I.

By act of the Legislature in 1974, the Director of the Department of Planning and Economic Development (since renamed the Department of Business, Economic Development, and Tourism, or DBEDT) was designated as the State Energy Resources Coordinator.

The Legislature recognized the danger inherent in Hawai'i's near total dependence on imported fossil fuel. Even though 34 percent of Hawai'i's oil is imported from Alaska, the remainder comes from foreign nations, primarily Indonesia and Australia. The state has been severely impacted by market disruptions caused by political and economic activities in the Middle East, where most of the world's petroleum reserves are located.

Noting that the islands' abundant natural energy resources should be developed to address this danger, the Energy Resources Coordinator was directed to orchestrate statewide efforts which maximize energy conservation and alternative energy development.

The Coordinator administers the State Energy Policy and the energy portion of the Hawai'i State Plan. The State Plan, enacted into law as Chapter 226 of the Hawai'i Revised Statutes, calls for:

✧ dependable, efficient, and economical statewide energy systems capable of supporting the peoples' needs;

✧ an increased proportion of indigenous energy use to improve self-sufficiency; and

✧ greater energy security.

By law, the state's energy policy also requires that the total costs and benefits of all energy resource options, including efficiency, be compared. This ensures that economic, environmental and societal impacts are all considered. Furthermore, alternative transportation fuels and efficient transportation practices are to be promoted.

The state is, therefore, pursuing the complementary objectives of increasing the efficiency of energy use while diversifying the state's energy resources. Additional program goals include increasing public awareness of energy issues and preparing for energy emergencies.

Serving the Coordinator in the effort to achieve these goals, DBEDT's Energy, Resources, and Technology Division (ERTD) manages a portfolio of energy conservation, diversification, and planning programs. Significant federal funds supplement state allocations. As part of the Coordinator's responsibilities to facilitate programs statewide, DBEDT also supports the activities of energy agents in the counties of Kaua'i, Maui, and Hawai'i.

This document meets the statutory requirement of the Energy Resources Coordinator to provide an annual report on energy activities across the state. The following pages emphasize the impact of energy on Hawai'i's economy, highlight projects undertaken in 1997, describe trends in the state's energy sector, and provide recommendations for continuing action. ✦

II.

II. Energy and the Economy

Energy continues to be a key factor shaping Hawai'i's economy, environment and standard of living. A stable energy supply is necessary to support continued prosperity.

In 1996, overall energy use per capita (based on defacto population) grew only slightly compared to the previous year (see Figure 1). Greater efficiency has resulted in a 14 percent decline in energy use per capita since 1970.

This decline has primarily been in the non-electricity sectors, which represent about two-thirds of overall energy use. On the other hand, electricity sales have continued to rise faster than the population has grown, and in recent years have also risen faster than the Gross State Product (GSP).

During 1996, electricity sales grew 2.0 percent, compared to the GSP growth of 0.9 percent (with GSP calculated in constant dollars). This corresponded to a 1.75 percent increase in per capita sales, two times the rate of defacto population growth.

As Figure 1 shows, the trend of growth in electricity sales has been consistent since 1970. Electricity sales in 1996 were two-and-a-half times 1970 levels.

In 1996, isle residents and businesses spent $2.6 billion on energy, or more than 8 percent of the $33.5 billion GSP (in 1996 dollars).

DBEDT continues to attract significant out-of-state funds for energy and technology programs which benefit the residential, commercial and transportation sectors of the state's economy. In FY 1997, $1.5 million in federal grants was received to encourage conservation, promote energy efficiency, and continue energy planning.

Energy efficiency, performance contracting, and demand-side management (DSM) programs also stimulate the state's economy. DSM programs modify utility customers' energy use, such as using less energy through conservation and efficiency measures, or shifting the time of day that energy is used, which can reduce peak generation needs.

In addition to encouraging local business investments and creating employment within the state, efficiency programs reduce residents' and businesses' energy expenditures, thus generating more discretionary income. Furthermore, improved efficiency in the public sector will save tax dollars.

Energy-related businesses continue to contribute significantly to the state's economy. For instance, Puna Geothermal Venture employs over 30 full-time workers, and supports the economy of the Big Island with a $6.5 million annual operating budget. In addition to paying state and county taxes, the project also contributes more than $500,000 annually in royalties to the state, county, and Office of Hawaiian Affairs. ❖

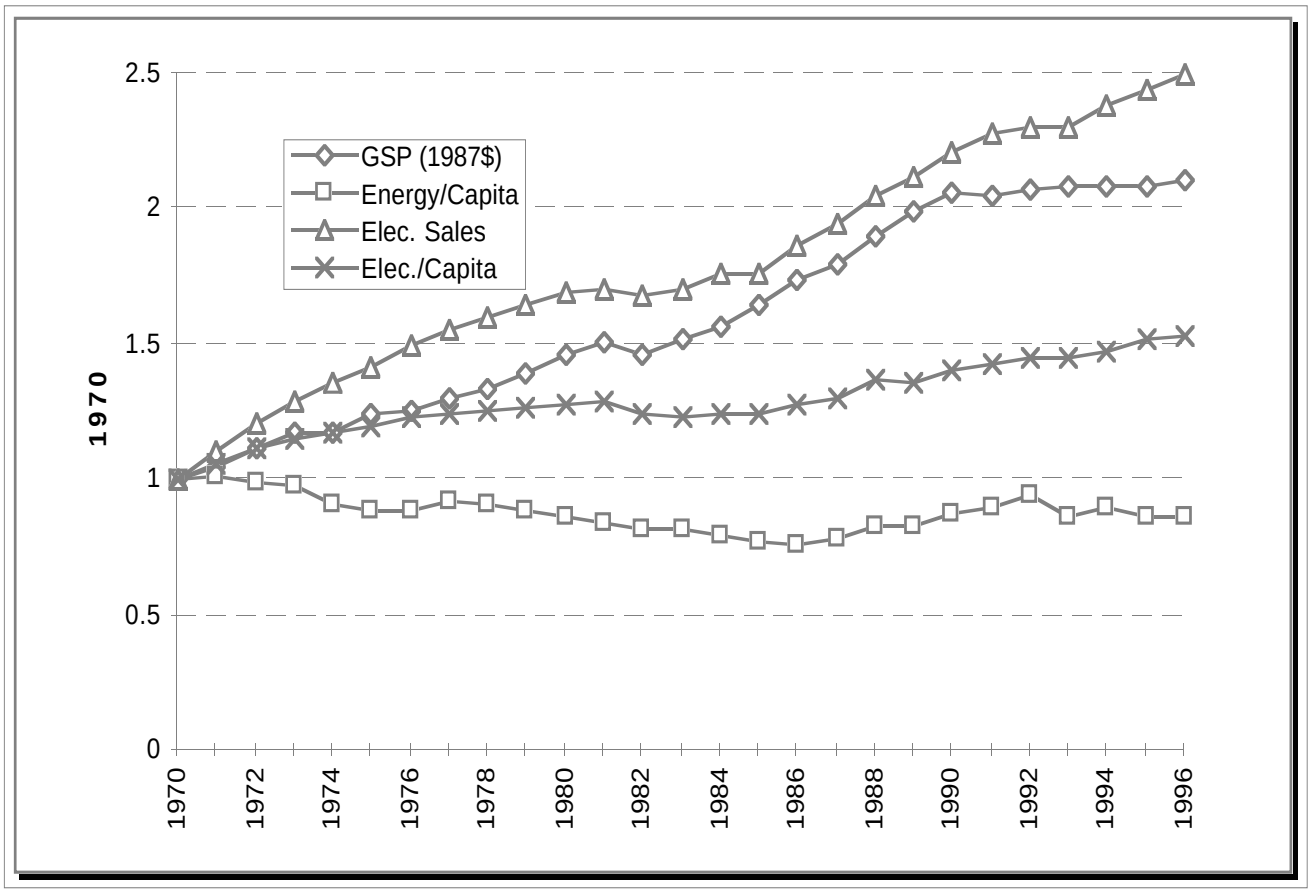

Figure 1. Key Energy and Economic Indicators in Hawai‘i, 1970-1996

III.

III. 1997 Achievements

The highlights of projects undertaken during 1997 by DBEDT's Energy, Resources, and Technology Division (ERTD) and other cooperating agencies in the fields of energy efficiency and diversity are outlined below.

Energy Code Honored

The State's development of the Model Energy Code was specifically cited by the U.S. Department of Energy when DBEDT received a Special Recognition Award in May for its leadership and exceptional work in fostering energy efficiency and reducing energy demand in Hawai'i.

The projected savings when the Code is fully adopted statewide are impressive: after 20 years, Hawai'i will avoid $240 million in utility costs and will reduce peak electricity demand by approximately 50 megawatts.

The commercial buildings section of the Model Energy Code, developed by ERTD, is in place in three of Hawai'i's four counties. The Code requires the energy-efficient design of new and renovated buildings, minimizing energy utilization without sacrificing either the comfort or productivity of the occupants.

More information on the Code, including examples and the application software, is available via internet at **http://www.hawaii.gov/dbedt/ert/mec.**

The rewritten HiLight lighting software continued to be tested in 1997, with comments solicited from over 50 practicing lighting designers and engineers. As soon as the software is finalized, local and national training in its implementation can commence.

In 1997, two new initiatives were defined; work will begin in 1998. One project will monitor Code compliance to determine if any improvements are needed in the multistep path between building design and construction. The second will measure the effectiveness of three types of residential roof insulation. A control residence without insulation will be measured to serve as the baseline.

Rebuild Hawai'i

The State of Hawai'i joined with three counties and the federal Rebuild America initiative to begin a new program stimulating public- and private-sector use of energy-efficient technologies. Targeting the counties of Hawai'i, Kaua'i and Maui, the Rebuild Hawai'i State program is committed to efficiency retrofits in 9.3 million square feet of state and county facilities, schools, universities, and community colleges within two to five years.

In support of this effort, DBEDT received $98,000 from the U.S. Department of Energy.

An anticipated 49 million kilowatt-hours of electricity and $7 million in utility bills will be saved by this program, which also expects to create 500 jobs with a total investment exceeding $35 million. The efficient technologies will reduce carbon dioxide emissions by an estimated 42,700 tons.

Under the Rebuild Hawai'i State

program, marketing, technical services and financial assistance efforts are coordinated with participating partners. ERTD will help partners assess their needs, and facilitate delivery of services by national laboratories and private contractors. The State will also serve as an informed resource for complementary programs carried out by U.S.-affiliated Pacific Island entities.

In October, DBEDT, with the Hawaiian Electric Company (HECO) and the U.S. Department of Energy, co-sponsored the Rebuild America's Community Partnership Workshop in Honolulu to kick-off the partnership.

Performance Contracting

Performance contracting is among the strategies that are being promoted by Rebuild Hawai'i. Performance contracting is an arrangement in which a private company finances and installs building improvements for a fee determined by future energy savings. Because these payments are contingent on actual achieved savings, the private company bears the risk of nonperformance. All project costs, including engineering and construction, are borne by the contractor.

Because of the potential for savings in the public sector, ERTD has been encouraging state and county agencies to consider performance contracting. Acting as a catalyst, ERTD brings together teams of people from various state government facilities, and provides technical assistance through consulting services.

Once an agency decides to seriously pursue a performance contract, a Memorandum of Understanding between that agency and ERTD is completed. Then, ERTD provides assistance by surveying the facility for performance contracting potential, tailoring a "boilerplate" request for proposals to the facility's needs, evaluating the proposals, negotiating the contract, reviewing the energy study, and monitoring the installed system's performance. In some instances, a fee is charged for these services. This program is expected to run until all state facilities have been evaluated for performance contracting potential and have made a decision whether or not to participate in the program.

During 1997, enabling legislation for performance contracting was amended to increase the allowable term of contracts from 10 to 15 years. Because large retrofits may require longer paybacks to be cost-effective, this measure will further encourage performance contracting.

To further assist agencies considering this means of improving efficiency, ERTD developed a *Guide to Energy Performance Contracting* which contains a boilerplate Request For Proposals and a sample contract.

So far, ERTD has directly assisted the University of Hawai'i at Hilo, Hawai'i Community College, six other community colleges on four islands, the Judiciary, the Hawai'i Army National Guard, and the Department of Education and its libraries. The division also provides non-financial assistance to the four counties' programs, as needed.

Potential savings from the state facilities listed above total more than $4.9 million per year, with an estimated $25.3 million of private funds being

Potential Savings Nearly $5 Million Annually

invested by energy service companies which undertake the performance contracts. If completed, the work would create 384 new jobs and provide an estimated $14 million in income to the state.

Hawai'i County's performance contracting project has achieved promising results. In March 1997, installation of energy efficiency measures in the Hawai'i County Building was completed by the contractor, Honeywell Inc. Electricity consumption in the building dropped 30 percent over the course of the year, and operational costs are on track to meet the first year's projected savings of $69,000.

Energy Use Dropped Significantly

Encouraged by these figures, the county of Hawai'i issued its second request for proposals for performance contracting in November 1997. This project will encompass the installation of energy efficiency measures in the 200 additional buildings owned and operated by the county; they have a combined annual electricity bill of $1.7 million.

Advanced Buildings

In 1997, ERTD received a $255,000 grant from the U.S. Department of Energy to develop guidelines for energy efficient residential buildings. The guidelines will promote cost-effective, energy-saving materials, equipment, and practices for locally built homes. An informational campaign directed at consumers will give builders a new sales tool in the housing market.

Complementing the guidelines project, the Advanced Building Technologies Training Program (ABTTP) will train local building designers and contractors in the use of energy efficient, recycled, and nontoxic materials and practices. The ABTTP will present statewide workshops and a mobile display to inform the local construction industry about energy- and resource-efficient methods to make homes more comfortable, durable, and affordable.

Clean Hawai'i

The Clean Hawai'i Center (CHC) is designed to promote recycling and remanufacturing markets through the development of local end-use businesses, cooperative marketing, cooperative purchasing of recycled products, and promotion of Buy Recycled in Hawai'i.

CHC has been working in concert with other agencies, businesses, and nonprofit groups to divert recyclable material from landfills and incinerators. CHC has also been working to support and develop local businesses that manufacture products from waste paper, glass, plastics, green waste, and construction and demolition materials.

During 1997, CHC sponsored four "Buy Recycled in Hawai'i" workshops and printed an updated directory, *Buy Recycled in Hawai'i—Where to Buy Recycled Products and Recycling Services*, as well as publications on *Permitting Requirements for Recycling and Related Activities*. CHC also participated in the annual America and Hawai'i Recycles Day, and exhibited displays of recycled-content and other environmentally-responsible building materials at the Better Home Show, the

Buy Recycled Workshop, the University of Hawai'i School of Architecture's gallery, the City and County's Partnership for the Environment Workshop, and the Hawai'i Environmental Education Association's annual conference.

CHC also managed contracts to remanufacturers and solicited, evaluated and awarded three new remanufacturing contracts. CHC was awarded a $236,000 Jobs Through Recycling grant from the U.S. Environmental Protection Agency to develop materials exchange facilities in Hawai'i. The purpose of the grant is to reuse or recycle building material, saving space in landfills.

IRP & DSM Support

ERTD continued to monitor the Integrated Resource Planning (IRP) programs of Hawai'i's energy utilities, participating regularly in advisory group meetings. During 1997, the Kaua'i Electric Integrated Resource Plan was finished, and work on the updated HECO plan neared completion. Plans are also being updated for Maui Electric Company (MECO) and the Hawai'i Electric Light Company (HELCO).

Integrated resource planning is a comprehensive approach which blends conventional "supply-side" strategies (such as building more power plants to meet increasing demand for electricity) with demand-side management (DSM), while considering environmental, social and cultural impacts.

DSM programs seek to modify energy use by maximizing energy efficiency and involve utility activities which encourage customers to change their energy use habits through rebates and other incentives. The counties are also active in IRP and DSM programs.

Several of the utilities' DSM programs provide cash rebates to individuals or businesses installing qualified energy-saving equipment. For instance, under HELCO's commercial and industrial DSM program, Hawai'i County received $21,697 in incentive payments for the energy efficiency measures it installed in new and retrofitted facilities. Rebates were given to numerous other public and private facilities, including a payment of $95,000 to the University of Hawai'i at Hilo. The Hawai'i Convention Center was awarded a total of $250,000—the maximum allowable by HECO's program—for its state-of-the-art lighting, air conditioning and mechanical systems.

HECO, MECO and HELCO have adopted DBEDT's DSM resource assessment as the best estimate of the maximum technical, economic, and market potential for demand-side management in the state, and are using it to modify their existing DSM programs. These three utilities project savings of 382,000 megawatt-hours of electricity and 66 kilowatts in generating capacity during the first five years of their integrated resource planning efforts.

In addition to the utilities' integrated resource plans, HECO, HELCO and MECO produce annual sales and peak forecasts. ERTD actively contributes to the development of these forecasts in advisory group meetings.

Utility Restructuring

Hawai'i, along with almost every other state, is involved in a process

Integrated Planning Continues

which is expected to restructure the electric utility industry. Federal laws, especially the Energy Policy Act of 1992, have set the stage for increased competition. Anticipated benefits of competition in the electric utility industry include long-term cost savings and reduced electricity rates.

On December 30, 1996, the Public Utilities Commission instituted a proceeding on electric competition, including an investigation of the electric utility infrastructure in Hawai'i. A collaborative group was formed to examine the issues. This group conducted several meetings in 1997, but was unable to reach consensus. Further action by the Commission is expected.

State Energy Plan

Work began in 1997 on the triennial State Energy Plan, employing results from the Hawai'i Energy Strategy Program which was completed in 1995. The State Energy Plan will examine Hawai'i's current energy system and status, and develop new recommendations to meet state energy objectives.

Triennial Review

The Hawai'i Energy Strategy produced a comprehensive set of recommendations to increase the diversification of Hawai'i's energy supplies, energy efficiency and conservation, and use of renewable energy resources. In addition, a transportation energy strategy provided a phased plan for reducing oil consumption in the transportation sector.

More information on the Hawai'i Energy Strategy is available over the internet at **http://www.hawaii.gov/dbedt/ert/hes.**

This planning effort will be aided by ERTD's computerized energy modeling capabilities. In April 1997, training on the Regional Economic Models, Inc. (REMI) economic forecasting model was undertaken. REMI was calibrated with local data, refining existing information from national sources and making the model more applicable to Hawai'i. Work continued on the calibration of the ENERGY 2020 model. These two models are electronically linked, allowing the economic effects of energy policies to be evaluated.

Climate Change

A Greenhouse Gas Reduction Strategy for the State of Hawai'i is being prepared by DBEDT and the State Department of Health, under a grant from the U.S. Environmental Protection Agency. The *Hawai'i Greenhouse Gas Inventory, Estimates for 1990* was published in July 1997, completing the first phase of the project.

The second phase, the development of a State of Hawai'i Climate Action Plan, is underway. A public workshop was held on October 30, 1997 to obtain input on goals and potential actions to reduce future emissions at the lowest resource and social costs. This plan is scheduled to be completed in mid-1998.

Greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, are thought to contribute to global warming and such predicted climatic and environmental changes as temperature and sea level rise.

Petroleum Reporting

A new law enacted in 1997 consolidates petroleum industry reporting under DBEDT, which will strengthen the department's ability to gather information critical to understanding how oil impacts Hawai'i's economy, environment, and energy needs. Previously, both DBEDT and the Public Utilities Commission were authorized to collect various data from the industry.

Act 257 of the Hawai'i Revised Statutes now requires oil producers, refiners, marketers, oil transporters, and oil storers to report to ERTD. In past years, the division only collected data from companies refining or importing fuel.

In order to implement Act 257, DBEDT is preparing administrative rules and regulations governing the reporting. The rules will specify the frequency of reporting, which may be monthly in most cases. Data will be summarized to protect proprietary information. Public hearings will be held on the proposed rules, which must also be approved by the Governor.

The new law also calls for the establishment of a voluntary petroleum advisory council consisting of eleven members representing retail service stations, independent dealers, petroleum jobbers and refiners, as well as staff from DBEDT, the Attorney General's office, and the Dept. of Commerce and Consumer Affairs. The council will advise DBEDT of trends and activities in the retail petroleum industry which may require statutory action.

Among the information to be collected by ERTD will be monthly weighted average prices for gasoline,

New Rules & Regs

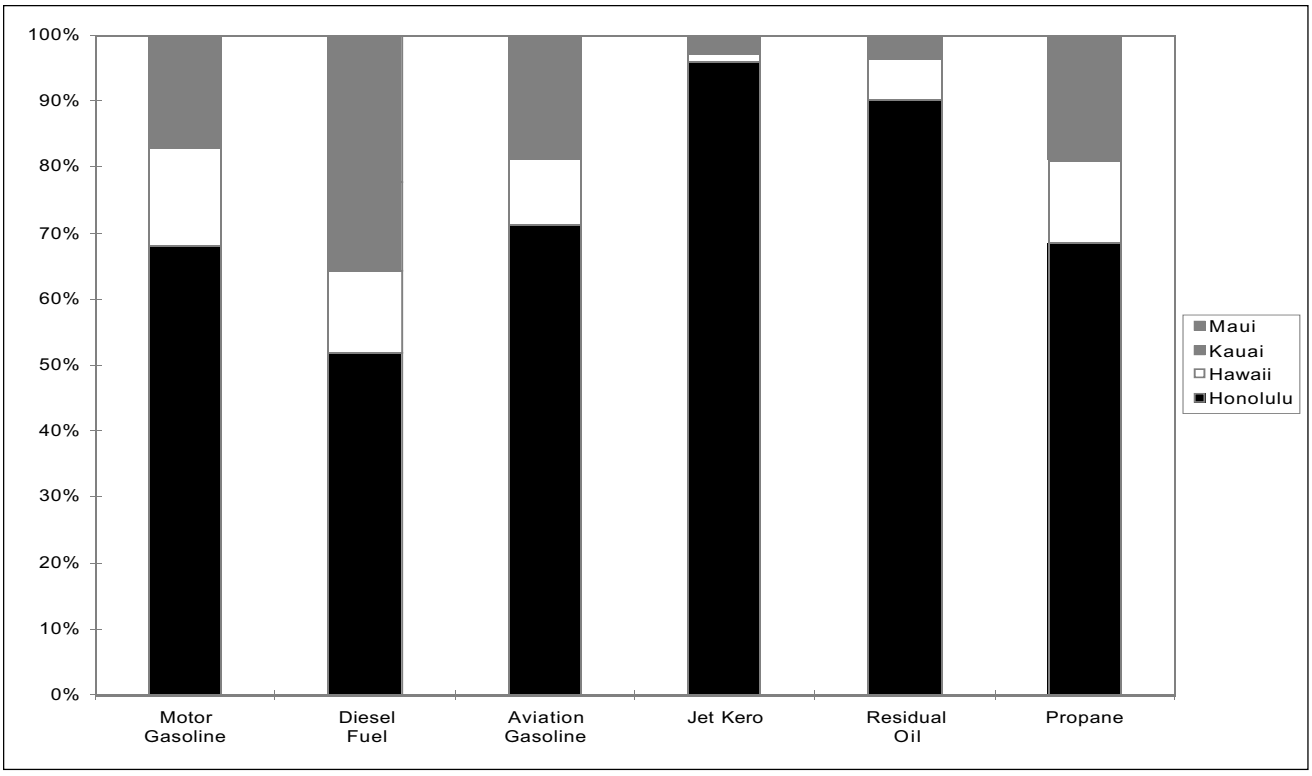

Figure 2. Liquid Fuel Distribution by County, 1996

diesel, jet fuel and residual fuel. The amount of fuel transported interisland and the capacity of petroleum product storage facilities are other examples of data to be reported. ERTD is currently receiving reports which, for instance, outline the amount of fuel sold and distributed by refiners to various sectors in the different counties, giving planners a rough idea of the state's petroleum distribution (see Figure 2).

These data will be used by ERTD analysts to support work in energy modeling and planning, emergency preparedness, and greenhouse gas calculations.

No New Power Plants in 1997

Emergency Preparedness

DBEDT participated in the successful State Civil Defense (SCD) Disaster Field Office exercise held in May 1997. At the request of SCD, ERTD developed and conducted an Energy Council energy emergency simulation exercise involving industry and all levels of government as a special activity of the Makani Pahili '97 hurricane simulation.

Based on the success of the 1997 exercise and on Hawai'i's unique Energy Council, an emergency coordinating and response organization, DBEDT was awarded a $50,300 grant in 1997 to conduct a regional energy emergency seminar and simulation exercise for Hawai'i, the western states, and the Pacific Island territories in May 1998. This exercise will highlight the critical importance of energy emergency planning, preparedness, and response to energy disaster recovery effort.

Following the recommendations of earlier hazard mitigation analyses, ERTD prepared a $50,000 Request For Proposals (RFP) during 1997 to inventory emergency generator capacity at essential service facilities. The completed inventory will enable swifter response during energy emergencies. The RFP will be released in 1998.

Progress with Renewables

Renewable energy resources—including biomass, municipal solid waste, hydroelectricity, geothermal, solar, and wind—continue to make significant contributions to Hawai'i's electricity supply. Table 1 illustrates the increasing diversity of the islands' electricity generation.

Although no significant new power plants came on-line in 1997, renewable resources continued to contribute electricity to utility grids on several islands.

A summary of Hawai'i's renewable energy use since 1980 was published by DBEDT in 1997 and is accessible on ERTD's web site. *1995 Hawai'i Renewable Energy Data Report* describes the history and status of every renewable energy facility in the islands that has made a significant contribution to the reduction of Hawai'i's importation of fossil fuels.

Steady progress in the acceptance of photovoltaic (PV) technology for small, distributed applications continued. A 17-kilowatt PV system is now providing power at Hickam Air Force Base in a cooperative project also involving HECO and the U.S. Environmental Protection Agency. To test acceptance of utility-provided remote residential power, HELCO initiated a demonstration of packaged PV systems, complete with battery banks, inverters, and other equipment.

FUEL	GWH		FUEL	% OF TOTAL	
	1987	1996		1987	1996
Oil	7,577	8,026	Oil	90.5%	74.7%
Wind	79	22	Wind	0.9%	0.2%
Biomass	605	270	Biomass	7.2%	2.5%
Geothermal	14	228	Geothermal	0.2%	2.1%
Hydroelectric	93	110	Hydroelectric	1.1%	1.0%
Municipal Waste		326	Municipal Waste		3.0%
Photovoltaics		0.1	Photovoltaics		0.0001%
Coal		1,739	Coal		16.2%
Landfill Methane		19	Landfill Methane		0.2%
TOTAL	8,368	10,740	Total	100%	100%

Table 1. Fuel Diversification in Electricity Production in Hawai'i, 1987 and 1996

Members of the Photovoltaics for Utilities (PV4U) group continued to support PV power development in 1997. Among their activities was a joint meeting with representatives of U.S. Pacific Island territories and a visit to the demonstration 15-kilowatt rooftop installation on the Kona gymnasium, in conjunction with the Pacific Coast Electrical Association conference in September 1997. DBEDT provides administrative support to the group.

Solar water heating continued as the most popular renewable energy technology. Financial incentives offered by the electric utilities' DSM programs on several islands, in addition to the state income tax credits, encouraged homeowners to purchase systems.

Reliable Geothermal

Puna Geothermal Venture, a commercial power generation company which sells electricity to HELCO, supplied steady power to the Big Island's grid.

Since the plant became fully operational, its composite capacity factor is about 104 percent, and plant availability is at 97 percent. The 30-megawatt power plant provides approximately one-fourth of the island's electricity.

In late 1997, Puna Geothermal Venture calculated that its plant had displaced nearly 1.9 million barrels of oil—equivalent to over 18 oil tankers—since it began generating in 1993.

An ERTD analysis of greenhouse gases estimates that the production of at least 965,000 tons of carbon dioxide has been avoided by generating electricity with geothermal energy rather than fossil fuels.

OTEC, Gasification Research

Experimentation at two major renewable energy research and demonstration sites wound down in 1997. At

the Natural Energy Laboratory of Hawai'i Authority facility in Kona, testing of a novel open-cycle ocean thermal energy conversion (OTEC) process was concluded in the middle of the year. Funding has been requested to continue research at the facility.

On Maui, the second phase of testing at the Biomass Gasification Facility at Pa'ia was terminated late in the year. Problems with the biomass feed system and other subsystems prevented the continuous operation of the facility. The State, the U.S. Department of Energy, and Westinghouse Electric Corporation are evaluating options for continuing the project.

Federal Rules on Alternative Fuel Use

Diesel from Vegetable Oil

A commercial biodiesel refinery on Maui is producing motor vehicle fuel from discarded restaurant cooking oil. Pacific Biodiesel's plant, the second such refinery in the U.S., is capable of manufacturing 150,000 gallons of fuel annually. In 1997, Pacific Biodiesel opened a similar facility in Japan.

Maui County has been successfully using biodiesel in several heavy-duty vehicles. The difference in price between petroleum-based diesel and the biodiesel is covered by a federal grant.

Biodiesel is biodegradable and produces fewer harmful emissions than petroleum-based fuels, yet has similar performance and fuel efficiency characteristics. It can be burned in diesel engines straight with no modification, or can be mixed with petroleum-based diesel.

Alternative Fuels

An outreach program intended to expand the use of alternative fuels among the general public, as well as accelerating their use in municipal and private vehicle fleets, was funded in 1997 with $50,000 from the U.S. Department of Energy. This program will support vehicle conversions, the Electron Marathon high school competition, publication of student information, displays, exhibitions, trade shows and seminars.

Alternative fuels are a major focus of the Honolulu Clean Cities group, a voluntary public/private partnership program coordinated at a national level by the U.S. Department of Energy. DBEDT is an active local partner. In 1997, workshops on alternative fuels were offered to fleet managers. Propane, electric, and biodiesel-fueled vehicles were demonstrated to the public. Fact sheets and a quarterly newsletter were published.

The Clean Cities group also assisted managers of vehicle fleets with information on the new federal rules mandating purchase of alternatively fueled vehicles. The rules require that at least 10 percent of light duty vehicles purchased by state government fleets in model year 1997 must run on an alternative fuel such as ethanol, methanol, propane or electricity. Likewise, 30 percent of vehicles purchased in model year 1997 by private sector fuel providers must be alternatively fueled.

In model year 1998, the requirements increase to 15 percent and 50 percent, respectively, and continue to increase until model year 2001, at which time alternatively fueled vehicles must comprise 75 percent of new vehicles purchased by state fleets and 90 percent for fuel provider fleets.

The Hawai'i Electric Vehicle Demonstration Project continued throughout 1997, with 35 sedans and light trucks, three buses, one trolley, and one advanced electric boat in use, and an additional 20 vehicles (including a bus, trucks, and a trolley) under development. The project is managed by the High Technology Development Corporation, an agency administratively attached to DBEDT.

Neighbor Island Assistance

ERTD continued its Neighbor Island Energy Assistance Program with funding from the U.S. Department of Energy. In Fiscal Year 1996/97, about $181,550 was budgeted for the counties of Hawai'i, Maui and Kaua'i for economic development projects involving energy efficiency and the support of renewable energy technologies and resources. The counties provided cost-sharing and services worth an additional $310,450.

Promotion of performance contracting, enforcing the Model Energy Code, preparing for emergencies, monitoring electric utilities, and enhancing business opportunities in recycling and remanufacturing are among the tasks undertaken in the Neighbor Island counties. A grant of $9,500 was provided to the county of Hawai'i to obtain technical assistance necessary to implement a performance contract in its Wastewater Division. Topical workshops are also offered periodically.

Technology Transfer

Information on ERTD's many programs is available electronically through the division's internet web site. The site contains descriptions of each branch of the division; fact sheets on alternative fuels, renewable resources and energy efficiency measures; profiles of Pacific Rim nations participating in DBEDT's technology and services export initiatives; and other information, including remarks by DBEDT Director Dr. Seiji Naya.

Energy Web Site is Posted on the Internet

The web site is continually updated with facts, figures, graphics, announcements and the text of recent reports. Access it at **http://www.hawaii.gov/dbedt/ert/**.

One of the reports which will be posted on ERTD's web site will be the *Energy, Environmental and Engineering Technology Services Export Directory*, which began to be prepared in 1997. Also to be available in hardcopy and published in English, Chinese and Japanese, the directory will promote Hawai'i's capabilities in energy supply, alternative energy development, energy efficiency technologies, engineering, planning, and environmental technologies and services.

Also during 1997, ERTD supported a number of training courses, workshops and expositions aimed at increasing the use of energy-efficient technologies in the marketplace.

Three issue-oriented workshops were held in Honolulu during the month of January. First, a two-day Workshop on Contemporary Issues in Electrical Utility Regulations was held at the State Capitol, examining the implications of deregulation and increased competition in the electric utility industry for Hawai'i.

Then, a Solar Policy and Net Metering Workshop was offered, co-sponsored by the National Renewable

Energy Laboratory. Another two-day workshop, on Baseline, Management, and Verification of Energy Efficiency Savings, was co-sponsored by DBEDT, the U.S. Department of Energy, and HECO.

During April, four training workshops for end users of large pumping systems were offered, one on each of the major islands. The workshops' overall goal was to improve energy efficiency in wastewater, water, agricultural and large commercial pumping systems. A total of 181 representatives of fresh water and wastewater facilities, irrigation firms, resorts, golf courses, aquaculture operations, consulting engineers, dairies, plantations, and government agencies attended.

In September, DBEDT joined HECO in co-sponsoring the Pacific Coast Electrical Association Conference and Expo, "Partnering for Hawai'i's Future," in Waikoloa. Objectives of the conference included promoting the use of energy-efficient technologies, and educating technology firms from Hawai'i and the rest of the U.S.

Workshops to Improve Efficiency

Additional assistance was provided to educators and students in classroom presentations, and through support of such activities as the Science and Engineering Fair and the Hawai'i Science Bowl. Publications and promotional items were also distributed to the general public.

Technology Exports

A number of important trade missions and technology transfer projects were completed in 1997 by ERTD's Strategic Technology Market Assessment and Development (STMAD) Program. STMAD facilitates exports of U.S. technology and related services from Hawai'i, especially into the Asia/Pacific region. This will advance sustainable, technology-related economic development for Hawai'i, support diversification of the state's economy, and create higher valued jobs.

The potential for technology export is significant. Over the next 10 years in the Asia/Pacific region, the World Bank estimates basic infrastructure investment requirements will surpass $1.5 trillion. Robust economic growth like China's, however, could be badly constrained by infrastructure shortages.

Hainan. A delegation of both public and private sector representatives, organized by DBEDT, traveled to Hainan Province, China, during March 1997 to conduct a preliminary energy infrastructure assessment.

The delegation identified five power generation and transmission projects needed by Hainan during the next five years, when electricity demand is projected to nearly double. One member of the mission, the Hawaiian Electric Industries Power Corporation, is evaluating the development of these projects.

A proposal soliciting federal or multi-agency funding for a comprehensive energy infrastructure assessment of Hainan is under development. Also, several Hawai'i companies specializing in energy, agriculture, and tourism and resort development are keenly interested in investment opportunities in Hainan.

Thailand. Twenty Hawai'i firms participated in a "Thailand Business Opportunities Mission" in April and

May 1997 led by DBEDT in cooperation with the Thailand Ministry of Commerce. The industries represented included energy, engineering, architecture, ocean resources, environmental services, planning, post-secondary education, construction materials, and communications. These firms met with regional and provincial business associations and government leaders, and more than 300 private sector representatives.

While in Thailand, a Memorandum of Understanding was signed between a Hawai'i solar energy company and a Thai company to jointly develop projects. Additionally, discussion is underway between a Hawai'i firm and Thai sugar companies to develop a joint biomass project.

Philippines. Also in May, a successful technology trade and policy advisory mission to the Philippines was conducted. A Memorandum of Understanding for a cooperative assessment of Philippine biomass-to-energy potential, including at least two case studies of commercial bio-energy projects, was signed during the mission. This project commenced in November 1997 with a technical visit to the Philippines by DBEDT staff and a senior research engineer from the University of Hawai'i at Manoa Hawai'i Natural Energy Institute.

In a related effort, ERTD is advising the Philippine Department of Energy regarding the development of energy policies which will encourage the efficient and sustainable use of resources. Support for policies encouraging energy efficiency has been received from the U.S. Agency for International Development (USAID) and the National Association of State Energy Officials.

A final STMAD activity for 1997 was a December international seminar at the East-West Center on infrastructure project finance, hosted by the State of Hawai'i with a focus on opportunities in the People's Republic of China. Chinese seminar participants presented details on specific projects for analysis by private sector financial experts and Hawai'i project developers. One-on-one business development meeting venues were also offered to Chinese and Hawai'i participants.

Concurrently, the Hawai'i State Bar Association held its 1997 annual convention, focusing on the principles of law in the U.S. and China. Approximately 45 attorneys and judges from Hainan and Guangdong were invited. The first two days of the Project Finance seminar, conducted jointly with these Chinese officials, highlighted the legal aspects of infrastructure finance such as contract enforceability. ❖

Missions to China, Thailand and the Philippines

IV.

IV. Trends and Forecasts

This section outlines trends identified by the Energy, Resources, and Technology Division (ERTD) and presents forecasts for critical sectors.

Continuing Diversification

Hawai‘i continues to make progress in its efforts to achieve greater energy diversification. Looking back over the past 45 years, Hawai‘i was least dependent on oil in 1962, when sugarcane bagasse met 18.5 percent of the islands' energy needs. Figure 3 depicts trends in energy supply over the past several decades.

Since then, the share of Hawai‘i's energy produced from bagasse began a long decline, reaching 3.3 percent in 1996. While other energy sources entered the picture in the 1970s, petroleum filled ever-increasing percentages of Hawai‘i's energy needs, hovering around 90 percent since 1977.

Fortunately, the decline in the use of bagasse has been somewhat offset by increased use of other non-oil sources of energy, particularly since 1980. The greatest contribution to diversification has been the use of coal, which provided over five percent of the state's energy needs in 1996, surpassing bagasse in 1995.

Municipal solid waste (MSW), an energy resource since 1989, is the third most important source of non-oil energy at 1.5 percent. Solar water heating and geothermal each grew from zero to just under one percent in the past 20 years. Hydroelectric facilities and wind farms each generated less than half a percent of Hawai‘i's energy.

With contributions by all these energy resources, petroleum fuels produced 88 percent of Hawai‘i's energy in 1996, up slightly from 1995's low of 86.9 percent.

Continued improvement in the efficiency with which Hawai‘i's people use electricity is expected, with its concurrent environmental and economic benefits.

Utility System Challenges

Unfortunately, 1995's lower level of oil use may only be a temporary valley. It will be difficult to sustain the downward trend of oil use observed since 1990 because of the loss of bagasse fuel. Recent and proposed additions to the islands' electricity grids are nearly all oil-fired. Exceptions are a biomass-fired boiler at the former sugar mill at Waialua, O‘ahu, which sells power to the utility, a proposed wind power plant in North Kohala, and a proposed waste-to-energy facility on Kaua‘i.

The exact form of the future electric utility industry remains to be determined, particularly in light of the recent activities on the Mainland which increase competition.

A certain level of competition already exists in Hawai‘i: independent power producers on O‘ahu and the Big Island have power purchase agreements with the electric utilities. Competition could occur in a similar manner through a system of competitive bidding to meet new power generation requirements.

Other possibilities range from wholesale competition for generation to retail competition under which consumers could select from among competing power producers. Electricity services might be packaged with other services.

While the transmission and distribution systems may remain regulated, there are various other options for competition throughout the system. Whatever form competition eventually takes, there are many unresolved issues to be faced during the transition.

Transportation Trends

Significant advances in vehicle fuel efficiency are not expected soon.

Figure 4 describes transportation energy use in Hawai'i over the past 10 years. Energy for transportation accounts for about two-thirds of the state's total energy use; aviation fuel continues to dominate.

Ground transportation fuel use has been steadily increasing. Although the number of registered vehicles has declined, fuel use continues to increase, suggesting that vehicles traveled farther and the overall fuel efficiency of the islands' motor vehicles decreased.

Marine fuel use has risen since 1986 due to efforts by Hawai'i's refiners to market fuel oil to fishing fleets and other ships. Such fuel sales benefit Hawai'i's economy and provide a market for high-sulfur fuel oil which cannot be burned on shore. ❖

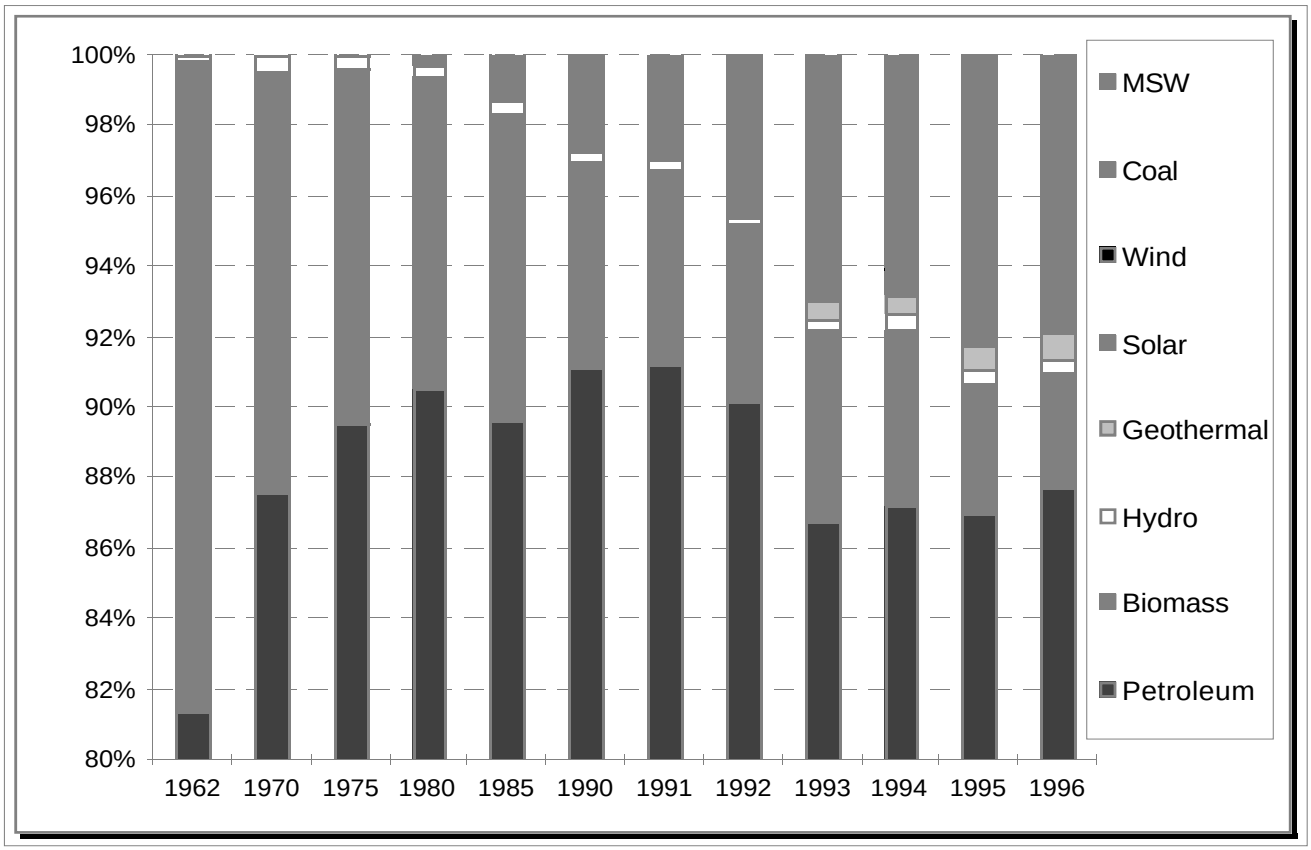

Figure 3. Primary Energy Sources in Hawai'i, 1962 - 1996, Selected Years

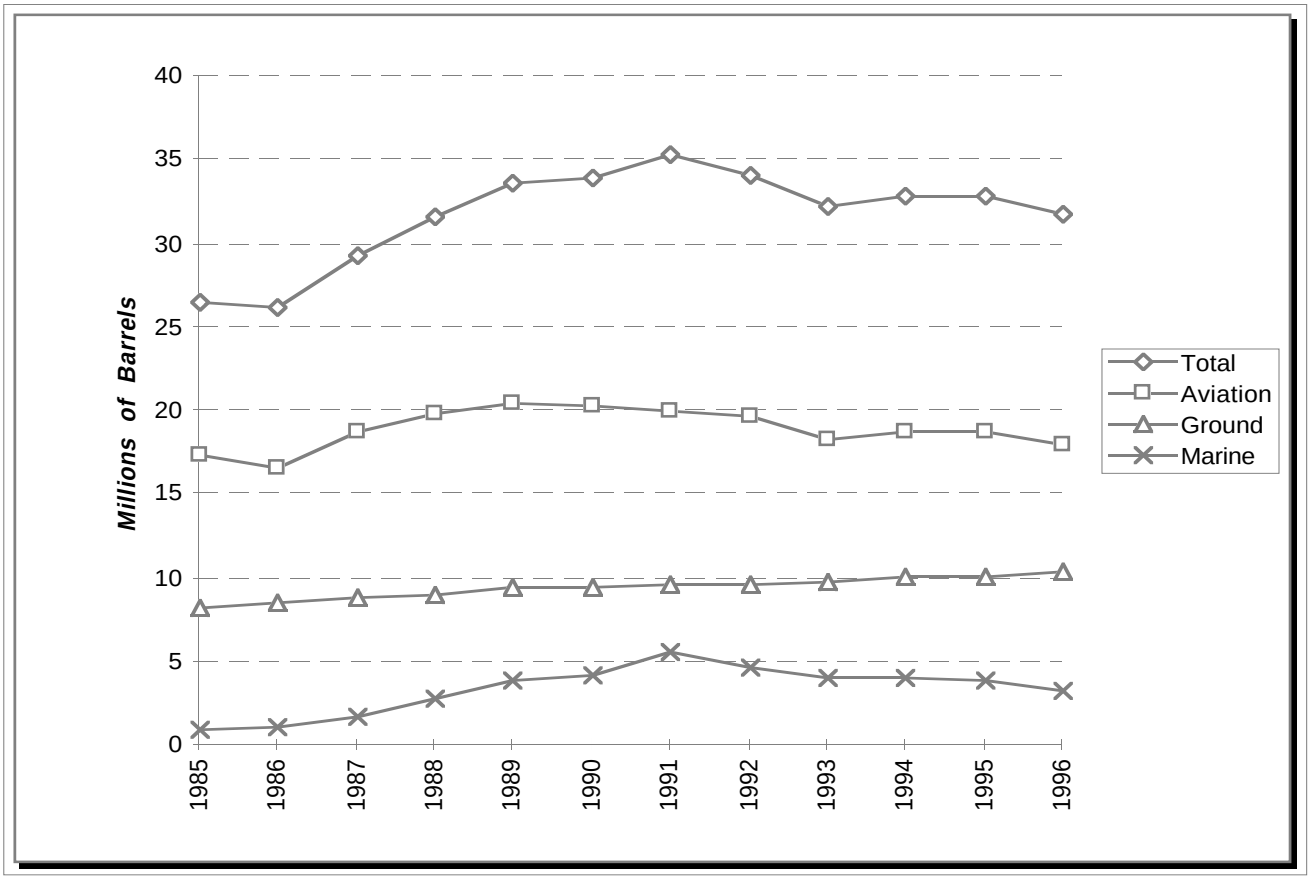

Figure 4. Transportation Energy Use

V.

As a result of the work completed during 1997, the Energy Resources Coordinator makes the following recommendations to achieve Hawai'i's energy program objectives.

Support Sustainables

The state must continue to support sustainable energy technologies.

Biomass remains promising as a potential source of liquid and gaseous fuels, as well as for power plant fuel. For the Big Island, geothermal resources have proven to be reliable and consistent. Wind, hydroelectric and solar resources on several islands can also contribute significantly to our energy supply.

Solar water heating, in particular, should continue to be promoted as a practical alternative for many island residents, and the decentralized use of photovoltaics encouraged as a practical power source for many small applications.

Efficiency and diversity in energy supply are key to strengthening our state's energy security.

Geothermal Oversight

Although the state remains committed to supporting geothermal development for the Big Island, funding for its geothermal program has been severely reduced. The state government must ensure that an appropriate level of oversight is maintained to continue the effective regulation and management of this resource.

Lighting Code Upgrade

In order to continue the savings made possible by the Model Energy Code, a contract to finalize the HiLight lighting software should be executed promptly. Training in the use of HiLight should be offered to as many states and municipalities, both within Hawai'i and across the nation, as possible.

Support should continue to be provided to county initiatives expanding the Code to include single-family residences. The importance of roof insulation should be emphasized.

Innovative Financing

Access to innovative financing for energy efficiency upgrades needs to be eased.

Tax-exempt leasing should be considered for performance contracting, as was done in Hawai'i and Kaua'i counties. The opportunity for tax-exempt interest on financing allows larger projects to be implemented and results in greater savings. Furthermore, a federal tax exemption on interest income will permit state projects to be financed at lower interest rates, providing increased capital to finance additional energy efficiency improvements.

Another major factor delaying the implementation of performance contracting is the lack of staff. It is recommended that public agencies dedicate staff and staff support to pursue performance contracting options.

Maintain Preparedness

Continued vigilance in energy emergency preparedness planning is recommended, since readiness has a direct impact on how quickly a community can recover, physically and economically, from a disaster which disrupts its energy supply and distribution system.

Training sessions and simulations should continue to be scheduled, involving all pertinent agencies at the state, federal and county levels, as well as representatives from the U.S. Pacific Island entities when appropriate.

International Assessments

Participation should continue in trade missions, reverse trade missions, trade shows and exhibitions which promote Hawai‘i-based technology firms and attract new firms to Hawai‘i. Private sector cost-sharing should be sought wherever possible. ❖

VI.

DESCRIPTION	STATE FUNDS	FEDERAL FUNDS	GRAND TOTALS
CONSERVATION			
Buildings		278	278
Transportation		268	268
Education	10	345	355
Integrated Resource Planning		216	216
TOTAL: Conservation	10	1,107	1,117
ENERGY PLANNING			
Hawai‘i Energy Strategy		100	100
Technology-Based Economic Development	194	155	349
International Technological Collaboration	40		40
Climate Change Action Plan		84	84
Energy Emergency Planning		82	82
TOTAL: Energy Planning	234	421	655
GRAND TOTALS	244	1,528	1,772

Table 2. DBEDT Energy Program Budget, FY 96/97 (in thousands of dollars)

VII.

Year	Energy Consumed (Trillion Btu)	Constant GSP (Thousands of 1987 $)	Quantity (Thousand Btu per 1987 $)	Annual Change (Percent)
1960	120.4982	6,271,500	19.214	
1961	141.3156	6,273,800	22.525	17.2
1962	137.1934	6,538,000	20.984	-6.8
1963	143.8698	6,699,400	21.475	2.3
1964	153.9604	7,370,200	20.890	-2.7
1965	160.6014	8,023,600	20.016	-4.2
1966	175.5990	8,464,800	20.745	3.6
1967	196.1247	8,758,600	22.392	7.9
1968	214.9613	9,479,300	22.677	1.3
1969	221.9387	10,642,200	20.855	-8.0
1970	225.2299	11,142,900	20.213	-3.1
1971	241.0916	11,718,800	20.573	1.8
1972	245.1282	12,505,100	19.602	-4.7
1973	250.5421	13,124,000	19.090	-2.6
1974	237.2659	13,083,500	18.135	-5.0
1975	238.3572	13,857,900	17.200	-5.2
1976	240.5195	14,036,900	17.135	-0.4
1977	254.5484	14,463,400	17.599	2.7
1978	259.1148	14,917,100	17.370	-1.3
1979	278.4501	15,501,700	17.963	3.4
1980	273.8809	16,360,100	16.741	-6.8
1981	273.3227	16,756,900	16.311	-2.6
1982	272.1129	16,360,700	16.632	2.0
1983	279.0303	16,981,100	16.432	-1.2
1984	276.3700	17,491,600	15.800	-3.8
1985	266.2178	18,336,500	14.518	-8.1
1986	271.0562	19,323,900	14.027	-3.4
1987	284.2042	20,027,300	14.191	1.2
1988	306.9212	21,206,100	14.473	2.0
1989	315.0842	22,213,900	14.184	-2.0
1990r	312.1304	22,976,700	13.585	-4.2
1991r	322.9524	22,887,700	14.110	3.9
1992r	339.0912	23,095,100	14.682	4.1
1993r	307.7465	23,180,100	13.276	-9.6
1994r	327.4778	23,190,300	14.121	6.4
1995r	315.1186	23,297,800	13.526	-4.2
1996p	315.9492	23,504,400	13.442	-0.6

r = revised
p = preliminary

Table 3. Primary Energy Consumption and Energy Consumption per Dollar of Constant Gross State Product, Hawai'i: 1960 to 1996

Year	Primary Energy Consumption (Trillion Btu)	De Facto Population (July 1)	Per Capita Energy Consumption	
			Millions of Btu	Annual Change (Percent)
1960	120.4982	651,200	185.040	
1961	141.3156	668,200	211.487	14.3
1962	137.1934	693,600	197.799	-6.5
1963	143.8698	694,500	207.156	4.7
1964	153.9604	711,200	216.480	4.5
1965	160.6014	715,400	224.492	3.7
1966	175.5990	724,600	242.339	8.0
1967	196.1247	742,600	264.105	9.0
1968	214.9613	758,800	283.291	7.3
1969	221.9387	778,800	284.975	0.6
1970	225.2299	798,600	282.031	-1.0
1971	241.0916	833,100	289.391	2.6
1972	245.1282	869,800	281.821	-2.6
1973	250.5421	901,300	277.979	-1.4
1974	237.2659	923,700	256.865	-7.6
1975	238.3572	943,500	252.631	-1.6
1976	240.5195	970,300	247.882	-1.9
1977	254.5484	992,300	256.524	3.5
1978	259.1148	1,014,300	255.462	-0.4
1979	278.4501	1,042,700	267.047	4.5
1980	273.8809	1,055,400	259.504	-2.8
1981	273.3227	1,062,600	257.221	-0.9
1982	272.1129	1,084,600	250.888	-2.5
1983	279.0303	1,109,200	251.560	0.3
1984	276.3700	1,130,500	244.467	-2.8
1985	266.2178	1,137,800	233.976	-4.3
1986	271.0562	1,167,500	232.168	-0.8
1987	284.2042	1,186,500	239.532	3.2
1988	306.9212	1,200,400	255.682	6.7
1989	315.0842	1,245,600	252.958	-1.1
1990r	312.1304	1,257,000	248.314	-1.8
1991r	322.9524	1,274,800	253.336	2.0
1992r	339.0912	1,269,400	267.127	5.4
1993r	307.7465	1,265,100	243.259	-8.9
1994r	327.4778	1,287,600	254.332	4.6
1995r	315.1186	1,287,600	244.733	-3.8
1996p	315.9492	1,298,800	243.262	-0.6

r = revised
p = preliminary

Table 4. Primary Energy Consumption and Per Capita Consumption, Hawai'i: 1960 to 1996

Year	Total	Petroleum	Biomass	Hydro-Electric	Geo-thermal	Solar Hot Water	Wind	Coal	Municipal Solid Waste
1960	120.4982	98.8532	21.3450	0.3000	0	0	0	0	0
1961	141.3156	116.6716	24.3440	0.3000	0	0	0	0	0
1962	137.1934	111.5904	25.4030	0.2000	0	0	0	0	0
1963	143.8698	117.6498	26.0200	0.2000	0	0	0	0	0
1964	153.9604	126.0344	26.7260	1.2000	0	0	0	0	0
1965	160.6014	131.6284	27.8730	1.1000	0	0	0	0	0
1966	175.5990	146.7910	27.6080	1.2000	0	0	0	0	0
1967	196.1247	166.3587	28.6660	1.1000	0	0	0	0	0
1968	214.9613	185.2063	28.7550	1.0000	0	0	0	0	0
1969	221.9387	192.5367	28.4020	1.0000	0	0	0	0	0
1970	225.2299	197.2279	26.9020	1.1000	0	0	0	0	0
1971	241.0916	212.8486	27.3430	0.9000	0	0	0	0	0
1972	245.1282	218.3842	25.8440	0.9000	0	0	0	0	0
1973	250.5421	223.7861	25.7560	1.0000	0	0	0	0	0
1974	237.2659	212.2739	23.9920	1.0000	0	0	0	0	0
1975	238.3572	213.4572	24.0000	0.9000	0	0	0	0	0
1976	240.5195	215.5195	24.0000	1.0000	0	0	0	0	0
1977	254.5484	229.5889	24.0000	0.9000	0	0.0595	0	0	0
1978	259.1148	233.5357	24.4000	0.9000	0	0.2791	0	0	0
1979	278.4501	253.0344	24.0000	0.9000	0	0.5157	0	0	0
1980	273.8809	248.0109	24.2000	0.9000	0	0.7700	0	0	0
1981	273.3227	245.5086	24.0900	0.7356	0	1.1185	0	1.8700	0
1982	272.1129	244.3151	23.9200	1.0939	0.1572	1.3567	0	1.2700	0
1983	279.0303	250.6283	24.8500	0.8865	0.1886	1.5269	0	0.9500	0
1984	276.3700	248.4026	24.3650	0.7796	0.2075	1.7683	0	0.8470	0
1985	266.2178	238.6470	23.1430	0.9808	0.1886	2.1327	0.1697	0.9560	0
1986	271.0562	242.5857	23.9670	1.0562	0.1823	2.1644	0.6036	0.4970	0
1987	284.2042	256.4061	22.1840	0.9670	0.1446	2.1914	0.8236	1.4875	0
1988	306.9212	279.1052	22.7080	0.9826	0.1629	2.1931	0.4185	1.3509	0
1989	315.0842	289.2301	20.8020	1.0183	0.1435	2.3310	0.4189	0.8715	0.2689
1990r	312.1304	284.4906	18.1200	1.0700	0	2.3400	0.2900	0.8900	4.9298
1991r	322.9524	294.6222	17.9000	1.0000	0	2.3000	0.3060	0.8000	6.0242
1992r	339.0912	305.7758	16.9840	0.7226	0.0168	2.3000	0.2573	6.9207	6.1140
1993r	307.7465	266.9516	16.8310	0.8024	1.5988	2.3000	0.2352	13.2237	5.8038
1994r	327.4778	285.5010	16.3660	1.5300	1.8060	2.3000	0.2251	13.5599	6.1898
1995r	315.1186	273.9590	11.8232	1.0632	2.3045	2.8386	0.2364	16.5249	6.3688
1996p	315.9492	277.1298	10.3994	1.1332	2.3566	3.1225	0.2244	16.9294	4.6539
r = revised									
p = preliminary									

Table 5. Primary Energy Consumption by Source, Hawai‘i (trillion Btu)

Year	Petroleum	Biomass	Hydro-Electric	Geo-thermal	Solar Hot Water	Wind	Coal	Municipal Solid Waste	Total
1960	82.04	17.71	0.25	0.00	0.00	0.00	0.00	0.00	100.00
1961	82.56	17.23	0.21	0.00	0.00	0.00	0.00	0.00	100.00
1962	81.34	18.52	0.15	0.00	0.00	0.00	0.00	0.00	100.00
1963	81.78	18.09	0.14	0.00	0.00	0.00	0.00	0.00	100.00
1964	81.86	17.36	0.78	0.00	0.00	0.00	0.00	0.00	100.00
1965	81.96	17.36	0.68	0.00	0.00	0.00	0.00	0.00	100.00
1966	83.59	15.72	0.68	0.00	0.00	0.00	0.00	0.00	100.00
1967	84.82	14.62	0.56	0.00	0.00	0.00	0.00	0.00	100.00
1968	86.16	13.38	0.47	0.00	0.00	0.00	0.00	0.00	100.00
1969	86.75	12.80	0.45	0.00	0.00	0.00	0.00	0.00	100.00
1970	87.57	11.94	0.49	0.00	0.00	0.00	0.00	0.00	100.00
1971	88.29	11.34	0.37	0.00	0.00	0.00	0.00	0.00	100.00
1972	89.09	10.54	0.37	0.00	0.00	0.00	0.00	0.00	100.00
1973	89.32	10.28	0.40	0.00	0.00	0.00	0.00	0.00	100.00
1974	89.47	10.11	0.42	0.00	0.00	0.00	0.00	0.00	100.00
1975	89.55	10.07	0.38	0.00	0.00	0.00	0.00	0.00	100.00
1976	89.61	9.98	0.42	0.00	0.00	0.00	0.00	0.00	100.00
1977	90.19	9.43	0.35	0.00	0.02	0.00	0.00	0.00	100.00
1978	90.13	9.42	0.35	0.00	0.11	0.00	0.00	0.00	100.00
1979	90.87	8.62	0.32	0.00	0.19	0.00	0.00	0.00	100.00
1980	90.55	8.84	0.33	0.00	0.28	0.00	0.00	0.00	100.00
1981	89.82	8.81	0.27	0.00	0.41	0.00	0.68	0.00	100.00
1982	89.78	8.79	0.40	0.06	0.50	0.00	0.47	0.00	100.00
1983	89.82	8.91	0.32	0.07	0.55	0.00	0.34	0.00	100.00
1984	89.88	8.82	0.28	0.08	0.64	0.00	0.31	0.00	100.00
1985	89.64	8.69	0.37	0.07	0.80	0.06	0.36	0.00	100.00
1986	89.50	8.84	0.39	0.07	0.80	0.22	0.18	0.00	100.00
1987	90.22	7.81	0.34	0.05	0.77	0.29	0.52	0.00	100.00
1988	90.94	7.40	0.32	0.05	0.71	0.14	0.44	0.00	100.00
1989	91.79	6.60	0.32	0.05	0.74	0.13	0.28	0.09	100.00
1990r	91.14	5.81	0.34	0.00	0.75	0.09	0.29	1.58	100.00
1991r	91.23	5.54	0.31	0.00	0.71	0.09	0.25	1.87	100.00
1992r	90.18	5.01	0.21	0.00	0.68	0.08	2.04	1.80	100.00
1993r	86.74	5.47	0.26	0.52	0.75	0.08	4.30	1.89	100.00
1994r	87.18	5.00	0.47	0.55	0.70	0.07	4.14	1.89	100.00
1995r	86.94	3.75	0.34	0.73	0.90	0.08	5.24	2.02	100.00
1996p	87.71	3.29	0.36	0.75	0.99	0.07	5.36	1.47	100.00
r = revised									
p = preliminary									

Table 6. Primary Energy Consumption by Source, Hawai‘i (percent by source)

Country or region	Crude oil (Billion bbl)	Percent	Natural gas (Tril cu ft)	Percent
North America	76.0	7.46%	300.9	6.09%
Canada	4.9	0.48%	68.1	1.38%
Mexico	48.8	4.79%	67.7	1.37%
USA	22.4	2.19%	165.1	3.34%
Central & S. America	79.1	7.77%	208.5	4.22%
Venezuela	64.9	6.37%	141.6	2.86%
Other	14.3	1.40%	66.9	1.35%
Western Europe and North Sea	18.4	1.80%	165.6	3.35%
Mid East	676.4	66.38%	1,617.1	32.70%
Abu Dhabi	92.2	9.05%	189.0	3.82%
Iran	93.0	9.13%	741.6	15.00%
Iraq	112.0	10.99%	118.0	2.39%
Kuwait	94.0	9.23%	52.4	1.06%
Saudi Arabia	259.0	25.42%	188.6	3.81%
Other	26.2	2.57%	327.5	6.62%
Africa	67.6	6.63%	328.6	6.64%
Libya	29.5	2.90%	46.3	0.94%
Nigeria	15.5	1.52%	104.7	2.12%
Other	22.5	2.21%	177.6	3.59%
Far East, Oceania	18.3	1.80%	280.5	5.67%
India	4.3	0.43%	24.2	0.49%
Indonesia	5.0	0.49%	72.3	1.46%
Malaysia	4.0	0.39%	80.2	1.62%
Other	5.0	0.49%	103.8	2.10%
East Europe, China other Communist areas	83.1	8.16%	2,044.2	41.34%
Former USSR	57.0	5.59%	1,977.0	39.98%
China	24.0	2.36%	41.4	0.84%
Other	2.1	0.21%	25.8	0.52%
Total OPEC	788.6	77.40%	2,051.7	41.49%
World Total	1,018.8	100.00%	4,945.4	100.00%

Source: Oil & Gas Journal, Dec. 30, 1996

Table 7. World Crude Oil & Natural Gas Reserves: Jan. 1, 1997

Product	Imports			Exports		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Crude oil	52,043	18,149	33,894	-		
Distillates	102	102		542	352	190
Jet fuel	3,586	1,052	2,534	95	95	
Residual fuel oil	1,071	1,071		297	128	169
Naphtha	-			1,554		1,554
Other	672	672		2,724	956	1,768

Source: Hawai'i State Department of Business, Economic Development, & Tourism—Energy, Resources, and Technology Division records; and Energy Information Administration Data

Table 8. Imports & Exports of Crude Oil and Petroleum Products: 1996 (1,000 barrels)

Year	Total	Aviation Gas	Diesel	Jet Fuel	Kerosene	LPG/SNG	Motor Gasoline	Residual Fuel Oil	Other
1960	17,430	2,582	886	5,011	91	112	3,429	4,766	553
1961	20,474	2,994	1,663	5,558	69	140	3,546	5,926	578
1962	19,459	1,790	1,637	5,532	55	172	3,708	5,974	591
1963	20,444	1,084	1,362	6,892	49	232	3,756	6,431	638
1964	21,801	561	1,761	7,682	50	257	3,861	6,965	664
1965	22,777	626	1,612	8,275	49	219	4,082	7,230	684
1966	25,448	870	1,378	10,158	37	242	4,294	7,801	668
1967	28,785	477	1,208	12,802	33	285	4,526	8,818	636
1968	32,009	268	1,420	14,723	27	298	4,882	9,738	653
1969	33,469	195	1,601	14,834	29	912	5,176	10,056	666
1970	34,320	162	1,695	14,884	153	938	5,691	10,154	643
1971	37,047	165	1,709	16,939	80	963	5,872	10,701	618
1972	37,962	165	1,776	16,839	52	945	6,202	11,338	645
1973	38,922	153	1,837	17,043	41	942	6,608	11,575	723
1974	36,927	145	1,951	15,432	75	966	6,543	11,122	693
1975	37,106	133	1,948	15,363	76	872	6,766	11,255	693
1976	37,473	130	2,337	14,202	129	1,036	7,029	11,871	739
1977	39,823	147	2,865	14,875	169	877	7,406	12,695	789
1978	40,458	141	3,567	14,861	146	702	7,639	12,556	846
1979	44,115	152	6,567	15,276	40	1,583	7,506	12,167	824
1980	43,126	199	5,987	14,116	9	1,573	7,231	13,196	815
1981	42,680	55	4,604	16,451	-	1,285	7,033	13,223	29
1982	42,326	45	4,569	15,427	-	1,335	6,823	14,121	6
1983	43,400	215	4,853	14,724	-	1,360	7,274	14,958	16
1984	43,067	74	5,513	14,398	-	1,273	7,682	14,077	50
1985	41,787	65	4,262	17,297	-	1,292	7,528	11,293	50
1986	42,340	45	4,157	16,486	-	1,281	8,063	12,253	55
1987	44,837	29	3,124	18,775	-	1,333	8,911	12,606	59
1988	48,587	175	5,289	19,648	-	1,350	8,491	13,574	60
1989	50,484	51	4,749	20,399	-	1,476	8,755	15,054	-
1990r	49,673	45	5,541	19,922	-	1,490	8,940	13,735	-
1991r	51,242	45	5,355	19,598	-	1,490	8,958	15,796	-
1992r	53,404	48	6,067	19,258	-	2,375	9,100	16,556	-
1993r	46,750	37	5,007	17,990	-	1,648	9,154	12,913	-
1994r	49,276	38	6,128	18,347	-	1,772	9,258	13,733	-
1995r	47,960	37	5,291	18,462	-	1,609	9,441	13,119	-
1996p	48,444	32	5,452	17,733	-	1,611	9,680	13,936	-

r = revised
p = preliminary

Table 9. Petroleum Consumption, Hawai‘i (thousand barrels)

Year	Total energy expend.	Fuel expenditures			Less: electric utility fuel expend.	Plus: electric purch. by end-user
		Total	Electric utility	Other		
1970	282.7	215.9	17.3	198.6	17.3	84.1
1971	320.8	246.8	24.8	222.0	24.8	98.8
1972	332.4	250.4	27.3	223.1	27.3	109.3
1973	391.1	300.9	36.3	264.6	36.3	126.5
1974	534.5	433.2	49.8	383.4	49.8	151.1
1975	669.9	546.1	91.9	454.2	91.9	215.7
1976	735.6	600.0	100.4	499.6	100.4	236.0
1977	844.5	696.5	123.5	573.0	123.5	271.5
1978	932.2	767.8	149.3	618.5	149.3	313.7
1979	1,261.3	1,083.7	177.0	906.7	177.0	354.6
1980	1,721.3	1,529.8	267.8	1,262.0	267.8	459.3
1981	2,195.2	1,947.7	451.5	1,496.2	451.5	699.0
1982	2,153.8	1,869.6	439.4	1,430.2	439.4	723.6
1983	2,019.9	1,730.1	369.3	1,360.8	369.3	659.1
1984	2,048.4	1,724.8	379.3	1,345.5	379.3	702.9
1985	1,921.6	1,586.6	337.6	1,249.0	337.6	672.6
1986	1,564.0	1,147.3	224.6	922.7	224.6	641.3
1987	1,575.1	1,176.2	203.7	972.5	203.7	602.6
1988	1,664.1	1,314.6	238.0	1,076.6	238.0	587.5
1989	1,895.2	1,530.6	277.5	1,253.1	277.5	642.1
1990	2,204.4	1,807.0	352.5	1,454.5	352.5	749.9
1991	2,217.5	1,736.4	304.8	1,431.6	304.8	785.9
1992r.....	2,340.3	1,760.0	238.2	1,521.8	238.2	818.5
1993r.....	2,369.9	1,660.4	213.3	1,447.1	213.3	922.8
1994r.....	2,397.0	1,642.5	201.4	1,441.1	201.4	955.9
1995r.....	2,459.4	1,645.2	223.5	1,421.7	223.5	1,037.7
1996p	2,631.8	1,763.7	268.9	1,494.8	268.9	1,137.0

r = revised; p = preliminary.
Source: Hawai'i State Department of Business, Economic Development, & Tourism—Energy, Resources, and Technology Division, records.

Table 10. Expenditures for Fuels and Electricity, by Source: 1970 to 1996 (millions of dollars)

Year	Total	Petroleum	Biomass	MSW 1/	Hydro-electric	Geo-thermal	Wind	Coal	PV 2/	Other 3/
1987	8,368	7,577	605	-	93	14	79	-	-	-
1988	8,952	8,115	681	-	98	16	42	-	-	-
1989	9,280	8,511	614	-	100	14	41	-	-	(Z)
1990	9,566	8,589	538	-	105	-	28	-	-	306
1991	9,610	8,664	495	-	92	-	30	-	-	329
1992	10,104	8,556	460	-	67	1	21	-	-	999
1993	10,219	7,576	435	349	78	155	24	1,592	(Z)	10
1994	10,341	7,793	423	379	148	175	22	1,382	(Z)	19
1995	10,563	7,853	292	383	103	223	23	1,674	(Z)	12
1996	10,740	8,026	270	326	110	228	22	1,739	(Z)	19

Z Less than 500,000 kWh

1/ Electricity generated from Honolulu municipal solid waste plant.

2/ Electricity generated from photovoltaics.

3/ From 1987 to 1992, "other" includes electricity production by coal, geothermal (a test well which ceased operation in 1989), and photovoltaics.

Source: Hawai'i State Department of Commerce and Consumer Affairs, records; Hawai'i State Department of Business, Economic Development, & Tourism—Energy, Resources, and Technology Division, records; Hawai'i Agriculture Research Center/Hawaiian Sugar Planters' Association, records.

Table 11. Electricity Generation by Source: 1987 to 1996 (millions of kWh generated)

Island	Total	Petroleum	Biomass	MSW 1/	Hydro-electric	Wind	Geo-thermal	Coal	PV 2/	Other
State total..	10,741	8,027	270	326	110	22	228	1,739	-	19
Hawai'i	1,014	603	2	-	41	19	228	121	(Z)	-
Maui	1,210	1,010	143	-	18	-	-	39	(Z)	
Lana'i	28	28	-	-	-	-	-	-	-	-
Moloka'i	38	38	-	-	-	-	-	-	-	-
O'ahu	7,957	5,999	31	326	-	3	-	1,579	-	19
Kaua'i	494	349	94	-	51	-	-	-	-	-

Z less than 500,000 kWh

1/ Electricity generated from Honolulu municipal solid waste plant.

2/ Electricity generated from photovoltaics.

Source: Hawai'i State Department of Business, Economic Development, & Tourism—Energy, Resources, and Technology Division, records; Hawai'i State Department of Commerce and Consumer Affairs, records.

Table 12. Electricity Production, by Source, by Island: 1996 (million kWh)

Year	GSP (Thousands of 1987 $)	Total	Residential	Other	Total kWh Sales per $1,000 of Constant GSP	Annual Change (Percent)
1960	6,271,500	1,602,197	580,849	1,021,348	255	
1961	6,273,800	1,766,031	624,730	1,141,301	281	10.19
1962	6,538,000	1,966,105	678,628	1,287,477	301	6.83
1963	6,699,400	2,078,571	730,317	1,348,254	310	3.17
1964	7,370,200	2,284,275	786,118	1,498,157	310	-0.11
1965	8,023,600	2,445,025	853,086	1,591,939	305	-1.68
1966	8,464,800	2,639,866	912,616	1,727,250	312	2.34
1967	8,758,600	2,832,469	989,785	1,842,684	323	3.70
1968	9,479,300	3,109,256	1,083,233	2,026,023	328	1.43
1969	10,642,200	3,426,052	1,174,502	2,251,550	322	-1.85
1970	11,142,900	3,758,094	1,270,732	2,487,362	337	4.76
1971	11,718,800	4,167,127	1,375,308	2,791,819	356	5.43
1972	12,505,100	4,562,568	1,493,840	3,068,728	365	2.61
1973	13,124,000	4,867,850	1,581,855	3,285,995	371	1.66
1974	13,083,500	5,113,906	1,635,978	3,477,928	391	5.38
1975	13,857,900	5,334,755	1,676,438	3,658,317	385	-1.51
1976	14,036,900	5,615,210	1,750,618	3,864,592	400	3.91
1977	14,463,400	5,831,610	1,779,314	4,052,296	403	0.79
1978	14,917,100	6,004,891	1,799,024	4,205,867	403	-0.16
1979	15,501,700	6,197,426	1,851,457	4,345,969	400	-0.69
1980	16,360,100	6,345,531	1,852,984	4,492,547	388	-2.98
1981	16,756,900	6,424,016	1,855,837	4,568,179	383	-1.16
1982	16,360,700	6,332,707	1,801,297	4,531,410	387	0.97
1983	16,981,100	6,425,578	1,814,336	4,611,242	378	-2.24
1984	17,491,600	6,606,255	1,837,954	4,768,301	378	-0.19
1985	18,336,500	6,635,158	1,879,027	4,756,131	362	-4.19
1986	19,323,900	7,025,739	1,959,447	5,066,292	364	0.48
1987	20,027,300	7,298,178	2,070,052	5,228,126	364	0.23
1988	21,206,100	7,719,029	2,148,275	5,570,754	364	-0.11
1989	22,213,900	7,970,360	2,239,356	5,731,004	359	-1.43
1990	22,976,700	8,310,537	2,320,550	5,989,987	362	0.81
1991r	22,887,700	8,564,032	2,385,276	6,178,756	374	3.45
1992r	23,095,100	8,643,562	2,430,152	6,213,410	374	0.02
1993r	23,180,100	8,657,905	2,453,830	6,204,075	374	-0.20
1994r	23,190,300	8,948,458	2,551,240	6,397,218	386	3.31
1995r	23,297,800	9,187,429	2,597,010	6,590,419	394	2.20
1996p	23,504,400	9,378,962	2,669,654	6,709,308	399	1.19

r = revised
p = preliminary

Table 13. Electricity Sales and Gross State Product, Hawai'i: 1960 to 1996

Year	De Facto Population (July 1)	Total	Residential	Other	Total kWh Sales Per De Facto Population (kWh)	Annual Change (Percent)
1960	651,200	1,602,197	580,849	1,021,348	2,460	
1961	668,200	1,766,031	624,730	1,141,301	2,643	7.42
1962	693,600	1,966,105	678,628	1,287,477	2,835	7.25
1963	694,500	2,078,571	730,317	1,348,254	2,993	5.58
1964	711,200	2,284,275	786,118	1,498,157	3,212	7.32
1965	715,400	2,445,025	853,086	1,591,939	3,418	6.41
1966	724,600	2,639,866	912,616	1,727,250	3,643	6.60
1967	742,600	2,832,469	989,785	1,842,684	3,814	4.70
1968	758,800	3,109,256	1,083,233	2,026,023	4,098	7.43
1969	778,800	3,426,052	1,174,502	2,251,550	4,399	7.36
1970	798,600	3,758,094	1,270,732	2,487,362	4,706	6.97
1971	833,100	4,167,127	1,375,308	2,791,819	5,002	6.29
1972	869,800	4,562,568	1,493,840	3,068,728	5,246	4.87
1973	901,300	4,867,850	1,581,855	3,285,995	5,401	2.96
1974	923,700	5,113,906	1,635,978	3,477,928	5,536	2.51
1975	943,500	5,334,755	1,676,438	3,658,317	5,654	2.13
1976	970,300	5,615,210	1,750,618	3,864,592	5,787	2.35
1977	992,300	5,831,610	1,779,314	4,052,296	5,877	1.55
1978	1,014,300	6,004,891	1,799,024	4,205,867	5,920	0.74
1979	1,042,700	6,197,426	1,851,457	4,345,969	5,944	0.40
1980	1,055,400	6,345,531	1,852,984	4,492,547	6,012	1.16
1981	1,062,600	6,424,016	1,855,837	4,568,179	6,046	0.55
1982	1,084,600	6,332,707	1,801,297	4,531,410	5,839	-3.42
1983	1,109,200	6,425,578	1,814,336	4,611,242	5,793	-0.78
1984	1,130,500	6,606,255	1,837,954	4,768,301	5,844	0.87
1985	1,137,800	6,635,158	1,879,027	4,756,131	5,832	-0.21
1986	1,167,500	7,025,739	1,959,447	5,066,292	6,018	3.19
1987	1,186,500	7,298,178	2,070,052	5,228,126	6,151	2.21
1988	1,200,400	7,719,029	2,148,275	5,570,754	6,430	4.54
1989	1,245,600	7,970,360	2,239,356	5,731,004	6,399	-0.49
1990	1,257,000	8,310,537	2,320,550	5,989,987	6,611	3.32
1991	1,274,800	8,564,032	2,385,276	6,178,756	6,718	1.61
1992	1,269,400	8,643,562	2,430,152	6,213,410	6,809	1.36
1993r	1,265,100	8,657,905	2,453,830	6,204,075	6,844	0.51
1994r	1,287,600	8,948,458	2,551,240	6,397,218	6,950	1.55
1995r	1,287,600	9,187,429	2,597,010	6,590,419	7,135	2.67
1996p	1,298,800	9,378,962	2,669,654	6,709,308	7,221	1.20

r = revised
p = preliminary

Table 14. Electricity Sales and De Facto Population, Hawai'i: 1960 to 1996
(Electricity Sales by Utilities, thousand kWh)

Table 15. Electricity Sales, Hawai'i: 1960 to 1996 (electric utilities)

Year	Customer Accounts (No. at end of year)			Power Sold (Thous. kWh)			Revenues (Thous. $)		
	Total	Residential	Other	Total	Residential	Other	Total	Residential	Other
1960	157,578	132,440	25,138	1,602,197	580,849	1,021,348	39,284	17,265	22,019
1961	162,452	136,788	25,664	1,766,031	624,730	1,141,301	42,137	18,153	23,984
1962	167,101	140,661	26,440	1,966,105	678,628	1,287,477	46,282	19,603	26,679
1963	171,832	144,638	27,194	2,078,571	730,317	1,348,254	48,499	20,733	27,766
1964	177,684	149,547	28,137	2,284,275	786,118	1,498,157	52,133	21,971	30,162
1965	183,723	154,822	28,901	2,445,025	853,086	1,591,939	55,472	23,519	31,953
1966	190,276	160,784	29,492	2,639,866	912,616	1,727,250	59,362	24,905	34,457
1967	196,417	166,256	30,161	2,832,469	989,785	1,842,684	63,685	26,763	36,922
1968	202,167	171,346	30,821	3,109,256	1,083,233	2,026,023	69,599	29,034	40,565
1969	210,330	178,569	31,761	3,426,052	1,174,502	2,251,550	75,417	31,181	44,236
1970	219,003	186,282	32,721	3,758,094	1,270,732	2,487,362	84,096	34,068	50,028
1971	226,514	193,043	33,471	4,167,127	1,375,308	2,791,819	98,829	38,824	60,005
1972	236,309	201,903	34,406	4,562,568	1,493,840	3,068,728	109,213	42,560	66,653
1973	246,255	210,740	35,515	4,867,850	1,581,855	3,285,995	126,454	48,674	77,780
1974	255,901	219,633	36,268	5,113,906	1,635,978	3,477,928	151,188	57,145	94,043
1975	263,816	226,836	36,980	5,334,755	1,676,438	3,658,317	215,678	76,881	138,797
1976	270,035	232,070	37,965	5,615,210	1,750,618	3,864,592	235,999	83,957	152,042
1977	275,616	237,557	38,059	5,831,610	1,779,314	4,052,296	271,553	92,917	178,636
1978	284,064	244,863	39,201	6,004,891	1,799,024	4,205,867	313,722	105,846	207,876
1979	293,061	252,898	40,163	6,197,426	1,851,457	4,345,969	354,595	118,862	235,733
1980	301,544	260,358	41,186	6,345,531	1,852,984	4,492,547	459,251	146,397	312,854
1981	305,927	265,042	40,885	6,424,016	1,855,837	4,568,179	699,031	214,584	484,447
1982	313,009	270,712	42,297	6,332,707	1,801,297	4,531,410	723,622	222,423	501,199
1983	319,449	276,194	43,255	6,425,578	1,814,336	4,611,242	659,089	205,889	453,200
1984	324,384	280,518	43,866	6,606,255	1,837,954	4,768,301	702,899	217,447	485,452
1985	330,407	285,117	45,290	6,635,158	1,879,027	4,756,131	672,600	213,478	459,122
1986	337,563	291,222	46,341	7,025,739	1,959,447	5,066,292	562,344	182,110	380,234
1987	347,086	299,758	47,328	7,298,178	2,070,052	5,228,126	602,835	195,277	407,558
1988	354,887	306,375	48,512	7,719,029	2,148,275	5,570,754	587,528	189,689	397,839
1989	362,290	312,347	49,943	7,970,360	2,239,356	5,731,004	644,789	207,296	437,493
1990	370,952	320,215	50,737	8,310,537	2,320,550	5,989,987	749,845	238,103	511,742
1991	380,963	328,899	52,064	8,564,032	2,385,276	6,178,756	785,896	251,553	534,343
1992	385,055	332,863	52,192	8,643,562	2,430,152	6,213,410	818,525	265,667	552,858
1993	394,825	340,932	53,893	8,657,905	2,453,830	6,204,075	922,797	302,054	620,743
1994	403,595	346,977	56,618	8,948,458	2,551,240	6,397,218	955,907	317,984	637,923
1995	409,983	352,589	57,394	9,187,429	2,597,010	6,590,419	1,037,702	346,359	691,343
1996	413,830	356,205	57,625	9,378,962	2,669,654	6,709,308	1,137,045	381,011	756,034

Table 16. Average kWh Use and Rates, Hawai‘i: 1960 to 1996 (electric utilities)

Year	Customer Accounts (No. at End of Year)			Average Power Sold (kWh per Customer)			Average Rate ($ per kWh)			Average Rate (Constant $ per kWh)		
	Total	Residential	Other	Total	Residential	Other	Total	Residential	Other	Total	Residential	Other
1960	157,578	132,440	25,138	10,168	4,386	40,630	0.0245	0.0297	0.0216	0.0783	0.0950	0.0689
1961	162,452	136,788	25,664	10,871	4,567	44,471	0.0239	0.0291	0.0210	0.0743	0.0905	0.0655
1962	167,101	140,661	26,440	11,766	4,825	48,694	0.0235	0.0289	0.0207	0.0718	0.0881	0.0632
1963	171,832	144,638	27,194	12,097	5,049	49,579	0.0233	0.0284	0.0206	0.0697	0.0847	0.0615
1964	177,684	149,547	28,137	12,856	5,257	53,245	0.0228	0.0279	0.0201	0.0677	0.0829	0.0597
1965	183,723	154,822	28,901	13,308	5,510	55,082	0.0227	0.0276	0.0201	0.0660	0.0801	0.0583
1966	190,276	160,784	29,492	13,874	5,676	58,567	0.0225	0.0273	0.0199	0.0637	0.0773	0.0565
1967	196,417	166,256	30,161	14,421	5,953	61,095	0.0225	0.0270	0.0200	0.0619	0.0745	0.0552
1968	202,167	171,346	30,821	15,380	6,322	65,735	0.0224	0.0268	0.0200	0.0594	0.0711	0.0531
1969	210,330	178,569	31,761	16,289	6,577	70,890	0.0220	0.0265	0.0196	0.0559	0.0674	0.0499
1970	219,003	186,282	32,721	17,160	6,822	76,017	0.0224	0.0268	0.0201	0.0539	0.0646	0.0485
1971	226,514	193,043	33,471	18,397	7,124	83,410	0.0237	0.0282	0.0215	0.0549	0.0653	0.0498
1972	236,309	201,903	34,406	19,308	7,399	89,192	0.0239	0.0285	0.0217	0.0537	0.0639	0.0487
1973	246,255	210,740	35,515	19,768	7,506	92,524	0.0260	0.0308	0.0237	0.0557	0.0660	0.0508
1974	255,901	219,633	36,268	19,984	7,449	95,895	0.0296	0.0349	0.0270	0.0574	0.0678	0.0525
1975	263,816	226,836	36,980	20,221	7,391	98,927	0.0404	0.0459	0.0379	0.0718	0.0815	0.0674
1976	270,035	232,070	37,965	20,794	7,543	101,794	0.0420	0.0480	0.0393	0.0711	0.0811	0.0666
1977	275,616	237,557	38,059	21,158	7,490	106,474	0.0466	0.0522	0.0441	0.0750	0.0841	0.0710
1978	284,064	244,863	39,201	21,139	7,347	107,290	0.0522	0.0588	0.0494	0.0781	0.0879	0.0739
1979	293,061	252,898	40,163	21,147	7,321	108,208	0.0572	0.0642	0.0542	0.0770	0.0864	0.0730
1980	301,544	260,358	41,186	21,043	7,117	109,079	0.0724	0.0790	0.0696	0.0872	0.0952	0.0839
1981	305,927	265,042	40,885	20,999	7,002	111,732	0.1088	0.1156	0.1060	0.1187	0.1261	0.1156
1982	313,009	270,712	42,297	20,232	6,654	107,133	0.1143	0.1235	0.1106	0.1176	0.1270	0.1138
1983	319,449	276,194	43,255	20,115	6,569	106,606	0.1026	0.1135	0.0983	0.1033	0.1143	0.0990
1984	324,384	280,518	43,866	20,366	6,552	108,702	0.1064	0.1183	0.1018	0.1028	0.1143	0.0984
1985	330,407	285,117	45,290	20,082	6,590	105,015	0.1014	0.1136	0.0965	0.0949	0.1064	0.0904
1986	337,563	291,222	46,341	20,813	6,728	109,326	0.0800	0.0929	0.0751	0.0732	0.0850	0.0686
1987	347,086	299,758	47,328	21,027	6,906	110,466	0.0826	0.0943	0.0780	0.0719	0.0821	0.0678
1988	354,887	306,375	48,512	21,751	7,012	114,832	0.0761	0.0883	0.0714	0.0625	0.0726	0.0587
1989	362,290	312,347	49,943	22,000	7,169	114,751	0.0809	0.0926	0.0763	0.0629	0.0719	0.0593
1990	370,952	320,215	50,737	22,403	7,247	118,060	0.0902	0.1026	0.0854	0.0653	0.0743	0.0619
1991	380,963	328,899	52,064	22,480	7,252	118,676	0.0918	0.1055	0.0865	0.0620	0.0713	0.0584
1992	385,055	332,863	52,192	22,448	7,301	119,049	0.0947	0.1093	0.0890	0.0611	0.0705	0.0574
1993	394,825	340,932	53,893	21,928	7,197	115,118	0.1066	0.1231	0.1001	0.0666	0.0769	0.0625
1994	403,595	346,977	56,618	22,172	7,353	112,989	0.1068	0.1246	0.0997	0.0649	0.0758	0.0606
1995	409,983	352,589	57,394	22,409	7,366	114,828	0.1129	0.1334	0.1049	0.0672	0.0793	0.0624
1996	413,830	356,205	57,625	22,664	7,495	116,431	0.1212	0.14272	0.11268	0.0710	0.0836	0.0660

Island	Location	No. of Units	Model	Capacity Each kW	Total Capacity MW	Gross Generation MWh	Annual Oil Equiv. (1000 Bbl)	Owner
HAWAI'I	Kahua Ranch***	3	Bergey - Excel R-240	10	0.03	69.05	0.12	Kahua
	Kahua Ranch	1	Carter	25	0.03		0.00	Kahua/PICHTR
	Lalamilo*	36/57	Jacobs	17.5/20	1.77	3,009.60	5.02	HEI
	South Point	37	Mitsubishi	250	9.40	15,428.50	25.71	Apollo Energy Sys.
						41.14	0.07	Independents+
	Island Total:	***134***			***11.23***	***18,548.29***	***30.91***	
O'AHU	Kahuku**	8	Westinghouse	600	4.80		0.00	Makani Uwila
	Kahuku**	1	MOD-5B	3,200	3.20	3,168.00	5.28	Makani Uwila
	Island Total:	***9***			***8.00***	***3,168.00***	***5.28***	
STATE TOTAL		***143***			***19.53***	***21,716.29***	***36.19***	

* The total MW capacity is for the 93 units. Lalamilo operated at 75% capacity during 1996.

** The HERS Makani Moae wind farm in Kahuku, Oahu, was closed by HERS parent company HEI in October 1992. HERS was purchased in April 1993 by New World Power Corp., which renamed it Makani Uwila Power Corp., resumed operation of the wind farm, and resumed providing electricity to HECO. Makani Uwila Power ceased producing wind power in December 1996.

*** Kahua Ranch - the Bergey turbines were installed in April 1996 and the Jacobs turbine retired.

\+ There are approximately 10 small privately owned wind generators selling power to HELCO. The generators vary in size from 10 kW-27 kW.

Gross generation is approximate for calendar year 1996 and will vary with annual wind conditions.
Oil equivalent based on 600 kWh per barrel of oil. Totals are rounded.

Table 17. Wind Power in Hawai'i: 1996

Island	Location	Stream	MW Capacity	Gross Generation (MWh)	Annual Oil Equiv.* (1000 Bbl)	Owner
HAWAI'I	Hilo	Wailuku	1.50	9,263.09	15.44	HELCO Puueo
	Hilo	Wailuku	0.75	2,210.99	3.68	HELCO Puueo
	Hilo	Wailuku	0.75	5,049.72	8.42	HELCO Waiau
	Hilo	Wailuku	0.35	1,634.84	2.72	HELCO Waiau
	Hilo	Ainako	0.01	28.53	0.05	Wenko Energy
	Hawi	Kohala Ditch	0.35	600.25	1.00	Hawi Ag & Energy
	Waimea	Waimea/Waikoloa Pipeline	0.04	87.26	0.15	Hawai'i County
	Haina[1]	Hamakua Ditch	0.80	0.00	0.00	Hamakua Sugar
	Hilo	Wailuku	12.00	21628.944**	36.05	Wailuku River Hydro Power
	Waimea	Kahua	***	***	***	Kahua Ranch
	North Hilo[2]		0.08	21.24	0.04	Ho'owaiwai Farms
	Island Total:		***16.55***	***40,524.86***	***67.51***	
KAUA'I	Waimea	Waiawa	0.50	160.00	0.27	Kekaha Sugar
	Waiawa	Kehaha Ditch	1.00	5,590.00	9.32	Kekaha Sugar
	Lihue	Wailua Ditch	0.50	5,170.00	8.62	Lihu'e Plantation[3]
	Lihue	Wailua Ditch	0.80			Lihu'e Plantation
	North	Wainiha	3.80	28,930.00	48.22	McBryde Sugar
	Kalaheo	Alexander Reservoir	1.00	5,090.00	8.48	McBryde Sugar
	Kaumakani	Makawili	1.25	6,510.00	10.85	Olokele Sugar
	Island Total:		***8.85***	***51,450.00***	***85.75***	
MAUI	Kaheka	Wailoa Ditch	4.50	12,479.51	20.80	HC&S
	Paia	Wailoa Ditch	0.90	4,896.65	8.16	HC&S
	Hamakua	Wailoa Ditch	0.50	77.08	0.13	HC&S
	Lahaina	Kauaula	0.50	250.00	0.42	Pioneer Mill Co., Ltd.
	Island Total:		***6.40***	***17,703.23***	***29.51***	
STATE TOTAL			***31.80***	***109,678.10***	***182.76***	

* Oil equivalent based on 600 kWh per barrel of oil. Totals are rounded.
** Facility dedicated on July 30, 1993, but began providing electricity to HELCO in May 1993
*** Research facility.

1 Hamakua Sugar ceased production in early 1995
2 Ho'owaiwai data are for December 1996.
3 Combined generation for Lihu'e Plantation

Table 18. Hydroelectric Power Plants in Hawai'i: 1996