate change. Higher temperatures could make Hawaii less of a paradise. Greater heat may cause more heat-related mortality. Concentrations of ground-level ozone could increase, causing respiratory illnesses. Warmer seas could enhance growth of toxic algae and bacterial contamination of coastal waters. Warmer weather could expand the habitat of disease-carrying insects to Hawaii (USEPA 1998a).

Sea level rise is occurring and could lead to coastal flooding, erosion of beaches, and saltwater contamination of drinking water. Hawaii can expect other negative effects on its water resources, as well as on its agriculture, forests, and other ecosystems. During storms, additional areas will become vulnerable to waves and storm surge (USEPA 1998a).

1.3.2 Hawaii and Reduction of Greenhouse Gas Emissions

The Intergovernmental Panel on Climate Change (IPCC) is a panel of international climate scientists jointly established in 1988 by the World Meteorological Organization and the United Nations Environment Program to (a) assess available information on climate change, (b) assess the environmental and socio-economic impacts of climate change, and (c) formulate response strategies. The IPCC First Assessment Report, completed in 1990, served as the basis for the negotiation of the United Nations Framework Convention on Climate Change. The IPCC's Second Assessment Report, completed in 1995, stated that "the balance of evidence suggests a discernible human influence on global climate" (IPCC 1996). The IPCC Second Assessment Report also noted the increased concentration of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) since pre-industrial times, largely due to human activity. These increased concentrations have warmed the earth's surface, which tends to produce other changes in climate. Climate change effects have already been observed and will occur in the future.

It will be necessary to stabilize concentrations of greenhouse gases to prevent even more dramatic changes in climate than are expected over the next century due to greenhouse gases already in the atmosphere. Although Hawaii's greenhouse gas emissions are only 0.3% of total U.S. greenhouse gas emissions, no matter how small they are, Hawaii's greenhouse gas emissions contribute to climate change, and they can and should be reduced. All states and all nations will ultimately need to contribute to efforts to mitigate future climate change.

1.3.3 Hawaii's Participation in the State and Local Climate Change Program

Hawaii has become a Climate Change Partner in the U.S. Environmental Protection Agency (USEPA) State and Local Climate Change Program. The

USEPA has involved individual States in its program out of recognition that "although problems such as global warming need to be addressed through cooperative national and international efforts, many of the critical responses can be initiated locally. If the adverse effects of climate change are to be avoided, states will need to take an active and immediate role in addressing greenhouse gas emissions" (USEPA 1998b, 2-11).

The reasons the USEPA cites for seeking State involvement in the Climate Change Program included the following:

- States retain much of the policy jurisdiction over emissions sources;
- The United States Climate Change Action Plan (CCAP) creates new opportunities for states for support to state action;
- States have the capacity for enacting "low risk" policies to address climate change;
- States will feel the impacts of climate change and will likely be called upon to address them (2-12).

1.3.4 Inventory of Hawaii Greenhouse Gas Emissions, Estimates for 1990

Under a grant from the USEPA, the *Inventory of Hawaii Greenhouse Gas Emissions, Estimates for 1990* was completed in 1997 (DBEDT 1997a). The *Inventory* was Phase I of the Program for Developing, Implementing, and Evaluating a Greenhouse Reduction Strategy for the State of Hawaii, which is being jointly conducted by the DBEDT's Energy, Resources, and Technology Division; and the Department of Health's (DOH) Clean Air Branch. This work was performed with the support of a grant from the USEPA and had following purposes:

- Identifying their greenhouse gas emissions sources and estimating their overall contribution to radiative forcing;
- Assessing the areas of the state that are most vulnerable to climate change; and
- Developing state-specific greenhouse gas mitigation strategies (USEPA 1995, v).

The inventory is a basis for future efforts to reduce Hawaii's contribution to global warming.

1.3.5 Hawaii's Climate Change Action Plan

A Hawaii Climate Change Action Plan Workshop on October 30, 1997, was an initial effort to obtain citizen input on Hawaii's goals and suggestions for emission reduction measures. About 100 citizens heard a report on the State's efforts in the area of climate change action and provided their views on ways to reduce future greenhouse gas emissions. These were included in the Plan.

As Phase II of the Program, the first iteration of a *Hawaii Climate Change Action Plan* (DBEDT 1998b) was completed in November 1998. The plan did not set specific goals but was intended as a catalyst for discussion by Hawaii's people about their involvement in future efforts to reduce emissions and to adapt to climate change. The major recommendation of the first plan was to develop consensus as to Hawaii's goals for reducing greenhouse gas emissions.

1.3.6 Recommendations Related to Climate Change

1.3.6.1 RECOMMENDATION: Propose a New State Energy Objective Related to Climate Change

Suggested Lead Organizations: DBEDT (ERTD and Office of Planning with supporting testimony by interested stakeholders) for consideration by the Legislature

The phrase "Reduce greenhouse gas emissions from energy supply and use" should be added to the State of Hawaii energy objectives in §226-18a, HRS. This proposed objective is intended to add a planning consideration and not to specify reduction levels or to set other requirements.

1.3.6.2 RECOMMENDATION: Continue Hawaii Climate Change Action Program and Participation in U.S. Environmental Protection Agency's State and Local Climate Change Partners' Program

Suggested Lead Organizations: DBEDT, Department of Health, Department of Land and Natural Resources, and other State Agencies, the Counties, and Interested Stakeholders

Further work is needed to set specific goals for greenhouse gas reductions; for implementing emission reductions; and to identify future effects of climate change on Hawaii's people, environment, ecosystems, and economy in order to identify the changes to which the State must adapt. Continued participation in USEPA State and Local Climate Change Partners' Program will provide valuable information, supporting analyses, and potential funding of Hawaii climate change activities.

1.3.6.3 RECOMMENDATION: Set Hawaii Greenhouse Gas Reduction Goals with Public Input

Suggested Lead Organizations: DBEDT, Department of Health, Department of Land and Natural Resources, other State Agencies, Counties, and Interested Stakeholders

Public input should be solicited to help set any Hawaii-specific greenhouse gas reduction goals. A commission or task force charged with considering public input could lead this effort. Educational efforts to inform the population on the issues should precede the goal-setting process.

Hawaii's efforts should focus on those emissions that can be managed locally. This would exclude emissions from overseas marine activities, all international aviation activities, and military activities. In the near term, due to the high level of their contribution of emissions, the focus should be on electricity generation, ground transportation, and municipal waste management. Forest development and reforestation offers ways to offset some of Hawaii's emissions.

There are many geographic, climatological, technological, economic, environmental, cultural, and other considerations that must be considered. In particular, Hawaii's high level of energy efficiency leaves fewer options for emissions reduction than elsewhere, but high energy costs in Hawaii can help make many reductions financially rewarding. At the same time, Hawaii offers such resources as abundant sunshine for solar power and trade winds for wind power. These should be more fully developed.

Hawaii's tourism-based economy poses yet another special challenge. For example, the State economy is dependent on transoceanic and interisland air travel; thus a large percentage of Hawaii's emissions are from the use of jet fuel. Significant reductions in air travel would be an economic disaster for the State. To reduce emissions from this source, Hawaii must depend on aircraft manufacturers providing more efficient aircraft and on efficient operations by airlines.

1.3.6.4 RECOMMENDATION: Identify Future Effects of Climate Change on Hawaii and Plan Adaptation Measures

Suggested Lead Organizations: DBEDT (Office of Planning and ERTD), DOH, DLNR, Other State Agencies, Counties, and Interested Stakeholders

Hawaii's emissions are small and reductions will contribute only a small amount to global efforts. Hawaii will experience various effects from climate change caused by past and current greenhouse gas emissions that occurred or will occur elsewhere. As global reductions in emissions are likely to take many years, the effects forecast for the next century on temperature change, sea level rise, and other concerns *will* happen. Their specific effects on Hawaii should be further explored and modeled. Adaptation measures may also take many years, if not decades, to implement. The measures required must be identified and initiated soon.

CHAPTER 2 ENERGY, THE ECONOMY, AND THE ENVIRONMENT

Energy is one of the key factors shaping Hawaii's standard of living, economy, and environment. This section briefly examines the benefits of energy and the interrelationships between energy, the economy, and the environment.

2.1 The Need for Energy

Energy is essential to modern life. Hawaii's citizens use energy for transportation, hot water, refrigeration, heating, air conditioning, ventilation, lighting, cooking, operating office and industrial machines, running appliances, and for other essential uses. Hawaii's people use less energy per capita than the citizens of any other state, except New York, primarily because of Hawaii's comfortable climate and short driving distances. Hawaii's total energy use per capita ranked 50th of the states and District of Columbia in 1995 (EIA 1997, 18).

2.2 Energy and Hawaii's Economy

2.2.1 Energy for Economic Activity

Energy is the power behind Hawaii's economy. Energy is used by the jets carrying visitors and residents to and among the islands. It takes energy to provide the ground transportation, air conditioning, hot water, and lights to make visitors' stay more comfortable. Energy supports Hawaii's military installations and the military's Hawaii-based operations. Energy is used to produce Hawaii's sugar and other agricultural products. Energy lights Hawaii's stores, refrigerates and cooks food, and provides myriad other services. 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. Hawaii's top 15 energy companies had sales of $2.7 billion in 1998. The four electric utilities and the gas utility had sales of $1.1 billion. Hawaii's two refining oil companies had sales of over $1 billion. Combined, the companies listed above employed over 4,000 people.

Due to a number of factors, Hawaii's economy is overly dependent on oil. Oil is easy to transport, and an oil-based infrastructure has evolved in Hawaii over the years. The system is supported by historically low real oil prices.

The system requires massive exports of money to pay for imports of crude oil and some refined products. This money is not used for further development of Hawaii's economy and does not have local multiplier effects. Much of Hawaii's energy demand is inelastic, so that when energy prices rise, even more money is diverted from other sectors of the economy to meet energy needs. In addition, Hawaii's own renewable resources are not fully used, and additional energy efficiency measures could be adopted.

Renewable energy and energy efficiency offer the economic benefits of keeping money in the State and providing greater levels of employment per unit of energy. Greater local employment would result in multiplier effects that would enhance the local economy. Numerous studies have found that greater use of energy efficiency measures and renewable energy result in more jobs, higher personal income, and slightly higher economic output than the fossil-fuel base case.[1] Energy efficiency reduces bills paid by consumers and businesses, who can then shift their spending to sectors that employ more workers per dollar received (Geller 1992, III). This could increase employment in Hawaii and keep money in the State's economy that otherwise would have gone abroad to pay for fossil fuel.

2.2.2 The High Costs of Energy to the Economy

Total energy expenditures in Hawaii amounted to $2.76 billion in 1997 (the latest year for which sufficient data were available), or about 8% of the gross state product (GSP) in 1997 dollars. This was an average of $2,323 per capita (DBEDT 1999). Hawaii's energy costs are detailed in Section 3.1.2.1.

Based upon the components in the 1996 U.S. Bureau of Labor Statistics Honolulu Consumer Price Index, electricity accounted for 2.18% of the average Honolulu resident's expenditures; 0.18% was expended on utility gas; and 3.02% was spent on motor fuel. Together these costs represented 5.38% of total consumer expenditures (DBEDT 1998e, 388–389).

2.2.3 The Economic Risks in Hawaii's Current Energy System

Hawaii's residents and visitors use oil to meet 90% of their energy needs. Hawaii's dependence on oil poses risks to Hawaii's economy from sudden price increases or from supply problems as were experienced in 1973, 1979, 1991, and 1992. In the 1995 *Hawaii Energy Strategy* (*HES 1995*), an oil price spike scenario was modeled based upon a scenario in which oil prices increased from a 1996 cost of $19.42 per barrel to $45.00 per barrel for a one-year period, after which they dropped back to normal levels. The scenario was based upon the actual oil price spike of 1979. Based on runs in the ENERGY 2020 model, this scenario produced considerable short-term economic dislocation. Employment dropped 2%, or around 15,000 jobs and took two years to regain former levels. Gross state product dropped by $791 million in the spike year and was down $271 million the following year. Personal income dropped $1.18 billion in the spike year (DBEDT 1995a, Appendix 2-2 to 2-3).

While oil prices in early 1999 were at historic lows on an inflation-adjusted basis compared with 1973, they rose sharply beginning in March, and the possibility of a disruption of oil supplies and oil markets due to armed conflict or political action remains. This will be discussed in more detail in Chapter 3.

[1] See Bernow 1999; Clemmer 1994; Geller 1992; Hamrin 1993; Laitner 1994; Loudat 1995; Marshall 1995; Pacific International Center for High Technology Research 1994; State of Missouri 1992; State of Vermont 1997.

2.3 The Links between Hawaii's Energy Use, the Economy, and the Environment

Hawaii enjoys a beautiful natural environment that provides pleasant living conditions for residents, and many regard it as paradise. Hawaii's economy is based upon its beautiful environment, and the environment is the major reason tourists come to the Islands. 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. The most serious immediate threat to both Hawaii's environment and economy is the small but real potential for a large oil spill and damage to beaches and the tourism industry.

2.3.1 The Oil Spill Threat

Transportation of oil and oil products poses the constant risk of a spill, with subsequent damage to the environment and the economy. In 1997, almost 51 million barrels of crude oil and another 6.6 million barrels of refined oil products were imported into Hawaii by sea, mainly via Barbers Point, Oahu. The crude oil was offloaded from tankers at separate offshore moorings at Barbers Point operated by Chevron USA Hawaii and Tesoro Hawaii. In addition, 9 million barrels of refined products were shipped by barge from Oahu to neighbor islands (DBEDT 1999). Ships carrying oil as fuel also pose an oil spill risk. On Oahu, large quantities of petroleum products are transported via pipelines, which have suffered accidental leaks in the past. Transportation of petroleum products on all islands by tanker truck poses the further risk of accidental spills.

Following the *Exxon Valdez* disaster in Alaska in 1989, the State of Hawaii Department of Health commissioned a study by the University of Hawaii Sea Grant College Program of the potential impacts of oil spills at sea on Hawaii. Dr. Rose Pfund led the study and edited the final report, *Oil Spills at Sea, Potential Impacts on Hawaii* (Pfund 1991). The study evaluated a worst-case scenario, developed by the U.S. Coast Guard, in which a tanker lost one-third of its cargo, or 9.8 million gallons (233,000 barrels), in the Kaiwi Channel, then the primary route used by tankers en route to Oahu. The oil then washed up on Oahu and Kauai (6).

The economic costs would have been huge for such a spill. Cleanup costs alone would have been $210 to $305 million (35). It was estimated that oil washed up on the beaches of Oahu would result in a 32% reduction in tourism in the first year and a $3.06 billion loss in revenues to the tourism industry (57). Oahu's beaches and coral reefs would also have suffered severe environmental damage, and wildlife would have been killed in large numbers (69).

As a result of the study, tanker operators agreed to use the wider Kauai Channel, to reduce the risk of collision and to provide more maneuvering space in event of mechanical malfunction. Soon thereafter, in reaction to the *Exxon Valdez* disaster, the Federal Oil Pollution Act of 1990 set up a planning and command structure emphasizing oil spill prevention and a response structure. Additional liability was placed on tanker operators as a strong incentive to increase safety. Hawaii's spill-prevention efforts and preparedness to deal with spills were enhanced (Rappa 1996, 20).

Hawaii's readiness to handle an oil spill was enhanced by the creation of the Clean Islands Council and the purchase of spill-response ships and equipment. The State recently acquired an aerial oil-dispersant application system that can be used by Hawaii Air National Guard C-130 transport aircraft. In addition, the State and the U.S. Coast Guard negotiated a memorandum of understanding that would allow in-situ burning of oil spills at sea (Munger 1999a, 4-5), a technique that has seen successful application elsewhere.

Hawaii remains vulnerable to oil spills. The offshore terminals are well managed, but human error or mechanical failure could lead to a major spill (22). For example, the *Exxon Houston* grounded near Barbers Point a few years ago. Through hard work and luck the ship was saved, and the loss of its 3.8 million gallons (90,000 barrels) of crude oil and its bunker fuel was prevented (24).

Further risks are posed to the environment when products refined in Hawaii, such as high-sulfur fuel oil and naphtha, are exported. While air pollution control regulations restrict the use of high-sulfur fuel oil to ships, naphtha is used to produce synthetic natural gas (SNG) and can be used as a fuel for combustion turbines. Increased SNG use on Oahu could reduce the spill risks from export shipments.

2.3.2 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 (Juvik 1998, 297). Most emissions from energy use are highly regulated by Federal and State laws.

Under the Clean Air Act, the United States Environmental Protection Agency set National Ambient Air Quality Standards (NAAQS) for a variety of "criteria pollutants." These include ground-level ozone, nitrogen dioxide (NO_2), particles less than 10 microns in diameter (PM10), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (ERG 1997, 5-1 to 5-2). The State Health Department has set standards that are up to twice as stringent as the EPA criteria for most of the criteria pollutants (5-2).

The Hawaiian Electric Company's (HECO) externality study, *Hawaii Externalities Workbook* (HECO 1997b), analyzed the effects of the criteria pollutants and other air pollutants in Hawaii. Damages were estimated by quantifying emissions, determining ambient concentrations, identifying exposure to determine physical effects, and finally, monetizing damages (5-8). Effects evaluated included mortality, morbidity, materials damages, and reduction of visibility (5-16). As effects were specific to type of generator and its location, the calculation of monetary damages was necessarily complex. Damages from three types of pollutants were monetized. The mid-range values, without adjustment for the $43 per ton emission fee currently paid to the Department of Health, were as depicted in Table 2.1. The HECO utilities did not provide an externality value for greenhouse gases.

These values were intended for use in quantifying the costs of power plant air emissions in selecting among resource options for future fossil fuel generation. They demonstrate that air emissions that meet federal and State standards do have external costs that affect Hawaii's environment and economy.

Table 2.1 Mid-Range Estimated Damages from Air Pollutants Without Adjustment for Emission Fees

Pollutant	HECO	MECO	HELCO
Damages in Dollars Per Ton			
NO_x	$ 9.95	$ 5.28	$ 2.12
SO_2	$ 20.52	$ 10.25	$ 5.09
PM 10	$ 1,280.02	$ 706.21	$ 284.34
Damages in Cents Per KWh			
All	0.005-0.044	0.004-0.026	0.002-0.011

ERG 1997, 5-36 to 5-37

In its Integrated Resource Plan (IRP), The Gas Company (TGC) defined "externalities" as "those impacts (or benefits) of an activity that are generally not reflected in the 'internal' or direct market costs of an activity" (5-1). TGC considered environmental, energy security, macroeconomic and employment, and social and cultural externalities.

TGC placed the externalities into three categories by priority. These were:

- Greenhouse gases (CO_2, CH_4, and N_2O, etc.) that contribute to climate change;
- Criteria air pollutants as defined by the Clean Air Act (CO, NO_x, SO_2, PM10,[2] ozone, and lead);
- All other externalities resulting from gas production, transportation, and use (5-2).

TGC stated that "including reasonable values for CO_2 and CH_4 in utility planning is one way to begin to recognize climate change risks [in] Hawaii's energy decisions" (5-11). TGC evaluated a variety of values assigned by various jurisdictions for greenhouse gas emissions and criteria air pollutants and proposed the externality values depicted in Table 2.2.

[2] Particulate matter greater than or equal to 10 microns

Table 2.2 TGC's Proposed Greenhouse Gas and Air Emissions Externality Values Per Ton of Emissions

	Greenhouse Gases		Criteria Air Pollutants				
Estimate	CO_2	CH_4	NOx	SOx	PM_{10}	CO	VOC
Low	$ 10	$ 210	$ 3	$ 4	$ 162	N/A	N/A
Mid	$ 27	$ 567	$ 8,100	$ 1,913	$ 4,162	$ 1,080	$ 6,683
High	$ 77	$ 1,617	$ 18,147	$ 9,304	$ 59,668	$ 11,653	$ 8,659

TGC 1999, 5-13

In addition, it should be noted that transportation fuel emissions in Hawaii likely have greater effects, because about twice as much fuel is used for transportation as is used for electricity generation.

2.3.3 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.

2.3.4 Land Impacts of Energy Use

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 Environmental Impact Statement approval process (ERG 1997, 7-3 to 7-14). Transportation fueling facilities, oil refineries, oil terminals and pipelines, oil and coal storage facilities, and coal handling facilities also have significant land impacts.

2.3.5 Energy Use, Greenhouse Gas Emissions, and Climate Change

2.3.5.1 The Greenhouse Effect, Greenhouse Gas Emissions, and Climate Change

The earth's weather and climate are driven by energy from the sun. Water vapor, carbon dioxide, and other gases in the atmosphere trap some of the energy from the sun, creating a natural "greenhouse effect" (USEPA 1998a, 1). There is strong evidence that due to industrialization, energy use, other human activities (and population growth), greenhouse gas concentrations in the atmosphere have increased. The greenhouse gases (primarily CO_2, CH_4, N_2O, and chlorofluorocarbons) are implicated in the global warming of the earth's atmosphere.

International climate scientists of the Intergovernmental Panel on Climate Change have concluded:

- Greenhouse gas concentrations have continued to increase since pre-industrial times (about 1750);

- Human-caused aerosols can offset heat increases caused by greenhouse gases for the short-term, but greenhouse gases have long-term effects;
- Climate has changed over the past century (average temperatures have increased by 0.6 to 1.2 degrees F from today's levels), and recent years have been the warmest since 1860, when systematic recording of temperature data began;
- The balance of evidence suggests a discernible human influence on global climate;
- Climate is expected to continue to change in the future. By 2100, average surface temperatures could increase 1.6 to 6.3 degrees F. Sea level could increase 6 to 38 inches. Significant changes in air and ocean circulation patterns could significantly alter global climate and the ecological balance among species;
- There are still many uncertainties, and scientists continue to study the issues (IPCC WGI 1995, 8-13).

2.3.5.2 Climate Change and Hawaii

Honolulu's average temperature has increased by 4.4 degrees over the last century. Rainfall has decreased by about 20% over the past 90 years. By 2100, average temperatures in Hawaii could increase by 1 to 5 degrees F in all seasons and slightly more in fall. Estimates for future rainfall are highly uncertain because reliable projections of El Niño effects have yet to be made. It is possible that large precipitation increases could occur in summer and fall. It is also not yet clear how the intensity of hurricanes might be affected, but it is expected that there would be more frequent and more severe thunderstorms (USEPA 1998a, 2).

Climate Change and Human Health in Hawaii. The health of Hawaii's people may be negatively affected by climate change. Higher temperatures may lead to greater numbers of heat-related deaths and illnesses. Increased respiratory illnesses may result due to greater ground-level ozone. Increased use of air conditioning could increase power plant emissions and air pollution. Viral and bacterial contamination of fish and shellfish habitats could also cause human illness. Expansion of the habitat and infectivity of disease-carrying insects could increase the potential for malaria and dengue fever (2-3).

Climate Change, Sea Level Rise, and Hawaii. At Honolulu, Nawiliwili, and Hilo, sea level has increased 6 to 14 inches in this century and is likely to rise another 17 to 25 inches by 2100. The expected rise in sea level could cause flooding of low-lying property, loss of coastal wetlands, beach erosion, saltwater contamination of drinking water, and damage to coastal roads and bridges. During storms, coastal areas would be increasingly vulnerable to flooding (3).

Climate Change and Hawaii's Water Resources. Higher temperatures could result in increased evaporation and changes in rainfall. While increased rainfall could recharge aquifers, it could also cause flooding. As the variability of climate is expected to increase, there could also be frequent and long droughts (3).

Climate Change and Hawaii's Agriculture and Forestry. Agriculture might be enhanced by climate change, unless droughts decrease water supplies. Forests may find adapting to climate change more difficult. For example, 'ohi'a trees are sensitive to drought and heavy rains. Changes could disproportionately stress native tree species because non-native species are more tolerant of temperature and rainfall changes. Climatic stress on trees also makes them vulnerable to fungal and insect pests. Droughts would also increase the danger of forest fires (4).

Climate Change and Hawaii's Ecosystems. Hawaii's diverse environments and geographic isolation have resulted in a great variety of native species found only in Hawaii. However, 70% of U.S. extinctions of species have occurred in Hawaii, and many species are endangered. Climate change would add another threat (4). Higher temperatures could also cause coral bleaching and the death of coral reefs.

Climate Change and Hawaii's Economy. Hawaii's economy could also be hurt if the combination of higher temperatures, changes in weather, and the effects of sea level rise on beaches make Hawaii less attractive to visitors. 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.

2.3.5.3 Hawaii's 1990 Baseline Greenhouse Gas Emissions

A 1990 baseline was established as a benchmark for Hawaii's efforts to reduce greenhouse gas emissions. Under the Kyoto Protocol to the United Nations Framework Convention on Climate Change, signed by the United States in November 1998, the U.S. is committed to reduce its emissions by 7% less than 1990 emissions by 2008–2010. The Protocol has not been ratified by Congress, but the target provides an interim standard. Hawaii 's human-caused greenhouse gas emissions for the 1990 baseline year were estimated at 16,961,453 tons of CO_2, 75,717 tons of CH_4, and 680 tons of N_2O.

To allow aggregation of the effects of these three gases, their global warming potential (GWP) was calculated. GWP is a measure used to compare the relative effects of each of the different greenhouse gases on warming of the atmosphere over some future time-horizon. For such comparisons, using a 100-year time horizon, CH_4 has 22 times the radiative forcing direct impact of CO_2, and N_2O has 270 times the direct impact (USEPA 1995b, viii). The GWP of Hawaii's 1990 emissions was 18,810,906 tons CO_2-equivalent. This was 0.3% of total U.S. emissions in 1990. While it is not expected that the national target for emissions reduction will be apportioned among the states, a 7% reduction in Hawaii's 1990 GWP would be 17,494,143 tons CO_2-equivalent. Table 2.3 shows the components of Hawaii's 1990 Baseline GWP by sector.

Hawaii's energy use produced the greatest GWP in the 1990 baseline year – an estimated 16,813,006 tons CO_2-equivalent, or 89.4% of total GWP. Municipal solid waste (MSW) management and wastewater management together produced 7.4% of Hawaii's 1990 GWP; agricultural activities emitted 2.7%; and industrial processes emitted the remaining 0.6%. For purposes of comparison, 15,636,096 tons

Table 2.3 Estimated Global Warming Potential of Hawaii Greenhouse Gas Emissions, 1990 (Tons CO_2-Equivalent)

Sector	GWP	% Total GWP	% Energy GWP
Energy Use			
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%	

*Municipal solid waste

CO_2-equivalent is 7% below the 1990 level of energy sector emissions. Again, it is stressed that neither the State nor any particular sector is likely to be expected to make a “quota” reduction toward the national goal.

The emissions presented in Table 2.3 are from energy use in Hawaii only, or for overseas domestic flights and marine use. In accordance with the United Nations Framework Convention on Climate Change and USEPA guidance, emissions from overseas international air and marine transportation that was provided fuel in Hawaii were not counted. In addition, about 4% of the energy sold or distributed in Hawaii in 1990 was provided to the U.S. military. Because there is no data available concerning where this fuel was actually used, it also was not included in the estimate.

2.3.5.4 The State of Hawaii Climate Change Action Plan

Under a grant from the USEPA under the State and Local Climate Change Partners’ Program, DBEDT also completed a *Hawaii Climate Change Action Plan* (DBEDT 1998b). This work was intended to become a basis for actions to reduce Hawaii’s greenhouse gas emissions and the impact of climate change. Many of the recommendations of the *Hawaii Climate Change Action Plan* in the energy sector directly support State of Hawaii energy objectives and are also recommended in this report. Greater energy efficiency and increased use of alternative renewable energy would reduce Hawaii’s emissions. Such actions can also have positive economic and environmental effects, as discussed above.

2.3.5.5 Hawaii's Future Greenhouse Gas Emissions

Figure 2.1 shows the GWP of Hawaii's actual and forecast greenhouse gas emissions from 1990 to 2020 compared with the Kyoto Protocol target. Hawaii 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.

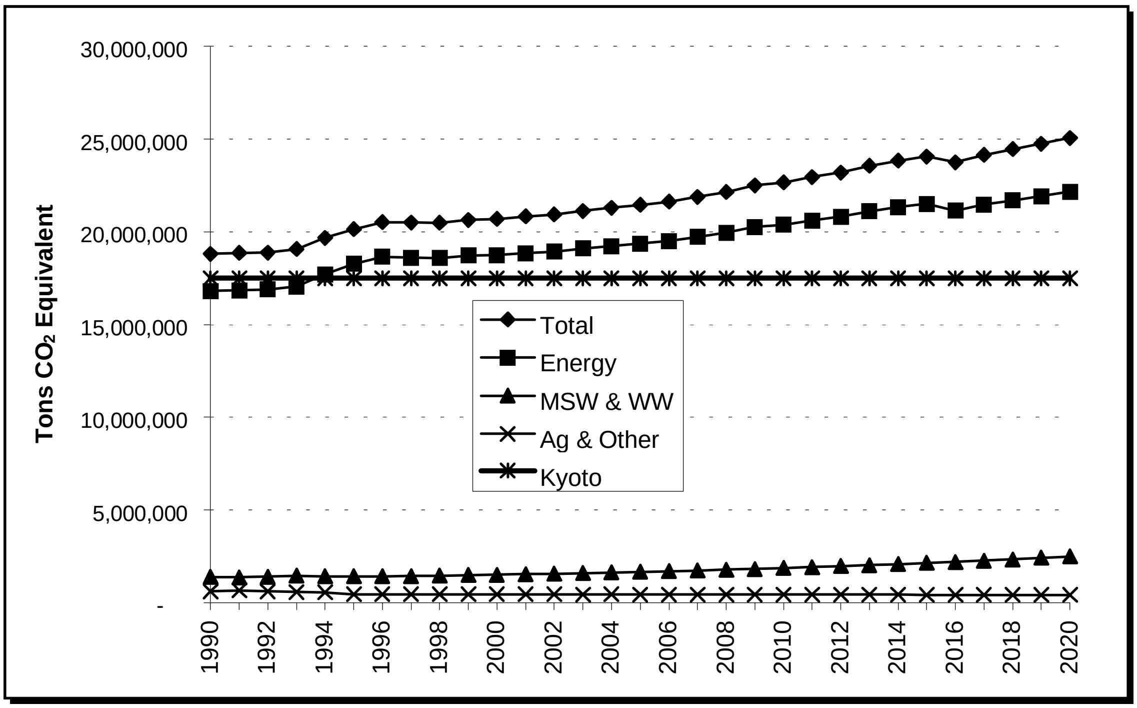


Figure 2.1 Forecast Hawaii and Domestic Overseas Energy Use Global Warming Potential and the Kyoto Protocol Target, 1990-2020

Continuing with "business as usual", Hawaii's overall domestic GWP was forecast to be 22% over the Kyoto Protocol target by 2010 and 36% over the Kyoto Protocol target by 2020. The domestic GWP from energy use was forecast to be 23% above the energy emission Kyoto Protocol target by 2010 and 32% above the target in 2020. (Note: these estimates are slightly higher than those in the *Hawaii Climate Change Action Plan* because they reflect new ENERGY 2020 model runs using new data.) Other categories shown on the chart include MSW and wastewater management (WW), which will be 34% greater than 1990 in 2010 and 79% greater by 2020, unless actions to reduce greenhouse gas emissions are taken.

"Ag & Other" includes domestic animals, manure management, fertilizer, sugarcane burning, the oil refineries, and the cement industry. Emissions are expected to decline to 30% below 1990 levels, primarily due to relatively little increase in these areas and this increase being offset by the closure of cement making operations in 1995.

In 2010, energy sector emissions were forecast to make up 90% of Hawaii's domestic GWP, followed by municipal solid waste at 8%, and agriculture and other at 2%.

2.3.6 Recommendations Related to Climate Change and Hawaii

The *Hawaii Climate Change Action Plan* offered many recommendations for reducing greenhouse gas emissions. It also pointed out the need to develop emissions reduction goals for Hawaii and the need to identify and plan adaptation measures as discussed and recommended in Chapter 1 of this report.

2.4 Balancing Energy Needs, Economic Growth, and Environmental Protection

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.

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.

CHAPTER 3 MEETING HAWAII'S ENERGY NEEDS

3.1 Hawaii's Energy Requirements

This chapter examines how Hawaii currently meets its energy needs and the sources of Hawaii's energy. It provides an estimate of Hawaii's future energy needs and discusses problems that could be encountered in meeting those needs.

3.1.1 Hawaii's Primary Energy Sources, 1997

Table 3.1 summarizes Hawaii's primary energy sources in 1997.

Table 3.1 Hawaii's Energy by Fuel or Source (Million Btu), 1997

Fuel or Energy Source	Fuel Sold, Distributed, or Produced in Hawaii	Fuel for International Transportation or Sold to Military	Fuel or Energy Used in Hawaii and for Domestic Transportation
Fossil Fuel			
Aviation Gasoline	161,819		161,819
Coal	17,949,336		17,949,336
Diesel	35,405,923	7,057,028	28,348,894
Gasoline	50,333,915	207,641	50,126,274
Jet Fuel	102,507,397	54,704,727	47,802,670
LPG	3,329,190		3,329,190
Residual	83,747,373	8,709,475	75,037,898
SNG	3,120,815		3,120,815
Oil Subtotal	278,606,432	70,678,871	207,927,560
Fossil Subtotal	296,555,767	70,678,871	225,876,896
Fossil %	**100%**	**24%**	**76%**
Renewables			
Bagasse	7,569,000		7,569,000
Geothermal	2,363,272		2,363,272
Hydro	958,382		958,382
Landfill Methane	274,000		274,000
MSW	5,803,389		5,803,389
Solar Water Heating	3,200,000		3,200,000
Wind	179,600		179,600
Renewables Subtotal	20,347,643		20,347,643
Renewables %	**100%**	**0%**	**100%**
Total Energy	316,903,410	70,678,871	246,224,539
Total Energy %	**100%**	**22%**	**78%**

The first column lists the fuels and energy sources. The second column lists the total heat value (in millions of Btu) of Hawaii's primary energy consumption, for all fossil fuel sold and distributed in Hawaii and renewable energy produced in Hawaii. The third column lists fuels that were used for international air and marine transportation or were sold to the military. Note that about 24% of the fossil fuels were used for international air and marine transportation or were sold to the military. This distinction was made because only fuel use in Hawaii and fuel for domestic transportation (Column 4) may be subject to some influence through state energy policy. These are also the fuels used in calculating Hawaii's greenhouse gas emissions under U.S. Environmental Protection Agency (USEPA) guidance and under the United Nations Framework Convention on Climate Change reporting guidelines, which exclude overseas fuel use emissions from national inventories of greenhouse gas emissions. In this chapter, however, we will generally discuss all fuels sold and distributed in Hawaii – Hawaii's "primary energy consumption".

As Figure 3.1 shows, renewable energy sources, including hydroelectricity, bagasse, MSW, wind, geothermal, and landfill methane were 5.4% of Hawaii's primary energy consumption. Solar water heating added another 1% and together these resources accounted for 6.4% of Hawaii's primary energy consumption.

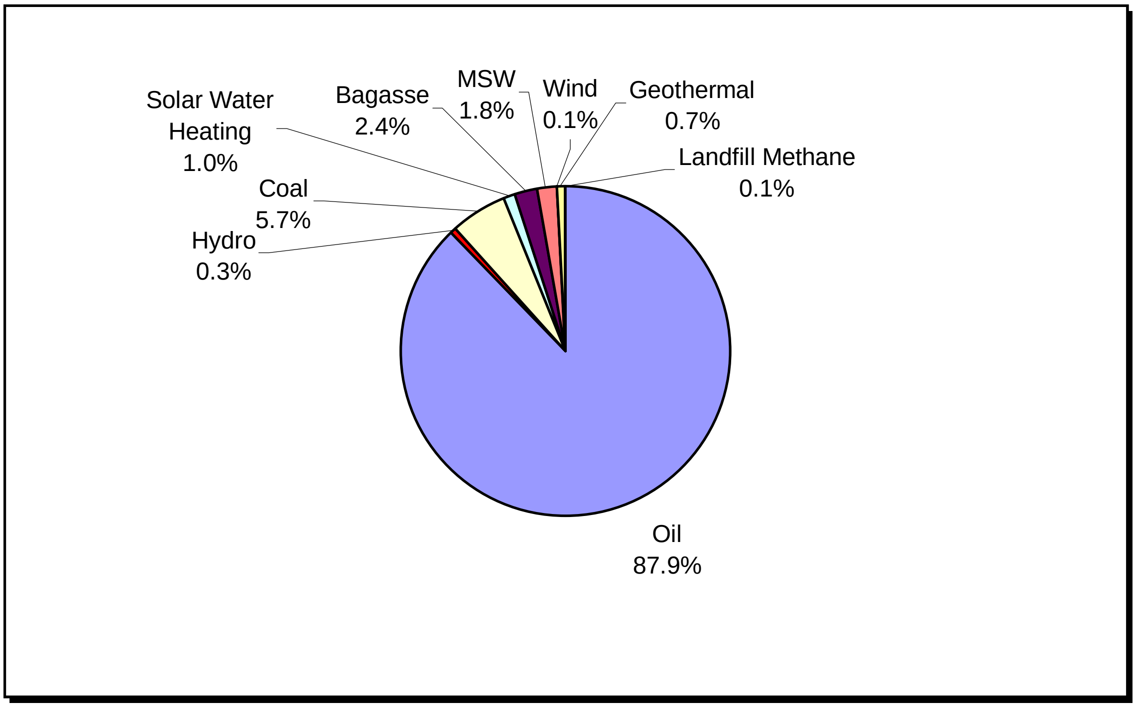


Figure 3.1 Hawaii Primary Energy Consumption by Fuel or Source, 1997

Figure 3.2 shows the percentages of energy use by sector of fuel produced, sold, or distributed in Hawaii in 1997. Oil, coal, and renewable energy for electricity generation were 37.3% of the total.

Table 3.2 details energy use by fuel or renewable energy source by County. The amounts in the overseas and military category were almost entirely sold and distributed on Oahu, but are separated on the table from the internal and domestic overseas energy uses. Solar water heating is not listed by County; it is a statewide estimate.

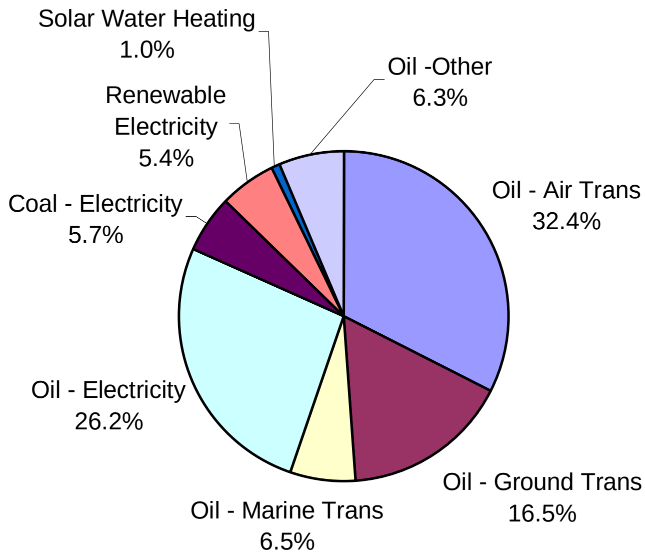


Figure 3.2 Hawaii Primary Energy Consumption by Sector, 1997

Table 3.2 Hawaii Energy Use by Fuel/Energy Source (Million Btu), 1997

Million Btu	Hawaii	Honolulu	Kauai	Maui	Overseas & Military	Total
Fossil Fuel						
Aviation Gasoline	22,413	114,625	5,199	19,581	-	161,819
Coal	2,102,738	14,776,732	-	1,069,866	-	17,949,336
Diesel	4,177,119	10,913,336	4,260,789	8,997,650	7,057,028	35,405,923
Gasoline	7,769,539	33,849,812	2,778,811	5,728,113	207,641	50,333,915
Jet Fuel	1,580,150	43,037,608	258,603	2,926,310	54,704,727	102,507,397
LPG	821,005	1,254,239	339,297	914,650	-	3,329,190
Residual	5,518,370	65,087,035	-	4,432,492	8,709,475	83,747,373
SNG	0	3,120,815	-	-	-	3,120,815
Oil Subtotal	19,888,596	157,377,468	7,642,699	23,018,797	70,678,871	278,606,432
Fossil Subtotal	21,991,333	172,154,201	7,642,699	24,088,663	70,678,871	296,555,767
Fossil Percent	**7%**	**58%**	**3%**	**8%**	**24%**	**100%**
Renewables						
Bagasse	-	-	3,036,000	4,533,000	-	7,569,000
Geothermal	2,363,272	-	-	-	-	2,363,272
Hydro	526,834	-	179,502	252,046	-	958,382
Landfill Methane	-	274,000	-	-	-	274,000
MSW	-	5,803,389	-	-	-	5,803,389
Solar Water Heating	-	-	-	-	-	3,200,000
Wind	179,600	-	-	-	-	179,600
Renewable Subtotal	3,069,706	6,077,389	3,215,502	4,785,046	-	20,347,643
Renewable Percent	15%	30%	16%	24%	0%	100%
Total Energy	**25,061,040**	**178,231,590**	**10,858,201**	**28,873,709**	**70,678,871**	**316,903,410**
Total Energy Percent	**8%**	**56%**	**3%**	**9%**	**22%**	**100%**

3.1.2 Hawaii's Energy Use and State Energy Policy

The following sections will briefly consider Hawaii's energy use in terms of the major elements of the State of Hawaii energy objectives (See Section 1.1.2).

3.1.2.1 Objective 1: Dependable, Efficient, and Economical Energy

Dependability. Hawaii's energy supply and energy system remains dependable, on the whole. Gasoline lines have not occurred since the 1970s. In the 1990s, Oahu has had one island-wide electricity blackout and there were occasional rolling blackouts on the Island of Hawaii in 1992. Following Hurricane Iniki, in 1992, parts of Kauai suffered outages lasting months.

Efficiency. Energy is used relatively efficiently in Hawaii. Figure 3.3 shows that energy use per capita was less than the national average from 1970 to 1997. In 1970, Hawaii's per capita energy use was 86% of the national average, but by 1997, it was only 70% of the national average. National per capita use increased with economic growth in the nineties, and Hawaii's economic stagnation may have contributed to reducing the State's relative per capita energy use. In 1997, Hawaii's per capita energy use was 13% less than in 1970, while national use was almost 8% higher.

Figure 3.3 shows a closer relationship between the U.S. as a whole and Hawaii in energy use per dollar of economic output. In 1970, Hawaii's energy use per dollar of Gross State Product (GSP) was 79% of the U.S. average. Both Hawaii and the U.S. as a whole have become consistently more efficient in these measures.

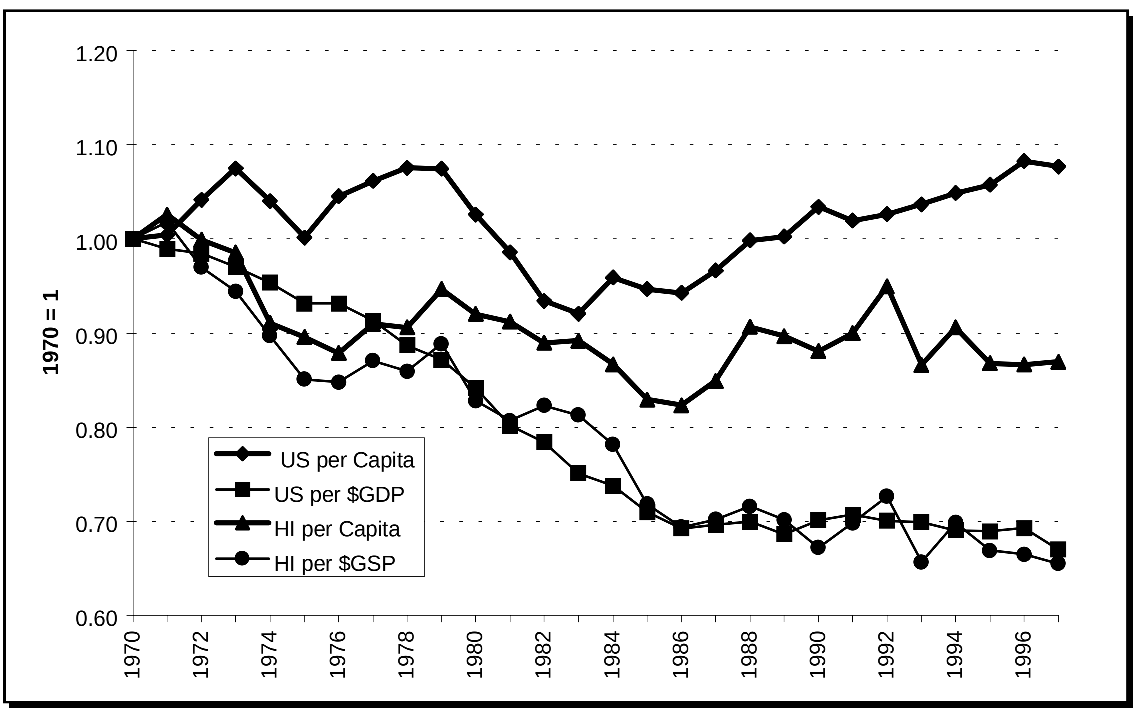
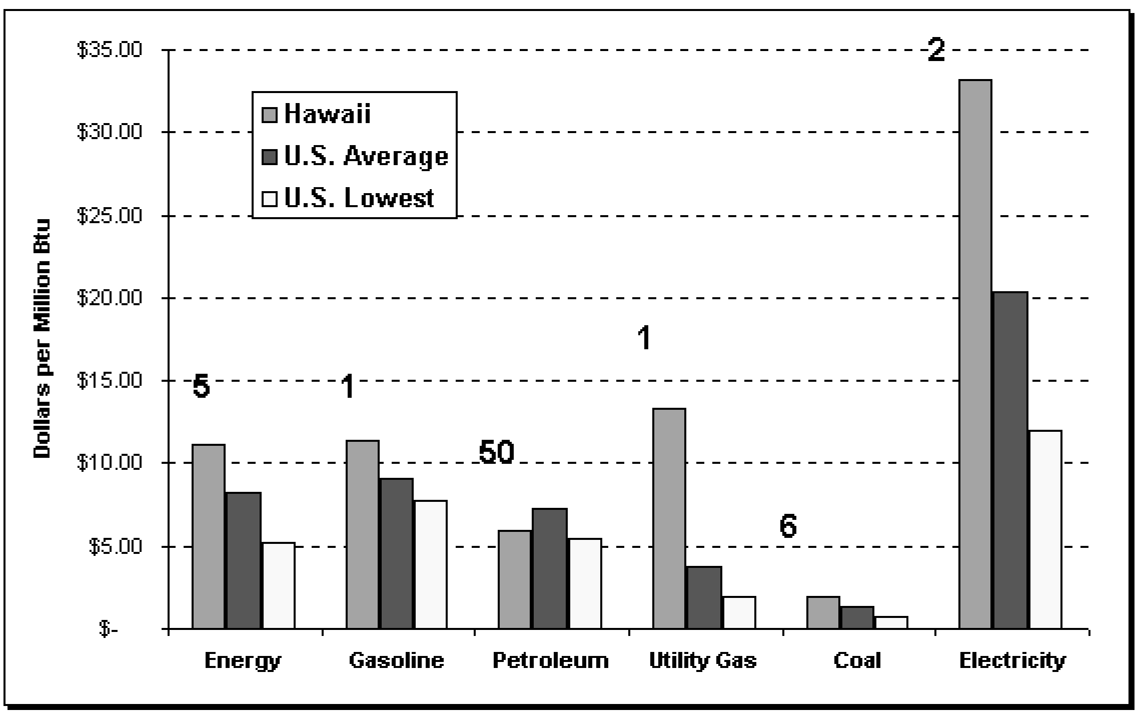


Figure 3.3 Hawaii and U.S. Energy Use Per Capita and Per Dollar of Economic Output, 1970–1997

By 1997, Hawaii required only 10,110 Btu per dollar of GSP; this was 77% of the U.S. energy use of 13,100 Btu per dollar of GDP. In 1997, Hawaii required only 65% as much energy per dollar of output, compared with 1970, while the nation as a whole used 67%. Some of the reasons Hawaii is more efficient include high energy prices that discourage energy use, the high cost of living, little requirement for space heating, few energy-intensive industries, short driving distances, utility demand-side management programs, and the greater environmental awareness resulting from living on an island.

Economical Energy. Recently, the U.S. Energy Information Administration (EIA) compared 1995 energy prices in each of the 50 states and the District of Columbia. Figure 3.4 depicts the results of a comparison of Hawaii's energy prices with those of other states. Hawaii's national rank is indicated for each category above the column showing Hawaii's prices compared to the U.S. average and the lowest U.S. prices (EIA 1998f, 8). Note that utility gas for Hawaii is synthetic natural gas manufactured in Hawaii, while utility gas on the Mainland and in Alaska is natural gas, available in large quantities at low prices (9). The surprising ranking for Hawaii in this comparison was 50th for petroleum, at $5.97 per million Btu. This was based on the prices per million Btu of distillate (diesel) ($7.11), jet fuel ($4.44), LPG ($11.40), motor gasoline ($11.40), residual fuel oil ($2.98), and other oil products ($5.07), weighted by amount of sales. About 43% of expenditures for petroleum products were for gasoline, but residual fuel oil sales were significant, which pulled down the average (7, 87).



Source: Data from EIA 1998f

Figure 3.4 Comparison of Hawaii Energy Prices with U.S. Average and Lowest U.S. Price, 1995

3.1.2.2 Objective 2: Increased Use of Indigenous Resources

Figure 3.5 shows changes in the relative proportions of the use of oil, coal, and indigenous renewable energy in this decade. In 1962, 18% of Hawaii's primary energy came from biomass-fired electrical generation and hydroelectricity produced by sugar plantations. The plantations sold substantial amounts of energy to the electric utilities. As Hawaii grew and rapidly developed, electricity needs were met by new oil-fired utility generation and little or no new sugar industry generation was added.

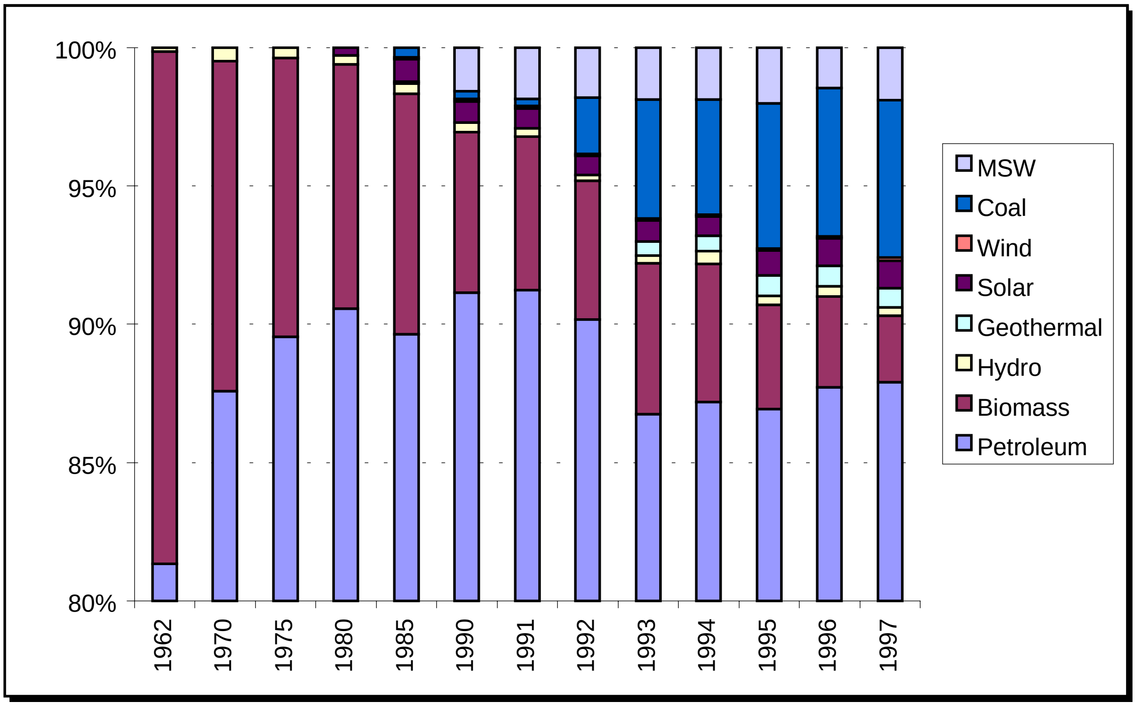


Figure 3.5 Indigenous Energy and Energy Diversification in Hawaii, 1990–1997

Even as oil prices rose dramatically in the 1970s, the proportion of energy from oil increased to 90.5%. Biomass, hydro, and solar water heating accounted for 9% of energy in 1980. High oil prices in the early 1980s led to the addition of more solar water heaters, some wind generation, geothermal test wells, and coal as a supplemental fuel for a few sugar plantations. This reduced oil use to 89.5%. In the mid 1980s, oil prices began to drop, reducing the incentive to offset oil use. Hawaii's dependence on oil peaked in 1989 at 91.8% of total energy use. In 1990, the addition of the Honolulu Project of Waste Energy Recovery (H-POWER) municipal solid-waste-to-energy plant helped offset declines in biomass electricity production. By 1994, due to the addition of 30 megawatts (MW) of geothermal energy on the Big Island and a new 180 MW coal plant on Oahu, oil use declined to 87.1%, the lowest level since 1969.

By 1997, oil prices had declined further, and oil use was up again to 87.9%. Sugar operations had closed entirely on the Big Island and Oahu and had been scaled back on Kauai. Wind-power operations on Oahu ended in 1986. Coal diversified the energy mix at 5.7%, while H-POWER, landfill methane, geothermal, solar water heating, hydro, and wind together amounted to 6.4% of primary energy use. As oil prices increased in 1999, they improved the near-term economic attractiveness of renewable energy. In addition, the energy security and environmental arguments for technically feasible renewable energy deployment remain powerful.

3.1.2.3 Objective 3: Energy Security

Energy security includes supply security, price security or stability, and economic security. Supply security means ensuring that energy is available despite market disruptions elsewhere. Price stability means that energy consumers are protected against price fluctuations. Economic security results from both of the above. Unreliable supply and price fluctuations affect the economy and hurt economic security (Yamaguchi 1993, 240–241). The use of indigenous renewable energy and diversification of fossil energy sources contribute significantly to all three forms of energy security, but there are other important measures.

Fuel substitution, energy efficiency, and preparedness for energy emergencies (including maintaining oil stockpiles) help protect supply security. While Hawaii has sought a Regional Strategic Petroleum Reserve in the past, the necessary federal funds were not provided. However, through the concerted efforts of Senator Akaka and the Hawaii Congressional Delegation in 1998, Hawaii was granted priority access to the U.S. Strategic Petroleum Reserve in times of emergency.

Total economic security may be impossible to achieve through local effort. Modeling of oil price spikes in *Hawaii Energy Strategy Report* (DBEDT 1995a) showed significant negative effects on Hawaii's employment, GSP, and personal income. However, there does not seem to be a practical way to insulate Hawaii from the world oil market. Even if all of Hawaii's energy came from indigenous sources at prices competitive in the normal market, the economy would not be fully insulated. The higher cost of jet fuel and airline tickets and greater share of the budgets of potential visitors going to meet their energy needs at home would likely reduce the number of visitors. The result would be serious negative effects on the State's economy.

3.2 The Hawaii's Energy System

Figure 3.6 depicts Hawaii's energy system. Sources of energy are shown at the top of the graphic. Hawaii's imports include coal, crude oil, and in varying amounts, a selection of refined oil products. Hawaii's indigenous sources are biomass (including bagasse, municipal solid waste, and landfill methane), geothermal, hydro, wind, and solar (both solar water heating and photovoltaic electricity).

Hawaii's refiners convert crude oil into a variety of refined products such as jet fuel, gasoline, diesel fuel, LPG, and residual fuel oil. These serve the energy end-users in the residential, commercial, industrial, and transportation sectors depicted at the bottom of the chart. Some refinery products are exported or sold as bunker fuel for shipping and airline operations originating in Hawaii for overseas use or use at sea. The Tesoro Hawaii refinery provides feedstock to The Gas Company's (TGC) synthetic natural gas (SNG) plant. SNG is used as utility gas on Oahu. Coal, imported and locally refined products, and renewable energy are used to produce electricity. These serve a variety of end uses in all four end-use sectors. Some solar energy is used to heat water or dry agricultural products. In addition, bagasse provides process heat in the sugar industry, and excess energy is used to generate electricity for use at the mill and for sale to the utilities.

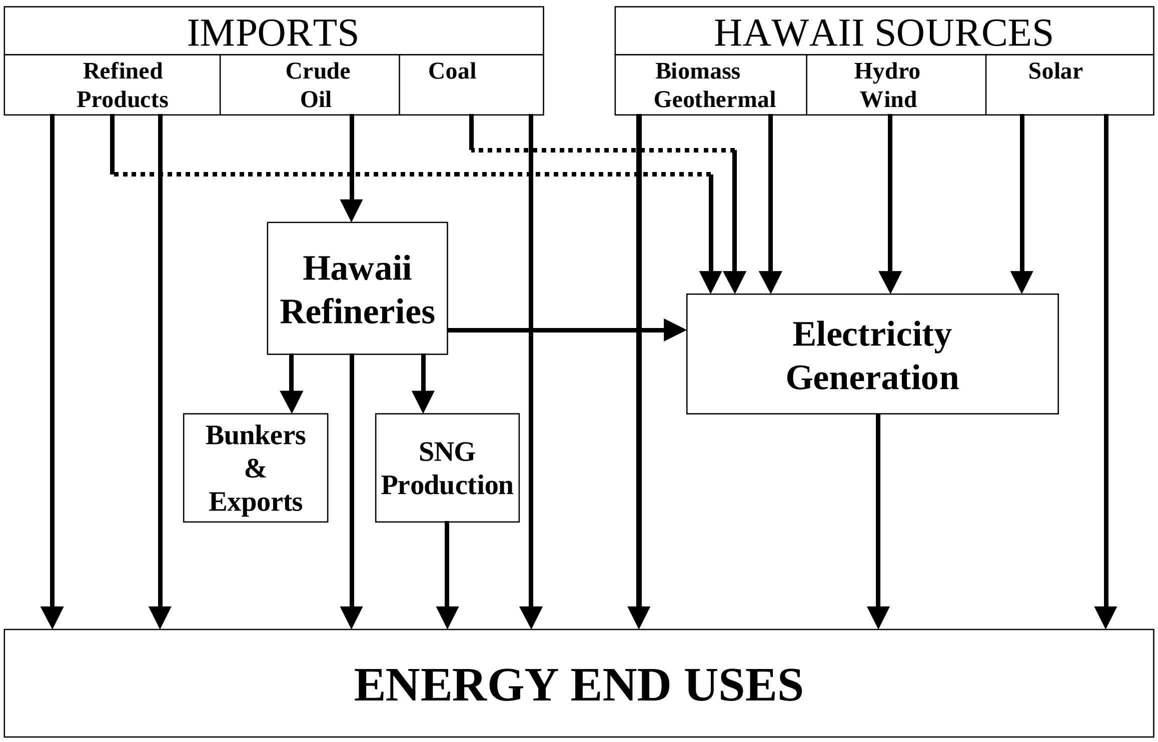


Figure 3.6 Hawaii's Energy System

3.3 Fossil Energy for Hawaii

3.3.1 Crude Oil Imports

Hawaii has no fossil energy resources. In 1997, Hawaii imported 50,850,609 barrels of crude oil, down almost 8% from a high of over 55 million barrels in 1994, but up 5% compared to 1990. Seventy-one percent of the oil came from foreign sources, and only 29% came from domestic sources, principally Alaska. Hawaii's crude oil imports are detailed in Table A.1, in Appendix A.

3.3.2 Hawaii's Refined Oil Products

3.3.2.1 Imports of Refined Oil Product

In 1997, the total volume of refined product imports and exports was roughly in quantitative balance – 6,662,722 barrels were imported and 6,835,388 were exported. Imports of refined product were 13% of the volume of crude oil imports. Since there are only two refiners and few other importers of refined products, some details of refined product imports and exports must be held in confidence by DBEDT and EIA to protect competition.

Jet fuel imports in 1997 were the greatest of the decade, significantly exceeding the 2,330,000 barrel annual average in the 1990s. The lack of reported imports of low-sulfur residual fuel oil was unusual. In each year before 1997, a significant amount was imported because the requirements of the electric utilities apparently could not be met from local production.

High-sulfur fuel oil, naphtha, and distillates were exported in relatively large amounts in the nineties. Naphtha was usually sold to Asian customers for use as a chemical feedstock. Both the Hamakua Energy Partners (formerly Encogen) power plant being built on the Big Island and the next generation unit planned for Kauai by Kauai Power Partners intend to use naphtha as the primary fuel for their combustion turbines, which will provide a significant local market. Excess Hawaii-refined diesel finds a ready market on the U.S. West Coast. Data on imports of refined products into Hawaii in 1997 is provided in Table A.2. In addition, Table A.3 reports the average amount of each major product imported or exported between 1990 and 1997.

3.3.2.2 Oil Products Refined in Hawaii

The two local refiners, Chevron USA and Tesoro Hawaii, produced most of the refined products used in Hawaii. The Chevron refinery has a current capacity of about 20 million barrels per year. Chevron maximizes gasoline production. The Tesoro Hawaii refinery has a capacity of about 33 million barrels per year and maximizes production of jet fuel.

3.3.3 Synthetic Natural Gas Production

TGC is a division of Citizens Energy Services (formerly Citizens Utilities) that provides all utility gas service in Hawaii. It serves approximately 36,000 customers through distribution networks on Oahu, Hawaii, Maui, Molokai, and Kauai. The largest group of TGC customers is on the company's main Oahu distribution network, which provides them with SNG produced at the TGC plant in Kapolei, Oahu. Outside of urban Honolulu, TGC customers are served with propane through pipelines supplied from storage tanks (TGC 1999, 1-8 to 1-9).

The SNG plant manufactures SNG from a light hydrocarbon feedstock provided by pipeline from the adjacent Tesoro refinery. The SNG plant can produce 150,000 therms per day (one therm = 100,000 Btu), or 5,475,000 million Btu per year. From 1990 to 1997, only 53% of the SNG plant's capacity was needed to meet the average demand (4-8). TGC's high estimate is that by 2020, demand could reach 112,500 therms per day, still only 75% of plant capacity (2-16).

The current excess capacity of the SNG production facility provides an opportunity to help diversify Hawaii's fuels, increase supply security, reduce greenhouse gas emissions, and possibly delay the need to build additional electricity generation on the island of Oahu. Fuel switching should be examined in order to take advantage of this opportunity.

3.3.4 Coal Imports

Very low sulfur (0.4%) and low ash (5%) coal for the AES Hawaii 180 MW atmospheric fluidized bed coal power plant is imported under a long-term contract from Indonesia's Kaltim Prima mine (Yamaguchi 1993, 185). Coal for Hawaiian Commercial & Sugar's (HC&S) Puunene Mill and for the Hilo Coast Power Company plant is generally imported from Australia. Table A.4 details coal use in Hawaii from 1990 through 1997, and Table A.5 provides data on coal imports.

3.4 Hawaii's Renewable Energy Sources

About 6.4% of Hawaii's primary energy was produced by indigenous renewable energy sources in 1997. Biomass, geothermal, hydro, solar, and wind energy were used to produce electricity. Biomass was also used to produce process heat and solar energy was used for food drying and to heat water. Additional detail on renewable energy technologies can be found on DBEDT Energy, Research, and Technology web pages at http://www.hawaii.gov/dbedt/ert/.

3.4.1 Biomass

Energy is produced using several biomass sources in Hawaii. Bagasse, the crushed fibers that remain after the sugar has been removed from the sugar cane, was the largest source of biomass energy in Hawaii in 1997, providing 2.4% of total primary energy. Macadamia nut shells and husks and eucalyptus and kiawe trees were also used as biomass energy sources. Municipal solid waste (MSW) is also a form of biomass, and MSW, in the form of refuse-derived fuel is used to generate electricity. Methane gas collected from food waste and manure and from landfills was burned as fuel to produce heat and power. An additional potential energy source for Hawaii is ethanol. Ethanol, a liquid fuel generally used for transportation, can be made from various forms of biomass.

3.4.1.1 Electricity from the Sugar Industry

Sugar factories in Hawaii burn bagasse to provide steam for sugar processing and to generate electricity. Electricity not needed for factory operations is sold to local utility companies. The amount of bagasse boiler fuel burned in Hawaii has declined 43% since 1990, as shown in Figure 3.7, and by 1997, electricity production from bagasse was only 40% of 1990 production, or 211 GWh. In 1997, the heat value of bagasse was 7,568,000 million Btu, offsetting the equivalent of 1.2 million barrels of residual fuel oil.

The sugar plantations on Oahu and the Island of Hawaii have all closed, and some on Maui and Kauai have closed. The remaining sugar plantations on Maui and Kauai remain important sources of renewable energy. Bagasse is often supplemented in sugar plantation boilers by diesel oil, residual fuel oil, waste oil, or coal. In addition to using their steam boilers to generate electricity, some sugar plantations operate small hydroelectric generators and internal combustion diesel generators. Table A.6 details electricity production from bagasse; Table A.7 shows the percentage of total sugar industry electricity production, from all sources of energy, sold to the utilities.

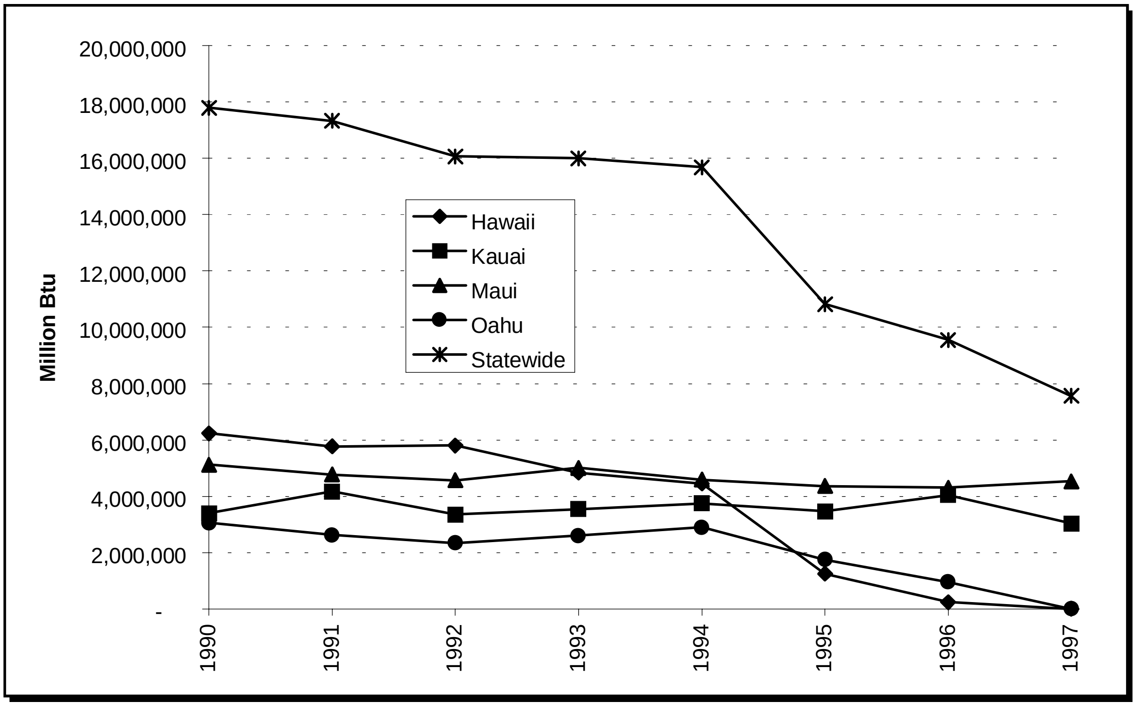


Figure 3.7 Heat Value of Bagasse Boiler Fuel in Hawaii, 1990–1997

3.4.1.2 Electricity from Methane Gas from Food and Animal Wastes

In 1997, several private companies processed animal waste to produce methane gas. The gas was used for heat and to generate electricity to operate the processing facilities. None was sold to any of the electric utilities.

3.4.1.3 Electricity from Refuse Derived Fuel, H-POWER, Oahu

H-POWER on Oahu burns refuse-derived fuel to generate electricity. The plant produces approximately 6% of Oahu's electricity. Since beginning operations in May 1990, it has processed more than 4.4 million tons of waste, generating electricity that otherwise would have required about 7 million barrels of oil to produce. In 1997, H-POWER used 529,500 tons of municipal solid waste (MSW) to generate 371 GWh of electricity and sold 323 GWh to the Hawaiian Electric Company (HECO). This generation displaced about 842,000 barrels of residual fuel oil and represented about 1.8% of the state's primary energy.

3.4.1.4 Electricity from Landfill Gas

Since 1990, Kapaa Generating Partners (KGP) has collected methane from the Kapaa landfill, on Oahu, to power a 3.2 MW combustion turbine generator. In

1997, the landfill gas used was equivalent to 43,500 barrels of residual fuel oil and represented 0.1% of the state's primary energy. KGP sold 15.17 GWh to HECO. Waste heat from the turbine exhaust is used to dry sand at Ameron HCD's collocated quarry operation, saving the equivalent of about 10,000 barrels of oil annually (Lum 1997, A-2).

3.4.1.5 Electricity from Green Waste and Energy Crops

After Oahu's Waialua Sugar Company closed in 1996, Waialua Power Company was formed with the intention of using the former sugar mill's 12.5 MW generator, ultimately fueled by energy crops, to produce electricity for sale to HECO. In 1997, Waialua Power Company sold 15.3 GWh of electricity to HECO, generated from green waste, waste oil, and residual fuel oil. Waialua Power Company ended operations in July 1998, citing an inability to obtain sufficient green waste for fuel.

3.4.1.6 Biodiesel from Vegetable Oil

Used cooking oil is converted into biodiesel for use on Maui. Biodiesel may be blended with regular diesel and used in existing diesel engines in trucks, buses, and boats.

3.4.2 Geothermal

Electricity is generated from geothermal energy by drilling into the ground to bring underground steam or hot fluids to the surface. These are used to drive a turbine generator to make electricity. Spent geothermal fluids and gases are re-injected into the ground to eliminate surface disposal and air pollution. The 30 MW geothermal power plant operated by Puna Geothermal Venture (PGV) on the Island of Hawaii sold 228.7 GWh to HELCO in 1997, about 25% of electricity sold to consumers. This replaced about 407,000 barrels of residual fuel oil and prevented the emission of 240,000 tons of CO_2. Table A.8 depicts geothermal energy performance in Hawaii since 1992.

3.4.3 Hydroelectricity

Hawaii's current hydroelectric power plants are "run-of-the-river" plants generating electricity from the flow of the river without using dams or reservoirs. Hawaii's hydro plants provided 0.3% of the State's primary energy in 1997. In 1997, hydro plants on Hawaii, Kauai, and Maui amounted to 29.9 MW of electricity generation capacity and generated 92.69 GWh of electricity. Details of these power plants are shown on Table A.9. Table A.10 shows hydroelectric generation from 1990 to 1997 by island.

3.4.4 Solar Photovoltaics

Photovoltaic (PV) cells, or solar cells, convert the sun's light into direct current (DC), which can be used or stored in batteries. The solar cells are made of thin layers of material, usually silicon. Most electric appliances operate on alternating current, although some operate on direct current. Therefore, utilities and other solar cell users typically use inverters to change PV-generated direct current into alternating current used in most homes and buildings.

A 20 kW photovoltaic demonstration project is operating at Kihei, Maui, as a satellite project of the national Photovoltaics for Utility-Scale Applications (PVUSA) program. In 1996, an 18 kW photovoltaic system was installed on the auto craft shop building at Hickam Air Force Base. The Navy is planning a 2 kW building-integrated photovoltaic system installation on the Boat House on Ford Island (Seki 1998).

In addition, the three HECO companies' Sunpower for Schools project has installed photovoltaic systems on several Hawaii high schools. The installations are financed by the company and voluntary customer contributions.

On the Big Island, the Mauna Lani Bay Resort installed a 70 kW photovoltaic system on its roof in May 1998. The PV cells are mounted on insulating roof tiles, which reduces heat gain through the roof and reduces the air conditioning load. The resort has added another 110 kW on two golf course maintenance buildings. The two projects were expected to generate an internal rate of return of 23–25% and to save about $2.5 million in net operating costs over 25 years. Over 30 years, the PV system will offset the burning of 30,000 barrels of oil (Gomes 1999). This will avoid emission of about 16,225 tons of CO_2.

3.4.5 Solar Thermal Energy

There are several basic kinds of solar thermal energy systems, including flat plate solar water heaters, concentrating collectors (such as central tower receivers), and parabolic trough and dish collectors.

3.4.5.1 Solar Water Heating and Hawaii

Solar water heaters heat water as it flows through tubes that are attached to a black metal absorber plate. Solar water heaters generate no electricity, but produce hot water, offsetting the need for electric or gas water heating. Solar water heaters serve an estimated 58,000 to 65,000 single-family homes, multi-unit dwellings, and institutional facilities in Hawaii. These solar water heaters were estimated to produce the thermal equivalent of about 1% of the State's primary energy (DBEDT 1998e). The State offers income tax credits for solar water heaters of 35%, up to stated limits. Under demand-side management programs to customers with electric water heaters, Hawaii's electric utilities offer incentives of $800 to $1,000 per system.

3.4.5.2 Solar Thermal Steam and Electricity Production in Hawaii

Solar thermal systems, including power towers, parabolic troughs, and dish systems, can be used for large commercial-scale steam and electricity production.

A power tower uses a field of tracking mirrors to focus sunlight onto a single receiver mounted on a tower. Water or other heat transfer fluid in the tower is heated and used directly or converted into steam for electricity. Currently, there are no operating power towers anywhere.

Parabolic dishes or troughs are curved panels that follow the direction of the sun's rays and focus the sunlight onto receivers. A liquid inside the pipes at each receiver's focal point absorbs the thermal energy. The heated fluid can be used to produce electricity. One local example is a solar-powered desalination facility in Milolii, Hawaii, that produces up to 1,000 gallons of fresh water per day. Another is a concentrating parabolic-trough solar water heating system at the Pacific Missile Range Facility on Kauai.

3.4.6 Wind

The wind can be used to power a pump or turn a generator that produces electricity. For producing large amounts of electricity, many machines can be grouped together to form a "wind farm."

In 1990, there were 196 wind generators in Hawaii, with a total capacity of 23.3 MW. In 1997, although Hawaii had the fourth largest capacity in wind-generated electricity in the nation, there were only about 121 large wind machines totaling about 11 MW. See Table A.11 for current wind farms, their capacities, and electricity production in 1997. In 1997, wind generation produced about 16,210 MWh of electricity – about 0.1% of the State's primary energy.

All of the operating wind farms were on the Island of Hawaii, and most of the wind-generated electricity was sold to HELCO, although some was sold to the County water department for pumping. At Kahua Ranch, three 10 kW Bergey wind turbines, a 10kW PV array, and a 30 kW diesel generator – in conjunction with a battery bank and pumped hydro system – supply power to a greenhouse and 11 homes and shops on the ranch. This system is not connected to the electrical grid.

3.5 Hawaii's Future Energy Needs

The ENERGY 2020 computer model of Hawaii's energy system and economy was used to estimate Hawaii's future energy needs. Assumptions used in creating the estimate are discussed in Chapter 13, which examines several scenarios for Hawaii's energy future. Figure 3.8 depicts the base case forecast of each county's energy demand from 2000 to 2020.

Total energy demand is projected to grow 16.4%, from 310.2 trillion Btu (TBtu) in 2000 to 360.8 TBtu in 2020. Among the Counties, Kauai's energy demand is estimated to grow most rapidly, increasing 26%, from 12.4 TBtu in 2000 to 15.6 TBtu in 2000. Hawaii County's demand is forecast to grow by 24%, from 22.9 TBtu to 28.6 TBtu. Energy demand in the City and County of Honolulu is projected to grow 17%, from 246.9 TBtu to 287.9 TBtu. Maui County energy demand was forecast to grow 10%, from 26.2 TBtu to 28.8 TBtu.

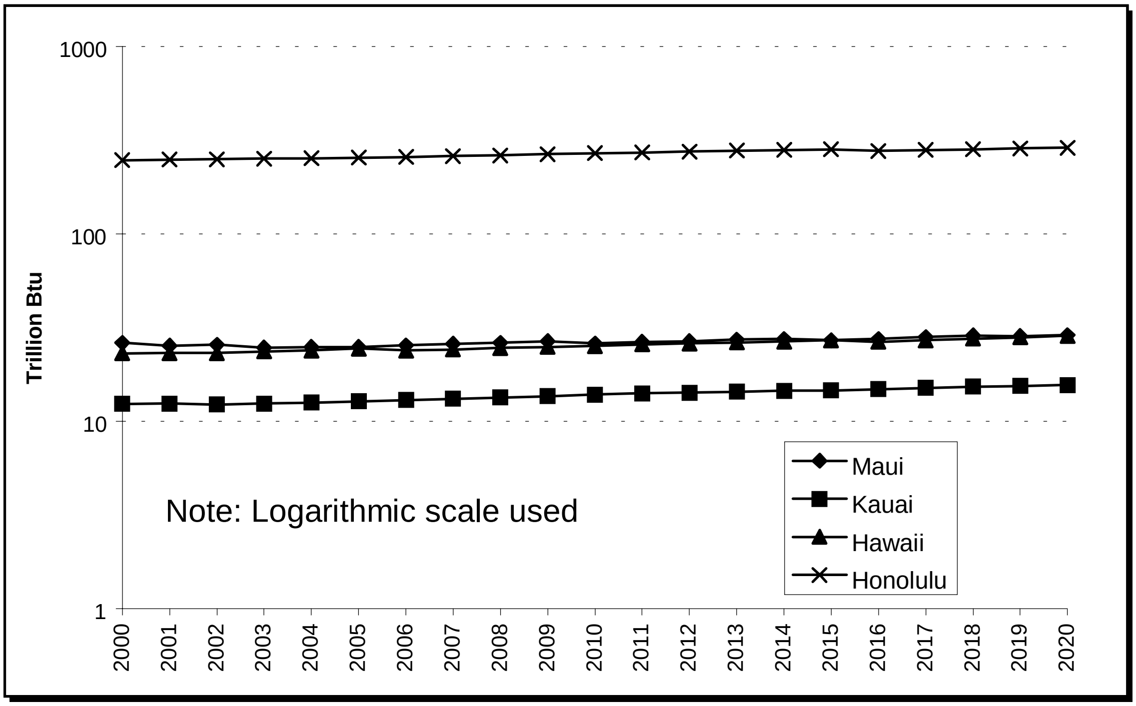


Figure 3.8 Base Case Forecast of Hawaii Energy Demand by County, 2000–2020

3.6 Future Fossil-Fuel Energy Supply for Hawaii

This section discusses the future supply of imported oil and coal. Renewable resources will continue to exist in abundance. The relative cost of fossil fuels in comparison to renewable alternatives will be a major factor influencing whether additional renewable energy systems are deployed.

3.6.1 Hawaii and the World Oil Market

As detailed in the *HES 1995* Project 2 Report, *Fossil Energy in Hawaii*, Hawaii's location in the middle of the Pacific Ocean has advantages and disadvantages in terms of importing crude oil. The report noted that although Hawaii is in the middle of an active oil market, the size of Hawaii's market is so small that it can easily obtain the oil it needs as long as it is willing to pay the price (82). However, Hawaii is also far away from its sources of oil and remains dangerously dependent on oil for its energy needs. When Asian economic growth resumes, the resulting demand for oil products will likely shift increasing amounts of that region's crude oil to Asian refiners. Alaska and California are closer, but their crude production is declining.

As in 1993, Hawaii was not dependent on "insecure" sources of oil from politically unstable regions in 1997. Hawaii had no oil and coal supply problems during the recent Asian economic crisis, despite considerable political and social unrest in Indonesia – the source of 31% of Hawaii's oil imports in 1997. In the future, Hawaii may need more oil from the unstable Middle East, but in 1997 only

0.5% of Hawaii's supply came from that region. Nevertheless, future domination of the world oil market by Middle Eastern oil producers could affect the price of oil from all sources.

3.6.2 The Outlook for Oil

3.6.2.1 U.S. Department of Energy's Forecast of the Future

This section is based on the U.S. Department of Energy's EIA *Annual Energy Outlook 1999 With Projections to 2020* (EIA 1998a), published in December 1998, and hereafter referred to as *AEO 1999.* A key issue that influenced the *AEO 1999* forecasts was weakened worldwide oil demand due to economic developments in Asia in the preceding 18 months. EIA expected the trend to continue for several years, affecting oil markets and prices. The *AEO 1999* forecasts were made in December 1998, prior to the action by the Oil Producing and Exporting Countries (OPEC) in March 1999 to reduce production in order to increase oil prices (2).

3.6.2.2 Long-Term Outlook for International Oil Markets

Figure 3.9 presents the *AEO 1999* forecast of world oil prices for the next two decades. Oil prices are driven by the relationship between supply and demand. Prices in early 1999 were low because of an oversupply created in part by reduced demand in developing nations, especially in Asia. The three price cases were based on assumptions about oil production in the nations of the OPEC cartel. OPEC, especially the nations in the Persian Gulf region, were expected by EIA to be the "principal source of marginal supply to meet future incremental demand" (46). Thus, in the low price case, OPEC production was assumed to be high, and in the high price case, OPEC production was assumed to be low.

As noted above, in March 1999, OPEC took action to reduce production and raise prices. This tactic drove mid-1999 oil prices even higher than estimated in the *AEO 1999* high case. The EIA *Short-Term Energy Outlook* (EIA 1999c) quarterly projection in June 1999 was that 1999 oil prices would average $20.58 per barrel and that 2000 oil prices would moderate slightly, to $20.51 per barrel. For ENERGY 2020 runs, forecast prices for 2001 to 2004 were interpolated between the short-term 2000 estimate and the 2005 reference case, as shown on Figure 3.9.

Many non-OPEC nations also contribute to meeting growing demand. EIA forecast in the reference case that production from non-OPEC nations would reach 55 million barrels per day by 2010 and remain at about that level through 2020. In addition to continuing production from the North Sea, Canada, Australia, and Mexico, increased production is expected from Latin America, off the West African coast, in the South China Sea, and in the nations of the former Soviet Union (47).

The prospect, however, is for OPEC to control an increasing share of the market. OPEC's market share is expected to grow from about 52% soon after the turn of the century and could reach 72% by 2020. Obviously, this could have significant effects on prices. From EIA's perspective, greater OPEC market share would result from greater OPEC supply, reducing prices. Others are more concerned about the potential negative consequences of growing OPEC market dominance.

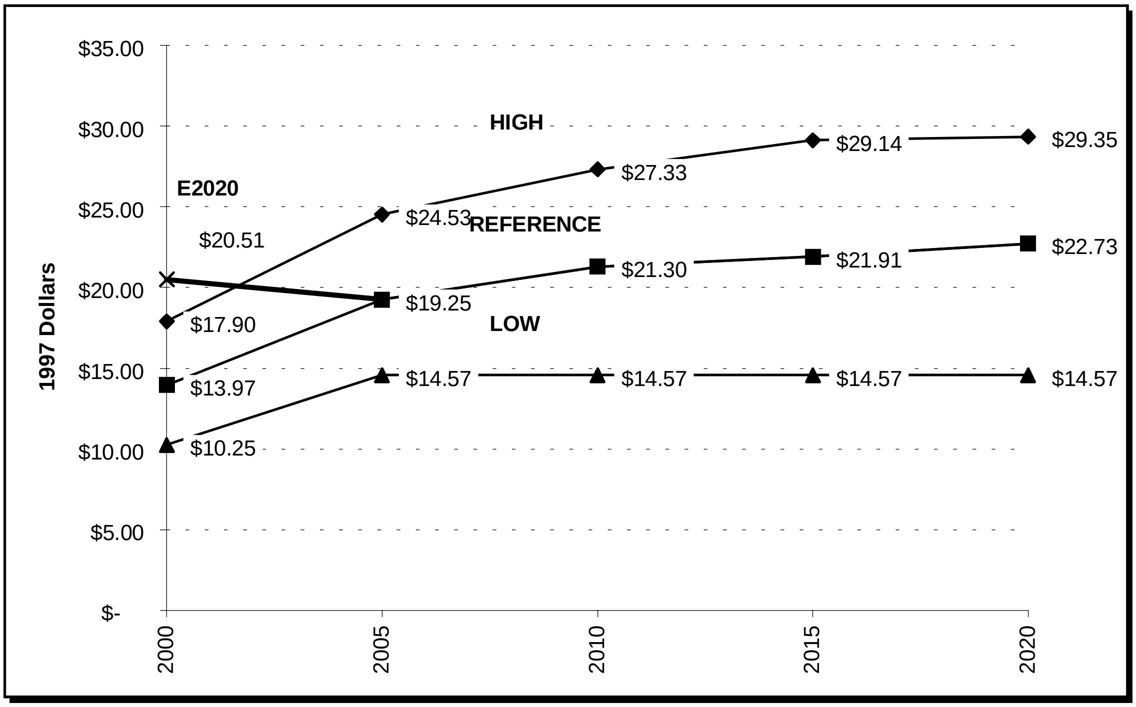
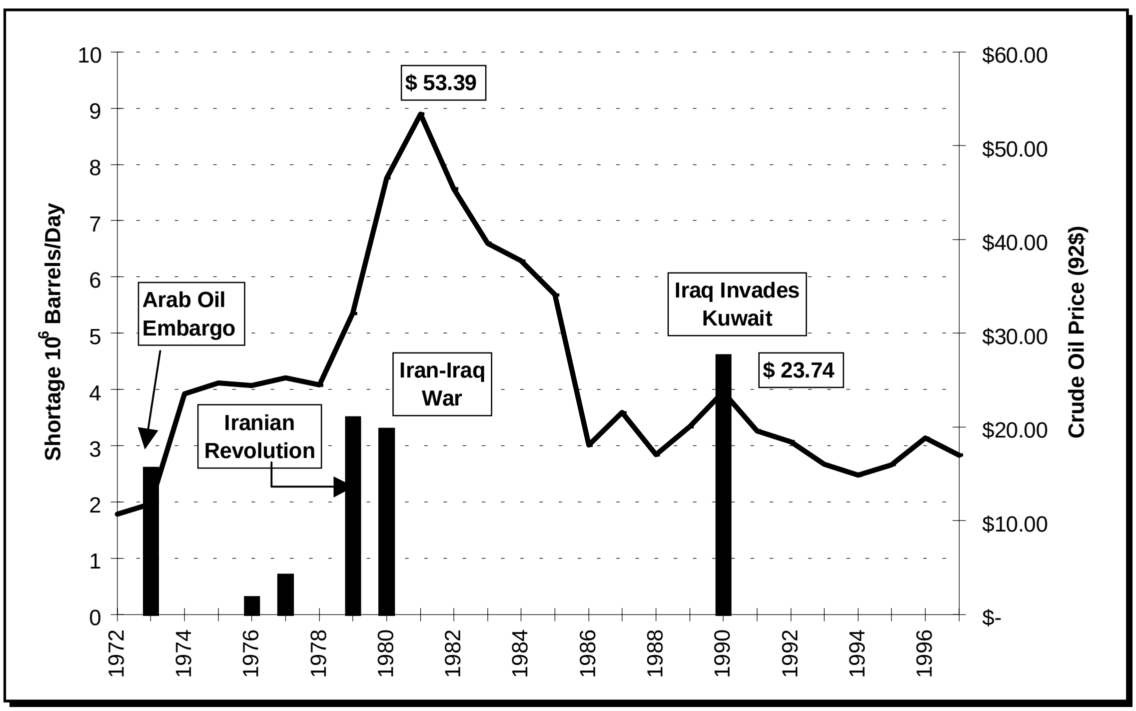


Figure 3.9 Long-Term Forecast of World Oil Prices, 2000–2020



Source: Data from EIA 1998a, 273

Figure 3.10 Shortages and Oil Prices, 1972–1997

Figure 3.10 shows the historical consequences of shortages in oil supply in the past. The left axis shows the crude oil prices to U.S. refiners in 1992 dollars, and the right axis shows percentage change in U.S. GDP. Key events are noted on the figure.

3.6.2.3 International Oil Market Concerns – Are Oil Supplies Declining?

Some authors, such as Colin J. Campbell, argue that "within the next decade, the supply of conventional oil will be unable to keep up with demand" (Campbell, 1998, 78). Campbell suggests that estimates of world proved and unproved oil reserves were inflated (79–80). He regards the EIA's projection of decades of increasing world oil production as an illusion.

A decline in production available to meet growing demand would drive prices higher. Campbell believes OPEC production will peak in 2010 with radical increases in oil prices as a result of the combined factors of declining supply and OPEC dominance of the market (83). Campbell calls for a transition to a post-oil economy through production of liquid fuels from natural gas for transportation fuel, safer nuclear power, cheaper renewable energy, and conservation programs. This, he argues, could help delay the decline of conventional oil (83).

3.6.2.4 International Oil Market Concerns – Will the OPEC Cartel Again Drive Prices Higher?

On March 23, 1999, in an effort to boost oil prices, members of OPEC formally agreed to cut crude oil production by 2.1 million barrels per day for a full year starting April 1, 1999. When the agreement was initially reached two weeks before, crude oil prices rose 20%. OPEC sought a price of $17 to $18 per barrel of benchmark North Sea Brent in 1999, which was $13.50 a barrel in late March 1999. OPEC plans to consider any additional action in March 2000 (Bird 1999).

According to David Greene, of the USDOE's Oak Ridge National Laboratory, the main threat to U.S. energy security is economic scarcity, not physical or geologic scarcity. Monopolistic behavior or any of a variety of shocks to the world's oil producing regions could create economic scarcity. He noted that oil markets cannot adjust quickly to sudden changes in supply. Thus, supply shocks could cause huge increases in oil prices, which would mean huge profits for oil producers and huge losses for consumers (16). The economies of the United States and Hawaii depend heavily on oil and are susceptible to enormous economic losses as shown in Figure 3.10, above.

Greene views oil as an inexhaustible resource, citing M. A. Adelman's view that "oil reserves are not a fixed stock to be allocated over time, but an inventory, constantly consumed and replenished by investment" (17). However, this assumes development of technologies to extract unconventional oil and a willingness to pay the financial and environmental costs.

He notes that the greater concentration of oil use in the transportation sector may have decreased the price elasticity of demand, increasing OPEC's market power

(65). He says that economic analysis shows what OPEC *can* do, but cannot predict what it *will* do. Simulations of the effects of future OPEC oil supply reductions indicate that OPEC could create price shocks and profit from them. A USDOE study showed that a supply cut of 5.25 million barrels per day in 2000 could result in oil prices of $55 per barrel (65).

Greene states that future price shocks could be caused by deliberate cartel action to curtail supplies, by wars, insurrections, terrorism, or natural disaster (65). He sees the solution in actions that reduce OPEC market share, increase the price elasticity of oil demand, increase the price responsiveness of non-OPEC oil supply, and slow the growth of world oil consumption. This can be done by the development of more efficient oil-using technology (especially for transportation), the use of alternatives to petroleum, and by developing cheaper and better technology for finding and producing oil (66).

3.6.2.5 International Oil Market Concerns – Will Political or Military Crises Disrupt the Market?

The world's first major oil price shock was created by the Arab oil embargo of 1973–1974, in response to the 1973 Arab-Israeli War. In 1979, revolution in Iran spiked oil prices again. Military action between oil producing nations created oil price shocks during the Iran-Iraq War in the eighties and following the Iraqi invasion of Kuwait in August 1990.

Since 1970, oil price shocks have been triggered by political or military crises. At the end of the nineties, conflicting claims to the Spratley Islands and other areas of the South China Sea by China, Vietnam, the Philippines, Taiwan, Brunei, Indonesia, and Malaysia are principally motivated by the potential for oil in the area. Domestic unrest in Angola and Algeria could affect oil supplies from those nations. Kurdish guerrillas in eastern Turkey and continuing civil war in Afghanistan and other areas offering potential pipeline access to Central Asian oil supplies may delay or prevent this oil from reaching the world market.

John C. Gannon, then the Central Intelligence Agency's Deputy Director for Intelligence, spoke on the topic "A Global Perspective on Energy Security" in December 1996. Gannon cited military threats to neighbors and Persian Gulf oil transit routes from Iran and Iraq, the threats of domestic terrorism and Islamic militancy in Saudi Arabia, violence in Algeria, and possible actions by Libya as concerns. Economic problems in Russia and deterioration of relations between Russia and Ukraine also threatened Russian gas exports to Europe through Ukrainian controlled pipelines (Gannon 1996).

Gannon also saw positive trends in some areas, including a growing openness to U.S. and other outside investment in most current and potential oil-producing countries. Algeria's and Venezuela's nationalized oil industries were among those seeking to attract foreign investment and technology. Foreign investment in Russia, the former Soviet republics, Vietnam, and Colombia were seen as contributing to future production from outside the volatile Persian Gulf area (Gannon 1996).

In 1998, Gannon, by then Chairman of the National Intelligence Council, expressed concern that then low oil prices threatened the economic and political stability of Persian Gulf nations. “A protracted weakness in oil prices would force these governments into tough choices between military and social spending, increasing the appeal of Islamic extremism and the risk of political unrest” (Gannon 1998). Mamdouh Salameh, an international oil economist, also saw a link between the decline in oil prices and oil revenues since the mid 1980s and the rise in Islamic fundamentalism in the Middle East and North Africa. “Islamic fundamentalism has its roots in mounting conflicts of income distribution, exacerbated by rising social tensions. Oil may have reduced the conflict potential when revenues were rising and subsequently enhanced it when revenues started to fall” (22).

We cannot predict which specific political change or military action will affect one or several of the oil producing nations of the world, but it is clear that there are many unstable situations that could disrupt the world oil market, resulting in price shocks and highly negative economic effects on the world and Hawaii.

3.6.2.6 International Oil Market Concerns – What Will Be the Effect of the Projected Decline in Alaska Production?

One factor that may increase Hawaii’s dependence on foreign crude oil is the expected decline in oil production from Alaska. Production is expected to decline 79% from the 676 million barrels produced in 1990 to 144 million barrels in 2020. While even the lowest levels forecast for Alaska production could meet all of Hawaii’s needs, there is competition for this supply from a variety of West Coast refiners. This situation may slightly reduce Hawaii’s supply security, but given Hawaii’s tiny demand in the context of the overall world oil market, it is expected that oil will be available in the future at some price – but when supplies are tight, the price could be very high.

3.6.3 The Outlook for Coal

Coal is one of the world’s most widely available sources of energy. The United States, Australia, and Canada have about a third of world coal reserves and serve over half of the seaborne coal trade (Yamaguchi 1993, 183). As discussed in section 3.3.4, above, AES Hawaii imports coal under a long-term contract from Indonesia’s Kaltim Prima mine, and coal for other uses is generally imported from Australia.

The EIA forecasts growth in world coal production from 5.1 billion tons in 1995 to 8.6 billion tons by 2020. Most of the 3.5 billion-ton increase in use is expected in Asia, primarily in China and India (EIA 1998f, 69). Exports from Australia and Indonesia are also expected to grow (82). Should these countries remain Hawaii’s main suppliers, they should have little difficulty in meeting Hawaii’s relatively small needs. In any event, a wide range of potential suppliers is available, making coal Hawaii’s most secure imported fuel. EIA expects the average price of coal used in the United States to decline by 2020 (EIA 1998a, Table 3). However, coal-fired generation emits 20% more CO_2 per energy unit than oil-fired generation. It is possible that carbon taxes or other measures such as carbon trading could, in the future, raise the financial cost of using coal relative to oil and gas.

3.6.4 The Possibility of Importing Liquefied Natural Gas

3.6.4.1 The 1993 Perspective

In 1993, DBEDT initiated a study by the East-West Center of the possibility of importing liquefied natural gas (LNG) for use as a fuel for electricity generation, utility gas, and for ground transportation. The results of the study appeared in *HES 1995*. The study found that option unattractive, but TGC reexamined the option in its 1999 IRP and offered new conclusions.

In the 1993 study, LNG use was seen as offering fuel diversification for Hawaii and reduced environmental impacts compared with oil and coal. Most electricity generators, cars and trucks on Oahu could be fueled with LNG. LNG could also replace SNG in the utility gas system. However, the study reported that demand on the Neighbor Islands was too small to justify construction of receiving terminals. Based upon 1997 fuel use on Oahu, LNG could theoretically substitute for 32% of Hawaii's total energy requirements and 36% of Hawaii's oil use.

An LNG chain would have been needed, 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 (26). According to the study, such a system would have cost $5.38 billion (27-31). The unit cost of delivered gas was estimated at 2.5 times the cost of residual fuel oil (31), which was clearly not economical. The system would also have increased supply vulnerability due to the need to rely on a single supplier. LNG imports were also not recommended due to safety hazards posed by the LNG carriers, regasification facilities at the receiving terminal, and pipelines. In particular, providing an adequate safety zone surrounding the receiving terminal seemed nearly impossible (4)

3.6.4.2 The 1999 Perspective

In its 1999 IRP, TGC looked at importing LNG for use in the utility gas system. In 1999, it was possible to buy LNG on the spot market in shipload increments using short-term contracts. The spot market developed when buyers backed out of long-term contracts with suppliers of the type envisioned in the 1993 study. Buying LNG on the spot market would have eliminated the need to invest directly in the LNG supply and transport elements of the LNG chain, but a receiving terminal would still have been required. According to the study, it is not clear whether this is really a long-term option or whether the spot market might end when demand recovers.

TGC's imports would have been intended to replace only current Oahu SNG and utility propane. The cost of the TGC terminal was estimated at $113 million and it was assumed that LNG could be delivered at a cost of $3.50 per million Btu. The plan also had the potential for supplying more of Hawaii's energy needs (TGC 1999, 4-15). TGC saw the availability of a receiving facility site and related safety issues, pipeline requirements, and political issues as major obstacles (4-16) and did not select the LNG import option. The main obstacle to LNG imports, besides cost, remains finding a site of sufficient size for necessary processing, storage, and a safety buffer.

3.7 Summary

Despite increased use of coal, which diversified energy supply in Hawaii, the State remains dependent on oil for most of its energy. In the 1990s, deployment of geothermal resources, additional solar water heating, and additional hydroelectricity only offset the declining use of bagasse and wind, keeping the renewable share relatively constant.

Hawaii's energy system was generally reliable. However, it retains the potential to seriously damage the economy due to price shocks that could occur for a variety of reasons. Hawaii is unable to affect the world oil market, but would itself be greatly affected by instability in that market. The EIA forecasts relatively modest price increases over the next twenty years, but others are concerned about diminishing supplies, inelastic demand, and a variety of potential international events that could cause sharp increases in oil prices. OPEC's recent action to raise prices is a case in point. This could have a greater effect on oil prices as the Asian economies recover and their demand increases.

Coal offers an alternative in greater supply and is available from U.S. sources, but at the cost of greater greenhouse gas emissions. While it would be theoretically possible to substitute LNG for all Hawaii energy uses except aviation and international shipping, cost and safety issues appear at this time to preclude that option.

Additional use of naphtha and SNG would diversify Hawaii's fuels, and provide greater in-State use of oil already brought in for refining. SNG use, in particular, produces less greenhouse gas per unit of energy as well as reducing the environmental risks associated with exporting excess naphtha because naphtha is used as the feedstock for SNG production. Fuel switching from electricity to SNG or LPG could delay the need to build new electricity generation. Fuel switching from gas to electricity should also be considered where it offers greater efficiency.

Should oil prices rise, renewable resources will become more cost effective. However, Hawaii's small, isolated electricity grids and current lack of inexpensive electricity storage options impose constraints on the use of intermittent renewable electricity generation. Geothermal, landfill methane, MSW, and biomass are the only potential baseload renewable sources. Biomass conversion into alcohol fuels or renewable fuels for electricity generation for electric vehicles appear to be the only current options for renewable transportation fuels. Hawaii continues to face major uncertainties about the price of oil. At current, relatively low prices, energy companies have not sought to ensure future supply through greater reliance on renewable resources.

CHAPTER 4 ENERGY FOR GROUND TRANSPORTATION

4.1 Ground Transportation in Hawaii

This chapter examines energy use by ground transportation in Hawaii, factors that influence demand, and alternative transportation fuels. Energy demand in the transportation sector is based upon the number and types of vehicles in use, and how many miles these vehicles travel. The increased use of pickup trucks and sport utility vehicles in place of passenger vehicles and increased travel distances as residential development and job growth occur in different areas have caused increased ground transportation fuel use in Hawaii and nationally.

In 1997 there were 884,267 motor vehicles registered in Hawaii (Table 4.1). This number was 1.4% below the statewide 1991 peak of 897,193 vehicles. Table A.12, in Appendix A, depicts the numbers of registered motor vehicles by county, from 1990 to 1997. Most of these vehicles were classed as passenger vehicles, a category that includes vans, pickups, and other trucks weighing less than 6,500 pounds and in personal use.

Table 4.1 Motor Vehicle Registrations by Type and by County, 1997

Type of Vehicle	City and County of Honolulu	County of Hawaii	County of Kauai	County of Maui	State Total
Passenger	484,761	90,281	39,078	90,573	704,693
Ambulances	30	14	-	10	54
Buses	2,633	240	25	328	3,226
Trucks	95,102	25,393	14,027	23,935	158,457
Truck Tractors	201	103	42	111	457
Truck Cranes	112	16	13	79	220
Motorcycles, Motorscooters	12,282	2,317	719	1,842	17,160
Total	595,121	118,364	53,904	116,878	884,267

DBEDT 1998e, Table 18.08

4.2 Ground Transportation Fuel Demand

4.2.1 Current Ground Transportation Fuel Use

Although the number of registered vehicles in Hawaii declined during the period 1990–1997, and the estimated vehicle miles traveled declined slightly, highway fuel use (which included gasoline, diesel, and LPG) increased. Gasoline use increased 6.7%, and diesel use increased 21.6%, but LPG highway use declined 61%. Table A.13 shows estimated Hawaii ground transportation activity and energy use between 1990 and 1997.

Hawaii's estimated average highway vehicle fuel efficiency declined from 20 mpg in 1990 to 18.4 mpg in 1997, a 7.8% decline. This was despite the increased federal Corporate Average Fuel Efficiency (CAFE) standards for newer vehicles, whose number grew in relation to the total fleet of registered vehicles each year. New vehicles registered in Hawaii were, on average, less efficient than the CAFE standard. Table 4.2 compares vehicle miles traveled (VMT), highway fuel use, and estimated average vehicle efficiency by County. Trends are shown in Figure 4.1. In Figure 4.1, registered vehicles, estimated VMT, highway fuel use, and de facto population[a] are all indexed to their 1990 values (1990 = 1.0 as the base year).

Table 4.2 Vehicle Miles Traveled, Fuel Use, and Average Fuel Efficiency by County, 1997

	City and County of Honolulu	County of Hawaii	County of Kauai	County of Maui	State Total
Vehicle Miles Traveled					
Miles (000)	5,225,200	1,161,500	570,300	1,046,000	8,003,000
Highway Fuel Used (000 Gallons)					
Gasoline	262,768	61,441	23,364	52,863	400,436
Diesel	19,229	5,718	1,419	3,743	30,109
LPG	277	16	13	21	327
Highway Fuel Use (Gasoline-Equivalent)					
Gallons (000)	284,302	67,794	24,947	57,030	434,073
Estimated Average Vehicle Fuel Efficiency					
Miles per Gallon	18.4	17.1	22.9	18.3	18.4

DBEDT 1998, Tables 17.18 and 18.18

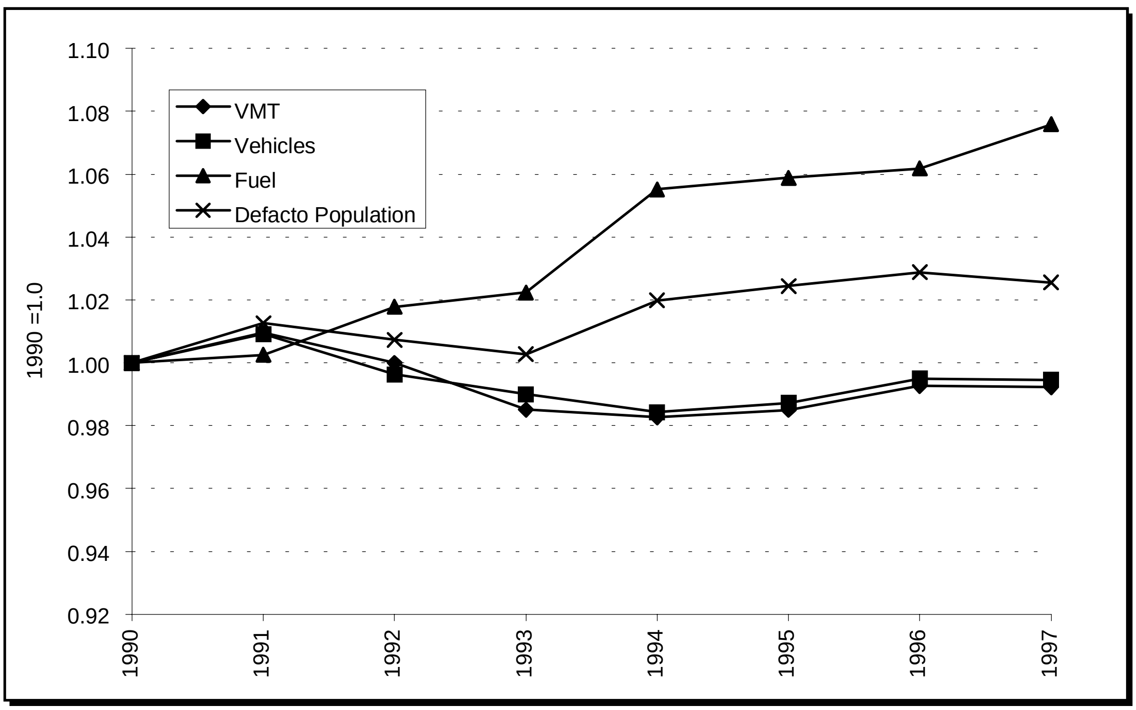


Figure 4.1 Hawaii Registered Vehicles, Estimated VMT, and Fuel Use Compared with De Facto Population, 1990–1997

There was a decline in the number of vehicles between 1990 and 1997, and the trend in estimated VMT was similarly downward, but within a narrow range. Fuel

[a] Resident population plus average number of visitors

use for all three fuels grew 7.6% in total Btu value, a greater increase than the nominal 2.6% growth in the de facto population.

4.2.2 Future Ground Transportation Fuel Demand

The ENERGY 2020 model was used to estimate Hawaii's future demand for transportation fuels from the year 2000 to 2020. As shown on Figure 4.2, highway gasoline use is estimated to grow from 54.9 TBtu in 2000 to 72.7 TBtu in 2020, a 32% increase. Over the same period, highway diesel use is estimated to decline by 4%, from 1.09 TBtu in 2000 to 1.04 TBtu in 2020.

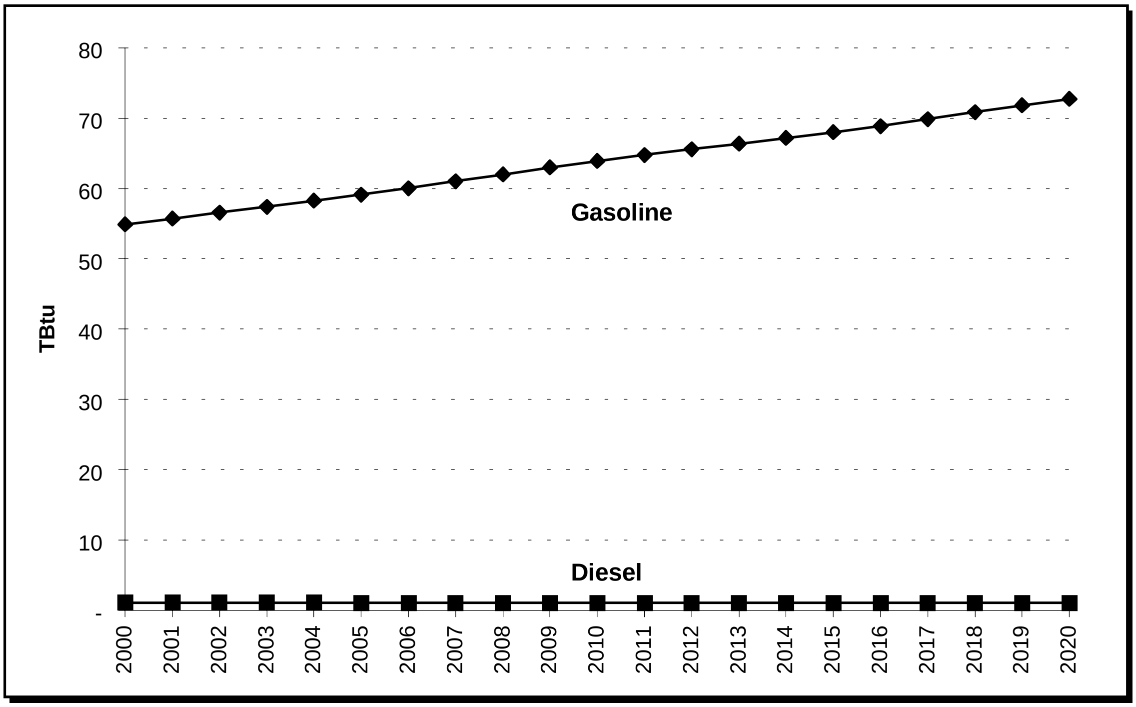


Figure 4.2 Estimated Highway Gasoline and Diesel Use in Hawaii, 2000–2020

4.3 Greenhouse Gas Emissions from Ground Transportation Fuel Use

Figure 4.3 shows historical and estimated CO_2 emissions from ground transportation fuel use from 1990 to 2020. Unless there is greater efficiency in the ground transportation sector, increased use of alternative transportation fuels, or both, CO_2 emissions from this sector in the year 2010 will be 16% greater than they were in 1990 and 20% greater than the Kyoto target. The comparison with the Kyoto target is made for reference only. It is not expected that any sector or any state will be required to meet the Kyoto standard independently of overall national efforts, should the United States ratify the treaty.

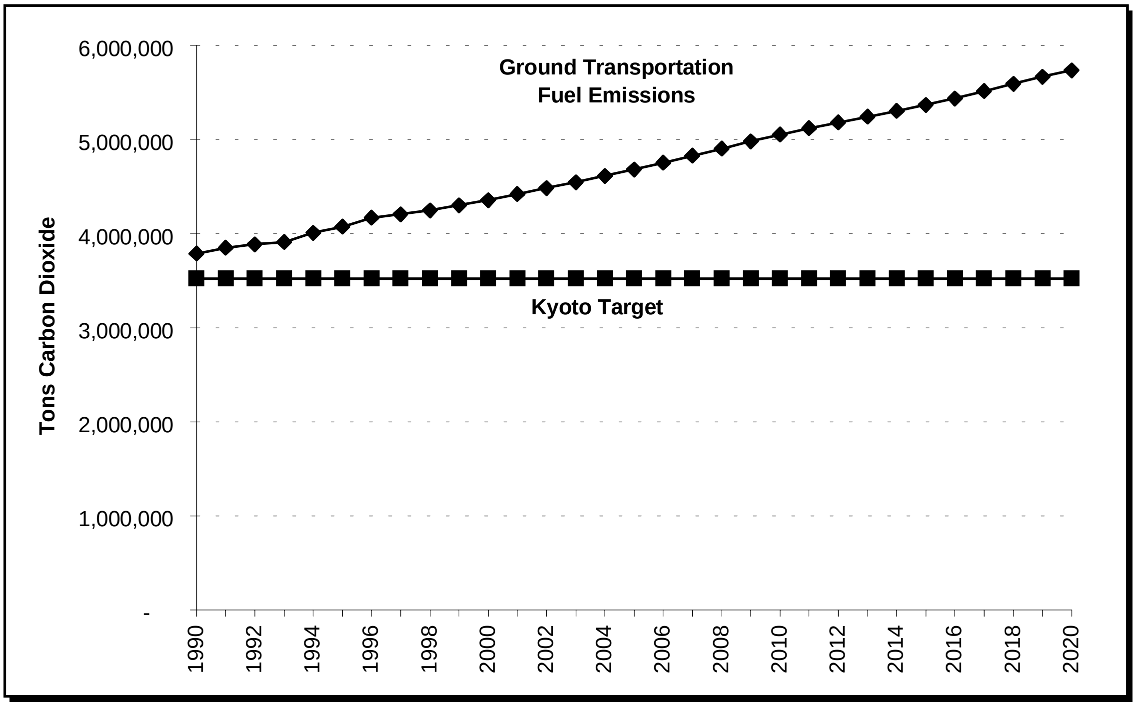


Figure 4.3 Estimated CO_2 Emissions from Ground Transportation Fuel Use in Hawaii, 1990–2020

4.4 Economic Effects of Ground Transportation Fuel Use

Based upon the Bureau of Labor Statistics Honolulu Consumer Price Index, the average Honolulu resident expended 3.02% of his or her total expenditures on motor fuel (DBEDT 1998e, 388–389). The U.S. Energy Information Administration (EIA) estimated this to be about $679 million in 1995 (EIA 1998, 91). A significant portion of this money left the state. If locally produced alcohol fuels or electricity for electric vehicles produced from renewable resources had been available to supply a portion of that demand, expenditures for the locally produced fuels might have contributed more to the growth of the State's economy.

4.5 Reducing Ground Transportation Energy Demand

The following sections offer recommendations as to how ground transportation energy demand can be reduced, with potential benefits to Hawaii's environment, economy, and people.

4.5.1 Improving the Fuel Efficiency of the Hawaii Vehicle Fleet

One means of decreasing energy demand and greenhouse gas emissions in the ground transportation sector would be to increase the average fuel efficiency of vehicles operating in Hawaii. The following recommendations are intended to improve fuel efficiency.

4.5.1.1 RECOMMENDATION: Consider Increasing the Visibility of Driving Costs

Suggested Lead Organization: Legislature, DBEDT and DOH

The federal law setting CAFE standards (Title V of the Motor Vehicle Information and Cost Savings Act, 15 U.S.C. 2001-2013) preempts states from setting their own fuel efficiency standards. However, states can encourage the purchase of more fuel-efficient vehicles indirectly by increasing the proportion of driving costs paid through assessments on fuels. For example, highway maintenance is now partially financed through state fuel taxes. Traffic law enforcement and liability insurance could also be financed through pay-at-the-pump systems. Such actions would internalize the costs of driving in the gasoline price. These matters are policy decisions within the purview of the Legislature and are recommended for consideration. The apparent fuel cost would be increased (while actual driving costs to many motorists might be reduced), which would make drivers more aware of their own fuel use. This may encourage some drivers to give greater consideration to fuel economy in the purchase of vehicles.

4.5.1.2 RECOMMENDATION: Increase Information on the Environmental Costs of Vehicle Fuel Use through a New Environmental Impact Information Sheet

Suggested Lead Organizations: Legislature, DBEDT and DOH

If the CAFE standards were effective, Hawaii's vehicle fleet would be more efficient than it was in 1990. Newer vehicles, overall, should have greater average fuel economy, and this should be reflected in lower fuel use per registered vehicle.

The Current Vehicle Fleet Does Not Meet CAFE Standards. Table 4.3, depicts the 20 best-selling automobiles and light trucks in Hawaii in 1998. These models accounted for 1/3 of the 93,110 vehicles sold in that year, and of these, pickup trucks or minivans made up 28.5% (PBN 1999). As a result, overall fuel economy of the national vehicle fleet did not improve. Since increased fuel use per vehicle in Hawaii was also suggested by available data, it appears that Hawaii vehicle sales may be following the national trend to less fuel-efficient vehicles.

The CAFE standard was 27.5 mpg for automobiles and 20.7 mpg for trucks. The over 40,000 automobiles purchased in Hawaii in 1998 averaged 27.3 mpg, or 99.4% of the CAFE standard. The 27,700 light trucks, vans, and sport utility vehicles sold averaged 19.4 mpg, or 93.8% of the CAFE standard. Together, the 1998 sales-weighted average fuel economy of all new vehicles sold in Hawaii was 25 mpg, or 98.2% of the sales weighted CAFE standard of 25.5. Thus, in 1998, Hawaii vehicle buyers chose vehicles that, all together, were less efficient than the CAFE standard, despite high gasoline prices. A flattening in reported fuel use suggests that recent purchases may have generally been more efficient overall than in previous years.

Table 4.3 Fuel Economy and CO_2 Emissions of Top 20 Vehicles in Sales in Hawaii, 1998

Make and Model	Total Sold	Average MPG	Tons CO2 per 10,000 mi.	Gallons per 10,000 mi.
Dodge/Plymouth Neon[a]	**3,235**	**31.8**	**3.1**	**315**
Toyota Camry	2,196	25.3	3.8	396
Toyota Corolla	**2,160**	**33.1**	**2.9**	**302**
Nissan Altima	1,893	26.0	3.7	385
Honda Civic	**1,817**	**38.4**	**2.5**	**261**
Ford Escort	**1,711**	**30.8**	**3.2**	**325**
Honda Accord	1,665	26.8	3.6	374
Ford RANGER[b]	**1,556**	**23.5**	**4.1**	**426**
Ford Mustang	1,473	22.5	4.3	445
Dodge CARAVAN	**1,446**	**21.7**	**4.5**	**461**
Chevrolet Cavalier	1,355	26.7	3.6	374
Ford WINDSTAR	1,327	19.9	4.9	502
Ford EXPLORER	1,213	18.2	5.3	550
Dodge Stratus	**1,146**	**29.8**	**3.3**	**336**
Chevrolet Malibu	1,096	25.5	3.8	392
Jeep GRAND CHEROKEE	1,093	18.9	5.1	528
Pontiac Grand Am	1,052	25.7	3.8	389
Jeep WRANGLER	1,043	18.7	5.2	535
Toyota 4RUNNER	**1,021**	**21.2**	**4.6**	**472**
Ford Taurus	1,017	21.4	4.5	466

Source: The Polk Company via *Pacific Business News*, 1999

[a] Fuel economy of models in boldface was better than the CAFE standard in their category.
[b] Models in all caps are light trucks, vans, and sport utility vehicles.

In aggregate, the 20 top-selling vehicles averaged 24.1 mpg. The Table also shows the estimated CO_2 emissions per vehicle, based upon driving 10,000 miles per year. Such information could be made available to vehicle shoppers for consideration in making purchase decisions.

The Current Fuel Economy Label. Vehicle shoppers may not consider relative fuel efficiency between vehicle options beyond the cost of the fuel, which is now relatively low. The Fuel Economy Label includes estimates of gasoline mileage, an estimated range of fuel economy that most drivers achieve with the particular model, estimated annual fuel cost, and the range of fuel economy for other models of the same vehicle size class (USDOE 1996, 12).

The Proposed Environmental Impact Information Sheet (EIIS). Vehicle buyers could be provided additional information regarding the greenhouse gas emissions of each type of vehicle. The EIIS would include the current information supplemented with information on the vehicle's estimated contribution to global warming per mile and for a typical year's operation. These values would be compared on the EIIS with the current CAFE standard. This additional information would enable consumers to choose vehicles that would improve the fuel efficiency of the U.S. and Hawaii vehicle fleets and reduce their personal contribution to greenhouse gas emissions.

4.5.1.3 RECOMMENDATION: Encourage Purchase and Use of Fuel-Efficient Conventional Vehicles and Hybrid Vehicles

Suggested Lead Organization: Vehicle Dealers

Two manufacturers intend to begin selling hybrid vehicles capable of 60 to 80 mpg in the near future. These hybrid vehicles use a small gasoline e***n***gine to charge batteries for an electric motor that drives the vehicle. The use of hybrid and high-efficiency gasoline vehicles by Hawaii motorists will help reduce ground greenhouse gas emissions from transportation fuel use.

4.5.2 Reducing Fuel Use

The following recommendations are intended to reduce fuel use, decreasing Hawaii's dependence on imported oil and its negative effects on Hawaii's environment.

4.5.2.1 RECOMMENDATION to Reduce Fuel Use: Continue Efforts to Increase Use of Mass Transit

Suggested Lead Organization: City and County of Honolulu and other Counties

Oahu's mass transit system consists of a fleet of 525 buses, which carried over 74.4 million passengers in 1997 (DBEDT 1998e). As part of the City and County's *Oahu Trans 2K* planning, now ongoing and soliciting public input, the City proposes a high-capacity electric trolley system throughout the primary urban center with easy access parking facilities served by the trolleys at all peripheral entrance points to downtown. Expanded fleets of express buses to bring residents from Central Oahu and other outlying districts to downtown on dedicated bus lanes would interface with the trolley system (C&C 1998b).

In addition, based upon the earlier Oahu Regional Transportation Plan (Kaku Associates 1995), the City is enlarging the bus fleet to about 715 vehicles. Buses will be supplemented by 125 Handi-Vans (Table A-3b). The bus and trolley system would be also supplemented by planned additional vanpools and water taxis and ferries under the *Oahu Trans 2K Plan*.

4.5.2.2 RECOMMENDATION: Improve the Bicycle Transportation System

Suggested Lead Organizations: State Department of Transportation and the Counties

There has been considerable interest in increased use of bicycles in the counties and at the State level. Bicycles do not use fossil fuels and do not produce greenhouse gas emissions. The bicycle racks recently added to City buses in Honolulu are frequently used, indicating that the combination of individual mobility and mass transit is effective. However, statewide there are few bicycle lanes, making bicycling difficult and – and in many cases dangerous. The state and counties have developed plans for increasing the number and safety of bicycle lanes and paths. Action should be taken to improve the bicycle transportation system. (See DOT 1994, C&C 1998a, Kaku Associates 1997, and F. Harris 1998)

4.5.2.3 RECOMMENDATION: Use Land Use Planning to Reduce Congestion and Need for Transportation

Suggested Lead Organizations: State Land Use Commission, Office of Planning, Department of Land and Natural Resources, Department of Transportation, and the Counties

Mixed-use development plans, in which residential and commercial land uses are allowed in the same neighborhood, can reduce the need for commuting from residential districts to commercial districts. The State of Hawaii and the City and County of Honolulu appear to be moving in directions supportive of this recommendation as outlined in Mayor Harris' *21st Century Oahu – A Shared Vision for the Future, Oahu Vision Presentation* (Mayor Harris 1998). By reducing congestion and the need for transportation, less vehicle fuel will be used and less greenhouse gas emission will occur.

4.5.2.4 RECOMMENDATION: Reduce Congestion Through the Use of Transportation Control Measures

Suggested Lead Organizations: Department of Transportation, Oahu Metropolitan Planning Organization, and Counties

Transportation Control Measures. Transportation control measures (TCMs) improve the efficiency of the transportation system and reduce transportation demand. Those measures that emphasize improving the operating efficiency and maximizing the capacity of the existing transportation system often address localized concerns and may help reduce congestion. These measures focus on the “supply side” of transportation service (PBQD 1995, 3-1).

In theory, improved transportation efficiency should result in reduced fuel use; however, when congestion is reduced and the system performs better, additional trips are typically generated. In addition, the energy efficiency of internal combustion engine vehicles varies in a nonlinear fashion with vehicle speed. At a speed specific to each vehicle, but often around 25–35 mph for a passenger car, maximum fuel efficiency is attained. Therefore, if transportation system management measures result in a change in average speeds, average fuel efficiency could increase or decrease (3-1 to 3-2).

In *HES 1995*’s Project 5,*Transportation Energy Strategy*, it was estimated that 10% of the fuel making up the ground-sector transportation energy demand on Oahu was wasted due to congestion (3-2). In 1997, that would have resulted in about 390,000 tons of CO_2 emissions as idling vehicles burned gasoline and diesel fuel.

Where the transportation control measures reduce the demand for transportation, they can help reduce greenhouse gas emissions because fuels are not used to move people or things – or people or things do not need to be moved as far. Demand-side transportation control measures include land-use planning, telecommuting, and schedule changes (e.g., going from a five-day workweek to a four-day workweek).

Transportation Control Measures in Hawaii. The *2020 Oahu Regional Transportation Plan* considered a wide range of TCMs and adopted many of them. (For a more detailed discussion of possible TCMs, please see *the HES 1995*, Project 5, *Transportation Energy Strategy* [PBQD 1995]). The measures planned for implementation through 2000 were as follows:

- High Occupancy Vehicle (HOV) facilities and enforcement;
- Park-and-Ride lots;
- Rideshare programs;
- Increased telecommuting, encouragement of flexible work hours, and compressed work weeks;
- Public transit support such as transit pass subsidies and public transit marketing;
- Mandating preparation and implementation of trip reduction plans by developers and employers;
- Bicycle facilities; and
- Improved pedestrian facilities (Kaku Assoc. 1995, Table A-1c).
- Parking management measures that would reduce the attractiveness of commuting by automobile by making parking less available and more costly (Table A-2c, 3c).

4.5.2.5 RECOMMENDATION: Develop Estimates of the Energy- and Emission-Saving Effectiveness of TCMs

Suggested Lead Organizations: Department of Transportation, Oahu Metropolitan Planning Organization, and the Counties

TCMs are designed to affect travel performance. Energy saving could be a by-product but is not usually a primary goal. It is quite difficult to determine the energy effectiveness of the many TCMs included above. Those measures that show the greatest energy-saving potential in the short- and mid-term operate by reducing total regional VMT through travel mode shifts away from single occupant vehicles, or by decreasing the need for travel. The potential energy savings associated with certain combinations of TCMs may be as much 18% less than previously estimated for by 2020 (PBQD 1995, 3-50). Additional efforts to analyze and model TCMs are recommended.

4.6 Alternative Fuels for Ground Transportation

Alternative transportation fuels could reduce demand for gasoline and diesel fuel in the ground transportation sector. This could provide a certain amount of diversification of fuel demand as well as create a market for locally produced fuels and fuel feedstocks. These alternative fuels and relevant laws, incentives, and programs are discussed in this section.

4.6.1 Alternative Fuels

Alternative ground transportation fuels include alcohol fuels (methanol and ethanol), propane, natural gas, electricity, biodiesel, and hydrogen. Table 4.4 introduces the alternative fuels.

4.6.2 Encouraging Production and Use of Alternative Fuels in Hawaii

4.6.2.1 RECOMMENDATION: Publicize Incentives for Ownership of Alternative Fuel Vehicles (AFVs)

Suggested Lead Organization: DBEDT and the Counties

Hawaii laws offer incentives to own and operate AFVs:

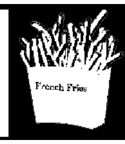
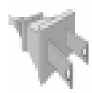
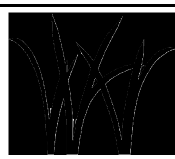
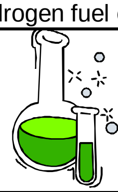
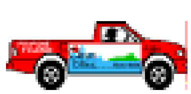
- The state fuel tax on propane is 11¢ per gallon (compared to 16¢ per gallon for diesel);
- Electric vehicles (identified by special license plates) may park free at parking meters and use HOV lanes at any time;
- The cost of equipment to dispense "clean fuel" is tax deductible; and
- AFVs are exempt from vehicle registration fees until 2000.

4.6.2.2 RECOMMENDATION: Encourage Production and Sale of 10% Ethanol Blend Gasoline in Hawaii

Suggested Lead Organizations: DBEDT through formal rule making and Department of Agriculture

Alcohol fuels are not currently available in Hawaii, but there has been a great deal of discussion over the years about producing alcohol fuels in Hawaii. Cost estimates for an aggressive alcohol fuels program were made as part of the *Hawaii Energy Strategy's Project 5, Transportation Energy Strategy* (PBQD 1995). Legislation enacted in 1994 stated that "gasoline in Hawaii shall contain ten percent ethanol by volume" with details to be addressed through a formal rule making process under the direction of the Department of Business, Economic,

Table 4.4 Alternative Ground Transportation Fuels

Fuel	Description
Biodiesel	 A substitute for diesel fuel. Limited quantities are made from vegetable oil (including used cooking oil) in Hawaii. Can also be made from microalgae, rapeseed, and other plants. Used in boats, buses, and large trucks.
Electricity (for "electric vehicles")	 An electric vehicle has an electric motor instead of an internal combustion engine. Electricity for the motor comes from batteries or fuel cells. Since there's no combustion happening on the vehicle, electric vehicles are "zero emission," quiet, and cool. Electricity is made in Hawaii and can be produced from renewable resources.
Ethanol	 An alcohol fuel made from corn or sugar cane. Techniques are under development to make ethanol from waste paper, sawdust, and other low-cost materials. Ethanol is a liquid fuel that can be used in an internal combustion engine or a fuel cell. Ethanol could be made in Hawaii.
Fuel Cells (not commercially available in vehicles)	Fuel cells vehicles use various liquid or gaseous fuels in an electrochemical process to deliver electricity to an electric motor. Thus, they are a form of electric vehicle that could be re-fueled with alternative fuels (ethanol, methanol, or hydrogen, for example). This is attractive since re-fueling is faster than re-charging. The technology is still in the research and development stage.
Hydrogen (not commercially available as a vehicle fuel)	Hydrogen is being considered for use in fuel cells and has been used in internal combustion engines. The main obstacle is fuel distribution and storage, both on and off the vehicle. Vehicles are still in the research and development stage. Hydrogen fuel could be made in Hawaii.
Methanol	 An alcohol fuel made from natural gas. It could also be made from landfill gas, bagasse, or wood chips. Methanol is a liquid fuel that can be used in an internal combustion engine or a fuel cell. Methanol could be made in Hawaii.
Natural gas	Not commercially available in Hawaii. Synthetic natural gas is made from refinery byproducts on Oahu. It has a different composition from the natural gas used on the Mainland. Also, Hawaii's synthetic natural gas is only available in a limited area of Oahu (neighbor islands and other areas of Oahu use propane instead).
Propane (also known as "LPG", or liquefied petroleum gas)	 Propane, which is made on Oahu from refinery byproducts, is more practical than natural gas for Hawaii and is available statewide. Propane vehicles have been in use in Hawaii for many years. The fuel is made in Hawaii from imported petroleum.
Solar Cars	Although fun for racing, a typical solar car requires solar panels that would be too big to be practical (the car wouldn't fit in a normal lane or parking space). But a car doesn't have to carry solar cells with it – an electric car can plug into solar panels installed on a carport or garage roof, and charge up while parked in the shade.

Development, and Tourism" (Chapter 486-10j, HRS). The preliminary work is underway in preparation for the necessary formal rule making. One concern is the current lack of local ethanol fuel production, which is needed to keep economic advantages of ethanol use largely within the State. Various developers continue to evaluate the feasibility of projects.

4.6.2.3 RECOMMENDATION: Encourage Early Deployment of Electric Vehicles in Hawaii

Suggested Lead Organization: DBEDT, the Counties, Electric Utilities, and Hawaii Electric Vehicle Demonstration Program

Honolulu is becoming the first "electric vehicle-ready" city in the United States, as Hawaiian Electric Company installs a network of up to 20 electric Rapid-Charger stations where electric vehicles can be recharged in less than nine minutes. This will be an important element of infrastructure to support deployment of electric vehicles. Early deployment of electric vehicles will help reduce greenhouse gas emissions. In addition, nighttime charging of electric vehicles could help improve the efficiency of electric utility systems by increasing base load levels. Base load utility operations produce less greenhouse gas emissions per kWh generated than peak load and cycling operations. (HECO 1998).

Encourage Electric Vehicle Manufacturers to Offer Electric Vehicles for Sale. Hawaii offers an ideal place for electric vehicle use. The temperate climate reduces thermal management problems and the geographic limits of islands guarantee that no driver could ever stray beyond a network of charging stations. The charging station network will make operation anywhere on Oahu possible. Most commuters' round trips are within the range offered by current battery technology. Because Hawaii motorists do not need a car capable of interstate vacation trips, they may purchase electric vehicles as their primary vehicle. Hawaii also offers a marketing opportunity for rental car agencies and electric vehicle manufacturers. Rental agencies can offer a unique and exciting vehicle option while providing manufacturers the opportunity to show off their electric vehicles to new customers (HECO 1998).

Expand Hawaii Electric Vehicle Demonstration Project. The Hawaii Electric Vehicle Demonstration Project (HEVDP) is a consortium established initially through a federal grant from the United States Department of Defense, Advanced Research Projects Agency, to facilitate the development of electric vehicle technologies in the State, for both commercial and military applications. HEVDP has deployed nearly 40 electric vehicles on Hawaii's roads. These are operated primarily by the military, the State, and the electric utilities. Vehicles include pickup trucks, automobiles, buses, and a specialized industrial vehicle. In addition, E Noa Tours operates an electric "Waikiki Trolley" (Quinn 1998). HEVDP is also coordinating the Rapid Charger program.

4.6.2.4 RECOMMENDATION: Continue to Assist Fleets in Complying with EPACT Requirements for Alternative Fuel Vehicles

Suggested Lead Organization: DBEDT

In 1992, the National Energy Policy Act (EPACT) became law. This law required fleets of more than 20 centrally fueled light-duty vehicles located in metropolitan areas (in Hawaii, only Oahu is included) to purchase "alternative fueled vehicles." The percentages of new vehicles purchased each year that must be alternative fuel vehicles are as shown on Table 4.5.

Alternative fuels permitted by EPACT are alcohol fuels, natural gas, liquefied petroleum gas (also known as LPG or propane), hydrogen, biodiesel, coal derived fuels, fuels derived from biological materials, and electricity. EPACT also provides tax incentives for AFV purchases, conversions, and the installation of "clean fuel"

Table 4.5 EPACT Requirements for AFV Percentages in Fleets, 1997-2006

Model Year	Federal Gov't	State Gov't	Municipal Gov't & Private Fleets	Fuel Provider
1997	25%	10%		50%
1998	33%	15%		70%
1999	50%	25%		90%
2000	75%	50%		90%
2001	75%	75%		90%
2002	75%	75%	20%	90%
2003	75%	75%	40%	90%
2004	75%	75%	60%	90%
2005	75%	75%	70%	90%
2006	75%	75%	70%	90%

dispensing equipment (PL 102-486). An amendment allows 20% biodiesel and 80% diesel blends to be used to offset up to 50% of a fleet's light-duty vehicle purchase requirements (PL 105-388).

4.6.2.5 RECOMMENDATION: Support Honolulu Clean Cities Program

Suggested Lead Organizations: City and County of Honolulu, DBEDT, and other participants

Honolulu Clean Cities is part of the nation-wide Clean Cities program sponsored by the U.S. Department of Energy. The program promotes use of alternative transportation fuels. The twenty-seven organizations participating in the Honolulu Clean Cities Program include County, State, and federal government agencies, fuel suppliers, fleets, and industry and community organizations.

The primary activities of Honolulu Clean Cities include alternative fuel vehicle displays at public events; ride-and-drive events for fleet managers, the media, and decision-makers; development of an alternative fuels activity book for children; publication and distribution of an alternative fuels newsletter for fleet managers and decision-makers; development of programs to convert vehicles and to share information among participants' own fleets; development of joint fueling arrangements; and training.

CHAPTER 5 ENERGY FOR AIR TRANSPORTATION

5.1 Air Transportation and Hawaii

Air transportation is vital to Hawaii. Overseas air transportation is essential to Hawaii's tourism-based economy, providing transportation to millions of visitors annually. Overseas air transportation is the only regular passenger connection to the mainland United States and international destinations for Hawaii's citizens.

Interisland air transportation is equally critical. It is the only passenger connection between Hawaii's islands for residents and visitors alike. As Hawaiian Airlines aptly noted, "One-third of this market is represented by residents of Hawaii who rely on interisland flights in much the same way as Mainland residents rely on a state highway system" (Hawaiian Airlines 1997).

The importance of air transportation in Hawaii is borne out by comparing its jet fuel use in 1995 to other states. Hawaii ranked 40th nationally in population, but 8th in the amount of jet fuel used. On a per capita basis, Hawaii (14.76 Bbl per capita) ranked second to Alaska (28.03 Bbl per capita) (DBEDT 1999 and EIA 1997).

The significance of air transportation is further highlighted by the fact that four Hawaii city-pairs rank in the top 22 airline markets in the United States. Honolulu-Kahului is ranked 2nd, Honolulu-Lihue is 15th, Honolulu-Kona is 21st, and Honolulu-Hilo is 22nd. Among overseas routes, Honolulu-Los Angeles is the 19th busiest domestic city-pair market and Honolulu-Tokyo is the 6th most traveled international city-pair market (Lampl 1997).

5.1.1 Interisland Airlines

Aloha Airlines and Hawaiian Airlines are Hawaii's primary interisland carriers. Currently, Aloha operates 18 Boeing 737-200 aircraft. The Hawaiian Airlines fleet includes 15 DC-9-50 aircraft in its interisland operations. In addition, Hawaiian has 12 DC-10-10 aircraft used in scheduled service to the mainland United States and South Pacific destinations (Carey 1999). Four other small passenger carriers operate smaller aircraft. One of these small carriers is Island Air, a subsidiary of Aloha Airlines. Island Air operates DeHavilland Dash-6 and Dash-8 turboprop aircraft.

Interisland passengers numbered 10,448,099 in 1997, up 5.5% from 1990 levels. This represented a decline of 133,726 (1.2%) from the 1996 peak of 10,581,825 passengers (DBEDT 1998f). Additional detail is provided on Table A-14 in Appendix A.

The aggregate interisland load factor for Aloha Airlines and Hawaiian Air increased by 5% from 57.3% in 1990 to 60.1% in 1996. About 3% less fuel was used to provide the increased service, increasing the average available seat miles per gallon (ASM/gallon) to 27.3.

While Mainland airlines with newer equipment and longer routes achieve over twice the ASM per gallon, the shorter flights of the interisland carriers are inherently less efficient. These short flights require high fuel use for takeoff and climb to cruising altitude that is not amortized by long cruise and descent segments, which characterize many longer Mainland routes operating similar equipment. As Table 5.1 shows, the lengths of interisland flights range from 54 to 214 statute miles (DBEDT 1998f). As noted above, the 98-mile Honolulu-Kahului city-pair has the second highest volume of all city-pairs in the United States (Lampl 1997).

Table 5.1 Distances from Honolulu International Airport

Airport	Statute Miles
Hilo Airport, Hawaii	214
Kona Int'l Airport, Hawaii	168
Lihue Airport, Kauai	103
Kahului Airport, Maui	98
Lanai Airport, Lanai	72
Molokai Airport, Molokai	54

DBEDT 1998e

5.1.2 Overseas Air Transportation

In 1997, there were 25 carriers conducting overseas operations to and from Hawaii. Twelve were domestic carriers and 13 were foreign carriers (DBEDT 1998f). Since 1990, overseas air carriers operating between Hawaii and the mainland United States and a variety of international destinations have increased their load factors. During the 1990s, the number of estimated westbound arrivals decreased by 1% and eastbound arrivals decreased by 3%. While the reduced numbers of passengers have had negative effects on Hawaii’s tourism industry, the increased load factors, coupled with increased efficiency as newer aircraft are used on Hawaii routes, has increased fuel efficiency and reduced greenhouse gas emissions.

Table A.15 provides an estimate of the number of available seats and passengers between overseas destinations and Hawaii based upon U.S. Department of Transportation data compiled by BACK Information Services. The data included revenue passengers on virtually all scheduled airline flights, but did not include charter flights. Since anecdotal information indicates that many westbound passengers come to Hawaii using frequent flyer benefits, the load factors are likely understated. Based upon the available data, the average load factor of overseas flights to Hawaii improved by 7% from 1990 to 1997.

Load factors on routes to and from Hawaii are high compared to overall U.S. airline load factors, which averaged 69% in 1996. In addition, according to information compiled by DBEDT economist Chris Grandy, monthly westbound load factors were 90% or greater for eight months over the three years 1995–1997 (Grandy 1999). When non-revenue passengers are considered, it appears that any future improvements in fuel efficiency on westbound overseas routes will have to come primarily through the use of more efficient aircraft or improved operating techniques. In addition, traffic growth can be expected to partially offset reductions in greenhouse emissions achieved through greater efficiency.

5.2 Air Transportation Energy Demand

5.2.1 Current Aviation Fuel Use

In 1997, 8.442 million barrels of domestic jet fuel were used by civilian scheduled airlines on interisland flights and flights between Hawaii and the mainland United States. Piston-engine aircraft operating in Hawaii used about 32,000 barrels of aviation gasoline. Air carriers on international operations used 8.901 million barrels of bonded jet fuel. The military purchased 735,290 barrels of jet fuel from Hawaii refiners or distributors, but that fuel was not necessarily used by Hawaii-based aircraft. In this report, as in the *Hawaii Climate Change Action Plan* (DBEDT 1998b), only domestic jet fuel and aviation gasoline were used in calculating total Hawaii greenhouse gas emissions. Table A.16 details estimated jet fuel use or sales in each of these categories for the years 1990–1997.

5.2.2 Future Aviation Fuel Requirements

This section provides an estimate, produced by the ENERGY 2020 model, for future civilian jet fuel use for both domestic and international operations. Since military jet fuel purchases from Hawaii refiners followed no consistent pattern in recent years, such purchases were not estimated. Aviation gasoline use was small and was not estimated.

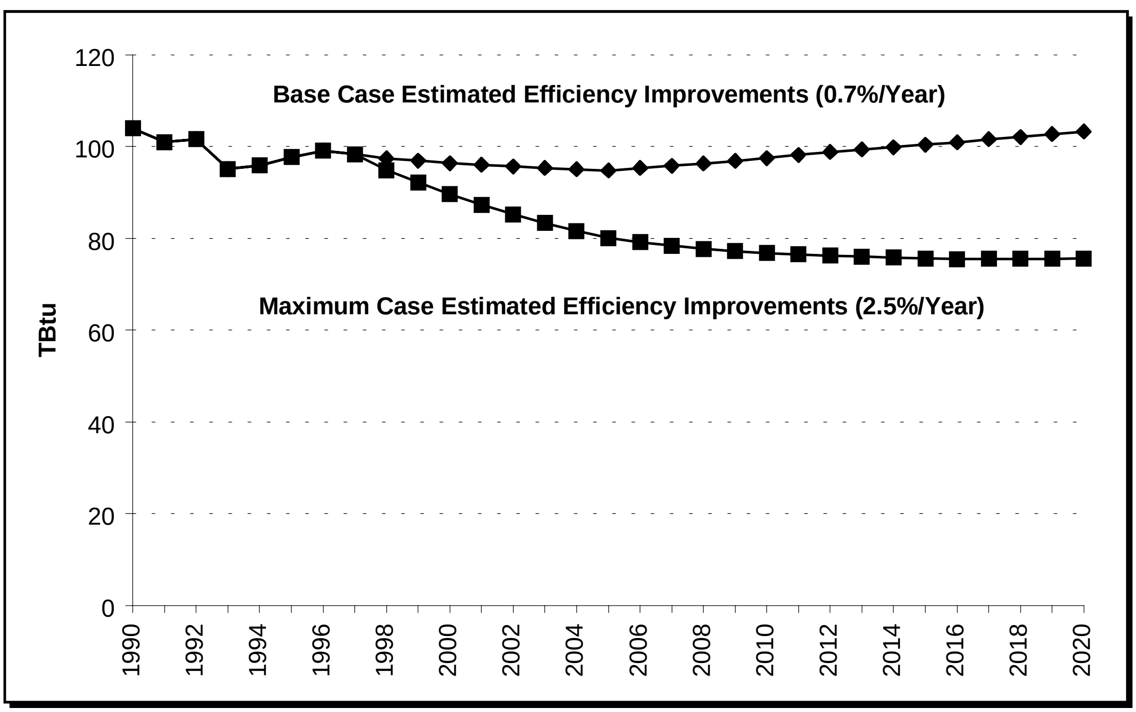


Figure 5.1 Actual and Forecast Jet Fuel Sold or Distributed in Hawaii for Civilian Use, 1990–2020

Figure 5.1 shows forecast amounts of jet fuel sold or distributed in Hawaii for civilian use from 2000 to 2020. The base case efficiency estimate was based on the USDOE best estimate of an average efficiency improvement of 0.7% per year starting in 1998. About 103.9 TBtu of jet fuel were required in 1990. Although efficiency improved, growth in traffic overcame most of the efficiency improvements in the base case, resulting in an estimated need for 103.2 TBtu in 2020, a value 99% of the 1990 level.

If maximum estimated efficiency improvements occur (on the order of 2.5% per year), jet fuel use would decline from 103.9 TBtu in 1990 to 75.6 TBtu in 2020, a 27% decrease. Maximum forecast aircraft efficiency improvements could reduce civilian jet fuel demand in Hawaii by as much as 28.4 TBtu, less than the base case, by 2020. This could have significant implications for Hawaii refiners, which maximize jet fuel production, and for consumers of other refined products. It would also significantly contribute to reducing greenhouse gas emissions.

5.3 Greenhouse Gas Emissions from Aviation Fuel Use

The use of aviation fuel produces a number of pollutants. Due to their contribution to global warming and climate change, greenhouse gas emissions are of particular concern in *Hawaii Energy Strategy 2000* (*HES 2000*).

In the *Hawaii Climate Change Action Plan* (DBEDT 1998b), the focus was on emissions from domestic aviation operations. Under the Intergovernmental Panel on Climate Change (IPCC) guidelines for preparing national inventories of greenhouse gas emissions, international aviation and marine bunker fuel were to be recorded as separate categories and were not included under the national total (Michaelis 1997a, 20). The *Action Plan* and *HES 2000* followed that practice and did not count international aviation (bonded) and military fuel sold or distributed in Hawaii in their calculations of Hawaii's greenhouse gas emissions. Table A.17 provides details on the greenhouse gas emissions from all of these categories.

Figure 5.2 presents two estimates of future CO_2 emissions from Hawaii domestic aviation fuel use produced by the ENERGY 2020 model and compares them to the Kyoto Protocol target of 7% below 1990 emissions by 2008–2012. These correspond to the estimates of fuel use depicted in Figure 5.1, above. It is stressed that the Kyoto Target is shown for reference only. There is no expectation that each sector, let alone each state, will be required to meet the goals specified in the Protocol.

By 2010, the Maximum Efficiency Case (2.5% annual efficiency improvement) was estimated to produce 21.2% less CO_2 than the Base Case (0.7% annual efficiency improvement) and 21.6% less than the Kyoto target. The Base Case was estimated to produce 0.5% less CO_2 than the Kyoto Target. By 2020, due to continued traffic growth, the Maximum Efficiency Case was estimated to produce 26.8% less CO_2 than the Base Case and 22.8% less than the Kyoto target. The Base Case was estimated to produce 5.4% more CO_2 than the Kyoto Target. It is not clear that the maximum efficiency growth rate will be achieved or whether it will offset passenger mile increases as forecast.

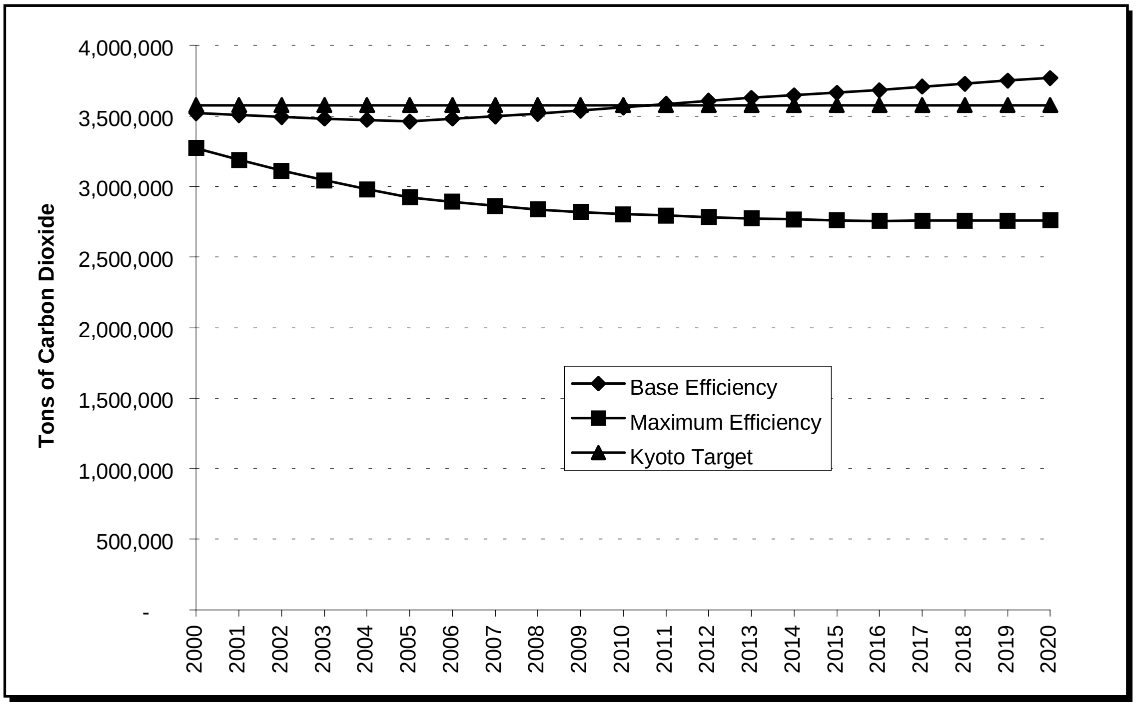


Figure 5.2 Estimate of Greenhouse Gas Emissions from Domestic Aviation Fuel Use in Hawaii, 2000–2020

5.4 Economic Effects of Aviation Fuel Use

5.4.1 Cost of Aviation Fuels

As noted above, aviation brings visitors to Hawaii who support its largest industry and provides the passenger links between Hawaii's islands. As a result, Hawaii's economy is highly vulnerable to increases in the cost of aviation fuel. In 1995, an estimated $250 million was spent in Hawaii on jet fuel. This amount does not include the cost of bonded fuel or fuel purchased elsewhere but loaded in Hawaii. About $9 million was spent on aviation gasoline (DBEDT 1998d, 91). Higher fuel prices would increase the price of tickets, reducing the demand for air travel (DeCicco 1997, 227). This would be very undesirable for Hawaii's tourism-based economy and for its airline-based interisland transportation system.

Market forces, especially fuel prices, will also be important in determining the efficiency of the future air transport fleet. Higher fuel prices create an incentive to retire obsolete, less-efficient aircraft in favor of newer, more-efficient aircraft.

5.4.2 Possible Carbon Taxes

HES 2000 seeks to identify ways to improve energy efficiency and reduce energy use. Such efforts should also benefit Hawaii's economy or at least not have major negative effects. Carbon taxes, which would increase the cost of fossil fuel use, are often discussed as potential measures for reducing fossil fuel use and greenhouse gas emissions.

Carbon taxes may make sense in those energy sectors where there are currently non-fossil fuel options or where there are further efficiency measures that would become cost-effective at the resulting higher energy price. However, in the air transportation sector, there are no currently available non-fossil-fuel alternatives, and it appears that the industry is already actively pursuing energy efficiency due to the economic value of such efficiency. The use of carbon taxes would likely have major negative consequences on Hawaii's economy.

The Annex I Expert Group on the United Nations Framework Convention on Climate Change published an analysis of the effects of carbon taxes on international aviation fuel in March 1997 (Michaelis 1997a). Michaelis modeled carbon taxes at $5, $25, and $125 per tonne of carbon (one tonne is a metric ton, equal to 2,200 lbs.). These charges equated to roughly 2%, 10%, and 50% of current jet fuel prices. The increased fuel costs were assumed to be passed through to airline customers, resulting in higher fares and lower demand for air transport, and thus lower emissions.

At $5 per tonne, ticket prices would increase less than one percent, resulting in less than a one-percent reduction in traffic. At $25 per tonne, ticket prices would rise 1.4% and the number of passengers would decline 0.9% to 2.9%. At $125 per tonne, ticket prices would be about 7% higher, reducing traffic by 4.4% to 13%. It was also expected that airlines would attempt to mitigate the effects as much as possible by reducing non-fuel costs, by reducing fuel consumption through more efficient operation, and by re-equipping with more efficient aircraft or replacing less efficient engines (7).

5.4.2.1 RECOMMENDATION: Ensure That Proposals for Carbon Taxes on Aviation Fuels Do Not Adversely Affect Hawaii

Suggested Lead Organizations: Hawaii Congressional Delegation and Legislature

It is strongly recommended that Hawaii *not* be subject to any carbon taxes on aviation fuels that could adversely affect the State's economy. Any national carbon taxes should take into account Hawaii's lack of alternatives to air transportation for interisland and overseas travel and the potential effects of higher air fares on tourism. Alternative means of increasing the efficiency of air travel should instead be considered.

5.5 Reducing Air Transportation Energy Requirements

5.5.1 Actions Taken to Reduce Air Transportation Energy Demand

Airlines have considerable incentive to reduce fuel use. Fuel amounts to approximately 15% of total operating expenses, the second largest operating expense. As a result, airlines and aircraft manufacturers have made increased fuel efficiency a top industry priority for many years (ATA 1997).

5.5.1.1 ACTION TAKEN: Improved Load Factors

Lead Organizations: Airlines

As discussed above, airlines with Hawaii operations improved load factors in the 1990s. By filling higher percentages of available seats with passengers, overall efficiency improved.

5.5.1.2 ACTION TAKEN: Operational Changes

Lead Organizations: Airlines

Aloha Airlines provided information that its flight operations department began a fuel efficiency program in 1993. The flight plans between all islands were changed to incorporate a parabolic profile. Aloha's aircraft now climb to higher altitudes and begin descent earlier, at lower airspeeds, to conserve fuel. An aircraft washing program also minimizes dirt on the aircraft, removing a source of drag (Ackerman 1997).

5.5.2 Recommendations to Reduce Air Transportation Energy Demand

5.5.2.1 RECOMMENDATION: Adopt Operating Measures to Increase Fuel Efficiency

Suggested Lead Organizations: Airlines

Generally, measures that reduce fuel use will reduce greenhouse gas emissions. There are a number of measures in use by U.S. airlines that have not been implemented in Hawaii. These should be considered by Hawaii's airlines to the extent that they are consistent with applicable Federal Aviation Administration regulations. These include reducing cruising speeds; determining optimum fuel loads and selecting altitudes and routes that minimize fuel burn; using flight simulators rather than real aircraft for pilot training; holding aircraft at gates with engines shut down when weather or other problems delay takeoff; using only one engine to taxi; keeping aircraft exteriors clean to minimize aerodynamic drag (ATA 1997); reducing the use of auxiliary power units and using ground (utility) electrical power instead; and converting airport vehicles and ground service equipment to alternative fuels (NRDC 1996).

5.5.2.2 RECOMMENDATION: Maintain High Aircraft Load Factors

Suggested Lead Organizations: Airlines

One of the competitive factors in the interisland market is flight availability and schedule frequency, which reduces the opportunity for increased efficiency through higher load factors. Load factors in overseas operations are at such high levels that increases may not be practical. Since availability of flights to Hawaii for visitors is critical to Hawaii's economy, there is some concern that lack of available flights may have reduced visitor counts over the past few years. Higher load factors could have negative economic effects.

5.5.2.3 RECOMMENDATION: Re-equip Interisland Airlines with Newer, More Efficient Aircraft

Suggested Lead Organizations: Interisland Airlines

Using newer aircraft on interisland routes could significantly improve fuel efficiency. The average age of Aloha's Boeing 737-200 fleet is 17 years (extrapolated from Lampl 1997, 34), the average age of Hawaiian's DC-9-50 fleet is 21 years, and the DC10-10s on Hawaiian's overseas routes are 26 years old (extrapolated from Hawaiian Airlines 1998).

According to the Air Transport Association of America, "The McDonnell-Douglas MD-80 (now produced in an updated form as the Boeing 717), Airbus A-320, and Boeing 737-300, for example, transport twice as many passengers per gallon of fuel than the DC-9 and earlier versions of the 737. In addition, they emit smaller amounts of the gases of concern to scientists studying global warming and other environmental trends" (ATA 1997).

As Hawaiian Airlines pointed out in its 1996 *Annual Report*, there are important economic and competitive considerations involved in replacing the current interisland fleet. Both Hawaiian and Aloha airlines face equipment replacement decisions early in the next decade. While the airlines could enjoy improved fuel efficiency and reduced maintenance costs, they must meet the purchase or leasing requirements necessary to replace their current fleets. Hawaiian Airlines announced in September 1999 that by the end of 2001 it would replace its 15 DC-9s in interisland service with 13 Boeing 717-200 aircraft. The new aircraft are reportedly 25% more fuel-efficient than the DC-9s they replace (Lynch 1999, A-1).

It is recommended that Hawaii's other interisland air carriers, and any other airlines that may enter the interisland market, give maximum consideration to reducing fuel costs and to maximizing reduction of greenhouse gas emissions through selection of the most fuel-efficient aircraft available. Such new equipment should offer more economical operation while reducing the potential harm that could result from future fuel price increases.

5.5.2.4 RECOMMENDATION: Use Newer, More Efficient Aircraft on Overseas Routes

Suggested Lead Organizations: Airlines and Department of Transportation

Overseas carriers operate a variety of aircraft of varying vintage. Operating measures similar to those discussed above can improve their fuel efficiency. Operation of newer equipment can also reduce fuel requirements. Another possible action, suggested by the Natural Resources Defense Council, is implementation of differential landing fees based upon aircraft emissions. This would encourage airlines to use their least-polluting aircraft (NRDC 1996).

5.5.3 Future Improvements in Aviation Technology for Energy Efficiency

Future gains in commercial aviation energy efficiency could be obtained through technological improvements to engines and airframes, and in the more distant future, new technologies for aircraft propulsion. These measures are beyond the control of Hawaii, but they will set the standard for potential future reductions of greenhouse gas emissions from air transportation.

Since the first commercial jet aircraft were introduced in the 1950s, fuel use in the cruising mode for short- to medium-range flights has decreased by 65% and for long-range aircraft by 55%. Seat miles per gallon increased from 26.2 to 48.6, nationally. The main factors behind these improvements are technological improvements in aircraft, a 30% increase in load factors, and an average 40% increase in aircraft size (DeCicco 1997, 210).

In 1992, the National Academy of Sciences set a goal of reducing fuel used per seat mile by 40% over the next two decades. It forecast a 25% reduction from improved engine performance and 15% from aerodynamic improvements and weight reductions (211).

CHAPTER 6 ENERGY FOR MARINE TRANSPORTATION

6.1 Marine Transportation and Hawaii

In the previous chapter, interisland air transportation of passengers was described as analogous to a Mainland intrastate highway system. In a similar manner interisland marine shipping is the analog of Mainland intrastate trucking, pipelines, and railroads. Interisland vessels, primarily towed barges, transport most of Hawaii's cargo among islands.

Transportation of cargo from the Mainland and overseas is primarily seaborne. 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.

6.2 Marine Transportation Energy Demand

6.2.1 Current Marine Fuel Use

Most fuel used or sold in the marine transportation category was bonded fuel for use in international shipping or international fishing operations or was loaded as cargo and exported from Hawaii. In 1997, such bonded fuel included 1.813 million barrels of residual fuel oil and 1.778 million barrels of diesel fuel oil. Sales for interisland use were 130,742 barrels of residual fuel oil, 235,598 barrels of diesel, and 997 barrels of gasoline (DBEDT 1999). Table A.18, in Appendix A, provides available data on marine fuel use from 1990 to 1997.

6.2.2 Future Marine Fuel Requirements

There was little information upon which to base an estimate of future marine fuel use. Much of the overseas fuel business was from foreign fishing vessels, and this varied based upon their activity and the relative price of fuel at alternative bunkering ports. To provide a very rough estimate, marine fuel use was modeled in the ENERGY 2020 model to grow at the rate of population growth. Figure 6.1 depicts the ENERGY 2020 estimate based upon this assumption.

6.3 Greenhouse Gas Emissions from Marine Fuel Use

In-state uses of marine fuels contributed about 150,400 tons CO_2-equivalent to Hawaii's greenhouse gas emissions. Table A-18 summarizes estimated greenhouse gas emissions from marine fuels from 1990 to 1997. Based upon estimates produced by the ENERGY 2020 model, Figure 6.2 depicts estimated CO_2 emissions from in-state marine fuel use from 2000 to 2020.

The ENERGY 2020 model predicts year 2010 emissions at about 208,000 tons of CO_2, or 33% above the Kyoto target of 139,875 tons by the years 2008–2010. The estimated emissions for 2020 were 238,000 tons, 41% above the target. The Kyoto target is provided as a reference and neither the marine sector, nor any other sector, nor any individual state is likely to be expected to independently meet it should it be ratified.

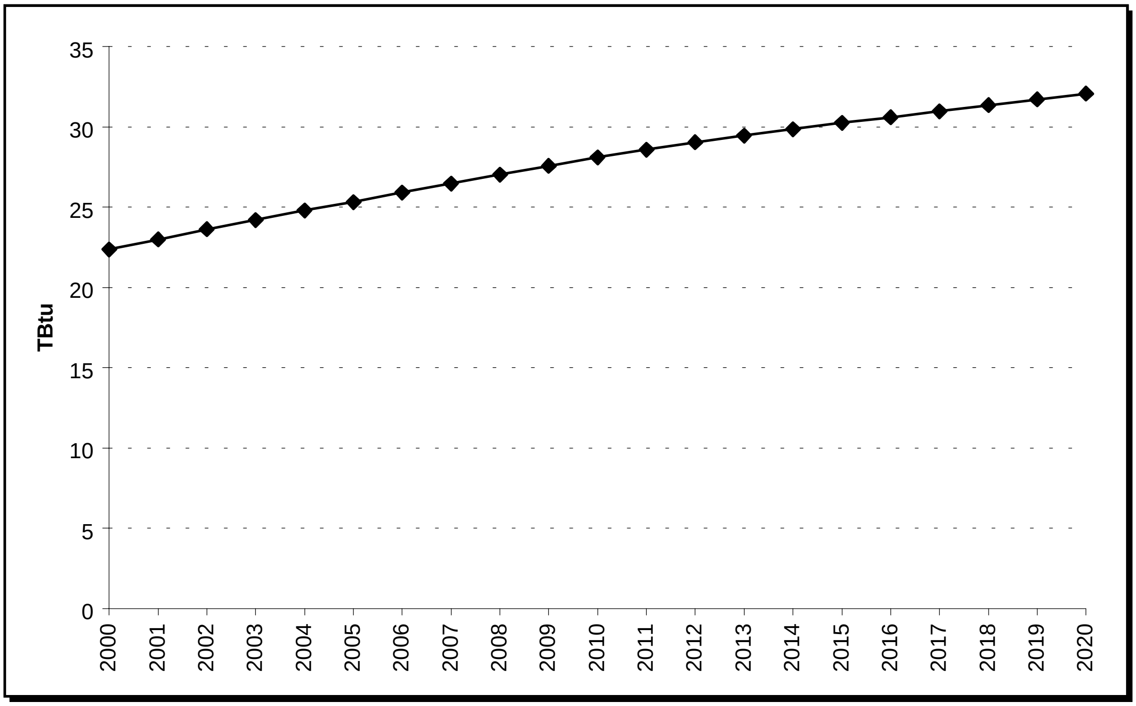


Figure 6.1 Estimated Marine Fuel Sold or Distributed in Hawaii, 2000–2020

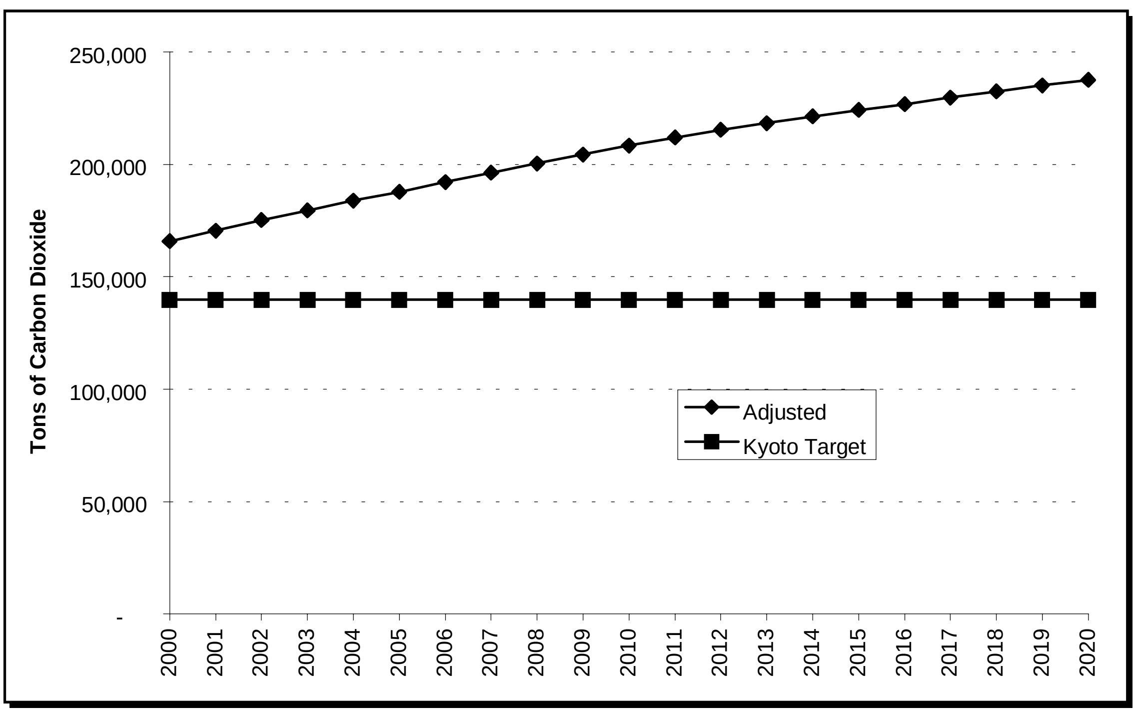


Figure 6.2 Estimated CO_2 Emissions from Hawaii Domestic Marine Fuel Use, 2000–2020

6.4 Reducing Marine Transportation Energy Requirements

6.4.1 Recommendations for Reducing Marine Fuel Use

6.4.1.1 RECOMMENDATION: Consider Changes in Operating Procedures for Energy Efficiency

Suggested Lead Organizations: Shipping Companies

Improvements in operating procedures could save energy. Examples include the following:

- Require crew training in efficient operations;
- Create financial incentives for fuel-efficient operations (Argonne National Laboratory, 1991, cited in PBQD 1995);
- Perform regular propeller maintenance (estimated reduction in fuel use, 5% or more);
- Use anti-fouling paint to ensure hull smoothness and reduce drag (estimated reduction in fuel use, 3–4%);
- Route ships to avoid heavy weather (estimated reduction in fuel use, 4%);
- Reduce average speed 10% (estimated 5% reduction in fuel use for older vessels); and
- Use adaptive autopilots (estimated reduction in fuel use, 2.5%) (Michaelis 1997b, 22).

6.4.1.2 RECOMMENDATION: Adopt Technical Improvements to Ships

Suggested Lead Organizations: Shipping Companies

A number of technical improvements that would also save energy could be made to future ships engaged in overseas trade or interisland operations.

- Replacement of two-stroke diesel engines with modern four-stroke diesels would reduce fuel consumption by 5 to 10 % or more;
- Replacing existing engines with less powerful ones could also achieve energy savings since diesels operate most efficiently at full power, and marine engines typically operate well below full power;
- New engine technologies such as turbo-compounding and rankine bottoming cycles have demonstrated fuel savings of 5 to 7 % and 12 %, respectively (PBQD 1995);
- Improved hull form on new ships could reduce fuel use up to 3%;
- Improved propeller designs could save small amounts of fuel;
- Wind assistance through installation of auxiliary sails could reduce fuel use by 10–20%;

- Doubling ship size for similar routes could save up to 30% of the fuel otherwise used by two ships of the current size;
- Fuel switching to biofuels could save up to 80% in greenhouse gas emissions compared with a similar fossil-fueled ship (Michaelis 1997b, 22).

6.4.1.3 RECOMMENDATION: Ensure That Proposals for Carbon Taxes on Marine Transportation Fuels Do Not Adversely Affect Hawaii

Suggested Lead Organizations: Hawaii Congressional Delegation and Legislature

As noted in the section on air transportation, carbon taxes are often discussed as potential measures for reducing fossil fuel use and greenhouse gas emissions. They would accomplish this by increasing the cost of using fossil fuel. As the Expert Group study notes, “a carbon charge on bunker fuel would only be feasible, fair and economically efficient in a context where such a charge is globally imposed, and where other transport modes pay their full social costs” (Michaelis 1997b, 6).

For Hawaii, the major likely effect would be increased costs for goods brought in by ship from overseas and those shipped interisland. Increases in efficiency could lag the imposition of the tax by many years due to the long life of ships in service. Consequently, use of a carbon tax on marine transportation fuel is *not* recommended. Should such a tax be enacted nationally, Hawaii should be exempted due to the lack of alternatives.

CHAPTER 7 GENERATING ELECTRICITY FOR HAWAII

7.1 Overview

Hawaii's electricity is generated by the four electric utilities, non-utility generators, and the sugar industry. Most of this electricity is sold to consumers by 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 Electric Division of Citizens Energy Services (KE) serves Kauai County; and Maui Electric Company, Ltd., (MECO) serves Maui County and Kalawao County. MECO operates separate systems for Maui, Lanai, and Molokai.

Non-utility generators include NUGs that have negotiated power purchase agreements to sell all the power they generate beyond plant use to the utilities. Cogenerators produce electric power and process-heat for their own or contracted use and sell surplus power to a utility. Hawaii's sugar plantations generate electricity to power their operations and sell surplus electricity to the utility on their island. The utilities resell the power to their customers.

Four chapters in *HES 2000* address electricity issues in Hawaii. Chapter 7 focuses on electricity supply. Chapter 8 offers recommendations on ways to increase renewable energy use for electricity generation in Hawaii. Chapter 9 discusses ways to restructure Hawaii's electricity system by increasing competition. Chapter 11 includes discussion of ways that electricity demand can be reduced in Hawaii's buildings.

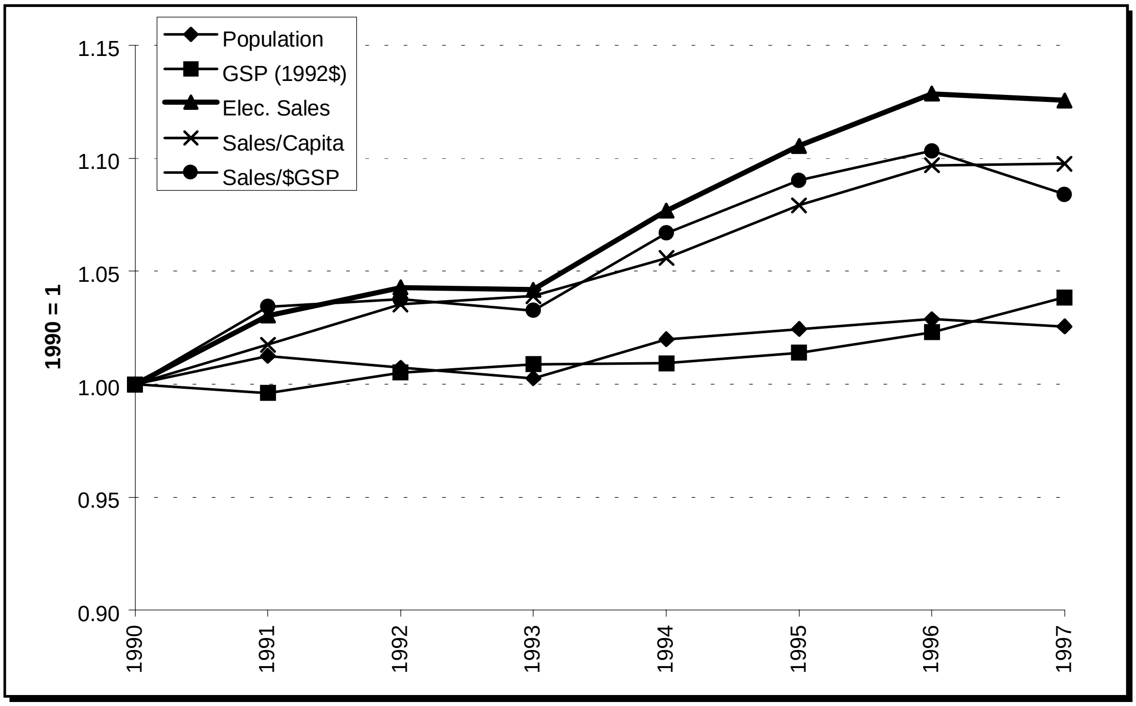
7.2 Hawaii's Electricity Challenges

Electricity is vital to modern life. Virtually all of Hawaii's citizens use electricity for essential functions such as lighting, water heating, refrigeration, air conditioning, ventilation, and cooling. At higher elevations, some Hawaii citizens even need heating. Electricity is used to operate home appliances, office machines, industrial equipment, communications systems, and other devices. A small number of electric vehicles charge their batteries with utility electricity.

7.2.1 Growing Electricity Sales

Electricity use grew faster between 1990 and 1997 than any other form of energy use. The slowdown in Hawaii's economy since 1991 was not evident in reduced electricity sales until 1997. As Figure 7.1 shows, increases in the sales of electricity outpaced growth in Hawaii's population and gross state product (GSP) during the period. By 1997, electricity sales were almost 13% greater than in 1990. The 15% growth in residential sales outpaced the 12% increase in commercial/industrial sales.

During the same period, Hawaii's de facto population grew about 1.1%, while GSP grew 3.8%. Electricity sales per capita grew 11.3%, and there was an 8.4% growth in electricity sales per real dollar of GSP.



Source: Utility FERC Forms 1 and Annual Reports, 1990–1997, DBEDT 1999

Figure 7.1 Hawaii Electricity Sales, De Facto Population, and GSP, 1990–1997

Hawaii's electricity intensity (kWh per dollar of GSP) is lower than the U.S. average. Hawaii's electricity intensity in 1997 was less than 0.3 kWh per dollar of GSP, approximately 70% of the 0.43 kWh per dollar of gross domestic product (GDP) for the nation as a whole. Figure 7.2, shows sales for each of the four utility systems for the period 1990–1997. MECO sales grew most rapidly, by 32%, HELCO sales increased 25%, Kauai Electric sales rose 11%, and HECO sales increased 9%.

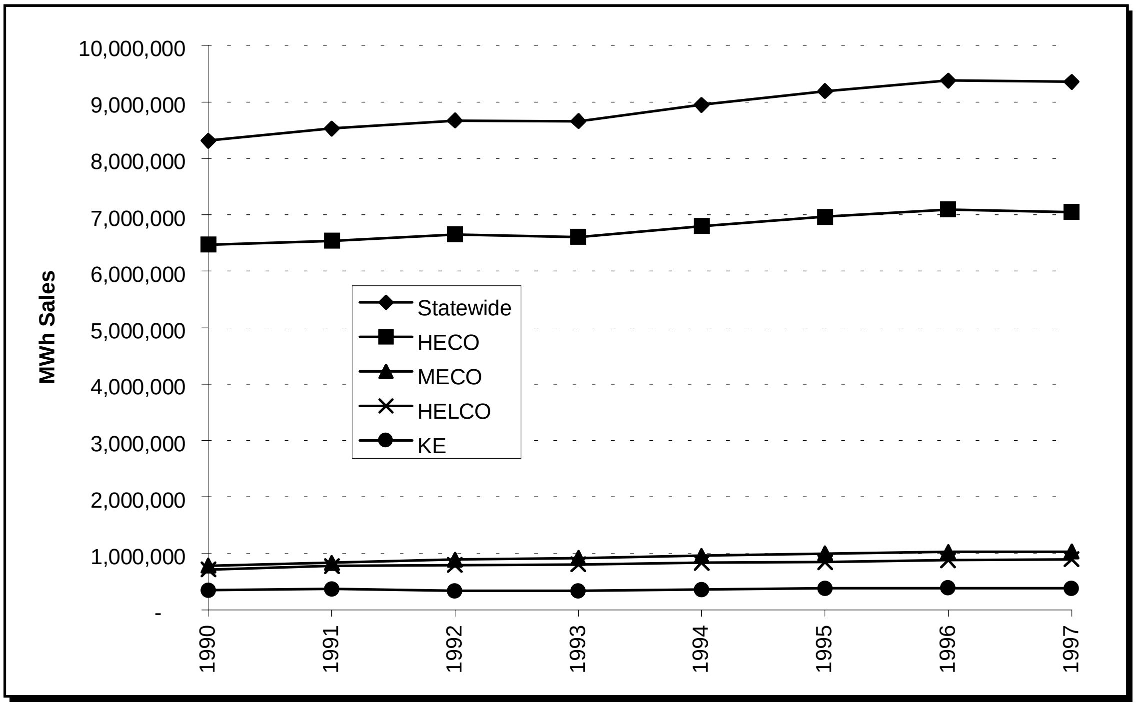
Figure 7.3, depicts the growth in electricity sales by rate classification from 1990 to 1997. Unfortunately, the rate classifications allow only a general analysis of the source of sales growth by sectors. Some large residential uses, such as master metered apartments or condominiums, are included in the commercial/industrial sector.

Despite the more rapid growth in sales on the neighbor islands, Oahu’s large population dominated statewide sales, and commercial/industrial sector sales were greater than residential sales on Oahu. Figure 7.4 shows the percentage of statewide electricity sales by rate classification and electric utility system in 1997.

7.2.2 The Rapidly Rising Cost of Electricity

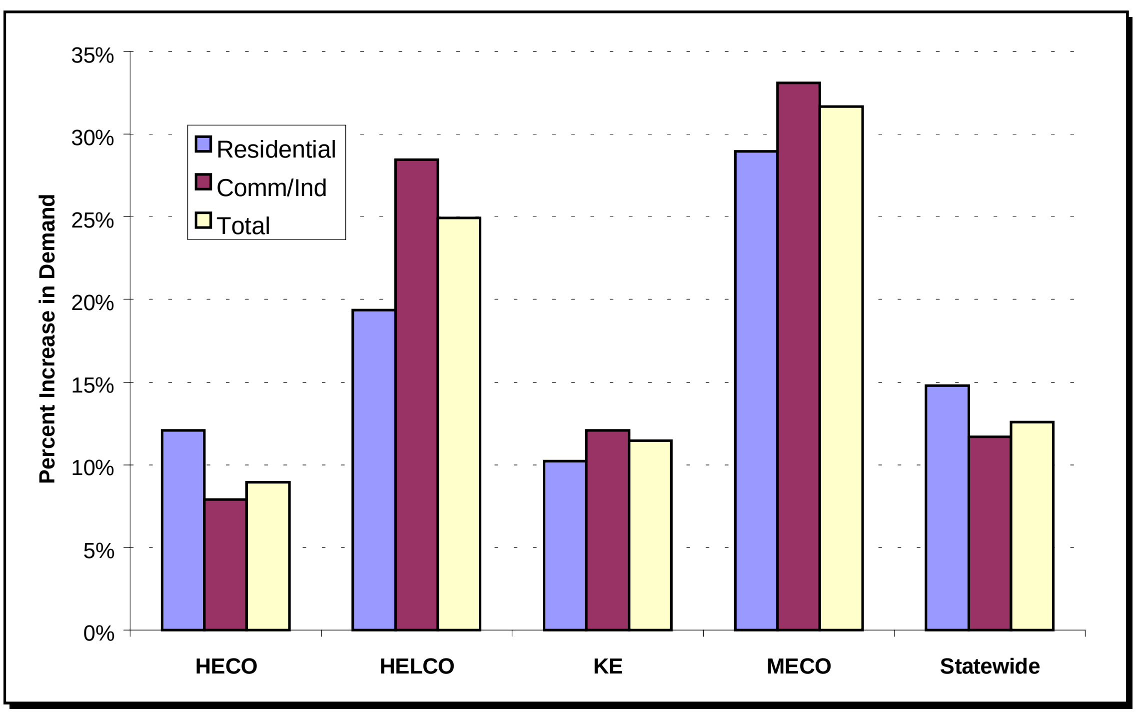
7.2.2.1 Hawaii's 1997 Average Electricity Revenues Were Nation’s Highest

Hawaii's average statewide electricity revenues were the highest in the nation in 1997. The average revenue per kWh in the United States was $0.069 (EIA 1998c, 42). In Hawaii, average revenues per kWh ranged from $0.11 for HECO to



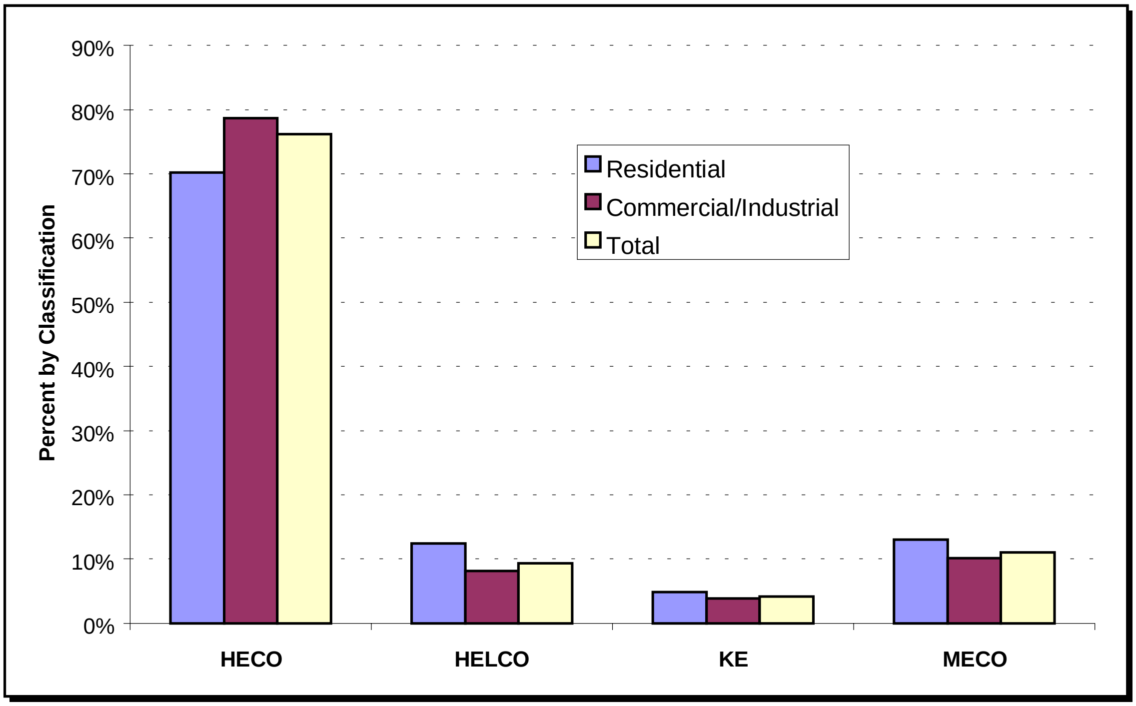
Source: Utility FERC Forms 1 and Annual Reports, 1990–1997

Figure 7.2 Electricity Sales by Hawaii Utilities (MWh), 1990–1997



Source: Utility FERC Forms 1 and Annual Reports, 1990–1997

Figure 7.3 Growth in Electricity Sales by Rate Classification, 1990–1997



Source: Utility FERC Forms 1 and Annual Reports, 1997

Figure 7.4 Percentage of Electricity Sales by Utility and Rate Classification, 1997

Table 7.1 Electricity Sales and Revenues in Hawaii, 1997

Utility	Sales (kWh)	Revenue	Average Revenue per kWh
HECO	7,049,777,000	$ 778,240,746	$ 0.110
HELCO	894,110,000	$ 160,331,960	$ 0.179
KE	382,112,000	$ 77,752,502	$ 0.203
MECO	1,028,768,000	$ 151,624,338	$ 0.147
Statewide	9,354,767,000	$ 1,167,949,546	$ 0.125

Sources: 1997 FERC Form 1 or Annual Report to PUC of each utility

$0.203 for Kauai Electric. The statewide average was $0.125 per kWh. Table 7.1 presents electricity sales and revenues of Hawaii utilities in 1997.

At about $1.17 billion, electricity revenues were 3.4% of Hawaii's estimated 1997 GSP of $34.2 billion dollars (DBEDT 1998f, Table 13.02). To the extent that electricity costs can be reduced, more money will be available for Hawaii's citizens to use for other purposes, which would benefit non-utility sectors of the economy.

Not only were Hawaii's electricity revenues the highest in the nation in 1997, electricity revenues for Hawaii utilities grew much faster than the U.S. average over the years 1990 to 1997. By 1997, revenues were 39.2% higher than in 1990 while the U.S. average was only 4.2% higher. The 39.2% increase in average Hawaii electricity revenues between 1990 and 1997 compares with an increase in the consumer price index for all urban consumers in Honolulu of only 24%. The overall U.S. consumer price index increased 23% during the same period.

7.2.2.2 Reasons for Hawaii's High Average Electricity Revenues

Some might argue that it is unfair to compare Hawaii's electricity revenues with the lower average revenues in states that have access to less expensive energy sources, such as large-scale hydroelectric power plants, coal plants, nuclear power plants, or highly efficient natural-gas-fired, combined cycle combustion turbine generating facilities. Most power plants in Hawaii burn oil, which is more expensive than the primary mainland fuels, and which is used in only 9% of generators nationwide.

Fuel costs are not the only possible explanation – in fact, for HECO, they declined slightly from 1990 ($0.046 per kWh) to 1997 ($0.045 per kWh) (Munger 1999a, 33). Hawaii's electricity system consists of six physically separate electricity systems. These systems are not interconnected and must operate independently. This requires each system to maintain enough excess generating capacity to ensure that electricity can be provided reliably on each of the six independent systems at all times. The costs of the units that provide this excess capacity are reflected in revenues.

In the early years of this decade, while mainland utilities added little new generation due to overcapacity, HECO, in particular, added a substantial amount of new generation. This added, through power purchase agreements with NUGs, about $0.017 per kWh of the $0.03 per kWh increase from 1990–1997 in HECO's prices. Two of the power plants added, the AES Hawaii coal plant and the MSW-fired H-POWER unit, helped provide additional energy security for Hawaii by diversifying fuel sources (33).

The costs of DSM programs also added to prices, although customers participating in the programs had lower bills. Taxes also played a part. During the period, taxes on electricity increased by $0.003 per kWh, from $0.007 per kWh in 1990 to about $0.01 kWh in 1997 (33).

Further, the cost of living in Hawaii is estimated to be 130–135% of the urban U.S. average (Bank of Hawaii 1997, 11). These higher costs are likely reflected in many of the expenses the Hawaii utilities face in providing electricity. Additional factors increasing electricity costs included duplicative permitting requirements and processes, sunrise/sunset dates on land use applications, and floor prices in some contracts for electricity generated by non-fossil-fuel qualified facilities (Munger 1998).

Kauai Electric's costs are relatively high compared with other Hawaii utilities, due in part to fixed costs associated with the restoration of its system after extensive damage caused by Hurricane Iniki, in 1992 (Gilman and Golden, 1999).

7.2.2.3 Electricity Prices and Hawaii's Economic Competitiveness

While Hawaii's utilities do face higher costs, the narrowing of regional differences and coincident decrease in electricity costs occurring in Mainland power markets due to restructuring suggest the need for Hawaii to reduce its electricity costs as much as possible to enhance its economic competitiveness.

7.2.2.4 RECOMMENDATION: Review Utility Costs and Require Utilities to Report on Actions Taken to Reduce Revenue Requirements

Suggested Lead Organizations: Public Utilities Commission and Utilities

Due to the negative economic and social consequences of Hawaii's high electricity costs, the Public Utilities Commission should conduct a comprehensive review of utility costs and require the utilities to report annually on actions taken to reduce revenue requirements.

7.2.2.5 RECOMMENDATION: Continue to Examine Electricity Competition for Hawaii

Suggested Lead Organizations: Public Utilities Commission and Parties to Docket

On December 30, 1996, the Hawaii Public Utilities Commission initiated Docket No. 96-0493, instituting a proceeding to examine electricity competition and Hawaii's electricity infrastructure. Parties to the Docket submitted position statements to the Commission on October 19, 1998. Electricity Competition and Hawaii are discussed in greater detail in Chapter 9 of this report.

7.2.3 Greenhouse Gas Emissions from Electricity Generation

Greenhouse gas emissions from electricity generation produced 41% of Hawaii's 1990 baseline emissions, contributing to global warming and climate change (DBEDT 1997a). Estimated future emissions, by utility system, are shown in Figure 7.5. The emissions include those from utility-owned generation and non-sugar industry, non-utility generators. The Kyoto target for the combination of the four electricity systems (7,117,000 tons CO_2-equivalent) is shown for reference only. This is not intended to imply that any one sector, utility, or even state would be expected to meet the target by itself if the Protocol is ratified. However, the emissions under current plans were forecast to be 38% above the Kyoto target, at 9,857,000 tons, by 2010 and 48%, or 10,552,000 tons, above the target by 2020.

7.3 Changing Ownership of Electricity Generation

In 1990, Hawaii's utilities produced 90.7% of the electricity sold to customers, while non-utility generators (NUGs) and sugar industry cogeneration almost equally accounted for the rest. By 1997, the utility share declined to 62% of the total, and sugar's contribution was down to 1.5%, as several sugar plantations closed, including all those on Oahu and the Island of Hawaii.

Major power purchase agreements by HECO and HELCO raised the NUG share of net generation to 37.5% of the statewide total. NUGs obtained contracts under the provisions of the *Public Utility Regulatory Policies Act of 1978* (PURPA), a federal law intended to enhance the use of renewable energy and cogeneration.

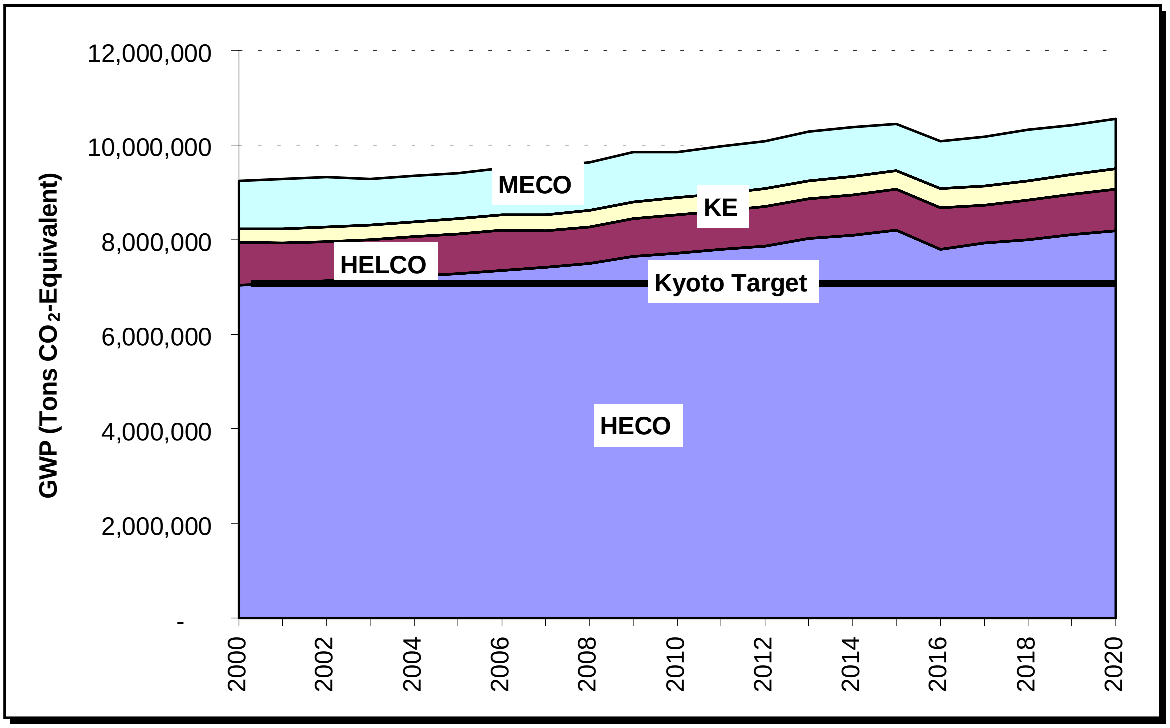


Figure 7.5 Estimated Global Warming Potential of Hawaii Electric Utility Emissions, 2000–2020

The law requires that utilities purchase from facilities qualifying under its provisions at or below the utility costs avoided by the non-utility generation. In some cases, provisions in the power purchase agreements negotiated between the utilities and their NUG suppliers have resulted, over time, in higher wholesale prices for electricity being paid by the utilities than current utility costs. While the utilities do not profit from the sales of electricity generated by non-utility generators, these costs are passed on to the consumer.

Sales under PURPA provide a form of competition, and the act has resulted in the application of advanced technology fossil fuel generation and renewable energy resources.

7.4 Fuels for Electricity Generation

7.4.1 Increasing Diversification of Fuels

In this decade, Hawaii's electricity system became increasingly diversified, consistent with the State's energy objective of greater energy security. As recently as 1991, over 92% of the electricity sold in Hawaii by the four electric utilities was generated using oil. Figure 7.6 shows the fuel and energy sources used to generate electricity in 1997. Solar water heating is not included as a generation source, but its use reduces the need for generation. Table A.19, in

Appendix A, details the significant diversification of the fuels used to generate electricity since 1990.

7.4.2 Renewable Energy

Another State energy objective calls for increasing the use of indigenous energy supplies. During the period 1990–1997, overall renewable energy use for electricity generation did not increase, but the shares of the various resources changed, principally due to the decline in wind generation and sugar industry electricity. The other renewables, especially geothermal and municipal solid waste, largely filled the void.

As Figure 7.6 depicts, while the percentage of oil use had been reduced to 76.5% in 1997, just over 92% of Hawaii's electricity was still generated using fossil fuels – oil and coal.

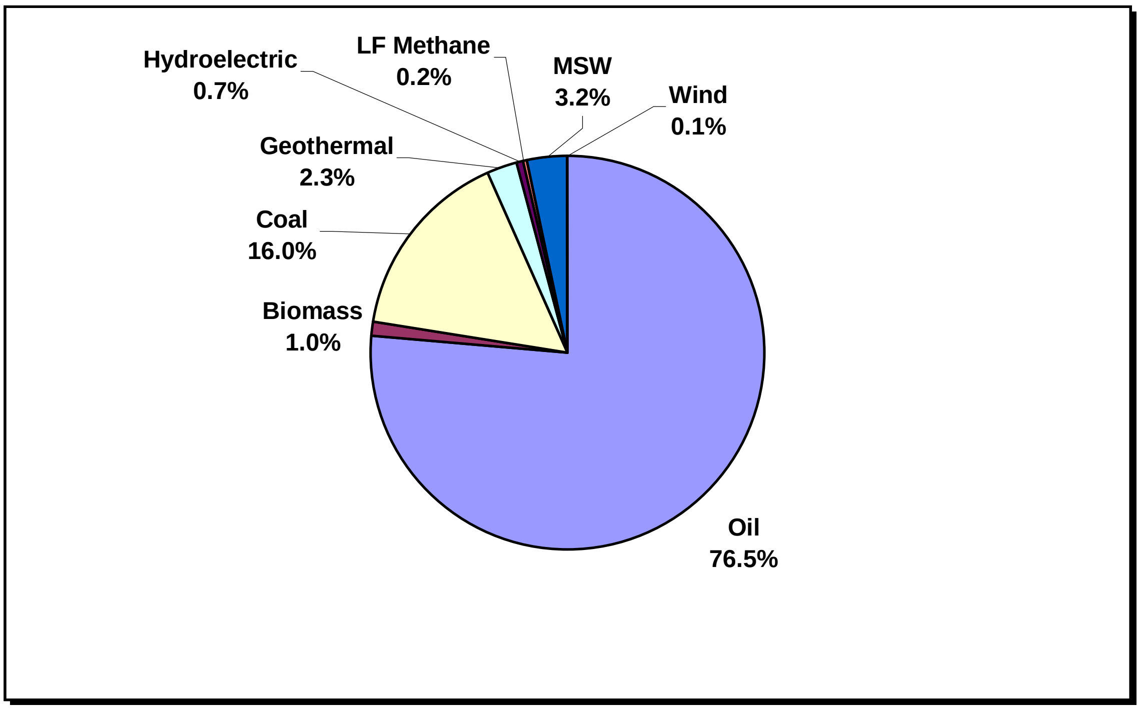


Figure 7.6 Percentage Share of Fuels Used for Electricity Generation in Hawaii, 1997

7.4.3 Recommendations for Electricity Fuels

7.4.3.1 RECOMMENDATION: Continue Diversification of Fuels Used for Electricity Generation in Hawaii

Suggested Lead Organizations: Electric Utilities and NUGs

Greater diversification of fuels in the electricity sector holds the promise of making the greatest contribution to reducing Hawaii's over-dependence on oil. In addition, renewable energy is important for offsetting fossil-fuel energy requirements (see the next recommendation and Chapter 8). Coal is the principal fossil fuel alternative, but coal produces 20% more CO_2 per unit of energy than

oil. Consequently, the economics of importing liquefied natural gas (LNG) should be monitored in case they become favorable for LNG use in Hawaii. Even more important, factors relating to the resolution of safety concerns should be monitored.

7.4.3.2 RECOMMENDATION: Increase Renewable Energy Use for Electricity Generation in Hawaii

Suggested Lead Organizations: Electric Utilities and NUGs

While a number of renewable energy projects have been proposed and are in various stages of development, it is not clear which will be deployed. Chapter 8 presents recommendations for specific renewable energy projects in each County. In addition, ways to encourage deployment of renewable energy systems, such as removing existing barriers, are discussed.

7.5 Integrated Resource Planning and Increased Efficiency

Integrated Resource Planning (IRP) is an approach to regulated utility planning that evaluates all potential energy options, including supply-side options (energy-production by conventional fuels and renewable energy resources) and demand-side management (energy conservation, efficiency, and load management). IRP also considers the social, environmental, and economic costs of these options. The goal is to meet consumer energy needs efficiently and reliably at the lowest reasonable cost.

In 1992, the Public Utilities Commission's A Framework for Integrated Resource Planning detailed the goal, governing principles, responsibilities, and requirements for IRP in Hawaii (PUC 1992). The Framework stated the goal as follows:

> The goal of integrated resource planning is the identification of the resources or the mix of resources for meeting near and long term consumer energy needs in an efficient and reliable manner at the lowest reasonable cost (3).

In 1993, the utilities filed their first IRPs for PUC approval. Each utility was to conduct a major review of its IRP every three years, adopting a new 20-year time horizon with each cycle. The second round of IRPs was delayed for a variety of reasons, but the second IRP for KE was submitted in April 1997. HECO filed its second IRP in January 1998, and HELCO completed its second IRP in September 1998. MECO was to file its second IRP in September 1999 but asked for a delay to May 2000 to allow additional analysis. KE began work on its third IRP in August 1999.

Each plan details the utility's plans to meet the forecast energy demand for its service area over the following 20 years. The plan includes a forecast, supply-side options, demand-side options, a description of the analysis and basis for the plan, and a five-year action plan. In their IRP processes, the utilities have developed DSM programs, have more efficient resource plans, and at least formally consider renewable energy options and the externalities of various plans.

7.6 Electricity for the Island of Oahu

HECO is the electric utility serving the people of Oahu. HECO generates most of the electricity sold to its customers, but of all Hawaii utilities, HECO purchased the largest percentage (42.5%) of net generation (before transmission and distribution losses) from non-utility generators. HECO is also the parent company of HELCO and MECO.

7.6.1 Oahu's Electricity Supply

7.6.1.1 HECO-Owned Generation

HECO currently owns and operates power plants at Kahe Point, Waiau, and in downtown Honolulu. In 1997, HECO's total sales were 7,049,300 MWh, or about 75% of all electricity sold in the state. HECO's own generators produced 60% of this total, or 4,265,844 MWh.

Oil-fired steam units (OFS) burning low-sulfur fuel oil (LSFO) or No. 6 fuel oil made up 92% of HECO's units. Two units totaling 102 MW were diesel-fired (low-sulfur No. 2 fuel oil) combustion turbines (CT) used primarily to meet peaks in demand. Table A-20 provides more detailed information on HECO-owned generation units in operation at the end of 1998.

7.6.1.2 Non-Utility Generation Sold to HECO

Non-utility generators generated 3,158,415 MWh for HECO in 1997, accounting for the remaining 40% of sales. AES Hawaii operates a 180 MW atmospheric fluidized bed combustion (AFBC) coal plant that produces electricity for sale to HECO and provides steam for use as process-heat to the Chevron USA refinery. The H-POWER plant burns municipal solid waste (MSW), selling electricity to HECO and using electricity to process the waste into fuel. Kalaeloa Partners' 180 MW dual-train combined cycle unit (DTCC) uses LSFO to generate electricity. Waste heat from the two combustion turbines provides steam used in a steam recovery generator to produce additional electricity. Excess steam is provided to the Tesoro Refinery for process heat.

The Tesoro Refinery and Chevron USA refineries use oil, gas, and refinery by-products to generate electricity in combustion turbines. Most of the electricity generated by the refineries is used for internal operations, but some surplus electricity is sold on an as-available basis to HECO. Landfill (LF) methane is used as a fuel for Kapaa Generating Partners' combustion turbine. Waste heat is provided to the nearby Ameron Quarry to dry quarry products. In addition, through July 1998, Waialua Power operated a 12 MW, former sugar mill steam generator using waste oil and greenwaste for fuel. Waialua Power sold 15,310 MWh to HECO in 1997. Table A.21, lists the non-utility generators providing electricity for HECO that were operational in 1998 and their sales to HECO in 1997.

7.6.1.3 HECO System Energy Sources

Figure 7.7 summarizes the energy sources used to generate electricity for sale to HECO customers in 1997. HECO used the smallest percentage of renewable energy of the four Hawaii electric utilities – only about 4.7%.

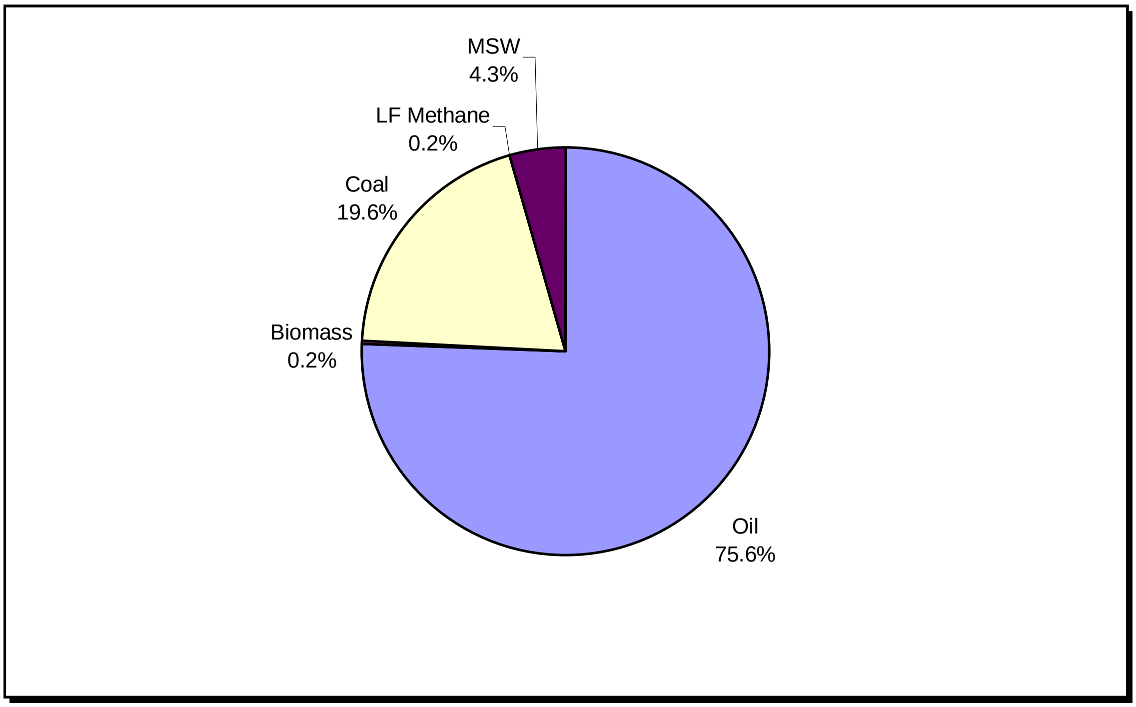
7.6.2 HECO's Integrated Resource Plan, 1998–2017

HECO filed its second IRP for the period 1998–2017 (also called IRP-97) in January 1998. The following is a brief summary of HECO’s preferred plan.

7.6.2.1 Electricity Demand on Oahu

Figure 7.8 shows HECO’s peak demand and sales forecasts for IRP-97 extrapolated to 2020. The forecast accounted for the expected results of DSM programs. The extrapolated HECO forecast was for a 425 MW increase in peak demand from 2000 to 2020 – a 34% increase to a total of 1,668 MW. The extrapolated sales forecast projects 9,189 GWh sales in 2020 – 31% growth.

HECO’s plan was based upon the continued operation of all current HECO-owned generating units (1,263 MW). The HECO plan adds 48% more capacity (605 MW) to the current system. 70% of the added capacity was planned to be diesel-fired, and 30% coal fired.



Note that values do not equal 100% due to rounding.

Figure 7.7 HECO System Energy Sources, 1997

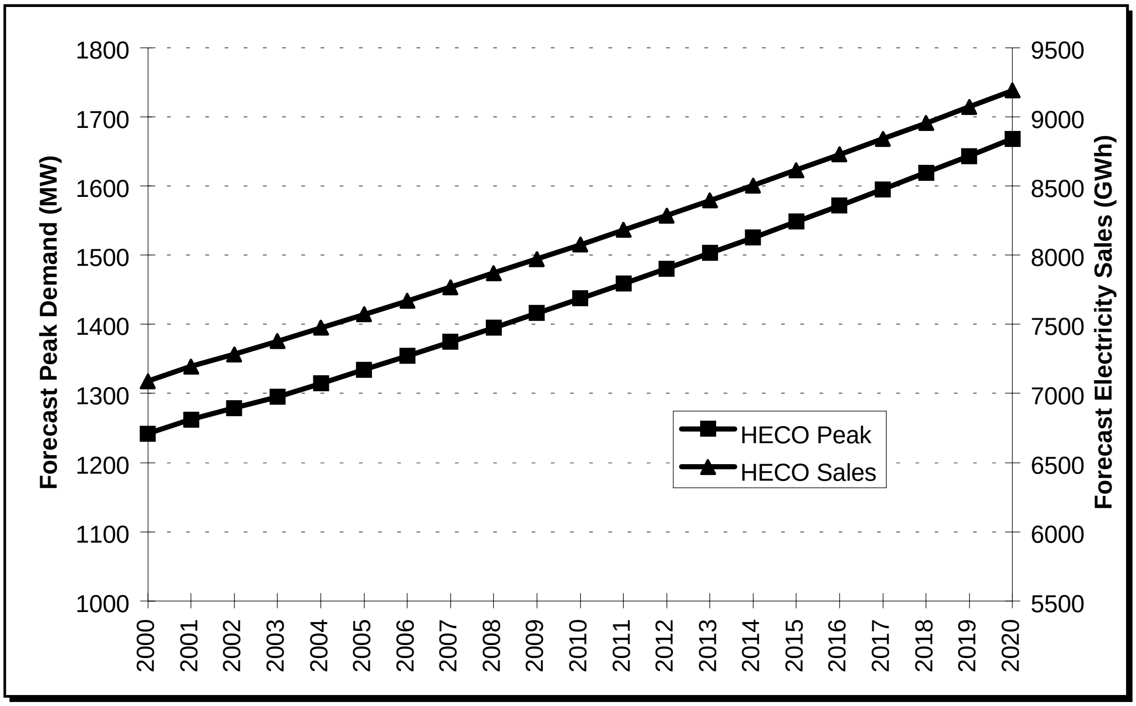


Figure 7.8 HECO Peak Demand and Electricity Sales Forecasts, 2000–2020

7.6.2.2 HECO Supply-Side 20-Year Resource Plan

The main features of HECO's supply-side resource plan are depicted in Table 7.2.

Table 7.2 HECO Supply Resource Plan, 1998-2017

	Additions		Retirements	
Year	**Capacity (MW)**	**Type**	**Capacity (MW)**	**Type**
2009	107	Phase 1 CT of DTCC		
2013	107	Phase 2 CT of DTCC		
2016	284	Phase 3 - 104 MW STG of DTCC: 180 MW AFBC	180	Kalaeloa DTCC
2017	107	SCCT		(contract expires)
Total	**605**		**180**	

Abbreviations: AFBC, atmospheric fluidized bed coal; CT, combustion turbine; DTCC, dual-train combined cycle; MW Megawatt; SCCT - simple cycle combustion turbine; STG - steam turbine generator.
(HECO 1998b, ES-3)

The new units will improve the efficiency of the HECO system. HECO's 1997 heat rate for existing HECO-owned units, which are planned to remain in service through 2020, was 11,241 Btu per kWh. Heat rates for the new units will depend upon their use. Of the planned baseload units, the 318 MW DTCC will have a heat rate of 8,170 Btu per kWh when all three phases are completed in 2016, and the heat rate of the 180 MW AFBC coal plant (to be added in 2016) will be 10,790 Btu per kWh. The 107 MW simple-cycle CT, (to be installed in 2017) is planned for operation as a peaking unit. Its heat rate will vary, depending on how the unit is operated, from 11,830 to 19,950 Btu per kWh. HECO estimated that its 2017 system efficiency will be 10,836 Btu per kWh, a 3.6% improvement over 1997 (11-32).

7.6.2.3 HECO Supply-Side Five-Year Action Plan

No generation units will be built during the five-year action plan period. Future IRPs, developed at three-year intervals, could significantly modify the 20-year plan. The main activity during the next five years will be planning and engineering for the first phase 107 MW CT to be installed by 2009 (ES-15).

Under the Action Plan, HECO has planned actions that could lead to increased renewable energy use. When the IRP was completed, HECO was negotiating with two renewable energy developers for wind and solar projects. As part of the Action Plan, HECO stated its intention to develop a Renewable Request for Proposals (RFP) for supplemental wind and/or photovoltaic energy on Oahu. The IRP called for award of a contract by January 2000, if winning bids were received (2-14 to 2-16). However, HECO did not issue an RFP in January 1999 because "the only realistic site, Kahuku, was not available for the RFP, in addition, the cost of an IRP process is significant and not warranted without the likelihood of viable projects" (Hashiro 1999).

In addition, HECO "will continue its commitment to assist in renewable energy development as presented in the PUC Renewable Energy Resource Investigation, Docket 94-0226 (HECO 1998b, 12-16). The actions include:

- Use of solar DSM programs to shift load to off-peak periods;
- Working with DBEDT to streamline the renewable energy permitting process;
- Purchase of energy from cost-effective renewable energy projects;
- Participate in and monitor renewable energy RD&D;
- Develop and implement a limited number of RD&D projects targeted to Hawaii-specific barriers;
- Implement a "green pricing" program through which customers can elect to pay more for renewable energy;[a] and
- Improve evaluation and consideration of the benefits of renewable energy in the IRP process (12-17 to 12-19).

[a] HECO's "Sunpower for Schools" project installed 2 kW photovoltaic systems at Kaimuki High School in 1997; Waianae, McKinley, Campbell, and Waipahu High Schools in 1998; and Mililani, Waialua, and Castle High Schools in 1999. These were funded by voluntary customer payments as a form of "green pricing."

7.6.2.4 HECO Demand-Side Management (DSM)

DSM is defined as any utility activity aimed at modifying the customer's use of energy to reduce demand. It includes conservation, load management, and efficiency programs. DSM offers the potential for lower customer utility bills, deferral of major power plant investments, reduced environmental impacts, and potential diversification of resources (NEOS 1995, ES-1). All of these potential benefits support the state's energy objectives. HECO's DSM plans are discussed further in Chapter 11.

7.7 Electricity for the Island of Hawaii

Hawaii Electric Light Company, Inc., (HELCO) is the electric utility serving the Island of Hawaii. HELCO's sales of 894,110 MWh in 1997 ranked third of the state's four utilities. HELCO generated most of the electricity sold to its customers, but purchased 37.6% of net generation from NUGs in 1997.

7.7.1 The Island of Hawaii's Electricity Supply

7.7.1.1 HELCO-Owned Generation

HELCO produces 150.3 MW of firm power using 69 MW of medium-sulfur fuel oil (MSFO)-fired steam generators (OFS), 38 MW of internal combustion (IC) diesel engine generators, and 43.3 MW in combustion turbine (CT) units fueled with diesel oil. In addition, HELCO is the only utility in the state that currently operates its own renewable resources. HELCO owns 3.35 MW of run-of-the-river hydro and 2.28 MW of wind generation, both used for supplemental power.

The OFS units provided 64% of the electricity generated by HELCO units in1997, the diesel units produced 32%, and HELCO's wind and hydro units provided 4%. Table A.22 details HELCO-owned generation in operation at the end of 1998.

7.7.1.2 Non-Utility Generation for Sale to HELCO

NUGs provided an additional 52 MW of firm capacity. Puna Geothermal Venture (30 MW geothermal nominal, derated temporarily to 24.5 MW at end of 1998) and Hilo Coast Power Company (HCPC) (22 MW coal-fired steam). Together, these companies provided 25% of the 202.3 MW of firm capacity available on the Island of Hawaii at the end of 1998.

Apollo Energy, at South Point, provided 7 MW of supplemental wind energy. Wailuku hydro provided 11 MW of run-of-the-river hydro, while other small wind and hydro units added 0.4 MW. Table A.23, depicts Hawaii County non-utility generators in 1998 and their 1997 sales to HELCO. Figure 7.9 summarizes the HELCO's energy sources in 1997.

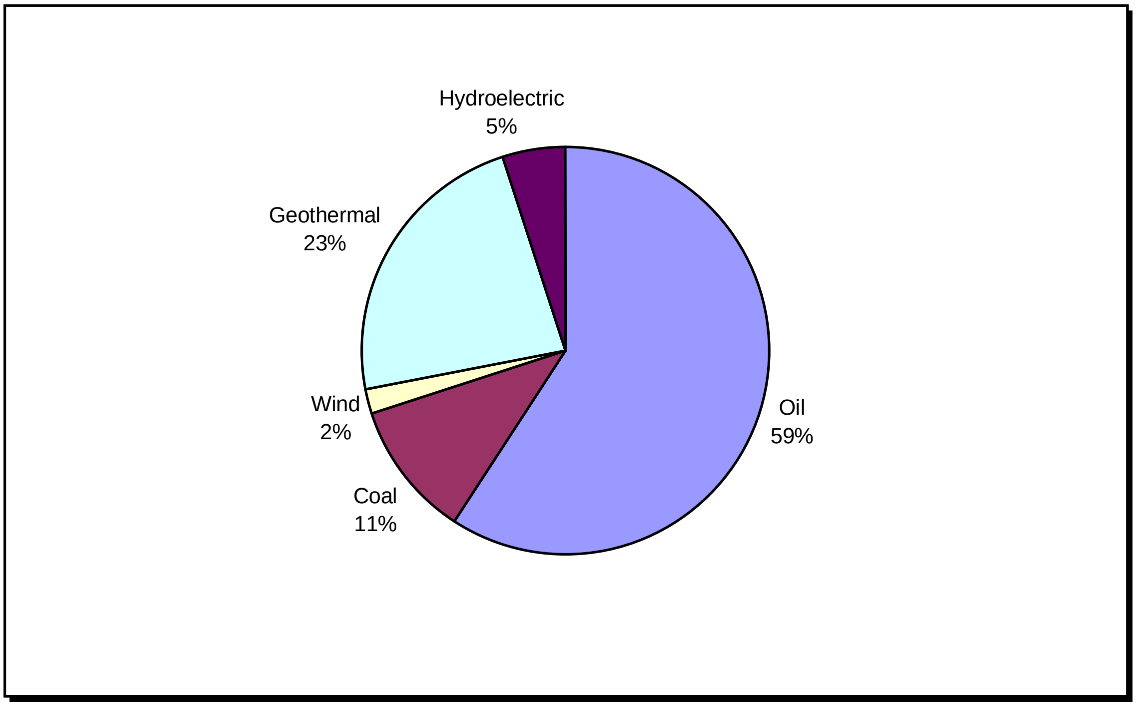


Figure 7.9 HELCO System Energy Sources, 1997

7.7.2 HELCO's Integrated Resource Plan, 1999–2018

HELCO filed its second integrated resource plan for the 20-year period 1999–2018 (IRP-98) on September 1, 1998. At this writing, in 1999, due to HELCO’s inability to resolve permitting and other issues, construction had not started on generation units at Keahole that HELCO had assumed would be in place in late 1998 as a basis for their IRP. Nevertheless, this discussion will be based upon HELCO’s IRP, with the expectation that HELCO will seek to adhere to their IRP as closely as possible in the future. There is no assurance, however, that the Keahole units will ever be installed.

7.7.2.1 Electricity Demand on the Island of Hawaii

HELCO forecast peak demand and sales through 2018 in IRP-98. These forecasts, presented in Figure 7.10, were extrapolated from 2018 to 2020, the *HES 2000* plan period.

7.7.2.2 HELCO’s Current Supply Situation

HELCO’s first IRP, issued in 1993 (IRP-93), called for installation of CT-4 and CT-5, 20 MW combustion turbines at Keahole in 1995. In 1997 these were to be connected to a steam turbine generator that would produce an additional 18 MW. HELCO also indicated that it would consider installing a 10 MW battery storage unit in 1995 as a contingency for delays in installing the Keahole generators. IRP-93 noted that the battery storage unit “could provide much needed-frequency control, voltage support, and on-line reserve for West Hawaii, as well as providing up to 10 MW of peaking capability” (HELCO 1993b, 5-7).

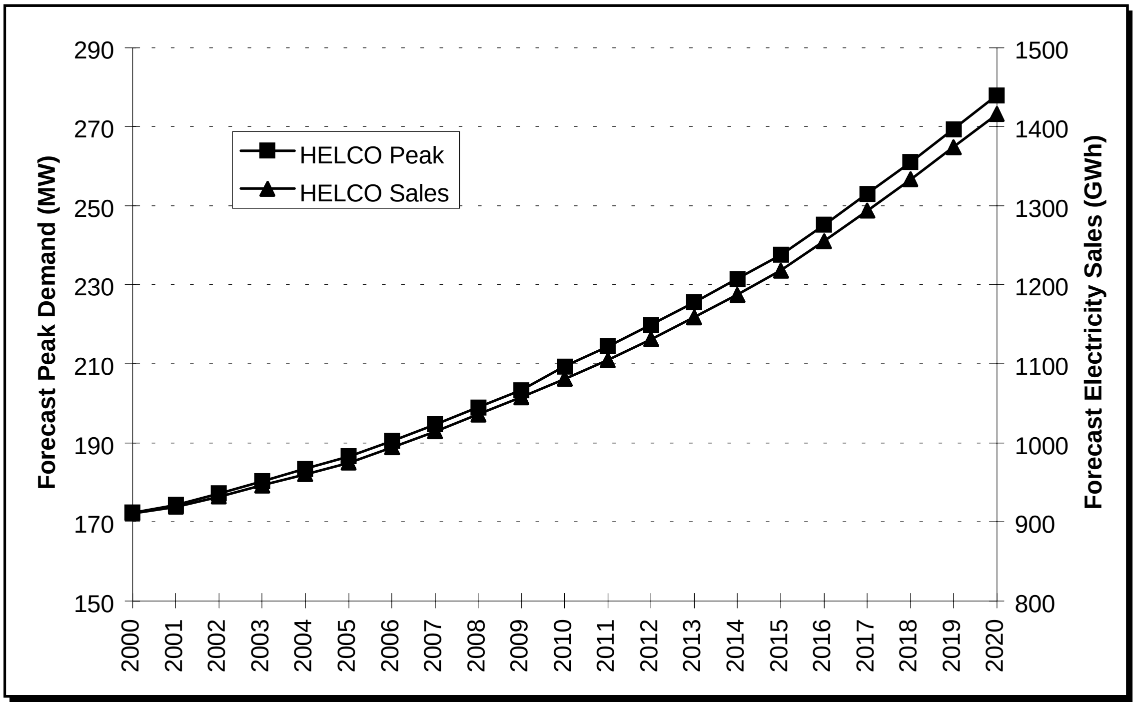


Figure 7.10 HELCO Peak Demand and Electricity Sales Forecasts, 2000–2020

None of the units planned in IRP-93 were installed due to permitting delays on the Keahole CTs and HELCO's decision not to deploy the battery storage unit. As the delays continued, on January 26, 1996, the Public Utilities Commission issued Order No. 14505 requiring HELCO to provide an assessment of its generating needs and capabilities for the period 1996–1998. HELCO's first assessment, issued in March 1996, and five subsequent updates, have been contingency plans discussing what the utility was doing and could do to ensure adequate reserve margins in the face of delays in adding new firm capacity (HELCO 1999a, i).

In IRP-98, HELCO intended to install Keahole CT-4 and CT-5 in December 1998, with the addition of ST-7 in 2006. It is not clear when HELCO will be permitted to install additional units at Keahole.

HELCO's preferred IRP also assumed that Encogen, a non-utility generator, would install a 62 MW DTCC cogeneration facility near Haina, Hawaii. IRP-98 projected installation of the first unit of Encogen's plant by April 1999, based upon an August 1998 approval. Approvals were received in 1999. Construction is underway, and the plant will be in operation in 2000.

HELCO proceeded with CT-4 and CT-5 in parallel with the Encogen contract to increase the likelihood of being able to continue to provide reliable power to Big Island customers (HELCO 1998b, 4-15). At present, neither project can be built without additional approvals from regulatory authorities.

7.7.2.3 HELCO’s Fifth Contingency Plan

HELCO has successfully maximized available generation by careful scheduling of generation unit overhauls and maintenance. HELCO deferred planned unit retirements, purchased increased power from Puna Geothermal Venture and

HCPC, and obtained load management contracts to reduce the evening peak by 7 MW (HELCO 1999a, i). HELCO has also initiated a variety of DSM programs (discussed in Chapter 11) and has applied to rezone the Puna Power Plant parcel for possible expanded use if neither planned project is successful. HELCO’s efforts to continue to meet electricity demand were aided by the slowdown in the Big Island’s economy and reduced growth of electricity demand.

HELCO continued to seek an air permit for its Keahole units. Should this and other issues be favorably resolved, HELCO estimated that the delay on the Keahole units could exceed a year from the expected service date of December 1998. The first two phases of the Encogen facility should be installed in April and August 2000 (iii). In addition, HELCO is negotiating with HCPC and Kawaihae Cogeneration Partners for possible power purchase agreements. According to HELCO, “HELCO continues to pursue, in parallel, the installation of its Keahole Project . . . as well as power purchased from Encogen. This strategy increases the likelihood of providing reliable electrical power to the residents of the Big Island” (iv).

HELCO’s contingency actions have sought to ensure adequate reserve margin (the difference between system generating capacity and peak system load). It also seeks to ensure a positive load service capability (LSC) margin that allows for planned maintenance plus the loss of the largest generating unit on line. According to *HELCO’s Contingency Plan Update* (HELCO 1999b), HELCO’s forecast lowest projected reserve margin for 1999 would be 21.1 MW at the day peak and the lowest LSC margins will be –3.4 MW at the day peak. In 2000, the lowest projected reserve margin will be 2.6 MW at the day peak and the lowest LSC margin will be –19.3 MW at the evening peak, if Encogen Phase 1 is not in service.

Encogen has received approval for their air permit and their power purchase agreement. It is anticipated that they will have their full 60 MW of generation on line in late 2000 (Munger 1999a).

7.7.2.4 HELCO Supply-Side 20-Year Resource Plan

HELCO’s IRP-98 was not initiated as planned, but it formed the basis for five alternative cases that HELCO filed with the Public Utilities Commission as a *Supplement to September 1, 1998 Integrated Resource Plan* on March 1, 1999 (HELCO 1999a). A *Revision to Supplement to September 1, 1998 Integrated Resource Plan* (HELCO 1999b) was filed with the Commission on June 16, 1999. The Supplement is discussed in the following section.

7.7.2.5 HELCO’s Supplement to IRP 1998

Faced with delays in implementing IRP-2’s Action Plan, as noted above, HELCO developed five combinations of potential generation additions. HELCO selected a preferred case – Case 4. The following summarizes the HELCO Supplement Case 4 Preferred Plan, as described in the June 1999 Revision. It is depicted on Table 7.3.

Table 7.3 HELCO Revised Supply Resource Plan, 1998-2017

	Additions		Retirements	
Year	Capacity (MW)	Type	Capacity (MW)	Type
2000	62	Encogen DTCC	23.9	Waimea D8-10,12-14; Kanoelehua 11,15-17; Keahole 18-19; Shipman 1 OFS
2001	40	Keahole CT-4, CT-5	16	Keahole D20-23; Kanoelehua CT-1
2001			15.5	Puna OFS on standby
2003	15.5	Puna OFS from standby		
2005			7	Shipman 3 OFS
			22	HCPC contract expires
2006	18	Keahole ST-7		
2008			7.7	Shipman 4 OFS
2009	21.3	W. Hawaii Ph 1 of DTCC		
2013	21.3	W. Hawaii Ph 2 of DTCC		
2015			14.1	Hill 5 OFS
2016	19	W. Hawaii Ph 3 of DTCC		
2017	21.3	W. Hawaii Ph 1 of DTCC		
2019			18	Keahole CT-2
2020	21.3	W. Hawaii Ph 2 of DTCC		
Total	**239.7**		**124.2**	

Abbreviations: CT, combustion turbine; DTCC, dual-train combined cycle; HCPC, Hilo Coast Power Company; MW, Megawatt; OFS, oil-fired steam (HELCO 1999b)

Case 4 modified HELCO's IRP 1998 preferred plan by changing the Keahole and Encogen in-service dates and related retirements to reflect the new situation. It assumed that the full Encogen 62 MW DTCC would be installed by August 2000, and that the Keahole CT-4 and CT-5 (40 MW total) would be installed by March 2001. The existing HCPC power purchase agreement was assumed to end on December 31, 1999. Unit retirements were also altered as needed.

7.7.2.6 HELCO Demand-Side Management (DSM) 20-Year Plan

HELCO's DSM plan is detailed in Chapter 11.

7.8 Electricity for Kauai

The Kauai Electric Division (KE) of Citizens Utilities Company is the investor-owned electric utility serving electricity customers on Kauai. KE sold 382,112 MWh of electricity in 1997, making it the smallest of Hawaii's utilities. This represented 4% of total statewide electricity production. KE generates most of the electricity sold to its customers, but purchased 18% of net generation (before losses) from NUGs in 1997.

This section describes Kauai's electricity supply at the end of 1998, including KE generation, the NUGs that sell power to KE, and renewable energy use. It is intended to provide the reader with a better understanding of Kauai's electricity system and future plans. Electricity production and fuel use statistics for 1997 are cited here since 1998 statistics were not available when this was written.

7.8.1 Kauai's Electricity Supply

7.8.1.1 KE-Owned and Non-Utility Generation Sold to KE Customers

KE-owned generators are all located at Port Allen and provided 96.55 MW, or 87% of the firm capacity on the system. Amfac East's Lihue Plantation provided an additional 14 MW, or 13% of capacity. Other sugar plantations provided as-available power from their steam-bagasse/oil power plants and hydroelectric generators. Table A.24 lists utility and non-utility generation serving the County of Kauai.

In 1997, KE used oil fired steam (OFS) generators to produce 14% of its electricity, and both combustion turbines using diesel fuel and internal combustion diesel generators (IC-Diesel) to produce 68% of the electricity sold. The remaining 18% was purchased from Lihue plantation and other sugar companies.

7.8.1.2 KE System Energy Sources

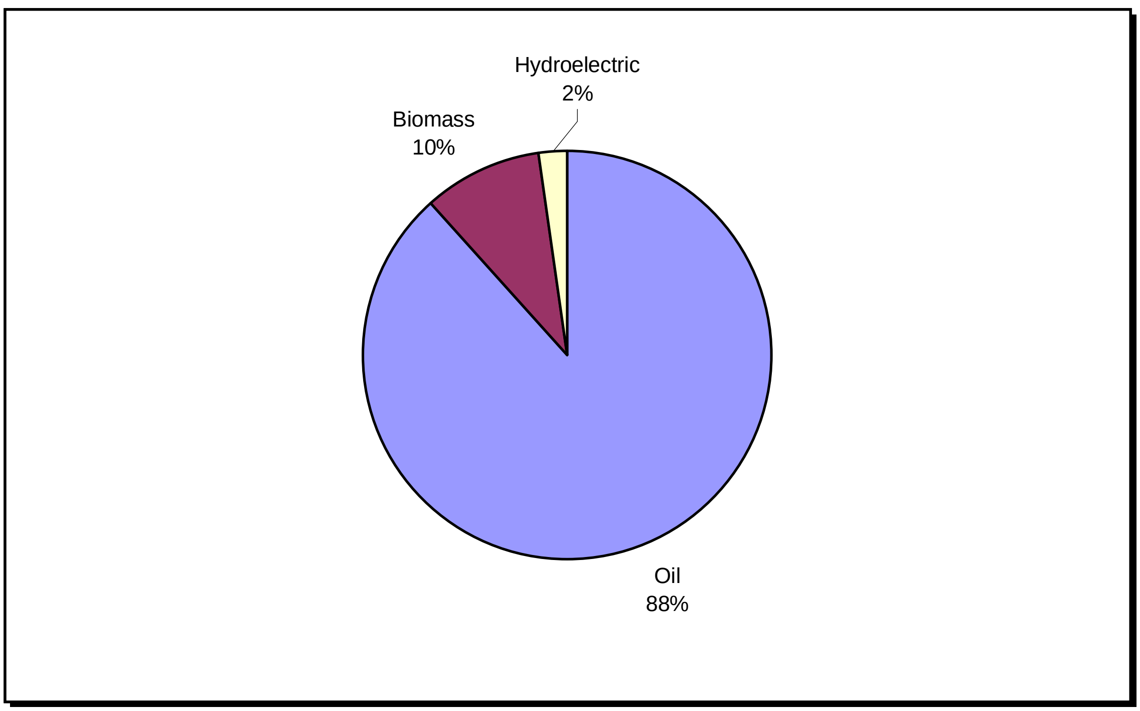


Figure 7.11 KE System Energy Sources, 1997

Figure 7.11 summarizes the energy sources used to generate electricity for sale to KE customers. On a percentage basis, KE ranked second for use of renewable energy in 1997, obtaining approximately 10% of its electricity from bagasse and 2% from hydroelectricity. The remaining 88% was produced using diesel fuel. No. 6 residual fuel oil has not been used on Kauai since 1993 due to oil spill liability concerns on the part of KE's fuel supplier.

7.8.2 KE's Integrated Resource Plan, 1997–2016

KE filed its second IRP for the 20-year period 1997–2016 with the PUC on April 1, 1997. The following discussion is based upon that plan.

7.8.2.1 Electricity Demand on Kauai

KE forecast peak demand and sales through 2016 in their second IRP. The KE peak demand forecast was extrapolated from 2016 to 2020 to match the *HES 2000* planning period and is depicted in Figure 7.12. KE forecast sales were not available in a form useable for inclusion.

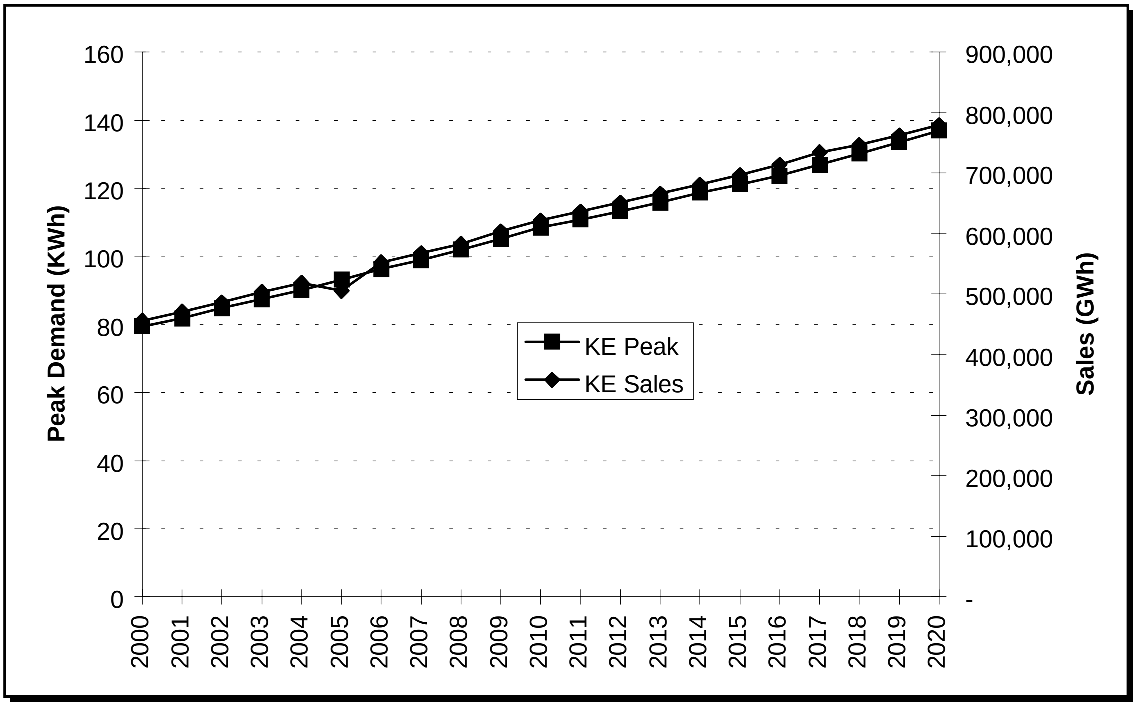


Figure 7.12 KE Peak Demand Forecast, 2000–2020

7.8.2.2 KE Supply-Side 20-Year Resource Plan

KE planned to meet its future supply through requests for proposals to NUGs to build the necessary capacity to meet their needs. KE issued an RFP in 1996 to see if an IPP could provide power at or below utility-built costs (KE 1997b, 1-5). The 1997 IRP preferred plan called for the units listed in Table 7.4 to be added during the 20-year period. KE has selected an IPP to build the first unit listed.

In the near term, Green Islands Corporation signed an energy-only contract of up to 10.3 MWh for an operation using plasma arc technology to convert Kauai’s solid waste into electricity (2-3).

KE indicated concern about the long-term viability of Lihue Plantation and its ability to continue providing 14 MW of firm power to the KE system. Flexible plans were to be prepared to deal with a closure or for if Lihue gave its 3-year notice under the existing contract (2-3 to 2-4).

Table 7.4 Kauai Electric Supply Resource Plan, 1997–2016		
Year	Capacity	Type
2002-2004	26.4 MW	Combustion Turbine with Cheng Cycle Waste Heat Recovery System
2012	10 MW	Medium Speed Internal Combustion Diesel
2014	24 MW	Coal Steam

KE 1997b

Further supply-side work under the second IRP included a study to reduce NO_x from KE's existing gas turbines and an effort to consolidate air permits for the Port Allen Generation Station. KE was also to seek system heat rate improvements that would result in greater efficiency and less fuel use per kWh generated. This would also reduce emissions (2-4).

If all the firm power units proposed in the second IRP are installed, KE will have an additional 60.4 MW, increasing total capacity to 170.95 MW by 2014. This capacity would be 55% greater than the 1998 firm capacity.

While none of KE's existing generating units was scheduled for retirement, they are relatively efficient. The new units planned were expected to be slightly less (1.6%) efficient. This will be due in part to the planned use of the coal fired steam unit, which offers fuel diversity at the price of lower efficiency.

7.8.2.3 KE Demand-Side Management (DSM) Plan

Kauai Electric developed six DSM programs in its first IRP in 1993. The six programs were incorporated into the 1994 DSM Action Plan (KE 1997b, D-7). These plans are discussed in detail in Chapter 11.

7.9 Electricity for Maui, Molokai, and Lanai

The Maui Electric Company, Ltd., serves the Islands of Maui, Molokai, and Lanai. MECO is unique among Hawaii's utilities in that it operates three separate utility grids, each serving one of the three islands. MECO was the second largest utility in the state, with sales of 1,028,768 MWh in 1997. MECO generated most of the electricity sold to its customers, but purchased about 9% of net generation from NUGs in 1997.

7.9.1 Maui County's Electricity Supply

7.9.1.1 MECO-Owned Generation

MECO's Maui units included 38 MW of OFS units burning MSFO No. 6 residual fuel oil at Kahului; the Maalaea plant, containing a DTCC unit consisting of two 20 MW CT units (Maalaea 14 and 16); and Maalaea 15, an 18 MW steam recovery generator (SRG). Maalaea 17 was a 21.2 MW CT intended to be the first phase of a similar DTCC. Maalaea's DTCC and the CT total 79.2 MW. There are also 15 internal combustion diesels (IC-Diesel) at Maalaea with a total capacity of 96 MW. All values represent gross generation. Table A.25 details MECO's Maui generation at the end of 1998.

On Lanai, MECO had two 1 MW internal combustion diesels on standby at Lanai City and six 1 MW diesels and two 2.2 MW diesels at Miki Basin. On Molokai, there were eight diesels of varying sizes totaling 13.06 MW and a single 2.22 MW combustion turbine. All utility electricity on both islands was produced by MECO in 1998. Table A.26 summarizes MECO-owned generation on Lanai and Molokai at the end of 1998.

7.9.1.2 Non-Utility Generation Sold to MECO

In addition, Hawaiian Commercial & Sugar Company (HC&S) has a contract with MECO to provide 16 MW of firm power from its Puunene Mill on Maui. The Puunene Mill burned bagasse supplemented by coal to provide this power. As-available power from the Paia Mill and three HC&S hydro plants was sometimes sold to MECO on Maui. The Pioneer Mill, at Lahaina, also provided small amounts of as-available power at times. A 20 kW photovoltaic demonstration unit and two 1 kW units for school projects provided small amounts of electricity. Figure 7.13 shows the energy sources used by MECO and NUGs to generate electricity for sale to MECO customers.

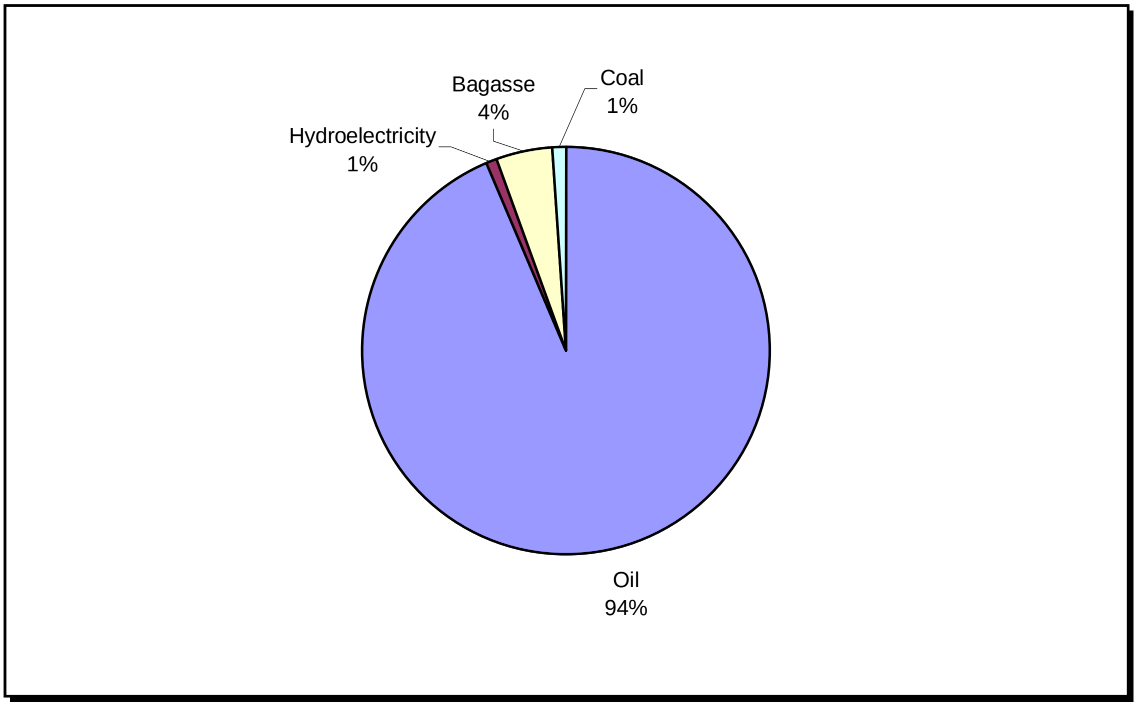


Figure 7.13 MECO System Energy Sources, 1997

7.9.1.3 MECO System Energy Sources

Energy sources on all three islands served by MECO are combined, although Lanai and Molokai use only diesel oil for their generation. On a percentage basis, MECO ranked third for use of renewable energy (5.1%). MECO used the highest percentage of oil, however.

7.9.2 MECO's Integrated Resource Plan, 1999–2018

MECO was originally scheduled to file its second IRP on September 1, 1999**.** However, in mid 1999, after conducting preliminary studies of the possibility of extending the operating life of existing units, MECO decided that this option deserved more detailed analysis in their IRP. Accordingly, MECO sought an extension to May 26, 2000 from the PUC. The MECO least-cost plan developed before the preliminary remaining useful life studies were conducted is presented below; however, a very different plan could emerge as the ultimate MECO IRP.

7.9.2.1 Electricity Demand in Maui County

Figure 7.14 shows forecast peak demand and sales through 2019, extrapolated from 2019 to 2020.

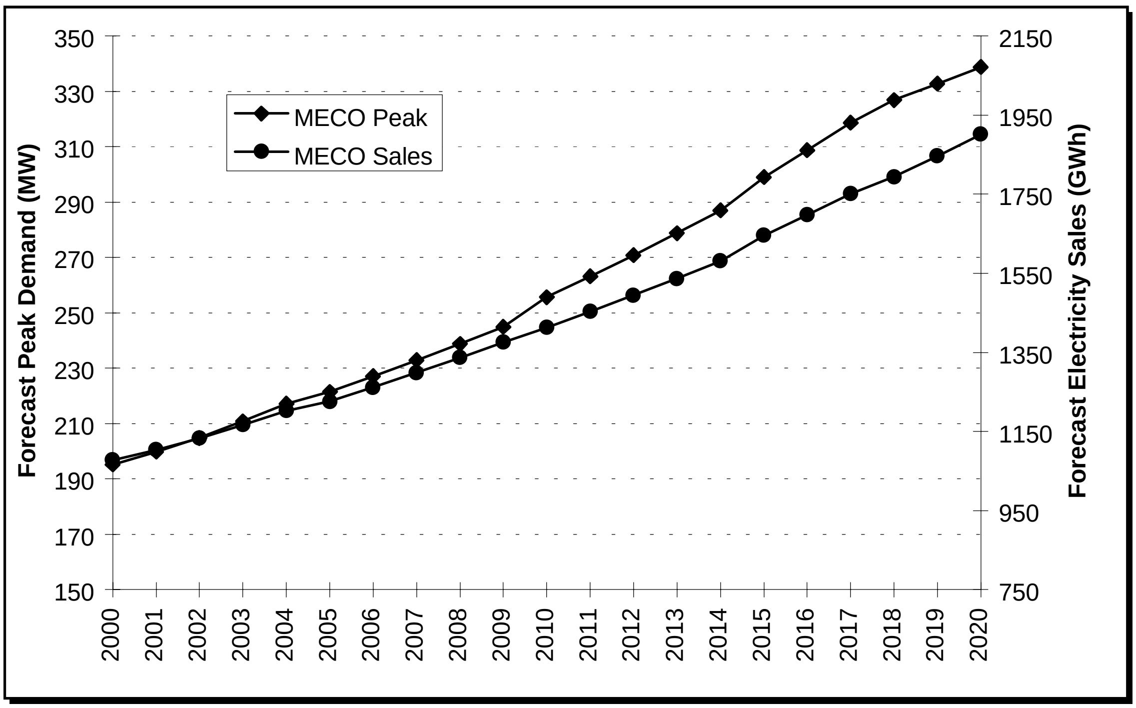


Figure 7.14 MECO Peak Demand and Electricity Sales Forecasts, 2000–2020

7.9.2.2 A Draft MECO Supply-Side 20-Year Resource Plan (1999–2018)

With three separate utility grids on three separate islands, MECO had to develop three separate plans. The plan depicted in Table 7.5 is based upon a mid-1999 draft least-cost plan. MECO's ultimate preferred plan may be considerably different. The generating capacities below are given in net generation values.

MECO planned to add 272.7 MW of new capacity by completing the Maalaea DTCC and adding four 58.7 MW DTCC at a new site. A total of 115.40 MW is to be replaced by these new units, including 96.18 MW of IC diesels, 35.92 MW of OFS units, and the expiration of the 16 MW power purchase agreement with HC&S. The planned units would be about 8% to 21% more efficient than the units they replace, depending on operating mode.

Table 7.5 MECO Preliminary Supply Resource Plan for Maui, 1999-2018				
	Additions		Retirements	
Year	Capacity (MW)	Type	Capacity (MW)	Type
1999	20.8	Maalaea 19 Ph 2 CT of DTCC		
2001			16.0	HC&S Contract Expires
			2.7	Maalaea 1 Diesel
2002			5.4	Maalaea 2-3 Diesels
2003	17.1	Maalaea 18 Ph 3 SRG of DTCC	12.3	Maalaea 4-5 Diesels
2004	20.8	CT-1 Phase 1 CT of DTCC	12.5	Kahului 3 OFS
2005			18.2	Maalaea 6-7 Diesels; Kahului 1 OFS
2006	20.8	CT-2 Phase 2 CT of DTCC	6.0	Kahului 2 OFS
2007	17.1	ST-3 Phase 3 STG of DTCC	5.6	Maalaea 8 Diesel
	20.8	CT-4 Phase 1 CT of DTCC		
2008			5.6	Maalaea 9 Diesel
2009	20.8	CT-5 Phase 2 CT of DTCC	12.9	Maalaea 10 Diesel
2010	17.1	ST-6 Phase 3 STG of DTCC	12.9	Maalaea 11 Diesel
2011	20.8	CT-7 Phase 1 CT of DTCC		
2012			5.4	Maalaea X1,X2 Diesels
2013	20.8	CT-8 Phase 2 CT of DTCC		
2015	17.1	ST-9 Phase 3 STG of DTCC		
2017	20.8	CT-10 Phase 1 CT of DTCC		
2018	20.8	CT-11 Phase 2 CT of DTCC		
2019	17.1	ST-12 Phase 3 STG of DTCC		
Total	**272.7**		**115.4**	

Abbreviations: CT, combustion turbine; DTCC, dual-train combustion turbine; HC&S, Hawaii Commercial & Sugar; MW, Megawatts,OFS, oil-fired steam; STG, steam turbine generator (MECO IRP-2 Preliminary Results via Munger 1999a, 15-16)

Table 7.6 MECO Preliminary Supply Resource Plan for Lanai and Molokai, 1999–2018				
	Additions		Retirements	
Year	Capacity (MW)	Type	Capacity (MW)	Type
Lanai				
2006	4.4	LL-9, LL-10 Diesels	6.0	LL1-LL6 Diesels
2008	2.2	LL-11 Diesel		
Molokai				
2006	2.2	P-10 – 2.2 MW Diesel	6.5	P1- P6 Diesels
2012			2.2	Palaau CT
2013	2.2	P-11 Diesel		

MECO 1998d; Abbreviations: CT, combustion turbine; MW - Megawatts

Lanai Supply-Side Plan. The plan developed for Lanai in the *1998 Annual Evaluation Report* (MECO 1998d) consisted of units shown on Table 7.6. The plan involved retiring six 1.0 MW IC diesels and adding three new 2.2 MW IC diesels over the period.

Molokai Supply-Side Plan. The *1998 Annual Evaluation Report* update for Molokai consisted of units shown on Table 7.6. The Molokai plan involved retiring six IC diesels totaling 6.46 MW, placing the 2.22 MW CT on standby, and adding two 2.2 MW IC diesels (MECO 1998d).

7.9.2.3 MECO Demand-Side Management Plan

MECO's DSM Plans are discussed in Chapter 11.

7.10 Siting Future Power Plants in Hawaii

7.10.1 The Need and the Dilemma

7.10.1.1 Summary of Utility Needs

Through the year 2020, Hawaii's electric utilities plan to build 1,041.4 MW of new generation, as follows:

- Oahu: 605 MW, including a 318 MW DTCC, a 180 MW AFBC coal plant, and a 107 MW simple-cycle CT;
- Hawaii: If CT4-5 and ST-7 (58MW) are built at Keahole, HELCO plans another 104.2 MW during the period, including a 58 MW DTCC, a 62.5 MW DTCC, and the first two 21.3 MW CT phases of another DTCC;
- Kauai: 61.4 MW, including a 26.4 MW CT with heat recovery system (HRS), a 10 MW internal combustion diesel, and a 24 MW coal steam plant at the Lihue Power Station;
- Maui: 234.8 MW, including four 58.7 MW DTCCs (MECO 1997d);[a]
- New additions for Molokai and Lanai are planned for existing sites.

Table A.27, summarizes the new unit additions described in the utility plans that will require sites and provides the dates they are planned to be in operation. Generally, new sites will be needed, although there may be options to add or replace generation at existing sites. It is possible, and desirable, that alternatives to central station power plants may reduce the need to build currently planned units. Alternatives to central station power plants could include varying combinations of renewable energy, energy efficiency, and distributed generation.

Nevertheless, it is likely that a significant portion of utility-planned generation will have to be built to meet Hawaii's future electricity needs. As a result, sites for future generation are needed on all islands.

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[a] (Note: This is based upon MECO's current draft least-cost plan. Additional work on their second IRP continues and may result in selection of a different plan.)

7.10.1.2 Siting Conflicts

Virtually everyone needs and uses electricity, and most people believe that new generation is fine – as long as it is "not in my back yard." Due to concerns about air pollution, noise, dust, fuel-truck traffic, and aesthetics, few people want to live or work near – or even within sight of – a major power plant. This complicates finding suitable locations for new generation to meet future electricity needs. Locations are needed well away from almost everyone's back yard, which, in turn increases transmission line requirements, which also face siting opposition.

7.10.1.3 Air Quality Constraints

On Oahu, HECO intends to build its next unit of generation, planned for operation in 2009, in the Campbell Industrial Park. The recent *CIP/Kahe Air Quality Assessment Study* indicated that the area could accept additional industrial growth or expansion of the industrial facilities (DOH 1999, 8-1). Nevertheless, the HECO must obtain an air permit for the project based upon the specifics of its planned emissions. Future projects will have to meet USEPA prevention of significant deterioration emission criteria and potentially higher emission standards. Accordingly, other areas may have to be considered for future generation in the second decade of the next century.

On Kauai, all KE-owned generation is now located at Port Allen. One of KE's motivations in seeking to develop an additional site was a preliminary estimate that the Port Allen airshed could accommodate no more than about 30 MW of additional fossil fuel generating capacity without expensive retrofits or replacement of existing units.

7.10.1.4 Other Factors

Other major siting considerations include proximity to load, availability of cooling water, access to fuel transportation links, zoning, presence of endangered species or archaeological sites, and the ability to obtain necessary State and County permits.

7.10.2 Prospects for Future Sites

Kauai Electric and Maui Electric have identified future sites for generation and are involved in the permitting process. The planned facilities will provide siting for all planned new generation noted in the KE and MECO IRPs. According to their most recent IRPs, HECO is in the process of permitting a site for its first planned new unit, and HELCO is seeking a new site in West Hawaii. Both utilities will need additional sites besides these to install all planned units.

7.10.2.1 Future Sites for HECO

HECO intends to install its planned DTCC plant at HECO's Barbers Point Tank Farm, in the Campbell Industrial Park at Kapolei. As part of its IRP action plan, HECO is seeking additional property for expansion of a related substation and the tank farm itself to accommodate the complete plant. The company is proceeding with air and land use permit activities that involve long lead-times.

HECO filed its air permit application on June 3, 1997, and expects to receive its permit by November 2006. Construction is scheduled to start in October 2007, and the Phase 1 combustion turbine is expected to begin commercial operation in simple-cycle mode in January 2009, followed by the Phase 2 unit in January 2013. With the addition of the Phase 3 steam turbine unit, operation as a DTCC is planned for January 2016 (HECO 1998b, 12-14).

It is not clear where the 180 MW AFBC coal plant planned for operation in 2016 and the 107 MW SCCT planned for operation in 2017 will be installed. If the HECO tank farm site is not permitted, HECO must obtain the necessary permits for another site by November 2006 to allow the CT to be released for manufacture (12-14).

7.10.2.2 Future Sites for HELCO

HELCO has sought a West Hawaii site since before 1988. In that year, a West Hawaii Site Study identified a number of potential sites to meet HELCO's stated need to locate new generation on the side of the island where of the new load growth will occur. HELCO encountered major obstacles in attempting to locate generation at the Puuanahulu and Kawaihae sites recommended in the Site Study. Ultimately, HELCO sought to site its next generation unit at Keahole and has pursued that goal since 1992. Additional air data is being collected as part of HELCO's efforts to obtain an air permit.

HELCO's IRP-1998 stated that "HELCO will begin efforts to select and acquire the new West Hawaii site within the five-year action plan period with the intent of securing the new site prior to initiating permitting and engineering efforts on the CT-6 unit" (HELCO 1998b, 9-7). It appears that HELCO is simultaneously negotiating for more than one site and will select the most suitable site "once the issues of concern are addressed with the landowners" (9-8). HELCO indicated in its March 1999 Contingency Plan that "specific work plans are currently being developed" (HELCO 1999a, 2).

In April 1999, the Hawaii County Council approved HELCO's request to rezone the Puna Power Plant parcel from agricultural to industrial and to amend the State land use boundary designation (Munger 1999, 17). While HELCO has no specific plan to use this site, it would be available for future generation. (2).

The permitting difficulties encountered by HELCO with its Keahole site clearly demonstrate the need to identify and permit future sites well before they may be required.

7.10.2.3 KE and the Lihue Energy Service Center

Kauai Electric is developing a master-planned energy service center in the Lihue area. The site could eventually contain 120 to 150 MW of new generating capability and a centralized transmission and distribution (T&D) facility base yard. Full build-out of the site would not occur for at least 30 years, and may not occur at all if emerging technologies such as microturbines and fuel cells, or some other form of distributed generation becomes more cost-effective than the KE's proposed central power station units (KE 1999, 2-1).

As outlined in KE's IRP-1997 and the final EIS for the Lihue Energy Service Central (KE 1999), in the 2002–2004 time frame, KE needed a new site to allow installation of the next planned generation unit, a 26.4 MW advanced steam-injected cycle combustion turbine in the 2002–2004 time frame. Should Lihue Plantation, a current supplier of electricity to KE, stop operations, the earlier installation date would be required to meet base case forecast demand.

If in the longer run, the year 2010 or beyond, alternatives to the proposed technologies for electrical generation on Kauai may become available or more economical, the continuing IRP process will identify and select such alternatives during one of the triennial planning cycles. In the meantime, DBEDT views the development of the Lihue Energy Service Center site is a prudent measure necessary to ensure timely provision of sufficient, reliable electricity to the people of Kauai.

7.10.2.4 MECO and the Waena Generating Station

MECO has proposed the Waena Generating Station as a master-planned site for up to 232 MW of new capacity (four 58 MW DTCC units) to be built in four stages. If MECO selects a plan similar to that proposed in their current draft least-cost plan, construction on the first unit would be started in 2004, and the fourth unit would be completed in 2020 (MECO 1999).

In its EIS, MECO reported that following current additions to its Maalaea facility, both Maalaea and Kahului facilities would be built to full land capacity (MECO 1997d 2-6). MECO determined that the need for additional units on the system could not be offset or postponed by planned DSM programs, potential contracts with NUGs, alternative energy, or deferred retirements of existing units (3-16 to 3-17). DBEDT concurs that at least a significant portion of the generation planned for Waena will likely need to be built to provide continuing, reliable electricity service on Maui. If alternatives to the currently proposed technologies for electricity generation become available or become more economical, the continuing IRP process will identify and select such alternatives during a future triennial planning cycle.

7.10.3 RECOMMENDATION: Identify, Designate, and Permit Energy Sites for Future Electricity Generation

Suggested Lead Organizations: Electric Utilities, Public Utilities Commission, State and County Permitting Agencies, Stakeholders

The utilities, State and County permitting agencies, and stakeholders could jointly identify and designate sufficient sites to support forecast new generation requirements for a 20-year period. Since under the current regulatory framework the Public Utilities Commission does not allow cost recovery for property held for future use if that use is more than 10 years in the future, the Commission is urged to consider extending this limit to the full 20-year IRP planning period. Permits for construction of new units would be sought on a unit-by-unit basis.

Sites would be established for fossil-fuel and renewable energy technologies. Renewable site areas would be selected based upon renewable resource assessments. Sites for other projects, such as biomass, hydroelectric, or pumped-storage hydro could be difficult to provide in advance. State and County permitting agencies should examine ways to streamline the approval process. Such improvements to the existing generation siting process are essential for meeting Hawaii’s future electricity needs.

7.11 The Potential of Future Technology for Electricity Supply

7.11.1 The Need for New Approaches

Hawaii’s geographic isolation helped create its dependence on fossil fuel, especially oil. As discussed above, there are likely limits to the number of current renewable energy technologies that can be used on each electrical system. In the area of firm power, biomass provides the greatest potential on all islands, but is constrained by available land for growing fuel, soil management issues, as well as by costs. On the Island of Hawaii, there is a potential for additional geothermal energy, but there are relatively low requirements at nighttime for power and cultural and health concerns to be met. A geothermal system capable of producing power that follows changing demand during the day is needed. In addition, problems with the current steam source, permits to access additional steam sources, and stakeholder concerns must be addressed.

7.11.2 Recommendations for Future Technologies

7.11.2.1 RECOMMENDATION: Continue to Pursue Greater Efficiency in Fossil Fuel Central Station Generation

Suggested Lead Organizations: Electric Utilities and NUGs

It appears that fossil fuels will continue to be used for the foreseeable future, and certainly for the 20 years covered by the strategy proposed in this document. The move by Hawaii’s utilities to DTCC units consisting of two combustion turbines and a steam turbine generator is a step in the right direction. The steam turbine generator allows additional efficiencies by using exhaust heat from the combustion turbines to create steam to drive a generator, thereby producing additional power with little additional fuel use and little additional greenhouse gas emissions. The new units are generally more efficient than the units they replace or supplement.

Where fossil-fuel generation is required, Hawaii’s utilities and NUGs should continue to install the most efficient generation technologies available. On the

Mainland, these are natural gas-fired DTCC systems. Unless it becomes feasible to import compressed natural gas into Hawaii, the most efficient units available for use here will likely be the latest versions of oil-fired DTCC and AFBC units.

7.11.2.2 RECOMMENDATION: Utility Integrated Resource Planning Should Consider Cost-Effective, Energy-Efficient Fuel Substitution between Electricity and Gas

Suggested Lead Organizations: Public Utilities Commission, Electric Utilities, The Gas Company

It is recommended that the IRP Framework be revised to require electric and gas utilities to consider whether the use of electricity or the use of gas most cost effectively meets end-use energy needs with the greatest energy efficiency.

7.11.2.3 RECOMMENDATION: Pursue Greater Efficiency Through Distributed Generation (Small Cogeneration, Microturbines, and Fuel Cells)

Suggested Lead Organizations: Electric Utilities, NUGs, Gas Utility, and Electricity Users

Distributed generation places small generators at the source of demand. Many evolving distributed generation technologies are highly efficient and further enhance efficiency by avoiding the line losses that would have occurred had the power come from a distant central power station. Distributed generation technologies include small combined cycle cogeneration units, microturbines, and fuel cells. These technologies should be closely monitored and encouraged.

Such policies as net metering can help encourage their use by allowing an owner of distributed generation unit to sell power to the utility system when it had excess power. This would offset the cost of power purchased from the system when the distributed unit could not meet all of the entity’s demand.

To retain customers, HECO recently sought and obtained rate provisions that allow them to offer rate discounts to customers that would be capable of installing their own distributed generation. To the extent that the discounts discourage installation of distributed generation systems that are more efficient than the utility system, this is economically and environmentally counter-productive.

As an alternative, utilities are encouraged to consider customer-owned distributed generation as a form of DSM in the same manner as solar water heating. In this context, it may be to the benefit of the utilities and society to offer DSM programs to encourage distributed generation. Utilities should also examine the potential for distributed generation as an alternative to future central station power generation.

7.11.2.4 RECOMMENDATION: Increase Use of Renewable Energy and Building Energy Efficiency

See Chapters 8 and 11 for detailed recommendations.

CHAPTER 8 INCREASING RENEWABLE ENERGY USE IN HAWAII

8.1 Why Renewable Energy Use Should Be Increased

Municipal solid waste, biomass, landfill methane, geothermal, hydroelectric, solar photovoltaic, and wind energy are renewable energy resources used to generate electricity in Hawaii and contribute to meeting the state's energy needs. Biomass is also used to produce process-heat, and solar heat is used for food drying and water heating. Hawaii's current use of renewable energy provides important diversification of the state's energy supply, helps keep funds spent for energy in the state, provides local jobs, and reduces environmental damage when compared with other forms of energy used for electricity generation. Additional use of renewable energy will add to these benefits and reduce Hawaii's dependence on imported fossil fuels.

Renewable energy can be less costly than fossil-fuel resources as evidenced by 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. On the other hand, when renewable resources are more costly than fossil-fuel resources, they increase electricity revenues. Whether this reduces economic performance, or costs more jobs than gained, depends upon the specifics of the renewable project. In addition, external benefits, such as reduced negative environmental impact, may lead to the selection of the renewable project over the less costly fossil-fuel option.

Another important advantage of renewable energy use is that most renewable resources do not produce greenhouse gases or are carbon neutral. Bagasse is an example of a renewable resource that is carbon neutral. While bagasse produces CO_2 when burned to generate electricity, growing sugar cane takes CO_2 out of the atmosphere, balancing the emissions. In 1996, the President's Council on Sustainable Development found that the relatively low impact of renewable energy technologies makes them ideal for sustainable economic development (Sissine 1999).

8.2 Renewable Energy Use in Hawaii

Biomass from sugar (bagasse), wind, hydroelectricity, geothermal, landfill methane, solar photovoltaics, and municipal solid waste were used to generate 7.9% of the state's electricity in 1997. Renewable energy technologies are discussed in Section 2.4. Statewide, 1997 renewable energy use in kWh was 16% greater than in 1990. Since the H-POWER facility on Oahu went into full operation in 1990, it has produced the largest percentage of the renewable energy sold to utilities. Bagasse was the second largest source of renewable energy until 1995, when it was surpassed by geothermal. Table A.28, in Appendix A, depicts the percentages of utility electricity from renewable sources, by utility, from 1990 to 1997. Table A.29 shows the percentages of utility electricity by renewable source for the same period.

8.3 Near-Term Prospects for Additional Renewable Energy

Over the last few years renewable energy developers have proposed new wind projects for Oahu, Maui, and Hawaii, and a large photovoltaic project for Hawaii. On Oahu, a wind farm with new wind turbines at the former Makani Uwila site was proposed. However, the Army has purchased the surrounding land as a training area and wants to purchase the existing non-operational wind sites and dismantle the idle wind turbines (Munger 1999b). The Army apparently sees them as potential hazards during training operations and would likely oppose re-powering of this site.

Also on Oahu, in 1995 the Air Force Space Command proposed a small wind farm at their Kaena Point facility. The environmental assessment circulated for agency review received no support. There was considerable opposition based upon concerns about heiau in the area, potential bird kills, and aesthetics. It was decided not to pursue the project (Munger 1999a, 19).

On Maui, Enron/Zond recently completed a Draft Environmental Impact Statement for the Kaheawa Pastures 20 MW wind farm. Enron/Zond is pursuing environmental permits for its site and has initiated negotiations with MECO for a power purchase agreement (Bollmeier 1999). An interconnection study will also be necessary to ensure operational compatibility with the MECO system (Munger 1999b).

On the Island of Hawaii, Enron/Zond and HELCO negotiated a power purchase agreement for a 10 MW wind farm at Kahua Ranch (Bollmeier 1999).

Also on the Big Island, another developer has proposed a 10 MW wind farm in the Hawi area and consideration is being given to re-powering the South Point wind farm. It appears that another project, a proposed 4 MW photovoltaic facility on the Big Island will not be pursued at this time (Munger 1999).

The new wind projects listed above are subject to interconnection studies to determine the limit of wind penetration appropriate to each utility system.

8.4 Recommended Renewable Energy Options for Hawaii

8.4.1 Background on the Renewable Energy Recommendations

8.4.1.1 *HES 1995* Project 3 Renewable Energy Assessment and Development Program Report

HES 1995 Project 3 developed a comprehensive assessment of Hawaii’s renewable energy resources and a long-range development strategy, *The Renewable Energy Assessment and Development Program Report* (DBEDT 1995b). The project first developed a Renewable Energy Resources Assessment Plan to determine constraints and requirements for wind, solar, biomass, hydroelectric, geothermal, wave, and ocean thermal energy conversion projects. Potential sites were identified and screened, and a plan was developed for additional monitoring of wind and solar conditions at several other potential sites to supplement existing data.

Renewable energy resource supply curves were developed by compiling cost and performance data on renewable energy systems and analyzing existing data on the Hawaii resources to allow comparison of the costs of various potential projects. Concurrently, a year's hourly wind and solar data were collected at selected locations statewide. Once data collection was completed, the resource supply curves were updated to reflect the new data. Recommended plans were then developed for each utility system for 1995 and 2005, based on expected cost and technology for each year.

The *HES 1995* Project 3 report was overly optimistic, concluding that "renewable energy projects can provide all the new generation required to meet projected energy demand increases between 1995 and 2005" (51). The study predicted that on the neighbor islands, this would be cost competitive under nominal cost assumptions. It predicted that on Oahu 30% of new needs could be met under nominal assumptions and that all new needs could be met under optimistic cost assumptions (51).

The report acknowledged that the "small size of Hawaii utility grids limits renewable energy development, particularly of intermittent technologies" (44). In identifying viable projects, the report assumed that renewables could meet or exceed 20% of peak demand without operating penalties, based upon a number of other studies. The report noted that "the results of such analyses are extremely variable and require detailed load flow and system stability analyses based on specific grid conditions to ensure utility reliability under all operating conditions" (44). Such studies were beyond the scope of *HES 1995* work, but the report suggested that "the wealth of potential renewable energy project development opportunities identified by this work should serve to encourage these activities (i.e., the necessary capacity studies) by utilities and other interested parties" (44).

It also should be noted that the *HES 1995* recommendations for ocean thermal energy conversion (OTEC) were based on ENERGY 2020 model runs that used overly ambitious cost claims made by an OTEC vendor. It is unlikely that such low costs are achievable in the near term. It is also clear that wave energy systems are unlikely to be acceptable to Hawaii's people, regardless of cost or technical feasibility. In addition, insufficient growth of the municipal solid waste stream, due in part to the success of recycling efforts, precludes further consideration of the previously recommended increase in H-POWER waste-to-energy generation on Oahu at this time.

8.4.1.2 Wind Penetration Studies by HECO Companies

In 1997, the HECO companies – HECO, HELCO, and MECO – completed a series of wind penetration studies to determine the amount of wind energy that could be accommodated on each system. These were "planning estimates" and involved many approximations and assumptions and very little actual performance data. There was insufficient operating data on the HECO and MECO systems to validate the assumptions, and the limited experience on the HELCO system suggested the analysis might have been too simplistic and the wind penetration estimate overstated (HECO 1999, 5). Nevertheless, they add another perspective to the problem that should be considered. The results of these studies were made available to DBEDT in July 1999 and were not available for use during the development of the *Hawaii Climate Change Action Plan* in 1997–1998 (DBEDT 1998b).

In 1980, HECO had contracted for an analysis of potential allowable wind penetration that was updated with additional data and extrapolated to 1998. The study estimated that 67 to 120 MW of wind-generated power could be accommodated on the HECO system (5). This was 3.9% to 7% of the HECO system's total 1998 capacity of 1,699 MW, which included both HECO-owned and NUG-owned generation.

The HELCO and MECO studies were performed in 1997. The HELCO study estimated allowable wind penetration at 4 to 14 MW, or 1.8% to 6.6% of the HELCO system's 1998 firm capacity. The MECO estimate was 4 to 11 MW, or 1.8% to 4.8% of the MECO system's firm capacity.

The consultant indicated that wind penetration might be increased by the use of new combined cycle units to regulate power on the system, by increasing spinning reserves, or by using energy storage. HECO and HELCO use automatic generation control (AGC), a system that facilitates power frequency control. The consultant noted that MECO might improve its ability to use wind if AGC were installed (10). These measures could improve system response to the minute-by-minute power fluctuations that occur in wind farm operation. The report also recommended additional data collection and more detailed analysis of specific projects (11). It suggested that future wind generation should be added incrementally. The consultant concluded "The data and experience will provide the technical, operational, and economic basis for determining how much more wind generation can be added" (12).

Energy storage options that would allow intermittent renewables to provide firm power include batteries, compressing air, electrolysis of water to produce hydrogen, flywheel storage, and pumped storage hydroelectricity. None of these appear to be cost effective at this time.

There are also a number of economic issues related to greater renewable energy use that are common to each utility system. To receive capacity payments, the operators of intermittent renewables such as wind and solar energy must provide some form of firm power backup to ensure that peak demand can be met when there is, respectively, little wind or sunshine. For example, HECO peak demand occurs in the 6–7 p.m. hour on most days. There is little or no sunshine at that time in Hawaii, especially in the winter, and wind speeds vary greatly by location.

Renewable energy's main attraction is reduced impact on the environment. (See Tables 8.1 to 8.4), greater use of renewable energy could avoid significant CO_2 emissions. Should oil prices again rise or should avoiding CO_2 emissions have economic value under a possible emission trading system, the fuel substitution value of both firm and intermittent renewables would increase, enhancing the economic value of these projects.

8.4.1.3 Use of *HES 2000* Renewable Energy Recommendations

In this section, *HES 2000* offers specific recommendations for renewable energy projects for each utility system. The recommendations are based upon the *HES 1995* study recommendations and data for biomass, hydro, photovoltaic, and wind systems only. These technologies are now commercially available. Cost and performance data developed in 1995 are presented for 1995 vintage systems and estimated data are presented for systems with capabilities expected to be available in 2005.

For HECO's second IRP, which was developed in 1996-1997, HECO's consultant used the DBEDT *HES 1995* consultant to provide wind data and limited hydro and geothermal data.

It must be stressed that in *HES 2000*, these recommendations represent portfolios of systems for consideration. Based upon available data, these projects appear to be the most promising. It is clear that updated cost data is needed (funds were not available to update the estimates contained in *HES 1995*) and that the interconnection feasibility of each intermittent system must be further evaluated, beyond the work done for the HECO companies.

It is recommended that the portfolios that follow be consulted in developing candidate plans for detailed analysis by each utility during the IRP process. At the same time, renewable energy developers could further examine some of these options for possible proposals for power purchase agreements.

8.4.2 Renewable Energy and Oahu

In 1997, renewable resources generated about 4.7% of Oahu's electricity. Most (4.3%) was provided by the H-POWER waste-to-energy facility; 0.2% was produced by the Kapaa landfill methane generator; and the remaining 0.2% came from Waialua Power, from greenwaste supplemented by heavy fuel oil and waste oil. Waialua Power ceased operations in July 1998. The capacity of H-POWER and Kapaa totaled 49 MW, or 2.8% of total HECO and NUG capacity on Oahu at the end of 1998. H-POWER provides firm power, while Kapaa's supply is provided as available.

8.4.2.1 Renewable Energy in HECO's IRP

Although HECO considered finalist plans with renewable energy in its first and second IRP processes, no renewable resources are currently planned (HECO 1998b, ES-8). In its second IRP, HECO considered wind in 20, 30, 40, 60, and 80 MW increments at Kahuku, and a 15 MW wind farm at Kaena Point. A 25 MW biomass plant was also evaluated (8-7). In addition, a study conducted for HECO, DBEDT, and the Department of Land and Natural Resources evaluated a pumped storage hydroelectric facility. Due to potential difficulties in acquiring necessary environmental and land use permits for the sites involved, the plan was screened out of the planning process (8-14 to 8-15).

HECO ultimately considered three finalist supply plans incorporating renewable resources (of 19 total). They were Plans F9 (20 MW) wind, F11 (25 MW biomass), and F13 (20 MW and 40 MW wind farms). The renewable plans ranked 12th, 14th, and 15th, respectively, in lowest total resource cost (TRC) of the 19 finalist plans (10-46). However, it should be noted that the difference between the TRC of the lowest and highest plans was only 3% – clearly within the range of error of the HECO models that were used to evaluate the plans. For example, the Unit Information Forms for the supply-side resources indicated that there was a plus or minus 10% "capital cost uncertainty" (Appendix J). The most expensive renewable plan (F13) had a TRC cost only 1.4% higher than the all fossil-fueled least-cost plans.

The renewable options were not part of HECO's preferred plan primarily due to their higher cost (despite the narrow range of cost estimates noted above), the intermittent nature of the wind options, and concerns about reliability of both the wind and biomass options. Instead, HECO indicated that it would issue a "Renewable Request for Proposal (RFP) to invite qualified renewable developers to submit proposals to provide energy to the HECO system in return for payments at or below HECO's avoided cost" (11-7). As of December 1999, the RFP had not been issued.

8.4.2.2 RECOMMENDATION: Consider Renewable Energy Options for Oahu

Suggested Lead Organizations: HECO and Renewable Energy Developers

The following recommended renewable energy options do not capture all potential projects that might be considered. They are offered as a starting point for further project identification and consideration by HECO and/or renewable energy developers.

Table 8.1 Selected Renewable Energy Options for Oahu

Estimated Costs

Name	Capacity (MW)	Capacity Factor 1995/2000	Capital Costs (Million $) 1995	Capital Costs (Million $) 2005	Capital Costs (1993$/kW) 1995	Capital Costs (1993$/kW) 2005
Wind at Kahuku (20)	**20**	**17.3%/21.7%**	**22.6**	**20.3**	**1,130**	**1,015**
Wind at Kaena Point	15	19.2%/24.0%	19.0	17.3	1,270	1,155
Wind at Kahuku (30)	30	17.3%/21.7%	34.0	30.5	1,132	1,017
Biomass at Waialua	**25**	**70%/70%**	**47.7**	**47.7**	**1,907**	**1,908**
Oahu Total	**90**		**123.3**	**115.8**		

Estimated Equivalent Capacity, Energy and CO_2 Savings, and Cost of CO_2 Savings

Name	Average Net Generation (GWh/Year) 1995	Average Net Generation (GWh/Year) 2005	Annual CO_2 Emissions Savings (Tons/Year) 1995	Annual CO_2 Emissions Savings (Tons/Year) 2005	Capital Cost per Ton of CO_2 Savings (Project Life) 1995	Capital Cost per Ton of CO_2 Savings (Project Life) 2005
Wind at Kahuku (20)	**30.4**	**38.0**	**29,760**	**37,225**	**$ 25.31**	**$ 18.18**
Wind at Kaena Point	25.2	31.6	24,725	30,927	**$ 25.67**	**$ 18.68**
Wind at Kahuku (30)	45.6	57.0	44,640	55,857	**$ 25.36**	**$ 18.21**
Biomass at Waialua	**153.3**	**153.3**	**150,234**	**150,234**	**$ 10.58**	**$ 10.58**
Oahu Total	**254.4**	**279.8**	**249,359**	**274,243**		

DBEDT 1995b

In Table 8.1, selected renewable energy options for Oahu are presented for consideration. The options were selected based on *HES 1995* resource supply curves. The 20 MW wind unit in bold corresponds to a recent developer proposal and the 25 MW biomass unit, also in bold, operated at a lower capacity until mid 1998, at Waialua. The table also shows the potential energy production and CO_2 emissions reductions offered by each option.

The cost data presented in Table 8.1 are taken from *HES 1995*. The options identified do not offer a major contribution to HECO's portfolio. If sites could be found for all 65 MW of intermittent wind projects, and if the 25 MW biomass unit were built, HECO would offset only 36.5 to 39.5 MW of fossil-fuel generation, or only 1.7 to 1.8% of planned HECO system firm capacity of 2,094 MW in 2017. The use of the recommended renewable energy projects could provide 254.4 to 279.8 GWh of electricity and reduce annual CO_2 emissions by 249,359 to 274,243 tons annually.

As noted in section 8.3, above, a proposal to build a small wind farm at Kaena Point was opposed in the environmental assessment phase and not pursued. The existing wind farm at Kahuku is no longer operational and the Army wants to incorporate the land into their training area. Thus, it will likely be necessary to find other suitable sites on Oahu. While there is considerable former sugar land, some areas may not have a good wind resource, or wind developers may have to compete with diversified agriculture or development. Future biomass projects face similar competition in finding land on which to grow energy crops.

8.4.3 Renewable Energy and the Island of Hawaii

The HELCO system has the greatest percentage of renewable energy in Hawaii. Geothermal provided 23% of electricity in 1997, followed by hydroelectricity at 5% and wind at 2%. The geothermal energy was firm, baseload power, while the hydro and wind were intermittent.

8.4.3.1 Renewable Energy in HELCO's IRP

During development of its second IRP, HELCO considered 7 of 14 finalist plans that offered a variety of renewable energy resources. These included 10 MW of additional wind, 4 MW of photovoltaics, 13.8 MW of hydroelectricity, up to 50 MW of biomass (in 25 MW units), 30 MW pumped storage hydro, and 25 MW of geothermal (HELCO 1998, 8-5).

HELCO's preferred plan consisted of 81.6 MW of oil-fired units; however, Alternate Plan A called for possible acquisition of additional wind and photovoltaic facilities. HELCO indicated that to increase renewable energy development and public awareness and to meet the state energy policy objectives for increased renewable energy, it would continue to pursue renewable energy installations. Since that time, HELCO concluded an agreement with Enron/Zond for a 10 MW wind farm at Kahua Ranch and additional proposals are under discussion.

The range of estimated total resource costs between the 14 finalist plans was relatively narrow, at 7.7%. The "Minimize Oil" plan was the most expensive of the finalist plans. It included 10 MW wind and two 25 MW biomass units. While HELCO planned to return its Puna steam unit from standby in all plans, and to install the steam recovery unit on its planned Keahole unit, there was only one fossil unit in this plan, a 22 MW unit to be installed in 2016.

8.4.3.2 RECOMMENDATION: Consider Renewable Energy Options for the Island of Hawaii

Suggested Lead Organizations: HELCO and Renewable Developers

The following recommended renewable energy options do not capture all potential projects that might be considered. They are offered as a starting point for further project identification and consideration by the utility and renewable energy developers.

Table 8.2 depicts renewable energy options for the Big Island, selected based on *HES 1995* resource supply curves. The projects in bold were reportedly under recent negotiation for power purchase agreements. The 20 MW wind farm for the Kahua site was recommended by the *HES 1995* Project 3 report, but Zond/Enron has signed a power purchase agreement for a 10 MW wind farm at that location. This project is contingent upon extension of federal tax credits for renewable energy that expired on July 1, 1999. Further analysis is needed to determine whether HELCO's system can handle additional wind generation.

Table 8.2 Selected Renewable Energy Options for the Island of Hawaii

Estimated Costs

Name	Capacity (MW)	Capacity Factor 1995/2000	Capital Costs (Million $) 1995	Capital Costs (Million $) 2005	Capital Costs (1993$/kW) 1995	Capital Costs (1993$/kW) 2005
Wind at Kahua Ranch	**20.0**	**23%/29%**	**24.7**	**22.4**	**1,233**	**1,119**
Photovoltaic (Fixed) at Waikoloa	**4.0**	**43%/54%**	**24.0**	**16.1**	**6,012**	**4,026**
Wind at North Kohala	15.0	43%/54%	18.6	16.9	1,241	1,127
Wind at Lalamilo Wells	50.0	35%/44%	56.4	50.6	1,127	1,012
Hydro at Umauma Stream	13.8	33%/33%	24.0	24.0	1,736	1,736
Geothermal	50.0	none/83%	not estimated	121.0	not estimated	2,420
Biomass at Hilo Coast	50.0	none/70%	not estimated	96.9	not estimated	1,938
Hawaii Total	**202.8**		**147.6**	**130.0**	**11,348.1**	**9,020.5**

Estimated Equivalent Capacity, Energy and CO_2 Savings, and Cost of CO_2 Savings

Name	Avg. Net Generation (GWh/Year) 1995	Avg. Net Generation (GWh/Year) 2005	Annual CO_2 Emissions Savings (Tons/Year) 1995	Annual CO_2 Emissions Savings (Tons/Year) 2005	Capital Cost per Ton of CO_2 Savings (Project Life) 1995	Capital Cost per Ton of CO_2 Savings (Project Life) 2005
Wind at Kahua Ranch	**40.5**	**50.7**	**39,920**	**49,934**	**$ 20.58**	**$ 14.95**
Photovoltaic (Fixed) at Waikoloa	**9.1**	**8.5**	**9,009**	**8,335**	**$ 88.98**	**$ 64.40**
Wind at North Kohala	56.9	71.2	56,051	70,110	$ 11.07	$ 8.04
Wind at Lalamilo Wells	154.2	192.1	151,870	189,205	$ 12.37	$ 8.92
Hydro at Umauma Stream	40.2	40.2	39,596	39,596	$ 20.16	$ 20.16
Geothermal	n/a	362.3	n/a	356,879	n/a	$ 11.30
Biomass at Hilo Coast	n/a	306.6	n/a	302,001	n/a	$ 10.70
Hawaii Total	**301.0**	**1,031.5**	**296,447**	**1,016,060**		

DBEDT 1995b

A 50 MW biomass electric plant and an additional 50 MW of geothermal are recommended for consideration. If these or similar units were built, they could displace about 82% of HELCO's planned new fossil-fueled generation. Both units would have to be capable of operating at less than full capacity to accommodate HELCO's low nighttime peak. They would also fit the HELCO system better if built in 25 MW increments to simplify maintenance scheduling. Implementing two 25 MW units would also reduce the potential impact of unit malfunction on the system. To support the biomass option, land would need to be obtained to support cultivation of energy crops, in competition with other projects such as forestry and diversified agriculture. Based upon the recently released wind penetration analysis, it appears unlikely that all of the wind capacity identified above for consideration could be employed. The analysis suggested that 4 to 14 MW might be accommodated on the HELCO system. Smaller increments at each location could be considered and, as recommended by the HELCO Wind Penetration Analysis, projects would need to be evaluated individually and incrementally (HECO 1999).

As shown on Table 8.2, renewable energy could produce significant oil savings and reduce CO_2 emissions from 296,447 to 1,016,060 tons per year. Should oil prices again rise or should avoiding CO_2 emissions come under an emission trading system, the value of both firm and intermittent renewables would increase.

8.4.4 Renewable Energy and Kauai

KE uses the second greatest percentage of renewable energy, including 10 MW of baseload bagasse-generated power and 2% hydroelectricity.

8.4.4.1 Renewable Energy in KE's IRP

In its IRP action plan, KE committed to seeking opportunities for third party development of photovoltaic, solar, hydro, and wind generation applications. KE was to review existing draft purchase contracts to negotiate NUG renewable options and to actively participate in state government renewable energy efforts (KE 1997, 2-3). Renewable resources were not selected from among the responses to RFPs issued by KE. Green Islands Corporation proposed a plasma arc waste-to-energy plant that would receive energy-only payments.

8.4.4.2 RECOMMENDATION: Consider Renewable Energy Options for Kauai

Suggested Lead Organizations: KE and Renewable Developers

The following recommended renewable energy options do not capture all potential projects that might be considered. They are offered as a starting point for further project identification and consideration by the utility and renewable energy developers.

Table 8.3 lists selected renewable energy options for Kauai, based on the *HES 1995* resource supply curves. The MSW plant at Kaumakani, in bold on Table 8.3, represents the plasma arc plant proposed by Plasma Environmental

Technologies. A biomass plant is also listed. If the MSW plant were developed to provide firm power (perhaps with an energy crop supplement to MSW), together with the biomass plant, KE could enjoy 50 MW of firm, renewable energy. This would provide for all but 10.4 MW of the fossil-fuel power scheduled for deployment through 2017.

Table 8.3 Selected Renewable Energy Options for Kauai

Estimated Costs

Name	Capacity (MW)	Capacity Factor 1995/2005	Capital Costs (Million $) 1995	Capital Costs (Million $) 2005	Capital Costs (1993$/kW) 1995	Capital Costs (1993$/kW) 2005
MSW plant at Kaumakani	**25**	**none/70%**	not estimated	**48.1**	not estimated	**1,922**
Wind at North Hanapepe	10	21%/26%	12.0	10.7	1,198	1,074
Hydro at Wailua River	7	28%/28%	11.3	11.3	1,709	1,709
Wind at Port Allen	5	18%/21%	6.2	5.4	1,241	1,087
Biomass at Kaumakani	25	none/70%	not estimated	48.1	not estimated	1,922
Kauai Total	**71.6**		**29.5**	**123.6**	**4,148.8**	**7,715**

Estimated Equivalent Capacity, Energy and CO_2 Savings, and Cost of CO_2 Savings

Name	Avg. Net Generation (GWh/Year) 1995	Avg. Net Generation (GWh/Year) 2005	Annual CO_2 Emissions Savings (Tons/Year) 1995	Annual CO_2 Emissions Savings (Tons/Year) 2005	Capital Cost per Ton of CO_2 Savings (Project Life) 1995	Capital Cost per Ton of CO_2 Savings (Project Life) 2005
MSW plant at Kaumakani	**n/a**	**153.3**	**n/a**	**151,001**	**n/a**	**$ 10.61**
Wind at North Hanapepe	18.3	22.6	17,978	22,263	$ 22.21	$ 16.07
Hydro at Wailua River	16.4	16.4	16,188	16,188	$ 23.23	$ 23.23
Wind at Port Allen	7.8	9.3	7,647	9,181	$ 27.05	$ 19.74
Biomass at Kaumakani	n/a	153.3	n/a	151,001	n/a	$ 10.61
Kauai Total	**42.5**	**355.0**	**41,813**	**349,634**		

DBEDT 1995b

8.4.5 Renewable Energy and Maui

MECO used 5% renewable energy in 1997, ranking third in the state on a percentage basis. This included 4% baseload bagasse generation and 1% intermittent hydroelectricity.

8.4.5.1 Renewable Energy in MECO's IRP

As noted in Chapter 7, MECO is in the process of developing its second IRP, which it plans to complete by May 31, 2000. In work on the second IRP, MECO had developed a list of finalist plans that will likely be considered, along with generator life-extension, as options for the future. Seven of the 10 plans presented to the Advisory Group included renewable energy components. Plan F2 had 10 MW of wind, F3 had two 10 MW wind farms, F5 had a 4 MW photovoltaic system, F7 had 10 MW of wind and a 30 MW pumped-storage hydroelectric system, F8 had a 25 MW biomass plant, and F9 had 4 MW photovoltaics, 10 MW wind, 30 MW pumped storage hydro, and a 25 MW biomass plant. A tenth plan, based upon that modeled in the *Hawaii Climate Change Action Plan* (DBEDT 1998b), had 20 MW wind in two wind farms and a 25 MW biomass plant. During a discussion of the finalist plans in April 1999, the Maui County representative proposed a “Maui County Plan” that included 4 MW photovoltaics, 20 MW wind, and 24 MW of biomass (MECO 1999).

There was a relatively narrow range of 15.8% between the lowest-cost all-fossil-fuel plan and the F9 “Maximum Renewables Plan”. The Maui County Plan was about 9.86% more expensive than F9. The range between the total resource cost of the lowest cost fossil plan and F2, F3, and F5 was only 1.16%, suggesting that these wind and PV plans would increase costs minimally, if at all.

8.4.5.2 RECOMMENDATION: Consider Renewable Energy Options for Maui

Suggested Lead Organizations: MECO and Renewable Developers

The following recommended renewable energy options do not capture all potential projects that might be considered. They are offered as a starting point for further project identification and consideration by the utility and renewable energy developers.

Table 8.4 presents selected renewable energy options for Maui, based on HES 1995 resource supply curves. The 25 MW biomass plant would be the only firm power renewable unit on the system, representing only 25 of the 272.4 MW in additional units that were being considered in ongoing work on MECO’s second IRP (MECO 1999). This unit would be the nominal equivalent of the 27.9 MW diesel that was planned for installation in 2010. Land for energy crops would need to be obtained. Table 8. 6 also lists forty megawatts of wind, but the MECO Wind Penetration Analysis suggests that only 4 to 11 MW of wind could operate on the MECO system. Each potential increment would need to be evaluated individually (HECO 1999).

Table 8.4 Selected Renewable Energy Options for Maui

Estimated Costs

Name	Capacity (MW)	Capacity Factor 1995/2005	Capital Costs (Million $) 1995	Capital Costs (Million $) 2005	Capital Costs (1993$/kW) 1995	Capital Costs (1993$/kW) 2005
Wind at West Maui	**20**	**14%/18%**	**23.5**	**21.1**	**1,176**	**1,053**
Biomass at Puunene	25	70%/70%	66.7	68.7	2,667	2,749
Wind at NW Haleakala	20	20%/24%	23.1	20.6	1,153	1,031
Maui Total	65		113.2	110.4	4,995.8	4,833.7

Estimated Equivalent Capacity, Energy and CO_2 Savings, and Cost of CO_2 Savings

Name	Avg. Net Generation (GWh/Year) 1995	Avg. Net Generation (GWh/Year) 2005	Annual CO_2 Emissions Savings (Tons/Year) 1995	Annual CO_2 Emissions Savings (Tons/Year) 2005	Capital Cost per Ton of CO_2 Savings (Project Life) 1995	Capital Cost per Ton of CO_2 Savings (Project Life) 2005
Wind at West Maui	**25**	**30.8**	**24,525**	**30,370**	$ 31.97	**$ 23.12**
Biomass at Puunene	153.3	153.3	151,001	151,001	$ 14.72	$ 15.17
Wind at NW Haleakala	34.2	42.4	33,734	41,774	$ 22.79	$ 16.46
Maui Total	**212.4**	**226.5**	**209,259**	**223,144**		

DBEDT 1995b

8.5 Recommended Actions to Increase Renewable Energy Use in Hawaii

8.5.1 The Need for Accurate Cost Data on Renewables for Integrated Resource Planning

8.5.1.1 RECOMMENDATION: Obtain Accurate Cost Data on Renewable Energy Options for Integrated Resource Planning

Suggested Lead Organizations: Electric Utilities

As part of the IRP process, the electric utilities should obtain accurate, up-to-date cost information for renewable energy options under consideration. For their second IRPs, supply-side consultants for HECO, HELCO, and MECO used DBEDT's consultant for wind data and portions of hydro and geothermal data.

While the utilities frequently caution that renewable energy will increase electricity costs to consumers, up-to-date information is needed to ensure accuracy. The fact that a geothermal developer, a hydroelectricity developer, and a wind developer were able to obtain power purchase agreements at or below the utility cost calls the utility view into question. Accurate data is needed for the IRP process, and obtaining that data is the responsibility of the utility doing the planning.

8.5.2 Tax Credits to Encourage Renewable Energy Use

8.5.2.1 RECOMMENDATION: Continue to Assess the Need for Renewable Energy State Income Tax Credits beyond 2003

Suggested Lead Organizations: DBEDT, Electric Utilities, and renewable energy industry

The State of Hawaii began offering renewable energy tax credits in 1977, starting with an energy-device tax credit that allowed a state resident to claim 10% of the cost of a solar water heater against his or her state income tax. At the time, the state tax credit supplemented a federal tax credit of 30%, but the federal credit ended in 1985.

There have been many changes in the State Energy Tax Credit over the years. Current credits, extended in 1998 for five years (to 2003), are summarized in Table 8.5. Most of the credits have gone for solar water heating systems, although some photovoltaic systems and photovoltaic-powered ceiling vent systems have also employed the credit. The need for further extension of the tax credit should be evaluated and recommendations made to the Governor and Legislature before the 2003 Legislative session.

Table 8.5 Hawaii Energy Tax Credits

Technology	State Income Tax Credit	Maximum Amount
Solar Systems (Thermal and Photovoltaic)		
Single Family Home	35%	$1,750
Mulit-Unit Dwelling Unit	35%	$350
Hotels, Commercial, and Industrial Facilities	35%	Actual Cost
Heat Pumps		
Single Family Home	20%	$400
Mulit-Unit Dwelling Unit	20%	$200
Hotels, Commercial, and Industrial Facilities	20%	Actual Cost
Wind System	20%	Actual Cost
Ice Storage System*	50%	Actual Cost

DBEDT 1996c

*Note: Ice storage is not a renewable energy system, but tax credits are offered. Ice storage allows use of off-peak generation or gas refrigeration to be used to produce ice to be used for cooling at on-peak times.

The Hawaii Energy Tax credits contributed to the installation of 9,029 solar water heaters through utility demand-side management programs in 1998 and through July 1999. Of these, 6,415 were on the HECO system, 1,119 were on the HELCO system, and 1,495 were on the MECO system (Munger 1999a, 31).

8.5.2.2 RECOMMENDATION: Encourage Renewable Energy Use through Federal Tax Credits

Suggested Lead Organization: Hawaii Congressional Delegation

The U.S. government offered residential solar tax credits and residential and business tax credits for wind energy until December 31, 1985. Business investment tax credits applicable to renewable projects were extended repeatedly throughout the 1980s. Current federal tax credits include:

- Section 1996 of the *Energy Policy Act of 1992* (EPACT) (P.L 102-486) extended 10% business tax credits for solar and geothermal equipment indefinitely; and
- Section 1914 of EPACT provided a tax “production” credit of 1.5 cents per kWh for electricity produced by wind and closed-loop biomass systems that expires in 1999 (Sissine 1999).

The Administration’s FY 1999 Climate Change Technology Initiative sought $6.3 billion in tax incentives over the next five years for energy efficiency, cleaner energy sources, and renewable energy programs (Sissine 1999). Such programs have great potential in increasing the cost-competitiveness of renewable energy resources in Hawaii and should be supported.

8.5.3 Additional Recommendations

8.5.3.1 RECOMMENDATION: Continue to Increase the Use of Solar Water Heating

Suggested Lead Organizations: Electric Utilities and Solar Water Heating Industry

A large base of solar water heating in Hawaii was installed prior to the current residential water heating DSM programs offered by the electric utilities. Utility DSM incentives and the renewable energy tax exemption complement each other in encouraging installation of additional solar water heating. Significant additional fuel savings and emissions reductions are likely possible from new solar water heating systems. See the discussion of utility DSM programs in Chapter 11.

8.5.3.2 RECOMMENDATION: Implement Recommendations of Renewable Resource Docket

Suggested Lead Organizations: Public Utilities Commission, Counties, and organizations identified in report

Hawaii's 1994 Legislature adopted *Senate Concurrent Resolution No. 40*, which requested the Public Utilities Commission to initiate an informational docket to facilitate the development and use of renewable resources in the State of Hawaii. The Commission opened Docket No. 94-0226 to accomplish the following objectives:

- Study the policies, statutes, and programs of other jurisdictions, as well as the strategies employed by these jurisdictions to implement the development of renewable energy resources;
- Examine policies presently employed by the State of Hawaii with respect to facilitating the utilization of renewable energy resources;
- Identify barriers to the development of renewables in Hawaii; and
- Formulate strategies to remove the barriers and implement the use of renewables in Hawaii. (PUC 1996, 1)

There were twenty-one parties to the collaborative, which produced a two-part report entitled *Strategies to Facilitate the Development and Use of Renewable Energy Resources in Hawaii* (PUC 1996). Part one was a study by the National Renewable Energy Laboratory (NREL), "Renewable Energy Policy Options for the State of Hawaii". The second part, the Collaborative Document, summarized the parties' collaborative efforts to identify barriers and formulate strategies for the use of renewables in Hawaii.

NREL Report: Renewable Energy Policy Options for Hawaii. NREL cited the following primary impediments to the successful development of renewable energy resources in Hawaii:

- Renewable energy systems require a large initial capital investment;

- Electric utilities fail to incorporate the benefits of renewables into their market decisions; and
- Market power is concentrated in the hands of the electric utility companies, impeding investments in renewables (2).

The report cited three policy measures commonly used to foster renewable energy development in other states that have been used by the State of Hawaii:

- Financial incentives such as tax credits, tax exemptions, or direct loans and grants, which lower the cost of renewable energy systems;
- Power purchase contract rules, which assist non-utility developers in securing contracts for the sale of power to a utility by guiding contract negotiations and the determination of “avoided cost” payments; and
- Integrated resource planning requirements for utilities to consider renewable energy among the range of generation alternatives when developing their least-cost plan (2).

NREL identified a number of basic strategies implemented or considered by other states to further the deployment of renewable energy resources. These included net-metering, renewable energy set-asides, legislative requirements for renewables, direct access to the grid for renewable energy suppliers, risk allocation, targeted financial incentives and disincentives for utilities, system benefits charges, “green” RFPs, and renewables portfolio standards. The following specific strategies were suggested for Hawaii:

- A clear pronouncement by the State that renewable energy development remains an important objective, and the establishment of a concrete goal for renewable energy policies;[a]
- Establishment by the State of an official preference that all new generating capacity employ renewable energy resources unless it is demonstrated that a specific use is not in the public interest;
- Development of financial incentives to utilities, renewable energy providers, and customers, funded from general revenues or by a “system benefit charge” assessed on all electricity customers;
- Establishment of a portfolio standard imposing a minimum renewable energy requirement for the State’s electricity mix;
- Development by the utilities of a competitive green power product that allows customers to exercise voluntarily a preference for electricity from renewable energy sources;

[a] Note: This was accomplished through the addition of the statutory energy objective "increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased" by Act 96, Session Laws of Hawaii 1994.

- Authorization for alternative renewable energy providers to supply renewable energy service options directly to a utility's wholesale and retail customers; and
- Establishment of a net energy metering policy that allows customers to offset high retail rates with small-scale renewable electricity systems (3-4).

The Collaborative Document. The Collaborative document identified real and perceived barriers to renewable resource development and developed a list of targeted recommendations. It should be pointed out that despite its name, the Collaborative Document is not a consensus document and does not represent unanimous agreement by all parties.

Barriers included the following:

- Insufficient avoided cost prices for developer financing;
- Operational limitations on the amount of renewable energy;
- Complex and lengthy permitting processes and site availability
- Form of price offered to developers does not facilitate financing;
- Lack of new renewables in current integrated resource plans;
- Protracted nature of purchase power negotiations;
- Lack of direct consumer access to renewable power;
- Potential negative environmental and societal impacts;
- Certain renewable and storage technologies insufficiently mature to be economically viable; and
- Fragmented and overlapping efforts by the State in renewable energy research, development, demonstration, and commercialization (4-5).

The Collaborative document listed key strategies for consideration by the Legislature, the Commission, the utilities, DBEDT, the Counties, and renewable energy developers. The Commission has taken no direct action on the report other than to provide it to the State Legislature, but the recommendations remain valid.

8.5.3.3 RECOMMENDATION:, Consider Implementing a Renewable Portfolio Standard, a Public Benefits Charge, or Green Pricing to Increase Renewable Energy Use

Suggested Lead Organization: Legislature and Public Utilities Commission

Renewable resources require support until they become fully cost-competitive. Methods for ensuring the future promotion, development, and use of Hawaii's renewable resources could include the use of options such as a renewable portfolio standard (RPS), public benefit funding for installation of renewable systems, or allowing Hawaii's utilities to market "green" power.

Renewable Portfolio Standard. A renewable portfolio standard, or RPS, requires that a certain percentage of electricity generation be obtained from renewable resources. An RPS could be set and phased in over a period of time. These percentages should be studied further to determine what values are appropriate and whether different standards might be necessary on different islands. The percentages could be adjusted over time, if needed, to remain consistent with State renewable energy goals and to respond to customer demand for renewable energy alternatives. A statewide trading program could also be established. This would allow the standard to be met on any island, allowing selection of the lowest cost options.

To reduce demand for non-renewable resources, the RPS could provide incentives to stimulate use of solar water heating or other non-grid-connected systems by end users. Credit could be given for renewable resources behind an end-user's meter. This would be facilitated by net metering, already instituted in many states, and also called for in the Clinton Administration's *Comprehensive Electricity Competition Act*.

In addition, the *Act* would establish a Federal RPS to guarantee that a minimum level of renewable generation is developed in the United States. The RPS would require sellers to provide a percentage of their new generation from non-hydroelectric renewable technologies, including wind, solar, biomass, or geothermal. The RPS for 2000–2004 would be set a the current ratio of RPS-eligible generation to retail electricity sales. A standard between the initial RPS and less than 7.5% would be set by the Secretary of Energy for 2005–2009. In 2010–2015, the RPS would be 7.5%. With its abundant renewable energy resources, Hawaii could consider a greater amount. The national RPS proposed in the *Act* would expire in 2015, when it is expected that the economics and benefits of renewable energy resources will be fully established (USDOE 1999, 4).

Public Benefits Funding of Renewable Energy Resources. State public utilities commissions have historically used public benefits funding to finance renewable energy programs. Utilities have been required to collect in their rates, funds to pay for renewable energy programs, as well as energy efficiency programs and energy research and development programs.

In the Clinton Administration's *Comprehensive Electricity Competition Act*, submitted to Congress in April 1999, contained a provision for a Public Benefits Fund administered by a Joint Board that would disburse matching funds to States for low-income assistance for electricity service, energy conservation and efficiency measures, consumer education, and development of emerging electricity generation technologies (USDOE 1999, 4). The latter could include renewable energy. While the proposed *Act* would not require Hawaii to have a competitive system, the matching funds may be available under the current structure or under a restructured competitive system.

Marketing "Green" Power. Marketing "green" power is a means of increasing the use of renewables. Customer surveys nationally and in Hawaii have indicated that many people are willing to pay more for electricity from renewable sources.

In a form of “green” power in Hawaii, the HECO companies are funding “Sunpower for Schools”, the installation of photovoltaic units on public schools, through voluntary ratepayer payments. While a very small percentage of customers participate, it is expected that greater numbers would want to buy “green power” for their own homes or businesses if offered the opportunity. The utilities could be permitted to offer customers the option of buying electricity produced by renewable resources in various percentages. Emissions disclosure to consumers is one method for stimulating consumer choice for green power options.

CHAPTER 9 ELECTRICITY COMPETITION AND HAWAII

9.1 Overview

Currently, Hawaii's four electric utilities are regulated monopolies with franchise rights to sell electricity to retail customers in their service territories. The utilities are regulated by the Hawaii Public Utilities Commission, which sets rates and approves the utilities' integrated resource plans. On the Mainland, many states are restructuring their utilities' business and financial structures to provide for increased competition at the wholesale and retail levels.

This chapter discusses the actions of the Hawaii Public Utilities Commission in its pending consideration of electricity competition and examines possible electricity competition in Hawaii. The following discussion does not attempt to summarize the positions of all parties. Instead, it will focus on DBEDT's view of the situation and recommendations submitted to the Commission for its consideration. It will also briefly summarize the HECO companies' proposal for modifications to the current system, as an alternative to implementing competition, which the HECO companies oppose.

9.2 Electricity Competition on the Mainland

The main stimulus for electricity competition nationally was the passage of the Energy Policy Act of 1992 (EPACT), which expanded the opportunities for wholesale competition and permitted the introduction of more market entrants on the generation side of the electricity business.

In 1996, the Federal Energy Regulatory Commission (FERC) issued Orders No. 888 and 889. Order No. 888 essentially required all electric utilities under FERC's jurisdiction to file so-called Open Access Transmission Tariffs. FERC mandated that all users of transmission facilities be treated on a basis comparable with that of the utilities. Order No. 889 set up a new information system intended to permit transparent use of information on transmission pricing and capacity availability to facilitate use of bulk transmission facilities.

As of September 1999, twenty-two states had enacted legislation or promulgated regulations establishing retail competition. California, Massachusetts, Pennsylvania, and Rhode Island have fully implemented competition. Delaware, Illinois, and New Jersey were to begin implementing competition before the end of the year. Arizona, Arkansas, Connecticut, Delaware, Illinois, Maine, Maryland, Montana, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Texas, and Virginia had enacted restructuring legislation. Michigan, New York, and Vermont had issued comprehensive regulatory orders. Most of the other states, including Hawaii, are actively considering competition. (USDOE 1999d).

At the federal level, in April 1999, the Clinton Administration submitted a proposed Comprehensive Electricity Competition Act to Congress for consideration.

> The Act: (1) encourages States to implement retail competition; (2) protects consumers by facilitating competitive markets, enhancing

> information flows, and outlawing various customer abuses, such as "slamming" and "cramming"; (3) assures access to and reliability of the transmission system; (4) promotes and preserves public benefits, including support for renewable energy and energy efficiency; and (5) . . . ; (6) protects the interests of rural and remote communities and Indian tribes; and (7) amends existing Federal statutes to clarify Federal and State authority (USDOE 1999c, vii).

Within Congress, a variety of related legislation has been proposed. Some proposals mandate retail competition for all states and others leave it up to the states

Because Hawaii, unlike the contiguous 48 states, Hawaii does not have electricity moving in interstate commerce, FERC jurisdiction does not generally apply. Thus, Hawaii may not be subject to certain newly proposed federal mandates. The *Comprehensive Electricity Competition Act* takes this into account by specifically giving Hawaii the option to participate in certain aspects of the Act, for example, the Public Benefits Fund, while exempting it from other requirements of the Act (USDOE 1999a, 31).

9.3 The Proceeding on Electricity Competition for Hawaii

The possibility of electricity competition is being investigated in Hawaii. On December 30, 1996, the Public Utilities Commission issued Order Number 15285, opening Docket Number 96-0493, *Instituting a Proceeding on Electric Competition, Including an Investigation of the Electric Utility Infrastructure in the State of Hawaii* (PUC 1996a).

In its order, the Commission noted,

> Although Hawaii's stand-alone island energy systems are a contrast to the interconnected systems of the contiguous states, and the effects of federal plans and proposals are uncertain, we also recognize the need to prepare for a competitive electric industry environment in the State of Hawaii.
>
> In the transition to a competitive electric industry in Hawaii, competition and industry restructuring are expected to radically change the manner in which electricity services are planned, priced, and provided. Competitive issues are being raised by electric industry shareholders and by the State legislature. Furthermore, pending initiatives in the United States Congress to mandate retail competition could significantly impact the State's energy system and entire energy community.
>
> In light of all of the above, a proceeding is in order to examine the issues related to the introduction of competition in the electric industry in the State of Hawaii. A thorough examination of the issues will help the commission determine the potential impacts of

> competition, the feasibility of various options, and the appropriate extent to which competition should be encouraged for the overall benefit of all consumers. Our foremost concern is to ensure the long-term efficiency and reliability of the State's energy systems and the availability of safe, affordable, and equitable electricity services to Hawaii's citizens (3-5).

The Commission made the Consumer Advocate and the four electric utilities parties to the docket and invited all interested stakeholders to participate in the docket (5). The Commission directed that a collaborative group be established to discuss and narrow the issues. To initiate the discussion, the Commission posed a set of twelve preliminary issues and questions to be addressed (7-10).

On January 6 and 7, 1997, the Co-Chairs of the Senate Consumer Protection Committee and DBEDT co-sponsored a two-day Informational Briefing on Contemporary Issues in Electrical Utility Regulation that was held in the Hawaii State Capitol Auditorium. The meetings examined the implications of deregulation and increased competition in the electric utility industry for Hawaii.

The Commission issued Order No. 15371 on February 20, 1997, granting intervention status to the Waimana Enterprises, the US Department of Defense, the DBEDT, GTE Hawaiian Telephone; Hawaii Renewable Energy Alliance (HREA), Puna Geothermal Venture, Life of the Land, International Brotherhood of Electrical Workers Local 1260, County of Maui, County of Kauai, County of Hawaii, AES Hawaii, and Enserch Development Corporation. The Association for Competition in Electricity was given participant status without intervention. The parties were ordered to provide the Commission, by March 31, 1997, with Pre-hearing Conference Submissions covering a number of issues specified in the order (PUC 1997).

The parties provided their Pre-hearing Conference Submissions. On May 28–29, 1997, the parties participated in two days of discussions on electricity competition, sponsored by the Commission. A variety of experts made presentations on electricity competition on the Mainland.

Over the next year, the parties, meeting as the Competition Collaborative, attempted to discuss and narrow the issues, and if possible, to reach consensus. Due to the diverse views and interests involved, reaching consensus proved impossible. As a result, the Collaborative ultimately decided to provide the Commission with a collection of position papers produced by each of the parties. Initial drafts were discussed at a meeting at the end of June 1998. Many parties provided comments on other parties' papers for the other parties' consideration. The papers were then finalized and provided to the Commission on October 19, 1998.

9.4 Benefits of Electricity Competition

Some objectives of electricity competition include:

- Reduced cost of electricity for all customers and an improved economy;
- Stimulation of greater energy efficiency;

- Encouragement of the use of advanced, diverse generation technology;
- Greater use of renewable energy and diversity of supply;
- Consumer choice of electricity supplier; and
- Improved consistency with State energy policy.

9.4.1 Reduced Cost of Electricity and an Improved Economy

9.4.1.1 Hawaii's Average Electricity Revenues Were the Highest in the Nation in 1997 (and Were Second Highest in May 1999)

In 1997, average revenue per kilowatt-hour in the United States was $0.069 (EIA 1998g, 42). Hawaii’s statewide average electricity revenues were $0.125 per kWh in 1997, 182% of the U.S. average and the nation’s highest. Hawaii's total electricity sales revenues, at over $1.17 billion, represented 3.4% of Hawaii’s estimated 1997 GSP of $ 34.2 billion dollars (DBEDT 1998f, Table 13.02). By May 1999, Hawaii’s average electricity revenues dropped to $0.114 per kWh, second highest in the nation behind New Hampshire at $0.117 per kWh. The national average in May 1999 was $0.647 per kWh (EIA 1999b, 62). To the extent that electricity competition in Hawaii could reduce electricity costs, more money could be available for Hawaii’s citizens to use for other purposes, benefiting non-utility sectors of the economy.

9.4.1.2 Hawaii's Revenues Grew Faster than U.S. Average and Consumer Price Index

Hawaii's electricity revenues grew faster than U.S. average and faster than the consumer price index between 1990 and 1997. By 1997, Hawaii average revenues per kWh were 39.2% higher than 1990 (Utility FERC Reports 1998) while the U.S. average was only 4.2% higher (EIA 1998g). In addition, between 1990 and 1997, average electricity revenues increased by 39.2%, while the consumer price index for all urban consumers in Honolulu grew 24%. The overall U.S. consumer price index increased by 23% during the same period (DBEDT 1998f, Table 14.02). The difference between the growth of Hawaii and U.S. average electricity revenue per kWh should be explored further, as recommended in section 7.2.2.4, whether or not competition is initiated in Hawaii.

9.4.1.3 High Electricity Revenues Reduce Economic Performance and Cost Jobs

DBEDT's Research and Economic Analysis Division used the State of Hawaii Input/Output Model to examine the effects of various growth rates of electricity revenues on Hawaii's economy (DBEDT 1998f). Had electricity revenues grown at the U.S. average, Hawaii's GSP in 1997 would have been $876.32 million, or 1.0031 times greater. If revenues had grown at the Honolulu Consumer Price Index rate, the GSP would have been $109.2 million, or about 0.1% higher (DBEDT 1998f).

High electricity revenues also tend to reduce employment. Using the same scenarios, the number of jobs that would have been generated in Hawaii under the growth-rate scenarios for electricity revenues was estimated. If electricity rates had grown at the US average, it was estimated that there would have been 5,292 more jobs in 1997. If electricity revenues had grown at the same rate as the Honolulu CPI, there would have been about 2,048 more jobs in 1997 (DBEDT 1998f).

9.4.1.4 Electricity Prices and Hawaii's Economic Competitiveness

While Hawaii does face larger transportation and local market costs, the narrowing of regional differences and coincident decrease in electricity costs occurring in Mainland power markets due to restructuring suggests the need for Hawaii to reduce its electricity costs to maintain economic competitiveness (see EIA 1998e, 2).

9.4.2 Reduction of Costs and Greater Energy Efficiency

9.4.2.1 Can Competition Reduce Electricity Costs?

The authors of *Consumer Choice, Consumer Value: An Analysis of Retail Competition in America's Electric Industry* estimated that rate reductions from 1994 of about 26% would be possible in Hawaii under competition (Maloney, 1996, xxiv). An extensive review will be necessary to assess the potential for rate reductions.

Competition can result in electric power at a lower price when it is being sold in excess of marginal cost. In Hawaii, this applies particularly to excessive charges levied on off-peak consumers. Early implementation of changes in rate design, as well as adoption of time-of-use rates, could be helpful in relaying proper price signals to consumers, enabling utilities to reduce long-term costs.

9.4.2.2 Sources of Potential Savings from Competition

A critical first step to competition is a clear decision that all new generation requirements will be subjected to competitive bidding. In the *Oahu Power Market Study* (GDS 1998), DBEDT's consultant, GDS Associates, suggested additional ways that electricity costs in Hawaii could be reduced. As the title suggests, the review focused on Oahu, and additional analysis would be required to determine whether these conclusions are valid for any or all of the neighbor islands. Based upon this analysis, electricity costs could be reduced through the following measures, if authorized:

- Restructuring of existing power purchase agreements;
- Renegotiation of existing fuel supply agreements;
- Reduction in non-fuel power production operations and maintenance expenses;
- Reduction in Oahu reserve generation capacity;
- Increased generating and dispatch efficiencies;
- Improvements to generation siting process;
- Cost reductions through new generating technology; and

- Market incentives for retirement of inefficient units (GDS 1998, 15-19).

9.4.2.3 Stimulation of Greater Efficiency with Time-of-Use Pricing

With Hawaii's high electricity prices, energy efficiency measures can be highly cost-effective and should be encouraged for economic growth. Competition could create the needed price signals to encourage greater energy efficiency. For example, time-of-use pricing has been used on the Mainland for at least two decades to stimulate energy efficiency. This should be used not only on the commercial level, but at the residential level as well. Electricity providers may offer, on their own initiative (or they could be required to offer) such pricing in a competitive environment.

9.4.3 Encourage Use of Advanced, Diverse Generation Technologies

On the Mainland, it is economically feasible in many instances to replace older and relatively inefficient existing generating facilities with new gas-fired DTCC combustion turbines due to their significantly higher efficiencies and relatively lower capital and operating costs. Although natural gas resources are not available in Hawaii, similar efficiencies may be achieved from oil-fired DTCC units. Further analysis is needed to determine whether it would be economically feasible to replace some of Hawaii's older, relatively inefficient, existing generating facilities with advanced generating technologies before their scheduled retirement.

9.4.4 Greater Use of Renewable Energy and Diversity of Supply

9.4.4.1 Renewable Energy

While Hawaii's utilities led the nation in installing renewable energy in the early 1980's, they have not installed new grid-connected renewable energy generation in recent years. In recent IRPs, some utilities have taken the position that renewable energy would not be cost effective, but nonetheless Renewable RFPs would be issued to invite renewable developers to submit proposals to provide energy at or below avoided cost. In the 1990's, geothermal, hydroelectric, and wind developers have been able to negotiate power purchase agreements at or below avoided cost. However, incentives may be needed under restructuring, until some sunset date. Renewable resources could be a significant contribution to a more competitive electricity market. Some customers will buy renewable energy, even at greater cost, due to their concern for the environment. Furthermore, any needed renewable energy programs can be designed in a manner that will prevent a materially adverse effect on the development of competition.

9.4.4.2 Diversification of Energy Supplies

One critical reason for encouraging diversity of energy supplies is to help reduce economic dislocations in the event of an oil emergency. Although oil prices are currently at very low levels, Hawaii continues to face risks as the most oil dependent state in the Nation.

9.4.5 Customer Choice of Electricity Supplier

Under competition, customers would have a choice of electricity suppliers. While electricity is a commodity, suppliers could bundle other services with electricity, such as telephone service, cable TV, and Internet access. Suppliers could also offer environmentally minded customers the opportunity to buy cleaner power or more renewable energy than competitors offer, perhaps at a price premium in the near term.

9.4.6 State Energy Policy

The primary reason for DBEDT's participation in the competition docket is to satisfy its statutory responsibility, under HRS, Section 196-4, for formulating plans, objectives, and criteria for optimum development of energy resources and to conduct systematic analysis of existing and proposed energy resource programs of Hawaii's electric utilities. DBEDT believes that electricity competition in Hawaii can and should be structured to comport with the state's statutory energy objectives.

9.5 Possible Competition in Hawaii

Competition in Hawaii could take a number of forms. In its position paper, DBEDT believes that generation, energy services, and retail sales of electricity should be subject to competition. Transmission and distribution of electricity should remain as regulated monopoly services. Creation of an Independent System Operator (ISO) should help facilitate wholesale and retail competition and reduce market barriers and the market power of the incumbent providers. Furthermore, retail aggregation options could be established. These options would create the best opportunity for commercial and residential customers to benefit from electricity restructuring. The following considers a variety of possible options ranging from the current situation to full competition.

9.5.1 Hawaii's Current Competitive Situation

There is limited competition in electricity generation in Hawaii under current law. In 1997, about 40% of the electricity sold to customers by Hawaii's utilities was purchased from NUGs and cogenerators. However, if Congress were to repeal the Public Utilities Regulatory Policy Act (PURPA), as has been proposed, Hawaii's utilities would have little incentive to enter into future contracts with NUGs, thus further reducing competitive pressures in Hawaii. One problem with the current system is that it leaves considerable control of the terms of the power purchase agreements with the utility. The utility sets technical requirements, establishes the avoided cost, negotiates, and accepts or rejects the proposed power purchase agreement, subject to approval of the Public Utilities Commission.

Under the present regulatory structure, building utility-owned generation is usually in the utility's financial interest. As a result, the current situation may not always result in a level playing field for an NUG or a timely agreement when an NUG meets all criteria for a power purchase agreement. This is suggested by several recent formal complaints to the Commission by NUGs related to power purchase agreement negotiations with HELCO (e.g., Docket 97-0102, Hilo Coast

Processing Company; Docket 94-0079 Enserch Development; Docket 7956, Kawaihae Cogeneration Partners). On the other hand, the other three electric utilities have recently negotiated and signed power purchase agreements in relatively short timeframes without any need for Commission intervention.

9.5.2 The HECO Concept for Increased Competition

The HECO Companies do not believe restructuring is feasible in Hawaii. As a result, they proposed an alternative approach that included three areas that "have the potential to provide many of the benefits of competition, while working within the existing regulatory system" (HECO Companies 1999, 115). These were (a) competitive bidding for new generation; (b) performance-based rate making; and (c) innovative pricing provisions.

9.5.2.1 HECO's Arguments Against Restructuring in Hawaii

HECO does not believe that full retail competition is possible in Hawaii. The company notes that each island has an independent power system served by a single utility, with some contracts for non-utility generation. The lack of interconnection between these systems contrasts with the situation on the Mainland, where numerous utilities are interconnected into systems encompassing many states throughout an entire region (1).

HECO also believes that the electricity markets on the individual Hawaiian Islands are too small to support multiple competitors and that the reduced economies of scale that would result from dividing these small markets among several competitors would offset other sources of potential cost advantage (1-3).

HECO states that "the implementation of retail generation competition would not be reasonable unless demonstrable benefits were reasonably expected to exceed the quantified costs" (4). The company expresses doubt that the hoped for benefits will materialize or that realized benefits will exceed the substantial transition costs. They cite the following main points:

- Transition costs would be incurred;
- Economies of scope and scale would be lost, increasing electricity prices;
- Transition, or stranded costs, must be addressed;
- The resulting generation market would still be relatively concentrated;
- Full competition assumes fully cost-based prices, which they expect would increase residential rates and rates on small islands;
- Competitors would concentrate on large customers (5-6).

9.5.2.2 HECO's Proposed Competitive Bidding for New Generation

This would increase competition slightly compared with the current situation in Hawaii, but it would be confined to new electricity generation. The HECO companies supported the use of competitive bidding "consistent with the unique structure of the electric power market in Hawaii" (115). While HECO stated that it would “propose measures designed to mitigate self-dealing” (118), some in the collaborative group were concerned that the HECO plan was not truly competitive. The primary source of the concerns was that under the plan, the HECO companies – themselves potential competitors to build the generation – would draft the RFPs and determine eligible bidders (albeit using “an outside consulting firm . . . to oversee and audit the evaluation process”) (118).

A process similar to the HECO plan has already been used successfully in Hawaii: Kauai Electric selected its next increment of generation from proposals by NUGs in response to a request for proposals as an alternative to adding its own generating unit.

9.5.2.3 Performance Based Rate Making

HECO’s performance-based rate making (PRB) proposal is complex and will not be described fully here. The plan included an index-based price cap, an earnings sharing mechanism, and a benchmark incentive plan. HECO stated that the plan is intended to strengthen incentives to enhance operations efficiency, to lower barriers to market-responsive rates and services, and share the benefits of improved performance with customers (119). It should be noted that by the company consultant’s admission, Hawaii's electricity consumers would have paid more under the PBR proposal offered by HECO than under continuation of existing regulation. It was not clear from HECO’s position paper whether their PBR proposal was offered with the expectation of reducing future prices or, at least, reducing future price increases.

Recently, the U.S. Energy Information Administration evaluated PBR. Their conclusion was as follows:

> To the extent that PBR plans lead to a decline in rates, their implementation may be preferable to the traditional regulatory approach. This possibility rests on the capability of PBR plans to respond more effectively to external changes that may cause other quality of service issues to be overlooked. Inadequacies in monitoring and evaluation could also lead to unintended results. PBR plans surveyed in this report [the EIA report] are all relatively recent. As such their effectiveness in reducing costs has yet to be determined (EIA 1998g, xi).

9.5.2.4 Innovative Pricing Procedures

HECO stated that its pricing proposals seek to achieve most benefits of competition, including “efficient pricing to provide accurate price signals, increasing customer choice, and lower energy cost to customers by offering them alternative rates that empower them to control their energy costs” (120). A variety of rate and service options would be offered to customers, who would theoretically select the option that provided the level of electricity service they wanted. These are intended to be similar to the options offered by electricity marketers under competition.

9.5.2.5 Implementation of HECO's Proposals

HECO stated that it intended to file applications for PUC approval of these proposals in 1999 and 2000. DBEDT and some other parties stated in their Statement of Position that such proposals should be considered only after the Commission decides on the form of competition that might be implemented in Hawaii under the current docket.

9.5.3 The Gas Company's Concept for Increased Competition

Several parties' Statements of Position on competition in the electricity industry observed that gas-on-electricity competition was one feasible form that that competition could take in Hawaii's small, island markets. SNG and LPG are alternatives to electricity for numerous uses, including water heating, drying, cooking, and some types of lighting. The Gas Company has argued in several forums that artificial regulatory barriers to interfuel competition should be eliminated.

The Gas Company has advocated modifications to the existing IRP Framework so that electric utilities can no longer escape screening SNG or LPG as DSM options, or fuel-switching to SNG or propane as alternatives to the construction of new generation or transmission and distribution (T&D) systems. In addition, it has supported dispersed generation and cogeneration using SNG or propane as fuels. The Gas Company has also argued for the elimination of regulatory electricity rate subsidies for proposed line extensions, and upstream reinforcements necessary to serve new load. Instead, regulated utilities should, according to The Gas Company, be required to charge new customers rates sufficient to fully recoup the marginal cost of new electric lines, just as non-regulated competitors must price new service to additional customers (Gilman and Golden 1999, 8).

9.5.4 Unbundling the Electricity System for Competition

Under the current system, as depicted in Figure 9.1, the Hawaii electricity system is a vertically integrated, regulated business. Each utility in Hawaii owns all three components of the system – generation, transmission, and distribution – in its service territory.

The separation of the vertically integrated utility into its three component parts is called unbundling. Under competition, these distinct functions could be performed by separate entities. This could come about by divestiture of all but one element by existing utilities so that each component would be owned by a separate entity. Thus, there could be competition among several generation owners. Retail power marketers might then be able to offer electricity from a variety of sources to electricity shoppers. Electricity would reach the purchaser through regulated T&D systems. The latter two elements might be under one owner, but would remain regulated.

Another alternative would be "functional unbundling," under which divestiture would not be required, but the utility would be required to set up independent subsidiaries that could not coordinate their business activities.

The Current System	An Unbundled System
Regulated Generation	Competitive Generation
Regulated Transmission	Regulated Transmission
Regulated Distribution	Regulated Distribution
Captive Rate Payer	Electricity Shopper

Figure 9.1 Comparison of the Current System with an Unbundled System

This way, competitors would be on an equal footing with the competing element of the former utility. FERC Order 888, which concerns open access, requires the following of unbundled utilities and could serve as a guide for Hawaii:

- Utilities must take transmission services (including ancillary services) under the same tariff of general applicability as do others;
- Utilities must state separate rates for wholesale generation, transmission, and ancillary services;
- Utilities must rely on the same electronic information network that its transmission customers rely on to obtain transmission information (EIA 1996b).

Clearly, the generation function, as already demonstrated by participation of non-utility generators in the Hawaii system, is the easiest portion to unbundle. Transmission and distribution will likely remain regulated in the near term, although Maloney suggests that transmission may ultimately prove to be competitive as well, at least on the mainland. He also suggests that regulated transmission and distribution should have a new form of regulation rather than traditional rate of return (1996, v).

Another consideration in Hawaii is the differences in the size of the six independent island systems. The question posed by some parties to the Competition Docket is whether the systems, even on Oahu, are large enough to support competition.

9.5.5 Implementing Competition in Hawaii

Competition could be undertaken by separating the vertically integrated utilities into their component parts – functionally unbundling Hawaii's utility system. To start, current bundled electricity rates should be unbundled to provide separate charges for the following:

- Generation services (with separately identified charges for back-up services to large customers);
- T&D services (with separate identification of any non-bypassable charges for customers who chose a third-party generation supplier);

- Metering services;
- Billing services; and
- Conservation and energy management services.

There should be separate accounting treatment of each functional category to prevent cost shifting and cross-subsidization.

9.5.5.1 Unbundling Through Divestiture

Ultimately Hawaii's utilities could become separate generation, transmission and distribution, and customer service entities. Customer service entities could also be separated, in the same manner as rates are unbundled, into metering, billing, and conservation and energy management services entities. Although additional study is required to determine the best option for Hawaii, unbundling can generally be done through divestiture of all but the T&D functions of existing utilities so that each component would be owned by a separate entity. The T&D functions would remain regulated.

9.5.5.2 Transmission and Distribution Would Remain a Regulated Monopoly

DBEDT recommends that T&D services remain regulated. The Commission should develop and implement rules that would open access to, and establish fair pricing for, electricity company T&D services.

9.5.5.3 Retail Competition Could Be Established

On the Mainland, retail competition, and the promise for its expansion, has led to new market combinations. These combinations have included electricity and natural gas companies, as well as energy efficiency providers, home security services, telecommunications providers. Retail competition also has promise for home banking, computing, cable, fiber optic, home office programs, and other services.

With retail competition comes the opportunity for aggregation of retail loads. For example, in Hawaii various aggregations could occur, such as groups of hotels, the Defense Department facilities, hospitals, all state and local government buildings, and among other commercial customers.

With retail aggregation comes the concern that individual residential consumers may be left behind. Therefore, any retail aggregation program must recognize the needs of residential consumers of all types and of varying financial means. In fact, facilitation of aggregation programs involving residential customers could be the most significant method for this class of customers to benefit through restructuring.

In addition, provisions would be needed to allow for distributed generation on the system. Customers who install their own generation at their facilities and have excess power to sell to others will need access to the transmission/distribution system

9.5.6 RECOMMENDATION: Consider Restructuring Hawaii's Electricity System

Suggested Lead Organization: Public Utilities Commission

DBEDT and the other parties to the Competition Docket submitted position papers to the Commission on October 19, 1998. The parties await the results of the Commission's consideration of the Position Statements. The Commission is encouraged to take further action in this docket in the near future to restructure the electricity system in a form appropriate for Hawaii's citizens, their economy, and their environment.

CHAPTER 10 UTILITY AND BOTTLED GAS FOR HAWAII

10.1 Gas Use in Hawaii

Because Hawaii does not have access to natural gas, other forms of petroleum-based gas met 2% of Hawaii's energy needs in 1997. Table 10.1 shows the percentage contribution of liquefied petroleum gas (LPG) and synthetic natural gas (SNG) to Hawaii's total energy use, by county, in 1997.

Table 10.1 Gas Contribution to Hawaii Total Energy Use, 1997

	Hawaii	Honolulu	Kauai	Maui	Statewide
Million Btu Used					
Utility SNG	none	2,900,675	none	none	2,900,675
Utility LPG	205,811	176,265	9,176	72,221	463,473
Non-Utility LPG	615,194	1,077,973	330,121	840,272	2,863,560
LPG Subtotal	821,005	1,254,239	339,297	912,493	3,327,033
Gas Subtotal	821,005	4,154,914	339,297	912,493	6,227,708
Total Energy	25,061,040	245,979,147	10,858,201	28,873,709	313,972,097
Percentage of Total Energy Used					
Utility SNG	none	1.2%	none	none	0.9%
Utility LPG	0.8%	0.1%	0.1%	0.3%	0.1%
Non-Utility LPG	2.5%	0.4%	3.0%	2.9%	0.9%
Total LPG	3.3%	0.5%	3.1%	3.2%	1.1%
Total Gas	3.3%	1.7%	3.1%	3.2%	2.0%

Source: DBEDT 1999; TGC 1998 a through e, 19

Gas is piped to customers through utility systems owned by The Gas Company (TGC), a division of Citizens Energy Services. For the southern portion of Honolulu, SNG is produced from refinery feedstock and provided to TGC customers via pipelines. In other areas of Oahu and on the neighbor islands, propane is stored in tanks and piped to customers through utility pipelines. LPG is also used in the form of bottled, non-utility gas on all islands.

The remaining sections of this chapter examine the utility gas system in more detail, including non-utility gas use, an estimate of future demand, and environmental and economic aspects of gas use in Hawaii.

10.2 Hawaii's Utility Gas Systems

10.2.1 Utility Gas Supply

TGC is a utility regulated by the Hawaii PUC. TGC provides SNG and propane to its customers through pipelines.

10.2.1.1 Synthetic Natural Gas for Oahu

TGC manufactures SNG at its plant in the Campbell Industrial Park on Oahu to supply the utility gas network serving the southern portion of Oahu. The SNG is manufactured from a low-octane hydrocarbon (or "light ends") feedstock provided under contract through a pipeline from the Tesoro Hawaii refinery. The feedstock price is tied to international prices for crude oil. The SNG plant has a maximum output of about 150,000 therms (15 billion Btu) a day (TGC 1999, 4-1 to 4-2). This capacity was well within demand forecast through 2020 in TGC's second Integrated Resource Plan (IRP) (2-17). TGC also has a backup propane-air unit to add a propane air mixture to the SNG utility pipeline on Oahu in event of an emergency (TGC 1999, 4-2).

10.2.1.2 Propane Utility Gas for Rural Oahu and the Neighbor Islands

The areas outside the SNG grid on Oahu, and the islands of Hawaii, Kauai, Maui, and Molokai, are served with propane. The propane is stored in tanks and sent to customers through distribution pipeline networks. There are 30 propane systems on Oahu, 4 on Hawaii, 5 on Kauai, 4 on Maui, and 2 on Molokai (A-3). The propane is usually purchased from Oahu refiners, although propane is occasionally imported directly. TGC owns two barges used to ship propane from Oahu to the neighbor islands, except Molokai, which is provided propane in ISO-container tanks shipped by container barge (4-2).

10.2.2 Utility Gas Demand

In 1997, hotels, restaurants, and other commercial and industrial customers accounted for 71% of utility gas use, as shown in Figure 10.1. Principal end uses are water heating, cooking, and clothes drying (TGC 1999, 2-15). Table 10.2 lists the numbers of utility gas customers in 1997 by rate classification and island and provides statewide totals. Table 10.3 shows 1997 utility gas use by customer rate classification and island.

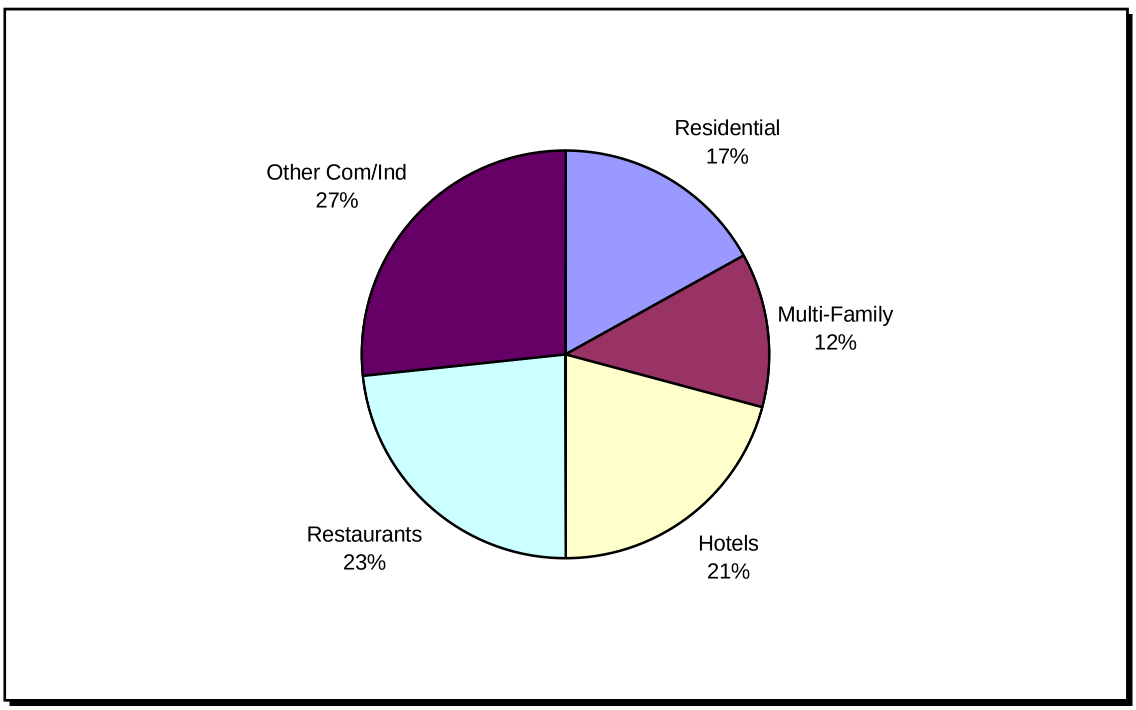

Figure 10.1 Percentage of Utility Gas Use by Customer Category, 1997

Table 10.2 Utility Gas Customers by Rate Classification and Island, 1997

Rate Classification	Hawaii	Honolulu	Kauai	Maui	Molokai	Statewide
Residential	1350	30,513	584	325	103	32,875
Residential (Employee)	2	61		1		64
Large Firm		72				72
Standby		14				14
General Service	83	882		4		969
Multi-Unit Housing	41	416		6		463
Comm & Industrial	175	1,787		56		2,018
Large Industry	7	2		1		10
Alternate Energy		1				1
Interruptible Svc - Oil		15				15
Interruptible Svc - Propane		9				9
Standby		28				28
Total Customers	1,658	33,800	584	393	103	36,538

Source: TGC 1998a through e, 40

Table 10.3 Utility Gas Sales by Rate Classification and Island (Million Btu), 1997

Rate Classification	Hawaii	Honolulu	Kauai	Maui	Molokai	Statewide
Residential	25,023	516,522	8,562	7,026	2,007	559,141
Residential (Employee)	22	1,100	3	20	-	1,145
Large Firm	-	743,337	-	-	-	743,337
Standby	-	362	-	-	-	362
General Service	1,909	34,127	-	127	-	36,163
Multi-Unit Housing	31,604	203,982	-	3,898	-	239,485
Comm & Industrial	107,013	1,075,445	-	41,578	-	1,224,035
Large Industry	66,349	70,862	-	19,329	-	156,540
Alternate Energy	-	925	-	-	-	925
Interruptible Svc - Oil	-	240,729	-	-	-	240,729
Interruptible Svc - Propane	-	88,911	-	-	-	88,911
Standby	-	7,262	-	-	-	7,262
Million Btu Sold	231,921	2,983,563	8,566	71,978	2,007	3,298,034
Percent of Statewide Total	0.7%	9.0%	0.0%	0.2%	0.0%	10%

Source: TGC 1998a through e, 40

10.3 Non-Utility Gas

For customers not on utility pipelines, an option for water heating, cooking, drying, and other gas uses is non-utility gas. Propane is distributed by tank truck to tanks on customer premises by TGC, Oahu-Maui Gas, and Aloha Gas. In addition, a number of vehicles are fueled with propane, usually at fleet bases or at some gasoline stations. As noted above, in 1997 the use of non-utility gas in 1997 was 2.86 TBtu

10.4 Future Demand for Gas

Figure 10.2 shows TGC forecasts of statewide utility gas demand in Hawaii for the years 2000 to 2020. Three forecasts were developed as part of their 1999 IRP: TGC High Case, TGC Base Case, and TGC Low Case. Based upon these estimates, utility gas demand in 2020 was estimated to range between 3.06 and 3.94 TBtu.

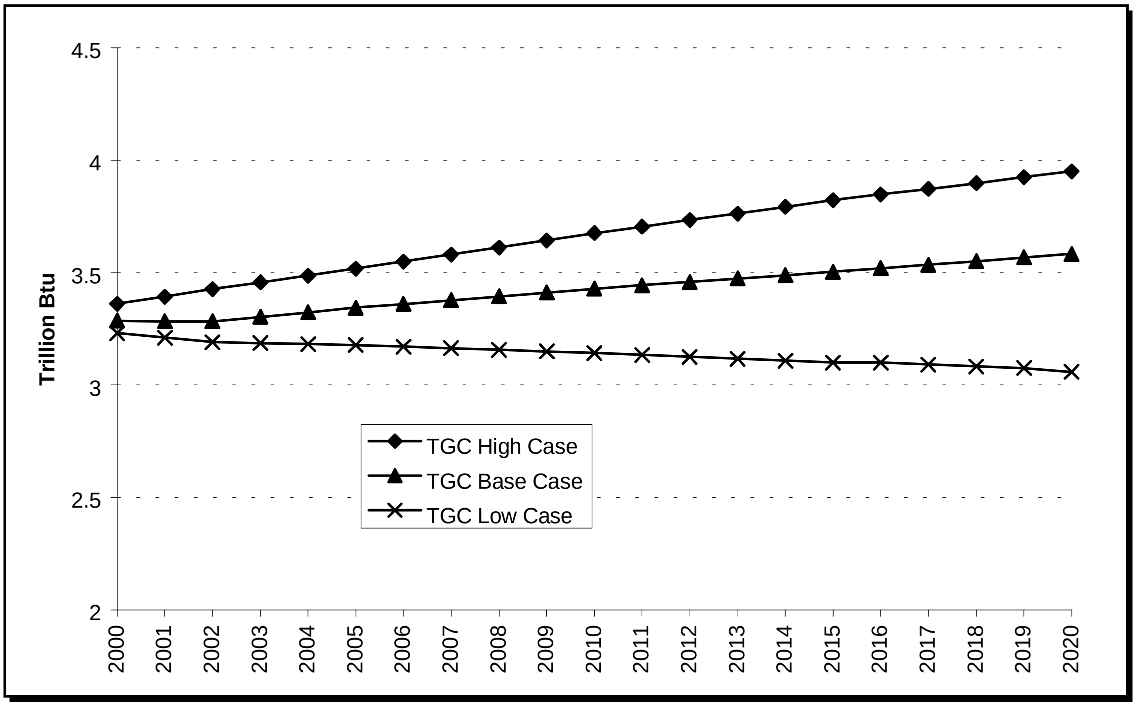

Figure 10.2 TGC Forecasts of Statewide Utility Gas Demand, 2000–2020

10.5 The Gas Company's Integrated Resource Plan

The Gas Company filed its second IRP with the PUC in March 1999. The IRP was the result of a comprehensive planning process that reviewed and analyzed TGC's options for supplying energy to its customers. TGC's IRP process included setting objectives, forecasting gas energy and peak demand, assessing DSM options, and preparing a list of candidate plans for supplying gas from the year 2000 to 2020. The relative costs of the plans were considered, external costs and benefits were considered, and a preferred IRP and contingency IRP were selected (TGC 1999, iii–iv).

The major supply-side elements of the TGC IRP were to continue to operate in the current manner, with modest major equipment and maintenance investments at the SNG plant. The contract for feedstock from the Tesoro Hawaii refinery was to be continued. Propane purchases were to be continued from on-island refiners, but options for imports, including imports in larger quantities, were to be explored. Distribution to Neighbor Islands was to continue, using current practices (7-2).

TGC also planned to continue its current program of upgrading distribution and service lines for about 8 to 10 years, and pending the results of structural testing, the company may replace its existing propane barges (7-2).

The plan did not propose DSM programs, but modest "DSM support activities" were estimated to save 630,000 therms. The activities included:

- Residential and small commercial customer-targeted water heating information on the benefits of replacing failed water heaters with high efficiency units and the benefits of low-cost water saving methods;
- Demonstration of high efficiency commercial cooking techniques, including installation of equipment on hosting premises;
- Audits of energy use and energy savings opportunities for large-volume commercial customers; and
- Activities to track cost and gas savings (7-1 to 7-2).

TGC considered a number of potential DSM plans, but instead decided to propose the support activities. The principal reason was that TGC has ample supply capacity for the entire IRP period. Any savings in gas use would not delay or prevent any capacity additions, as none are planned. As a result, TGC was also concerned that DSM programs would increase rates as customers paid for lost margins and because fixed costs would not be avoided. Finally, TGC was concerned that higher rates would reduce its competitiveness (3-23)

10.6 External Costs and Benefits

TGC's IRP defined "externalities" as "those impacts (or benefits) of an activity that are generally not reflected in the 'internal' or direct market costs of an activity" (5-1). Overall categories of externalities considered by TGC in its IRP included environmental, macroeconomic and employment, energy security, and social and cultural. TGC sought to prioritize externalities according to the impact the externality was likely to have on development of a preferred resource plan. Their objective was to determine the monetary value ("to monetize") the significant external costs and benefits.

TGC divided all externalities into three categories, in order of priority. These were:

- Greenhouse gases (CO_2, CH_4, and N_2O, etc.) that contribute to climate change;
- Criteria air pollutants as defined by the Clean Air Act (CO, NO_x, SO_2, PM, ozone, and lead);
- All other externalities resulting from gas production, transportation, and use (5-2).

TGC's quantification of the costs of these externalities was presented in Section 2.3.2. TGC planned a number of actions intended to help minimize emissions in the future. These actions include maintenance and replacement of transmission and distribution pipelines to minimize leaks and structural integrity testing of components of the SNG plant, propane barges, propane storage tanks, and other equipment (8-6).

10.7 Recommendations for Hawaii's Gas Sector

10.7.1 RECOMMENDATION: Encourage Cost-Effective Renewable Energy Substitution for Gas

Suggested Lead Organizations: The Gas Company, Renewable Energy Suppliers, and DBEDT

As part of TGC's IRP, potential substitution for SNG and propane was examined. TGC believes that after 2020, biogas and hydrogen offer some potential (4-16). In addition, solar water heating now offers a substitute for the gas water heating end use. While TGC did not select solar water heating as a DSM program, it is an obvious potential renewable energy replacement for one end use of utility and non-utility gas and electricity.

10.7.2 RECOMMENDATION: Encourage Use of Gas as a Fuel for Distributed Electricity Generation and Fuel Cells, Where Cost-Effective and Energy-Efficient

Suggested Lead Organizations: DBEDT, The Gas Company, and Distributed Generation Suppliers

Pipeline utility or non-utility gas could provide fuel for future distributed electricity generation or cogeneration at end-user facilities. In addition, it could be used to power fuel cells. These options deserve further study and analysis. Such uses could enhance the efficiency of Hawaii's gas and electricity systems.

10.7.3 RECOMMENDATION: Utility Integrated Resource Planning Should Consider Cost-Effective, Energy-Efficient Fuel Substitution between Electricity and Gas

Suggested Lead Organizations: Public Utilities Commission, Electric Utilities, The Gas Company

It is recommended that the IRP Framework be revised to require electricity and gas utilities to consider which fuel, electricity or gas, meets end-use energy needs most cost-effectively and with the greatest energy efficiency.

CHAPTER 11 INCREASING ENERGY EFFICIENCY IN HAWAII'S BUILDINGS

11.1 Energy Efficiency and Buildings

Most of Hawaii's electricity, utility gas, and non-transportation uses of fuel are used to provide lighting, heating, ventilation, air conditioning, water heating, drying, cooking, and other end-uses in buildings. This chapter examines ways to reduce energy demand in Hawaii's buildings and how energy efficiency can be increased. These goals involve a variety of energy efficiency programs in Hawaii, that are carried out by federal, State, and local governments, the utilities, and public-private partnerships such as the Rebuild America Program.

Increased energy efficiency reduces the need for imported fossil fuels, reduces the negative economic and environmental effects of energy use, and can contribute to deferring the construction of new electricity generation units. For energy users, energy costs can be significantly reduced.

11.2 Current Energy Efficiency Measures in Hawaii's Buildings

11.2.1 The Model Energy Code

11.2.1.1 Development of the Hawaii Model Energy Code

The Hawaii Model Energy Code was based on American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 90.1-1989; ASHRAE 90.2P, California's Title 24; and the USDOE standard for non-residential buildings. It was modified to make the code more appropriate to Hawaii's climate (DBEDT 1993b, 5). The code sets minimum requirements for the energy-efficient design of new buildings, provides criteria for energy-efficient design, and provides methods for determining compliance with these criteria (DBEDT 1993a, 1). It sets standards for electric power; lighting; building envelope; heating, ventilating, and air conditioning systems and equipment; water heating systems and equipment; and energy management.

11.2.1.2 Adoption of the Model Energy Code

In 1994, the State Legislature passed Act 168, which required the counties to adopt an energy code based on ASHRAE 90.1 by October 24, 1994. The Model Energy Code meets this requirement. All counties except Maui County have adopted the code. Honolulu and Kauai counties exempted low-rise residential buildings; Hawaii County exempted single-family dwellings and duplexes.

When adopted by all of the counties, the Model Energy Code will also bring Hawaii into compliance with the federal Energy Policy Act of 1992 (EPACT). EPACT required each state to certify by October 24, 1994 whether the state had met or exceeded the requirements of ASHRAE 90.1 for commercial buildings and whether the state had determined the appropriateness of meeting or exceeding the national Model Energy Code for residences. Hawaii's Model Energy Code has been determined to meet EPACT requirements. (DBEDT 1993b).

11.2.1.3 Impact of the Model Energy Code

All measures included in the Code are cost-effective. An *Impact Analysis of the Model Energy Code*, published in December 1993, predicted annual energy cost savings in Hawaii of about $1.086 million per year, at a one-time compliance cost of $1.649 million (DBEDT 1993b). Thus, the cost of implementing provisions of the Code was expected to be paid back by savings in about 1½ years. Annual peak demand reduction was expected to be 2.82 MW, and with about 11GWh per year were saved, and a reduction of CO_2 emissions by 11,300 tons. Table A.30, in Appendix A, shows the cumulative energy and cost savings forecast in the original impact study, and an estimate of CO_2 emissions reduction.

11.2.1.4 RECOMMENDATION: Adopt Model Energy Code for Maui County (Currently Under Consideration) and Adopt Residential Building Model Energy Code in All Counties

Suggested Lead Organizations: The Counties

The County of Maui is currently considering the MEC and is encouraged to adopt it. Since air conditioning appears to be a growing end-use for residential buildings in Hawaii, DBEDT encourages the counties to favorably reconsider adoption of the residential building portions of the original Model Energy Code or to adapt them further to their requirements.

11.2.1.5 RECOMMENDATION: Encourage Continued Use of HiLight Software Program by Lighting Designers to Ensure Model Energy Code Compliance

Suggested Lead Organization: The Building Industry and Design Professionals

HiLight is a software program developed for DBEDT in 1996 by Eley Associates on a cost-shared basis with the U.S. Department of Energy. The program is available at no charge on the Internet at http://www.state.hi.us/dbedt/ert/mec /app-b.html or http://www.eley.com. The software helps the lighting designer evaluate and document the lighting performance of new commercial buildings. It also allows plan checkers to quickly check plans for conformance with the Code.

11.2.1.6 RECOMMENDATION: Continue to Evaluate Impact of and Improve the Rate of Compliance with the Model Energy Code

Suggested Lead Organizations: DBEDT and the Counties

The *MEC Compliance Report* involved a detailed analysis of 21 building plans for buildings completed in the 1994–1997 period in Honolulu County and 11 building plans in Hawaii County (Eley 1999, 1). The report indicated that the original savings estimates made in the *1992 Impact Analysis* would have been on target if all counties had adopted the MEC (1). If 100% compliance were achieved, about $1.1 million would be saved yearly, resulting in a cumulative savings of $222 million in 20 years. The report showed an 87% rate of compliance in Honolulu and Hawaii counties. Thus about $160,000 in potential savings was lost due to non-compliance. The report includes recommendations for improving the rate of compliance (Eley 1999).

11.2.2 Utility Demand-Side Management Programs

DSM is defined as any utility activity aimed at modifying the customer's use of energy to reduce demand. It includes conservation, load management, and efficiency programs. DSM offers the potential for lower customer utility bills, deferral of major power plant investments, reduced environmental impacts, and potential diversification of resources (NEOS 1995, ES-1).

The four electric utilities each proposed DSM programs as part of their initial Integrated Resource Plans (IRPs) and filed their programs for Public Utility Commission approval and determination of cost recovery. Kauai Electric (KE), HECO, and HELCO filed their DSM programs in their second round IRPs.

11.2.2.1 HECO Demand-Side Management Plan

HECO's objectives for DSM, as stated in their second IRP, were to:

- Acquire cost-effective energy efficiency and peak reduction measures that were less expensive than supply alternatives;
- Enhance customer value by providing energy services not previously offered by the company; and
- Promote technologies which are environmentally sensitive and minimize environmental damage to Hawaii's unique ecosystem (HECO 1998b, 12-1).

As part of HECO's first IRP, the company filed a DSM Action Plan with the Commission on January 18, 1994. The plan included the following programs, which were approved by the Commission in 1996:

- **Commercial and Industrial Energy Efficiency Program –** promotes more efficient air conditioning, lighting, refrigeration, and motors (7-14).
- **Commercial and Industrial New Construction Program –** provides design and technical assistance for more efficient air conditioning, lighting, motors, and other end uses (7-19).
- **Commercial and Industrial Customized Rebate Program –** provides for cost-sharing arrangements to fund customer-proposed energy efficiency opportunities (7-23).

- **Residential Efficient Water Heating Program –** promotes the use of high-efficiency water heating technologies such as solar water heating, heat-pump water heaters, and high-efficiency resistance water heaters (7-10).
- **Residential Efficient Water Heating Program (New Construction) –** promotes solar water heating, heat-pump water heaters, and high-efficiency resistance water heating to developers of new housing (7-6).

HECO estimated that 9,279 GWh of electricity would be saved through its DSM programs over the 20-year plan period. This would reduce CO_2 emissions by 9,094 million tons. Annual emissions savings would reach 761,323 tons of CO_2 in 2017. Table A.31, in Appendix A, details the projected energy and emissions reductions.

In its second IRP, HECO reviewed the *Hawaii Demand-Side Management Opportunity Report*, produced by DBEDT as part of *HES 1995*. HECO elected to maintain and further develop the five DSM programs established in their first IRP and to add two load management programs (7-2). The two load management programs were:

- **Commercial and Industrial Capacity Buy-Back Program –** to provide 30 MW of interruptible load beyond that provided by existing customers under Rider I rates (7-36).
- **Residential Water Heating Direct Load Control Program –** to provide customers with a $2.50 monthly incentive to allow HECO to install a radio-controlled switch on their water heaters to allow them to be shut off in emergencies and to defer capacity additions (7-39).

The two load management programs are intended to defer the need for new capacity by reducing peak demand, a strategy known as “peak shaving.” The five original DSM programs also offer some peak demand savings. Estimated peak demand savings for each program are shown on Table A.32. The 167.58 MW expected to be deferred during the period covered by HECO’s IRP-97 (to 2017) can be compared in size with the planned 107 MW combustion turbine (CT) or the 180 MW atmospheric fluidized bed coal plant planned for installation late in the planning period.

11.2.2.2 HELCO Demand-Side Management Plan

HELCO set the same objectives for its DSM programs in IRP-98 as HECO (HELCO 1998b, 9-1). HELCO developed four DSM programs in its first IRP, which were approved by the PUC in December 1995. They included a Commercial and Industrial Energy Efficiency Program, Commercial and Industrial New Construction Program, Commercial and Industrial Custom Rebate Program, and Residential Efficient Water Heating Program. HELCO combined its new construction and existing customer residential efficient water heating programs into a single program. In addition, HELCO distributed high efficiency shower heads to customers. These reduce hot water use, and thereby, water-heating and water-pumping loads.

By 2018, the HELCO DSM programs were estimated to reduce annual Big Island energy requirements by 103.96 GWh, reducing CO_2 emissions in that year by 102,401 tons. Over the 20-year period of the plan, energy savings were estimated to be 1,024 GWh and the CO_2 emissions reduction was forecast to be 1.111 million tons. Table A.33 details the estimated energy savings and CO_2 emissions reductions for HELCO DSM programs. Table A.34 summarizes the estimated peak demand savings from HELCO DSM programs. The 15 MW peak demand savings estimated by 2018 represents partial deferral of a nominal 20 MW CT unit.

HELCO also received approval of a pilot Capacity Buy-Back DSM Program on March 24, 1997. However, HELCO decided not to implement the program due to positive customer response to its existing load management rates and rate riders, which give incentives to customers to curtail load during system peak periods. HECO had 28 contracts representing about 6.7 MW of peak-shaving capacity when the IRP was completed in September 1998. HELCO assumes curtailment of 5.5 MW for planning (ES-6).

11.2.2.3 KE Demand-Side Management Plan

Kauai Electric developed six DSM programs in its first IRP in 1993. They were incorporated into the 1994 DSM Action Plan (KE 1997b, D-7), approved by the Commission in August 1997. A new plan was developed as part of KE's 1997 IRP, filed on April 1, 1997. It included the following five programs:

- **Commercial Retrofit Program –** promotes energy efficiency improvements to existing commercial buildings through energy audits, customer education, and monetary incentives for measures installed (D-12).
- **Commercial New Construction Program –** provides education, technical assistance, and incentives to commercial new construction owners and trade allies to promote the use of energy-efficient equipment in building design (D-22).
- **Residential Retrofit Program –** involves a combination of trade allies, energy efficiency education, and incentives to encourage customers to adopt energy-efficient lighting and other low-cost measures, and to retrofit their homes with such technologies as heat-pump or solar water heaters, and hard-wired fluorescent fixtures (D-26).
- **Residential Direct Install Program –** provides efficient lighting and water heating measures to the low-income and renter markets. It includes a separate focus on State of Hawaii Housing Authority units (D-33).
- **Residential New Construction Program –** provides energy efficiency technical assistance to residential builders and trade allies. Incentives and financing will be provided to encourage inclusion of solar water heaters,

heat-pump water heaters, and hard-wired fluorescent fixtures in new units (D-39).

The programs are expected to reduce energy use over the 20-year period by 558 MWh and save about 390,500 tons of CO_2 emissions. Table A.35 depicts the estimated energy savings and reduction of greenhouse gas emissions from KE's programs. KE expects the estimated peak demand savings for DSM programs to be maximized in 2005, at 5.78 MW as presented on Table A.36.

11.2.2.4 MECO Demand-Side Management Plan

On June 2, 1995, MECO filed applications with the PUC for its DSM programs. The MECO programs were essentially the same as HECO's, but the residential efficient water heating programs for existing and new customers were combined (13-15). The programs were approved in 1996 (MECO 1997b, 11).

MECO projected energy savings of 936 GWh over the 20-year period, which would result in a DBEDT-estimated CO_2 emissions reduction of 880,169 tons. MECO reduced its estimate of the energy and capacity savings from its DSM programs as a result of the experience of HECO and HELCO. It should be noted that, while the County of Maui has not yet adopted the Hawaii Model Energy Code, such adoption could reduce the impact of MECO DSM programs. Table A.37 summarizes the projected energy savings and CO_2 emissions reductions. Table A.38, in Appendix A, shows estimated peak demand reductions from MECO DSM programs.

11.2.2.5 RECOMMENDATION: Continue to Support Cost-Effective Utility Demand-Side Management Programs through Partnership Programs and Participation in IRP Planning Activities

Suggested Lead Organizations: The Utilities, DBEDT, and Counties

The utility DSM programs outlined above contribute significantly to energy efficiency and reduction of the need for electricity generation. They should be strongly supported. DBEDT will continue its partnerships in several programs and will continue to participate in utility DSM Advisory Groups as part of the IRP process

11.2.3 State Government Efficiency Programs

This section outlines a number of energy efficiency programs that reduce the need for electricity generation and reduce electricity demand. Hawaii government programs identify, initiate, and implement energy and resource efficiency programs through public-private sector partnerships and through existing resources and competitive grants awarded from federal agencies.

Specific programs include residential and commercial building efficiency; alternative financing; Rebuild Hawaii; voluntary energy efficiency guidelines on appropriate methods, technologies, and appliances for single family residential dwellings; guidelines for energy efficiency in commercial buildings, and building commissioning. These programs are supported by specialized technical assistance and training to transform the market for energy and resource efficiency technologies. A major initiative is to develop private/public sector partnerships that use energy and resource efficiency as a catalyst for sustainable development.

11.2.3.1 RECOMMENDATION: Increase State Government Efforts to Improve Energy Efficiency by Meeting State Goals for Reduction of Energy Use in State Facilities

Suggested Lead Organizations: DBEDT and State Agencies

Administrative Directive No. 94-06 established an Energy Management and Efficiency Program for State Facilities to moderate the growth in energy demand through conservation and energy efficiency (Waihee 1994). Governor Cayetano endorsed the Directive through *Executive Memorandum No. 96-01, Subject Fiscal and Energy Management* on January 22, 1996 (Cayetano 1996). Governor Cayetano urged all departments and agencies to use public funds judiciously by making energy efficiency a priority.

11.2.3.2 RECOMMENDATION: Continue Transfer of Advanced Building Technologies and Development of Design Guidelines

Suggested Lead Organizations: DBEDT, the Utilities, Design Professionals, and the Building Industry

Under grants from the U.S. Department of Energy (USDOE), DBEDT ERT Division has contracted with several organizations in Hawaii to provide educational and informational materials, develop public-private partnerships, and conduct professional development training in areas related to building energy efficiency. Recent activities included:

Hawaii Advanced Building Technologies Program. The University of Hawaii at Manoa School of Architecture developed a training program for the Hawaii residential construction industry to assist with the integration of energy- and resource-efficient design, building materials, and techniques in the design and construction of homes in Hawaii.

Residential Energy-Efficient Building Guidelines. The Honolulu Chapter of the American Institute of Architects was contracted to develop and implement voluntary residential building guidelines to support and extend the State's Model Energy Code. This project included training materials and training sessions and the planning and building of at least one model demonstration house.

Commercial Building Efficiency Guidelines. Participants in the project will work toward the development of the next-generation building code for new and renovated commercial developments and buildings. HECO will provide matching funds to supplement the USDOE grant and will also offer its Energy Awards Program, technical assistance, and marketing programs to promote and support the project.

Demonstration Project in Building Commissioning. Based on a recommendation from the April 1999 Workshop on Energy Efficiency in Federal Facilities, DBEDT will work with the Department of Accounting and General Services to implement a demonstration commissioning project.

11.2.3.3 RECOMMENDATION: Expand Hawaii State Government Energy Performance Contracting and Alternative Financing for Energy Efficiency Projects

Suggested Lead Organizations: DBEDT, State Agencies, Financing Companies

Performance contracting is an arrangement in which a private company, called an energy service company, or ESCO, finances and installs energy-efficiency-related equipment and building improvements for a payment that depends on future energy savings resulting from the improvements. There are several features that distinguish energy performance contracting:

- A single procurement is used to purchase a complete package of services and one contractor is accountable for design, purchase, installation, maintenance, and operation of the equipment;
- The package of services includes financing of all of the project costs. No up-front money is needed by the building owner to implement a performance contract;
- The performance contract is structured so that the total payments *with* the contract are always less than the energy payments would have been *without*. This is because the annual energy savings produced by the project are greater than its amortized cost;
- State of the art, energy-efficient lighting, air-conditioning systems, energy management control systems, motor replacements, and variable-speed drives for pumps and fans are common improvements. In larger facilities, cogeneration units may be installed;
- Management and maintenance resources are included in the turnkey service; and
- The risk of energy savings performance is transferred to the ESCO, because payments are contingent on actual savings achieved, which are guaranteed by the ESCO.

DBEDT's ERT Division is coordinating a number of performance contracting efforts within Hawaii's state government. The ERT staff provides assistance to state agencies seeking to obtain the benefits of energy performance contracting under Section 36-41, Hawaii Revised Statutes. DBEDT ERT developed a *Guide to Energy Performance Contracting*, which is being used to stimulate performance contracting activities in other state organizations. Additional projects under development, if fully implemented, will save the state more than

$4 million annually in energy costs, leverage $23 million in private funds for energy improvements, bring in an estimated $11.5 million in income to the economy, and create 350 new jobs.

ERT is providing technical assistance to interested facility and agency managers throughout the performance contracting process, from developing the RFP through monitoring and verifying savings. The University of Hawaii at Manoa has signed an agreement with Hawaiian Electric Company, Inc., for a program to carry out energy efficiency retrofits on the Manoa campus. The Department of Education is proposing to implement energy efficiency in Maui schools through a lease purchase program.

Table A.39 shows the estimated results from performance contracting for the State projects now under development. It should be noted that part of the financing of these projects may come from utility DSM programs, so the energy and CO2 savings shown may be included in the DSM program savings cited above.

11.2.3.4 RECOMMENDATION: Continue to Support State Participation in Rebuild America and Other Public-Private Partnerships and Alliances to Improve Resource Efficiency

Suggested Lead Organizations: DBEDT, Hawaii Rebuild America Partnerships, Rebuild Hawaii Consortium, and Partner Organizations

The federal government has expertise, research capabilities, and access to energy efficiency technologies, but knowledge about specific resource-efficiency problems often exists at state or local levels. National governmental agencies are forging alliances with states and local governments to encourage resource efficiency. The USDOE's Rebuild America Program is an example of one such alliance. Other federal programs encouraging energy efficiency partnerships are the Million Solar Roofs Program, Energy $mart Schools Program, federal Energy Management Program, the Motor Challenge Program, and several EPA building efficiency programs. In 1999, DBEDT's Energy Branch was implementing more than $1.4 million in active competitive federal government grants, $313,000 of which was for the State's Rebuild America Program

Hawaii's Rebuild America Program. The State of Hawaii's Rebuild America Program focuses on stimulating the economy and achieving cost savings through the increased use of energy efficient technologies in the public and private sectors. The mission is to promote efficient resource utilization by: identifying and leveraging statewide resources, creating community awareness, building partnerships, and employing innovative solutions to resolve resource efficiency issues. There are ten Hawaii partners, including the four counties. The program is initially focusing on encouraging energy performance contracting to retrofit government buildings with energy efficient technologies. The program also includes public sector multi-family housing and small commercial programs. Potential energy, economic, and environmental benefits of existing Hawaii

Rebuild America Partnership Programs are detailed on Table A.40. Ongoing projects include:

- Performance contracts at the University of Hawaii at Hilo, the County of Hawaii, and the County of Kauai;
- A workshop and technical seminar on measurement and verification of energy savings in performance contracts;
- A small, commercial-sector energy efficiency market transformation project; and
- Support to Hawaii Rebuild America Partners.

Newly funded projects include:

- A community-sponsored rural energy project, the Na Makani Energy Initiative, in North Kohala, Hawaii, through which 100 low-cost solar water heating systems will be installed;
- Energy $mart Schools Project to train high-school students to be energy auditors, audit two public high schools, audit small businesses, and sustain energy efficiency education in schools and communities;
- Higher education projects, including an interdisciplinary team for a hotel efficiency project and "Greening the Campus" programs at the six Hawaii Community Colleges.

In August 1999, the State won the following U.S. Department of Energy national awards:

- **1999 Rebuild America State Representative of the Year Award –** Elizabeth Raman, DBEDT's Energy, Resources, and Technology Division, for individual performance in developing the Rebuild Hawaii Consortium.
- **1999 Rebuild America Award for Energy Excellence in State Government –** State of Hawaii for the DBEDT Rebuild Hawaii State Program.

These awards were for DBEDT's success in developing a statewide Rebuild America program and the Rebuild Hawaii Consortium, a network of community-based partnerships that empower Hawaii communities to save money, promote growth, create jobs, retain business, reduce energy waste, and protect the environment by investing in energy-efficient technologies.

11.2.3.5 RECOMMENDATION: Continue and Expand Energy Efficiency Technology Education and Training Programs

Suggested Lead Organization: DBEDT

Changing – or "transforming" – a market as an energy-efficiency policy option involves changing consumer preferences about their purchases of goods that use energy. Oftentimes, a problem with this approach is the higher up-front costs of goods that are more energy-efficient. However, changing consumer demand for energy-efficient goods is expected to lower production costs and create economies of scale in manufacturing and distribution, leading to more affordable prices in Hawaii.

The State of Hawaii is very active in market transformation through its educational and training programs. DBEDT promotes renewable energy and energy efficiency through educational and promotional projects such as workshops and technical seminars, science and engineering fairs, exhibits, and energy-efficiency publications.

DBEDT has recently conducted workshops and technical seminars in each of the following areas: roof insulation, window tinting, management of construction and demolition waste, lighting efficiency, water and air conditioning design, motor efficiency, optimizing large pump systems, measurement and verification of energy savings, efficient electro-technologies (in partnership with HECO), building energy- and resource-efficient homes, building commissioning, and energy efficiency for federal facilities.

11.2.3.6 RECOMMENDATION: Continue Solid Waste Reduction and Recycling Programs

Suggested Lead Organization: DBEDT

With Hawaii's economic and population growth, and its ever diminishing landfill space, recycling activities in the state will become more critical in the future. DBEDT supports the Clean Hawaii Center (CHC) in its efforts to build on the current cooperative working arrangements it has established with federal, State, and County governments, as well as community organizations and the private sector, to support business development for the creation of jobs, increased capital investment and sales, reduced energy use, and reduced landfill requirements. Through a U.S. Environmental Protection Agency grant, the CHC is focusing on reducing construction and demolition debris that accounts for about 30% of landfill requirements. Although the CHC statutorily sunset on June 30, 1999, DBEDT has committed to continuing the mission of CHC.

11.2.4 County Government Energy Efficiency Programs

Hawaii’s County governments are involved in a variety of energy efficiency programs, not only independently, but also in conjunction with the federal and State governments.

11.2.4.1 RECOMMENDATION: Continue and Expand County Government Energy Efficiency Programs

Suggested Lead Organizations: Counties, with DBEDT Support

County governments have programs and projects that contribute to reducing energy costs and improving Hawaii’s economy, as well as reducing environmental pollution. Table A.41 summarizes estimated benefits in energy savings and CO_2 emissions reduction from County projects.

11.2.5 Federal Energy Efficiency Programs in Hawaii

11.2.5.1 Federal Government Electricity Use in Hawaii

The federal government is a major user of electricity in Hawaii. In particular, Hawaii's large military facilities, especially on Oahu, are major consumers of electricity. In 1996, military facilities used 16.4% of the electricity sold on Oahu (Chang 1997). To generate the electricity purchased by the Department of Defense in 1996, HECO emitted 1,218,880 tons of CO_2. It should be noted that, while overall electricity sales grew by 10.1% between 1990 and 1996, military use increased at a slower rate, 8.9%. Some force reductions may have slowed the growth of military electricity use, but the federal Energy Management Program was a likely additional factor.

11.2.5.2 Federal Energy Management Program

The mission of the federal Energy Management Program (FEMP) is to reduce the cost of government by advancing energy efficiency, water conservation, and the use of solar and other renewable energy. Section 543 of the National Energy Conservation Policy Act, as amended by the Energy Policy Act of 1992, required each federal agency achieve:

- 10% reduction in energy consumption in its federal buildings on a Btu per gross square foot basis by FY1995 against a FY1985 baseline; and
- 20% reduction in Btu per gross square foot by FY2000 (USDOE 1998b).

In addition, agencies are required to achieve a 30% reduction against the FY1985 baseline by FY2005, per Executive Order 12902 (USDOE 1998b). A key element of FEMP activities has been partnership with local electric utilities and demand-side management incentives offered by those utilities.

In his radio address to the nation on July 25, 1998, President Clinton took further action to decrease energy use in federal buildings and facilities to reduce greenhouse gas emissions and to save taxpayer dollars (Clinton 1998). More recently, the President issued Executive Order 13123 of June 3, 1999, entitled "Greening the Government Through Efficient Energy Management" (Clinton 1999). It set the following goals for federal agencies:

- Reduce greenhouse gas emissions by 30% by 2010 compared to 1990;
- Reduce energy use per gross square foot by 30% by 2005, and 35% by 2010 relative to 1985;
- Increase use of renewable energy
- Reduce use of petroleum and switch to less greenhouse gas intensive energy sources;
- Reduce total greenhouse gas emissions; and
- Conserve water (30851-30852).

Actions being taken by the federal government offer examples that can be imitated at the state and county levels, as well as by private business.

11.2.5.3 RECOMMENDATION: Continue Cooperative Efforts to Support Energy Efficiency Programs in Federal Facilities in Hawaii

Suggested Lead Organizations: Federal Agencies, Gas and Electric Utilities, DBEDT

DBEDT/Federal Energy Management Program (FEMP) joint project. In April 1999, Under a $40,000 grant from FEMP, DBEDT conducted a workshop on energy efficiency for federal facilities at which selected agencies presented case studies of their energy efficiency projects. A companion workshop on Building Commissioning was also held. As a follow-on to the workshop, DBEDT's consultant is assisting federal agencies to implement energy efficiency as follows:

National Weather Service. The National Weather Services has a potential application for PV/Fuel Cell hybrid systems at approximately 6–12 remote sites in Hawaii, Micronesia, Guam, and America Samoa. Technologies would include High-Efficiency Thin Film (HETF) Photovoltaics (PV) to run an electrolyzer that generates hydrogen for weather balloons and as a fuel source for Polymer Exchange Membrane (PEM) fuel cells. Oxygen is also generated and is used for multiple applications including water purification. DBEDT's consultant is assisting the agency to develop an integrated, modular, sustainable, renewable solution that can be used in a number of applications. There is a large potential export market for such technology, and the project is attracting potential strategic partners including PV and fuel cell manufacturers, and financiers.

Veteran's Administration. There is a potential for developing a delivery order under the Western Region's Super Energy Savings Performance Contract at the Veteran's Administration Site at Tripler Hospital. DBEDT's consultant is assessing technology applications for retrofit opportunities and will develop the delivery order if potential is found.

National Marine Fisheries Service, Honolulu Laboratory (NMFS). There is potential for design assistance for new construction and commissioning of a showcase facility. DBEDT's consultant is reviewing the design and status of the project with the NMFS staff to identify needs and will assist the agency to locate technical assistance and funding for the project.

U.S. Coast Guard. The U.S. Coast Guard in Hawaii has identified a number of energy efficiency opportunities, but projects involving additional third party financing have been put on hold.

U.S. Air Force. The Air Force is interested in expanding the current scope of its Energy Savings Performance Contract, and DBEDT's consultant is assisting them to identify additional energy savings opportunities.

Other federal Projects:

Federal Civilian Energy Efficiency Projects. In 1997, renovation of the air conditioning system of the Prince Jonah Kuhio Kalanianaole Building, also known as the Federal Building, was completed. It provided new, more efficient chillers, cooling towers with two-speed, energy-efficient motors, and an energy-efficient pumping system – all integrated into a computerized energy management system (GSA 1997). The new system resulted in nearly a 16% reduction in building energy use. The $4 million project earned more than $170,000 in rebates (Munger 1999a, 22-23) and reduced greenhouse gas emissions.

Air Force Energy Efficiency Projects. Air Force energy efficiency projects include installation of efficient lighting and occupancy sensors in base industrial facilities. In addition, as part of the renovation of Hickam Air Force Base family housing, heat recovery systems on central air conditioning units will provide hot water. Opportunities for solar water heating are limited at Hickam, as trees shade most housing areas. An energy services performance contract was recently issued for improvements to the Pacific Air Force Headquarters Building, the largest building on base. It is currently in the design stage (Young 1998).

Other Air Force projects earned more than $75,000 in utility rebates through installation of high-efficiency lighting in the new base exchange and high-efficiency air conditioning, compact fluorescent lamps, and T8 lighting in new family housing units (Munger 1999a, 23).

Army Energy Efficiency Projects. The Army achieved major reductions in energy use through a variety of energy awareness and energy efficiency programs. A relamping contract, developed using FEMP funding, retrofitted over 100 buildings with T8 fluorescent bulbs with electronic ballast, compact fluorescent bulbs, and LED exit signs. A recycling program was developed to recycle the old fluorescent light tubes, which contain hazardous materials. The longer lifetimes of the new lighting will reduce future maintenance and disposal costs. The lower heat gain from the new lights also reduced air conditioning costs (USAG-HI 1997).

In addition, over 1,950 heat-pump water heaters were installed in Army family housing. These units, plus high-efficiency office lighting and barracks air conditioning, have earned the Army more than $1.04 million in utility rebates (Munger 1999a, 23).

Marine Corps Energy Efficiency Projects. The Energy Management Team at Marine Corps Base Hawaii developed a 25-year performance contract that will implement up to $24 million in energy savings. The objective is to significantly reduce the $8 million annual energy bill for the base and its $9 million maintenance and repair costs. The initial projects were to install high-efficiency lighting fixtures in four buildings (FEMP 1997). Through revitalization of hundreds of family housing units, the Marine Corps received more than $220,000 in utility rebates. Measures used included 237 efficient water heating tanks and timers, high-efficiency air conditioners, compact fluorescent lamps, and T8 fluorescent lighting (Munger 1995a, 23).

Navy Energy Efficiency Projects. The Navy is involved in a major energy efficiency program for implementation under a basic ordering agreement (BOA) with HECO at a number of Navy-operated facilities on Oahu. The BOA is similar to a performance contract except that upon completion of construction, the customer accepts ownership of the equipment and operation and maintenance (O&M) responsibilities. Under a performance contract, the contractor retains ownership and handles O&M for the life of the contract. Also, results under the BOA are not guaranteed, but were developed by an engineering estimate.

At this time, the Pacific Division, Naval Facilities Engineering Command is administering the contracts for the Navy. Any DoD component can use the BOA to get energy efficient equipment installed at their installation. The current Navy program is estimated to cost $24.9 million and will result in annual savings of 29 million kWh and about 29,000 tons of CO_2. The energy savings will reduce the Navy's electricity bill by about $3.4 million per year and will earn a rebate from HECO's DSM program of $1.3 million (Kawamoto 1998).

In addition to the BOA, the Navy's ongoing energy efficiency efforts have earned more than $1.75 million in DSM rebates. Most of the rebates have been associated with Navy construction of 1,000 new family housing units. The homes incorporate 1,000 solar water heaters, 700 efficient split air conditioning units, 14,000 compact fluorescent lamps, and thousands of efficient T8 and high-intensity discharge lamps. The Navy earned the 1998 HECO Energy Award for energy efficiency for its the new Seawolf Tower Bachelor Enlisted Quarters (Munger 1999a, 23).

11.3 New Technologies for Energy Efficiency

11.3.1 Emerging Energy Efficiency Technologies Identified

In 1998, the American Council for an Energy-Efficient Economy examined more than 200 emerging energy efficiency technologies and practices that were defined as commercialized, but that had not achieved more than 2% market penetration or that would be "off-the-shelf" by 2005. Various screens for cost-effectiveness and potential savings were used to develop a list of 80 measures, which was then reduced to 33 high- and medium-priority technologies and practices (Nadel 1998).

11.3.2 RECOMMENDATION: Investigate New Measures and Practices for Building Energy Efficiency

Suggested Lead Organizations: DBEDT, the Utilities, Building Industry and Design Professionals

DBEDT further screened the list for applicability to Hawaii and selected six high priority measures and 12 medium priority measures for recommendation as part of this strategy. The high priority measures are, in order of energy savings potential:

1. Integrated commercial building design;

2. Integrated new home design;
3. Aerosol-based duct sealing;
4. Commissioning existing buildings;
5. Integrated lighting fixtures with controls; and
6. Improved ducts and fittings.

It should be noted that items 1, 2, and 4 are practices that DBEDT is already encouraging through its various energy efficiency programs. The remainder are technologies that have been commercialized and should be investigated for their technical potential in Hawaii. Medium-priority measures, in order of energy savings, included the following:

1. Improved fluorescent dimming ballast;
2. Commercial air distribution system (air duct) sealing;
3. One-lamp fixtures and task lighting;
4. Compact fluorescent floor and table lamps;
5. Advanced clothes washers and dishwasher controls;
6. Heat reflecting roof coatings;
7. High R (> 4 windows);
8. High-efficiency dishwashers;
9. Integrated space conditioning and water heating systems (heat pumps); and
10. Switched reluctance drives (high efficiency electric motors).

The reader is referred to *Emerging Energy-Saving Technologies and Practices for the Buildings Sector*, published by the American Council for an Energy-Efficient Economy for details on these measures (Nadel 1998).

CHAPTER 12 ENERGY EMERGENCY PREPAREDNESS

12.1 Hawaii's Energy Emergency Challenge and Response

12.1.1 Hawaii's Potential Exposure to Energy Emergencies

Hawaii's geographic isolation and dependence on imported oil make Hawaii's people critically vulnerability to serious energy shortages. Hawaii's energy situation is detailed in Chapter 3.

The combination of over-dependence on oil, isolation from sources of supply, and the unpredictability of the world oil market create a great deal of energy security concern for Hawaii. Depending on the length and severity of an energy shortage, the outcome could range from inconvenience to a disaster situation requiring civil defense mobilization. The challenge for Hawaii is to be as prepared as possible to effectively contend with energy emergencies and threats to Hawaii's energy security. Energy emergencies can stem from oil market disruptions or from disasters (natural and man-made). Such events could lead to an energy shortage.

In the context of energy emergency preparedness, an "energy shortage" exists whenever the Governor determines that an increase in energy demand or a decrease in available energy supply, or both, may create a major adverse impact on the economy that the free market distribution system is unable to manage.

12.1.2 The State of Hawaii Energy Emergency Preparedness Program

The State's Energy Emergency Preparedness program (EEP) is structured to address both market and disaster-related energy emergencies. The State's EEP Program is made effective only by the hard work and cooperation of Hawaii's private sector energy companies – the front-line energy emergency responders. The State's EEP Program to assist industry is only activated when the private sector is stretched beyond its capabilities.

12.1.3 Recent Developments in the EEP Program

In 1991, the State of Hawaii's EEP was updated. Since 1991, additional important developments have occurred to further contribute to sound energy emergency policies and actions.

In 1992, the Hawaii State Legislature passed legislation, later enacted as Act 182, which completely overhauled the State's EEP statute by incorporating provisions for coordinated State and County EEP planning.

In 1996, an assessment of the vulnerability of Hawaii's energy systems to natural disasters was completed by the Federal Emergency Management Agency (FEMA), U.S. Department of Energy (USDOE), State Civil Defense (SCD), and the Energy, Resources, and Technology Division (ERTD) of the Department of Business, Economic Development & Tourism (DBEDT), in cooperation with Hawaii's energy industry. (See Appendix D for the recommendations and responses to this assessment.)

On May 6–8, 1998, the State of Hawaii conducted a *Regional Energy Emergency Seminar and Simulation Exercise* for Hawaii, the Western states, and Pacific Island Territories. This event, funded by a USDOE grant, was co-sponsored by the USDOE, the National Association of State Energy Officials, and the Pacific Disaster Center (PDC). Its purpose was to test and evaluate the effectiveness of a coordinated public- and private-sector response to an energy emergency and to test the operational concept developed by the Energy Council (EC). The EC approach was examined as an application that may be applicable in other jurisdictions, based on its demonstrated success in the aftermath of Hurricane Iniki, in 1992, and in a statewide energy emergency simulation exercise in 1997. Also, direct on-line connection to the PDC (located on Maui) through multiple computer workstations assisted the exercise by simulating a hurricane-related energy emergency and by providing a common situation electronic reporting format. This seminar and exercise were the premier events of SCD's annual statewide hurricane exercise, *Makani Pahili* 98.

On November 13, 1998, a new federal law (Public Law 105-388) was enacted by President Clinton, which provides Hawaii and the insular U.S. Pacific and Atlantic Territories priority access to Strategic Petroleum Reserve (SPR) oil in the event of a drawdown. This legislation, introduced by Senator Daniel Akaka, was passed with the support of Senator Daniel Inouye and Hawaii's Congressional representatives. DBEDT, in cooperation with Hawaii's energy industry, developed the policy analyses for priority access. On September 27, 1999, a memorandum of understanding to effect procedures for implementing Hawaii's priority access to SPR oil in the event of drawdown was executed by the State of Hawaii with the USDOE.

In September 1999, the U.S. Army Corps of Engineers (CORPS) completed a supplemental study on coastal hazard mitigation. Also, in September, the State initiated a project to survey emergency and essential service facilities with generators for the purpose of documenting emergency power requirements and technical specifications for generators.

The State ERTD remains very active in relevant emergency management activities such as:

- A USDOE Peer Exchange Meeting on Energy Emergencies and Y2K, in Port Orchard, Washington, September 15–16, 1999, to discuss and develop state energy emergency management and Y2K contingency planning for the Western states;
- The State and USDOE conducted a Workshop on Photovoltaics for Essential Services, September 13, 1999, on Kauai, and again on September 16th, on Oahu, which explored the application of photovoltaics for disaster relief; and
- The State participated in an Asia-Pacific Disaster Conference, on Kauai, September 19–23, 1999, to share emergency response expertise that with potential regional application.

EEP programs are designed to prepare for a wide range of conditions and scenarios involving reductions in available fuel supplies with the aim of decreasing the hardships and inequities that energy shortages could cause. Priority needs must be considered and essential services must be continued, and the public's critical needs in such areas as health, water, food, fire, police, ambulance, and transportation must be provided for. Contingency planning, by its very nature, must consider many factors that are indefinite, while it lays the foundation for rapid and decisive action when the need occurs.

No single solution or set of plans can entirely remove the vulnerability Hawaii faces. However, the State in seeking to reduce the impact of energy vulnerability, works in concert with industry and the county governments to:

- Annually exercise EEP plans statewide;
- Encourage the diversification of energy use;
- Use energy more efficiently;
- Plan and prepare for energy shortages when they occur; and
- Conduct hazard mitigation measures.

12.2 Hazard Mitigation

ERTD conducts hazard mitigation projects in coordination with industry, SCD, and FEMA. The purpose of these projects is to reduce the State's energy vulnerability and to enhance its ability to respond to an energy-related disruption of critical emergency and essential services.

12.2.1 Energy Vulnerability Assessment

The State conducted an energy vulnerability assessment to apply lessons learned during Hurricane Iniki. The assessment had two parts, a primary study of the vulnerability of Hawaii’s energy systems to natural disasters (conducted by USDOE), and a supporting study of the impact of coastal flooding (conducted by the CORPS). The *Hawaiian Islands Hazard Mitigation Report*, based on the energy vulnerability assessment by USDOE was completed in September 1996. As a result of the energy vulnerability assessment (35) recommendations were developed pertaining to electric, petroleum, gas, and lifeline service industry considerations (USDOE-OEM 1996, 35) (see Appendix D). In 1999, the CORPS completed a follow-on study of coastal flooding, which identified ten alternative measures for hazard mitigation (see Appendix D). The graphic below depicts Hawaii's utilities' exposure to damage from hurricanes. Noted by the arrow for the Island of Kauai is the actual cost of damages to Kauai Electric caused by Hurricane Iniki in 1992.

12.2.2 State Hazard Mitigation Initiatives

The focus of the State's initiatives is to implement a key recommendation of the *Hawaiian Islands Hazard Mitigation Report,* which proposed the documentation of emergency generator needs. The State is undertaking a two-phase project to identify existing emergency generators and to determine what facilities require emergency generator support in the event of an emergency.

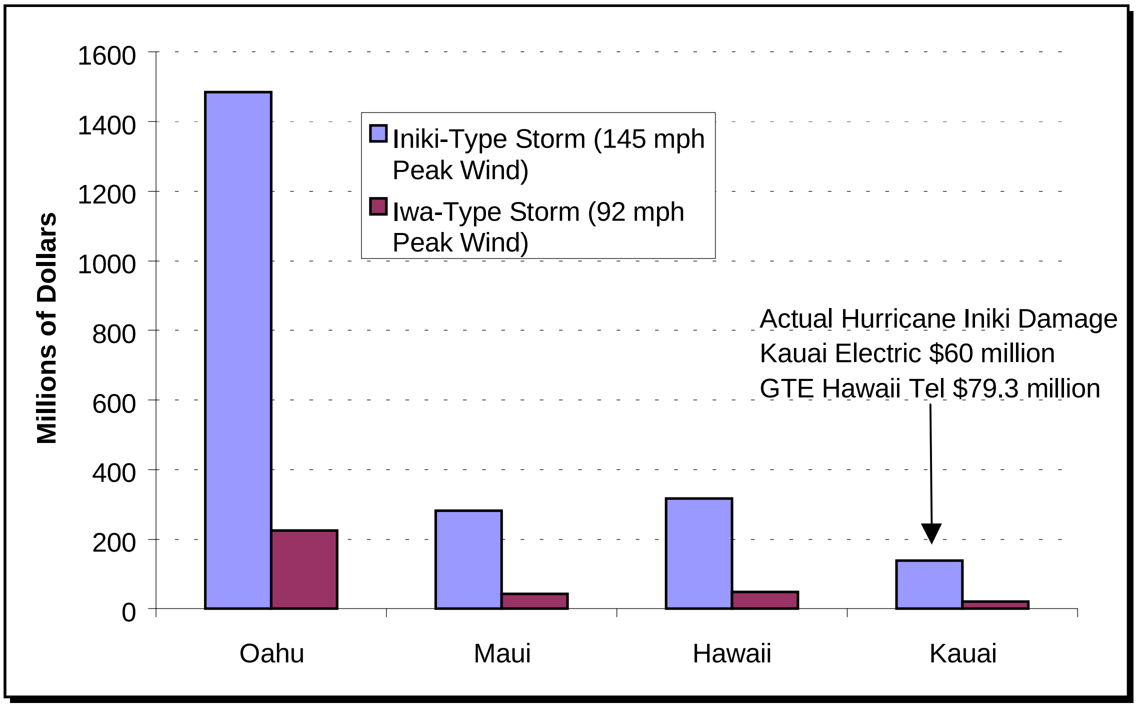

Figure 12.1 Potential Hawaii Hurricane Damage Costs

12.2.2.1 Phase 1 Emergency Generator Survey

The Phase I Emergency Generator Survey will survey emergency and essential service facilities to document the technical specifications of their emergency generators and electricity requirements. A database of the survey information will be produced for the PDC emergency management/geographic information system. Also, the project will advise operators on operation and maintenance measures for improved emergency generator reliability. The State began work on the project in November 1999.

12.2.2.2 Phase 2, Assessment of Facilities Requiring Emergency Generator Support

The Phase 2 assessment will identify the needs of emergency and essential service facilities that will require an emergency generator. Emergency and essential service facilities provide critical public services for the maintenance of the public's safety, health, and welfare. The project will supplement the database developed in Phase 1. The project will document the minimum emergency power needs of facilities, which will enable generators to be allocated effectively in response to an emergency. The data will also be incorporated into the PDC emergency management information system.

12.2.3 Young Brothers Hazard Mitigation Project

To assist interisland barge company Young Brothers in hardening facilities critical to its operations, DBEDT is helping the company to procure two new 275kW diesel emergency generators. The generators will be used to sustain refrigeration container operations and were purchased through the Hazard Mitigation Grant Program. FEMA and Young Brothers will share the $160,000.00 projected cost.

12.3 Energy Emergency Management

The State of Hawaii's Emergency Response Plan is based upon the Federal Response Plan. The Federal Response Plan assigns emergency support function (ESF) responsibilities to specific Federal agencies. SCD, in similar fashion, has provided for State counterpart ESFs. For ESF-12, Energy, USDOE and DBEDT are responsible for coordinating restoration of energy and fuel systems.

12.3.1 The Energy Council

The prototype of the EC organization and process as we know it today was first used by industry and government to coordinate Kauai Electric’s safe restoration of the grid after Hurricane Iniki. The organization, then called the “Power Council,” facilitated restoration of the system as rapidly as was possible. Its members also coordinated the deployment of temporary emergency generators. The responsibilities of the Energy Council have since been expanded, and the group reorganized, to address the availability and adequacy of fuel supplies, storage, and distribution.

The State continues to work with the EC to improve disaster-related planning and response. The EC's mission is to support the implementation of emergency Support Function -12 (ESF-12) Energy, consistent with the State's *Administrative Plan for State and Federal Coordination, enclosure 7 to Volume III, The State Plan for Emergency Preparedness*. The primary responsibility of the EC 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.

For the past three years, the Energy Council has been effectively exercised in the SCD's annual statewide hurricane exercise. Represented on the EC are Hawaii’s private sector energy companies, and representatives from supporting agencies within County, State, and Federal governments. The Director of DBEDT, or his designee, chairs the EC and reports directly to the Director of Civil Defense, or his designee. The structure and membership of the State of Hawaii EC are depicted in the following figure:

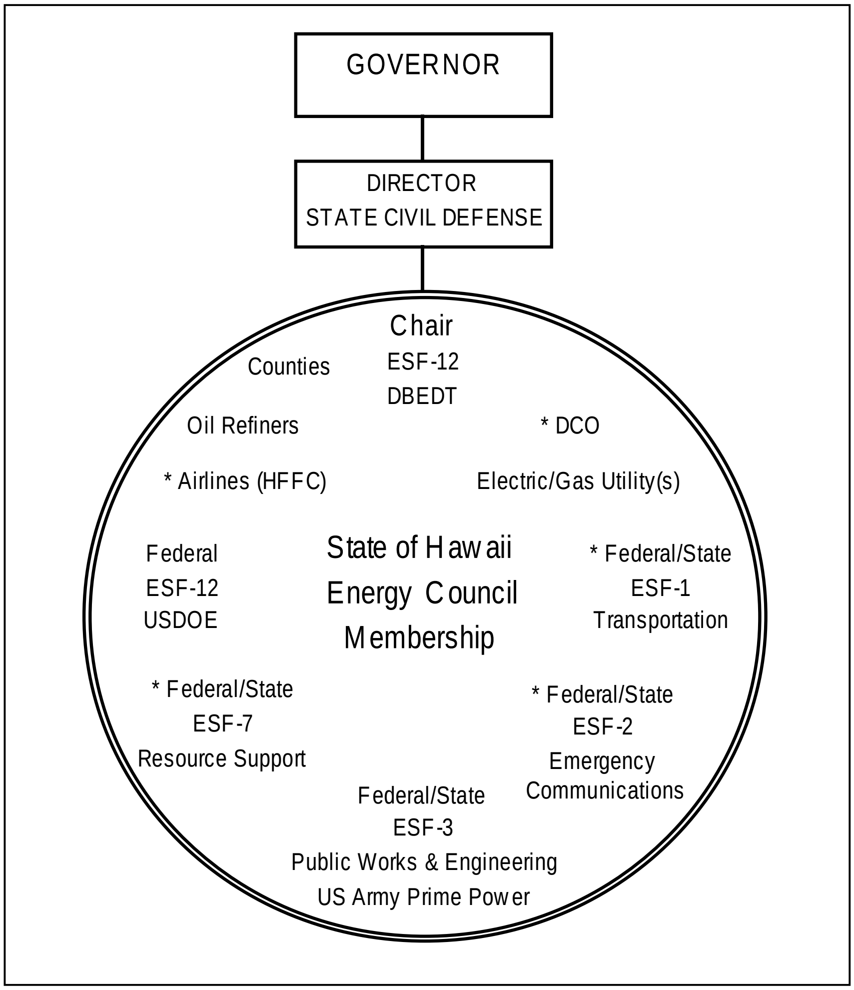

Figure 12.2 State of Hawaii Energy Council Structure and Membership*

12.3.2 Y2K and the Energy Council

Over the last two years, the EC has coordinated dialogue among members to facilitate collaboration on Y2K issues from a comprehensive, statewide, total-energy-system perspective. Energy-related Y2K readiness activities conducted by the EC have included the following:

- Coordination of ESF-12 (Energy) functions related to Y2K;
- Assistance with energy-related Y2K public information activities;
- Collaboration with the energy industry on official briefings;

*Note: Asterisk indicates EC Members that attend daily EC meetings at the Chair's request only when direct coordination and support are anticipated to be required for EC mission accomplishment.

- Development of U.S.-Hawaii Y2K Energy System Readiness Summary (updates July, September, November, and as needed thereafter);
- Participation in Hawaiian Electric Company Y2K exercise, September 1999; and
- Coordination of standby readiness of State of Hawaii Energy Office and EC points of contact over theY2K transition period (12/31/99 and 1/1/00, and as needed thereafter).

The EC meets quarterly, or more frequently, as required, to discuss energy issues, such as the current focus on Y2K compliance.

12.3.3 Makani Pahili 99 Energy Council Exercise

The EC, in coordination with SCD, developed and conducted an energy emergency exercise on May 5, 1999, as part of "Makani Pahili 99," SCD's annual hurricane exercise. The energy exercise focused on the energy-sector aspects of the simulated disaster and on exercising the EC process previously developed in hurricane exercises in 1997 and 1998. The objectives of this year's energy-emergency exercise were as follows:

- To simulate agency activation, disaster management, standard operating procedures, and interaction with an EC;
- To coordinate between industry and other agencies, for effective implementation of EEP response and recovery within the context of a large disaster; and
- To identify energy emergency-related issues for further consideration and resolution; and
- To provide additional testing of the ability of the PDC situation reporting system to coordinate energy system restoration and recovery.

12.3.4 State and County EEP Plan Revision

The State and Counties are continuing efforts to implement the provisions of Act 182, 1992, which called for them to develop integrated and coordinated EEP plans. In 1998, Kauai County administratively approved its EEP plans and formed a County-level Energy Council. Meanwhile, EEP plans drafted for Hawaii County are under discussion and review. Maui County and the City and County of Honolulu EEP plans meanwhile are under development. State EEP plans related to this project have been updated.

12.4 Recommendations for Further Actions

The following recommendations are made to enhance Hawaii's energy emergency preparedness.

12.4.1 RECOMMENDATION: Continue to Support the Readiness of Hawaii's Energy Council and Its Application to Other Jurisdictions

Suggested Lead Organization: DBEDT

The EC meets quarterly, as well as on other occasions, to conduct exercises and to coordinate on issues, such as Y2K. The EC approach used during the May 1998 *Regional Energy Emergency Seminar and Simulation Exercise*, was shared with the Western states and Pacific Island Territories. The EC also shared this approach with FEMA in a Regional Inter-agency Steering Committee meeting held in August 1999.

12.4.2 RECOMMENDATION: Continue to Work with USDOE to Provide for Appropriate Procedures for Rule Making and the Exercise of Hawaii's SPR Priority Access Sales Provisions

Suggested Lead Organizations: DBEDT and USDOE

The State has signed a Memorandum of Understanding with USDOE to implement Hawaii's ability to obtain access to SPR oil during an SPR drawdown and sale. Also, in a preliminary discussion, the State and USDOE considered Hawaii participation in a future SPR exercise.

12.4.3 Continue to Regularly Exercise Government and Industry EEP Plans; Emphasize Preparedness on the Local (First Responder) Level

Suggested Lead Organizations: DBEDT, SCD, the Counties, and industry participants

12.4.4 Complete Emergency Generator Inventories and Database Documentation of Emergency and Essential Service Facilities

Suggested Lead Organizations: DBEDT, State Civil Defense, Counties, and Industry Participants

Phase I initiation of the emergency generator survey will focus on documenting the technical specifications of existing emergency generators in emergency and essential-service facilities. Phase II of this project will document emergency generator needs at emergency and essential-service facilities that do not currently have emergency generators but which require emergency backup.

12.4.5 RECOMMENDATION: Complete the Young Brothers' Emergency Generator Hazard Mitigation Project

Suggested Lead Organizations: DBEDT, State Civil Defense, and Young Brothers, Inc.

Agreements are being reviewed for execution by SCD, DBEDT, and Young Brothers the state's only interisland carrier, to acquire two 275 kW diesel generators as emergency backup power. The generators would meet all shore-based power needs for refrigeration of cargo. When the project is complete, Young Brothers will be able to sustain critical barge shipping operations in ports throughout the islands.

12.4.6 RECOMMENDATION: Continue Progress in Hazard Mitigation to Reduce Hawaii's Energy System Vulnerability

Suggested Lead Organization: DBEDT

Measures for enhancing EEP contingency planning cited in the 1995 HES report, and progress to date in implementing the recommended measures are documented in Appendix D. The State will continue to monitor and periodically report on efforts towards reducing the vulnerability of Hawaii's energy system.

12.4.7 RECOMMENDATION: Develop an ESF-12 Concept of Operations for Activating DBEDT Staff During a Disaster or Market Shortage

Suggested Lead Organization: DBEDT and the Energy Council

This work will include identification and establishment of an alternative meeting place for EC use during an emergency. The facility would require backup emergency power and communications would need to be large enough for contingency use as a Shortage Management Center. DBEDT and the Energy Council will also assess alternative PV power, mobile satellite communication, and mobile trailer options for use if commercial power to ESF-12 offices is lost.

12.4.8 Continue to Work with the Counties to Complete Administratively Approved County EEP Plans

Suggested Lead Organization: Hawaii, Honolulu, and Maui Counties

Chapter 125C-32, *Procurement, Control, Distribution and Sale of Petroleum Products*, Hawaii Revised Statutes (Act 182, 1992), requires the development of County EEP plans that are integrated and coordinated with the State's EEP plan. Kauai County already has an administratively approved County EEP plan.

CHAPTER 13 SCENARIOS FOR HAWAII'S ENERGY FUTURE

13.1 Overview

Chapter 13 reports on the results of a number of scenario runs conducted to examine ways to improve Hawaii's energy future. The scenarios incorporated actions to increase the efficiency of Hawaii's energy system and to reduce the use of fossil fuels consistent with the other objectives of *HES 2000*. Some of the scenarios were originally designed to evaluate ways to reduce Hawaii's greenhouse gas emissions for the *Hawaii Climate Change Action Plan*. The scenarios discussed in this chapter are compared on the basis of reductions in CO_2 emissions from energy used in Hawaii and for domestic air and marine transportation. The CO_2 emission reductions primarily represent fossil-fuel energy savings, a principal objective of *HES 2000*.

The scenarios were run on the ENERGY 2020 model of Hawaii's energy system. ENERGY 2020 is linked to the Regional Economic Models, Inc. (REMI) model of the economies of each of Hawaii's counties. The REMI model was calibrated to conform to the DBEDT Research and Economic Analysis Division's *Population and Economic Projections for the State of Hawaii to 2020 (DBEDT 2020 Series)*. Additional information about the ENERGY 2020 model is provided in Appendix C of this report.

The scenarios were compared to a Base Scenario designed, to the extent possible, to replicate the current Hawaii energy system and known plans for additions through the year 2000. The continued use of existing technologies was assumed and their costs were based upon utility Integrated Resource Plans (IRP plans).

There are several important differences in the scenario runs in *HES 2000* when compared with those conducted in late 1998 for the *Hawaii Climate Change Action Plan*. The *HES 2000* runs used updated Base Scenario input, including the following:

- HELCO's amended IRP;
- MECO's preliminary least-cost IRP plan;
- Updated oil price estimates based on the U.S. Energy Information Administration's *Annual Energy Outlook 1999* (EIA 1998a) for long-term prices and the Second Quarter Short-Term Energy Outlook (EIA 1999c) for near-term prices;
- Renewable energy cost and performance projections from the most recent HECO, HELCO, and MECO IRPs; and
- KE renewable energy cost and performance projections based on nominally equivalent HELCO projects.

Any model must incorporate simplifications, but such simplifications do not negate its utility. The trends and patterns forecast by the model can be used to examine a variety of possible futures. By applying policy or scenario alternatives, the estimated effects of options can be compared against the Base Scenario to estimate their effectiveness. The model also yields estimates of economic effects that help in the evaluation of the costs or benefits of alternative measures. Scenarios that offer desirable outcomes warrant more detailed study and analysis by those organizations able to carry out the recommendations.

13.2 Electricity Scenarios

For *HES 2000*, three scenarios were modeled that were designed to increase renewable energy use and reduce future fossil-fuel energy use and greenhouse gas emissions.

The scenarios generally call for more use of wind than the HECO wind penetration analyses indicate may be used on the three HECO companies' systems. However, very large percentages of the capacity of other island systems are provided by wind. In addition, the wind systems used in these scenarios are additive to fossil-fuel generation and offer fuel savings, but do not provide firm capacity. The results of the modeling show the potential value of these installations and indicate that utilities should carefully analyze potential individual projects.

13.2.1 Base Scenario

The Base Scenario is the current planned Hawaii energy system. The generation units used in this scenario included current operating units and those identified for operation through the year 2020 in utility IRP plans (see Chapter 7). It was also assumed that utility DSM plans, described in Chapter 11, would be implemented for 20 years. The energy-demand reduction effects of all Federal appliance standards and the Hawaii Model Energy Code were also included.

Ground transportation efficiency was based upon observed Hawaii ground transportation fuel efficiency rather than federal CAFE standards (see discussion in Chapter 4). Air transportation was assumed to improve in efficiency at an average 0.7% per year, based upon USDOE base case forecasts. Marine fuel use was assumed to grow at a rate similar to population growth.

13.2.2 E2 – 20% Renewable Energy Scenario

The 20% Renewable Energy Scenario, E2, depicted on Table A.42, in Appendix A, was designed to reflect deployment of renewable energy systems totaling about 20% of all new generation added statewide during the 2000–2020 period. The additional renewables are presented in boldface on Table A.42. The renewable energy resources considered were selected from projects known to be under contract or under negotiation as of late 1999 and recommendations of *HES 1995*. Intermittent resources were added to the utility plans and were not assumed to displace fossil-fuel generation, but to reduce the use of fossil fuels.

13.2.3 E-3 – 10% Renewable Energy Scenario

The 10% Renewable Energy Scenario, E3, depicted on Table A.43 was designed to reflect deployment of renewable energy systems totaling about 10% of all new generation added during the 2000–2020 period. The additional renewables are presented in boldface on Table A.42. The renewable energy resources considered were selected from projects known to be under contract or under negotiation as of late 1999 and recommendations of *HES 1995*. Intermittent resources were added to the utility plans and were not assumed to displace fossil fuel generation, but to reduce fossil fuel use.

13.2.4 Results of the Electricity Scenario Runs

Figure 13.1 shows the CO_2 emissions estimated by the ENERGY 2020 model for the period 1990–2020. None of the three scenarios reduced greenhouse gas

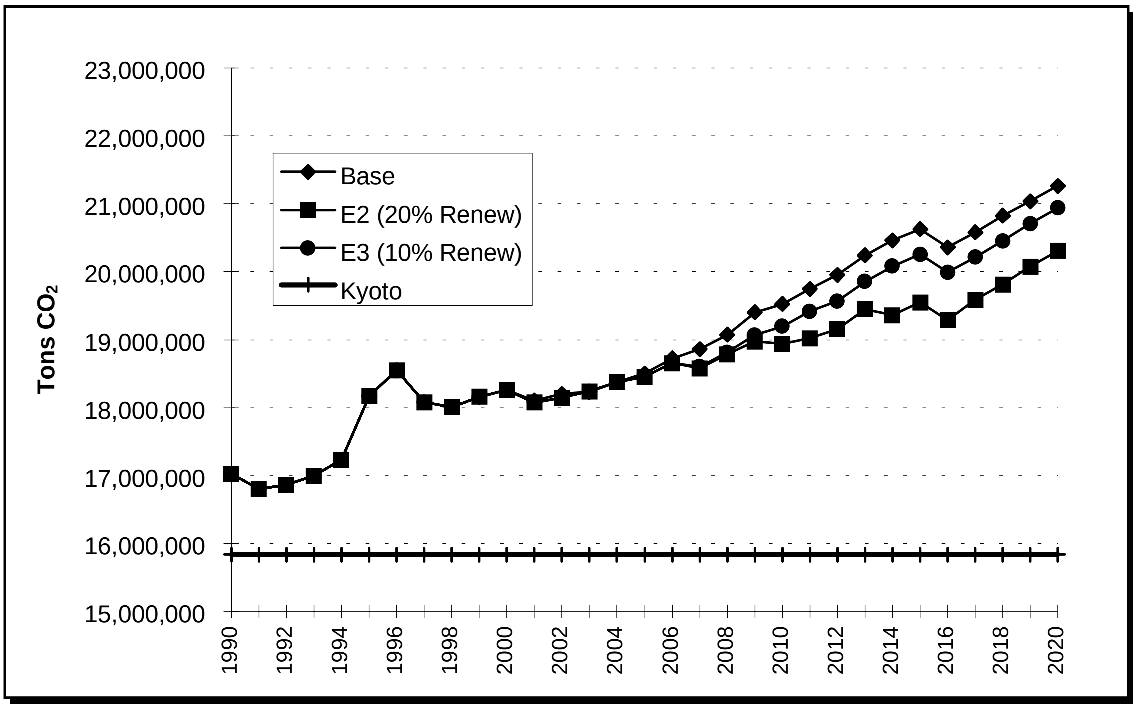

Figure 13.1 Estimated Hawaii CO2 Emissions under Electricity Sector Scenarios, 1990–2020

emissions below the Kyoto target of 7% less than 1990 levels. By 2010, under the Base Scenario, forecast CO_2 emissions were about 3.7 million tons, or 23.3%, above the Kyoto target. The 20% Renewable Scenario offered the greatest reduction of CO_2 but was still estimated to be 1.2 million tons, or 19.6%, above the 2010 target.

It should be kept in mind that these scenarios are presented only for analysis of the effectiveness of various strategies in reducing electricity sector CO_2 emissions. Any decision for actual construction of the projects modeled in the scenarios would require extensive further analysis, including evaluation of updated cost information, the technical feasibility of integrating the particular systems into the electricity system, site availability, and the likelihood of obtaining necessary permits.

13.3 Transportation Energy Scenarios

Transportation energy use was responsible for the largest percentage of Hawaii's CO_2 emissions from domestic energy use. The scenarios were designed to examine potential ways of reducing transportation emissions.

13.3.1 Baseline Scenario

The Baseline Scenario for the transportation scenarios was the same one as used in the electricity sector analysis above. (See Section 13.2.1.)

13.3.2 T2 – 10% Ethanol Blend Gasoline Scenario

Under the T2 Scenario, the use of a blend of 10% ethanol and 90% gasoline in Hawaii was projected to begin in 2000. It was assumed that the ethanol would be produced in Hawaii. Although the model depicted reaching the 10% ethanol level in the first year, in practice, it could take somewhat longer. Nevertheless, it was expected that the full 10% level would be reached before 2010. The T2 Scenario would be possible to implement without major modifications to vehicles or to the gasoline distribution and retailing system.

13.3.3 T3 – 10% Increase in New Vehicle Efficiency Scenario

The T3 Scenario assumed that Hawaii's citizens bought new vehicles 10% more efficient than 1998 purchases beginning in 2001. Such a change in purchase patterns could be initiated through a number of possible means, as discussed in Chapter 4.

13.3.4 T4 – 100% Increase in New Vehicle Efficiency Scenario

Transportation 4 Scenario assumed that Hawaii's citizens bought new vehicles 100% more efficient than 1998 purchases beginning in 2006. Such a change in purchase patterns could be initiated through a number of possible means. The essential factor would be the availability of highly efficient automobiles now in the research and development phase. The Transportation 4 Scenario could be achieved through the use of a combination of highly efficient conventional, hybrid, alternative fuel, and fuel-cell vehicles; and measures to reduce the demand for transportation.

13.3.5 A2 – Aircraft Efficiency Improvements Scenario

The Base Scenario assumed that civilian aircraft efficiency would improve at an average annual rate of 0.7% per year – the nominal estimate of the U.S. Department of Energy. The Department of Energy also estimated that efficiency could improve at a rate of up to 2.5% per year. Scenario A2 modeled such improvements beginning in 1998 and represents a nominal technical potential.

13.3.6 Results of the Transportation Energy Scenario Runs

Figure 13.2 depicts estimated CO_2 emissions for 1990 to 2020 under the transportation scenarios. As with the electricity sector, no single transportation sector scenario reduced CO_2 emissions to the target level.

Scenario T4, the availability and use of increasing numbers of new, highly efficient vehicles beginning in 2006, produced the greatest emissions savings. Yet, overall emissions were 2.23 million tons, or 14.1% greater than the 2010 target. Greater civil aircraft efficiency (Scenario A2) yielded the second greatest savings, but resulted in CO_2 emissions 2.95 million tons, or 18.7%, greater than the Kyoto target in 2010. Scenario T2, 10% ethanol fuel reduced emissions by 3.04 million tons or 19.2% by 2010. Under Scenario T3, 10% increase in fuel efficiency beginning in 2001, emissions were 3.34 million tons, or 21.2% greater than the target.

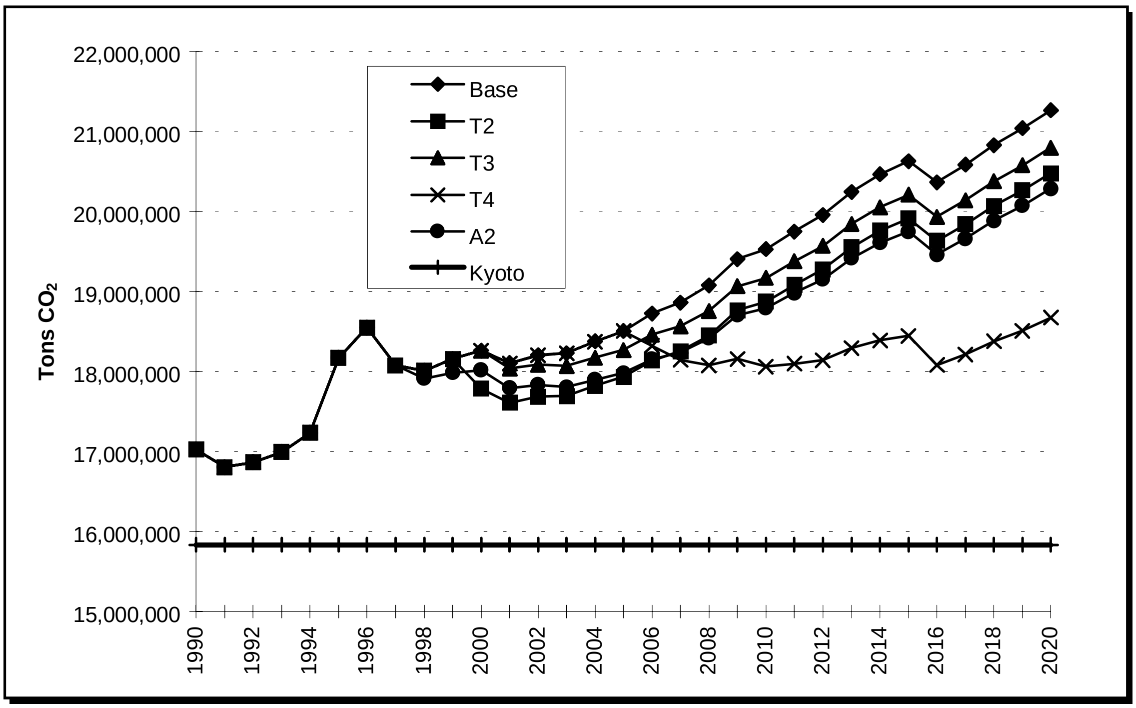

Figure 13.2 Estimated Hawaii CO_2 Emissions under Transportation Sector Scenarios, 1990–2020

13.4 Carbon Tax Scenarios

Carbon taxes, based upon the carbon content of fossil fuels, have been discussed as a way of internalizing the environmental costs of fossil fuel use. They would increase the cost of fuels, thus discouraging their use. In the ENERGY 2020 model, it was assumed that the taxes were a cost to Hawaii's economy. Alternatively, a carbon tax could be used instead to offset other taxes, which would likely reduce the negative consequences of carbon taxes while still tending to reduce fuel use.

It is not clear whether the fuel use reduction would differ depending upon the ultimate payee of the tax and any offsetting deductions from other taxes. These considerations, in addition to the likelihood that the negative economic consequences might be especially harsh for Hawaii, should be explored in detail before such a tax is considered or enacted. Two carbon tax scenarios were examined. They were applied to all fossil fuels and were implemented in 2005. They were as follows:

- **CT1 –** $50 per ton; and
- **CT2 –** $125 per ton.

Figure 13.3 shows the results compared to the Base Scenario, E1.

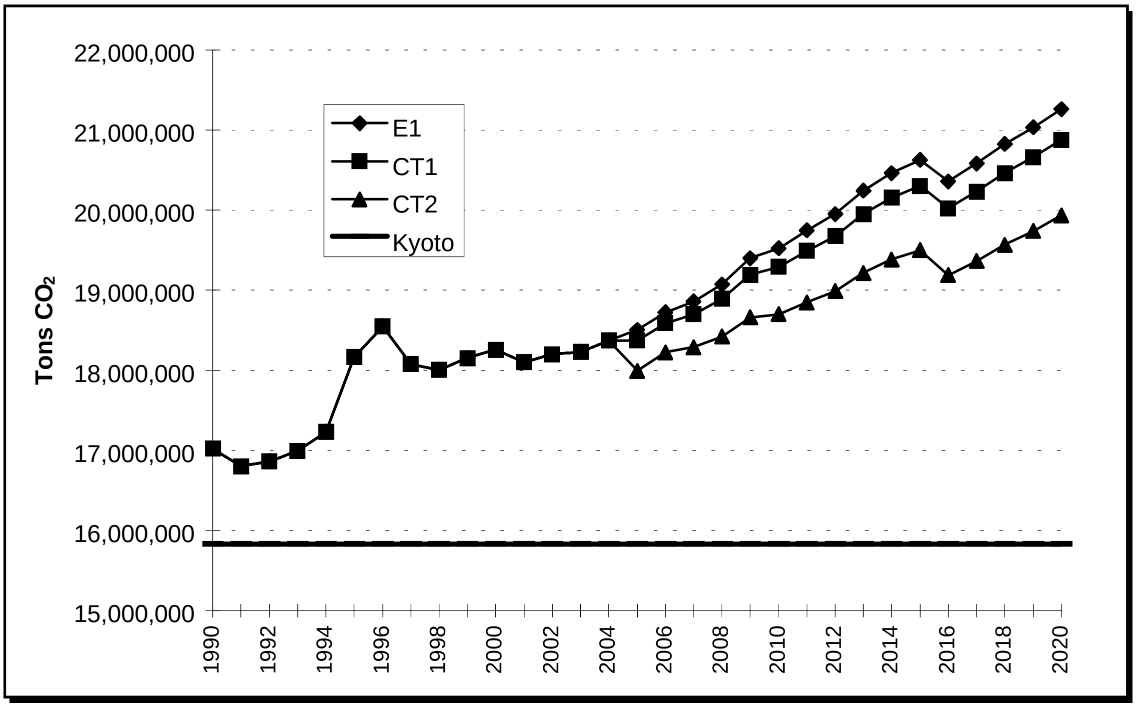

Figure 13.3 Estimated Hawaii CO_2 Emissions under Carbon Tax Scenarios, 1990 – 2020

With CT1, the $50 per ton carbon tax, the model predicted that CO_2 emissions would be 3.46 million tons in 2010, or 21.9% above the Kyoto target. The $125 per ton carbon tax modeled in CT2 still resulted in CO_2 emissions of 2.67 million tons, or 18.1% greater than the target.

Table 13.1, on the following page, shows the additional costs per million Btu and measure of quantity estimated for each level of carbon tax on the fossil fuels used in Hawaii. As expected, the carbon taxes as modeled in Scenarios CT1 ($50 per ton) and CT2 ($125 per ton) reduced energy use and consequent CO_2 emissions.

Table 13.1 Additional Costs of Carbon Taxes by Fuel				
	CT1 – \$50/Ton C		CT2 – \$125/Ton C	
Liquid Fuels	**Cost/10^6 Btu**	**Cost/Gallon**	**Cost/10^6 Btu**	**Cost/Gallon**
Avgas	\$ 1.04	\$ 0.12	\$ 2.60	\$ 0.31
Distillate	\$ 1.10	\$ 0.15	\$ 2.75	\$ 0.38
Gasoline	\$ 1.07	\$ 0.13	\$ 2.68	\$ 0.33
Jet Fuel	\$ 1.09	\$ 0.15	\$ 2.72	\$ 0.38
LPG	\$ 0.95	\$ 0.09	\$ 2.36	\$ 0.23
Residual	\$ 1.19	\$ 0.18	\$ 2.96	\$ 0.44
Solid Fuel	**Cost/10^6 Btu**	**Cost/Ton**	**Cost/10^6 Btu**	**Cost/Ton**
Coal	\$ 1.40	\$ 0.75	\$ 3.50	\$ 1.88
Gaseous Fuel	**Cost/10^6 Btu**		**Cost/10^6 Btu**	
SNG	\$ 0.80		\$ 1.99	

13.5 Combination Scenario Runs

In developing the Combination Scenarios, the individual scenarios discussed above were ranked in order of year 2010 CO_2 savings, as shown on Table 13.2. Table 13.2 shows CO_2 savings compared to the Kyoto target and the percentage by which the emissions under each scenario exceeded the Kyoto target for 2010 and 2020.

Table 13.2 Estimated CO_2 Savings in 2010, 2020, and 2000–2020 by Scenario Compared with Kyoto Target

2010 Rank	Scenario	2010 CO_2 Savings	Above Kyoto	2020 Rank	2020 CO_2 Savings	Above Kyoto
1	GT4 – 100% Vehicle Efficiency Improvement	1,465,366	14.1%	**1**	2,594,113	17.9%
2	CT2 – \$125/Ton Carbon Tax	823,656	18.1%	**2**	1,327,828	25.9%
3	A2 – Improved Aircraft Efficiency	735,281	18.7%	**3**	982,555	28.1%
4	GT2 – 10% Ethanol Gasoline	654,434	19.2%	**5**	787,124	29.3%
5	E2 – 20% Renewable Energy	590,867	19.6%	**4**	957,146	28.3%
6	GT3 – 10% Vehicle Efficiency Improvement	358,071	21.1%	**6**	468,378	31.4%
7	E3 – 10% Renewable Energy	330,490	21.2%	**8**	323,259	32.3%
8	CT1 – \$50 per Ton Carbon Tax	232,687	21.9%	**7**	382,982	31.9%
9	Base – Utility IRP and DSM	–	23.3%	**9**	–	34.3%

13.5.1 The Combination Scenarios

Three Combination Scenarios were created to group the scenarios that offered the greatest potential CO_2 reductions, to further explore some of the options available to policy-makers, including their effectiveness in reducing greenhouse gas emissions.

C1 – Maximum Reduction Scenario with Maximum Carbon Tax. Scenario C1 combined the electricity scenario with the greatest CO_2 reductions, E2 – 20% Renewable Energy, with four of the transportation scenarios. These included the following:

A2 – Aircraft Efficiency Improvements;

T2 – 10% Ethanol-based Gasoline; and

T4 – 100% Increase in New Vehicle Efficiency.

The maximum carbon tax scenario, CT-2, modeled at $125 per ton of CO_2 was also included.

C2 – Maximum Reduction Scenario without Carbon Tax. This scenario included all of the elements of C1 without the $125 per ton carbon tax (CT-2).

C3 – Hawaii-based Reductions Scenario. C3 was intended to examine the emission reductions under the control of various entities in Hawaii. The scenario also incorporated the E2 – 20% Renewable Energy electricity scenario, and in the transportation sector, T2 – 10% Ethanol-based Gasoline, and T3 – 10% Increase in New Vehicle Efficiency in 2001.

13.5.2 Results of the Combination Scenario Runs

Figure 13.4 and Table 13.3 depict the results of the three Combination Scenarios compared with the Base Scenario and the Kyoto target. The C1 Scenario, Maximum Reduction Scenario with Carbon Tax, reduced CO_2 emissions below the Kyoto target by 2009, and they remained there through 2020. The C2 Scenario, Maximum Reduction Scenario without Carbon Tax, achieved the next greatest estimated CO_2 emissions reduction, reaching a level only 3% above the Kyoto target in 2010, dipping below the target in 2016, and ending 2% above the target in 2020 The reader is reminded that these results depend upon expected advances in transportation technology that may not occur exactly as estimated. The C1 and C2 Scenarios also assume adoption of these technologies by Hawaii's people, businesses, and institutions. As Figure 13.4 shows, under both Scenarios, emissions growth began to overcome the improvements in efficiency and use of renewable energy about 2016, suggesting that additional measures will be required at that time to achieve further reductions.

C3, the Hawaii-based Reductions Scenario, brought emissions down to within 15% of the Kyoto target by 2010, an 8% improvement over the Base Scenario. By 2020, emissions increased to 19% above the Kyoto Target, a 10% improvement over the Base Scenario.

Under the C3 Scenario, as depicted on Figure 13.4, although the Combination Scenarios reduced CO_2 emissions significantly, energy use grew more rapidly, causing emissions to continue to rise.

13.6 Comparison of Estimated Economic Effects of Scenarios and Recommendations

13.6.1 Estimated Effects on GSP and Personal Income

Figure 13.5 shows the effects of each of the scenarios on Hawaii's estimated Gross State Product (GSP) and personal income over the period 2000–2020. The negative potential effect of carbon taxes on Hawaii's economy is shown by the results of CT1 and CT2, and Combined Scenario C1. CT2 was estimated to reduce GSP compared to the Base Scenario by $4.6 billion and over the years 2000–2020. This would be 0.55% of total GRP over that period.

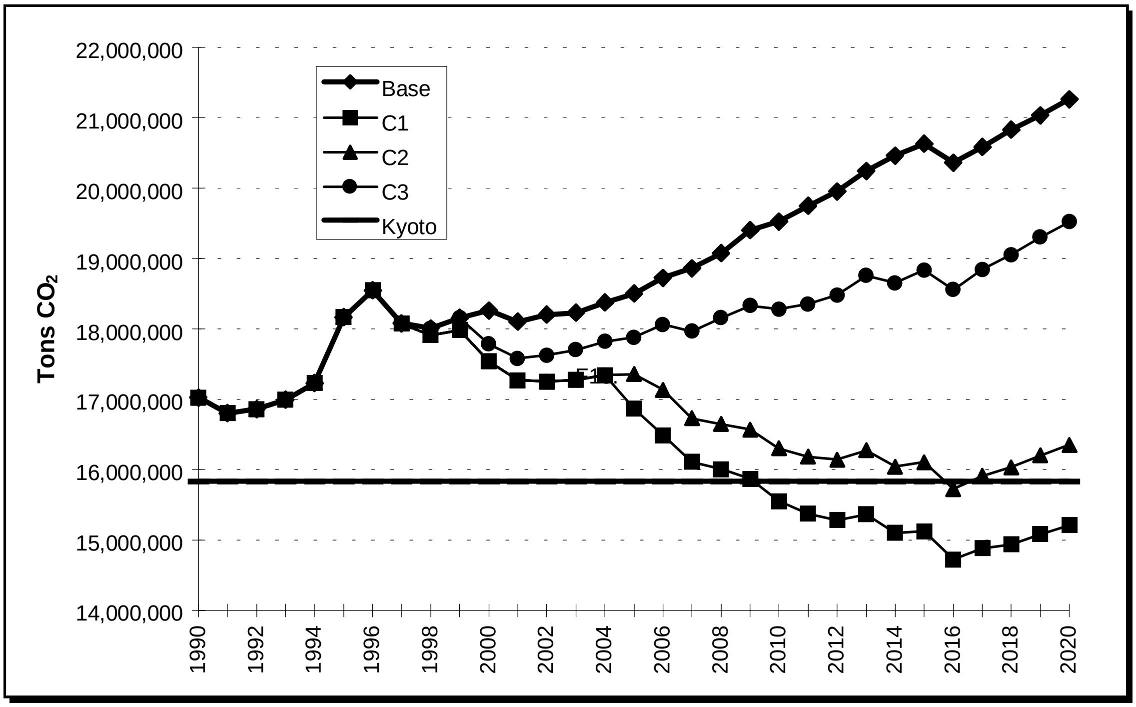

Figure 13.4 Estimated Hawaii CO_2 Emissions under Combination Scenarios, 1990–2020

Table 13.3 Comparison of Combination Scenario CO_2 Savings in Tons of CO_2

Rank	Scenario	2010 CO_2 Savings	% of Kyoto Target	2020 CO_2 Savings	% of Kyoto Target	2000–2020 CO_2 Savings	% of Kyoto Target
1	C1 – Maximum Reduction With Carbon Tax	3,975,836	98%	6,056,272	96%	79,716,821	96%
2	C2 – Maximum Reduction	3,227,055	103%	4,915,761	103%	65,233,163	102%
3	C3 – Hawaii-based Reductions	1,247,184	115%	1,742,424	123%	26,089,419	119%
4	Base – Utility IRP and DSM	–	123%	–	134%	–	129%

13.6.2 Estimated Effects on Employment

As seen in Figure 13.6 and Table 13.4, the effects of the scenarios on employment mirror those of their effect on GSP. The scenarios that included a carbon tax had the greatest detrimental effect on overall employment. Over the years 2000–2020, CT2 reduced employment by 75,123 job-years, or 0.54% (note that the decimal point was misplaced in a similar analysis in the *Hawaii Climate Change Action Plan*. CT1 reduced jobs by about 13,735 job years, or 0.1%. While these numbers are significant in human terms, they would occur over the 21-year period, which would mitigate their effect somewhat. The data do support the argument that a carbon tax should not be considered for Hawaii due to its probable negative economic effects.

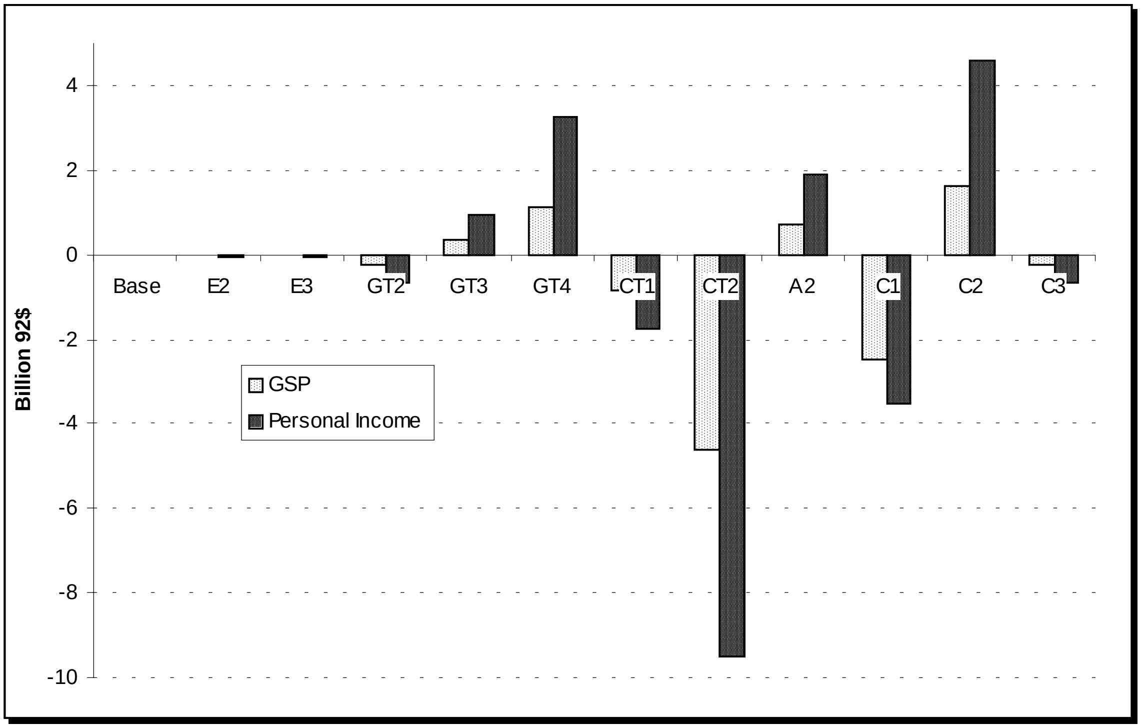

Figure 13.5 Estimated Effects of Scenarios on GSP and Personal Income in Hawaii, 2000–2020

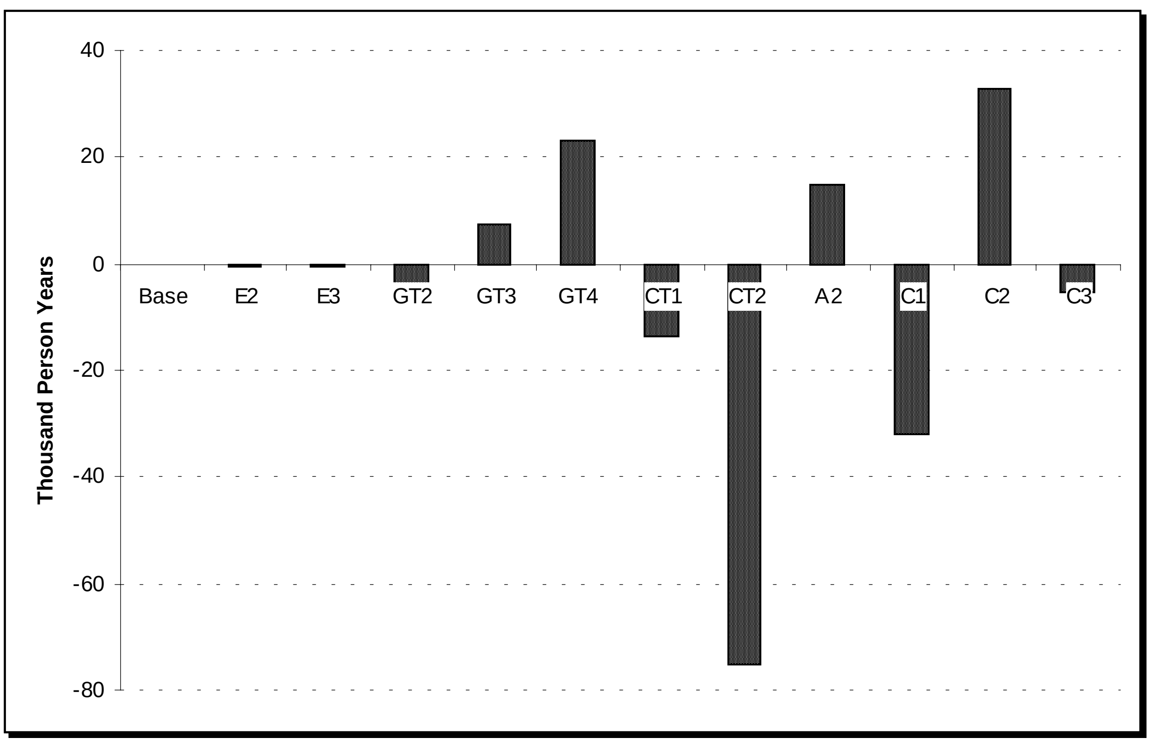

Figure 13.6 Estimated Effects of Scenarios on Employment in Hawaii, 2000–2020

On the positive side, Scenario C2 increased employment by 32,818 job years (0.24%), followed by GT4 at 23,229 job years (0.17%). In all, only four scenarios produced estimated increases in employment.

13.6.3 Summary of Scenario Results

Table 13.4 ranks the scenarios by their estimated CO_2 savings in 2010 and their benefit or cost compared to the Base Scenario GSP, Personal Income, and Employment for the period 2000–2020.

Table 13.4 Scenario Rankings by Estimated CO_2 Savings in 2010, and by GSP, Personal Income, and Employment, 2000–2020

		2010	Effects on Economy 2000–2020					
CO_2	Scenario	CO_2 Savings	GSP (92$)		Personal Income (92$)		Job Years	
Rank		(Tons)	Rank	Amount	Rank	Amount	Rank	Number
1	C1 – Max Reduction w/ Tax	3,975,836	**10**	(2,494,800,000)	**10**	$(3,536,200,000)	**7**	(2,495)
2	C2 – Max Reduction w/o Tax	3,227,055	**1**	$ 1,612,300,000	**1**	$ 4,583,000,000	**1**	32,818
3	GT4 – 100% Vehicle Efficiency Improvement	1,465,366	**2**	$ 1,136,000,000	**2**	$ 3,267,400,000	**2**	23,229
4	C3 – Hawaii-based Reductions	1,247,184	**8**	$ (248,800,000)	**7**	$ (641,600,000)	**9**	(5,490)
5	CT2 – $125/Ton Carbon Tax	823,656	**11**	(4,602,600,000)	**11**	$(9,486,200,000)	**11**	(75,123)
6	A2 – Improved Aircraft Efficiency	735,281	**3**	$ 711,100,000	**3**	$ 1,913,900,000	**3**	14,789
7	GT2 – 10% Ethanol Gasoline	654,434	**7**	$ (244,900,000)	**8**	$ (643,900,000)	**8**	(5,385)
8	E2 – 20% Renewable Energy	590,867	**5**	$ (18,900,000)	**5**	$ (52,900,000)	**5**	(470)
9	GT3 – 10% Vehicle Efficiency Improvement	358,071	**4**	$ 341,800,000	**4**	$ 940,200,000	**4**	7,196
10	E3 – 10% Renewable Energy	330,490	**6**	$ (27,400,000)	**6**	$ (69,300,000)	**6**	(580)
11	CT1 – $50 per Ton Carbon Tax	232,687	**9**	(817,600,000)	**9**	$(1,749,600,000)	**10**	(13,735)

Only four scenarios (C2, GT4, A2, and GT3) produced positive economic effects over the 2000–2020 period. Together these confirm the economic benefits of reducing the amount of money spent on imported oil. The next four scenarios, which did not include a carbon tax (E2, E3, GT2, and C3), had relatively small negative effects on GSP. Scenarios C2, CT1, and CT2, which contained a carbon tax had significant negative economic effects.

13.6.4 Scenario-Based Recommendations

The model results suggest that the negative economic effects were most significant in the scenarios with carbon taxes. Based upon the estimated effects of carbon taxes as modeled, however, it is recommended that carbon taxes not be part of efforts to reduce CO_2 emissions. It is possible that these could be imposed at the national level, however. This would add to the cost of fossil fuels and give additional impetus to energy efficiency efforts and the deployment of renewable energy.

13.6.4.1 RECOMMENDATION: Consider Implementing Elements of Scenario C3

Suggested Lead Organizations: DBEDT, Electric Utilities, Non-Utility Generators, and Renewable Energy Developers

Since the policies modeled in Scenario C3 could be implemented at the state level, they are recommended for consideration. Scenario C3 included Scenario E2, Maximize Renewable Energy in the electricity sector and in the ground transportation sector; Scenario GT2, 10% Ethanol-based Gasoline; and Scenario GT3, 10% New Vehicle Efficiency Improvement. GT3 might be implemented through measures that could include fee rebates where higher registration costs on inefficient vehicles are used as incentives to purchase more efficient vehicles. Consumer education could also play an important role in Scenario GT3. Additional recommendations may be found in Chapters 4 and 8.

13.6.4.2 RECOMMENDATION: Support Efforts to Increase the Fuel Efficiency of Aircraft and Ground Vehicles

Suggested Lead Organizations: DBEDT, Airlines, Auto Manufacturers, and the Hawaii Congressional Delegation

It was also clear that, due to the fact that most of Hawaii's energy use is in the form of jet fuel and ground transportation fuels Improvements in fleet efficiency would significantly help reduce energy use CO_2 emissions. As the results of Scenario A2, Aircraft Efficiency Improvements suggest, Hawaii should support aircraft research and development efforts at the national level and encourage airlines serving Hawaii to use their most efficient types of aircraft. The results of the ground transportation scenarios, especially GT4, 100% New Vehicle Efficiency Improvement, suggest that Hawaii should encourage efforts by auto manufacturers to develop and deploy alternative fuel vehicles and high-efficiency vehicles, and to seek federal increases in CAFE standards. Hawaii's citizens should also be made aware of the effects of vehicle use on Hawaii's economy as well as on climate change, and they should be encouraged to purchase fuel-efficient vehicles and to operate them efficiently. Additional recommendations were made in Chapters 4 and 5.

13.6.4.3 RECOMMENDATION: Maximize Renewable Energy and Demand-Side Management in the Electricity Sector

Suggested Lead Organizations: DBEDT, Electric Utilities, Non-Utility Generators, and Renewable Energy Developers

Hawaii should continue efforts to maximize the use of renewable energy, and it should conduct research and development and demonstration projects. Hawaii's utility DSM programs should be encouraged and supported with appropriate tax credits. The utilities should evaluate the full range of possible DSM programs in each IRP cycle to ensure that any measure that may become cost-effective in the face of increasing electricity prices is included. Specific recommendations were made in Chapters 8 and 11.

CHAPTER 14 FACILITATING EXPORTS OF SUSTAINABLE TECHNOLOGY TO THE ASIA-PACIFIC REGION

14.1 Hawaii's Strategic Technology Marketing and Development Program

Hawaii's Strategic Technology Market Assessment and Development (STMAD) program is designed to facilitate increased exports of U.S. energy, environmental, and other sustainable technologies and related services into Asia-Pacific markets. STMAD focuses on Asia-Pacific markets due to their high growth history and their potential for future growth. A key objective of STMAD is to facilitate sustainable, technology-related economic development for Hawaii, create higher-value jobs, and diversify the State's economy. Hawaii and U.S. exports include sustainable technology (especially renewable energy); energy efficiency; advanced, high-efficiency fossil-fuel energy; recycling, reuse, and remanufacturing; information technologies; health care; ocean science and technologies; and environmental management, control, protection, and remediation. The energy-related elements of STMAD will help reduce fossil fuel use and will also help to mitigate and reduce greenhouse gas emissions, which contribute to global climate change.

14.1.1 STMAD Partnerships

Partnerships with industry, through business opportunities missions, government-to-government contacts throughout Asia, and the development of business leads through workshops and conferences in Hawaii are the central components of STMAD. STMAD seeks to match commercial applications of sustainable technologies and related services to targeted demand in the Asia-Pacific region.

U.S. federal government agencies and non-governmental organizations (NGOs) such as the National Association of State Energy Officials, Export Council for Energy Efficiency, National Association of Energy Service Companies, Council of State Governments, and others are active partners and participants in program activities. Such governmental facilitation of U.S. technology exports is a key component of the U.S. Department of Energy's (USDOE) Comprehensive National Energy Strategy.

Partnerships with academe, especially between the University of Hawaii (UH) and, for example, the Hawaii Natural Energy Institute (HNEI), are also core components of STMAD. These are aimed at matching commercial applications of sustainable technologies and related services to demand in the Asia-Pacific region.

These organizations and host Asia-Pacific countries are collaboratively conducting several energy and environmental resource and infrastructure market assessments to identify development opportunities. Energy from biomass, for example, has the potential to contribute significantly to the power mix in developing countries in Asia and the Pacific Rim due to their increasing demand for electricity and sizable biomass resources. U.S. energy efficiency technologies and services are other high-growth Asia-Pacific markets.

Because government policies and regulations are most often major drivers of demand for these sustainable energy and environmentally sustainable technologies and related services, policy transfer is an important export. Grant opportunities for such activities, funded by U.S. and Asia-Pacific governments, are growing, and U.S. and Hawaii consultants in these fields can compete for these dollars, which can contribute to our economy.

14.1.2 STMAD Goal, Priorities, and Activities

STMAD has the following major goals, priorities, and activities in these areas:

- **Supply.** Expand and diversify the export activities of Hawaii's existing sustainable technology and related service companies; and as a second priority, attract Mainland technology firms to locate in Hawaii;
- **Demand.** Identify and develop niche markets in strategic technology that Hawaii companies can serve now, or gain the capacity to serve, or that will attract Mainland technology enterprises to Hawaii;
- **Technology Industry Development and Promotional Activities.** Identify, develop and provide activities such as mentioned in 14.1.1, above, to support and partner with targeted industry and public sector audiences;
- **Specific Projects.** Identify, and facilitate development of specific projects to increase exports of U.S. technologies and services from Hawaii;
- **Finance.** Provide financial training, relating specifically to sustainable infrastructure projects, for potential client-country decision-makers; facilitate financing arrangements for specific projects; and
- Market Analyses and Evaluation. Measure, analyze, and report technology-related economic development in Hawaii, with the aim of increasing the efficiency and effectiveness of future STMAD Program activities.

14.1.3 Opportunities in Environmental Technology Exports: Hawaii's Competitive Edge

Unlike straightforward product exports, the business and technical transactions inherent to development of environmental infrastructure in the Asia-Pacific region require strong cross-cultural understanding. Many projects in the areas of environmental engineering and infrastructure development have faltered or failed because of language and cultural impasses – even at the basic technical level.

Hawaii has a strong Asian orientation, and its citizens possess inherent and valuable knowledge of the various Asian cultures. This knowledge could enhance the State of Hawaii's ability to fill the emerging need for individuals who can operate cross-culturally in supporting the delivery of hands-on environmental technologies.

14.2 STMAD's Current Activities

14.2.1 Center for Asia-Pacific Infrastructure Development

The State of Hawaii established the Center for Asia-Pacific Infrastructure Development (CAPID) as part of STMAD to promote exports of U.S. energy, environmental, transportation-related, and other infrastructure technologies and related services to facilitate sustainable economic development throughout the Asia-Pacific region, while helping to diversify and strengthen the American economy. In short, the CAPID will help open foreign markets to American goods and services.

Through its activities, the CAPID has begun assisting Hawaii companies to establish relationships crucial to entering markets in the Asia-Pacific. CAPID provides the structure for foreign-policy makers and infrastructure project planners, developers, and financiers – especially from the Asia-Pacific region – to learn about the latest non-traditional, innovative options for infrastructure project development. This was the purpose of the initial infrastructure project finance seminar, held in December 1997. Eighty-five high-level Chinese officials attended the seminar.

CAPID has sponsored two additional seminars in Hawaii – *Business Opportunities in the Asia-Pacific*, held October 23, 1998, and *1998 Year of the Tiger: Opportunities for Trade and Investment in China*, held January 23, 1998. The seminars helped American firms establish direct lines of communication for the development of infrastructure projects.

14.2.2 Hawaii-Philippines Energy Efficiency Technology and Policy Transfer Project

This Hawaii-Philippines Project on Energy Efficiency and Technology Transfer, conducted under STMAD, has four primary objectives:

- Introduce advanced Hawaii and U.S. energy efficiency technologies and policies to the Philippines;
- Introduce Hawaii and U.S. energy service companies to business development and partnering opportunities in that country;
- Provide policy advisory support on the refinement and enforcement of Philippine energy codes and standards; and
- Provide policy and technical assistance on designing and implementing utility demand-side management (DSM) programs and energy efficiency performance contracting.

The project has involved extensive collaboration among its participants, ensuring that only mutually beneficial and agreed upon activities are pursued. The Council of State Governments (CSG), through its State Environmental Initiative, provided U.S.-Asia Environmental Partnership (USAEP) with funding ($142,000), and have been active partners throughout the project.

The Project was completed on June 30, 1999, and a report, *Energy Efficiency Policy and Technology Transfer: A Hawaii-Philippines Case Study*, describing the project findings, results, and recommendations was published in October 1999.

To achieve the project objectives, three workshops were conducted:

- **February 1–2, 1999: Workshop in Honolulu on Policy and Technology Transfer Opportunities.** Nearly 60 persons attended the workshop in Honolulu, including the Executive Director of the USAEP and several senior officials of the CSG. Private-sector companies from Hawaii were showcased including HEI Power Corporation, Honeywell, and Johnson Controls, Inc. The eleven-person Philippine delegation was led by Undersecretary of Energy Ben-Hur Salcedo, who also met with Lt. Governor Mazie Hirono;
- **February 2–5, 1999: Utility Photovoltaic Group's International Renewable Energy Business Opportunities Workshop.** The Philippine delegation also attended the Workshop in Kona, Hawaii; and
- **May 31 and June 1, 1999: Workshop on Hawaii Energy Technologies and Services.** The workshop, held in Manila, examined Hawaii energy technologies and services available for export. Nearly 100 persons attended, including the Philippine Secretary and Undersecretary of Energy, and the Senior Commercial Officer of the United States Embassy.

The project has proven so successful that the USDOE has approved a grant for an additional $50,000 to expand the work that will continue to assist the Philippines in creating energy efficiency programs. DBEDT's Energy Research & Technology Division (ERTD) and the Philippines DOE have also received a "bridge funding" grant from the Council of State Governments in the amount of $40,000 to initiate the first-ever energy performance contract in the Philippines. ERTD will continue to seek additional support for the following planned actions:

- Improve capacity building through training of Philippines personnel;
- Conduct audits of Philippine facilities for performance-contracted retrofits and implement a performance contracting demonstration project;
- Helping the Philippines government to set an energy efficiency leadership example; and
- Consider and address the impacts of the electricity industry restructuring and deregulation on energy efficiency and renewable energy deployment in the Philippines.

14.2.3 Hawaii-Philippines Biomass-to-Electricity Assessment and Commercial Case Study Project

In partnership with Hawaii's ERTD and the Philippines Department of Energy, the UH-HNEI is conducting a biomass-to-electricity assessment and commercial case study project. The project will conduct a complete inventory of Philippine biomass feedstocks and project the future availability these feedstocks for use as fuel for electricity generation. The project is also developing recommendations for commercial application of the most economic and environmentally responsible energy-conversion technologies to develop these biomass fuels. The database and networking of individuals and companies that stem from this effort will ultimately help to identify opportunities and strategies for Hawaii companies to serve markets in the Philippines for commercial deployment of bio-energy technologies, products, and services.

UH-HNEI is also developing two case studies focusing on power generation at two sugar mills using bagasse – Victorias Milling Company and First Farmers Holding Corporation. If these mills implement the engineering retrofits of their mills to sufficiently increase the efficiency of their facilities, they may significantly increase their power generation and export.

The UH-HNEI and ERTD project team is following up with HEI Power Corporation's Philippine's representative, who has expressed interest in working with First Farmers as the contractor to retrofit this sugar mill according to the UH-HNEI report.

14.2.4 Technical and Market Assessments

14.2.4.1 Hainan Province, China, Energy and Environmental Infrastructure Assessment, March 1997

The State of Hawaii ERTD and HEI Power Corporation conducted this preliminary survey of the energy infrastructure and opportunities for exporting Hawaii technology and services in Hainan Province, People's Republic of China. The study identified business opportunities for Hawaii companies in the areas of coastal resource management, agriculture and ocean research and development, minerals development, and energy resource and technology development, including expansion of power generation facilities, and development of power transmission projects.

14.2.4.2 Assessment of Potential for Biomass Electricity in Philippines, Thailand, Malaysia, and Indonesia

The UH-HNEI and ERTD conducted a broad-based assessment of the potential for electricity production from a variety of bio-residues in these four ASEAN countries. The purpose of the assessment, which has been used by local biomass co-generation developers in their preliminary market analyses, was to provide information on near-term opportunities for supplying more electricity from biomass, a particularly competitive and abundant fuel in Asia.

14.2.4.3 Hawaii's Asia-Pacific Infrastructure Demand Profiles on the World Wide Web

To support infrastructure development, ERTD developed demand profiles for basic infrastructure for all Asia-Pacific countries. The profiles also list business and government contact information for each of the twenty countries profiled. These are available on the Internet at http://www.state.hi.us/dbedt/ert/cp/cp.html.

14.2.5 Business Opportunities and Technical Exchange Missions

14.2.5.1 Business Mission to Hong Kong, May 31–June 4, 1999

DBEDT and the Hong Kong Business Association sponsored this business mission. Meetings with government decision-makers and potential joint venture partners allowed American firms to learn firsthand about infrastructure development and business opportunities

14.2.5.2 Hawaii Trade Mission to Vietnam, May 18–30, 1999

The Vietnamese-American Chamber of Commerce and DBEDT organized this mission to Hanoi, Haiphong, Hue, and Ho Chi Minh City by seven representatives of U.S. firms. On May 21, 1999, the DBEDT Deputy Director signed an agreement with the Vietnam Ministry of Science Technology and Environment to pursue development of a cooperative environmental project. This agreement was the first of its kind between Vietnam and a U.S. State.

14.2.5.3 Trade and Sustainable Energy Technical Exchange Mission to Hainan Province, China, November 13–22, 1998

Sixteen Hawaii delegates went on this mission, which introduced Hawaii companies to business opportunities in Hainan. Over 70 key Chinese government officials and industry leaders participated in an introductory one-day seminar. The *Hainan-Hawaii Cooperation Committee* was formally established by execution of a proclamation by the Deputy Director-General, Hainan Province Department of Foreign affairs, and the DBEDT Deputy Director during a ceremony officiated by Hainan Governor Wang Xiaofeng.

ERTD led a concurrent technical mission to assess commercial renewable energy and energy-efficiency business opportunities for Hawaii companies in Hainan Province. This team included research engineers from the UH-HNEI and the UH Biosystems Engineering Department of the College of Tropical Agricultural and Human Resources. Three business deals involving Hawaii and Chinese partners were consummated during the mission.

14.2.5.4 Thailand Business Opportunities Mission, April 25 – May 4, 1997

Approximately twenty representatives from eighteen companies participated in this mission to Bangkok, Chiang Mai, and Phuket. Molokai Solar, a small, local solar energy company, signed a memorandum of understanding for business development with a Thai company, while in Bangkok.

14.2.6 Other Facilitative Activities

14.2.6.1 State of Hawaii and Malaysian National Energy Strategy Delegation Mini-Workshop, August 27, 1999

The purpose of the workshop was to share and discuss the Malaysian National Energy Strategy Delegation's objectives for its technical visit to the United States and Europe. This delegation had been instructed personally by the Malaysian Prime Minister to develop a comprehensive national energy strategy, and it included a senior representative of the Prime Minister’s Department’s Planning Unit. Hawaii was the first stop on the delegation’s itinerary.

As requested, ERTD, UH-HNEI, and HECO shared their experiences in development of a comprehensive Hawaii Energy Strategy, the State’s international energy policy and technology outreach activities. This was done, in part, through focused discussions offering Hawaii's perspective on renewable energy (solar and biomass in particular); energy efficiency policies and incentives and their relationship to utility demand-side management programs; and energy industry restructuring. The Malaysian Delegation expressed enthusiastic interest in pursuing cooperative energy policy and technology transfer projects with Hawaii.

14.2.6.2 1998 Year of the Tiger: Opportunities for Trade and Investment in China, January 23, 1998

Taking advantage of the Chinese Trade and Investment Delegation visit, this one-day conference showcased closer ties between Hawaii and China. Trade and investment opportunities in China were presented by the Chinese delegation, and local firms shared their prospects for Hawaii firms in China’s tourism market. Approximately 90 people attended this event.

14.2.6.3 Hong Kong Workshop: Infrastructure Projects Worth US$30 Billion Planned, February 5, 1999

This workshop showcased rail, road, housing, commercial, retail, and recreational infrastructure projects scheduled for development in Hong Kong from 1999 to 2004. Approximately 100 people attended this forum sponsored by the Hong Kong Business Association of Hawaii, the Hong Kong Economic and Trade Office in San Francisco, and DBEDT.

14.2.6.4 Business Opportunities in the Asia-Pacific, October 23, 1998

Especially geared towards engineers and architects, this event featured a panel to discuss business opportunities in the Asia-Pacific. Approximately 130 people attended this forum.

14.2.6.5 Regional Energy Emergency Seminar and Exercise, May 6–8, 1998

This exercise and seminar was a component of the State of Hawaii's annual Civil Defense hurricane exercise, *Makani Pahili 98*. To simulate response capability during an energy emergency, regional dialogue between the USDOE, the Federal Emergency Management Agency, other federal agencies, the National Association of State Energy Officials, State and County governments, and private industry was demonstrated on-line through a direct Ethernet connection to the Pacific Disaster Center (located on Maui). The exercise simulated management information and decision-making processes supporting the multiple "Emergency Support Functions" that have been identified in federal and State disaster emergency plans. This exercise increased State and industry preparedness for an energy emergency. High-level Indian military officials, sponsored by the U.S. Department of Defense, also participated in this unique event.

14.2.6.6 December 8–12, 1997, Infrastructure Project Finance Seminar

In 1995, the Director of DBEDT led a small delegation to the People's Republic of China. As a result of this visit, Hawaii firms were able to establish direct business contacts with their Chinese counterparts and to began serious, detailed discussions with them. Due to the interest shown by the Chinese government officials and others in attendance at the State-sponsored investment seminar during this visit, DBEDT organized a seminar in December of 1997 to disseminate information on innovative financing of infrastructure projects. The theme for this seminar was "Hawaii: China's Gateway to America." Approximately eighty-five high-level Chinese infrastructure project planning and development officials, financial and banking officials, judges, and attorneys participated in the meeting.

14.2.6.7 Hawaii Energy, Environmental and Engineering Technology Export Directory

This 60-page directory, in English, Chinese, and Japanese, lists hundreds of Hawaii companies within the sectors named, and is used to promote Hawaii firms throughout the Asia-Pacific. It is in its second printing.

14.3 Specific Recommendations

The following are specific recommendations for the State's activities:

14.3.1 RECOMMENDATION: Continue to Take Advantage of Federal and NGO Support for State Energy and Environmental Technology Export Initiatives

Suggested Lead Organizations: DBEDT, Federal Agencies, and NGOs

Continue to obtain financial and technical support from federal agencies that offer technical and financial assistance to State programs designed to assist businesses increase exports of energy and environmental technologies from the Untied States to Asia. Potential sources include USDOE, USDOC, USAID, and several NGOs, such as the National Association of State Energy Officials, Export Council for Energy Efficiency, National Association of Energy Service Companies, Council of State Governments.

14.3.2 RECOMMENDATION: Continue to Conduct Market Analyses and Evaluations Relevant to the Needs of Hawaii Firms Interested in Technology-based Economic Development

Suggested Lead Organizations: DBEDT

Continue to gather relevant financial information, employment and salary data, current and desired export activities, and other information on Hawaii technology companies, and *most important*, industry recommendations on how state government programs can facilitate their enterprises. This information should be used to make future STMAD Program activities more efficient and effective. The inventory of Hawaii technology companies should be kept up to date. This database includes companies engaged in the areas of energy, ocean, environmental, and other sustainable technologies.

14.3.3 RECOMMENDATION: Continue to Publish The Hawaii Energy, Environmental, and Engineering Export Service Directory

Suggested Lead Organization: DBEDT

To further boost exports of Hawaii's advanced, sustainable technologies and services, DBEDT has published the *Hawaii Energy, Environmental, and Engineering Export Service Directory*. It is in its second printing. The directory promotes and markets Hawaii's technology and service providers to an Asia-Pacific and international readership. The directory lists firms such as traditional energy developers; biomass-to-energy and other alternative energy and energy efficiency technology providers and consultants; all categories of engineering, planning, and environmental technology and service providers. The directory is in English, Chinese, and Japanese, and is accessible on the Internet http://www.state.hi.us/dbedt/ert/heeetsed.html. The cost of this publication was shared with Hawaii companies to leverage funds to the fullest extent possible.

14.3.4 RECOMMENDATION: Continue to Conduct Business and Technical Exchange Missions and Reverse Trade and Technical Missions

Suggested Lead Organizations: DBEDT and Partner Organizations

Business and technical exchange missions and reverse trade and technical missions identify and facilitate development by Hawaii and other U.S. companies of specific technology and related service export opportunities; e.g., energy and environmental infrastructure development projects.

Technical exchange missions will focus on the assessment and matching of Hawaii-based technology, service expertise, and training resources with specific Asia-Pacific markets. Energy and environmental infrastructure assessments should be conducted in partnership with UH, industry, and host countries to identify specific project development opportunities for Hawaii companies and other U.S. businesses.

Reverse missions to Hawaii should be conducted to provide potential customers from abroad with a better understanding of Hawaii-based technology, service expertise, and training capabilities. This should be accomplished through participation by these potential customers in workshops with industry and through visits to commercial project sites in Hawaii.

14.3.5 RECOMMENDATION: Formalize the STMAD Process

Suggested Lead Organization: The Hawaii State Legislature

Establish a State-funded STMAD program in order to ensure its continued success through the development of long-term relationships with the private sector, NGOs, and other public organizations that offer significant leveraging of State funds. Without a long-term commitment of State funds, these relationships and the ability to provide match funds to maintain Hawaii's competitiveness for lucrative grants and partnerships cannot be sustained.

14.3.6 RECOMMENDATION: Actively Advise and Promote Hawaii Energy and Environmental Companies

Suggested Lead Organizations: DBEDT and Partner Organizations

The State of Hawaii, with the active involvement of, and support from, the companies themselves, and organizations such as the U.S. Department of Commerce, USDOE, Hawaii's Chambers of Commerce, and other relevant NGOs and organizations, should conduct a series of workshops to clarify the facilitative roles and to explain how to make the most effective use of government agencies and NGOs in promoting sustainable-technology-based economic development.

The workshop series should culminate with an international conference and exhibition, with local, national, and international experts addressing topics of high interest to the private sector. It should serve as a "sustainable technology fair" wherein local and Mainland sustainable technology companies, sustainable technology industry organizations, and companies offering support services may exhibit technologies and services, and prospect for business development opportunities in Hawaii and Asia-Pacific markets. Government and private sector officials from potential Asia-Pacific customer nations should be invited to participate.

14.3.7 RECOMMENDATION: Strongly Support and Sustain the Millennium Workforce Development Initiative

Suggested Lead Organization: DBEDT

Continue DBEDT's facilitation of the public- private-sector Environmental Science and Technology working group chartered under the Governor's Millennium Workforce Development Initiative. A short-term objective of the Initiative is to enable development of a skilled workforce that is relevant and responsive to immediate industry needs. Recognizing the importance of Asia-Pacific environmental markets, the Environmental Science and Technology Working Group also identified strategies for longer-term industry development. Its recommendations to the Governor will include near-term implementation of training programs in environmental technology and longer-term industry support for outreach to Asia-Pacific markets.

14.3.8 RECOMMENDATION: Establish a Center for Asia-Pacific Infrastructure Development in Hawaii

Suggested Lead Organizations: DBEDT and Partner Organizations

DBEDT is in the process of establishing a Center for Asia-Pacific Infrastructure Development. The Center will be a partnership with the U.S. Department of Commerce, private companies, and other organizations such as the East-West Center and the American Consulting Engineers Council.

The Center would assist American small- and medium-sized enterprises to establish relationships crucial to entering markets in the Asia-Pacific. This would be achieved by providing the structure for foreign policy makers and infrastructure project planners, and developers and financiers – especially from the Asia-Pacific region –to learn about the latest non-traditional, innovative options for development of infrastructure projects. Foreign officials would learn about the criteria used by international contractors and financial institutions to evaluate and prioritize projects. Most importantly, foreign participants (mostly from the Asia-Pacific region) would be provided the opportunity to network with representatives of American firms to establish direct lines of communication for the actual development of infrastructure projects. In this way, the Center would be able to provide American companies a competitive advantage in securing infrastructure development contracts. At the same time it would serve the needs of the foreign countries during the planning, finance, and development phases of infrastructure projects.

The Center will also be a place for learning. In particular, participants could bring actual projects to the Center and learn by working with others to design project prospectuses that meet the standards of international servers and funders of infrastructure development. The Center's programs will help attendees shape priorities, determine feasibility, prepare for funding, and develop bases for working with the entities (especially U.S. companies) required to help bring the infrastructure projects to fruition.

14.3.9 RECOMMENDATION: Continue to Promote Sustainability Programs in Cooperation with the East-West Center's Asia-Pacific Economic Cooperation Program (APEC)

Suggested Lead Organizations: East-West Center and DBEDT

DBEDT works closely with the East-West Center and other organizations to initiate partnerships that provide technical expertise in energy and environmental protection from Hawaii to the Pacific Islands and Pacific Rim nations. These partnerships will not only strengthen the region, but will increase opportunities for Hawaii business abroad. This was the case with the November 9, 1999, meeting of the APEC Expert Subgroup on Inter-Utility Demand-Side Management, coordinated by DBEDT. The event was co-sponsored by Electric Power Research Institute and the East-West Center.

CHAPTER 15 ENERGY IN HAWAII AND FUTURE TECHNOLOGY

15.1 Overview

This report has focused on ways to improve Hawaii's energy efficiency, reduce Hawaii's dependence on imported fossil fuels, increase the use of indigenous renewable energy resources, and to reduce greenhouse gas emissions.

DBEDT believes that new technology is needed to make major changes in Hawaii's energy system, to reduce energy costs, and reduce fossil fuel use and the resultant greenhouse gas emissions. In the model runs and analysis, existing technologies were considered in developing and addressing options. In the energy sector in particular, the estimates indicated that it would be very difficult to reach the Kyoto Protocol goal of 7% below 1990 levels of greenhouse gas emissions by the years 2008–2010 using existing technologies.

This chapter discusses several research and development efforts currently underway in Hawaii that may allow use of indigenous energy resources or more efficient fuels, such as hydrogen. These technologies could also contribute to reducing greenhouse gas emissions. The chapter also examines a number of other technologies under development that are expected to provide energy and transportation more efficiently and with reduced greenhouse gas emissions.

15.2 Technology, Economic Growth, and the Environment

In a draft paper prepared for DBEDT, entitled *Economic Opportunities in Energy and Resource Efficiency*, Lawrence J. Hill of the U.S. Department of Energy's Oak Ridge National Laboratory summarized the connection between technology, economic growth, and the environment. He wrote:

> Changes in technology are revolutionizing where and how products are produced. Technological change has already led to the introduction of information-related technologies and the innovation pipeline has not nearly been exhausted. . . .
>
> There are two consequences of these innovations. First, these new technologies require electricity as their fuel. The global demand for electricity, then, will be larger than it would have been without the technologies. The new information technologies will also make firms more efficient, promising higher growth rates for many economies and, consequently, an increased demand for electricity. Second, new information technologies afford business firms the opportunity to become global, allowing them to move their operations from one country to another based on local economic and political considerations. An important consideration – and one that policy makers are increasingly aware of – is the cost of doing business in a community. High resource prices do not attract these global firms.

> Technological innovation in the electric industry also portends significant changes. For example, dramatic improvements in the efficiency of gas turbine power plants have reduced the cost of producing electricity from these plants and have reduced the minimum size of the plants needed to obtain the cost reduction. These improvements have led national and state policy makers to legislate changes in the structure of the electric industry.
>
> In this new structure, the electric industry will be broken apart. . . . The traditional electric 'monopoly' will no longer be the sole provider to customers. . . .
>
> These technology-driven changes are intensifying concerns about global climate change resulting from greenhouse gas emissions from electric power plants and increased industrial production fueled by technological innovation. . . .
>
> Improving energy efficiency is one tool that policy makers can use to address the global climate change problem. Improving energy efficiency is an important policy tool in this regard because it also results in important income and employment benefits for the local economy. (Hill 1999, 6-7)

In addition, use of indigenous, renewable energy keeps money in the local economy and provides a greater multiplier effect than purchases of imported fuels. To the extent that technology can provide for energy efficiency, greater use of indigenous energy, or both, Hawaii's people, economy, and environment will all benefit.

15.3 Hawaii Research and Development Projects

There are a number of current and recent research and development projects in Hawaii that offer potential contributions to Hawaii's energy system and that may help reduce the production of greenhouse gases and mitigate climate change.

15.3.1 Hydrogen: Fuel of the Future

Hydrogen has been called the fuel of the future. It may be the ultimate energy carrier – a versatile, transportable fuel that can be converted easily and efficiently to other forms of energy without producing harmful emissions. Hydrogen can be used as a fuel for transportation, electricity generation, cooking, and heating. It can be produced from renewable resources, such as electrolysis of water into hydrogen and oxygen using solar energy or wind energy, or by direct conversion of biomass into hydrogen and other gases (HNEI 1998).

In the past, the cost of production, difficulties in storage, and lack of infrastructure have been obstacles to the everyday use of hydrogen. The U.S. Department of Energy (USDOE) Center for Excellence for Hydrogen Research and Education at the University of Hawaii's Hawaii Natural Energy Institute (HNEI) is conducting research to address the cost and storage issues. Work is underway in the area of photoelectrochemistry, biomass gasification of hydrogen, and hydrogen storage technologies (HNEI 1998).

15.3.1.1 Photoelectrochemistry

Research is being conducted at HNEI on ways to electrolyze water into hydrogen and oxygen using only sunlight for energy. Analyses indicate that photoelectrochemical reactors based on multijunction amorphous silicon solar cell technologies can potentially achieve highly efficient production of hydrogen at reasonable cost. Using high-efficiency, triple junction amorphous silicon solar cells provided by Solarex Thin Film Division and HNEI's own thin-film catalytic coatings, researchers have demonstrated conversion efficiencies greater than 7.5%. The technology has operating lifetimes in excess of 7,000 hours. HNEI research is now focused on improving protective coatings. In collaboration with the National Renewable Energy Laboratory, HNEI is also working to optimize the engineering design of these photoelectrochemistry reactors (HNEI 1998).

15.3.1.2 Biomass Gasification to Create Hydrogen

Researchers at HNEI's Renewable Resources Research Laboratory are optimizing a new catalytic process that causes biomass to react with "supercritical water" (water at high temperatures and pressures) to produce hydrogen, CO_2, and some CH_4. The process is similar to techniques currently used for commercial production of hydrogen using reaction of natural gas (CH_4) with water. The advantage of HNEI's process is that it can use renewable biomass (such as wood sawdust, water hyacinth, banana stems, or sewage sludge) and supercritical water as reactants. Unlike all other biomass gasification processes, the HNEI process produces no tars or char, only a hydrogen-rich gas. A patent is pending on the process and researchers recently issued a second patent disclosure. With support from the U.S. Department of Energy, General Atomics Corporation is now preparing a business plan to commercialize the HNEI work (HNEI 1998).

15.3.1.3 Hydrogen Storage Technology

Hydrogen storage has long been a problem. Hydrogen is normally stored as a gas in high-pressure tanks, or as a liquid at cryogenic temperatures. Hydrogen can also be stored as a solid by reacting it with a variety of metals. These materials, known as metal hydrides, provide safe, low-pressure storage; however, the process has so far proven able to store hydrogen only in amounts too small to be practical. In other cases, the hydrogen has been found to form too strong a bond with the metal hydride, requiring large energy inputs for its release (HNEI 1998).

Over the ten years from 1986 to 1996, HNEI's research has focused on developing "non-classical" polyhydrides – transition metal complexes – as storage media. Experiments showed that this new class of material could store and discharge hydrogen with lower energy inputs than conventional hydrides (HNEI 1998).

Recently, HNEI researchers discovered that these same metal complexes can catalyze the dehydrogenation of cyclic aromatic hydrocarbons at low temperatures, a step that had long been a barrier to using such hydrocarbons as a storage media. Research has been redirected to concentrate on the development of metal complex catalytic systems for reversible hydrogenation of unsaturated hydrocarbons. Within the past year, new and significantly improved catalysts have been developed. HNEI also initiated studies to characterize the kinetics and thermodynamics of the reaction system. Future work will include improvement of the fundamental properties of catalysts and construction of a membrane reactor to demonstrate reversible operation of the hydrocarbon storage system (HNEI 1998).

15.3.2 New Technology for Charcoal Production

Charcoal has been made in virtually the same way for 6,000 years. The process is long, causes severe air pollution, and has low yields. An innovation by HNEI researcher Dr. Michael J. Antal, Jr., at the University of Hawaii, offers the potential to greatly reduce production time – to an hour or less – while reducing smoke and other pollution and doubling or tripling yields. This technique could help slow deforestation and reduce pollution (and greenhouse gas emissions) in the many developing nations that use large amounts of charcoal. The process, which recently received a U.S. patent, can use a variety of feedstocks, including moist wood logs, wood chips, coconut shells, corn cobs, macadamia nut shells, and other commonly available biomass and agricultural byproducts. The greater efficiency of this method could save thousands of acres of forests from harvesting and reduce air pollution by shortening production times and improving yields.

15.3.3 Open-Cycle Ocean Thermal Energy Conversion

The technology for generating electricity from different ocean temperatures is known as ocean-thermal energy conversion, or OTEC. OTEC makes use of the difference in temperature between the warm surface water of the ocean and the cold water at depths below 2,000 feet to generate electricity. As long as a sufficient temperature difference (about 40 degrees Fahrenheit) exists between the warm upper layer of water and the cold deep water, net power can be generated.

Almost all of major U.S. OTEC experiments in recent years have taken place in Hawaii. The Natural Energy Laboratory of Hawaii Authority (NELHA), on the Big Island, is recognized as the world's foremost laboratory and test facility for OTEC and OTEC-related research. The State of Hawaii funded the facility, with significant USDOE participation. The Pacific International Center for High Technology Research (PICHTR), in Honolulu, designed, constructed, and operated a 210-kilowatt open-cycle OTEC plant. When it was operational, the plant set the world record for OTEC power production, at 255 kilowatts gross. Testing ended in 1997.

OTEC continues to offer a way to generate electricity without producing greenhouse gas-. Additional research, component cost reduction, and funding of a utility-scale plant are needed to create a viable commercial technology.

15.3.4 International CO_2 Ocean Sequestration Field Experiment

During the Third Conference of the Parties of the Framework Convention on Climate Change, at Kyoto in December 1997, agencies of the governments of the United States, Japan, and Norway signed a major international research agreement to develop technologies to sequester CO_2 removed during fossil fuel combustion to keep it from entering the atmosphere. Under the agreement, researchers from the three nations will test the feasibility of deep-ocean sequestration of CO_2 via discharge from submerged pipelines.

The objective of the experiment is to identify safe and practical means of reducing CO_2 emissions while ensuring a stable and inexpensive energy supply. The first phase of the experiment will release a modest amount of CO_2 at depths of more than 3,000 feet during the course of a month. Researchers will gather data on the dissolution and dilution of the CO_2 to assess any impacts on the deep-ocean environment and to develop models of the discharge that can be used to predict and quantify changes in sea water chemistry PICHTR is the general contractor, and the experiment will take place in the ocean research corridor offshore of the Natural Energy Laboratory of Hawaii Authority at Kailua-Kona, Hawaii.

It should be noted that ocean sequestration is potentially well suited for fossil-fueled power stations in Hawaii. As noted in Chapter 7, Hawaii's power producers do not enjoy the option of switching to lower cost and lower carbon content fuels such as natural gas as Mainland utilities can. CO2 removal from stack gases and sequestration in the deep ocean could be added to other CO2 reduction options such as improved heat rate, energy efficiency programs, and use of renewable energy resources.

Hawaii's power stations probably have the best access to the deep ocean in the U.S. (Masutani 1998). The USDOE, however, estimates that about 30% of U.S. power plants would have access to deep-water sequestration (USDOE 1997b). A pilot facility planned by the three nation consortium for development in the 2005–2010 time frame, could well be sited in Hawaii, possibly next to the Hawaiian Electric Company's Kahe station on Oahu (Masutani 1998).

Hawaii researchers have previously proposed and published papers on a process to reduce CO_2 emissions from power plants by “precombustion reforming” of fossil fuel and deep-ocean discharge of the CO_2 separated from the fuel. The process involves reforming a hydrocarbon fuel into a mixture of hydrogen and CO_2 before combustion takes place. The gases are separated and the hydrogen is used for power generation while the liquefied CO_2 is discharged into the deep ocean. Based upon their analysis of a 500 MW methane-fueled power plant, Nihous et al. (1994) reported that it appeared that the system would incur moderate power and cost penalties. In the future, such measures may be among those necessary to reduce CO_2 emissions and their impact on global climate.

15.4 Future Technology

15.4.1 The Need for New Technologies

Hawaii, and the rest of the world, will need new technologies to effect significant improvements in energy efficiency, to increase use of renewable energy, and to achieve the reductions in greenhouse gas emissions necessary to reduce the consequences of global warming and other, related, changes in the global climate. In the context of HES 2000, it is stressed that improvements in energy efficiency and use of renewable energy also offer economic and other environmental benefits.

The U.S. Secretary of Energy recently asked the Directors of the Department of Energy's national laboratories to identify technologies that could be used to meet this challenge nationally. The study was summarized in *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions* (NLD 1997), published in October 1997. As the National Laboratory Directors stated, "Advances in science and technology are necessary to reduce greenhouse gas emissions from the United States while sustaining economic growth and providing collateral benefits to the nation" (NLD 1997, xiii).

15.4.2 The Outlook for Technological Solutions

The National Laboratories Directors pointed out that solutions available early are have greater impact in reducing emissions than those available later. They believe that by 2030 a vigorous research, development, and demonstration program could result in a "wide array of cost-effective technologies that together could reduce the nation's carbon emissions by 400–800 million metric tons of carbon per year. This decrease represents a significant portion of the carbon emission reductions that may be targeted by the U.S. for 2030" (xiv).

Looking ahead over the next thirty years, each decade was characterized by a distinct range of potential technologies for reducing greenhouse gas emissions. The technological pathways identified were energy efficiency, clean energy, and carbon sequestration.

In the first decade (2000–2010), advances in energy efficiency would reduce the energy intensity of the U.S. economy. The use of clean-energy technologies would continue to grow, and carbon sequestration technologies could begin to emerge.

In the second decade (2011–2020), continued improvements in energy efficiency, and research-based advances in clean-energy technologies would significantly reduce the amount of carbon emitted per unit of energy used. A wide variety of improved renewable, nuclear, and fossil energy technologies could be introduced.

By 2025, during the third decade (2021–2030), the impacts of reductions through clean energy technology could begin to exceed the impact of increased energy efficiency. Success in the area of carbon sequestration is seen to be essential for the U.S. to continue its extensive use of fossil fuels without harming the global environment (xiv).

The following table, 15.1, is based upon the National Laboratory Director's study. It presents an illustrative time-line of anticipated technology products for the energy sector, 2000–2030 (5-10–5-11).

Table 15.1 Illustrative Time-Line of Anticipated Technology Products, 2000-2030

2000	2005	2010
Energy Efficiency	**Energy Efficiency**	**Energy Efficiency**
1 kWh/day refrigerator	Fuel cells providing combined heat and light for commercial buildings	Widespread use of hybrid lighting, combining light concentrators, efficient artificial sources, and fiber-optic distribution systems
80% efficient advanced turbine system for industrial cogeneration	R-10+ windows and electrochromic windows	Real-time monitoring of water and nutrients in agricultural systems
Advanced industrial process sensors and controls	Energy efficient catalysts for chemical synthesis	Three times greater fuel economy vehicle
Direct injection stratified charge gasoline engine	**Clean Energy**	**Clean Energy**
Advanced heavy duty diesel	Gasoline electric hybrid vehicle	Hybrid fuel cell advanced turbine system for power generation with efficiencies of 70%
	Clean diesel for light trucks and sport utility vehicles	Biofuels competing with petroleum-based transportation fuels
	Co-firing with biomass and coal	Clean coal technologies increase efficiencies to 55%
	Wind-generated electricity at 2.5 cents per kWh	Superconducting transformers an 200 HP+ industrial motors
	Superconducting cables for underground transmission	**Carbon Sequestration**
		Injection of carbon into aquifers

Continued next page

Table 15.1 Illustrative Time-Line of Anticipated Technology Products, 2000-2030

2015	2020	2025	2030
Clean Energy	**Energy Efficiency**	**Energy Efficiency**	**Clean Energy**
Widespread production of chemicals from biomass feedstocks	Phase-change building materials with storage capacity and adaptive release rates	NEW SYSTEM: Mass produced customized buildings and integrated envelope and equipment systems designed and sized for specific sites and climates	NEW SYSTEM: Broad-based biomass industry with new crops and feedstocks producing food, transportation fuels, chemicals, materials, and electricity
Hydrogen fuel cell vehicle	NEW SYSTEM: Widespread use of industrial ecology principles with linked industries and energy cascading	Travel demand reductions through real-time information systems	Utility scale photovoltaic systems
Superconducting generators for utility systems	**Clean Energy**	**Clean Energy**	NEW SYSTEM: Fission reactors with proliferation resistance, high efficiency, and lower costs
Diesel fuels from natural gas	Production of hydrogen from solar conversion of water	Advanced geothermal hot dry rock and magma energy systems	
Photovoltaics for distributed and peak shaving utility systems	NEW SYSTEM: Mature hydrogen supply infrastructure enabling multiple modes of hydrogen based transportation		NEW SYSTEM: Energyplexes that integrate fossil fuel-based production of power, fuels, and chemicals from coal, biomass, and municipal wastes with nearly zero emissions
	Simultaneous gas hydrate production and CO_2 Sequestration		**Carbon Sequestration**
	Feasibility of oceanic sequestration established		Enhanced natural CO_2 absorption

15.4.3 National Goals for Research, Development, and Demonstration

The National Laboratory Directors suggested the following goals for a Research, Development, and Demonstration (RD&D) program:

15.4.3.1 National Energy Efficiency RD&D Goals

- Use energy more efficiently through the development of advanced technologies (e.g., intelligent building control systems, cost-effective refrigerators that use half as much electricity as today's models, and fuel cells for heat and power in commercial buildings);
- Reduce the use of gas and oil for space and water heating through building efficiency measures (e.g., super insulation, gas-fired heat pumps that provide highly efficient space heating and cooling, and building envelopes that capture and store solar energy for later use). (Note: While Hawaii has minimal space-heating requirements, some of these measures can reduce the need for air conditioning or be used to provide cooling in large buildings. Solar water heating remains an important technology for Hawaii's residential and smaller commercial buildings.);
- Improve industrial resource recovery and use (e.g., develop an integrated gasification, combined cycle power technology, that can convert coal, biomass, and municipal wastes into power and products) and industrial processes to save energy (e.g., advanced catalysts and separations technologies);
- Increase transportation efficiency through new technologies (e.g., a hybrid electric vehicle that is three times more fuel-efficient than today's standard model) (xv).

15.4.3.2 National Clean Energy RD&D Goals

- Change the energy mix to increase use of sources with higher generating efficiencies and lower emissions, including increased use of natural gas, safer and more efficient nuclear power plants, renewable energy (e.g., solar and wind power; electricity and fuels from agricultural biomass), and hydrogen (to produce electricity through fuel cells);
- Develop "energyplexes" that would use carbon efficiently without emitting greenhouse gases for the integrated production of power, heat, fuels, and chemicals from coal, biomass, and municipal wastes;
- Distribute electricity more efficiently to reduce emissions (e.g., distributed generation using superconducting transformers, cables, and wires);

- Switch transportation to energy sources with lower emissions (e.g., trucks that run on biodiesel fuel or ethanol from cellulosic feedstocks);
- Remove carbon from fuels before combustion. (xv).

15.4.3.3 National Carbon Sequestration RD&D Goals

- Efficiently remove carbon dioxide from combustion emissions before they reach the atmosphere;
- Increase the rate at which oceans, forests, and soils naturally absorb atmospheric carbon dioxide;
- Develop technologies for long-term carbon storage in geological deposits, aquifers, and other reservoirs.

15.4.4.1 RECOMMENDATION: Support Deep-Ocean Carbon Sequestration Research and Possible Future Installation of a Pilot Facility in Hawaii

Suggested Lead Organizations: UH HNEI, PICHTR, NELHA, USDOE, County of Hawaii

This technology, if proven, could provide an excellent way of reducing Hawaii's near-term CO_2 emissions. If the CO_2 sequestration effort is successful, installation of a pilot facility at a power plant in Hawaii should be encouraged. Many of Hawaii's power plants could inject CO_2 from their locations relatively near the coast.

Hawaii's geography provides ready access to deep-ocean areas from coastal areas. The Natural Energy Laboratory of Hawaii Authority operates facilities that provide land-based access to deep, cold ocean waters offshore. This is highly useful for RD&D on deep-ocean carbon sequestration.

15.4.4.2 RECOMMENDATION: Conduct RD&D on Renewable Energy Technology Using Hawaii's Abundant Renewable Energy Resources

Suggested Lead Organizations: The Electric Utilities, Renewable Energy Developers, and USDOE

As noted in Chapter 7, Hawaii has significant wind and solar resources, which were identified during work on the Hawaii Energy Strategy project (see DBEDT 1995b). Hawaii has the highest national per capita use of solar water heating. In addition, volcanoes on the Big Island provide a major geothermal resource. As also noted in Chapter 7, and in the following section, Hawaii's sugar industry leads the world in efficient use of its electricity production from bagasse. Hawaii's lack of space for landfills led to construction of a municipal solid waste to energy plant on Oahu.

Land available due to the closure of sugar plantations could be used for further RD&D into biomass-to-energy systems. Although the Maui Biomass Gasifier project was canceled, Hawaii remains an excellent location for similar efforts to produce liquid fuels from biomass and municipal waste.

15.4.4.3 RECOMMENDATION: Conduct Rapid-Payback Building Efficiency RD&D in Hawaii

Suggested Lead Organizations: Electric and Gas Utilities, Energy Service Companies, Builders, Renewable Energy Developers, and USDOE

Hawaii's average statewide electricity costs are the highest in the nation. This factor enhances the attractiveness of conducting building efficiency RD&D in Hawaii. Efficiency measures will yield a rapid payback of their costs, which will help finance the RD&D. Hawaii is an excellent place to deploy new energy efficiency technologies that are being developed by USDOE. Due to the 12-month need for air conditioning in commercial buildings, Hawaii also offers an excellent location for RD&D aimed at improving the efficiency of air conditioning.

15.4.4.4 RECOMMENDATION: Conduct RD&D on Clean Energy and Transportation Energy Efficiency to Reduce Hawaii's Overdependence on Oil

Suggested Lead Organizations: Vehicle and Aircraft Manufacturers, Electric and Gas Utilities, Hawaii Transportation Companies, and USDOE

Hawaii's short driving distances make the islands an ideal location for RD&D involving widespread deployment of propane vehicles, electric vehicles, and hybrid vehicles. Hawaii's near total dependence on jet aircraft for its overseas, interstate, and interisland passenger transportation places a premium on the use of efficient aircraft. Hawaii should support RD&D efforts to improve aircraft efficiency and the development of alternative fuels for jet aircraft.

15.4.4.5 RECOMMENDATION: Conduct RD&D on Electricity System Efficiency and Clean Energy for Electricity Generation in Hawaii

Suggested Lead Organizations: Electric Utilities, Non-Utility Generators, Generator and Fuel Cell Manufacturers, USDOE

Hawaii has six relatively small, isolated electricity systems. The short transmission and distribution distances offer excellent test locations for superconductive cables, transformers, and wires. The high cost of electricity places a premium on efficiency and cogeneration (including combined heat and power systems). The isolated nature of Hawaii’s systems may provide opportunities to test distributed generation systems.

Hawaii also offers the opportunity to test a variety of fossil fuels and renewable technologies in integrated systems designed to overcome the challenges posed by the intermittent nature of some renewable technologies.

Technologies developed for Hawaii's separate island systems may also have application in developing nations that lack a national or regional power grid, especially developing countries in the Asia-Pacific region. Such nations effectively have "island" systems.

CHAPTER 16 SUMMARY OF HES 2000 RECOMMENDATIONS

The following table summarizes the recommendations of *HES 2000* based on the discussion in the preceding chapters. Recommendations are organized by chapter. For each recommendation, the organizations that are encouraged to take action are indicated in first column. For the convenience of the organizations involved, recommendations are listed alphabetically within chapters by the name of the first lead organization. The second column lists the recommendation, and the third column lists the section in the text upon which the recommendation is based.

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 1 The State of Hawaii Energy Program, Hawaii Energy Strategy 2000, and the Hawaii Climate Change Action Plan		
DBEDT and OP for consideration of Legislature	Propose a new State Energy Objective related to climate change	1.3.6.1
DBEDT, DLNR, other State agencies, Counties, and interested stakeholders	Continue the Hawaii Climate Change Action Program and participation in U.S. Environmental Protection Agency's State and Local Climate Change Partners' Program	1.3.6.2
DBEDT, DOH, DLNR, other State agencies, Counties and interested stakeholders	Set Hawaii Greenhouse Gas Reduction Goals with public input	1.3.6.3
DBEDT, DOH, DLNR, other State agencies, Counties and interested stakeholders	Identify future effects of climate change on Hawaii and plan adaptation measures	1.3.6.4
Chapter 4 Energy for Ground Transportation		
City and County of Honolulu and other Counties	Continue efforts to increase use of mass transit	4.5.2.1
DBEDT and DOA	Encourage production and sale of 10% ethanol blend gasoline in Hawaii	4.6.2.2
DBEDT	Continue to assist fleets in complying with EPACT requirements for alternative fuel vehicles	4.6.2.4
City and County of Honolulu, DBEDT, and other participants	Support the Honolulu Clean Cities Program	4.6.2.5
DBEDT and Counties	Publicize incentives for owning alternative-fuel vehicles	4.6.2.1
DBEDT, Counties, HEVDP, and electric utilities	Encourage early deployment of electric vehicles in Hawaii	4.6.2.3

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 4 Energy for Ground Transportation (Continued)		
Legislature, DBEDT and DOH	Consider increasing the visibility of driving costs	4.5.1.1
Legislature, DBEDT and DOH	Increase information on the environmental costs of vehicle fuel-use with a new Environmental Impact Information Sheet	4.5.1.2
State DOT and Counties	Improve the bicycle transportation system	4.5.2.2
State DOT, OMPO and Counties	Reduce congestion through the use of transportation control measures (TCMs)	4.5.2.4
State DOT, OMPO and Counties	Develop estimates of energy- and emissions-saving effectiveness of TCMs to help prioritize their potential use	4.5.2.5
State Land Use Commission, OP, DLNR, DOT and Counties	Use land use planning to reduce traffic congestion and the need for transportation	4.5.2.3
Vehicle dealers	Encourage purchase and use of fuel-efficient conventional vehicles and hybrid vehicles	4.5.1.3
Chapter 5 Energy for Air Transportation		
Airlines	Maintain improved load factors and continue operational changes for fuel efficiency (Actions have been taken)	5.5.1.1, 5.1.1.2
Airlines	Adopt operating measures to increase fuel efficiency (Action has been taken)	5.5.2.1
Airlines	Maintain high load factors while increasing overall overseas capacity	5.5.2.2
Airlines and DOT	Use newer, more efficient aircraft on overseas routes	5.5.2.4
Hawaii Congressional Delegation and Legislature	Ensure that proposals for carbon taxes on aviation fuels do not adversely affect Hawaii	5.4.2.1
Interisland airlines	Re-equip interisland airlines with newer, more efficient aircraft	5.5.2.3
Chapter 6 Energy for Marine Transportation		
Hawaii Congressional Delegation and Legislature	Ensure that proposals for carbon taxes on marine fuels do not adversely affect Hawaii	6.4.1.3
Shipping companies	Adopt technical improvements to ships	6.4.1.2
Shipping companies	Consider changes in operating procedures for energy efficiency	6.4.1.1
Chapter 7 Generating Electricity for Hawaii		
Electric utilities, State Land Use Commission, OP, Public Utilities Comm., Counties, and stakeholders	Identify, designate, and permits for sites for future electricity generation, consistent with Integrated Resource Plans	7.10.3
Electric utilities and non-utility generators (NUGs)	Continue diversification of fuels used for electricity generation in Hawaii	7.4.3.1
Electric utilities and NUGs	Continue to pursue greater efficiency in fossil fuel central station generation	7.11.2.1

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 7 Generating Electricity for Hawaii (Continued)		
Electric utilities and NUGs	Increase use of renewable energy for electricity generation in Hawaii	7.4.3.2
Electric utilities and NUGs, and large electricity users	Pursue greater efficiency through distributed generation (small cogeneration, microturbines, and fuel cells)	7.11.2.3
Public Utilities Commission, Electric Utilities, The Gas Company	Utility Integrated Resource Planning should consider cost-effective, energy-efficient fuel substitution between electricity and gas	7.11.2.2
Public Utilities Commission and participants	Continue examination of electricity competition for Hawaii	7.2.2.5
Public Utilities Commission and utilities	Review utility costs and require utilities to report on actions taken to reduce revenue requirements	7.2.2.4
Chapter 8 Increasing Renewable Energy Use in Hawaii		
DBEDT, electric utilities, and renewable energy industry	Continue to assess the need for state income tax credits for renewable energy beyond 2003	8.5.2.1
DBEDT, electric utilities, and solar water heating industry	Continue to increase use of solar water heating	8.5.3.1
Electric and Gas Utilities	Obtain accurate cost data for renewable energy options for Integrated Resource Planning	8.5.1.1
Hawaii Congressional Delegation	Encourage the use of renewable energy through federal tax credits	8.5.2.2
HECO and renewable energy developers	Consider renewable energy options for Oahu	8.4.2.2
HELCO and renewable energy developers	Consider renewable energy options for the Island of Hawaii	8.4.3.2
KE and renewable energy developers	Consider renewable energy options for Kauai	8.4.3.2
Legislature and Public Utilities Commission	Consider implementing a Renewable Portfolio Standard, a Public Benefits Charge, or Green Pricing to Increase Renewable Energy Use	8.5.3.3
MECO and renewable energy developers	Consider renewable energy options for Maui	8.4.4.2
Public Utilities Commission and organizations as identified by report	Implement recommendations of renewable resource docket	8.5.2.2
Chapter 9 Electricity Competition and Hawaii		
Public Utilities Commission	Consider restructuring Hawaii's electricity system	9.5.6

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 10 Utility and Bottled Gas in Hawaii		
DBEDT, The Gas Co., and distributed generation manufacturers	Encourage use of gas as a fuel for distributed electricity generation, cogeneration, and/or fuel cells where it is cost-effective and energy efficient	10.7.2
The Gas Co., renewable energy developers, and DBEDT	Encourage cost-effective renewable energy substitution for synthetic natural gas and propane	10.7.1
Public Utilities Commission, Electric Utilities, and The Gas Co.	Utility IRPs should consider cost-effective, energy-efficient fuel substitution between electricity and gas	10.7.3
Chapter 11 Increasing Energy Efficiency in Hawaii's Buildings		
Building industry	Encourage continued use of HiLight software program to ensure Model Energy Code compliance in lighting design	11.2.1.5
Counties	Adopt Model Energy Code for Maui County (currently under consideration) and adopt Residential Building Model Energy Code in all Counties	11.2.1.4
Counties with DBEDT support	Continue and expand County government energy efficiency programs	11.2.4.1
DBEDT, the Utilities, Design Professionals, and the Building Industry	Continue Transfer of Advanced Building Technologies and Development of Design Guidelines	11.2.3.2
DBEDT	Continue to expand energy efficiency technical education and training programs	11.2.3.5
DBEDT	Continue Solid Waste Reduction and Recycling Programs	11.2.3.6
DBEDT and Counties	Continue to evaluate impact of and improve the rate of compliance with Model Energy Code	11.2.1.6
DBEDT and partner organizations	Continue to support State participation in Rebuild America and other public-private partnerships and alliances to improve resource efficiency	11.2.3.4
DBEDT and State agencies	Increase efforts by State government to improve energy efficiency by meeting State goals for reduction of energy use in State facilities	11.2.3.1
DBEDT and State Agencies, and Finance Companies	Expand Hawaii State government energy Performance Contracting and alternative financing for energy projects	11.2.3.3
DBEDT, Utilities, Building Industry, and Design Professionals	Investigate new measures and practices for building energy efficiency	11.3.2
DBEDT, Utilities, Building Industry, and Design Professionals	Continue transfer of advanced building technologies and development of design guidelines	11.2.3.2
Federal agencies	Support energy efficiency programs in federal facilities in Hawaii	11.2.5.3
Utilities and DBEDT	Continue to support cost-effective utility Demand-Side Management programs	11.2.2.5

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 12 Energy Emergency Preparedness		
DBEDT	Continue to progress in hazard mitigation to reduce Hawaii's energy system vulnerability	12.4.6
DBEDT	Continue to support the Hawaii Energy Council's readiness and its application to other jurisdictions	12.4.1
DBEDT and Hawaii, Honolulu, and Maui Counties	Continue to work with Counties to complete administratively approved County EEP plans	12.4.8
DBEDT and Energy Council	Develop an ESF-12 concept of operations for activating DBEDT staff during a disaster or market shortage	12.4.7
DBEDT and USDOE	Continue to work with USDOE to provide for rule making to implement SPR priority access sales provisions	12.4.2
DBEDT, State Civil Defense, and Young Brothers	Complete the Young Brothers' emergency generator hazard mitigation project	12.4.5
DBEDT, State Civil Defense, Counties, and industry participants	Complete emergency generator inventories and database documentation of emergency and essential service facilities	12.4.4
DBEDT, State Civil Defense, Counties, and industry participants	Continue to regularly exercise government and industry EEP plans; emphasize preparedness on the local (first responder) level	12.4.3
Chapter 13 Scenarios for Hawaii's Energy Future		
DBEDT, airlines, auto manufacturers and Hawaii Congressional Delegation	Support efforts to increase the fuel efficiency of aircraft and ground vehicles	13.6.4.2
DBEDT, electric utilities, NUGs, and renewable energy developers	Maximize renewable energy and Demand-Side Management in the electricity sector	13.6.4.3
DBEDT, electric utilities, NUGs, renewable energy developers, and Legislature	Consider implementing elements of Scenario C3	13.6.4.1
Chapter 14 Facilitating Exports of Sustainable Technology to the Asia-Pacific Region		
DBEDT	Continue to conduct market analyses and evaluation relevant to the needs of Hawaii firms interested in technology-based economic development	14.3.2
DBEDT	Continue to publish *The Hawaii Energy, Environmental, and Engineering Export Service Directory*	14.3.3
DBEDT	Strongly support and sustain the Millennium Workforce Development Initiative	14.3.7
DBEDT and partner organizations	Continue to conduct business and technical exchange missions, and reverse trade missions	14.3.4
DBEDT and partner organizations	Actively advise and promote Hawaii energy and environmental companies	14.3.6
DBEDT and partner organizations	Establish a Center for Asia-Pacific Infrastructure Development in Hawaii	14.3.8

Suggested Lead Organization (s)	Recommendation	Reference Section
Chapter 14 Facilitating Exports of Sustainable Technology to the Asia-Pacific Region (Continued)		
DBEDT, Federal agencies, and NGOs	Continue to take advantage of Federal and NGO support for State energy and technology export initiatives	14.3.1
East-West Center and DBEDT	Continue to promote sustainability programs in cooperation with the East-West Center Asia-Pacific Economic Cooperation Program	14.3.9
Hawaii State Legislature	Formalize the STMAD process	14.3.5
Chapter 15 Energy in Hawaii and Future Technology		
UH HNEI, PICHTR, NELHA, USDOE, County of Hawaii	Support deep-ocean carbon sequestration research and possible future installation of a pilot facility in Hawaii	15.4.4.1
The Electric Utilities, Renewable Energy Developers, and USDOE	Conduct RD&D on renewable energy technology using Hawaii's abundant renewable energy resources	15.4.4.2
The Electric Utilities, Renewable Energy Developers, and USDOE	Conduct rapid-payback building-efficiency RD&D in Hawaii	15.4.4.3
Vehicle manufacturers, electric utilities, Hawaii transportation companies, and USDOE	Conduct RD&D on clean energy and transportation-energy efficiency to reduce Hawaii's overdependence on oil	15.4.4.4
Electric utilities, NUGs, generator/ fuel cell manufacturers, and USDOE	Conduct RD&D on electricity system efficiency, distributed generation, and clean energy for electricity generation in Hawaii	15.4.4.5

CHAPTER 17 COMMENTS FROM THE HAWAII ENERGY STRATEGY 2000 WORKSHOP

17.1 The Hawaii Energy Strategy 2000 Workshop

On December 9, 1999, the Hawaii Energy Strategy 2000 Workshop was held in Honolulu to discuss the draft HES 2000 with interested citizens and to obtain their input. Advance registrants received a copy of *The HES 2000 Summary* as a preview. This was intended to assist participants in developing their input. An idea sheet was included with the summary to use to provide on improving Hawaii's energy future by mail if a person could not attend in person.

During the Workshop, brief overviews of the major sections of the Strategy were presented, followed by a discussion period. Participants provided the written comments below. They are provided here to provide additional perspectives on energy issues to Hawaii's decision-makers and others interested in energy matters.

General comments are organized alphabetically by author in section 17.2. Specific comments are organized in section 17.3, first by chapter, and then, by referenced paragraph, followed by general comments related to the chapter.

17.2 General Comments from Participants

17.2.1 Comments by Henry Curtis, Executive Director, Life of the Land

Indigenous Energy Sources. The plan correctly points out that increasing the use of indigenous energy sources would be a better economic choice than our current "bleed" of our economy to purchase foreign fossil fuel. Exporting money from our economy only drains our local economy and provides for employment for workers in other countries. Hawaii needs to become more self-sufficient.

> "Hawaii's economy is overdependent on oil . . .. From Hawaii's perspective the system requires massive exports of money to pay for imports of crude oil . . .. Hawaii's own renewable resources are not fully used". (Draft *HES 2000 Summary* Page 1)
>
> "In addition, by investing in alternative energy sources within the state, expenses may not be reduce, but more of the money spent ill remain in the local economy and less oil use will reduce economic and environmental risks to Hawaii." (Draft *HES 2000 Summary* Page 2)
>
> "Hawaii is far away from its sources of oil and remains dangerously dependent on oil for its energy needs."(Draft *HES 2000 Summary* Page 6)

Purchasing fossil fuels is bleeding Hawaii and accounts for a large portion of the net financial loss to the state each year (the imbalance in the balance of payments).

Renewable Energy Options. At our recent Energy for the Millennium Conference, our keynote speaker, Dr. Donald Aitken, Senior Scientist for Renewable Energy with the Union of Concerned Scientists stated that Hawaii has almost every form of renewable energy available while most other states have just a couple of forms of renewable energy. Indeed, Hawaii has solar (solar water heating; photovoltaic cells), hydroelectric, wind, bagasse, landfill methane, refuse, and OTEC [ocean thermal energy conversion]. Why is Hawaii continuing to be so dependent on fossil fuel? Perhaps more importantly, why do we compare our rate of renewable energy with other states, when, in fact, we should compare what we do with the renewable resources we have to how other states do with the renewable energy resources they have.

At the same conference, Dr. Seiji Naya reported that the use of renewable energy had actually decreased. Auwe! We understood that the decline of the sugar industry has currently reduced the amount of biomass, but as Dr. Naya reported, "Hawaii has experience in almost every type of renewable energy, in one for or another." Why then, are we not using our indigenous resources to provide a sustainable alternative to fossil fuel for Hawaii's people?

A recommendation in Chapter 7 of the plan calls for "Continue diversification of fuels for electricity generation". Substituting coal for oil while reducing the use of renewables shouldn't be included in fuel diversification analysis. Instead, the recommendation should read: Implement renewable energy diversification.

Global Warming. The effects of global warming on Hawaii cannot be overstated. We understand that Hawaii is contributing 0.3 of 1% [of the U.S. contribution] to global warming, but raising the consciousness of the people of Hawaii is an important step in reducing our emissions. Prohibiting the construction of any more fossil fuel burning power generation plants. We therefore recommend that an effort be made to inform and educate the public on global warming issues.

> None of the three scenarios reduced greenhouse gas emissions below the Kyoto target of less than 7% less than the 1990 levels. (Draft *HES 2000 Summary* Page 15) All scenarios assume that Hawaii can not meet the Kyoto Protocol.

Life of the Land strongly urges that at least one scenario be analyzed that meets the Kyoto target! [The final HES 2000 contains a scenario in Chapter 13 that reduces emissions below the Kyoto target.] Perhaps a second scenario should look at how we could exceed the Kyoto target and then profit from marketing the excess [emissions savings] to other utilities not blessed with our renewable options.

Energy Efficiency. "Energy is used relatively efficiently in Hawaii. In 1970, Hawaii's per capita energy use was 86% of the national average, but by 1997, it was only 70% of the national average. Some of the reasons Hawaii is more efficient than the Mainland average include high energy prices that discourage energy use, little requirement for space heating, few energy-intensive industries, and short driving distances". (Draft *HES 2000 Summary* Pages 3-4) Life of the

Land wonders what our energy efficiency would be when the equations are normalized (cars: per mile efficiency; buildings: per degree heating and air conditioning efficiency).

Competition. "Implementing Competition in Hawaii . . . . Some are concerned that retail competition may leave individual residential customers behind". (Draft *HES 2000 Summary* Pages 12-13) Others are concerned that the unusual and uniquely high price of energy in Hawaii has already negatively impacted our individual residential customers and small businesses. Still others worry that competition may lead to lower prices, more options, and reduced monopolistic income.

Energy Preparedness. On May 6-8, 1998, the State of Hawaii conducted a regional energy emergency seminar and simulation exercise . . . ".". (Draft *HES 2000 Summary* Pages 14) "The [Hawaii Energy Council's] EC's primary responsibility will be to coordinate activities necessary to facilitate the affected energy utilities' safe, rapid restoration of the commercial energy grid, and provide 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, an facilitate the availability and adequacy of fuel supplies, storage, and distribution". (DBEDT ERT Webpage [http://www.hawaii.gov/dbedt/]) Distributed power would be nice. Let's adopt it as a statewide policy!

Competition. A recommendation in Chapter 7 of the plan states, "Continue to examine electric competition for Hawaii. Suggested Lead Organizations: Public Utilities Commission and Parties to Docket". Let's not examine, let's do something.

17.2.2 Comments by Dr. William H. Dorrance, Sc.D., Kailua

The proposed report is an excellent summary of things that are already done or contemplated. However it lacks the bold strategy that is required to meet the energy crisis soon to come (in the decade 2010 to 2020). Specific suggestions for the time when it becomes obvious that gasoline is too precious to use as a transportation fuel:

1. If LNG is to be imported, consider Kahoolawe as the location for unloading and storage tanks. The island is sufficiently isolated and the rental and employment could be a boon for Native Hawaiian. Consult a major gas distributor for what's needed to import LNG.
2. If a coal-to-gasoline converter is to be constructed using coal from Australia, put it on Kahoolawe. Visit South Africa to see how they do it.
3. Keep Hawaii's sugar farmers alive. Ethanol from cane will be cost-competitive sometime after 2010 but before 2020.
4. Prepare now a curfew on street lighting. Perhaps a partial curfew according to section and time of darkness.

5. Hydrogen stored under pressure within zeolites may become a transportation fuel.

6. Public acceptance depends on public perception of a need. What's missing is the kind of projection of future petroleum costs, uses, and reserves similar to the computer calculations done by M.I.T. for the Club of Rome in 1970. It's folly to depend on projections from Washington. They are sure to be colored by a political attempt to "avoid alarming the voting public". Hawaii should do such calculations. It would keep Washington honest. No calculations are more important to Hawaii's future.

7. Obviously, considerations of item 6 above must factor into plans for more highways and mass transit. I don't see that happening yet.

[Editor's Note: Dr. Dorrance also provided a paper on "Ethanol from Hawaii Cane" which analyzed Hawaii's sugar cane supply and potential production of ethanol from Hawaii cane. His analysis suggested that the costs would be relatively high, but given his expectation that crude oil supplies will decline, raising the price of gasoline above his projected sugar production cost after 2010. His conclusions were:]

1. Converting all Hawaii-produced raw sugar to ethanol would supply a substitute for less than 10% of the current consumption of gasoline.

2. However, because of the ever-growing world rate of consumption of petroleum, Hawaii-produced petroleum will become a cost-competitive substitute for gasoline in the decade from 2010 to 2020.

3. Converting Hawaii's sugar producers from raw sugar to ethanol substitutes a product for which there will be an ever-decreasing need for a product for which there are dependencies on uncertain, year-to-year, price supports.

4. This scenario depends on the uncertain knowledge of worldwide depletion of worldwide petroleum reserves. It is highly desirable that calculations be done to predict the depletion of petroleum reserves similar to those done at M.I.T. in 1968-1971.

[Editor's Note: In developing HES 1995, a DBEDT consultant produced a Transportation Energy Strategy (PBQD 1995). It contained a detailed analysis of the potential for ethanol production in Hawaii and estimated considerably lower costs than Dr. Dorrance, which could make ethanol production and use practical in the near term.]

17.2.3 Comments of Jeff Mikulina, Director, Sierra Club, Hawaii Chapter

[The following was based upon Mr. Mikulina's presentation at the Hawaii Energy Strategy 2000 Workshop, entitled "Visions of Hawaii's Energy Strategy".]

Weather Causes Record $89 Billion Damage

> WASHINGTON (AP) - Violent weather has cost the world a record $89 billion in 1998, more money than was lost from weather-related disasters in all of the 1980's, and researchers, in a study released blame human meddling for much of it. The report (by the Worldwatch Institute and Munich Re, the world's largest reinsurer) says a combination of deforestation and climate change has caused this year's most severe disasters.

Humans are altering the Earth's environment and completely altering the make up of our atmosphere. Developed nations are the leading source of greenhouse gas emissions. In Hawaii, we plan to follow a business-as-usual course when it comes to climate change, likely emitting 30% more CO_2 than the Kyoto goal (7% less than 1990 emissions, a compromise position of the Intergovernmental Panel on Climate Change, 1997). Yet climate change will intimately effect Hawaii--its people, ecosystems, and economy.

The goals of the Hawaii Energy Strategy are clear:

- Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;
- Increased energy self-sufficiency where the ratio of indigenous to imported energy is increased, and
- Greater energy security in the face of threats to Hawaii's energy supplies and systems.

But the Hawaii Energy Strategy 2000 (HES) fails to meet those goals: ·

- Does not reduce dependency on carbon-based fuels;
- Greatly increases carbon emissions;
- Subjects all of Hawaii's economy to the vagaries of world oil markets; and
- Misses opportunities to expand renewable energy markets in Hawaii

Climate change is already impacting Hawaii: ·

- Average temperature in Honolulu has increased 4.4 degrees F over the last century;
- Precipitation decreased 20% in same period · Droughts could lead to saltwater intrusion;
- Sea level is already rising 6-14 inches per century, likely to rise another 17-25 by 2100; and
- [There may be] Ecosystem disruptions, endangered species.

And the costs are, and will be, shocking: ·

- Eroding beaches and tourism;
- Cost of sand replenishment to protect coast from 20 inch rise:$340 million to $6 billion;

- Violent storms (more Inikis);
- Desalination of water
- Loss of agriculture; and
- Warmer temperatures

We can't predict exactly what climate change will bring, or how it will proceed, but its impacts on our environment will likely be greater than anything we've ever had to deal with. And once underway, scientists worry that feedback mechanisms, such as methane releases from melting tundra, will make catastrophic climatic shifts unstoppable.

Scientists worldwide agree: we must act now. A 1998, issue of the journal *Nature*, experts are urging for an all-out push for non-fossil energy. "The bottom line is that we are going to need an international effort pursued with the same urgency as the Manhattan Project or the Apollo space program. The roles of governments and market entrepreneurs in the eventual deployment of such technologies need to be considered more comprehensively than we have been able to do here. It is our hope that the potential adverse effects of humanity on Earth's climate will stimulate new industries in the 21st century, as did the Second World War and the Cold War in this century."

What does this mean for Hawaii? Hawaii needs to be a leader in its approach to energy. To meet this, the HES is challenged to clear a new energy future for Hawaii, and to use the Art of the Long View. Model all possible scenarios in a meaningful way, including the known and anticipated costs of climate change. Uses meaningful time horizons. Trend doesn't represent the future.

The HES must also be realistic. To ask marine and air transportation sectors to make dramatic cuts in emissions in the short term would be a challenge. Hawaii relies greatly on these sectors, and efficiency improvements won't likely be found in the near term. This means that ground transportation and electric utilities must take the greatest responsibility in decreasing Hawaii's greenhouse gas emissions. The HES focus should be on Ground Transportation and Electric Utilities for the following reasons: ·

- Constrained by reliance on air and marine for tourism and products;
- Technology unlikely to change greatly in marine and air transport sectors; and
- Combined sectors of ground transportation and electricity--69% of Hawaii's greenhouse gases from energy use.

Ground Transportation. Between 1990 and 1997, the fuel efficiency of our cars and trucks decreased 7%. Nearly one quarter of all carbon dioxide emissions in Hawaii come from our vehicles. The latest offering from Ford--the Excursion--a 4-ton, V-10, 10 mile per gallon 'sport' utility is currently available at Honolulu Ford dealers. Most trips in Hawaii are made with only the driver aboard. · 100% of our fuel comes from overseas · Average Honolulu resident expends 3% of his or her total expenditures on motor fuel · U.S. Energy Information Administration estimates this at $679 million in 1995--a significant portion leaving the state

There's more to the story. Not only are we clogging our streets and highways, risking our lives, and ruining our environment with automobiles, we're also draining money from the state. Cars coming to market now, like the Toyota Prius and the Honda Insight, are hybrid gasoline/electric vehicles that get up to 70 miles per gallon. And they offer the same comfort and performance of most passenger cars today. Reducing our ground transportation emissions is more than improving fuel efficiency. We need to reconsider our modes of mobility: public transit, car-pooling, telecommuting, and bicycling are better than driving alone. We also need to reduce the amount of driving that we do through smart land use planning. Different forms of transportation also make better use of the limited space we have.

Electric Utilities. The HES calls for the construction of new generating capacity on all four major islands in the next 20 years. Most of this electricity will be generated from oil- and coal- fired plants. Hawaii is the only state in the nation that is currently planning to build coal-fired power plants. There will be new generating capacity on every island -- mostly fossil fuel-based; and on Oahu: 605 MW of additional capacity, 70% coal, and 30% diesel

New [fossil fuel] Power Plants Mean: ·

Economic instability;

Money leaving the state;

Hastening climate change; and

Missed opportunities for demand-side management and renewables.

When Hunter Lovins, President of the Rocky Mountain Institute, was asked what new fossil-fuel power plants will mean for Hawaii, she responded, "Pure economic lunacy." When Donald Aitken, Senior Scientist at the Union of Concerned Scientists, was asked the same question, his response was "Economic folly".

The price of oil has been anything but stable over the past thirty years, but the HES uses only the U.S. *Annual Energy Outlook* to predict the price of oil over the next 20 years. The price of oil: ·

- Roller-coaster over the past 30 years;
- *Annual Energy Outlook* should be augmented with rigorous simulation, worst-case analysis;
- Hawaii is highly sensitive to price and supply; and
- Finite resource--inflection in supply all that is needed.

If we want to examine the outcomes of Hawaii's energy strategy in any meaningful way, worst-case scenarios for a doubling--or even quadrupling--of the price of oil must be considered. They're not in the HES. And no sensitivity analysis to was performed

Some oil strategists, such as Colin Campbell, believe that we have hit, or are nearing, the apex of oil availability, and we will see the price of oil dramatically rise as supply decreases and demand increases. Oil extraction has outpaced new oil field discoveries, yet we continue to pump oil without acknowledging its finiteness. One theory explaining the seemingly endless reported reserves is this: OPEC countries artificially inflated their "known" reserves in 1986 so that they could enjoy selling a greater quota. We don't need to run out of oil for serious economic disruptions to occur. In fact, because Hawaii's economy is so linked to the price of oil, the slightest shift could create economic chaos.

There are many sound reasons for leaving the carbon-based economy, and running out of oil is only one of them. As Hunter Lovins says, "We didn't leave the Stone Age because we ran out of stones."

It's time for Hawaii to lead. Hawaii has the best opportunities on the planet for demonstrating how clean energy can work. Not only do we have a diverse portfolio to draw upon (wind, solar, ocean energy, biomass, and perhaps geothermal), but we have the strength, location, and impetus to do it. No other U.S. state can boast that, and no other country has the stability, resources, or power.

Why Hawaii? ·

- Most dependent state on oil, relies on imported fuel for over 90% of energy needs;
- 21 degrees latitude;
- Political stability;
- Tethered to superpower;
- Complete portfolio to draw on;
- Developed nation-state; and
- Location to serve developing countries in Asia, Pacific Rim.

And it's our least expensive energy future, most reliable energy future, and best bargaining position for future carbon cutbacks. The bottom line for Hawaii is more money staying in the state economy, a more stable and secure future, and a strong bargaining position when carbon dioxide emissions become restricted.

Currently, money is pouring out of the state to pay for fossil fuels. Over 90% of our energy comes from oil. Smart companies and utilities are beginning to recognize that waste represents inefficiency. Carbon dioxide going out the smokestack is money. · For example:

- $1 billion LEAVES state on annual fossil fuel expenditures;
- Inefficiencies represent waste: generation and distribution; and

- Ahead of the curve - Intelligent big oil moving to renewables; and
- Companies like BP and Amoco are starting to realize that the future isn't in oil--it's in renewables. They've begun to invest heavily in more sustainable technologies.

The current HES is missing opportunities: ·

- Energy savings through aggressive DSM;
- Job creation
- Positioning Hawaii as world leader in sustainable technologies
- Exporter of renewable technology to developing countries; and
- Better environment

By fully embracing renewables as our energy future, we will create local wealth and jobs. Hawaii could be a training ground for developing countries to learn how to produce clean energy. The American Society for an Energy Efficient Economy estimates that over $500 billion dollars can be saved over the next 20 years in the U.S. if the U.S. exceeds the Kyoto goal.

Our future power plants can be found in our homes and business statewide. An aggressive DSM program would help place solar hot water heaters on homes, efficient chillers in buildings, and super-efficient lighting everywhere. Such measures would likely make projects like the Waahila Ridge powerline unnecessary, and keep money in the economy. We don't do enough DSM. On Kauai, a 26 MW naphtha-fired plant is proposed--but they only started their DSM in February 1998. Only 20% of homes have solar hot water. [Solar] Hot water heaters -- each would displace >1 kW. The 1996 Loudat Report indicated that every $1 spent on tax credit results in $1.30 created in Hawaii economy.

Just where does the hot water come from in 80% of homes on the islands?

- Conventional hot water heating: explore for oil--pump oil--pipe oil to supertankers--ship 5000+ miles--refine oil--burn at power plant--heat water to steam--send through turbine--turn generator to produce electricity--regulate electricity-- send current over grid--receive power at home--short circuit electricity in heating element-- heat water--take shower.
- Solar: send water through black pipes on roof--collect in water heater--take shower.

Hawaii doesn't need to venture into uncharted territory when it comes to DSM. In Sacramento (roughly the same population as Oahu), they found 400 MW of energy savings so they wouldn't have to build a replacement for their nuclear reactor. The Sacramento Municipal Utility District (SMUD) shut down an 800 MW nuclear generating station, and replaced that with a program of 400 MW of "conservation power plant" (DSM) and 400 MW of energy alternatives.

Renewables. Engineering economics of smaller sources are less expensive. The future is in decentralized renewables. No longer will we have huge dinosaurs burning fossil fuels and shipping out the electricity (with associated transmission line losses) to geographically scattered customers.

Can we afford this shift to renewables? We can't afford not to. Sacramento is making the shift quickly and easily--without raising everyone's utility rates. Sacramento installed photovoltaics on 450 homes, at utility expense, and then developed a buy-down program to yield another 1,500 PV roofs. SMUD is spending about 3% of its revenue for energy alternatives, 0.7% going to support their massive PV installation program, and rates are not increasing.

With limited land on our islands, the question always comes up, "How do we fit new renewable generating capacity?" Remember, think decentralized; a little here and a little there. The utilities are already figuring this out -- the Sun Power for Schools programs is placing photovoltaics on rooftops. We have a lot of roof space and parking lots to use as "power plants". And wind turbines can share land with other uses such as agriculture. These "power plants" include:

- Decentralized (small scale renewables, Rooftop PV, micro turbines); and
- Wind Power (Uses perhaps 1-3% of land that it actually occupies, Should be used with agriculture).

An essential component to demand side management is smart building. Intelligent design that utilizes daylighting, windows that open, efficient lighting, and smart building materials and floor layout minimize a building's energy load. One of the newest, most creative buildings doing this is in New York City. Why not Honolulu? An example of a smart building is Four Times Square -- Two 200 kW fuel cells in the basement, as well as 15 kW of solar electric glazing on its upper floors. It uses super efficient chillers, lighting, ballasts, and was designed to obviate need for lighting and cooling.

There's more to the story than just economics and the environment. LA's most important driver and justification for the utility's investment in on-site (decentralized) energy generation was to provide safety and reliability, especially in time of crisis. Harmony in St. Johns, which is a resort that is entirely powered by solar energy, was the only resort still functioning after the hurricane.

We need to change the system. Why do we reward the utility for burning more fossil fuel? With guaranteed returns on investment, this is essentially what we are doing. As an alternative:

- PUC should reward utility for cutting customers' bills (Pacific Gas and Electric says will never build another power plant after CA PUC changed); and
- Create third party to run DSM program.

We should follow PG & E's lead and have our PUC reward the utility for cutting their customers? bills through DSM. And if the utility can't seem to be handle this task, it's time to assign it to someone else.

The utility is stifling progress: ·

- Not supporting net metering;
- Offering incentives to stay on-grid;
- Confusing economics of renewables;
- Disregarding impacts of climate change;
- Cutting DSM programs, and
- Parent Company, HEI, makes coal investments in China and Philippines.

Utilities are in the business of making money for their shareholders. But if government is going to allow a monopoly in Hawaii, we should expect them to act in the public's best interest. But we must call on government leadership and grassroots pressure to create the change we need.

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- Need to do accurate modeling of all outcomes (climate change, oil prices, etc);
- Need to mandate a shift away from carbon economy--meet and exceed Kyoto Protocol;
- Incremental renewable energy growth at 5-year intervals to 100% renewable by 2050; and
- Trend does not represent destiny.

For the HES to have any validity in its recommendations, proper modeling of all outcomes must be performed. A carbon tax must be modeled as a proper revenue neutral tool with money staying in the economy, not as simply more expensive fuel. The impacts of climate change must be quantified and integrated into the model. And uncertainty analysis must be calculated for varying prices of fuels. If we choose, Hawaii can be independent of imported fossil fuels by 2050.

17.2.4 Comments of Dr. Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu

Hawaiian Electric Company, Inc. (HECO) has reviewed the draft *Hawaii Energy Strategy 2000* (*HES 2000)* report dated November 16, 1999. Again, thank you for the opportunity to participate in the review process of the *HES 2000* report and also the recent workshop on the *HES 2000*. We note that there are many areas where we are in agreement with the recommendations in the *HES 2000* report. The areas of agreement include:

- Encourage early deployment of electric vehicles,
- Identify, designate, and permit sites for future electricity generation consistent with IRPs,
- Continue to pursue greater efficiency in fossil fuel generation,

- Continue to assess need for renewable energy state income tax credit,
- Continue to support cost-effective utility DSM programs,
- Continue to work with USDOE to provide for rule making to implement Strategic Petroleum Reserves priority access sales provisions,
- Actively promote Hawaii energy and environmental companies (abroad),
- Conduct RD&D on renewable energy technology using Hawaii's abundant renewable energy resources, and
- Conduct RD&D on electric system efficiency and clean energy for electricity generation in Hawaii.

However, since the *HES 2000* is intended to be a basic element in the State energy planning and development process, we have serious concerns with other recommendations made in the report. This letter to you provides both general comments and detailed comments explaining our concerns. The detailed comments are presented in the attachments to this letter.

***HES 2000* should be corrected before publishing.** [Editor's note: Errors of fact brought to our attention by HECO were corrected. Many differences of opinion remained.] As stated in the draft report, the purpose of the *HES 2000* report is "to assist State of Hawaii planners and policymakers, members of the Hawaii energy community, and Hawaii's people to better understand Hawaii's current energy situation." Further, the draft report states that the *HES 2000* "develops and analyzes possible future energy scenarios and suggests a preferred energy future for Hawaii." To achieve this "preferred energy future for Hawaii", the *HES 2000* presents numerous policy recommendations, many of them very specific and many of them with potentially significant impacts on Hawaii. Our concerns stem from the fact that many of the potential impacts have not been fully analyzed. In many cases, misleading, incomplete, out-of-date or inaccurate information was used in the analysis of potential impacts. To achieve the stated purposes of the *HES 2000*, we strongly recommend that these flaws be remedied before the report is published. To do otherwise would be a great disservice to the audiences that the *HES 2000* is intended to serve.

***HES 2000* contains incomplete and misleading information.** We find in several instances the *HES 2000* selectively presents information to support the policy positions of DBEDT. Regarding forecasting future oil prices in section 3.6, the *HES 2000* provides the U.S. Department of Energy's fuel price forecast and balances it with section 3.6.2.4 which provides a competing view that oil prices will be much higher than forecasted.

However, in other instances, the *HES 2000* is one-sided and misleading. Regarding renewable energy, Chapter 8 contain many recommendations for installing non-cost-effective renewable energy systems for electricity generation in Hawaii. Table 13.4 in Chapter 13 shows the estimated negative impacts to the economy. However, there is little or no discussion of the negative economic impacts of these recommendations. Also, in Section 8.4.2.1, the *HES 2000* down plays the utility's concern on the limits to the amount of wind power the utility grid can accept. In fact, the *HES 2000* report presents only a portion of the conclusions from a utility study on allowable wind penetration (see comment 24 in Attachment 2) thereby changing the conclusions.

Regarding Global Warming, there is no mention in the *HES 2000* that many climate experts disagree with the Kyoto Protocol (see attached Congressional testimony of Dr. Fred Singer [provided by HECO] in [their] Attachment 3) or that some scientists who participated in the IPCC report claim that significant, unauthorized alterations were made to the conclusions in the final draft of the report before it was published.

Also, there is also no discussion in the HES 2000 report of the tradeoffs involved in a policy to reduce Hawaii's greenhouse gas emissions. The HES 2000 report shows that there will be negative economic impacts for Hawaii and that the associated reductions in greenhouse gas emissions will be nominal, at best. In addition, any state-based program initiated by Hawaii at this time may very well be inconsistent with and pre-empted by a national program.

Regarding electricity competition, the *HES 2000* goes into great detail on the possible benefits of competition in Hawaii based on recent developments occurring on the mainland. The *HES 2000* report recommends electricity competition in Hawaii. However, there is no discussion on whether the perceived benefits of competition would actually occur in Hawaii. The *HES 2000* does lists HECO's concerns for the possible negative impacts of electricity competition in Hawaii, but there is no further discussion or explanation on how or even if these negative impacts would be addressed.

Without a complete and balanced analysis of these complex issues, it will be impossible for planners and policy-makers to make informed decisions. The PUC has established a docket to consider all the issues related to electric competition in the state of Hawaii. Given this effort by the PUC, we recommend that recommendations regarding electric competition in Hawaii be deferred to the docket before the PUC.

***HES 2000* focuses on short-term impacts.** For many of the analyses in the *HES 2000*, short-term impacts appear to be the primary consideration. An example is the assessment of economic risks summarized in Section 2.2.3. These negative, short-term economic impacts are cited repeatedly in *HES 2000* as justification for the increased use of more expensive renewable technologies which will have long-term, negative impacts on electricity prices (i.e. electricity prices will be higher). The frequent focus in the *HES 2000* on the short-term impacts of long-term plans is inconsistent with the perspective provided by Dr. Seiji Naya, Director of DBEDT. In an April 22, 1997, meeting with Dr. Naya, you [Maurice Kaya], Michael May, President of Hawaiian Electric, and other HECO executives, Dr. Naya stated that long-range planning should be undertaken with "normal" conditions in mind.

The difference in long-term vs. short-term impacts is a key difference in planning perspectives and planning analyses. It is interesting to note that *HES 2000* acknowledges on page 2-10 that "by investing in alternate energy 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." This statement in the *HES 2000* is consistent with the results of an analysis done by the National Economic Research Associates (NERA) consulting firm as part of the HECO IRP-2 planning process. The NERA study showed that, in the long term, increased use of more expensive renewable generation technologies would create more jobs.

However, due to the resulting higher cost of electrical energy from these higher cost renewable technologies, the <u>long term</u>, <u>net economic impacts were negative</u> compared to the base case where the most cost-effective generation technologies were used. This was the case even when an oil price spike was included in the economic analysis. So, even with circumstances most favorable to renewables (i.e., an oil price spike), the long-term economy was better off without renewables than with renewables. Thus, renewable energy policy recommendations based on short-term impacts may not be in the best, long-term interests of the state.

HECO and DBEDT should work together Thank you for the opportunity to provide our comments and we would like additional opportunities to work with you in the refinement the *HES 2000* report prior to publication.

Attachment 1 -- HECO's General Comments on draft Hawaii Energy Strategy 2000 Report

The following points are general comments on the themes and issues contained in the *HES 2000* report. Specific comments on various sections in the report follow these general comments.

Electricity Competition. Electric competition is a complex issue that requires knowledge of the underlying market forces. It is too simplistic to attribute lower electricity prices on the mainland to competition without considering the effect of the deregulation of the natural gas industry and other effects. The HES 2000, in recommending the restructuring of the Hawaii electric industry, does not consider whether competition is feasible in Hawaii, the possible negative impacts from competition and the implications for the people and economy of Hawaii. Since the start of electric competition on the mainland, there have been instances of spikes in electricity prices of several thousands of dollars per MWh during generation shortages caused by heat waves.

In addition, the HES 2000 does not address how competition will address some of the reasons for higher electricity prices in Hawaii mentioned in section 7.2.2.2 of the HES 2000. The PUC has established a docket to consider all the issues related to electric competition in the state of Hawaii. Given this effort by the PUC, we recommend that recommendations regarding electric competition in Hawaii be deferred to the docket before the PUC.

Renewable Energy Technologies. The *HES 2000* report recommends considering implementing scenario E2 (maximize renewable energy in the electricity sector). There is very little discussion of the potential negative impacts that scenario E2 would have on the state economy even though there are tables and charts in the *HES 2000* that depict such impacts on the state economy. Furthermore, the recommendations to consider the non-cost-effective renewable energy resources contradicts other sections in the HES 2000 that indicate higher electricity prices are detrimental to the Hawaii economy and that steps need to be taken to reduce the cost of electricity in Hawaii.

Global Warming. The HES 2000 report has a predominant and seemingly overriding focus on the global warming issue. While this issue has received increased media attention, there are additional issues that need to be considered such as impact to the state economy and the implication of such impacts on the people of Hawaii, impact on energy consumers (both residential and commercial), and system reliability. Any recommendations concerning Hawaii's energy future should be based on a more balanced view of energy and should not be focused on global warming.

Setting specific goals at the state level for reducing greenhouse gas emissions is premature. At this time, the nations of the world have yet to reach agreement on the appropriate goals and strategies for dealing with climate change. There are still major unresolved issues such as the participation of developing countries and greenhouse gas accounting mechanisms. Hawaii's efforts should be coordinated with the rest of the nation and the world.

Please note that HECO is not advocating that the global warming issue be discounted or ignored. As you know, HECO has made voluntary commitments in its Climate Challenge Program in which, among other activities, HECO continuously aims to improve system generation efficiency thereby reducing greenhouse gas emissions. In addition, HECO plans to continue its demand-side management programs and renewable energy activities. HECO is simply urging DBEDT to present a balanced view of the issue so that planners and policy-makers can make an informed decision.

Oil Prices. Throughout the report there is speculation on many possible events that could increase oil prices, but the report makes no attempt to assess how likely they are to happen. For example, in section 3.7 on page 3-27, the 2nd to the last paragraph states that, "Should oil prices rise sharply…", but what is the chance of this happening? What is the chance of oil prices staying the same or declining?

Other Concerns. Many of the recommendations contained in the HES 2000 could have significant impacts to the consumers of energy in Hawaii. However, only one recommendation, that which deals with fuel substitution between gas and electric utilities, suggests involvement of the State's Consumer Advocate. Recommendations dealing with consumers, especially increasing renewable energy and electricity competition should also identify the State's Consumer Advocate as one of the lead organizations.

During the HES 2000 public workshop, ocean-water cooling for air conditioning was mentioned to be cost-effective for hotels in Waikiki area. Please note that it is our understanding that ocean-water cooling is not cost-effective because it would require a pipeline extending more than two miles out to sea to obtain sea water of sufficient cold temperature. Also, the associated potential environmental impacts and public opposition to shoreline construction in Waikiki would be significant factors in the viability of such a project.

[Editor's Note: Attachment 2 was the Testimony of Dr. S. Fred Singer, President, Science & Environmental Policy Project to the Committee on Small Business, U.S. House of Representatives, on July 27. 1998. It is not reproduced here. It is available on the Internet at http://www.sepp.org/glwarm/testimony.html

Attachment 3 contained detailed comments. Where HECO's suggestions were not included in the report, they are referenced below by Chapter.]

17.2.4 Comment by Dr. Bruce S. Plasch, Decision Analysts Hawaii, Inc., Honolulu

Excellent report and workshop.

17.2.5 Comments by John Shin, AES Hawaii, Kapolei

AES Hawaii, Inc. is the single largest supplier of electricity to Hawaiian Electric Company. The only coal-fired plant on Oahu is capable of supplying more than 180 megawatts of electricity, about 20 percent of Oahu's electricity needs. The plant also produces 30,000 pounds of steam per hour for the Chevron oil refinery in Campbell Industrial Park.

AES Hawaii, Inc. began commercial operations in September 1992. The plant uses state-of-the art clean coal technology called Circulating Fluidized Bed (CFB) that makes the plant one of the cleanest in the world. AES Hawaii also uses post-combustion technology to further reduce pollutant levels to well below EPA standards.

AES Hawaii is a subsidiary of the AES Corporation, founded in 1981, which is the world's largest global power company. The Company is dedicated to supplying safe, clean, reliable electricity to meet global energy needs. AES generates and distributes electricity and is also a retail marketer of heat and electricity.

AES owns or has an interest in one hundred and eleven plants totaling over 40,000 megawatts in 16 countries. AES also distributes electricity in 6 countries through 14 distribution businesses. In addition to having assets in excess of $10 billion, the Company has numerous projects in construction or late stages of development.

AES has placed more than $8 billion of financing with commercial banks, export credit agencies, multilateral financial institutions and public markets. The Company employs roughly 40,000 people around the world. [Editor's Note: A table depicting AES growth was provided, but is not reproduced here.]

Meeting the State's Energy Objectives: There were three main objectives identified for the workshop. AES Hawaii appreciates the opportunity to provide the following comments and ideas.

Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;

The CFB coal-fired plant, since starting operation in 1992, has proven to be highly efficient and reliable. It has an availability of almost 98 percent over the life of the plant, compared to about 88 percent industry average.

Since much of the infrastructure is already in place, new capacity can be added for 4-6 cents/kWh, comparable to the cost of new capacity for coal on the mainland. This is a significant advantage over new capacity for oil, which is 7-11 cents/kWh.

The emission of criteria air pollutants from the CFB coal-fired plant is well below the applicable Ambient Air Quality Standards, and lowest of the major generating plants on Oahu. A new coal-fired plant will have lower emissions overall than a comparable oil-fired plant. To offset all carbon dioxide emitted from the facility, AES Hawaii fully funded a program to preserve 143,000 acres of rain forest in Paraguay. AES will consider similar programs for carbon offset for new capacity that is brought online by us in Hawaii.

Increased energy self-sufficiency where the ratio of indigenous to imported energy is increased; AES, although mainly reliant on imported coal, uses technology that enables burning of locally produced fuel sources and waste products. AES already burns over 1% in alternate fuels such as shredded tires (TDF) and spent activated carbon from the Board of Water Supply. Fuel sources that would otherwise would be wasted and expensively transported out of state for disposal. AES is also capable of burning waste oil, other wastes and by-products, and renewable fuel sources from agriculture to alleviate the growing disposal problems that these wastes cause, as well as supplementing coal with renewable energy sources. It’s possible to replace significant amount of oil used on Oahu by using these waste or renewable fuel sources through the CFB boilers.

By being able to burn these wastes in a controlled process, the environmental damages that these wastes cause are largely mitigated. A CFB coal-fired plant has this technological advantage over an oil-fired plant.

Presently, the financial cost to the State and the consumers, of properly disposing of these wastes, is tremendous. AES Hawaii is the only electricity generator in the State that is properly permitted and has the necessary technology and capacity to handle all these waste products in an environmentally sound manner.

Greater energy security in the face of threats to Hawaii’s energy supplies and systems; AES Hawaii is the only electricity generator on Oahu that uses coal. As such, AES offers the only large-scale alternative to dependence on imported oil. High quality coal, such as the one AES uses, is readily available from many worldwide sources. The price of coal is much lower than oil and also much more stable. Additionally, by being able to use locally generated wastes and locally produced renewable energy sources, dependence on imported fuel will be reduced.

By planning new capacity using coal-fired technology, further reduction of the State’s dependence on oil can be achieved. The cost of new electricity generation will be lower, not just because of the lower price of coal, but also because of the reduced volatility of the fuel price. The consumers and businesses will see a lower and more stable cost on their electricity bill, thus promoting economic growth.

17.2.6 Comments by Cliff Slater, Honolulu, Hawaii

Attached is a recent *Honolulu Advertiser* column I wrote on "global warming." Please consider this letter and the column as my comments on the *Energy Strategy 2000* draft.

First, the underlying premise of the Energy Strategy 2000 draft that global warming is a real threat to our way of life. My column on global warming, and its accompanying footnotes, shows there is no agreement among our leading scientists that such is the case. Until there is some consensus among them on the global warming issue, the State of Hawaii should take no action that would negatively impact our already weak economy.

Second, the comments on oil use have no place in a serious document about energy use. They are reminiscent of the forecasts of impending doom from the World Watch Institute and others who have warned of imminent shortages since the 1970s. Such warnings have been around since the U.S. Geological Survey started warning about potential oil shortfalls in the 1890s.

The facts are that:

- The price of oil, in real terms, is not much higher than before the 1970s.
- Total world oil consumption is hardly more than it was 20 years ago.
- The world's proven reserves are higher than they have ever been.

Mr. Slater included a copy of his "Second Opinion" column article, entitled "Much ado about hot air" which appeared in the *Honolulu Advertiser* on October 14, 1999. It is available on the Internet at: http://www.lava.net/cslater/warmingf.htm.

17.2.7 Comments by Gabriela Taylor, Citizens for Clean Air, Kauai

I was impressed with the scope of information that was covered in the conference day. It was a thorough coverage of the topics. All the presenters were excellent. The discussion was not adequate, however.

My feeling is that there needs to be more of a dedication to the critical issues by DBEDT. The energy consumption situation is urgent in Hawaii and the IRP is the guiding force. In my opinion, DBEDT is far too casual in their regulation of the energy distributions systems. If DBEDT does indeed see the impending doom of continuing on the same course with the indiscriminant burning of fossil fuels in our automobiles and electric power plants, namely the contribution to global warming and devastating climatic changes, then DBEDT needs to become more aggressive in their regulatory function. [Editor's Note: DBEDT has no regulatory functions in energy.]

It was startling to learn that DBEDT does not consider the further contamination of the air we breathe by contaminants from diesel fuel power plants as a public health hazard (Steven Alber). [Editor's Note. No such statement was made in conference. In a separate discussion of the Kauai Power Partners project, Mr. Alber indicated that the emissions from the proposed plant would be within limits specified by EPA and State of Hawaii Department of Health regulations.] I believe that air contaminated to a significant (terminology used in the EIS [Environmental Impact Statement] by KE in regards to their proposed diesel fuel power plant) level by nitrous oxides, sulfur dioxides, and particulate matter should be a concern. Health [problems] such as lung disease are a cost that needs to be fit into the equation of costs when new projects are being considered. We have pristine air on the Island of Kauai (except by the Port Allen power plant) and any large increase (even below the EPA standards) is an unacceptable price to pay for "cheap, but dirty" power.

Hawaii is one of the few places in the USA where we have all three of the sustainable energy sources: water, sun, and wind. The improved technologies for these sustainable sources, plus fuel cells are making it possible for new directions in power production (using distributed energy systems). Diesel power plants are not being built in most states on the Mainland. Why are we saddled with outdated energy solutions? DBEDT needs to get some current statistics for the cost of these alternatives. The figures in the IRP are outdated. It is your job to supply current data for evaluation and comparison purposes.

In addition, it is your role to assist in the passage of bills in the Legislature regarding net metering and wheeling to go along with deregulation.

My recommendation is for you to put some teeth into your regulations and use the power you have to back up the evidence.

The people of Hawaii are entrusting you with their future. You have the opportunity to guide use into a clean and sustainable 21st Century.

17.3 Specific Comments Referenced by Chapters in the Report

The following comments are organized by referenced chapter. Only those chapters receiving comments are listed.

17.3.1 Chapter 1 State Energy Policy and Hawaii Energy Strategy 2000

- Besides proposing a new State energy objective related to climate change to the 2000 Hawaii State Legislature, the State of Hawaii government should mandate a (say) 20% reduction (relative to 1990) of its own energy use in a manner similar to the Federal government's own mandate of 30% [reduction] by year 2010. **(Dr. Ray Carr, Energy Coordinator, County of Hawaii, Hilo)**
- As the basic element of the planning and development process for DBEDT and the State, *HES 2000* should provide a comprehensive, unbiased, and balanced view of energy as it relates to business, economic development, and tourism in the State. This is necessary to (1) increase the understanding of Hawaii's energy situation, and (2) produce

recommendations to achieve State energy objectives. However, the predominant focus of *HES 2000* seems to be on climate change which is only one consideration of many in the planning and development process, and only one aspect of Hawaii's energy situation and energy objectives. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference Section 1.2.** Including "reduce greenhouse gas emissions from energy supply and use" as an objective for the HES is premature at this time. While climate change is an important issue for Hawaii, the focus on climate change in *HES 2000* is inappropriate and inconsistent with the *HCCAP* recommendations for goal setting. The *HCCAP* recommendation is to "develop consensus as to Hawaii's goals for greenhouse gas emission reductions." (*HCCAP* section 1.1.3 and section 5.1). As stated, the *HCCAP* recommendation does not support inclusion of an additional objective in the HES to reduce greenhouse gas emissions at this time.

  The position that Hawaii can and should play a role in reducing its greenhouse gas emissions that contribute to climate change is fundamental to most if not all recommendations in the HES report. However, this position is premature. The implementation of the Kyoto Protocol is still the subject of debate at international levels. Hawaii should first allow the goals and strategies for dealing with the global issue to be established at the national level, and then Hawaii should determine how it could cost-effectively participate. For Hawaii to act prior to and independently of a national strategy is premature and possibly counter-productive, as the state economy may be unnecessarily damaged. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

17.3.2 Chapter 2 Energy, the Economy, and the Environment

- **Reference: Section 2.2.1.** The statement, "Hawaii's own renewable resources are not fully used . . ." requires additional clarification to put it in the proper context. Using renewable resources requires land, which may be used for other "better" purposes. There are many competing uses for land in Hawaii because land is a very limited resource. From a business and economic viewpoint, although the "renewable resource" opportunity might be foregone, the alternative use might be the "better" use of the land resource.

  HES 2000 states that studies have found that energy efficiency and renewable energy result in more jobs, higher personal income, and marginally higher economic output than the fossil fuel base case. It should also state that other studies show that the higher cost of electricity from renewable energy would result in net, negative long-term impacts to economy. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference: Section 2.3.1.** Are these [oil spill] impact studies up to date? The recent, 1998 Tesoro single point mooring oil spill demonstrated that currents may not be as predictable as experts once thought. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**
- **Reference: Section 2.3.2.** *HES 2000* states that "about twice as much fuel is used for transportation than for electricity generation." Yet, DBEDT's primary focus is on the utility sector and not transportation. The *HES 2000* should focus additional effort on the energy use in the transportation sector. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**
- **Reference: Section 2.3.4.** When land use related to transportation is discussed, the focus is on the need to transport and store the fuel consumed by electric power facilities. Airports, roadways, parking facilities, and harbors are examples of transportation-related land use that would exist without the need to transport and store fuel for electric power facilities. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**
- **Reference: Section 2.3.5.** In regards the IPCC report, *HES 2000* does not provide balancing information, i.e., that there are credible critics to the IPCC report. See attached Congressional testimony of Dr. Fred Singer [see synopsis above]. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**
- **Reference: Section 2.3.5.5. (Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

17.2.3 Chapter 3 Meeting Hawaii's Energy Needs

- The strategy of Hawaii energy self-sufficiency must be based on sustainable development. We should set a firm schedule to meet this objective of self-sufficiency.

  Looking at the $1 billion expenditure for oil imports, we should set a reduction target and schedule to achieve that objective. Looking back at the 1973 energy crisis today, can we feel comfortable not cutting back a big percentage of oil imports? **(Dr. Yu-Si Fok, Professor, University of Hawaii at Manoa, Department of Civil Engineering)**
- **Reference 3.6.2.4.** It should be noted that Campbell is one of a few experts who believe that oil supplies will be declining in the near future. His opinion and the article that is cited need to be taken in the context of other expert assessments on oil supplies (e.g. the Scientific American special report published in March 1998) which balanced the view of declining oil supplies with the view that new technologies and

unconventional oil supplies will be able to meet future demands. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference Section 3.7.** That price shocks may or may not damage the economy is conjecture. The impact may be a function of the sustainability of high prices. There is a need to balance the possibility of oil price shock with the certainty of higher electricity prices from renewables.

  The statement that, "…energy companies have not sought to insure future supply through greater reliance on renewable resources" conflicts with DBEDT's concerns that "Hawaii's average electric revenues are the highest in the nation", and that "high electric revenues tend to reduce employment". **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- Recommendation: Use the Environmental Impact Statement process to identify energy needs for a project. Identify a measurement to compare energy usage to other similar activities.

  Develop energy-use guidelines for new/rebuilt projects. Develop a matrix with positive and negative factors highlighted for each proposed project. Make a big deal about energy usage so developers know that energy needs are an important criteria for projects.). **(Anonymous HES 2000 Workshop Attendee)**

- Energy needs:
  - To change peoples' consumption of energy (adopt California Air Resource Board energy efficiency rules).
  - More needs to be done to educate or force a reduction (through disincentives) of energy consumption.
  - Use "Environmental Ethic" to demonstrate that personal actions can save energy and have environmental impact (Take Hawaii Fun Fueled Activities Book to school – make it part of curriculum).
  - Promote recycling activities/tax waste (product life cycle considerations). Government specifications for recycled product use in public works. **(Anonymous HES 2000 Workshop Attendee)**

17.3.4 Chapter 4 Energy for Ground Transportation

- The biggest advance in ground transportation efficiency in many years is the hybrid vehicle. We need to stimulate their adoption in Hawaii as much as possible through public policies and/or legislation since these vehicles do not have a champion. **(Dr. Ray Carr, Energy Coordinator, County of Hawaii, Hilo)**

- I would recommend that the State encourage the use of electric cars or other low emission vehicles by making it easier for consumers to purchase such. Right now, and for the foreseeable future, an individual has no means to easily buy such a vehicle. If consumers have to go to great lengths to simply find a low emission vehicle they will not buy one. I know, I tried to find one, could not and ultimately bought a conventional gas burner.

The State should require that auto dealers and suppliers to provide such vehicles to their customers. Another option is to require the auto rental companies to provide electric cars to travelers. What better way to impress our visitors about our seriousness about keeping our paradise clean? If fleet vehicles are the only means to introduce low emission vehicles, rental cars may be a viable way to do so. However, the only way to get the vast amount of personal vehicle users to use alternatives, the alternatives must be easily accessible. **(Dan Nugent)**

- Need incentives to encourage purchase and use of hybrid gas/electric vehicles, which require no new infrastructure to support, yet are two to three times as efficient as gasoline engine vehicles without the range limitations of all-electric vehicles. The Toyota Prius is expected to be in major markets by summer 2000. **(Bill Nutting, Marine Corps Base Hawaii Facilities Department)**

- Poor land use planning. No long-range surface transportation planning that [includes] mass transit as opposed to road building**. (Jon Olson, Big Island Rainforest Action Network, Pahoa, Hawaii)**

- Continue efforts to increase ridesharing and use of mass transit to reduce energy use. **(Dr. Bruce Plasch, Decision Analysts Hawaii, Inc.)**

- Provide incentives for getting people out of their cars.
  Eliminate/minimize "all day" parking in urban areas.
  Price employee and government employee parking lots fairly to promote public transportation.
  Provide incentives for people to select smaller, more efficient cars (use California Air Resources Board rules).
  Partner to build public transit system (set goal of system to come on line as soon as possible).
  Build free car parks in areas to use public transit.
  Incentives for bike users and create SAFE bikeways.
  Build SAFE walkways in suburban areas.
  Minimize new road building projects (Shift funds to public transit and bike and walkways). **(Anonymous HES 2000 Workshop Attendee)**

- Suggest that state support "pay-at-the-pump" basic car insurance. Recognizing that this would increase the cost for each gallon of gas, it would have the following benefits:
  - Promote use of more energy efficient cars;
  - Promote use of mass transportation;
  - Promote car pooling;

- Provide basic auto insurance for everyone; and
- No net increase in cost for those who have car insurance.

(Anonymous HES 2000 Workshop Attendee)

- Presenting carbon and other pollutants on a per mile traveled basis for each fuel and alternative fuel would be a good educational tool. This emission estimate must be presented on a life cycle basis, not just combustion alone. For example: Electric car emissions associated with fuel, power plant emissions, transportation of fuel; photovoltaics – emissions associated with mining materials. Comparable numbers to help inform the decision maker. **(Anonymous HES 2000 Workshop Attendee)**

17.3.5 Chapter 7 Generating Electricity for Hawaii

- **Reference: 7.2.2.2.** The following paragraph should be inserted:

  "Inflation also contributes to higher costs, however, rate increases do not simply track the current rate of inflation. As the PUC has recognized in prior rate cases, the need for rate increases can be caused by current inflation, which causes expenses to increase faster than revenues, <u>or by the addition of substantial capital projects</u>. During periods when substantial capital additions are taking place, past inflation causes new plant additions and replacements to cost substantially more per unit of capacity than the depreciated original cost for an equivalent existing unit of capacity. Rate increases are needed as current or incremental costs rise above average and imbedded costs on a per-unit basis, and with electric rates fixed on a per-unit basis." **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference 7.2.2.3.** "The effect of differences in electricity cost between the Mainland and Hawaii also requires consideration of the differences in electricity usage intensity". **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference 7.2.2.4.** "Delete this section. Currently, the PUC reviews utility revenue requirements in comprehensive rate case proceedings. That is the proper forum for this review, and the Consumer Advocate has the responsibility to review the reasonableness of the utility's requested revenue requirement. Having the PUC conduct additional reviews would result in additional cost, without additional benefit". **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference 7.11.2.3.** The utilities testified against Distributed Power and Net Metering. The lead agency should be those entities that support distributed power. **(Henry Curtis, Executive Director, Life of the Land, Honolulu)**

- "Add 'Community' to Chapter 7 lead organization's chart". **(Jon Olson, Big Island Rainforest Action Network, Pahoa, Hawaii)**

17.2.6 Chapter 8 Increasing Renewable Energy Use in Hawaii

- Renewable energy [technologies] were identified many years ago. They are not used due to "high cost"!! Why do we just look at the tangible high cost and not consider the low intangible cost of using them? (We have to use the complete cost analysis of tangible and intangible costs to arrive at our conclusion.) Intangible costs [benefits, in this case] are mostly from environmental cost accounting. Government cannot avoid using them to justify our budget. **(Dr. Yu-Si Fok, Professor, University of Hawaii at Manoa, Department of Civil Engineering)**
- **Reference 8.4.2.2., 8.4.3.2, 8.4.4.2, and 8.4.5.2** Let's mandate photovoltaic cells and net metering for all buildings built with tax credits. **(Henry Curtis, Executive Director, Life of the Land, Honolulu)**
- **Reference 8.4.2.2.** Is a dedicated biomass-to-electricity facility reasonable for Oahu? There is no dedicated biomass-to-electricity facility in operation in the U.S. All biomass operations in the U.S. use biomass waste products. *HES 2000* should recommend how biomass can fit into the energy mix. **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**
- **Reference 8.5.1.1.** If accurate cost data is not available now from the electric utilities, why ask them for accurate cost data in the future? It is clear that our utilities like high prices, they oppose competition. DBED should also find the true cost of oil, so we can make a true assessment of the relative cost of fossil fuel versus photovoltaics. Finally, just as photovoltaics should include generation and storage, fossil fuel costs should include generation and transmission. **(Henry Curtis, Executive Director, Life of the Land, Honolulu)**
- **Reference Sections 8.5.3.2 and 8.5.3.3.** NREL lists specific strategies, which include system benefit charges and renewable energy portfolio standards. The *HES 2000* recommendation to implement the NREL strategies of the renewable resource docket contradicts other sections of *HES 2000,* which seek reductions in electricity cost.

  A system benefit charge is a tax or user fee to the electric customers. This adds cost to the utility which will be reflected in the electricity rates. *HES 2000* reports that high electricity revenues reduce economic performance and cost jobs. This is not consistent with sound economic policy in the State.

  HECO's own experience and the experience of other companies currently installing renewable energy resources indicate that the cost estimates and assessments of commercial availability of most renewable resources are highly optimistic and unsupported. In time, some of these renewable energy technologies may become cost-effective and commercially available. Mandating renewable energy portfolio standard requirements would be arbitrary and would not provide the best cost options to the customers. Renewable energy portfolio standards would be analogous to agreeing to buy something without knowing the price of either what is being purchased or the alternatives. Is this the kind of policy that is good for sound, economic development in the State? **(Dr Brenner Munger, Manager, Power Supply Planning and Engineering, Hawaiian Electric Company, Inc., Honolulu)**

- **Reference 8.5.3.3.** Let's have 50% renewables by 2020. Those who immediately say "can't be done" are not included as lead agencies. Everyone who has read the recommendation "Consider implementing a Renewable Energy Portfolio Standard, Public Benefit Charge, or Green Pricing" has considered it. Now let's do it.**(Henry Curtis, Executive Director, Life of the Land, Honolulu)**
- We do not view geothermal as successful. H_2S (hydrogen sulfide) leaks/pentane loss of nearly 50,000 gallons per year. Use of caustic soda to abate air emissions and that impact. Social impact to surrounding community of loss of land value; noise as an impact. **(Jon Olson, Big Island Rainforest Action Network, Pahoa, Hawaii)**

17.3.7 Chapter 11 Increasing Energy Efficiency in Hawaii's Buildings

To improve energy use efficiency:

- Phase out low-efficiency hardware (similar to phase out of 5-gallon tank toilets.
- Promote automatic turn-off switches. (If there is enough sunlight, street lights, office lights, and others will be turned off automatically.
- If the state can cut its budget at 4-4-4, why can't our electricity be cut 4-4-4?

(Dr. Yu-Si Fok, Professor, University of Hawaii at Manoa, Department of Civil Engineering)

APPENDIX A TABLES

Table A.1 Hawaii Crude Oil Imports (Barrels/Year), 1990-1997

Source	1990	1991	1992	1993	1994	1995	1996	1997
Foreign Crude Oil Imports								
Asia								
Australia	8,431,500	3,945,650	1,992,900	2,819,000	4,096,000	5,068,000	7,617,000	9,022,000
China	1,938,150	1,237,350	3,595,250	829,000		1,013,000	6,155,000	5,846,000
Indonesia	16,837,450	18,636,900	15,731,500	19,295,000	25,797,000	20,983,000	11,577,000	15,636,000
Malaysia	2,332,350	4,223,050	2,452,800	1,014,000		1,400,000	502,000	649,000
Papua NG			740,950	993,000	3,475,000	1,669,000	2,707,000	1,375,000
Vietnam						346,000	4,949,000	1,557,000
Americas								
Argentina			372,300					721,000
Canada			175,200	128,000				390,000
Colombia								218,000
Ecuador	974,550		693,500	703,000	672,000		200,000	
Venezuela		171,550	160,600	352,000	166,000	200,000	182,000	197,000
Mideast						1,391,000		
Oman			197,100	611,000				240,000
Foreign Subtotal	**30,514,000**	**28,214,500**	**26,112,100**	**26,744,000**	**34,206,000**	**32,070,000**	**33,889,000**	**35,851,000**
Domestic Imports	**17,630,553**	**23,909,420**	**20,755,738**	**22,321,911**	**21,049,157**	**19,070,492**	**18,149,220**	**14,999,609**
Total	**48,144,553**	**52,123,920**	**46,867,838**	**49,065,911**	**55,255,157**	**51,140,492**	**52,038,220**	**50,850,609**

Sources: 1990-1992, Pacific West Oil Data cited in EWC 1993; 1993-1997 DBEDT 1999

Table A.2 Hawaii Refined Petroleum Product Trade, 1997

Barrels of Product	Imports			Exports		
	Domestic	Foreign	Total	Domestic	Foreign	Total
Distillates	62,786		62,786	668,000	11,000	679,000
Jet Fuel	311,084	5,134,912	5,445,996	126,000		126,000
Naphtha					1,201,000	1,201,000
Residual Fuel Oil				42,000	415,000	457,000
Other	1,153,940		1,153,940	2,663,388	1,709,000	4,372,388

Table A.3 Average Hawaii Refined Product Imports and Exports, 1990-1997

Barrels of Product	Imports			Exports		
	Domestic	Foreign	Total	Domestic	Foreign	Total
Distillates	395,382	19,500	414,882	939,500	190,934	1,130,434
Jet Fuel	1,021,871	1,312,664	2,334,535	82,375	240,286	322,661
Motor Gasoline	96,775	0	96,775	272,276	183,520	455,796
Naphtha	33,083	0	33,083	365,568	1,055,504	1,421,072
Residual Fuel Oil	1,015,592	470,750	1,486,342	508,089	987,092	1,495,180
Other	163,618	74,500	238,118	404,674	303,625	708,299
Total	2,726,320	1,877,414	4,603,734	2,572,480	2,960,961	5,533,441

Table A.4 Coal Use in Hawaii (Short Tons), 1990 - 1997

	1990	1991	1992	1993	1994	1995	1996	1997
Cement	26,369	30,000	28,659	29,943	34,697	35,697	22,544	0
Sugar Ind	7,809	9,365	56,654	65,337	49,781	14,216	42,534	50,946
AES Hawaii	0	0	175,000	579,000	563,365	620,286	664,190	673,998
HCPC	included with sugar industry					82,900	96,556	93,455
Total	34,178	39,365	260,313	674,280	647,843	753,099	825,824	818,399

Sources: Hawaiian Cement, HARC Unpublished Data, DBEDT Data

Table A.5 Hawaii Coal Imports, 1990-1997

Country	1990	1991	1992	1993	1994	1995	1996	1997
Australia	34,178	39,365	85,313	98,947	109,737	211,099	147,294	155,632
Indonesia	0	0	175,000	561,332	560,268	633,686	662,882	603,753
Total	34,178	39,365	260,313	660,279	670,005	844,785	810,176	759,385

Sources: 1990-1992: DBEDT; and 1993-1997: EIA 1999a

Table A.6 Hawaii Electricity Production from Bagasse (GWh), 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Hawaii	168	162	158	127	113	11	2	closed
Kauai	124	111	90	86	79	77	94	78
Maui	146	152	163	152	166	152	143	133
Oahu	93	82	79	88	88	56	31	closed
Statewide	531	507	490	453	446	296	270	211

Source: Unpublished data, Hawaii Agricultural Research Center

Table A.7 Percentage of Hawaii Sugar Industry-Generated Electricity Sold to Utilities, 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Hawaii	72%	72%	71%	65%	69%	0%	0%	closed
Kauai	53%	54%	55%	57%	49%	48%	57%	49%
Maui	43%	40%	42%	42%	43%	37%	32%	36%
Oahu	17%	37%	32%	33%	51%	53%	61%	closed
Statewide	51%	48%	52%	49%	52%	42%	42%	40%

Source: Unpublished data, Hawaii Agricultural Research Center

Table A.8 Geothermal Electricity Generation and Avoided Oil Use and CO2 Emissions, 1992-1997

	1992	1993	1994	1995	1996	1997	Total
Electricity Sold to HELCO							
KWh	1,261,141	142,523,997	174,761,434	223,000,772	228,041,630	228,668,755	998,257,729
Savings Compared to Fossil-Fueled Generation on HELCO System							
Barrels Oil	3,802	395,624	449,377	456,356	416,883	407,443	2,129,485
Tons CO_2	1,127	154,779	189,479	243,085	245,588	240,842	1,074,900

Table A.9 Hydroelectric Power Plants in Hawaii, 1997

Island	Location	Stream	MW Capacity	Gross Generation (MWh)	Oil Equiv.* (1000 Bbl)	Owner
HAWAII	Hilo	Wailuku	1.50	9,281	15.47	HELCO Puueo
	Hilo	Wailuku	0.75	2,964	4.94	HELCO Puueo
	Hilo	Wailuku	0.75	5,235	8.72	HELCO Waiau
	Hilo	Wailuku	0.35	1,609	2.68	HELCO Waiau
	Hilo	Ainako	0.007	28	0.05	Wenko Energy
	Hawi	Kohala Ditch	0.20	956	1.59	Hawi Ag & Energy
	Waimea	Waimea/ Waikoloa Pipeline	0.04	74	0.12	Hawaii County
	Hilo	Wailuku	11.00	30,445	50.74	Wailuku River Hydro
	North Hilo		0.08	339	0.57	Hoowaiwai Farms
		Subtotal	**14.68**	**50,932**	**84.32**	
KAUAI	Waimea	Waiawa	0.50	7,050	11.75	AMFAC Sugar (West)[1]
	Waiawa	Kehaha Ditch	1.00			AMFAC Sugar (West)
	Lihue	Wailua Ditch	0.50	2,890	4.82	AMFAC Sugar (East)[2]
	Lihue	Wailua Ditch	0.80			AMFAC Sugar (East)
	North	Wainiha	3.80	0	0	McBryde Sugar
	Kalaheo	Alexander Res.	1.00	0	0	McBryde Sugar
	Kaumakani	Makawili	1.25	7,430	12.38	Gay & Robinson Sugar
		Subtotal	**8.85**	**17,370**	**28.95**	
MAUI	Kaheka	Wailoa Ditch	4.50	18,360	30.60	HC&S
	Paia	Wailoa Ditch	0.90	5,920	9.87	HC&S
	Hamakua	Wailoa Ditch	0.50	0	0	HC&S
	Lahaina	Kauaula	0.50	110	0.18	Pioneer Mill Co., Ltd.
		Subtotal	**6.40**	**24,390**	**40.65**	
		Total	**29.93**	**92,692**	**153.92**	

* Oil equivalent based on 600 kWh per barrel of oil. Totals are rounded.

[1] Combined generation for AMFAC Sugar Kauai (West)

[2] Combined generation for AMFAC Sugar Kauai (East)

Table A.10 Hydroelectric Generation Sold to or Produced by Hawaii Utilities (GWh), 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Hawaii	25.19	19.10	9.99	31.94	64.37	34.75	40.55	50.93
Kauai	53.37	52.88	33.48	19.87	52.40	52.24	51.45	17.37
Maui	26.30	16.43	20.32	22.71	28.08	14.56	17.70	24.39
Statewide	104.86	88.41	63.79	74.52	144.85	101.55	109.70	92.69

Table A.11 Wind Power in Hawaii, 1997

Location	No. of Units	Model	Capacity Each kW	Total Capacity MW	Gross Generation MWh	Annual Oil Equiv. (1000 Bbl)	Owner
Kahua Ranch	3	Bergey-Excel R-240	10	0.03	84	140	Kahua
Lalamilo	26/55	Jacobs	17.5/20	2.28	4,030	6,717	HEI
South Point	37	Mitsubishi	250	7.00	12,047	20,078	Apollo Energy
Various					49	82	Various
Total	121			9.31	16,210	27,017	

Table A.12 Registered Motor Vehicles in Hawaii by County, 1990-1997

Year	City and County of Honolulu	County of Hawaii	County of Kauai	County of Maui	State Total
1990	612,742	110,834	55,927	109,593	889,096
1991	613,119	113,265	57,751	113,058	897,193
1992	611,513	113,080	51,165	110,003	885,761
1993	604,602	111,138	54,068	110,344	880,152
1994	600,087	111,532	52,817	110,708	875,144
1995	601,239	111,624	52,364	112,529	877,756
1996	598,772	115,647	52,984	117,214	884,617
1997	595,121	118,364	53,904	116,878	884,267
Percent 1997	67%	13%	6%	13%	100%

DBEDT 1998, Table 18.07

Table A.13 Hawaii Highway Vehicles, Vehicle Miles Traveled (VMT), Fuel Use and Fuel Efficiency, 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Registered Vehicles								
Number	889,096	897,193	885,761	880,152	875,144	877,756	884,617	884,267
Vehicle Miles Traveled (VMT)								
Miles (000)	8,065,400	8,142,200	8,065,500	7,945,300	7,925,200	7,944,100	8,005,900	8,003,000
Highway Fuel Use (Gasoline-Equivalent)								
Gallons (000)	403,478	404,490	410,676	412,527	425,761	427,234	428,420	434,073
Estimated Average Vehicle Fuel Efficiency								
Miles per Gallon	20.0	20.1	19.6	19.3	18.6	18.6	18.7	18.4

DBEDT 1998, Table 18.07, 18.18

Table A.14 Hawaii Interisland Airline Activity, 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Passengers	9,907,154	9,368,576	9,568,464	9,345,320	9,920,709	10,388,281	10,581,825	10,448,099
Aloha Airlines and Hawaiian Airlines								
ASM (000)	1,978,493	1,849,059	2,029,999	1,817,291	1,915,300	2,032,080	2,002,095	not available
RPM (000)	1,134,404	1,063,201	1,102,609	1,077,184	1,158,940	1,186,409	1,204,002	not available
Load Factor	57.3%	57.5%	54.3%	59.3%	60.5%	58.4%	60.1%	not available
Estimated Fuel Used (Bbl)	1,800,249	1,636,393	1,781,460	1,489,651	1,578,553	1,696,847	1,747,129	not available
ASM/Gallon	**26.2**	**26.9**	**27.1**	**29.0**	**28.9**	**28.5**	**27.3**	not available

Sources: Ackerman 1997; Chun 1997; Fujitani 1997; HAL 1994, 1995; The State of Hawaii Data Book 1998

ASM = Available Seat Miles; RPM = Revenue Passenger Miles

Table A.15 Estimated Overseas Airline Seats, Passengers, and Load Factors, 1990-1997

Year	Westbound Seats	Westbound Passengers	Westbound Load Factor	Eastbound Seats	Eastbound Passengers	Eastbound Load Factor	Average Load Factor
1990	5,966,265	4,378,238	73%	4,427,382	3,215,019	73%	73%
1991	5,519,555	4,199,748	76%	5,038,046	3,136,100	62%	69%
1992	5,330,206	4,055,012	76%	5,291,926	3,418,027	65%	70%
1993	5,023,345	3,956,548	79%	4,645,839	3,232,605	70%	74%
1994	5,012,724	3,926,724	78%	4,061,019	2,851,259	70%	75%
1995	4,945,549	4,023,164	81%	4,583,040	3,271,618	71%	77%
1996	5,168,937	4,091,091	79%	4,421,396	3,313,140	75%	77%
1997	5,275,132	4,335,653	82%	4,293,502	3,128,106	73%	78%

Source: BACK 1999

Table A.16 Estimated Aviation Fuel Use and Sales from Hawaii Sources (Bbl), 1990-1997

Fuel	1990	1991	1992	1993	1994	1995	1996	1997
Domestic Jet	8,592,397	7,948,266	7,950,386	7,359,913	8,220,593	8,203,185	8,635,095	8,442,008
Bonded Jet	9,744,361	9,855,053	9,966,179	9,411,294	8,691,605	9,025,344	8,846,322	8,901,608
Military Jet	255,579	33,912	1,223,252	1,219,115	1,434,394	1,233,902	252,056	735,290
Military JP-4	1,329,953	1,760,963	118,299					
Jet Fuel Total	19,922,290	19,598,194	19,258,116	17,990,322	18,346,592	18,462,431	17,733,473	18,078,906
Domestic Avgas	43,278	44,000	40,154	35,730	37,176	37,291	31,692	32,056
Military Avgas	1,546	1,533	1,136	1,247	913			
Avgas Total	44,824	45,533	41,290	36,977	38,089	37,291	31,692	32,056

Table A.17 Estimated Greenhouse Gas Emissions from Hawaii Aviation Fuels (Tons) 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Domestic Jet Fuel								
CO_2	3,846,478	3,558,126	3,559,075	3,294,744	3,680,036	3,672,243	3,865,592	3,779,155
CH_4	107	99	99	92	103	102	108	105
Domestic Aviation Gasoline								
CO_2	16,495	16,770	15,304	13,618	14,169	14,213	12,079	12,218
CH_4	15	15	13	12	12	13	11	11
N_2O	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Domestic Subtotal								
CO_2	3,862,973	3,574,897	3,574,379	3,308,362	3,694,206	3,686,457	3,877,671	3,791,373
CH_4	122	114	113	104	115	115	118	116
N_2O	0.22	0.22	0.20	0.18	0.19	0.19	0.16	0.16
Bonded (International) Jet Fuel								
CO_2	4,362,167	4,411,719	4,461,467	4,213,066	3,890,890	4,040,292	3,960,151	3,984,900
CH_4	122	123	124	117	108	113	110	111
Military Jet Fuel								
CO_2	676,704	759,700	597,618	545,750	642,122	552,369	112,836	329,160
CH_4	19	21	17	15	18	15	3	9
Military Aviation Gasoline								
CO_2	589	584	433	475	348	-	-	-
CH_4	1	1	0.4	0.4	0.3	-	-	-
N_2O	0.01	0.01	0.01	0.01	0.005	-	-	-
Total								
CO_2	8,902,434	8,746,900	8,633,897	8,067,653	8,227,565	8,279,118	7,950,658	8,105,433
CH_4	263	259	254	237	242	243	232	236
N_2O	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Global Warming Potential								
Domestic	3,848,836	3,560,308	3,561,257	3,296,763	3,682,292	3,674,494	3,867,962	3,781,472
Bonded	4,364,841	4,414,424	4,464,202	4,215,649	3,893,275	4,042,768	3,962,578	3,987,343
Military	677,722	760,763	598,427	546,571	642,871	552,708	112,905	329,362
Total	8,891,399	8,735,495	8,623,885	8,058,983	8,218,439	8,269,971	7,943,445	8,098,177

Table A.18 Marine Fuels Sold or Distrubuted in Hawaii (Bbl) and Greenhouse Gas Emissions (Tons), 1990-1997

Fuel/Use	1990	1991	1992	1993	1994	1995	1996	1997
Distillate								
In-State	322,175	424,904	421,700	367,174	266,691	207,498	258,859	235,598
Overseas	1,735,339	1,568,259	1,672,255	1,655,316	1,444,687	1,506,093	1,063,268	1,177,667
Subtotal	2,057,514	1,993,163	2,093,955	2,022,490	1,711,378	1,713,591	1,322,127	1,413,265
Motor Gasoline								
In-State	3,879	1,238	1,143	833	1,429	1,190	1,380	997
Subtotal	3,879	1,238	1,143	833	1,429	1,190	1,380	997
Residual Fuel Oil								
In-State	6,789	17,216	-	-	5,114	191,841	143,337	130,742
Overseas	2,056,854	3,598,180	2,573,210	2,019,376	2,303,229	1,992,753	1,838,106	1,813,039
Subtotal	2,063,643	3,615,396	2,573,210	2,019,376	2,308,343	2,184,594	1,981,443	1,943,781
Total In-State Greenhouse Gas Emissions								
CO_2	149,871	197,659	196,168	170,804	124,061	96,525	120,417	109,597
CH_4	0.11	0.04	0.03	0.02	0.04	0.03	0.04	0.03
N_2O	2	3	2	2	2	2	2	2
GWP	150,404	198,361	196,836	171,384	124,494	97,181	121,073	110,193

DBEDT 1999

Table A.19 Fuel and Energy Sources Used to Generate Electricity for Utility Sales in Hawaii, 1990-1997

Fuel/Source	1990	1991	1992	1993	1994	1995	1996	1997
Oil	92.5%	92.1%	87.2%	78.6%	77.6%	76.6%	77.0%	76.5%
Biomass	3.0%	3.0%	2.7%	2.4%	2.4%	1.2%	1.2%	1.0%
Coal	0.04%	0.1%	5.8%	14.7%	13.3%	15.5%	15.7%	16.0%
Geothermal	none	none	none	none	1.8%	2.3%	2.3%	2.3%
Hydroelectric	0.7%	0.7%	0.4%	0.6%	1.1%	0.7%	0.7%	0.7%
LF Methane*	0.1%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%	0.2%
MSW	3.5%	3.6%	3.5%	3.3%	3.4%	3.4%	2.8%	3.2%
Wind	0.1%	0.4%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%

* Landfill Methane

Table A.20 HECO-Owned Generators, 1998						
Unit	Unit Type & Fuel	Mode of Operation	Initial Operation	Service Review Date	Capacity (MW)	1997 MWh
Existing HECO-Owned Generation						
Honolulu 8	OFS-LSFO	Cycling	1954	2024	56	
Honolulu 9	OFS-LSFO	Cycling	1957	2024	57	
						110,785
Waiau 3	OFS-LSFO	Cycling	1947	2035	49	
Waiau 4	OFS-LSFO	Cycling	1950	2035	49	
Waiau 5	OFS-LSFO	Cycling	1959	2035	57	
Waiau 6	OFS-LSFO	Cycling	1961	2035	58	
Waiau 7	OFS-LSFO	Baseload	1966	2035	92	
Waiau 8	OFS-LSFO	Baseload	1968	2035	92	
						1,079,250
Waiau 9	CT-Diesel	Peaking	1973	2030	52	
Waiau 10	CT-Diesel	Peaking	1973	2030	50	
						2,351
Kahe 1	OFS-LSFO	Baseload	1963	2035	92	
Kahe 2	OFS-LSFO	Baseload	1964	2035	90	
Kahe 3	OFS-LSFO	Baseload	1970	2035	92	
Kahe 4	OFS-LSFO	Baseload	1972	2035	93	
Kahe 5	OFS-LSFO	Baseload	1974	not set	142	
Kahe 6	OFS-LSFO	Baseload	1981	not set	142	
						3,073,458
				Total Capacity	**1,263**	**4,265,844**

Table A.21 Oahu Non-Utility Generators, 1998						
Unit	Unit Type & Fuel	Mode of Operation	Initial Operation	End of Contract	Capacity MW	1997 Sales MWh[1]
Firm Power Purchase Agreements						
AES-Hawaii	AFBC - Coal	Baseload	1993	2022	180	1,454,602
H-Power	Steam - MSW	Baseload	1990	2015	46	322,887
Kalaeloa Partners	DTCC-LSFO	Baseload	1992	2016	180	1,345,632
				Subtotal	406	3,123,121
As Available Power Purchase Agreements						
BHP Refinery[2]	CT - Oil Gas	As Available	<1990	Not Available	18	4,728
Kapaa Partners	CT - Landfill Methane	As Available	1990	Not Available	3	15,175
Chevron Refinery	CT - Oil Gas	As Available	1993	Not Available	9	81
				Subtotal	30	19,984
				Total	**436**	**3,143,105**

1 Amount sold to HECO. Does not include plant use. [2] Now Tesoro Hawaii

Abbreviations: AFBC - atmospheric fluidized bed coal; MSW - municipal solid waste; DTCC -LSFO - dual-train combined cycle - low sulfur fuel oil (residual); CT - combustion turbine

Source: HECO 1998b; HECO FERC Fm. 1, 1998a

Table A.22 HELCO-Owned Generation, 1998

Unit	Unit Type & Fuel	Mode of Operation	Initial Operation	Service Review Date	Capacity MW	1997 MWh
MSFO-Fired Generation						
Hill 5	OFS-MSFO	Baseload	1965	2015	14.10	
Hill 6	OFS-MSFO	Baseload	1974	2024	20.80	
Puna	OFS-MSFO	Baseload	1970	2020	15.50	
Shipman 1	OFS-MSFO	Cycling	1943	1999	3.40	
Shipman 3	OFS-MSFO	Cycling	1955	2005	7.50	
Shipman 4	OFS-MSFO	Cycling	1958	2008	7.70	
			Steam/MSFO Subtotal		**69.00**	**412,864**
Diesel-Fired Generation						
Kanoelehua 11	IC-Diesel	Peaking	1962	2001	2.00	
Kanoelehua 15	IC-Diesel	Peaking	1972	2000	2.75	
Kanoelehua 16	IC-Diesel	Peaking	1972	2000	2.75	
Kanoelehua 17	IC-Diesel	Peaking	1973	2000	2.75	
Kanoelehua CT1	CT-Diesel	Peaking	1962	2000	11.50	
Keahole 18	IC-Diesel	Peaking	1974	2000	2.75	
Keahole 19	IC-Diesel	Peaking	1974	2000	2.75	
Keahole 20	IC-Diesel	Peaking	1966	2001	2.75	
Keahole 21	IC-Diesel	Peaking	1967	2001	2.75	
Keahole 22	IC-Diesel	Peaking	1967	2001	2.75	
Keahole 23	IC-Diesel	Peaking	1970	2001	2.75	
Keahole CT2	CT-Diesel	Cycling	1989	2019	11.00	
Puna CT3	CT-Diesel	Cycling	1992	2022	20.80	
Waimea 8	IC-Diesel	Peaking	1954	2000	1.00	
Waimea 9	IC-Diesel	Peaking	1954	2000	1.00	
Waimea 10	IC-Diesel	Peaking	1954	2000	1.00	
Waimea 12	IC-Diesel	Peaking	1970	2000	2.75	
Waimea 13	IC-Diesel	Peaking	1972	2000	2.75	
Waimea 14	IC-Diesel	Peaking	1972	2000	2.75	
			IC/CT-Diesel Subtotal		**81.30**	**195,359**
			Total HELCO Firm Generation		**150.30**	**608,223**
HELCO Renewable Generation						
Puueo 1&2	Hydro	Supplemental			2.25	
Waiau 1&2	Hydro	Supplemental			1.10	
Lalamilo	Wind	Supplemental			2.28	
			Hydro/Wind Subtotal		**5.63**	**23,119**
			Total HELCO Generation		**155.93**	**631,342**

Abbreviations: MSFO - medium sulfur fuel oil (residual); OFS - oil-fired steam; IC - internal combustion; CT - combustion turbine

Sources: HELCO 1998a, Schedule C; HELCO 1998b, 4-12 to 4-13

Table A.23 Hawaii County Non-Utility Generators, 1998

Unit	Unit Type & Fuel	Mode of Operation	Contract Start	End of Contract	Capacity MW	1997 MWh Sold
Firm Capacity Power Purchase Agreements						
HCPC	Coal	Baseload	1995	1999	22.0	123,307
Puna Geothermal	Geothermal	Baseload	1993	2027	24.5	228,689
			Hawaii NUG Firm Subtotal		46.5	351,996
Non-Firm Capacity Power Purchase Generators (Renewable)						
Apollo Energy	Wind	Non-Firm			7.0	12,047
Wailuku	Hydro	Non-Firm			11.0	30,445
Other	Hydro/Wind	Non-Firm			0.4	1,446
			Hawaii NUG Non-Firm Subtotal		18.4	43,938
			Hawaii NUG Total		64.9	395,935

Abbreviation: HCPC - Hilo Coast Power Company

Sources: HELCO 1998a, Schedule C; HELCO 1998b, 4-12 to 4-13

Table A.24 Electricity Generation on Kauai, 1998

Unit	Unit Type & Fuel	Initial Operation	Capacity MW	1997 Net MWh
KE-Owned Generation				
Steam Plant	OFS-Diesel	1968	10	33,402
Gas Turbine 1	CT-Diesel	1973	19.2	17,036
Gas Turbine 2	CT-Diesel	1977	23.7	72,918
Diesel 1	IC- Diesel	1964	2	
Diesel 2	IC- Diesel	1964	2	
Diesel 3	IC- Diesel	1968	2.75	
Diesel 4	IC- Diesel	1968	2.75	
Diesel 5	IC- Diesel	1968	2.75	
Diesel 6	IC- Diesel	1990	7.85	
Diesel 7	IC- Diesel	1990	7.85	
Diesel 8	IC- Diesel	1991	7.85	
Diesel 9	IC- Diesel	1991	7.85	
		IC Diesel Subtotal	**43.65**	**207,525**
		KE-Owned Subtotal	**96.55**	**330,881**
Non-Utility Generation				
AMFAC-East (Lihue)	Steam-Bagasse/Diesel	1981	14	43,963
AMFAC-West	various	various	various	2,584
Gay&Robinson	various	various	various	3,275
McBryde Sugar	various	various	various	23,484
		NUG Subtotal	**14**	**73,305**
		Kauai Total	**110.55**	**404,186**

Abbreviations: OFS - oil -fired steam; CT - combustion turbine; IC - internal combustion

Source: KE 1997b; KE 1998a; HARC 1998

Table A.25 MECO-Owned Generators on Maui, 1998						
Unit(s)	Unit Type & Fuel	Mode of Operation	Initial Operation	Planned Retirement	Gross Capacity MW	1997 MWh
Maui Generation Units						
Kahului 1	OFS-MSFO	Baseload	1948	2005	5.9	
Kahului 2	OFS-MSFO	Baseload	1949	2006	6.0	
Kahului 3	OFS-MSFO	Baseload	1954	2004	12.7	
Kahului 4	OFS-MSFO	Baseload	1966	2016	13.0	
				Kahului Subtotal	**38**	**214,828**
Maalaea 1	IC-Diesel	Peaking	1971	2006	2.5	
Maalaea 2	IC-Diesel	Peaking	1972	2007	2.5	
Maalaea 3	IC-Diesel	Peaking	1972	2007	2.5	
Maalaea 4	IC-Diesel	Cycling	1973	2003	5.6	
Maalaea 5	IC-Diesel	Cycling	1973	2003	5.6	
Maalaea 6	IC-Diesel	Cycling	1975	2005	5.6	
Maalaea 7	IC-Diesel	Cycling	1975	2005	5.6	
Maalaea 8	IC-Diesel	Cycling	1977	2007	5.6	
Maalaea 9	IC-Diesel	Cycling	1977	2008	5.6	
Maalaea 10	IC-Diesel	Cyc/Base	1978	2009	12.5	
Maalaea 11	IC-Diesel	Cyc/Base	1979	2010	12.5	
Maalaea 12	IC-Diesel	Cyc/Base	1988	2018	12.5	
Maalaea 13	IC-Diesel	Cyc/Base	1989	2019	12.5	
Maalaea 14	CT-Diesel	Baseload	1992	2023	20.0	
Maalaea 15	SRG	Baseload	1993	2023	18.0	
Maalaea 16	CT-Diesel	Baseload	1993	2023	20.0	
Maalaea 17	CT-Diesel	Baseload	1998	2028	21.2	
Maalaea X1	IC-Diesel	Peaking	1987	2012	2.5	
Maalaea X2	IC-Diesel	Peaking	1987	2012	2.5	
				Maalaea Subtotal	**175**	**740,350**
				Maui Subtotal	**213**	**955,178**

Abbreviations: OFS-MSFO - oil-fired steam - medium sulfur fuel oil (residual); IC - internal combustion; CT - combustion turbine; SRG - steam recovery generator: Cyc - cycling

Source: MECO IRP Prelimnary Results

Table A.26 MECO-Owned Generators on Lanai and Molokai, 1998

Unit	Unit Type & Fuel	Mode of Operation	Initial Operation	Planned Retirement	Capacity MW	1997 MWh
Lanai Generating Units						
Lanai City L7	IC-Diesel	Standby	1988	Standby 1997	1.0	
Lanai City L8	IC-Diesel	Standby	1985	Standby 1998	1.0	
Miki Basin LL1	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL2	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL3	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL4	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL5	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL6	IC-Diesel	-	1990	2006	1.0	
Miki Basin LL7	IC-Diesel	-	1996	TBD	2.2	
Miki Basin LL8	IC-Diesel	-	1996	TBD	2.2	
				Lanai Subtotal	**12**	**27,944**
Molokai Generating Units						
Palaau P-1	IC-Diesel	Peaking	1985	2006	1.29	
Palaau P-2	IC-Diesel	Peaking	1985	2006	1.29	
Palaau P-3	IC-Diesel	Peaking	1985	2006	0.97	
Palaau P-4	IC-Diesel	Peaking	1985	2006	0.97	
Palaau P-5	IC-Diesel	Peaking	1985	2006	0.97	
Palaau P-6	IC-Diesel	-	1991	2006	0.97	
Palaau CT	CT-Diesel	-	1982	2012	2.22	
Palaau P-7	IC-Diesel	-	1996	2021	2.20	
Palaau P-8	IC-Diesel	-	1996	2021	2.20	
Palaau P-9	IC-Diesel	-	1996	2021	2.20	
				Molokai Subtotal	**15**	**37,096**
				Lanai and Molokai Total	**27**	**65,040**

Abbreviations: IC - internal combustion; CT - combustion turbine

Sources: MECO 1998a; MECO 1998c

Table A.27 Future Generation in Hawaii Utility IRP Plans Requiring New Sites, 2000-2020

	HECO		HELCO		KE		MECO	
Year	**Type**	**MW**	**Type**	**MW**	**Type**	**MW**	**Type**	**MW**
2000								
2001								
2002					CT w/HRS	26.4		
2003								
2004							DTCC Ph 1	20.8
2005								
2006			ST-7	18.0			DTCC Ph 2	20.8
2007							DTCC Ph 3	17.1
2008							DTCC Ph 1	20.8
2009	DTCC Ph 1	107.0	DTCC Ph 1	21.3			DTCC Ph 2	20.8
2010							DTCC Ph 3	17.1
2011							DTCC Ph 1	20.8
2012					IC Diesel	10.0		
2013	DTCC Ph 2	107.0	DTCC Ph 2	21.3			DTCC Ph 2	20.8
2014					Coal Steam	24.0		
2015							DTCC Ph 3	17.1
2016	DTCC Ph 3	104.0	DTCC Ph 3	19.0				
	AFBC	180.0						
2017	SCCT	107.0	DTCC Ph 1	21.3			DTCC Ph 1	20.8
2018							DTCC Ph 2	20.8
2019							DTCC Ph 3	17.1
2020								
Total		**605.0**		**100.9**		**60.4**		**234.8**

Abbreviations: CT w/HRS - combustion turbine with heat recovery system; DTCC - dual-train combined cycle;
ST- steam turbine (added to two combustion turbines (CT-4 and 5) to make a DTCC; IC - internal combustion; AFBC - atmospheric fluidized bed coal; SCCT - simple cycle combustin turbine

Table A.28 Percentage of Utility Electricity from Renewable Sources, 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
HECO	5%	5%	5%	5%	5%	5%	4%	5%
HELCO	21%	19%	19%	31%	37%	32%	33%	35%
KE	25%	22%	18%	16%	16%	15%	18%	11%
MECO	8%	7%	8%	7%	7%	8%	7%	7%
Statewide	7.7%	7.7%	7.0%	8.0%	8.6%	8.0%	7.4%	7.9%

Table A.29 Percentage Contribution to Utility Sales by Renewable Resource, 1990-1997

	1990	1991	1992	1993	1994	1995	1996	1997
Sugar Bagasse	3.0%	3.0%	2.7%	2.4%	2.3%	1.5%	1.4%	1.1%
Geothermal	0%	0%	0%	1.5%	1.8%	2.3%	2.3%	2.3%
Hydroelectric	0.7%	0.6%	0.4%	0.4%	0.6%	0.5%	0.5%	0.4%
Wind	0.4%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
LF Methane	0.1%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%	0.2%
MSW	3.5%	3.6%	3.5%	3.3%	3.5%	3.5%	2.8%	3.8%
Total Renewable	**7.7%**	**7.7%**	**7.0%**	**8.0%**	**8.6%**	**8.0%**	**7.4%**	**7.9%**

Table A.30 Estimated Model Energy Code Savings					
Year	New Non-Res. (GWh)	Non-Res. Renov. (GWh)	Total (GWh)	Estimated Tons CO_2 Saved	Energy Cost Savings
1994	8	3	11	11,330	$ 1,100,000
1995	16	6	22	22,660	$ 2,200,000
1996	24	8	32	32,960	$ 3,200,000
1997	32	11	43	44,290	$ 4,300,000
1998	40	14	54	55,620	$ 5,400,000
1999	49	17	66	67,980	$ 6,600,000
2000	57	20	77	79,310	$ 7,700,000
2005	97	33	130	133,900	$ 13,000,000
2010	138	40	178	183,340	$ 17,800,000
2013	162	41	203	191,580	$ 20,300,000
20-yr Total	1,699	529	2,228	2,294,840	$ 222,800,000

Based on State of Hawaii 1998b, Table 4, 17

Table A.31 Estimated Energy Savings (GWh) and Emissions Reductions from HECO DSM Programs							
Year	Residential Water Heating (Existing)	Residential Water Heating (New)	Commercial/ Industrial Prescriptive Measures	Commercial/ Industrial New Construction	Commercial/ Industrial Custom Rebate	Annual Total GWh Savings	Annual Total Savings [1] (Tons CO_2)
1996	1.35	0.08	9.38	1.66	0.27	12.74	12,480
1997	5.79	1.28	12.29	5.32	2.09	26.77	26,235
1998	6.58	1.84	15.87	6.81	5.39	36.49	35,760
1999	13.52	3.74	32.74	14.17	13.79	77.96	76,401
2000	20.81	5.62	50.48	21.92	29.32	128.15	125,587
2001	28.37	7.50	69.06	30.09	36.21	171.23	167,805
2002	36.21	9.32	88.40	38.84	42.86	215.63	211,317
2003	44.27	11.14	108.42	48.24	49.40	261.47	256,241
2004	52.59	14.82	129.24	58.55	55.40	308.75	302,575
2005	60.90	14.82	150.05	68.86	61.40	356.03	348,909
2006	69.41	16.80	171.51	80.19	71.72	409.63	401,433
2007	77.92	18.78	192.96	91.52	82.04	463.22	453,956
2008	86.44	20.78	214.53	103.83	86.64	512.22	501,971
2009	94.96	22.78	236.09	116.14	91.24	561.21	549,986
2010	111.80	24.78	257.35	128.87	98.36	621.16	608,732
2011	115.10	26.78	278.60	141.60	105.48	667.56	654,206
2012	118.39	27.85	292.14	151.36	105.66	695.39	681,481
2013	121.69	28.91	305.68	161.11	105.83	723.22	708,756
2014	122.70	28.96	310.41	168.04	107.58	737.68	722,922
2015	123.70	29.01	315.13	174.96	109.33	752.13	737,087
2016	124.05	29.06	318.12	181.66	111.62	764.50	749,205
2017	124.40	29.10	321.11	188.35	113.90	776.86	761,323
Total	1,560.94	373.74	3,879.54	1,982.08	1,485.52	9,279.97	9,094,366

[1] CO_2 savings calculated based upon HECO's 1997 system average emissions of 2.064 lbs CO_2 per kWh sales or 1,032 tons/GWh sales

HECO 1998b - Even years 2006-2016 are interpolated.

Table A.32 Estimated Peak Demand Reduction from HECO DSM Programs (MW)								
Year	Residential Water Heating (Existing)	Residential Water Heating (New)	Commercial/ Industrial Prescriptive Measures	Commercial/ Industrial New Construction	Commercial/ Industrial Custom Rebate	Residential Direct Load Control	Commercial/ Industrial Capacity Buy Back	Total
1998	2.15	0.76	3.15	1.32	1.15	-	0.81	9.34
1999	3.66	1.27	5.30	2.25	2.52	1.59	10.00	26.59
2000	5.35	1.82	7.78	3.31	5.20	4.76	19.10	47.32
2005	14.42	4.34	21.38	9.62	10.22	11.00	27.29	98.27
2010	24.49	7.25	36.69	18.03	16.37	11.00	27.29	141.12
2015	29.35	8.49	44.96	24.54	18.19	11.00	27.29	163.82
2017	29.54	8.51	45.83	26.46	18.95	11.00	27.29	167.58

Source: HECO 1998b

Table A.33 Estimated Energy Savings (GWh) and CO_2 Emissions Reductions from HELCO DSM Programs						
Year	Residential Efficient Water Heating	Commercial/ Industrial Energy Efficiency	Commercial/ Industrial New Construction	Commercial/ Industrial Customized Rebate	Annual Total GWh Savings	Annual Total Savings (Tons CO_2)
1999	0.64	1.66	0.30	0.40	3.00	2,955
2000	1.78	4.10	1.00	1.48	8.36	8,235
2005	7.66	15.38	7.90	5.61	36.55	35,997
2010	12.96	24.57	18.20	10.65	66.38	65,384
2015	16.10	30.93	29.15	16.54	92.73	91,339
2018	16.12	32.37	35.00	20.47	103.96	102,401
20-Year Total						
	193	375	284	172	1,024	1,111,154

[1] CO_2 savings calculated based upon HELCO's 1997 average emissions of 1.97 lbs CO_2 per kWh sales or 985 tons/GWh sales

HELCO 1998b

Table A.34 Estimated Peak Demand Reductions from HELCO DSM Programs (MW)					
Year	Residential Efficient Water Heating	Commercial/ Industrial Energy Efficiency	Commercial/ Industrial New Construction	Commercial/ Industrial Customized Rebate	Total MW Savings
1999	0.25	0.03	0.10	0.10	0.48
2000	0.49	0.58	0.20	0.21	1.48
2005	2.11	1.61	1.20	0.82	5.74
2010	2.73	2.59	2.80	1.56	9.68
2015	3.39	3.28	4.45	2.42	13.54
2018	3.41	3.45	5.30	2.99	15.15

HELCO 1998b

Table A.35 Estimated Energy Savings (MWh) and CO_2 Emissions Reductions from KE DSM Programs

Year	Residential Retrofit	Residential Direct Install	Residential New Construction	Commercial Retrofit	Commercial New Construction	Annual Total MWh Savings [1]	Annual Total Savings [2] (Tons CO_2)
1998	1.01	0.68	-	2.90	-	5	3,214
1999	3.32	2.22	-	9.47	-	15	10,499
2000	6.35	4.24	-	18.06	-	29	20,052
2005	8.36	5.47	1.74	23.22	1.89	41	28,477
2010	5.26	2.66	1.74	18.79	0.57	29	20,313
2015	1.14	0.62	1.33	12.55	0.50	16	11,293
2017	0.13	0.07	0.90	11.79	0.47	13	9,349
20-Year Total	**103**	**64**	**23**	**354**	**15**	**558**	**390,513**

[1] Annual energy savings from measures implemented over program's first seven years.

[2] CO_2 savings calculated based upon KE's 1997 average emissions of 1.4 lbs CO_2 per kWh sales or 700 tons per GWh

KE 1997b, Appendix D, Table B. Program Summary Spreadsheets

Table A.36 Estimated Peak Demand Reduction from KE DSM Programs (MW)

Year	Residential Retrofit	Residential Direct Install	Residential New Construction	Commercial Retrofit	Commercial New Construction	Total MW Savings
1998	0.17	0.12	-	0.39	-	0.67
1999	0.54	0.40	-	1.17	-	2.12
2000	1.04	0.77	-	2.24	-	4.04
2005	1.37	1.01	0.29	2.89	0.22	5.78
2010	0.87	0.48	0.29	2.33	0.04	3.99
2015	0.19	0.10	0.22	1.53	0.03	2.07
2017	0.022	0.01	0.15	1.42	0.02	1.63

KE 1997b, Appendix D, Table B. Program Summary Spreadsheets

Table A.37 Estimated Energy Savings (GWh) and Emissions Reductions from MECO DSM Programs

Year	Residential Efficient Water Heating	Commercial/ Industrial Energy Efficiency	Commercial/ Industrial New Construction	Commercial/ Industrial Customized Rebate	Annual Total GWh Savings	Annual Total Savings [1] (Tons CO_2)
1997	1.60	7.70	0.45	0.29	8.44	7,934
1998	2.97	12.78	1.30	0.74	17.79	16,722
1999	7.93	18.49	2.47	1.41	30.31	28,488
2000	11.94	23.95	3.98	2.23	42.08	39,559
2001	16.48	28.40	5.89	3.16	53.94	50,699
2002	21.10	31.51	7.66	4.19	64.46	60,590
2003	21.10	31.51	7.66	4.19	64.46	60,590
2004	21.10	31.51	7.66	4.19	64.46	60,590
2005	21.10	31.51	7.66	4.19	64.46	60,590
2006	21.10	31.51	7.66	4.19	64.46	60,590
2007	21.10	31.51	7.66	4.19	64.46	60,590
2008	21.10	31.51	7.66	4.19	64.46	60,590
2009	21.10	31.51	7.66	4.19	64.46	60,590
2010	21.10	31.51	7.66	4.19	64.46	60,590
2011	21.10	31.51	7.66	4.19	64.46	60,590
2012	19.50	23.81	7.21	3.90	54.42	51,152
2013	18.13	18.73	6.36	3.45	46.67	43,868
2014	13.17	13.01	5.19	2.78	34.15	32,102
2015	9.17	7.56	3.69	1.96	22.37	21,031
2016	4.62	3.11	1.77	1.02	10.52	9,891
20-Year Total	**317**	**473**	**115**	**63**	**965**	**907,340**

[1] CO_2 savings calculated based upon MECO's 1997 average emissions of 1.88 lbs CO_2 per kWh sales or 940 tons/GWh sales

Table A.38 Estimated Peak Demand Reduction (MW) from MECO DSM Programs

Year	Residential Efficient Water Heating	Commercial/ Industrial Energy Efficiency	Commercial/ Industrial New Construction	Commercial/ Industrial Customized Rebate	Total MW Savings
1997	0.63	0.39	0.22	0.02	1.26
1998	1.04	0.70	0.34	0.02	2.10
1999	1.53	0.86	0.50	0.02	2.91
2000	2.01	1.12	0.58	0.07	3.78
2005	4.35	2.12	1.23	0.34	8.04
2010	6.46	3.53	2.20	0.61	12.80
2015	6.84	4.41	2.83	0.86	14.94
2016	3.79	4.67	3.02	0.91	15.39

Table A.39 Estimated Future Monetary, Electricity, and CO_2 Emissions Savings from State of Hawaii Government Performance Contracting Projects

Project		Estimated Annual Savings ($)	Estimated Annual Electricity Savings (kWh)	Estimated Annual CO_2 Emissions Avoided (Tons)
State of Hawaii				
Community College System	$	924,543	8,374,484	8,207
Hawaii Army Nat'l Guard	$	68,576	321,651	315
Judiciary Facilities	$	448,360	3,043,443	2,983
State Library System	$	200,000	1,550,388	1,519
UH Hilo	$	577,000	3,218,070	3,170
Total	$	2,218,479	16,508,035	16,194

Table A.40 Estimated Benefits of Existing Hawaii Rebuild America Partnership Programs

Partner	Annual kWh Savings	Annual Savings	Investment in Retrofits	Jobs Created	Income to Economy	Reduction in CO_2 (Tons)
State Buildings	8,929,906	$ 967,000	$ 5,485,000	83	$ 3,236,150	9,123
Public Library System	1,165,000	$ 200,000	$ 1,000,000	15	$ 590,000	1,200
Community College System	8,460,896	$ 924,000	$ 4,260,000	70	$ 27,258,000	8,715
Department of Education	10,159,638	$ 1,440,000	$ 7,200,000	109	$ 4,248,000	10,464
UH at Manoa School of Architecture	14,424,750	$ 1,225,500	$ 6,127,500	93	$ 3,615,225	14,857
County of Hawaii	3,800,000	$ 735,000	$ 3,675,000	56	$ 2,168,250	3,838
County of Kauai	16,680,000	$ 3,005,611	$ 15,028,055	228	$ 8,866,552	10,675
County of Maui	9,580,000	$ 1,150,000	$ 5,750,000	87	$ 3,392,500	8,957
City and County of Honolulu	200,000	$ 40,000	$ 200,000	3	$ 118,000	206
Subtotal	**73,400,190**	**$ 9,687,111**	**$ 48,725,555**	**744**	**$ 53,492,677**	**68,035**
HECO Programs	**21,826,667**	**$ 2,510,067**	**$ 12,550,334**	**191**	**$ 7,404,697**	**22,481**
Total	**95,226,857**	**$ 12,197,178**	**$ 61,275,889**	**935**	**$ 60,897,374**	**90,516**

Table A.41 Estimated Savings from County Government Projects			
Project	**Estimated Annual Energy Savings**	**CO_2 Reduction (Tons/Year)**	**Project Status**
City and County of Honolulu[1]			
Civic Center Parking Structure Lighting	120,000 kWh	118	Completed 1998
Building Dept. Lighting Projects	700,000 kWh	686	Completed 1999
Honolulu Hale Performance Contract	500,000 kWh	490	Completed 1999
City and County of Honolulu Subtotal		**1,294**	
County of Hawaii[2]			
County Building Retrofit	405,594 kWh	409	Performance Contract
Add'l County Building Retrofits	3,400,000 kWh	3,427	Planned FY 1998-1999
Division of Water Supply	4,700,000 kWh	4,737	Planned FY 1999-2000
Wastewater Division	400,000 kWh	403	Planned FY 1999-2000
County of Hawaii Subtotal		**8,976**	
County of Kauai[3]			
County Facility Retrofits	4,175,000 kWh	2,923	Completed Summer 98
County of Kauai Subtotal		**2,923**	
County of Maui[4]			
County Building Retrofit	400,000 kWh	376	Completed 1994
Swimming Pool Heating and Cooling Retrofit	120 Bbl LPG	33	Initiated 1997
Streetlight Retrofit	473,000 kWh	445	Completed 1998
"Rebuild Maui County" Projects for County Facilities	6,250,000 kWh	5,875	Completed 1999
Biodiesel Demonstration	476 Bbl Diesel	221	5-yr Project to Spring 2002
County of Maui Subtotal		**6,950**	
County Projects Total		**20,142**	

[1] Fujiki 1998; [2] Carr 1997; [3] County of Kauai 1997; [4] Kobayashi 1997

Table A.42 20% Renewable Scenario Generation Additions and Retirements

Year	HECO	HELCO	KE	MECO
2000		60MW DTCC (IPP) -23.9MW Diesel -3MW OFS **4MW PV**		
2001		40 MW CTCC Ph1/2 -10 Diesel, -6 CT **10MW Wind**		-2.7MW Diesel **20 MW Wind**
2002		**10MW Wind**	26MW CT	-5.4MW Diesel
2003				-12.32MW Diesel 17.1MW DTCC Ph 3
2004				20.8MW DTCC Ph1 -12.32MW Diesel
2005	**20MW Wind**	-22MW Coal (IPP) -7 OFS		-12.32MW Diesel 2.2MW Diesel -5.9MW Steam
2006		18MW DTCC Ph3 **13.8MW Hydro**		20.8 MW DTCC Ph2 4.4 MW Diesel -6MW Steam -12.5MW Diesel
2007	**15MW Wind**	-7.7MW Steam	**10MW Wind**	17.1MW DTCC Ph3 20.8MW DTCC Ph1 **25MW Biomass** -5.6MW Diesel
2008		-8 MW OFS		2.2MW Diesel -5.6MW Diesel
2009	107MW DTCC Ph1 **30MW Wind**	**25 MW Geothermal**	**6.6MW Hydro**	20.8MW DTCC Ph2 **20MW Wind** -12.85MW Diesel
2010			**10 MW MSW**	17.1MW DTCC Ph3 -12.85MW Diesel
2011	**25MW Biomass**			20MW DTCC Ph1
2012				-7.6MW Diesel
2013	107MW DTCC Ph2			2.2MW Diesel 20.8MW DTCC Ph 2
2014			**25 MW Biomass**	
2015		-14.1MW Steam		17.1MW DTCC Ph3
2016	104MW DTCC Ph3 180MW AFBC	21MW DTCC Ph2		
2017	107MW SCCT - 180MW DTCC (IPP)	21MW DTCC Ph2		20.8MW DTCC Ph1
2018				20.8MW DTCC Ph 2
2019		-18 CT		
2020		18.7MW DTCC Ph3		

Abbreviations: DTCC - dual-train combined cycle; OFS - oil-fired steam; CT - combustion turbine; IPP - independent powe producer; PV - photovoltaic; MSW - municipal solid waste; AFBC - atmospheric fluidized bed coal; SCCT - simple cycle combustion turbine; CT - combustion turbine

Table A.43 10% Renewable Scenario Generation Additions and Retirements

Year	HECO	HELCO	KE	MECO
2000		60MW DTCC (IPP) -23.9MW Diesel -3MW OFS **4MW PV**		
2001		40 MW CTCC Ph1/2 -10 Diesel, -6 CT **10MW Wind**		-2.7MW Diesel **20 MW Wind**
2002		**10MW Wind**	26MW CT	-5.4MW Diesel
2003				-12.32MW Diesel 17.1MW DTCC Ph 3
2004				20.8MW DTCC Ph1 -12.32MW Diesel
2005	**20MW Wind**	-22MW Coal (IPP) -7 OFS		-12.32MW Diesel 2.2MW Diesel -5.9MW Steam
2006		18MW DTCC Ph3		20.8 MW DTCC Ph2 4.4 MW Diesel -6MW Steam -12.5MW Diesel
2007	**15MW Wind**	-7.7MW Steam	**10MW Wind**	17.1MW DTCC Ph3 20.8MW DTCC Ph1 **25MW Biomass** -5.6MW Diesel
2008		-8 MW OFS		2.2MW Diesel -5.6MW Diesel
2009	107MW DTCC Ph1 **30MW Wind**		**6.6MW Hydro**	20.8MW DTCC Ph2 -12.85MW Diesel
2010			**10 MW MSW**	17.1MW DTCC Ph3 -12.85MW Diesel
2011				20MW DTCC Ph1
2012				-7.6MW Diesel
2013	107MW DTCC Ph2			2.2MW Diesel 20.8MW DTCC Ph 2
2014			24MW Coal	
2015		-14.1MW Steam		17.1MW DTCC Ph3
2016	104MW DTCC Ph3 180MW AFBC	21MW DTCC Ph2		
2017	107MW SCCT - 180MW DTCC (IPP)	21MW DTCC Ph2		20.8MW DTCC Ph1
2018				20.8MW DTCC Ph 2
2019		-18 CT		
2020		18.7MW DTCC Ph3		

Abbreviations: DTCC - dual-train combined cycle; OFS - oil-fired steam; CT - combustion turbine; IPP - independent powe producer; PV - photovoltaic; MSW - municipal solid waste; AFBC - atmospheric fluidized bed coal; SCCT - simple cycle combustion turbine; CT - combustion turbine

APPENDIX B BIBLIOGRAPHY

Note: A modified version of the MLA format for citations was used in *HES 2000*. Works are cited in the text in the following format (Author Year, Page). Subsequent citations from the same work with no intervening citation from another source are identified only by page number, e.g., "(34)," if available. To differentiate between multiple works by the same author or organization published in the same year, a lowercase letter is used after the date. This letter corresponds to the work's listing in the bibliography (e.g., HECO 1999a, HECO 1999b).

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APPENDIX C THE ENERGY 2020 MODEL

C.1. ENERGY 2020 – The Energy Model

ENERGY 2020 is a system dynamics model developed by Systematic Solutions, Inc. (SSI), and designed especially for comprehensive energy planning at a regional level. The complete ENERGY 2020 model integrates energy demand, energy supply, and the economy, allowing policy analyses to be performed. Specifically, ENERGY 2020 simulates the major departments of regulated electric and gas utilities, other energy supply sources, and the major components of energy demand, including transportation demand, in a single comprehensive framework connected by several important feedback responses. The interactions among all the components of the energy system are consistently represented.

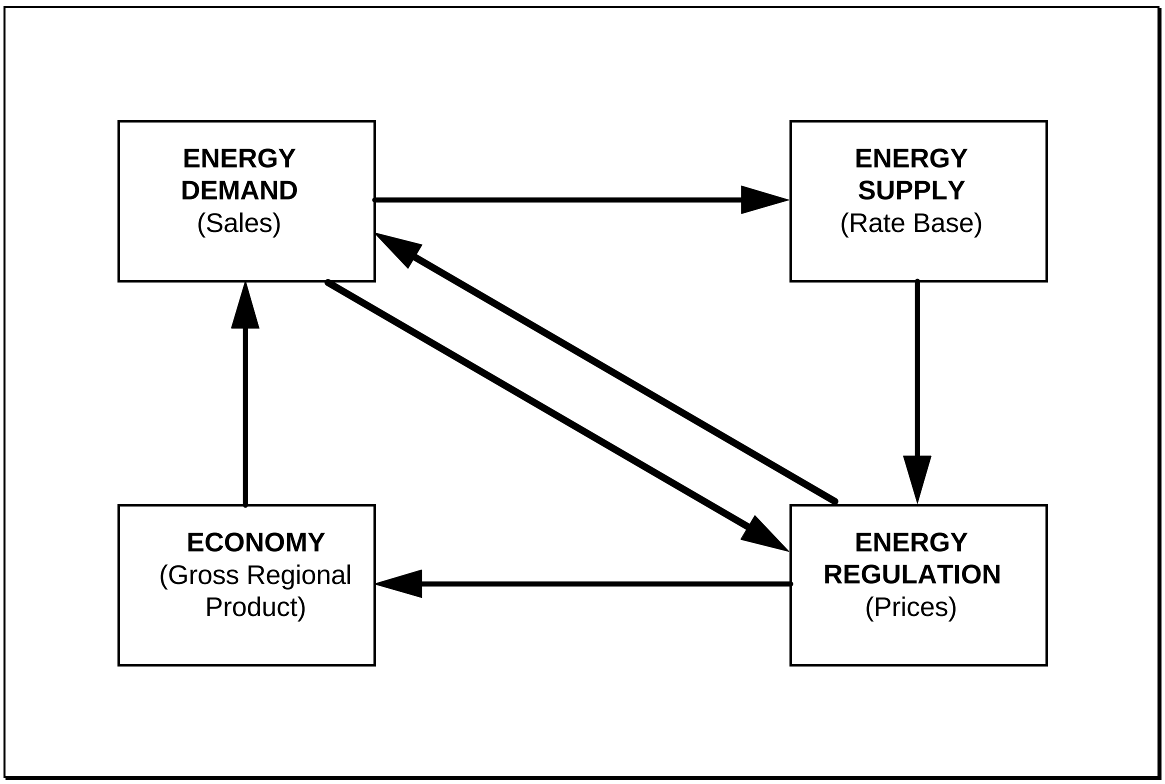

Figure C-1. Feedback Loops Linking the Components of ENERGY 2020

Figure C-1 illustrates the basic feedback loops in ENERGY 2020. Through causal modeling, in combination with econometric, engineering, and system dynamics techniques, the closed loop system is simulated. There are many interconnections between the four segments (boxes). These result in feedback, which must be taken into account. Some relationships reinforce behaviors, while others stabilize and control the system by countering any disturbance. In some instances, the effect of policies and programs in the long-term will be opposite the effect in the short-term. Thus, for robust planning, it is important that dynamic behaviors over time be explicitly addressed.

C.1.1. The Structure of ENERGY 2020

The structure of the ENERGY 2020 model, representing how decision-makers act, determines the model results. The ENERGY 2020 model is calibrated to replicate history. This is important because unless a model can reproduce history, the user will have little confidence that it can legitimately represent the future. However, because ENERGY 2020 simulates how participants in an energy system make decisions, it is also able to determine how decision makers may act when they are faced with conditions for which there is no historical precedent.

In an internally consistent manner, the ENERGY 2020 scenario framework integrates all three major components of the energy system: the economy of the county (or utility service area), the energy demands of the county or utility-service-area consumers, and energy supplies.

Each of these components is represented by one or more sectors. Four detailed demand modules – one each for the counties of Hawaii, Kauai, and Maui, and the City and County of Honolulu – were linked with the corresponding macroeconomic models designed by Regional Economic Models, Inc. (REMI). These were also linked to explicitly modeled electric utility, ground transportation, and both bottled gas and utility-gas sectors. Oil refining, air transportation, and marine transportation were modeled at the State level. Demand was divided into four customer classes: residential, commercial, industrial, and transportation. These, in turn, were disaggregated into numerous end-use groups.

ENERGY 2020 models the demand for energy services. It takes into account many factors affecting energy choices including both device and process efficiency choices; the consumer's budget constraints, preferences, and information requirements; economic growth impacts; changes in technology; and take-back dynamics. ENERGY 2020 causally formulates the energy demand equation. It explicitly identifies the multiple ways price changes influence the relative economics of alternative technologies and behaviors, which in turn determine consumer demands. In this sense, price elasticities are outputs, not inputs, of ENERGY 2020. The model recognizes that price responses vary over time and depend upon factors such as the rate of investment, the age and efficiency of the capital stock, and the relative prices of alternative technologies. Figure C-2 illustrates the basic demand configuration of ENERGY 2020.

The basic supply sector of ENERGY 2020 provides price feedback to the demand and economy sectors. The supply sector includes not only the energy-producing and energy-delivering companies, but also the regulators and market mechanisms.

ENERGY 2020 also simulates the detailed operation of Hawaii's four regulated electric companies and its one regulated gas company. Figure C-3 depicts the basic ENERGY 2020 electric utility sector. The model endogenously forecasts

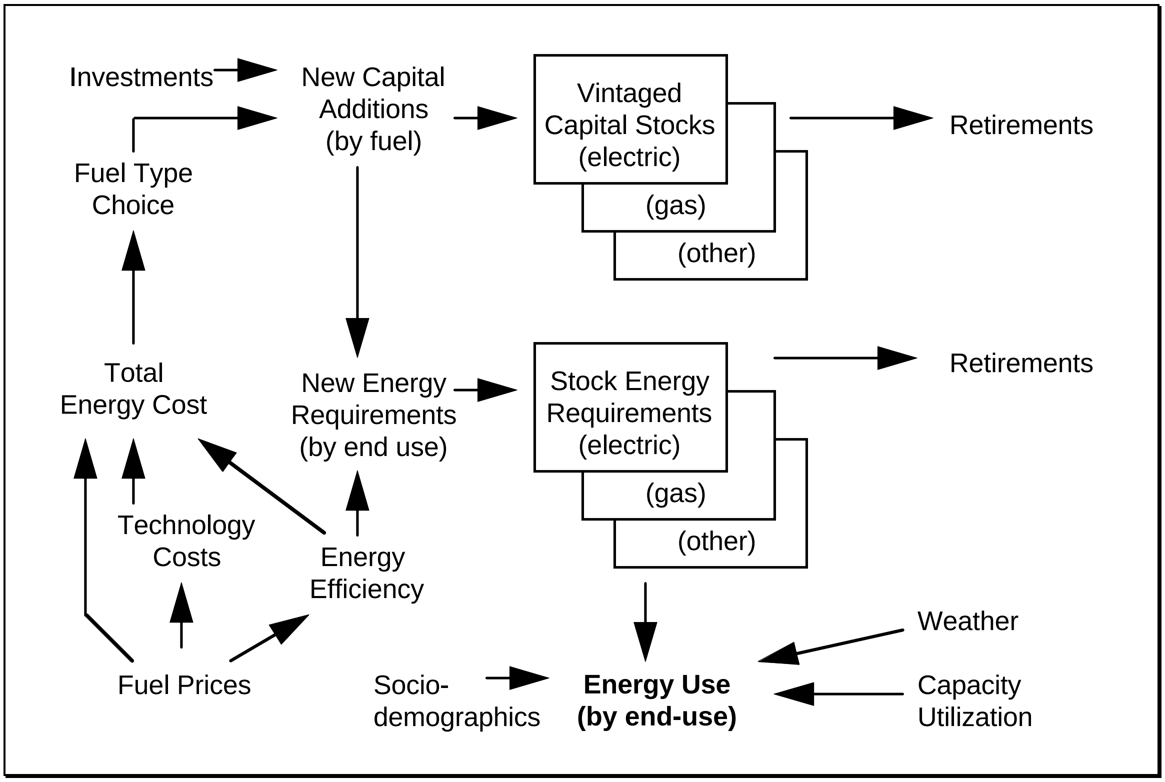

Figure C-2. ENERGY 2020 Demand Configuration

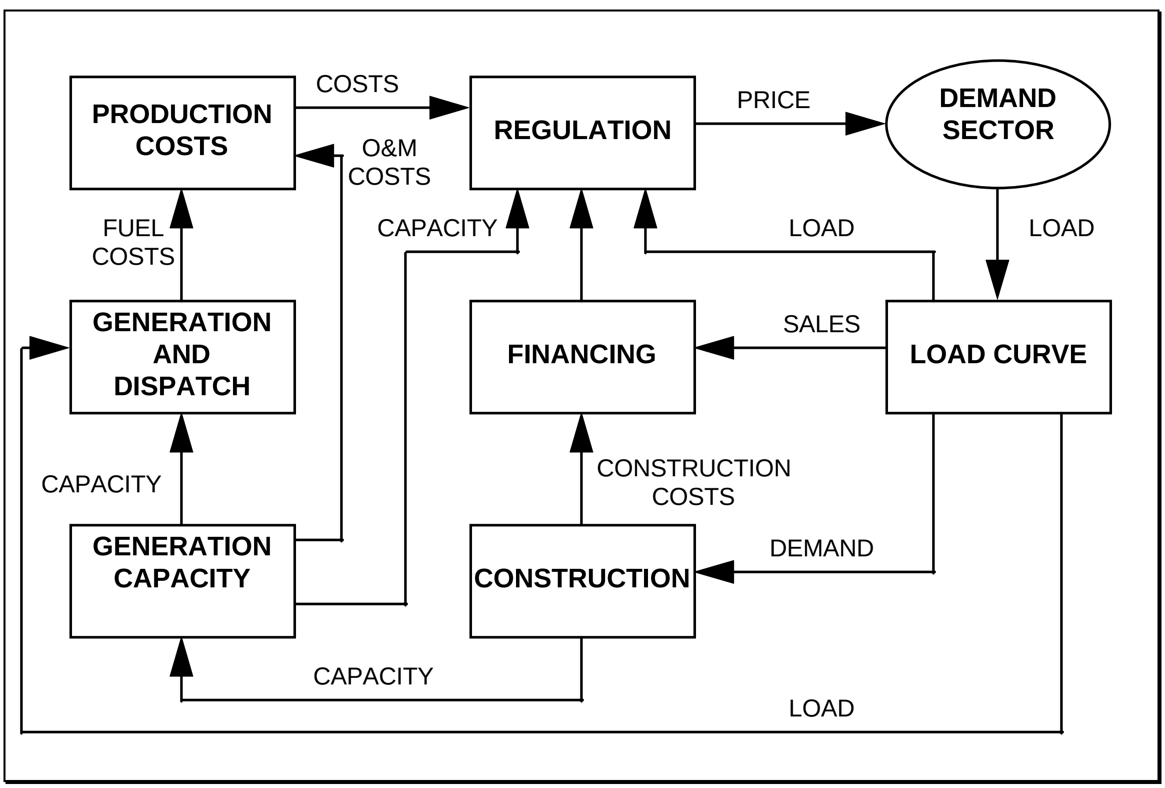

Figure C-3. Basic ENERGY 2020 Electric Utility Sector

capacity needs, as well as the planning, construction, operation, and retirement of generating plants and transmission facilities. In the model, revenues, debt, and the sale of stock finance each step. Like their real-world counterparts, the simulated utilities pay taxes. The model also generates a complete set of accounting records. In ENERGY 2020, the regulatory function is modeled as a part of the utility sector. The regulator sets the allowed rate of return; divides revenue responsibility among customer classes; approves rate base, revenues, and expenses; and sets fuel adjustment charges. Detailed supply sectors for oil refining on Oahu, and air and marine transportation statewide, were also explicitly modeled.

A pollution or emission accounting module in ENERGY 2020 tracks pollution generation by end-use and fuel type from the demand sector, and from the utility sector by supply and plant type. ENERGY 2020's pollution accounting module also tracks energy-related pollution in the transportation sector by mode and in the industrial sector by two-digit Bureau of Labor Statistics Standard Industrial Code (SIC) code. The program also tracks greenhouse gases CO_2, CH_4, and N_2O. The levels of pollution generated are fed back to the supply sectors, which allows policies to be introduced that adjust production to meet environmental constraints.

C.1.2. ENERGY 2020 Data Sources

ENERGY 2020's internal national and state databases contain historical economic, price, and demand data by economic sector, fuel, and end-use. Regional and utility-specific data override and supplement aggregate data when available. The Hawaii configuration of ENERGY 2020 used the reports from HES Projects 2, 3, 4, and 5; Federal Energy Regulatory Commission (FERC) Form 1; FERC Annual Reports; and utility Integrated Resource Plans (IRPs); as well as other local data supplied by DBEDT to model the economy sectors.

C.2. ENERGY 2020 and the REMI Economic Model

A macroeconomic forecasting model developed by Regional Economic Models, Inc., is used to create the specific economic drivers for ENERGY 2020's energy forecast. The current state population and economic forecast (State of Hawaii, 1997b) was used to calibrate the REMI model, and the REMI model was used to forecast economic drivers. The REMI service-area-specific model simulated the competition between the local service area and the "rest-of-the-world" for markets, business, and population. When linked to REMI, ENERGY 2020 captures the feedback impacts of rates, construction, and conservation programs on local economic growth, employment, and energy use.

C.2.1. The REMI Model and Its Relationship to ENERGY 2020

Four integrated economic and energy models representing the four counties Honolulu (Oahu), Maui (including Molokai and Lanai), Hawaii, and Kauai were developed. Each has a REMI model simulating the economic future of that county and an appropriate version of ENERGY 2020 simulating that county's energy markets. When all four county models are run simultaneously, inter-County interactions are captured, as the forecast is executed a year at a time.

ENERGY 2020 is fully linked with the REMI model, which allows energy prices and price changes generated in ENERGY 2020 to interact dynamically with REMI's economic forecast. The forecast economic changes then flow back to ENERGY 2020, affecting future demand, utility rates, and resource planning.

Personal income and gross output by industry from the REMI model are the principal drivers for ENERGY 2020. Other REMI variables used in the ENERGY 2020 databases include population, new capital investment, gross state product (GSP), and employment. The different sectors of ENERGY 2020 in the Hawaii model include residential, commercial, industrial, and transportation demands; electric utility, regulated utility, and unregulated gas service; and oil refining. Each is driven by one or more economic variable. For example, personal income is the principal driver for the residential sector, while gross output by industry is the principal driver for the commercial and industrial sectors. Policies developed for the regulated and unregulated energy sectors cause energy price changes and possible direct changes in employment. These, when fed back into the REMI model, affect the drivers of the other sectors. REMI outputs drive ENERGY 2020, and ENERGY 2020 outputs, in turn, influence the REMI simulations.

Prior to the Hawaii Energy Strategy project, ENERGY 2020 and REMI were linked principally through energy-price feedback loops that allowed the simulation of economic changes from changing electricity and gas prices. Because the Hawaii version of the ENERGY 2020 model required more detail, new feedback loops from utility policy simulations (e.g., supply side, DSM, and economic impacts from transportation policies) were developed and incorporated into the linkage structure. Therefore, the baseline economic forecasts described include any economic alteration from the feedback effects of ENERGY 2020's baseline outputs. As energy policies are developed, changed, and implemented, the model captures these effects and causes the baseline economic simulation to change accordingly.

The basic structure of the REMI model is shown in Figure C-4. The model is composed of five sectors, termed linkages by REMI . They are output, demand (for both labor and capital), supply (of population and labor), market share, and wages (including prices and profits). These parts are linked to each other through common variables. The local demand for components of personal consumption determined in the output linkage is a function of real income, investment, and government expenditures. Investment demand is also endogenously determined and is a function of both relative factor prices and expected economic activity. Government expenditures depend in part on the size of the local population. When coupled with export demand, these demands determine industry demand by sector and the industry output of the model.

C.2.2. Structure of the REMI Model

The employment demand by industry and occupation is a function of local output, determined in the output linkage, and of the number of employees per dollar of output. The latter is determined in part by the relative costs and substitutability of all the factors of production. The structure of the REMI model is shown in Figure C-4.

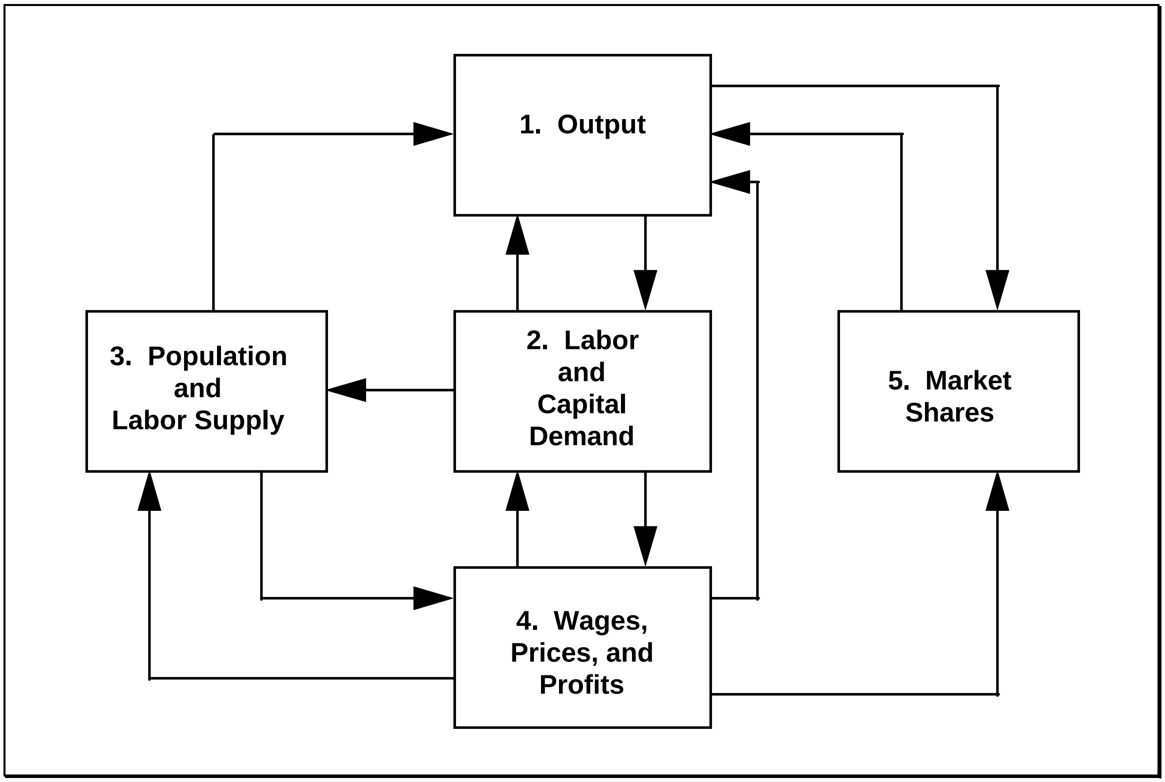

Figure C-4. Structure of the REMI Model

Labor supply and population are closely linked. Population by age and sex in the REMI model is calculated in the demographic/migration module from interactions of natural causes (e.g., births and deaths) and migration shifts (for economic or other reasons). Therefore, population depends on migration (retirement, military, international, and economic) as well as on the cohort survival aspects of population change. Natural population changes are derived from appropriate fertility and survival rates. Economic migration further depends on expected income, which is calculated from the employment/labor force ratio, the real wage rate, and the mix of industries.

The wage rates are determined by the aggregate employment/labor-force ratio and occupation-specific demand and supply conditions.

Market shares, both locally and in the export market, depend on selling prices and profitability – the ability to compete. Competitive pricing depends on factor costs including the cost of labor.

C.2.3 REMI Data Sources

C.2.3.1 Primary Historical Data

A complete documentation of the data sources used in REMI (definitions, descriptions, and estimation procedures for missing data) can be found in Chapter IV of *Model Documentation for the REMI EDFS-53 Forecasting and Simulation Model*, March 1997, Volume 1 (Treyz 1997). The primary historical data source is the Bureau of Economic Analysis (BEA) employment, wage, and personal income series covering the years from 1969, which is available for counties at the one-digit SIC code level. A secondary source is the Bureau of Labor Statistics (BLS) data on annual average employment and total annual wages. Supplementary data sources such as *County Business Patterns* (CBP) data were also used when available.

C.2.3.2 Supplemental Historical Data

State-specific fuel-cost data came from the EIA's *State Price and Expenditure Report*. Fuel-weight data by SIC code came from 1982 *Census of Manufacturers – Subject Series*; Table 3 1982 Census of Manufacturers was used for manufacturing. Other census data was used for construction, service, retail and wholesale trade, and agriculture. EIA data were used for transportation and public utilities.

Tax data used to calculate the cost of capital and to estimate residential and non-residential capital stock came from the *Government Finances* (Revenue) publication and the *Survey of Current Business.* Gross State Product (GSP) data came from BEA and BLS (U.S. input-output table) and the *Survey of Current Business.* Data on housing prices came from the *Census of Housing*.

C.2.3.3 National Forecast Data

The primary set of projections used in the REMI model came from the BLS Outlook 2005 projections published in the November 1991 issue of the *Monthly Labor Review.* Data for compiling the output time series for manufacturing industries are in the U.S. Census and the *Annual Survey of Manufacturers*. For non-manufacturing industries, a variety of sources were used including *Service Annual Survey, National Income and Products Accounts* data, *IRS Business Income Tax Receipts*, and other sources.

The 1990 Bureau of Census Survey provides initial population data that were normalized to data from the BEA. Data from Current Population Reports provides fertility and survival rates and five-year cohort rates, as well as data on international immigration. Birth and death rates came from the *Statistical Abstract of the United States.* Other sources of data were used for specific components of migration. REMI uses a linearly trended forecast from 1990 to 2005. After 2005, the BLS moderate-growth labor force participation rates and the Census Bureau's middle population projections for the U.S. were used to forecast the labor force. Business cycles were added to the U.S. forecast from the short-term national forecast from the University of Michigan's Research Seminar in Quantitative Economics (RSQE). Occupation demands were derived from a fixed-proportion occupation-by-industry matrix based on the BLS 1990 and projected 2005 National OES Matrices.

C.2.4 Adjustments to REMI Default Data

REMI data from national sources can be overridden with better local data when it is available. For the initial REMI forecast, most of the default data were used with the following exceptions. Local estimates of military employment were used in place of the REMI default data. The national trend is a reduced presence of the military in most local economies, but in Hawaii, because of its strategic location, military downsizing has not occurred to the same extent as in the rest of the United States. The military employment estimates from the utility IRPs were used in place of the default REMI data.

State and local government employment was altered to account for local sentiment against the growth of this sector. The population-driven REMI variable was modified to reflect the trend toward a smaller government presence in the counties where the initial REMI percentages were relatively higher.

Hawaii's tourism-driven economy makes forecasting tourist arrivals very important. The REMI model alone does not forecast visitor census (although it is a policy variable in the model). However, the REMI/ENERGY 2020 interface produces a visitor census calculation and a forecast of de facto population in a post-processing routine. As proxy variables for number of tourists, the service industry variables simulated by REMI were evaluated and compared with projected growth rates in the number of tourists.

Hotel sales were altered, if necessary and when possible, to grow at a rate compatible with the rate that is forecast for future tourists. These tourists come Rim countries are increasing in importance, and Canada sends a significant number of tourists to Hawaii every year as well. The increase in sales reflects both the anticipated increase in tourist numbers and the different spending patterns of Japanese and U.S. tourists.

In addition to the specific changes above, the initial REMI forecast was further altered by the changes caused by the feedback loops in ENERGY 2020 that modify energy prices. Many energy policies simulated in the model resulted in relatively small changes to the baseline economic forecast. These differences were generally ignored.

APPENDIX D *HES 1995* RECOMMENDATIONS AND RESULTS

HES 1995 findings and recommendations were initially presented in Chapter 9 of the *Hawaii Energy Strategy Report*. Those recommendations and their results are presented here. Some of the recommendations have been edited or abbreviated for this summary. The recommendations were not numbered in the original report, but are so organized in this Appendix.

Recommendation 1: Diversify Fuels and Sources of Supply

Oil is likely to remain Hawaii's primary fuel for the foreseeable future. Hawaii must recognize that it faces potentially volatile oil prices and potential supply problems and that the State should continue to seek diversification of fuels and sources of supply (DBEDT 1995a, 9-2).

Results. Decreases in oil prices over the period 1995–1998 made Hawaii's efforts to diversify fuels and sources of supply more difficult because the economic advantages of many renewable resources were reduced – although not eliminated. In addition, closure of the Makani Uwila wind farm, on Oahu, and closure of all sugar plantations on Oahu and Hawaii (and some plantations on Kauai) reduced renewable energy production from biomass and hydroelectricity. The former Waialua Sugar Mill, on Oahu, became Waialua Power in 1997 and produced electricity from waste oil and green waste until it closed in 1998.

There was a notable success. On the Big Island, Puna Geothermal Venture increased its capacity from 25 MW to 30 MW in 1996 and provided up to 25% of Hawaii County's electricity.

In addition, there was increased use of coal beginning in 1992, and utility Integrated Resource Plans (IRPs) call for future additional coal-fired generation on Oahu and Kauai. More detail on coal can be found in the discussion of Recommendation 3, below.

Recommendation 2: Focus Diversification on Power Generation and Ground Transportation Energy

Hawaii's energy diversification plans should first focus on conversion of power generation and process heat to fuels other than oil, and transportation energy to 10% alcohol/gasoline blending. Substituting oil demand much beyond one-third of current use involves bolder and more speculative measures (9-2).

Results. Power generation and ground transportation continue to be the focus of DBEDT's efforts in seeking energy diversification. These areas offer the greatest opportunities for greater efficiency and application of renewable alternatives to fossil fuel use.

Recommendation 3: Pursue Coal as an Option for Oahu Energy Diversification

Coal offers an opportunity for diversification of Hawaii's energy supply. The long-term price of coal is not expected to increase significantly, and coal is projected to remain the lowest fuel-cost option for large power plants on Oahu. The higher relative costs of smaller coal plants, sized for the neighbor island utility systems, make them less attractive options for now (9-2).

Results. Hawaiian Electric Company considered a number of options using coal-fired units in its second IRP. The final plan selected included a 180 MW (AFBC) plant scheduled for 2016. With the scheduled retirement of the Kalaeloa 180-MW LSFO-fired DTCC unit in that year, additional baseload generation will be required, shortening the economic payback period. The plan selected offers fuel diversification without significant added cost (HECO 1998b, 11-34).

In addition, when the AES Hawaii 180 MW AFBC plant was built at Campbell Industrial Park, on Oahu, in 1991-1992, it was designed to allow construction of a second 180-MW AFBC plant on site. The second plant would share much of the existing infrastructure, including coal-handling and transport conveyor equipment and storage. Such an approach remains an option for installation of additional coal-fired generation.

On the Big Island, with the closure of sugar operations, the former Hilo Coast Processing Company converted its steam generator to use coal as fuel and renegotiated its contract to increase the power it provides to HELCO from 18 to 22 MW. The HCPC power purchase agreement expires at the end of 1999 but HCPC is attempting to negotiate a new agreement or extension to increase the capacity provided (HELCO 1998b, ES-10).

Kauai Electric's second IRP schedules a 24-MW coal steam generator for 2014, providing additional diversification (KE 1997b, 1-1).

While coal offers fuel diversification to Hawaii, growing concern about the effects of greenhouse gas emissions on global climate may make coal use less attractive. Coal produces about 20% more CO_2 per equivalent Btu than oil. Nevertheless, such emissions may be offset by carbon sequestration projects such as the forest preserve voluntarily funded in Paraguay by AES Hawaii in 1991. This preserve sequesters twice as much CO2 as AES Hawaii will emit over its lifetime.

Recommendation 4: Encourage Hawaii's Refineries to Upgrade Capabilities

Increased refinery flexibility would enhance refiners' capability to respond to changes in the world oil market and give much more latitude to State programs in alternative fuels. The refinery upgrades needed would include additional improvements to facilities, including some expansion of crude distillation and catalytic reforming capacity, and substantial expansion of hydrocracking capacity (DBEDT 1995a, 9 2).

Results. This recommendation encouraged additional crude and conversion capacity additions by Hawaii's refineries to enhance the ability to respond to changes in world oil markets. According to Mr. Tom Simons, Chevron Hawaii Refinery Resources Superintendent, "Chevron makes investments in upgraded facilities based on the market-driven economics for justifying expenditures. To the extent that changes in market economics make upgrading facilities economically viable, Chevron has and will continue to make these investments."

Tesoro Hawaii reported that the following projects have been implemented since 1995.

- A mercaptan-treating unit was installed, allowing purchase of crude oil containing mercaptan sulfur components. The unit can remove these components, increasing refinery flexibility and allowing it to purchase crude oil from a larger number of sources.
- Additional flexibility permitting the refinery to purchase very light crude oil was achieved by re-engineering the upper part of Tesoro Hawaii's crude distillation tower with new trays and debottlenecking the overhead system (McMullen 1999).

Recommendation 5: Increase Use of Renewable Energy

Increase use of renewable energy to decrease Hawaii's dependence on oil (9-2).

Results. Renewable energy use was not increased significantly during the period. With the decline of the sugar industry, the percentage of electricity sold by the utilities generated from bagasse declined from 3% in 1990 to 1.1% in 1991. The closure of Makani Uwila wind farm on Oahu in 1996 contributed to the decline of the wind-energy contribution from 0.4% in 1990 to 0.2% in 1997. The addition of geothermal energy to the mix helped offset these losses. Run-of-the river hydroelectric plants provided additional renewable energy. A landfill-methane-powered generator operated on Oahu. The following table shows the percentage contribution to utility electricity sales by renewable energy by source. Note that municipal solid waste (MSW) burned at the H-POWER plant remains the main source of renewable energy.

Table D-1 Percentage Contribution to Utility Sales by Renewable Resource, 1990–1997

	1990	1991	1992	1993	1994	1995	1996	1997
Bagasse	3.0%	3.0%	2.7%	2.4%	2.3%	1.5%	1.4%	1.1%
Geothermal	0%	0%	0%	1.5%	1.8%	2.3%	2.3%	2.3%
Hydroelectric	0.7%	0.6%	0.4%	0.4%	0.6%	0.5%	0.5%	0.4%
Wind	0.4%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
LF Methane	0.1%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%	0.2%
MSW	3.5%	3.6%	3.5%	3.3%	3.5%	3.5%	2.8%	3.8%
Total Renewable	7.7%	7.7%	7.0%	8.0%	8.6%	8.0%	7.4%	7.9%

Recommendation 6: Focus First on Cost-Effective Energy Efficiency and Conservation

Conservation and demand-side management (DSM) measures could result in substantial energy savings and are likely to be the most cost-effective ways of lowering current levels of dependence (9-3).

Results. Energy efficiency and conservation are proving highly cost effective in reducing energy use. Measures include adoption of the Model Energy Code, performance contracting efforts, and continued use of utility demand-side management programs. These efforts are reviewed in more detail in the body of the *HES 2000* report.

Recommendation 7: Consider HES DSM Measures in Utility Integrated Resource Planning

Utilities should be encouraged to evaluate the DSM measures found to be cost effective by HES program models. All those that are cost-effective should be included in their IRPs (9-3).

Results. While the utilities developed their DSM programs independently, many of the measures that were recommended in *HES 1995* became part of the utility programs. Utility adoption was not necessarily a result of *HES 1995* recommendations, but the work of the program contributed to the dialogue. Recommendations for mandated measures were either not pursued further because such efforts were not deemed necessary or because their adoption was infeasible

In the residential sector, all of the utilities provided residential efficient water heating programs offering rebates on solar water heating, heat-pump water heating, and efficient water heaters. Some utilities have distributed or provided rebates for compact fluorescent light bulbs and low-flow shower heads. Such measures as second refrigerator removal and horizontal axis clothes washers were not found to be cost effective. One proposed mandate, load control devices on electric water heaters, is under consideration as a voluntary DSM measure by at least one utility.

In the commercial/industrial sector, most of the DSM options recommended are part of a variety of customized-rebate DSM programs available for new construction and for existing commercial/industrial buildings. These include rebates for optical reflectors, T-8 fluorescent bulbs with electronic ballasts, occupancy sensors, heat pumps, and electronic ballast refits. Solar process-heat and most of the recommended mandates have not yet become part of utility DSM programs. Building energy-management systems, proposed as a mandate, could be obtained voluntarily by building-owners with rebates under utility custom programs.

Recommendation 8: Evaluate DSM Mandates

The State government should consider the proposed mandates in light of their capability to reduce energy demand. In some case, the actions could be encouraged as part of the Model Energy Code (9-4).

Results. It was decided not to pursue DSM mandates beyond the provisions of the Model Energy Code due to the relatively small effect that the proposed mandates might have. Some measures, such as load control devices on water heating systems are under consideration for voluntary installation as part of utility DSM programs.

Recommendation 9: State and Utilities Should Cooperate on DSM Data Gathering

The State and the utilities should cooperate further on data gathering in support of DSM measures and program design (9-4)

Results. DBEDT and the utilities continue to cooperate on the development of DSM measures and program design through DBEDT participation in utility IRP advisory groups. Resource limitations have reduced DBEDT's ability to develop new recommendations. The HECO utilities did, however, adopt *HES 1995* Project 4's assessment of DSM potential impacts, as reported in *Hawaii Demand-Side Management Opportunity Report*, to select the optimum level of DSM in the second round of IRP (HECO 1998b, 7-3).

Recommendation 10: Adopt Transportation Energy Conservation Measures

Energy conservation can greatly decrease the absolute amount of energy that would be required for transportation in comparison with a future without conservation measures. Recommended measures to encourage transportation energy conservation follow (DBEDT 1995a, 9-4).

A. Improve Vehicle Fuel Efficiency

Vehicle fuel efficiency has a powerful effect on total ground transportation energy demand. The technology for significant increases in fuel efficiency is available. Cars that average more than 50 miles per gallon are in showrooms today, and prototypes that can travel 70–120 miles on a gallon of gasoline have already been developed (9-4).

Results. While industry has provided many vehicles with greater efficiency for sale, the popularity of larger automobiles, sport utility vehicles, and light trucks – in combination with historically low gasoline prices – has reduced the demand for fuel-efficient vehicles. As discussed in *HES 2000*, Chapter 3, it appears that the average efficiency of Hawaii's vehicles has declined in recent years.

B. Adopt More Stringent CAFE Standards

Hawaii could challenge the federal law that preempts states from setting their own standards. If successful, Hawaii could then institute fuel efficiency standards more stringent than the national Corporate Average Fuel Efficiency (CAFE) standards and thus reduce demand for transportation fuels of all types (9-4).

Results. This recommendation has not yet been pursued. However, alternative-fuel vehicles have become increasingly available, at least partly due to the provision in the existing fuel efficiency standard that gives manufacturers of alternative-fuel vehicles "credit" toward meeting the CAFE standard. For example, flexible-fuel capability is standard in Model Year 1999 Chrysler minivans and Ford Ranger pickup trucks (Chrysler 1997 and Frey 1998).

C. *Improve Efficiency of State Vehicle Fleet*

The State government should set an example by improving the efficiency of its fleets. For example, a fleet rule could be established that would require the procurement of County and State vehicles that are 2.5 mpg higher than the current CAFE standard. While this would not save large amounts of energy, such a program would set an example and introduce additional people to higher-efficiency vehicles (9-4).

Results. This recommendation has not yet been pursued.

D. *Adopt Travel Reduction Measures*

The measures with the greatest potential to decrease vehicle miles traveled (VMT) in Hawaii, and particularly in the City and County of Honolulu, were transit programs, transportation management associations, actions by educational institutions, high-occupancy vehicle (HOV) facilities and meaningful enforcement, automobile use limitations (such as road pricing), and land use planning (9-4).

Results. The City and County of Honolulu has announced plans to increase the number of buses in its bus system. In addition, HOV facilities have been added and improved, most recently with the addition of "zipper lanes," moveable barriers that separate HOV traffic from non-HOV traffic. Enforcement of HOV lanes was also improved. Ride sharing and vanpool promotion activities have continued. Also, Kapolei, which is intended to become a "second city" and provide increased employment opportunities in a central location outside the existing central business district, have progressed. These were discussed in more detail in Chapter 4. Other recommended measures have not been adopted.

E. *Increase the Focus on Energy in the Transportation Planning Process*

Energy use currently receives very little emphasis in the State's transportation planning process. There is statutory authority for energy concerns to play a much larger role. For example, the *Intermodal Surface Transportation Efficiency Act* has energy efficiency as a goal, and the Clean Air Act Amendments of 1990 support energy efficient strategies. It would be helpful to update and maintain ground transportation sector energy demand projections such as VMT projections to show the energy consequences of transportation policy decisions in the State Transportation Improvement Plan (9-4).

Results. The State Energy Office has assisted the Technical Advisory Group of the Oahu Metropolitan Planning Organization's Model Development Task Force. Energy use and costs are included in the model so that when transportation and land use alternatives are considered in the future, the energy impacts may be quantified.

F. *Increase the Focus on Energy in Land Use Planning Process*

Land use planning at the State and local levels has not emphasized transportation energy use. Land use patterns can, over time, have a powerful effect on transportation energy use, and an increased emphasis on transportation energy use during the land use planning process (e.g., revisions to Development Plans) would help achieve State goals (9-5).

Results. The process initiated by Mayor Harris in the City and County of Honolulu considers energy as a component of the vision of sustainable communities intended to become part of the City and County of Honolulu General Plan.

G. Expand Use of Alternative Fuels and Vehicles

There are already several hundred alternative-fuel vehicles (AFVs) in use in Hawaii. Continued and expanded use of alternative fuels and vehicles is expected to occur in response to federal and State requirements, public support of "clean fuels," and the increasing availability of alternative-fuel options on popular models of cars and trucks. The development of a local alternative-fuels industry could provide local jobs. The production alcohol fuel from agricultural materials has the greatest employment potential, although costs and benefits must be evaluated on a site-specific basis. Generally, production of alternative fuels makes sense only when done in conjunction with the production of higher-value products (9-5).

HES Project 5 also recommended specific actions for the period 1995–2002. These included incentives for off-peak charging of electric vehicles, adjustment of fuel taxes on the basis of energy content to remove a disincentive to alternative fuel use, and public education and outreach. The latter is essential for public acceptance and voluntary purchases of AFVs (9-5).

Results. A special reduced rate for recharging electric vehicles by residential and commercial customers went into effect on Maui on April 15, 1999. A similar program is under final review for Oahu (Maskrey 1999). A bill to adjust fuel taxes on the basis of energy content was drafted. It has been considered by the Legislature but has not yet passed. A variety of public and private agencies, particularly the Honolulu Clean Cities Coalition and its member organizations (including private organizations and State, federal, and County agencies) have carried out several public education and outreach efforts.

H. Use Alcohol/Gasoline Blends as Motor Vehicle Fuel

Out of the 21 transportation measures evaluated, and nine combinations of measures, an alcohol/gasoline blend program was the least costly means of encouraging the use of significant quantities of renewable, locally produced alternative transportation fuels. Low-level alcohol blends (E10 – 10% ethanol) are much closer to being competitively priced than the higher level alcohol fuels (M85 – 85% methanol and E85 – 85% ethanol), which will facilitate the introduction of alternative fuels (9-5).

The objective of alcohol blending would be to have the alcohol (most likely ethanol) produced locally. Consideration should be given to replacing the existing excise tax exemption for ethanol blends by a producer incentive available only to alternative fuel producers in Hawaii (9-5).

Results. Several potential ethanol producers have requested information on Hawaii's previous studies, incentives, and laws, and have considered or are considering the possibility of importation of ethanol or production of ethanol in Hawaii.

I. Conduct Transportation Energy Research and Development Programs

Research and development programs could play an important part in the achievement of Hawaii's energy goals. Specific recommendations for programs were provided in *HES 1995* (9-6).

Results. Several federally funded research and demonstration projects have been initiated and are ongoing. The largest is the Electric Vehicle Demonstration Program, funded by the Advanced Research Projects Agency of the U.S. Department of Defense. Several electric vehicles and electric vehicle technologies have been developed, refined, and tested in Hawaii, including a network of rapid chargers to be installed at various locations on Oahu. See Chapter 4 for additional details.

Recommendation 11: Improve State Energy Analysis

A. Improve Data Collection and Reporting

To further the understanding of State government policy makers, the State should improve its data collection and reporting system to better track imports of crude oil and refined products, Hawaii refinery production, production of indigenous energy resources, and use of these energy resources. The completeness, accuracy, and resolution of the State's data collection efforts should be improved (9-7).

Results. Since the *HES 1995* report was issued, data collection has been significantly improved and better organized into a set of useful databases. Currently, data is collected from all fuel distributors in Hawaii under procedures developed under Chapter 486E - *Fuel Distribution*, Hawaii Revised Statutes. Chapter 486E was replaced in 1997 by Chapter 486J - *Petroleum Industry Information Reporting Act*, Hawaii Revised Statues. Chapter 486J increased the scope of data collection to include the collection of fuel data from oil producers, refiners, marketers, oil transporters, and oil storers. Chapter 486J also included provisions for the collection of pricing data. Administrative rules are being developed to effect the reporting requirements of Chapter 486J.

To improve the tracking of crude oil and refined products, the data collection form was revised. The revisions increased the number of consumption sectors and improved differentiation between the fuel products. Reporting compliance by distributors was also improved through follow-up and by assisting distributors in understanding how to fill out the data collection form. A new database was developed to maintain new data in a more organized manner, and historical data back to 1982 was also entered.

The ERT Division maintains other databases that are used to help assess the completeness and accuracy of data collected from distributors. Databases are maintained on the Department of Taxation monthly fuel tax report and a more detailed database on the quantity of taxable fuel used in the City and County of

Honolulu. The division also maintains a database based upon the Energy Information Administration's Form 782c monthly report on sales of selected petroleum products by prime suppliers for local consumption. This report serves to check local fuel consumption data.

Other sources used to track energy production include the *Energy Report* provided by the Hawaii Agriculture Research Center, annual reports prepared by independent power producers, Federal Energy Regulatory Commission reports submitted by Hawaii's electric and gas utilities to the Hawaii Public Utilities Commission (PUC), discussions with utilities and independent power producers, and a variety of Internet sites.

B. Monitor Key Aspects of the World Oil Market

The DBEDT Energy Division should monitor the world oil market and Hawaii's relationship to that market, to better understand and predict the effects of the market on Hawaii's economy. Concentration should be placed on the Asia-Pacific oil market and on oil production in Alaska and other areas that become sources of crude oil for Hawaii's refineries or of imports of refined products (9-8).

Results. Collection of data on the world oil market was improved since the *HES 1995* report, and a set of databases was developed to follow long-term trends. ERT collects data on the quantities of foreign or domestic crude oil imported to Hawaii. Data on crude oil imports from local refiners and importers is supplemented by data from the Energy Information Administration on foreign crude oil imports by country of origin.

Sources used to monitor the world oil market include EIA's *Weekly Petroleum Status Report*, and Internet sites such as Energy Intelligence Group and Oil World. Additional work is needed to better monitor oil supply and prices in the Asia-Pacific area. Databases need to be developed to provide a historical series of oil supply and pricing data.

C. Improve Energy Planning and Policy Development

1. Formalize Comprehensive, Integrated Energy Planning as a Statutory Requirement

HES 1995 recommended that the State formalize comprehensive, integrated energy planning as a statutory requirement by amending Chapter 196, HRS, and provide resources to continue this requirement triennially by 1997. Implementation of this recommendation is also supported by Act 96, SLH, 1994, an Energy and Environmental Summit initiative that strengthened the energy section of Chapter 226-18, HRS (9-8).

Results. The preparation of *Hawaii Energy Strategy 2000* demonstrates the State's commitment to comprehensive, integrated energy planning to support the State's statutory energy policies. Although Chapter 196, HRS, was not amended to mandate the triennial planning cycle, this statute does require the Energy Resources Coordinator to develop recommendations related to improving Hawaii's energy situation by achievement of the State's energy policies, Chapter

226-18, HRS. *HES 2000* was delayed due to lack of staff time, but DBEDT plans to continue this important activity on a triennial schedule in the future.

2. Support DBEDT Energy Division Staff Positions with State Funds

HES 1995 also recommended that by 1999 the State support with State funds DBEDT Energy Division staff positions that are currently funded by federal funds (9-8).

Results. This recommendation was not implemented. Due to severe fiscal constraints, the Energy Program, like other programs in the State, has had its mission expanded to literally “do more with less.” To accomplish this, the Energy Program has been successful in developing, through competitively awarded grants, over $2 million for program activities over the past four years. Accordingly, until the State’s fiscal condition improves, the Energy Program will continue to leverage its available State funding by developing other-than-State funding for program activities.

3. Complete the Assessment and Assignment of Externalities Values of Energy Resources in Hawaii

Working with public and private organizations from Hawaii’s energy community, complete the assessment and assignment of externalities values of energy resources in Hawaii by 1997. This work supports the mandates of the PUC (IRP) and State Legislature (Act 96, SLH, 1994) regarding factoring external costs and benefits into energy planning in the utility and transportation energy sectors.

Results. The ERT Division of DBEDT participated, along with a variety of public and private stakeholders, in the HECO companies’ Externalities Advisory Group (EAG). The Externalities Study was initiated in November 1994, but work began in November 1995 following selection of a consultant and development of a work plan. It resulted in completion of a *Hawaii Externalities Workbook,* submitted in July 1997 (with a number of caveats by the companies), to the PUC as their proposed “findings and recommendations regarding the identification and quantification of externalities” (HECO 1997b, Atch III, p.1).

In its comments on the *Workbook*, DBEDT acknowledged that it represented a major effort, at considerable expense on the part of the companies and their contractors. It is the most thorough inventory and analysis of the externalities resulting from the production of electricity in Hawaii available. A good faith effort was made to involve the EAG in the process and the companies were receptive to comments, additional information, and suggestions made by the Group.

Nevertheless, DBEDT had a number of concerns about the resulting document, and believes that economic externalities and global warming impacts were not adequately covered. DBEDT also believes that the $43 per ton emissions fee charged by the State Department of Health should not have been used to reduce the costs of damages produced by air pollutants.

As promised in the HECO companies’ statement of position on the report, externalities received greater attention in the second round of IRP. All externalities that were quantifiable were listed for each plan alternative and were monetized for the few categories where values were developed in the *Workbook*. While it is not clear that this effort had major effect on ultimate plan selection, it makes the externalities explicit in the process.

DBEDT does not have the resources to do an independent externalities study, but continues to monitor the issue for sources of alternative valuations. In addition, under a grant from the U.S. Environmental Protection Agency, DBEDT produced an *Inventory of Hawaii Greenhouse Gas Emission, Estimates for 1990* in 1997, and the *Hawaii Climate Change Action Plan*. These studies served as a basis developing goals for greenhouse gas reduction and suggested a variety of continuing and new measures for future reductions. DBEDT intends to emphasize the need to consider such emissions through its participation in the utility IRP advisory group process.

Externality costs and benefits for the transportation sector have not been developed.

4. Open a Collaborative Dialogue on the Future of Oil in the State's Energy Supply

As State policies on alternative fuels are shaped, there should be ongoing discussions with the energy industry about the timing and impacts of measures under consideration. The dialog would identify solid technical arguments and could identify areas where support could be forthcoming. The triennial planning process that was recommended by the HES program could serve this function (9-8).

Results. The collaborative dialogue was not initiated due to resource limitations.

5. Focus Planning on Energy Efficiency, Fuel Substitution, and Developing Alternative Energy Resources

Planning focus should be on improvements in energy conservation and using energy efficiently, encouraging cost-effective fuel substitution, and developing alternative energy resources (9-8).

Results. The planning focus as recommended by *HES 1995* was adopted in subsequent ERT Division activities. These actions are detailed in this Appendix in the discussions of specific related recommendations.

Recommendation 12: Improve Energy Modeling

The ENERGY 2020 model, the DBEDT DSM Assessment Model, and the Renewable Energy Resource Supply Curve model will continue to be valuable tools for analysis. Uses include energy planning and policy development, supporting DBEDT participation in the IRP process, evaluating new business development options, exploring the impacts of proposed energy incentives or disincentives. The necessary resources should be devoted to maintenance and upkeep of the models.

A. *Improve the ENERGY 2020 Model*

DBEDT Energy Division staff has been trained in the use of ENERGY 2020. The intention is for the staff to maintain, use, and develop the capabilities of the model (9-8).

Results. The ENERGY 2020 Model was used in the development of the *Hawaii Climate Change Action Plan* (HCCAP) in 1997 and 1998. While ERT staff was not able to maintain or program the model, they helped calibrate the model, reviewed model output, and prompted refinements made by the contractor. ERT staff designed the scenarios tested in the model.

As part of the work on HCCAP, the staff of ERT received training in model calibration in April 1997 and in scenario development and model runs in February 1998. The model runs conducted in mid 1998 for the HCCAP were directly applicable to *HES 2000* and were used as an analytical basis for the report.

As staff time permits, ERT Staff intends to work on understanding the model with the aim of learning to use it without the aid of the consultant. The consultant recently announced that a Windows version of the model was nearing completion. ERT will evaluate this version to determine whether it is easier to use. Should it represent a substantial improvement over the current DOS-based version, a contract to obtain a Hawaii version will be considered.

B. *Interface ENERGY 2020/REMI with State Economic Model*

This project demonstrated the need for a current official State forecast of macroeconomic variables; the last published State forecast was seven years old at the time of this report. Due to the absence of a current official forecast of macroeconomic variables, the REMI model was adopted and adapted for use by the Hawaii version of ENERGY 2020. The Research and Economic Analysis Division (READ) of DBEDT is currently updating the 1988 forecast, and these results will be compared with REMI outputs. However, the State should have only one “official” forecast, and all State agencies should use it (9-9).

The REMI model directly interacts with ENERGY 2020. It remains to be decided whether an interface between READ’s model and ENERGY 2020 will be developed, or whether REMI will continue to be used for energy forecasting. Either option will require additional resources. The results from READ’s forecast could be used in ENERGY 2020, but without the interface between the economic forecast and ENERGY 2020, the feedback effects would be lost (9-9).

Results. The DBEDT Research and Economic Analysis Division released a new official State forecast, Population and Economic Projections for the State of Hawaii to 2020 (DBEDT 2020 Series), in May 1997. ERT staff used the final draft version of the forecast during training with their consultant in April 1997 to calibrate the REMI model for use with ENERGY 2020. Such calibration represented the best option at the time. ERT now owns the Hawaii version of the REMI model and is under contract for annual maintenance updates through 2001.

C. Improve Capability to Evaluate Economic and Employment Effects of Energy Policies

The capability to evaluate economic and employment effects of energy policies should be enhanced in support of decision-making (9-9).

Results. The ENERGY 2020/REMI model combination produces estimates of the effects of alternative energy policies on a variety of economic factors, including personal income and Gross State Product. It also provides an estimate of effects on employment. Such estimates were produced in the model runs used in the *Hawaii Climate Change Action Plan* and in the *HES 2000* report. Often, proposed policies under evaluation involve very small effects on the overall State economy and differences are correspondingly small.

D. Improve DSM Modeling and Programs

The work to identify the size of Hawaii's DSM resource and identify the DSM measures with the greatest potential required explicitly estimating the impacts of DSM measures on representative Hawaii buildings using Hawaii-specific weather files. This methodology was based on the best information available. The State's DSM modeling capability should be improved to support evaluation of utility DSM programs (9-9).

Results. Additional resources have not been available to pursue this recommendation.

Recommendation 13: Increase Use of Indigenous, Renewable Energy Resources

A. Improve Power Purchase Contract Terms for Renewable Energy

Economic conditions unrelated to the pace of technology development will also be a major factor in determining the magnitude of renewable energy integration in Hawaii. Avoided-cost payment levels or power purchase contract terms will pay a large role in determining the renewable energy projects that can be developed. In addition to encouraging utilities to construct contracts with favorable terms for renewables the State must also allow the costs associated with these contracts to be included in the utility rate bases. Factors that have been shown to be favorable to renewables include consideration of capacity value, externalities benefits, and time-of-day pricing. Contract structures that assist in obtaining financing at favorable rates (such as front-loaded contracts and long-term contracts with specified payment schedules) will also promote development and integration of renewable energy (9-9).

Results. In 1996, a similar recommendation was made in *Strategies to Facilitate the Development and Use of Renewable Energy Resources in the State of Hawaii*, which was a report to the legislature pursuant to S.C.R. 40, S.D. 1, 1994 by the PUC. A working group of stakeholders, including renewable energy developers, utility company representatives, environmental groups, government agencies (including DBEDT), and others had prepared the report. No modifications to power purchase contract terms have yet been made.

B. Conduct Additional Renewable Energy R&D

Encourage and support research and analysis that promote the commercial application of renewable energy in Hawaii. Studies addressing penetration limits for intermittent resources on isolated grids should be a top priority because this issue restricts deployment of intermittent renewable energy resources. These analyses should be conducted in partnership with the utilities (9-9).

Economical energy storage options would also address the issue of penetration limits. The costs and operation of promising energy-storage technologies should be evaluated using the same methodology as the Resource Supply Curve Computer Model (9-9).

The Hawaii Integrated Energy Policy project called for the development of a renewable energy research, development, demonstration, and commercialization strategy to overcome the remaining technical hurdles to renewable energy use. This also remains to be done (9-9).

Results. A biomass gasifier research and development project was carried out on Maui but was dismantled when no further resources could be provided by the partners, the State of Hawaii, the U.S. Department of Energy, and Westinghouse.

C. Conduct Renewable Energy Assessments

For projects that appear viable, detailed feasibility studies can be conducted to refine estimates of their costs and performance. This could include additional long-term renewable energy resource modeling. The developer, utility, and/or government agencies interested in developing the project may do this (9-9).

Results. Wind developers have reportedly carried out additional assessments on Maui and the Big Island. Resource limitations have precluded additional assessment by DBEDT. Several Hawaii utilities are conducting renewable energy penetration studies that will help identify the extent to which intermittent renewable resources can be deployed on their systems.

D. Obtain Access to Land for Renewable Energy Projects

One of the most important factors in eliminating renewable energy projects from consideration was the lack of available land without conflicting or potentially competing land uses. Only on the island of Hawaii and on the lightly populated islands of Lanai and Molokai were competing uses rarely an issue. Access to lands for any type of project requires a complex permitting process (9-9).

Renewable energy projects should be encouraged by active efforts to provide necessary access to land by State and County governments. Creating pre-permitted renewable-energy enterprise zones to favorable leases of State or County lands and outright land grants to developers of renewables are just two possible options. These and other options should be explored further, and action taken, to help developers of renewables gain needed access more quickly (9-9).

Results. These recommended actions have not been pursued further due to staff limitations.

E. Develop Cost-Effective Renewable Energy Projects Now

The total generating capacity of the utility grid and projected demand growth on each island provides the greatest limitation to implementing renewable energy projects in the next ten years. It is important however, to consider the long-term value of renewable projects in near-term energy supply decisions because of the long life of fossil-fuel energy generation resources that may be put in place. In *HES 1995,* the recommendation included a detailed discussion by type of option (9-10).

Results. A number of viable wind projects already exist. In Hawaii and Maui counties, more electricity could be generated by proposed wind projects than the utilities can accept. On Oahu, a new wind project to replace the units shut down at Kahuku would be feasible.

The main solar projects installed include a large photovoltaic (PV) system at the Mauna Lani Resort, on the Big Island, and the Sunpower for Schools project of the HECO utilities. Other projects are under consideration. PV remains costly but is especially useful in areas not served by the grid.

Hybrid solar systems that use gas, biomass, or other fuels in conjunction with solar thermal heat are receiving considerable attention and have promise for Hawaii applications, but they have not been pursued.

A biomass gasifier research and development project was carried out on Maui but it was dismantled when no further resources could be provided by the partners, the State of Hawaii, the U.S. Department of Energy, and Westinghouse.

The Puna Geothermal Venture geothermal plant is successfully operating on the Big Island and has increased its output from 25 MW to 30 MW. Additional steam resources will be needed for continued long-term operations. The potential exists for additional geothermal power in the area.

Hydroelectric projects are commercially viable in Hawaii; however, a limited number of developable sites exist. Further hydroelectric development is subject to significant public opposition due to perceived conflicts with other uses.

Ocean Thermal Energy Conversion (OTEC) development was discontinued because no additional funding was provided. OTEC was not competitive in the face of low oil prices, and it is not expected to be competitive with other energy options in the next ten years In the more distant future, OTEC may offer a significant contribution to Hawaii's generation mix in the long-term.

F. Consider HES 1995 Project 3 Renewable Energy Implementation Plan

The Project 3 report presented a renewable energy implementation plan for each of Hawaii's four major islands. The plans were based upon the 2005 resource supply curves, consideration of constraints such as projected load growth on each island, a 20 % assumed maximum penetration limit, and the nominal relative cost of energy. In all cases, the integration plans include intermittent projects totaling less than 20 % of the annual peak load. Even with this limitation, it appeared feasible to meet all new generating requirements with renewable energy additions. This was cited as an objective that the State government should pursue (9-13).

Results. DBEDT representatives on the electric utility Integrated Resources Planning Advisory Groups urged consideration of elements of the recommended plans. While renewable options were considered by the utilities, none have yet been included in the utility action plans, primarily because all fossil fuel options are cheaper.

In addition, it was not clear whether some systems could, for technical reasons, use as much as 20% intermittent renewable systems. The HECO utilities were conducting studies of their capacity for intermittent renewables as of early 1999.

Recommendation 15. Enhance Energy Emergency Contingency Planning

Project 6, the Energy Vulnerability Hazard Mitigation Study examined thirty-three proposals pertaining to Hawaii's energy systems and lifeline services. They were evaluated for cost-effectiveness and the functional effectiveness of the option. Specific Recommendations were as follows (all from DBEDT 1995a, 9-14 to 9-17):

A. Recommendations for the Electricity Industry

1. Industry Lead

a. Use ocean water for power-plant cooling water to eliminate vulnerable cooling towers.

Results. H-POWER staff indicated an interest in ocean-water cooling, but noted that the U.S. Army Corps of Engineers had not looked upon such requests favorably. It was suggested that the State and Federal governments could best resolve such permitting issues (Jones 1999).

AES Hawaii reported in June 1999 that it had investigated the need to replace its aging cooling tower. The company considered direct ocean-water cooling, but scheduling, cost, land, and permitting issues were too significant to overcome. Instead, AES Hawaii plans to replace its nine-year-old wooden cooling tower, designed for 80 mph wind loads, with a new fiberglass cooling tower designed for hurricane wind speeds of 120 mph (Kanja 1999).

b. Close radial transmission line loops on Oahu and Kauai.

Results. HECO indicates that it does not have radial transmission lines on its system. However, a major transmission loop project is being implemented to improve East Oahu reliability (HECO 1997c)

Kauai Electric reported the following:

> KE currently operates two radial lines, to the Princeville and Mana substations. If KE loses the Princeville substation, it currently can

support service to the North Shore of Kauai with its 12 kV system out of Kapaa. As load growth on the North Shore continues, however, KE expects to have to plan for closing that loop by building a 69 kV line that will have to proceed from Kilauea along the highway to Princeville. When, in 1991, KE began planning for the 69 kV line to close the loop, it was sued in the United States District Court by several citizens, the Sierra Club, and the Hawaii Audubon Society. The suit resulted in a consent decree (Civ. No. 92 00170) that was approved by the court. The consent decree required KE to surrender various permits it had obtained and applications it had filed, and to declare a moratorium on construction of 69 kV lines (i) across Kalihiwai Valley until after January 1, 1998, and (ii) along Kalihiwai Road until after January 1, 2004.

The Mana radial serves only the Pacific Missile Range Facility, which can be supported from Kekaha by KE's 12 kV line. Practically speaking, the loop to this remote location could only be closed by using the same poles, so that many common causes of outages would not be mitigated. Accordingly, KE has no current plans to close the loop on the Mana radial (Gilman and Golden 1999, 3-4).

c. Consider alternatives to wood for new transmission lines on Kauai, sections of Oahu, and the island of Hawaii.

Results. HECO reported that its current design methodology for transmission lines results in the use of steel structures for most locations and that HELCO and MECO employ the same design methodology in their 69kV transmission lines (HECO 1997c).

KE indicated that since about 1990 it has systematically considered steel poles as alternatives to wood to harden its transmission lines. Approximately 28% of KE's system now uses steel poles. Only one of the steel poles in place during Hurricane Iniki failed. (Subsequently KE determined that the failure was due to the failure of a piece of hardware that was mistakenly used by the contractor to attach a down-guy to the pole.) Engineering considerations, terrain, and community input are all taken into account when KE plans for new or replacement transmission lines (Gilman and Golden 1999, 4).

d. Existing power lines serving critical lifeline facilities should be upgraded as necessary to withstand ANSI-7 wind loading.

Results. HECO indicates that it uses guideline No. 74 for electrical transmission line structural loading, as recommended by the American Society of Civil Engineers (ASCE). The company deems this standard more appropriate for transmission lines than ANSI/ASCE-7 standards for buildings and structures. This guideline, implemented through its program of transmission line structure modification, is intended to upgrade important transmission line structures to meet more stringent requirements than those used when the structures were first constructed (HECO 1997c).

HELCO reports that it uses the G.O. 6 methodology of determining allowable wind loading for wooden-pole design for wind speeds, as recommended by the *Hawaii Island Wind Study*. For its steel transmission poles, it uses the ASCE 74 guidelines and a design wind speed of 100-mph (Lee 1999).

KE adopted new design standards for lifeline facilities in 1990. KE's steel pole system is designed for wind loading to 125 mph, with a 1.25 safety factor. Electrical equipment serving lifeline facilities (including poles, conductors, switches, and circuit configurations) has been hardened (Gilman and Golden 1999, 4).

MECO also employs the G.O. 6 methodology (HECO 1997c).

e. Wood poles should be inspected at least every five years, replaced or repaired as necessary to ANSI/ASCE 7 wind loading standards.

Results. HECO conducts an inspection and treatment of wooden poles program, which operates on a five-year cycle. Replacement and repair of poles is based on guidelines appropriate to overhead engineering standards referenced in d, above (HECO 1997c).

HELCO performs quarterly aerial inspections of all transmission lines. Ground pole inspections are done over a five-year cycle. Replacement and repair of poles is based on guidelines appropriate to overhead engineering standards referenced in d, above (Lee 1999).

KE conducts aerial inspections of its transmission system semiannually and ground inspections of the whole transmission and distribution system annually. It also performs annual termite inspections and treatments, follows an inspection work-order program, and inspects lines to ensure that all clearances are maintained as required under G.O.6. In addition, KE has stepped up its tree-trimming program, a measure that has greatly increased the reliability of its system. When pole replacements or repairs are needed, KE follows the standards set forth in the HECO construction standards manual (Gilman and Golden 1999, 4-5).

MECO reported that it followed the same procedures as HECO (Bonnet, 1999).

f. Shared use of distribution poles by communications utilities can reduce the reliability of electricity distribution circuits and should be considered prior to their installation.

Results. HECO is a member of a Joint Pole Committee that has been established to allow for a cooperative evaluation of the shared use of distribution structures (HECO 1997c).

HELCO has a joint pole agreement with the County of Hawaii and GTE-Hawaiian Tel covering the joint use of poles. HELCO, GTE, and all cable TV providers jointly review pole loading. The G.O.6 methodology is used to determine allowable loading for all new pole installations (Lee 1999).

KE has a joint pole agreement with GTE that governs the construction and maintenance of poles. To date, however, GTE has not elected to attach its lines to KE's steel poles, although KE has consistently ordered these poles with the appropriate attachments to accommodate telephone cables. The primary problem

KE has experienced in operating under the pole agreement is difficulty in getting GTE to honor its tree-trimming obligations.

Although KE has experienced some problems with heavy communications cables and highly tensioned messengers, this problem has not been as common as it has been on other islands. (Gilman and Golden 1999, 5).

MECO is a member of a Joint Pole Committee and has Joint Pole Agreements with communications utilities (Bonnet 1999).

g. All electric utilities in Hawaii should have current and complete emergency operating plans that should be exercised both internally and in conjunction with the State government and other lifeline entities.

Results. In February 1998, HECO revamped its emergency plans to provide for a comprehensive and coordinated *Energy Delivery Emergency Response Plan* (Nakamura 1998).

In July 1999, HELCO was in the process of revising its emergency plan to provide for a comprehensive and coordinated emergency response (Lee 1999).

KE maintains a detailed and multifaceted *Emergency Preparedness and Recovery Plan*, which is updated annually. KE participates in exercises and mock disaster trials with the State, County, military, and other entities. In addition, KE engages in tabletop exercises of its emergency operating plans at least annually (Gilman and Golden 1999, 5).

MECO's Disaster Plan became effective in September 1994 and was revised in May 1997. It provides "for effective and comprehensive corporate preparedness for a prompt, fully coordinated response for the safe and rapid restoration of energy services on Maui in the event of a natural disaster" (Bonnet, 1999).

h. Hazard mitigation measures to harden electric utility operations should be adopted, including anchoring transmission and distribution transformers and hardening batteries; providing flexible equipment connections; and maintaining and hardening spare equipment storage.

Results. HECO is considering modifications to its distribution standards that should result in their improved ability to withstand hurricane conditions. HECO is also studying the feasibility of a new base yard designed to store emergency equipment that will allow for survival of hurricane and earthquake loading (HECO 1997c).

HELCO currently designs new distribution substations and switching station equipment to resist earthquake forces in any horizontal direction and to transmit such forces to the equipment foundation. As part of the revision of the emergency plan that was underway in July 1999, equipment and materials storage will be evaluated (Lee 1999).

KE rebuilt its system after Hurricane Iniki and since 1990 has systematically hardened poles and other facilities during regular construction activities. For example, KE has upgraded the standards for connectors and the compression tools that will improve connections. It has replaced its equipment storage warehouse and increased the capacity of some of its substation battery banks (Gilman and Golden 1999, 5).

MECO follows distribution standards developed or revised by HECO (Bonnet 1999).

i. Conduct wind-speed studies to determine wind-loading requirements for Hawaii's electrical facilities.

Results. A transmission-line study by the American Society of Civil Engineers, based on Hawaii's hurricane wind conditions, was used to document HECO's ANSI 7 request to the PUC. Safety factors were modified to loading factors for "ultimate strength design," in place of allowable load stress for a "working stress design" (Nakanishi 1998).

HELCO completed the Hawaii Island Wind Study that produced estimates of the extreme wind speeds that might be expected over a 50-year period. HELCO engineers now use the results of the study to determine design wind speeds for overhead and distribution transmission facilities (Lee 1999).

KE has not conducted any post Hurricane Iniki wind studies (Gilman and Golden 1999, 6).

MECO did not report on any wind study activity.

2. State Lead

a. Increase fuel storage recoverable under the utility rate base from 30 to 35 days.

Results. HECO has increased of fuel storage from 30 to 35 days without seeking cost recovery (Kageura 1998).

HELCO's fuel storage will be increased in the near future. The commercial operation of the Encogen 60-MW independent power producer facility will result in increased fuel storage reserve for HELCO units (Lee 1999).

KE's contract with its fuel supplier obligates the supplier to keep fuel sufficient for 21 days use in storage. The contract comes up for renegotiation in 2002 (Gilman and Golden 1999, 6).

MECO's average fuel storage practices are consistent with HECO's (Bonnet 1999).

b. Improve business climate for electric utilities in Hawaii.

Results. In 1998, Governor signed 14 measures into law to help businesses and Hawaii's economy. In general, the electric utilities will also benefit from an improved business climate. However, they will specifically benefit from the extension of the State solar tax credit, as a factor in their integrated resource planning.

c. General Order No. 6 (G.O. 6), rules for overhead electrical line construction should be upgraded to ANSI-7 minimum wind loading.

Results. An upgrade to ANSI-7 minimum wind loading is being incorporated in G.O. 6 by the PUC. PUC action is based on a request from the utilities modified by the PUC (Nakanishi 1998).

B. Recommendations for the Petroleum Industry

1. Industry Lead

a. Survey industry requirements for back-up electrical generation.

Results. DBEDT is conducting a survey and assessment to identify minimum emergency power needs at emergency and essential service facilities and to develop a database to document generator specifications.

Chevron reported that it operates three separate 3-MW cogeneration units at the Chevron Hawaii Refinery (totaling 9 MW generating capacity) and also has the ability to draw electricity from the HECO grid. Chevron also has full back-up generator capacity at its terminals on Oahu and the island of Hawaii. In addition, as of August 1999, the company was installing a back-up generator at their Kahului, Maui terminal, which will be on-line in 1999. Chevron's fourth terminal, on Kauai in Port Allen, does not have back-up generator facilities but is sited near the Kauai Electric power plant (Simons 1999).

Tesoro Hawaii reported that its refinery in Campbell industrial park operates a 20-MW cogeneration plant that provides an independent source of electricity and steam for the refinery. The refinery can also draw on the HECO grid, if necessary (Kusunoki 1999). Tesoro Hawaii also provided specific back-up generator requirements for its fuel terminals on Maui, the Island of Hawaii, and Kauai. On Oahu, it uses the Tosco facility.

b. Use water fill to protect petroleum storage tanks.

Results. This recommendation is intended to help protect tanks from storm surge, which could cause tanks to float off their bases.

The Chevron Hawaii Refinery reported that it has developed specific procedures for tropical storm and hurricane preparedness as part of its Emergency Plans and Procedures. Water fill is used to completely fill fresh water tanks in the refinery ahead of an emergency. Chevron's petroleum tanks are designed and located on elevated platforms, within bermed enclosures, so that the tank bottoms are above storm surge levels. This design prevents the tanks from floating off their bases and precludes the need to use water fill. Water fill may still be appropriate for lower level tanks (Simons 1999).

Water fill is used by the Tesoro Hawaii refinery as part of its emergency response procedures. Water fill is not used at neighbor-island fuel terminals due to logistical and environmental concerns. In the event of an emergency, the terminals may fill or redistribute fuel products in their storage tanks (Kusunoki 1999).

c. Replace central cooling towers at refineries.

Results. Chevron Hawaii reported that their refinery has one centralized cooling tower in addition to many decentralized fin-fan cooling units in the various process plants. In addition, Chevron uses once-through cooling from nearby aquifers in several plant processes. As modifications and upgrades are made to the refinery, they are designed with emphasis on decentralized cooling units (Simons 1999).

Tesoro Hawaii's refinery uses decentralized fan units for generator cooling and an air cooling process, as recommended in the Hazard Mitigation Report (Kusunoki 1999).

d. Promote offshore tanker mooring compatibility/interconnection between refineries.

Results. This recommendation calls for installing a land-based inter-tie between the two refineries' respective mooring facilities.

According to Chevron Hawaii, both refineries deliver fuel oil to HECO's terminal in Campbell Industrial Park, and this may permit a common connection between the two refineries. This existing product line provides flexibility for back-up supply in emergencies. In addition, the two refineries have the ability to interconnect light product lines. These interconnections provide flexibility for back-up lines in the event of an emergency (Simons 1999).

Tesoro Hawaii indicated that it supports examining the feasibility of an interconnection between Hawaii's two refineries and their respective offshore mooring facilities (Kusunoki 1999).

e. Keep petroleum terminals open 24 hours per day following a major emergency.

Results. Chevron Hawaii reported that the company's terminals on Oahu are already open 24 hours per day and that it is Chevron's policy to keep terminals open during emergencies on any of the Neighbor Islands by bringing in additional people from other Chevron locations (Simons 1999).

Tesoro Hawaii's terminals on Oahu and Maui normally operate 24 hours per day. At Hilo and on Kauai, around-the-clock operations could be maintained if merited by an emergency (Kusunoki 1999).

2. State Lead

a. Improve emergency communications capabilities on the Neighbor Islands.

Results. State Civil Defense purchased 26 mobile satellite access telephones to provide statewide coverage for emergency communications. Existing Statewide data communications networks were improved to make them more robust (Burnett 1998).

b. Promote use of the harbor on west coast of the Island of Hawaii.

Results. The *Hawaii Commercial Harbors Master Plan* calls for major improvements to Kawaihae Harbor. It includes improvements to fuel and lubricant handling and storage facilities. The Department of Transportation is developing a business plan and is starting the permitting process for these improvements (Pascua 1998).

c. Promote industry mutual assistance pacts.

Results. The value of mutual assistance pacts has been cited at Energy Council meetings and in exercise evaluations. The preparedness emphasis is to pre-position emergency assistance (Kang 1998).

4. Consider separate a Federal Emergency Management Agency - Regional Interagency Steering Committee (RISC) sub-region for Hawaii.

Results. There have been informal discussions on creating a RISC sub-region for Hawaii, between DBEDT and the U.S. Department of Energy, Region IX RISC representative.

C. Recommendations for the Gas Industry

1. Industry Lead

a. Protect LPG barges used in interisland service.

Results. The Gas Company has contingency plans to move its two LPG barges out to sea, away from any approaching hurricane (Miyasaki 1998).

b. Install automatic shutoff valves on mainline gas pipelines in urban areas exposed to earthquake risk.

Results. The Gas Company reported that it is continuing to review this recommendation but has determined not to act on it at this time, as discussed further below.

Seismic automatic shutoff valves are not required on gas main lines (or on services) by either National Fire Protection Association Standard 59 or by the US Department of Transportation Office of Pipeline Safety. This is in part because none of the available devices that are reliably triggered by seismic motion are relatively immune from trips due to other vibrations or events unrelated to earthquakes. False trips can damage commercial processes and require time-consuming and expensive pilot relightings. TGC's mainline pipelines in urban areas of Hawaii are confined to Honolulu, Hilo, and Lahaina. Table 1 of the *Hawaiian Islands Hazard Mitigation Report*, published by the USDOE in 1996 ("DOE Report"), shows that potentially damaging earthquakes occur on Oahu and Maui less than once in fifty years. On the Big Island it is once in 25 years. Based on the considerations of effectiveness and risk, as well as on historical experience, TGC does not deem the installation of seismic automatic shutoff valves worthwhile at this time.

The DOE Report suggested the possibility of a pipeline rupture in Hawaii comparable to that experienced by Texas Eastern in New Jersey. There, manual shutoff of the longline transmission mainline required 75 turns of each of three valves, which took over two hours and resulted in $25 million of preventable property damage. Significantly, in contrast to Texas Eastern's high-pressure transmission mains, TGC's Hilo and Lahaina LPG systems comprised distribution lines operating at pressures of only 6–10 psig. Unlike Texas Eastern, which had to dispatch operational personnel from Houston, TGC handles operations for each island locally and has personnel on call 24 hours a day who can quickly respond in case of emergency. Both the Hilo and Lahaina LPG lines can be shut off manually by the closing of strategically located valves within the system. The entire system can also be quickly shut down with a few turns of a valve in the nearby base yard or holder sites. It is also worth noting that these LPG distribution systems, which are located on islands where earthquakes occur more frequently, are connected to tanks with finite fuel storage capacity. TGC's fuel-feed situation is much different than that of Texas Eastern, which was linked with other pipelines, gathering systems, and wells that responded to the leak-related mainline pressure reduction with ever-greater production.

TGC's SNG distribution system in Honolulu also operates at relatively low pressures. Again, valves capable of manual shut-off with just a few turns are located in strategically significant areas. Even the "transmission" portion of TGC's SNG system operates at a maximum pressure of 500 psig, which is low by mainland standards. Pneumatic (as opposed to motor-driven) block valves capable of remote shutoff from the SNG plant are installed approximately every five miles along the transmission line. These valves are not automatic, but are capable of virtually immediate shutoff in the event of a leak, explosion, or other emergency. The pressure of the transmission line is continuously monitored at the SNG plant.

Based on the foregoing, TGC has elected to rely, at this time, on existing valves that are geared to safe operation of the system in case of a gas leak or overpressure event, rather than on automatic valves geared to seismic motion.

c. Provide maps showing locations of key shutoff valves for underground gas utility systems to fire department officials.

Results. The Gas Company reported that it is in compliance with National Fire Protection Association Standard 59, which requires the planning and coordination of effective fire control measures with local fire and police departments. In addition, TGC is in compliance with US DOT Office of Pipeline Safety regulations (49 CFR § 192.615(a)(8)). These regulations require coordination with local fire, police, and other public officials in the event of gas pipeline emergencies, as well as coordinating with them in both planned and actual responses.

This local coordination has produced emergency response plans that are tailored to local geographic, operational, traffic, public safety, and security concerns. On Oahu, for example, TGC has a dispatcher on duty 24 hours a day, who monitors police and fire department incidents and dispatches company repair crews if needed. On Oahu, TGC has elected to provide maps showing the locations of shutoff valves to the local Civil Defense authorities, but not to the multitude of local fire departments. As part of appropriate coordination efforts, TGC has also given selected fire departments facilities tours that include general orientation and identification of red-painted gas shut-off valves. TGC recognizes that in the event of an emergency, the primary responsibility of its personnel is to protect the public safety using their knowledge of the system, then-available information, and their specialized training. TGC plans to continue this flexible cooperation and coordination with local authorities.

2. State Lead

a. Require installation of shutoff devices on all LPG tanks in inundation areas.

Results. Automatic shutoff devices for LPG tanks are not part of the Uniform Fire Code or National Fire Protection Association regulations followed by the Counties. However, tanks over 100 gallons must have a permit to be sited and all tanks must be anchored. Further, tanks in inundation zones on Oahu must obtain approval from the State Department of Land and Natural Resources and the County Department of Land Utilization (Azevedo 1998).

D. Recommendations for Lifeline Services

1. State Lead

a. Arrange for priority restoration of commercial electric power to all lifeline entities during supply disruptions.

Results. The Energy Council was incorporated into revised State and County Energy Emergency Preparedness Plans and will be used to prioritize requests by lifeline entities during energy supply disruptions.

b. Set emergency generator standards.

Results. The promotion of emergency generator standards as the application of "best practices" for the operation and maintenance of back-up generation for emergency and essential service facilities is one of the tasks of the Emergency Generator Survey project initiated in 1999.

c. Information regarding critical locations not having back-up emergency generators should be provided to Hawaii State Civil Defense authorities.

Results. An assessment to identify emergency and essential service facilities that may need emergency generator support was initiated in 1999. The database to be developed will supplement a database being developed in a Phase I project to assess facilities with existing back-up generation.

d. Promote seven-day minimum vehicle fuel supply for emergency vehicles as a guideline.

Results. No further action has been taken on this recommendation. The applicability of the program has not been substantiated.

E. General Recommendations for Protection of Facilities in Coastal Inundation Zones

a. Flood-plain management and regulation, including zoning to discourage construction within flood plain.

Results. Information not available.

b. Improved flood warning and temporary evacuation, including use of weather radios that automatically sound an alarm when a warning signal is transmitted.

Results. Information not available.

c. Permanent evacuation and relocation of facilities from flood plains is clearly the most effective measure, but would be extremely costly in many cases.

Results. Information not available.

d. Construct facilities above flood levels.

Results. Checking with State and County agencies on the status of this recommendation.

f. Use of bulkheads, sea walls, and revetments.

Results. Checking with State and County agencies on the status of this recommendation.

Recommendation 16: Additional Actions

The HES program provided a wealth of energy data and information, a set of recommendations on how to improve Hawaii's energy system, and a set of tools to continue to evaluate options for future actions. This capability should be used for the following:

A. Develop a New State Energy Plan and Update It Triennially

Results. Due to lack of available staff time, completion of the second HES was delayed. It was completed in 1999.

B. Continue to Participate in the Utilities' IRP Processes

Results. DBEDT continues to actively participate on the Advisory Groups in each utility's IRP process.

C. Propose Legislation to Implement HES Recommendations Under State Control

Results. DBEDT proposed a resolution to the 1998 Legislature calling for the PUC to submit legislation for restructuring the electric utility system by December 31, 1998. The resolution was not passed. The Commission had initiated a proceeding to investigate electricity competition on December 30, 1996 and involved a collaborative group of parties. The parties were unable to reach consensus as to recommendations to the Commission. As a result, they each submitted individual position papers to the Commission on October 19, 1998. The 1999 Legislature passed a resolution asking the Commission to report on the status of its restructuring efforts before the start of the 2000 Legislative Session.

APPENDIX E HES 2000 WORKSHOP ATTENDEES

Michael T. Amii, Deputy Director
Dept. of Parks & Recreation
City and County of Honolulu

Keith Avery, President
Zond Pacific

Keith Block
Hawaiian Electric Company, Inc.

Warren Bollmeier, President
Hawaii Renewable Energy Association.

Kat Brady
Life of the Land

Raymond Carr, Energy Coordinator
County of Hawaii

Colton Ching
Hawaiian Electric Co., Inc.

The Honorable Suzanne Chun Oakland
State of Hawaii Senate

Henry Curtis
Life of the Land

Anders Daniels
University of Hawaii at Manoa
Department of Meteorology

William H. Dorrance

Lynne Ebisui
The Gas Company

Nate Eisenpress
US Navy Regional Facilities Office

Yu-Si Fok
University of Hawaii at Manoa
Department of Civil Engineering

Michele Fukuji
Hawaiian Electric Co., Inc.

Kathleen Ganiko-Orlowski
Campanella & Associates

Marissa C. Garcia
Energy Project, East-West Center

Gail Gilman
The Gas Company

Lance Godenzi
Dick Pacific Construction Co.

Steve Golden
The Gas Company

Alvin Goto
Hawaiian Electric Co., Inc.

Warren Hall, Manager
EA Engineering, Science, and Technology, Inc.

Gary Hashiro
Hawaiian Electric Co., Inc.

Herb Hendrickson, Manager
Hawaii Electric Vehicle Demonstration Project

George Hirose
Hawaiian Electric Company

The Honorable Steve Holmes
Honolulu City Council

Russell Honma
State of Hawaii Department of Transportation

The Honorable Gary Hooser
Kauai County Council

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