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DEPARTMENT OF BUSINESS
AND ECONOMIC DEVELOPMENT

STATE ENERGY RESOURCES COORDINATOR

Annual Report

July 1, 1987 to June 30, 1988

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GOVERNOR'S FOREWORD

One of Hawaii's major concerns, both economically and socially, is the State's dependence on imported oil for more than 90 percent of our energy needs. This energy provides the power that lights our homes; moves our ships, planes, trucks, and cars; air-conditions our offices; and cooks our food.

Faced with increasing dependence on foreign oil, a predicted rise in oil prices, and the ever-present possibility of a disruption in oil supplies, Hawaii must reduce its dependency on foreign oil. We do not wish to face again the disruptions to our economy and to our everyday lives that occurred during the oil crises of the 1970s. We need to reduce the dollars leaving the State to buy oil, in order that those dollars can stay in Hawaii to improve our economy and benefit our people.

Over the past 15 years, we have undertaken a dynamic program to reduce our oil dependence through energy conservation and the development of Hawaii's unique variety of abundant renewable energy resources. This program has moved forward positively, as a result of the cooperative efforts of government and private sectors. Our energy conservation programs have been an integral part of Hawaii's rapid shift to energy efficiency -- since 1980, we have achieved an

impressive 21 percent reduction in per-capita energy demand and a 26 percent reduction in energy demand per dollar of gross state product.

However, energy conservation alone is not enough. We have a broad range of programs to develop our State's alternative energy resources by supporting research and development and advancing the commercialization of renewable energy technologies. Major achievements in the past year include creation of the Advisory Board on the Geothermal/Cable Project and legislation enacted to facilitate the project; significant progress in the Hawaii Deep Water Cable Program; dedication of the magnificent 3.2 megawatt MOD-5B wind turbine on Oahu; production of more than 770 million kilowatt hours of electricity from biomass, wind, and hydropower throughout the State; displacement of 349,000 barrels of oil by roughly 50,000 rooftop solar water heaters; and plans for building a photovoltaic manufacturing plant in Hawaii.

ENERGY RESOURCES COORDINATOR'S MESSAGE

As the Energy Resources Coordinator (ERC) for the State of Hawaii, it is my pleasure to present this annual report on the progress of energy activities undertaken in the State during Fiscal Year 1987/1988 (FY 87/88) to the Administration, the Legislature, and the people of Hawaii. The report covers both public and private sector programs as mandated under the provisions of Section 196-4 (11) Hawaii Revised Statutes.

My responsibilities under the law require the formulation of comprehensive plans and specific proposals for the optimum development and use of Hawaii's energy resources. These include development of alternative energy resources; conservation of energy; contingency plans for the maintenance of essential services in an energy emergency; public education programs; the coordination of Federal, State, County and private actions taken in support of the State's energy objectives; recommendations to the Governor on energy matters; and an annual report.

Commercializing Hawaii's many alternative energy resources and implementing a wide range of energy conservation technologies and programs have been the primary objectives of the State's energy programs during this Administration. The Energy Division of the Department of Business and Economic Development (DBED) is responsible for carrying out these energy objectives with specialized assistance provided by other divisions of our Department, and other agencies of

State and County governments. The Energy Division was headed between December 1982 and January 1988 by Dr. Takeshi Yoshihara and, since February 1988, by Maurice H. Kaya.

We wish to express our appreciation for the encouragement and strong support provided by Governor Waihee, the State Legislature, our Congressional Delegation, agencies of the Federal, State, and County governments, the University of Hawaii, and local and national companies in the private sector. Their support has contributed significantly to the accomplishments and the progress achieved during this past fiscal year.

OVERVIEW OF HAWAII'S ENERGY SITUATION

Hawaii, of all the states in the nation, is the most vulnerable to petroleum shortages or rapid inflation in oil prices. Located in the middle of the Pacific Ocean, the 50th State has no fossil fuel resources of its own. Its mid-ocean location requires tanker ships to supply oil to its two refineries; in times of emergency these tankers may not be available. In addition, the multi-island structure of the state requires relatively small electric generating plants on each of the islands, with the consequent lack of an inter-tied utility grid for backup power and the economic advantages of large-scale production.

Hawaii's Energy Demand

Hawaii consumes energy equivalent to 44 million 42-gallon barrels of oil each year -- an average of 37 barrels per person, enough energy to produce 22,000 kilowatt hours (kWh) of electricity, but 25 percent less than the national average per capita.

With enormous requirement for aircraft fuel, but little need for space heating, Hawaii's energy demand differs markedly from national trends:

	Percent of Energy Demand	
	Hawaii	U.S. Mainland
Transportation	58%	27%
Electricity	30%	36%
All other energy	12%	37%

A total of 58 percent of Hawaii's energy is used for transportation -- more than double the national average.

Within the electricity sector, Hawaii's consumption patterns also differ from the national average. In Hawaii, for a typical family of four, nearly 40

percent of the electricity produced for residential use is for water heating, 20 percent for a frost-free refrigerator, and 40 percent for cooking and other uses, but practically none for space heating. National averages on the other hand, show 15 percent of the nation's residential electricity is used for water heating, 68 percent for space heating and only 17 percent for cooking and other uses.

State and National Dependence Upon Oil

In contrast to the national average of 4.6 percent, Hawaii relies upon petroleum to generate over 90 percent of its electricity. Biomass provides about seven percent; other indigenous sources including hydropower, wind and geothermal make up the rest. Only Hawaii, Rhode Island, and the District of Columbia rely on petroleum to supply as much as 90 percent of their electricity demand; only six other states use petroleum for more than 20 percent of their electric generation needs.

Overall, the nation is only 43 percent dependent on petroleum for energy; Hawaii is about 90 percent dependent on petroleum for all its energy needs including transportation fuels. All of the state's ground vehicle, aircraft and seacraft fuel is derived from imported petroleum.

Where Does Hawaii's Oil Come From?

Hawaii must import 100 percent of its oil either from foreign or domestic sources. In 1987, about 62 percent of Hawaii's net oil imports came from foreign sources. The remaining 38 percent shipped into the state, primarily crude oil from Alaska and some refined products, originated in the United States.

The United States, as a whole, imported 35 percent of its total net oil needs, about 2.2 billion barrels per year, at a current cost of $33 billion

per year. The percentage of imports, the largest since 1980, was due mainly to a combination of lowered oil prices and increased demand.

Hawaii's energy supply and demand patterns reveal the need for continued commercial development of indigenous alternative energy resources to lessen the state's dependence upon imported petroleum. For maximum effectiveness, conservation programs are aimed at specific areas of major use in Hawaii.

The World Oil Picture

At present, the world oil market is experiencing a glut -- an abundance of oil is keeping prices down. There are two major reasons for the oil glut. On the supply side, several major oil reserves have begun producing since the oil crisis of 1973, including Alaska, Mexico, the North Sea and China. In response to this new production, the OPEC nations have decreased oil production by 43 percent since 1973 in an attempt to maintain oil prices.

On the demand side, the development and widespread use of energy-conserving technologies and alternative energy resources have kept worldwide petroleum demand in check. The U.S. uses four percent less oil than it did in 1973, and most other industrialized nations have reduced their consumption by a much greater percentage. In 1988, the world is using no more oil than it did in 1973, about 56 million barrels per day or 20 billion barrels per year.

It would be unwise, however, to count on low oil prices for an extended period. Twice in the past 15 years, disruptions on the opposite side of the globe have unexpectedly tripled world oil prices. Oil prices have been in a continual state of flux during the entire period.

Far more certain is our country's own oil crisis. The United States, the world's largest consumer and second largest producer of oil, is reportedly

running dry. With a total "proved reserve" of 24 billion barrels, the U.S. is pumping three billion barrels per year. By comparison, Middle Eastern countries pump a total of seven billion barrels per year from total proved reserves of 565 billion barrels.

What Are the Alternatives?

The physical features for which Hawaii is noted -- tropical sunshine, active volcanoes, steady winds, intensive vegetation, and the Pacific Ocean -- are all vast sources of usable energy. This report describes efforts to commercialize energy production from these resources, and to reduce Hawaii's total energy consumption, in order to stabilize energy costs and ensure Hawaii's own energy future.

The ERC shall ... formulate comprehensive plans ... for the optimum development of Hawaii's energy resources, conservation of energy and the allocation and distribution of fuel ...

STATE ENERGY PLANNING

Hawaii's energy problems are long-term, and their solutions require comprehensive, long-term planning. This is especially true under today's conditions when currently adequate oil supplies and relatively lower prices have greatly diminished our once prevalent sense of urgency. In planning for future years when oil is expected once again to be both scarce and expensive, the State must continue to promote and support conservation measures and technologies and the development of diverse energy sources, as well as contingency planning for the maintenance of essential services and the stability of the State's economy during emergency periods.

Overall energy planning for Hawaii is guided by three major documents: The Hawaii State Plan, The State Energy Functional Plan, and the DBED Strategic Plan. The State Energy Emergency Plan depicts actions to be taken by State and private agencies to protect health and safety in the event of future oil shortages or drastic price increases.

The Hawaii State Plan

This plan, enacted by the Legislature in 1978 (Chap 226, HRS) and amended by Act 276, SLH 1986, provides the substantive basis for Statewide energy planning and energy program implementation. The Plan's primary objectives for

energy are: (1) the provision of dependable, efficient and economical Statewide systems capable of supporting the needs of the people; and (2) increased energy self-sufficiency.

Policies of the State Plan provide more specific guidance and call for:

(1) acceleration of research, development and use of new energy sources;

(2) provision of adequate, reasonably priced and dependable power and communication services to accommodate the demands of anticipated growth;

(3) promotion of prudent use of power and fuel supplies through education, conservation, and energy-efficient practices; and

(4) adequate consideration of environmental, public health and safety concerns.

State Energy Functional Plan

The State Energy Functional Plan, adopted by the Legislature in 1984, provided detailed guidance for energy programs throughout the State. It provides the linkage between the broad policy guidelines of the Hawaii State Plan and specific energy-related activities of both the public and private sectors. More than 40 specific Implementing Actions in the Functional Plan set forth a strategy to meet Hawaii's future energy needs.

The Energy Functional Plan, and its companion Technical Reference Document were reviewed and updated in-house in 1987 to reflect the changes made in the revised Hawaii State Plan and the many achievements in the field of energy over the past decade. Draft versions of both documents were reviewed by public and private agencies and were submitted to the Office of State Planning (OSP) in October 1987 for review and evaluation.

DBED Strategic Plan

DBED's Strategic Plan for Industry, published in January 1988, stresses the goal of import substitution as a means of encouraging local industry. Replacing imports of crude oil is regarded as the State's major import-reducing business strategy. Each year, almost a billion dollars leaves the State to pay for crude oil and other petroleum products. Reducing the amount of money spent on these purchases will free funds to support the State's local economy, enhance the State's economic security, and produce more employment and local income for Hawaii's people.

Additional goals of the Strategic Plan relevant to the State's energy programs are: the provision of a positive, supportive business environment; accelerated development of growth-oriented enterprises; and the promotion of available financial resources to fund new business activities.

Throughout the Strategic Plan, emphasis is placed on those initiatives which have the potential for results in the near future.

State Energy Emergency Preparedness Planning

For those citizens who waited in the long gasoline lines of the early '70s, the oil crisis is still a vivid memory. The petroleum shortage disrupted both the lives of Hawaii's people and the economy of the islands. Government administrators faced proposed national oil restrictions which could have had a disastrous effect on the State's major industry, tourism. As rapidly rising petroleum prices drove up the cost of living, low-income families often had to request governmental assistance to meet energy-related expenses. Other citizens had to reallocate their budgets to meet the increasing energy costs.

In order to deal with similar crises in the future, the State has developed an overall energy emergency program to prevent damage to Hawaii's economy and threats to the health and safety of its citizens and visitors. The Energy Division has been charged with the responsibility of implementing the Energy Emergency Plan. The program seeks to ensure that, in the event of an energy shortage, essential public services are maintained and that economic and personal hardships are alleviated as much as possible.

Public Utilities Commission Energy Planning

The Public Utilities Commission (PUC) has the responsibility of reviewing requests from the utilities for new or expanded equipment and changes in rate charges and to rule whether the requested changes are justified. Their decisions, then, have a definite effect on the kinds of power resources to be used in areas served by utilities as well as on the cost of the power to the consumer. The kinds of power resources chosen affect the development of alternative energy sources; the price of power provides incentives or disincentives to conservation practices.

In recent years, many public regulatory agencies throughout the nation have investigated the subject of Integrated Resources Planning (IRP). IRP provides a wide-spectrum view of supply-side/demand-side energy planning, with particular emphasis on consideration of available options. Although Hawaii's utilities, because of the State's physical insularity, may not have the same range of opportunities as those on the Mainland to implement various demand-side and supply-side options, the potential benefits of IRP to Hawaii are considered sufficient to continue investigation of this kind of energy planning.

Recognizing the importance of PUC decisions upon alternate energy commercialization and consumer costs, Governor John Waihee in July 1987 requested the PUC to undertake a study of the IRP as it would apply to Hawaii.

In March, 1988, a request for proposals was announced by the PUC for a study to investigate the nature of long-term energy planning by Hawaii's electric utilities. Also to be considered in this study are the effectiveness of each electric utility's existing planning and review process in accomplishing the objectives of planning and promoting the State's energy goals, and the feasibility of developing and implementing an IRP by each electric utility. Replies received in answer to the request for proposals were reviewed by the PUC staff; a contract for the study will be awarded in the fall of 1988.

INTERNATIONAL RENEWABLE ENERGY CONFERENCE

In the spring of 1987, the State Legislature in House Concurrent Resolution (HCR 222), requested the Director of DBED to sponsor a conference on renewable energy systems. Hawaii's leadership in the development of renewable sources of energy and the State's efforts to become the Pacific center for research and development, manufacturing, and marketing of renewable energy technologies made taking action on this resolution an exciting challenge.

Plans were made to conduct the International Renewable Energy Conference (IREC) in September 1988, in conjunction with Windpower '88, the 18th National Conference of the American Wind Energy Association. Co-sponsorship was obtained from the following public and private agencies and organizations:

State of Hawaii, DBED
Alternative Sources of Energy (Conference Magazine)
City and County of Honolulu
Energy Resources International
Hawaiian Electric Company, Inc.
Interstate Solar Coordination Council
National Association of State Energy Officials
National Research Council of Thailand
Ormat Energy Systems, Inc.
Pacific International Center for High Technology Research
Solar Energy Research Institute
The East-West Center
Thermal Power, Inc.
United Airlines
University of Hawaii
U.S. Department of Commerce
U.S. Department of Energy
U.S. Export Council for Renewable Energy
U.S. Overseas Private Investment Corporation
U.S. Trade and Development Program
World Resources Institute

Support from these co-sponsors, as well as the use of Oil Overcharge Funds to finance the conference, will permit IREC to be conducted at no expense to the Hawaii State taxpayer.

The theme chosen for IREC is: "Developing Indigenous Energy Resources: The Path to Economic Security and Growth." The conference will cover all aspects of renewable forms of energy, including the application of energy technologies

related to wind, biomass, solar thermal, photovoltaic, geothermal, ocean thermal, and hydroelectric power.

IREC's primary purpose is to promote and advance the fullest development of renewable energy resources and technologies in Hawaii and throughout the Asia/Pacific region by expanding commercialization and trade in renewables. IREC's specific objectives are: (1) to provide an overview of the status of worldwide accomplishments and opportunities for renewable energy development; (2) to provide a one-stop look at applications of Hawaii's unique aggregation of renewable resources; and (3) to facilitate the transfer of renewable energy technology among participating nations. There will be a renewable energy technologies exhibition, conference sessions on the major technologies, special subject adjunct sessions, and field trips to the major renewable energy project sites on both Oahu and the Island of Hawaii.

Combined IREC/Windpower '88 attendance is expected to reach 500, with delegates from more than 30 countries and all regions of the United States. Approximately one-third will be international participants. Delegates will include high-level government energy planners, utility executives and technicians, and world-renowned energy scientists and engineers.

The ERC shall ... develop programs to encourage private and public exploration and research of alternative energy resources ...

ALTERNATIVE ENERGY DEVELOPMENT

Alternative energy development is critical to the displacement of oil as the primary energy source for Hawaii. In order to facilitate oil displacement, Hawaii's abundant resources of indigenous, non-fossil energy such as geothermal, wind, biomass, hydroelectric, ocean thermal, solar thermal, photovoltaic power and other forms of solar energy should be developed and commercialized. The positive actions which must be taken in order to utilize Hawaii's indigenous energy resources more fully include: (1) providing financial and regulatory incentives to facilitate development; (2) making the development process less costly and time-consuming; (3) finding means of storing intermittent energy so that firm power can be supplied from intermittent sources; (4) assessing and mitigating possible environmental impacts; and (5) providing technically and economically feasible means of transporting energy from one island of the State to another.

Efforts to find replacements for oil include the use of other forms of energy which are not indigenous resources but may be more plentiful or cheaper than oil. Coal, for example, is abundantly available in the world and with present technology can be used to generate electricity economically and in an environmentally beneficial manner.

Finding replacements for gasoline and other petroleum-based transportation fuels is a more difficult problem. Research in producing ethanol and methanol

from indigenous sources, as well as developing transportation modes utilizing these fuels and/or electricity must be encouraged. Basic research into the production and use of hydrogen, storage of electricity or other forms of energy generated from intermittent sources, and the commercial development of laboratory phenomena such as superconductors are examples of energy-related technologies which need continued support by both government and private sectors.

Highlights of the advances made in the development of alternative energy in Hawaii during FY 87/88 are described in the following pages. These achievements are the result of private industry and government agencies working together to secure the energy future of our Island State.

As a preview of work to be carried out in FY 88/89, the 1988 State Legislature allocated funds for development of a wind energy system on Maui, plans for a Hawaii Pacific Center for Renewable Energy, and a cooperative energy research program with the People's Republic of China.

ALTERNATIVE ENERGY DEVELOPMENT

STATE FUNDED COMMERCIAL DEMONSTRATION PROJECTS IN ALTERNATIVE ENERGY

A total of $1.3 million in State funds appropriated to implement alternative energy demonstration and commercialization were committed during FY 87/88. The twelve projects funded were:

- Scientific Observation Hole for Geothermal Resource Development on Maui.
- Alternative Energy Development at the Kailua Municipal Wastewater Treatment Plant
- A Pumped-Hydro Facility at the HNEI/Kahua Wind Energy Storage Test Facility
- A Utility-Intertied 9.2 kW Photovoltaic System for Maui
- A Demonstration OTEC Power Plant at NELH
- A Small Hydroelectric Plant on Molokai
- Geothermal Abatement by Noncondensible Gas Absorption
- A Process Development Unit for Producing Charcoal from Hawaiian Biomass
- Solar Air Conditioning and Dehumidification as Applied to a Representative State Office Building
- A Wind-powered 1,500 kW Hydrogen Fuel Cell
- A Firm-power Demonstration of a Wind-Diesel Hybrid System for Pumping Water for Maui County
- Lighting for Remote Bus Stops Using a Photovoltaic System

Three other projects were selected for funding under a $300,000 allocation authorized by the 1988 State Legislature. They are:

- Wind energy system on Maui
- Plans for a Hawaii Pacific Center for Renewable Energy
- A cooperative energy research program with the People's Republic of China.

GEOTHERMAL POWER

In Hawaii, the nation's multi-island state created by past and present volcanic activity, geothermal power offers the greatest near-term source of new base-load electric power - - estimated conservatively at 600 megawatts (MW) capacity annually for the coming century. During FY 87/88, the HGP-A geothermal plant in Puna produced 14.8 million kWh of power which was sold to the Hawaii Electric Light Company (HELCO) for use by electric customers on the Island of Hawaii. An extensive maintenance overhaul of the HGP-A power plant was completed, extending the service life of the plant for another three to five years.

Geothermal Power Development

In 1988, Ormat Energy Systems, Inc. purchased Puna Geothermal Venture (PGV) from Thermal Power Company and Amfac, Inc. Ormat assumed an existing power purchase agreement between PGV and HELCO to deliver 25 MW of power to the HELCO grid beginning in 1989.

True/MidPacific Geothermal Venture, together with the Estate of James Campbell, continued preparations for geothermal drilling in the Kilauea Middle East Rift Zone on the Island of Hawaii. The necessary permits to explore for 100 MW of geothermal power are being obtained.

DBED awarded a contract to MCM Planning, Inc. for an environmental assessment of the development of 600 MW (gross) of geothermal power in the Kilauea East Rift Zone.

In 1987, DBED awarded a contract to the Hawaii Natural Energy Institute (HNEI) at the University of Hawaii at Manoa (UHM) to site and drill a scientific observation hole to the depth of approximately 2,000 feet to test the geothermal

potential of a site on State-owned land within the Haleakala Southwest Rift Geothermal Resources Subzone on Maui. Commercial interest in the development of geothermal power has been expressed, providing the resource is proven. A viable geothermal resource on Maui could make the island much more energy self-sufficient. A three-island undersea cable system linking Maui, Molokai and Lanai could also supply the two smaller islands with geothermally produced electricity.

During 1988, DBED awarded a contract to investigate the feasibility of reinjecting non-condensible gases such as H_2S into the geothermal reservoir as a primary means of air emissions abatement. This method is thought to be less expensive, easier to operate, and more environmentally benign than the usual surface mechanical abatement system.

The HGP-A monitoring program, dealing with air quality, fluid monitoring and general plant operations assessment continued during FY 87/88. The primary purposes of the monitoring program are the continued successful operation of the power plant and demonstration of continued technical and economic feasibility of electric power generation from the geothermal resource. The monitoring program showed that the environmental impact of the generator facilities is minimal under present approved operation and maintenance procedures. During the year, new steam measuring equipment was installed, and the use of a weir box arrangement to measure plant brine flow in order to determine reservoir characteristics was inaugurated.

A project on the use and field testing of fiber optics sensors for monitoring geothermal fluids was initiated by HNEI, utilizing research performed at the Lawrence Livermore National Laboratory and the University of Hawaii (UH).

Puna Research Center

The Puna Research Center, Noi'i O Puna, managed by the Natural Energy Laboratory of Hawaii (NELH) is designed to demonstrate commercial uses of the geothermal resource. Five direct-use, non-electric geothermal projects funded by the Community Geothermal Technology Program (CGTP) located at Noi'i O Puna were completed at the end of FY 87/88. These projects demonstrated that geothermal heat and by-products can be used to dry fruits, season wood, dye cloth, heat greenhouses, and make glass. Five new projects were initiated in the Spring of 1988 under the CGTP. They include small-scale geothermal-enhanced aquaculture, bottom heating of plants, use of geothermal silica as a refractory material for bronze art work, electrodeposition of minerals, and pasteurization of coconut husks for use as a growing media. This program is administered jointly by DBED and HNEI with funding from the U.S. Department of Energy (U.S. DOE), County of Hawaii, and private donations. Another project sponsored by NELH at the Center is the demonstration of a geothermal spa.

Expansion and upgrading of Noi'i O Puna was begun in 1988 to provide more research facilities and resources. Owners of surrounding lands are being contacted to identify commercial sites for some of the direct-use applications. These direct-use applications increase the economic feasibility of geothermal power through the added value of by-products. They also contribute to increased public awareness of the benefits of geothermal power to residents of nearby communities.

Legislation For Geothermal Development

In 1988, the Hawaii State Legislature appropriated $3 million to fund a geothermal resource exploration and development program. The program will be

administered by DBED. The Legislature passed SB 3182-88, which was signed into law as Act 301-88. This Act provided legislative support for the commercial development of the undersea cable/geothermal system by authorizing the consolidation of permitting procedures for geothermal and cable transmission projects, assigning overall responsibility to the State Department of Land and Natural Resources (DLNR). Also signed was Act 378-88 which grants the surface owner of land the first right of refusal for a mining lease where the Board of Land and Natural Resources (BLNR) has determined it appropriate to grant a geothermal lease on reserved lands. Geothermal development activities on the land within the mining lease are prohibited until the area is designated a geothermal resource subzone.

Act 246-88 applies to geothermal as well as other alternative energy resources. It authorizes the PUC under certain conditions to allow payments made by the utility to non-fossil fuel producers of firm capacity to be recovered through an interim increase in rates.

Geothermal Public Information

Public information meetings, seminars, facility tours, newspaper items and classroom presentations provided outreach information to the general public on geothermal activities. The Hawaii Island Energy Extension Service (EES) made a presentation on "Direct Uses of Geothermal Energy" to 100 teachers attending a workshop on "Energy in the 80s." Displays were prepared and shown at the Hawaii County Fair and at other events. An open house tour of Noi'i O Puna in October, featuring CGTP grantees and their projects, attracted 400 persons. Other tours were provided for government officials and agency personnel. A public forum presentation on geothermal energy was given at the University of Hawaii at Hilo (UHH).

Assistance was given by the Maui County EES staff to scientists preparing a proposal for the assessment of geothermal resources within the geothermal resources subzone on Haleakala.

The State Department of Health (DOH) held a public hearing on underground injection control in May 1988.

HELCO held public information meetings to obtain input from Hawaii Island residents and government agencies concerning route planning for two 69-kv transmission lines connecting Ormat's proposed 25 MW geothermal plant and HELCO's grid. In November 1987, a report was completed which identified two preferred corridors for the transmission lines. Information on the proposed routes and other geothermal activities appeared in the utility's flyer, "Consumer Lines" which is distributed each month with customers' bills.

INTER-ISLAND DEEP WATER CABLE

An inter-island electric transmission cable between the islands of Hawaii, Maui and Oahu is considered essential if electricity generated from alternative energy resources is to be transmitted from the relatively low-demand, high-supply Neighbor Islands to the high-demand, low-supply Island of Oahu. Oahu has 77 percent of the State's population and about 80 percent of the electricity demand. Oahu is more than 97 percent dependent upon petroleum for its electricity at present, with no large-scale indigenous alternatives apparent in the near term. A combined overland and undersea cable system from the proven geothermal resource on the Island of Hawaii to Oahu, could transport 500 MW of power to Oahu, supplying half of Oahu's total electrical needs. An inter-island supply grid would also furnish backup power in case of major power emergencies on other islands.

To date the State has contributed $5 million and the Federal government will contribute more than $22 million to the Hawaii Deep Water Cable (HDWC) project. HDWC has demonstrated considerable success in determining the technical feasibility of installing and operating a submarine power cable transmission system between Hawaii, Maui and Oahu.

Ocean bottom surveys using sophisticated sonar technologies and unmanned submarine surveillance resulted in selection of a "preferred" cable route between Hawaii, Maui and Oahu. During 1987, 6,000 feet of cable was fabricated in Milan, Italy for mechanical and electrical testing. A contract for a cable-laying vessel has been signed. A "surrogate" non-electrical cable, with dynamic characteristics of the selected cable design but slightly smaller in size, has been designed for at-sea testing and the Federal government has issued a notice to proceed with the at-sea test. The objective of the at-sea test is to determine the technical feasibility of deploying and retrieving a submarine power cable with required accuracy and proper cable tensions along a predetermined path within the deep channel. These studies indicate positive cable survival for its 30-year design life.

In August, 1987, Governor John Waihee appointed the Governor's Advisory Board on the Geothermal/Cable project, a blue-ribbon group representing State and County governments, private industry and labor unions, under the chairmanship of former governor William F. Quinn. The Cable Advisory Board oversees the planning of the combined geothermal/cable project to determine the feasibility of the project and the appropriate role of the State in the project. The Board held several meetings with international cable company officials, utility officials and financial advisors during the year. The technical feasibility of the proposed cable system was supported strongly in these meetings.

A report was commissioned by DBED and prepared by Decision Analysts, Hawaii, Inc. to evaluate the economic feasibility of the proposed cable/geothermal power system. The report, published in February 1988, provided a favorable view of the combined projects.

OCEAN THERMAL ENERGY CONVERSION

Next to geothermal power, ocean thermal energy conversion (OTEC) offers the greatest potential for base-load, firm power for generating electricity. The technology has been proven with the at-sea testing on board the barge Mini-OTEC in 1979. Extensive testing of component parts including heat exchangers has been carried out both on the converted Navy tanker, OTEC-1, and in the laboratories at NELH. The major deterrent to commercialization has been economic -- the temporary low cost of oil has made OTEC-produced electricity non-competitive at present.

In the past 20 years, Hawaii made significant contributions to OTEC research, development and demonstration and continues to be a worldwide leader in the field. During FY 87/88, several major projects have been initiated which will significantly advance the development of commercialized OTEC power for Hawaii and the Pacific Rim countries. A valuable by-product of one form of OTEC is the production of fresh water, a badly needed resource for many island nations and communities. The NELH Kona Seacoast Facility on the Island of Hawaii is

considered the world's foremost testing facility for OTEC and OTEC-related activities. It remains unique in its ability to supply large flows of cold, nutrient-rich seawater from 2,000 foot depths at 6° Centigrade (C) and warm, surface seawater at 26° C.

OTEC Technology

The ocean thermal energy process is based upon the temperature differences between the sun-warmed surface water and the very cold waters in the ocean depths. Hawaii and many of the other Pacific Ocean archipelagos are well-suited for OTEC facilities because surface waters are warm the year-round and ocean depths exceeding 2,000 ft are often found within a mile of the shore, facilitating the use of both warm and cold water sources for OTEC systems.

There are three forms of OTEC systems: closed-cycle, open-cycle, and hybrid. In the closed-cycle system, warm water from the ocean surface is pumped through a heat exchanger to evaporate a volatile fluid, such as ammonia, which vaporizes at a relatively low temperature. The vaporized fluid drives a turbine to generate electricity. After passing through the turbine, the vapor is condensed in a second heat exchanger by using the cold water brought up from ocean depths and the process repeats.

The open-cycle OTEC system is based on the same technology, except that warm surface water is used as the working fluid and evaporated under a partial vacuum. The resulting vapor is used to drive a turbine and then is condensed back into liquid form. Some of the condensate can be brought out of the system as fresh water.

The third system, hybrid OTEC, combines open- and closed-cycle technologies with the advantages of providing fresh water as a by-product and

using smaller-sized components. This approach utilizes equipment which, to a large extent, is already developed and proven.

Each of these three systems utilizes valuable nutrient-rich and almost pathogen-free cold water which can subsequently be used for aquacultural and cold water agricultural purposes. Among the aquacultural uses which have been successfully demonstrated at NELH are abalone, nori, fish, lobsters, giant clams, opihi, kelp, strawberries, micro-algae and health food products. Some of these experimental products have been developed commercially and developers have initiated plans to expand their projects in the Hawaii Ocean Science and Technology (HOST) Park located next to NELH.

OTEC Demonstration Projects

During 1987/88, 18 OTEC demonstration projects, many continued from prior years, were conducted at NELH. Experiments in heat exchange, bio-fouling, and corrosion confirmed that substantial savings in commercial OTEC plants can be made. The U.S. DOE's Solar Energy Research Institute (SERI) with the Argonne National Laboratory (ANL) and Alcan International, Ltd. continued their OTEC research at NELH throughout the year. Both groups are planning to construct small demonstration-scale OTEC power plants at NELH.

Closed-Cycle OTEC Demonstration

In 1987, negotiations were initiated between the State and Marine Development Associates, Inc. for the conceptual design and feasibility study of a 200-kW closed-cycle demonstration OTEC plant to be built onshore at NELH using warm and cold seawater provided by existing piping systems. Phase I of the project calls for the conceptual design and feasibility study of a 200-kW,

continuously operating, closed-cycle OTEC plant. Electricity generated by the demonstration plant can be used at NELH. If the concept proves attractive, a facility called "Demi-OTEC" will be designed and constructed in Phase II with test and demonstration operations carried out later in Phase III.

Open-Cycle OTEC Demonstration

Funding was provided by the U.S. DOE through SERI, ANL, and Pacific International Center for High Technology (PICHTR) to bring together a system design team to develop a 165-kW open-cycle OTEC power plant at NELH and to resolve the issues related to the development of a commercial-size plant of at least 2.5 MW. The open-cycle system design will make provision for fresh water production. The design tasks include evaluation of existing turbine designs, research on the release of non-condensible gases from seawater during the OTEC process, risk analysis of options for constructing and installing a 10 to 17 foot diameter cold-water piping system, construction and evaluation of a direct-contact condenser vessel, and thermo-economic models for the production of power and fresh water. Work on this project began in January, 1988.

NELH Upgrade

During the past year, several important OTEC projects have been initiated through the cooperative efforts of PICHTR, NELH, Hawaiian Electric Company (HECO), U.S. DOE, and the State of Hawaii. Among these is the construction and monitoring of the upgrade project for the Seacoast Test Facility of NELH at Keahole. Installation of two new cold-water pipelines was completed during the year. A 40-inch diameter cold-water pipeline was installed by the State's High Technology Development Corporation (HTDC) and the U.S. DOE. NELH also installed

an 18-inch diameter pipeline with State funds. Also completed were a conduit for discharging mixed cold and warm seawater from the experimental area to a discharge structure and associated pumping and control equipment.

A DBED-funded capital improvement for NELH utilizes cold seawater as part of the air conditioning system for the laboratory building,saving nearly $5,000 per year in electricity costs. The project is one of Hawaii's entries in the U.S. DOE National Awards Program for Energy Innovation.

Commercial Aquaculture Production Underway

NELH is the site of numerous projects to commercialize aquaculture using the cold, nutrient-rich, almost pathogen-free deep seawater as an adjunct to OTEC use of the cold water. Hawaiian Abalone Farms, after several years of research at NELH, is raising and selling abalone to local hotels. Cyanotech Corporation has begun to sell high-value micro-algae produced from the cold seawater at NELH. Royal Hawaiian Sea Farms and Aquaculture Enterprises began large-scale demonstration projects in nori seaweed and cold-water lobster production at NELH during the year.

Other projects have successfully cultivated salmon, flounder, oysters, clams, opihi and kelp. Agricultural projects which use the cool water pipes to lower soil temperature have cultivated strawberries, lettuce and flowers. One agricultural project uses the water that condenses on the outside of the pipes as a form of drip irrigation.

Other OTEC Research

Related OTEC projects continued in FY 87/88 were investigations in fluid dynamics, mass transfer in spout evaporation, and the mist-lift process.

A combined project of PICHTR and the Sanki Corporation, initiated in FY 87/88, is a technology transfer partnership which has produced ten potential cooperative projects between Japan and Hawaii. These projects combine business counseling and state-of-the-art energy and water development projects with international partners. The major emphasis of this program is arranging for technology transfer agreements between PICHTR and Asian organizations, focusing on technologies relatively close to commercialization and having the potential to address energy and water resource problems in the near future. Several projects were developed during the year, including monitoring of the Japanese Ministry of International Trade and Industry's (MITI) new programs in open-cycle OTEC, marine biotechnology and ocean mining with potential joint research or liaison work for PICHTR.

SOLAR ENERGY

Direct solar energy is obtained by collecting and/or focusing the sun's rays onto a collector device. There are three major categories of direct solar energy: solar thermal energy, which uses the sun's rays (insolation) as a source of heat; solar thermal energy conversion, which harnesses the sun's rays to produce process heat and/or steam for electric generation; and photovoltaic (PV) conversion, which produces an electric current directly from the effect of sunlight upon solar cells. Both solar thermal and PV systems are well suited to Hawaii which has high insolation the year around, a mild climate, and high energy costs.

Solar Thermal Power

The best known and presently most cost-effective use of solar thermal energy in Hawaii is in the form of solar water heaters. These rooftop water heaters serve approximately 50,000 residential and institutional units in the State. Heating water is the largest use of residential electricity in Hawaii and the electricity saved from the use of solar panels to heat water results in savings of about 160 million kWh per year -- the equivalent of approximately 349,000 barrels of oil per year. A 15 percent State tax credit for the purchase and installation of solar water heaters is still in effect, but elimination of the 40 percent Federal tax credit has seriously curtailed installation of new units.

The State has allotted $50,000 for plans, design, construction, and equipment for a solar-powered water desalination demonstration project at NELH. The system, as conceptualized, will operate on solar thermal power and will be capable of producing 1,000 gallons of fresh water per day. Following completion and testing, the system may be relocated to the small fishing village of Milolii, Hawaii, to provide an on-site fresh water supply for the Hawaiian community residing in the village.

DBED awarded a grant in FY 87/88 for a project to demonstrate solar-assisted dehumidification and air conditioning in a State office building. The principal component of the system is a desiccant wheel, which removes moisture from the incoming air. The technology is one which SERI regards as one of the most promising types of solar air conditioning available today. The proposed project will serve as a test for the hardware involved in the technology, providing a baseline for the commercialization of desiccant air conditioning in Hawaii and the Pacific Basin. Solar-assisted dehumidification and air

conditioning will be compared to a heat-pipe-assisted system and to a conventional air conditioning system.

Photovoltaic Power

Photovoltaic systems can be used to power direct-current (DC) appliances and other devices or can be converted to alternating current (AC) for use in AC equipment or for distribution through a utility grid.

Historically, the earliest PV projects reported in Hawaii were a private home built in 1971 using PV power for appliances and a remote weather station which began operating in 1977 at South Point, Hawaii. Other applications include navigational aids, stand-alone lighting systems and seismic sensors. A large PV demonstration project was dedicated in 1981 at the G.N. Wilcox Memorial Hospital in Kauai and operated there until 1983. The system was moved to the Pacific Missile Range Test Facility at Barking Sands, Kauai, where it is used to furnish hot water for a 64-person barracks and a cafeteria. The Navy is evaluating the feasibility of design modifications which will increase the output of hot water.

State-funded demonstration projects include a lighting system installed at the Maunalua Bay boat ramp on Oahu, in which PV-powered low-pressure sodium lamps light an area where utility lines are not readily available. A 128-panel PV installation at the Hawaii Institute of Marine Biology on Coconut Island, Oahu, furnishes electricity for the laboratory section of the facility.

During FY 87/88 plans were initiated for a 9.2 kW utility-scale PV-power system in Maui. DBED has provided $142,500 in funding for this project and Maui Electric Company (MECO) has expressed interest in further research and development for the project. The system may be expanded to 20 kW and be included

as an auxiliary part of the Photovoltaics for Utility Scale Applications (PVUSA) program of the U.S. DOE and Pacific Gas and Electric Company.

In FY 87/88, DBED funded, under a program administered by the U.S. DOE, a conceptual design study of renewable energy systems to be demonstrated at NELH. A solar-powered cogeneration system which would provide refrigeration, air conditioning, process heat, fresh water and electricity, was selected for detailed design. Under the same program, DBED funded a project to produce solar-dried fish jerky.

DBED provided partial funding for a large-scale stand-alone residential PV system for a home in Manoa Valley on Oahu. The home combines PV power for AC and DC appliances, a solar heater provides hot-water and a standby generator provides backup power for a residence that can operate totally independent of the utility grid. Throughout the State, an estimated 500 homes have installed PV systems to operate home lighting and appliances, especially in isolated areas where utility power is not readily available.

DBED also provided funding for a project to provide PV-powered lighting at ten remote bus stops on Oahu. The project will design, install and monitor PV lighting systems at selected City and County of Honolulu bus stops. Each system will consist of a PV panel to collect sunlight and convert it to electricity, a deep-cycle battery to store the electricity, a light, and a controller to turn the light on at night and off during the day.

The State Legislature passed Act 142-88 which authorizes the issuance of special purpose revenue bonds to assist either Energy Conversion Devices, Inc. or Chronar Corporation in the generation of new capital for the manufacture of amorphous silicon alloy PV products or equipment in Hawaii. The Act requires DBED, with the assistance of HNEI, to perform technical and economic analyses

of the two candidate companies and to recommend one of them to be assisted by the bonds.

Photovoltaic-Powered Cars

PV power has now been demonstrated successfully as a fuel for automobiles. The photovoltaic- and wind-powered car, "Mana La," was developed in Hawaii with private funding from the John Paul Mitchell Systems which sponsors and invests in environmental and alternative energy projects.

The "Mana La" is an experimental ultra-light car with unique features. It has an arched wing configuration holding a 125-square foot solar cell array. The vertical sections are computer-designed, low-speed airfoils which increase the speed of the car. According to its developer, Mana La has been driven at 85 miles an hour in favorable winds. Direct current from the solar cell array charge batteries which provide electricity for the motor.

The "Mana La" competed in the World Solar Challenge, a long-distance endurance race for photovoltaic-powered cars, which was held in Australia in November 1988. The experimental car was featured in a National Geographic documentary and will be one of Hawaii's entries in the annual U.S. DOE National Awards Program for Energy Innovation.

DBED has funded a State Department of Education pilot program for three schools, one each on Oahu, Hawaii and Maui, which will provide intermediate and high school students and teachers an opportunity to design, construct, and demonstrate operational PV-powered vehicles during the 1988/89 school year.

BIOMASS

Biomass is the second largest source of energy for Hawaii, providing more than seven percent of the State's total energy demand. It is an important energy resource for the State, not only as a replacement for petroleum in the generation of process steam and electricity but also a potential replacement for petroleum-based transportation fuels. Because transportation fuels comprise 58 percent of the State's total energy demand, biomass will continue to have major significance in Hawaii's energy future.

Biomass for Electricity

Biomass has been an important source of energy for process steam and electricity in Hawaii sugar mills for many years. Bagasse, the fibrous residue of sugarcane stalks and leaves, is dried and burned in sugar mill power plants to produce steam and electricity. Electricity in excess of the companies' needs is transmitted and sold to local utilities. In recent years, several mills have contracted with utilities to provide a set amount of electricity each year. Oil, woodchips, and coal are used as supplemental fuels when bagasse supplies are insufficient to produce the contracted-for electricity.

In FY 87/88, more than 605 million kWh of biomass-produced electricity was purchased by the State's utilities, accounting for approximately seven percent of the State's total supply of electricity. On Hawaii, HELCO purchased 258.8 million kWh from Puna Biomass Power, Hilo Coast Processing Company and the Hamakua Sugar Company. On Maui, MECO bought over 110 million kWh from Pioneer Mill and Hawaiian Commercial & Sugar Company. On Oahu, HECO purchased over 47 million kWh of biomass power from the Waialua Sugar Company and Oahu Sugar

Company. On Kauai, 33 percent of the total electric output came from biomass, from the island's sugar companies.

The use of woodchips as a supplement to bagasse has increased in the past decade. Extensive research into the cultivation of trees and plants which provide a quick-rotation crop of biomass is ongoing in several projects. The Bio-Energy Development Corporation and the U.S. DOE continued a ten-year program of species selection, cultivation and harvesting with the goal of providing a short rotation crop of biomass for energy on the Island of Hawaii.

A multi-year planting project initiated in five locations on four islands by the Hawaiian Sugar Planters' Association (HSPA) under joint funding with DBED was continued. Participating in this program in addition to DBED are the State Department of Land and Natural Resources (DLNR), the UH College of Agriculture and Human Resources, and HNEI. The Federal government is contributing through the U.S. Department of Agriculture, Forest Service and Conservation Service. Selected sugar plantations are providing land, equipment, irrigation where required, and staff services. This program exemplifies cooperative efforts by State and Federal government agencies, UHM, and the private sector in the development of alternate energy resources.

Commercial companies on Hawaii, Kauai and Molokai have been given permits to harvest and chip trees for use as fuel for generating electricity. Molokai Electric Company received permission from the PUC to purchase electric power from Onsite Energy Company which plans to produce electricity by burning chipped kiawe wood for fuel.

The Renewable Resources Research Laboratory (R^3L) at UHM initiated a project for the fabrication and testing of a process development unit which will produce high yields of charcoal from bagasse, wood chips and other biomass

materials. The laboratory unit will evaluate and verify laboratory test results of a UH invention which demonstrated very high yields of charcoal from biomass. The project will provide the knowledge and experience necessary for the development of commercial units for the production of high-energy fuel for local consumption and export.

Other biomass projects funded by the State were the design of a high-efficiency biomass harvesting machine and the expansion of petroleum products quality assurance testing to include biomass-derived fuel additives and blends.

Municipal solid waste (MSW) is another form of biomass that can be used as a substitute for oil to generate process steam and electricity. Work was resumed on H-POWER, the City and County of Honolulu's solid-waste-to-energy project which had been delayed due to environmental equipment requirements. The plant will be operated under a contract with Amfac Energy Division and Combustion Engineering at Campbell Industrial Park on Oahu. The plant is designed to process about 600,000 tons of refuse annually with some substances removed for recycling. The waste will be converted into fuel which will be burned to produce steam for a 50-MW turbogenerator capable of generating as much as 300 million kWh of electricity per year. The electricity will be sold to HECO for distribution on Oahu. This use of Oahu's MSW as a fuel source will reduce the State's dependence on oil by an estimated 500,000 barrels annually, as well as tripling the life of existing landfills.

DBED funded a County of Maui study to identify and compare specific alternative solid waste disposal systems for West Maui.

The County governments of Hawaii and Kauai have already studied the potential use of MSW as a source of electricity, but reports have indicated that the process is not cost-effective for these islands at present.

Biomass for Liquid Fuels

Biomass as a source of liquid fuels offers promise for reducing Hawaii's need for transportation fuels which comprise 58 percent of the State's total energy demand. The use of molasses as a feedstock for ethanol has been studied extensively. In 1985, Pacific Ethanol Products, Inc., completed a $3 million ethanol production plant at Campbell Industrial Park on Oahu. This facility, using molasses as feedstock, had an annual production capacity of two million gallons of fuel-grade ethanol per year. The ethanol was intended for use in an ethanol-gasoline blend; however, lower prices of gasoline and technical problems made the fuel difficult to market profitably and production at the plant has stopped.

At HNEI, the Hawaii Integrated Biofuels Research Program, initiated in December 1987 is a partnership of the UH, the sugar industry and the Federal and State governments. The goal of the program is to develop biomass-based transportation fuels to replace gasoline, diesel, and jet fuel. Biomass energy crops being studied include sugarcane, eucalyptus and various nitrogen-fixing trees. Funding for a methanol-from-biomass pilot plant has been appropriated by the State of Hawaii, contingent upon cost-shared funds from the U.S. DOE and a consortium of private industry and foreign nations.

Methanol can be used as a fuel for automotive vehicles. DBED, under a program administered by the U.S. DOE, assisted HNEI with funding for experimental testing of seven internal combustion engine vehicles fueled with either neat (100 percent) methanol or M-85 (85 percent methanol/15 percent regular unleaded gasoline). Two methanol-fueled range-extender demonstration electric vehicles will also be tested. In addition to performance evaluation, the project will help provide information on environmental and marketing considerations.

During the year, R^3L continued active research into the processes of converting biomass to liquid and gaseous fuels, focusing on means of obtaining more effective use of bagasse, wood and molasses in producing liquid fuels.

The State Legislature supported research on alternative liquid fuels in passing HB 2042-88 (Act 116-88) appropriating $3 million in matching funds for a sugar research program conducted by HSPA. Also passed was HB 2068-88 (Act 311-88) appropriating $220,000 in matching funds to the UH for a methanol-from-biomass research pilot plant feasibility study by HNEI. An appropriation of $2 million was made to the UH for plans and construction of a methanol-from-biomass research pilot plant.

HCR 82-88 requested DBED to study the use of alcohol fuel as an alternative energy source and to address related issues including the feasibility of requiring the use of ethanol-blended fuel in all state-owned vehicles. HCR 85-88 requested DBED, with the assistance of HSPA, the Department of Agriculture, and the UH College of Tropical Agriculture and Human Resources, to continue research into the use of biomass to produce electricity, the development of new energy systems and sources to replace petroleum fuels and the production of high value, co-product chemicals. HCR 23-88 requested DBED to identify the needs of Pacific Rim countries with regard to renewable energy needs and systems.

Biomass for Gaseous Fuels

Biomass in the form of wastes is also utilized in Hawaii as a source of combustible gases -- primarily methane, the main constituent of natural gas. During the year, several private ventures continued work on systems that produce biogas from animal and other wastes. The methane gas from these systems fuels generators which produce electricity for on-site use. Universal Synergistics

(UNISYN) in Waimanalo, Oahu, completed an integrated system for producing a high grade biogas with a methane concentration of more than 70 percent, from cow and chicken manure. It installed a system for generating 750 kW of electricity at its Waimanalo facility using a fuel mixture of 90 percent biogas and 10 percent diesel oil. A hog farm on Maui and one on Kauai continued DBED-funded operation of methane collection systems using animal wastes as the source.

Kapaa Energy Partners (KEP) was awarded a contract by the City and County of Honolulu and began work on a landfill gas recovery and utilization system at the Kapaa Valley landfill near Kailua, Oahu. More than 30 of the projected 42 methane wells had been dug by the end of FY 87/88.

DBED funded a study conducted by HSPA to demonstrate the technical and economic feasibility of producing methane gas through anaerobic treatment of waste water from sugar mills. The State also funded a project by the Board of Water Supply, City and County of Honolulu in which the Kailua Municipal Wastewater Treatment plant is being equipped to generate electricity from digester gas. If successful, the demonstration of a cost-effective digester gas utilization system at the Kailua plant will encourage implementation of similar equipment at other wastewater treatment facilities.

HYDROPOWER

Hydropower has been used to produce electricity commercially in Hawaii for many decades. A hydroelectric plant installed at the Kekaha Sugar Company in 1908 is still in operation. Today, 20 hydropower plants provide a significant portion of the electricity produced on the Neighbor Islands. See Appendix B, Table 29.

Kauai has seven installations which provide 8.57 MW of generating capacity. In 1987, they produced about 55,800 megawatt hours of electricity for Kauai or 16.2 percent of the island's electricity needs.

Hawaii Island has nine hydro facilities ranging in size from the 1.5 MW HELCO Wailuku station to the tiny 7 kW plant shared by two households in Hilo. These facilities produce about 23,500 megawatt hours annually or about four percent of the island's demand.

Maui's four hydro plants, all owned by sugar companies, have an aggregate capacity of 6.3 MW, producing about 25,100 megawatt hours annually or 3.6 percent of Maui's demand.

During the past year, DBED and County agencies assisted several energy developers with the financing and permitting processes for the construction of new hydro plants in Hawaii, Kauai and Maui totalling 48 MW. If developed, these plants would almost triple the State's present hydroelectric capacity. Mauna Kea Power, Inc. has plans for a 14.6 MW hydro facility on the Honolii Stream on Hawaii. The Kahala Energy Development Corporation initiated plans for a 9 MW plant on the Wailuku Stream also on Hawaii. Bonneville Pacific Corporation is planning a 2.7 MW plant on the Wailua Iki Stream on Maui, and a 6.6 MW plant and a 1.3 MW facility on the Wailua and Upper Wailua Streams respectively in Kauai. McBryde Sugar Company continued work on plans for a 3.8 MW hydro plant in the Upper Wainiha Stream in Kauai. The Dominion Hydro Group also continued work on plans for a 6MW plant on the Hanalei River in Kauai. Garratt Callahan Company maintained its interest in a 4 MW hydro plant on the Lumahai Stream in Kauai.

The State began negotiations for the planning and design of a small hydroelectric plant on Molokai. The plant will utilize the energy produced from

water being conveyed from a new deep well source at a 1,000-foot elevation through a pipeline to a 230-foot site to operate a 100-kW generator. If the project is determined to be economically and technologically feasible, construction cost-sharing by the State will be provided.

During the Legislative session, DBED supported HB 461-88 which authorized special purpose revenue bonds up to $5 million to assist Island Power Company in the construction and operation of its Upper Wailua hydroelectric project and related facilities in Kauai. This bill was approved by the Legislature and signed into law as Act 224-88. Island Power Company was later purchased by Bonneville Pacific Corporation.

WIND POWER

Hawaii has some of the best wind regimes in the world for the production of wind energy, due to its mountain contours and the northeasterly trade winds which prevail almost 70 percent of the time. Long-term measurements have recorded wind speeds averaging 15-25 miles per hour in many locations and superior wind speeds exceeding 25 miles per hour in several locations. The best wind regimes classified to date are located at Kahuku, Oahu; Maalaea Bay and Honolua, Maui; Ilio Point and Kualapuu, Molokai; Kilauea and Poipu, Kauai; North Kohala, South Kohala and South Point, Hawaii. In addition to generating electricity which is used at the site or fed into local utility grids, wind energy can be applied to pumping water for irrigation, circulating water for aquaculture or supplying pumped hydro energy storage facilities.

Wind energy is a long-term, proven resource -- an early painting in Honolulu, dated 1837, shows a windmill among the thatched roofs of the city. The use of wind energy for generating electricity has expanded rapidly in Hawaii.

By mid-1988, almost 500 wind energy conversion systems (WECS) were installed in Hawaii and most of these were connected to utility grids.

Much of the impetus for the construction of wind farms throughout the nation came not only from a desire to use alternatives to petroleum, but also from very favorable tax incentives. Although Federal tax benefits were sharply reduced at the end of 1985, the State Legislature extended Hawaii's 10 percent tax credit for wind energy devices until December 31, 1992 and provided for an increase of the tax credit to 15 percent if the Federal tax credits were cancelled (Act 232, SLH 1985). See Appendix B, Table 30.

Wind Power in Operation

On August 25, 1987, Hawaiian Electric Renewable Systems (HERS), a subsidiary of Hawaiian Electric Industries, Inc. (HEI), dedicated the 3.2 MW MOD-5B wind turbine at Kahuku, Oahu. This turbine with blades 320 feet in diameter is considered the largest and most advanced wind turbine of its kind in the world. In FY 87/88, the MOD-5B produced 4.8 million kWh of electricity. The 9,000 kW Makani Moa'e wind farm in Kahuku, also operated by HERS, delivered almost 14.4 million kWh to HECO's utility system during FY 87/88. A few other WECS operated on Oahu were used primarily for irrigation and aquaculture.

The 198-machine wind farm at Kahua Ranch in Kohala, Hawaii, is also operated by HERS. It provided 4.4 million kWh to HELCO's utility system in FY 87/88. HERS estimates that Kahua machines are now capable of producing about five percent of the late afternoon peak needs of the Island of Hawaii. HERS also operates 120 wind machines at Lalamilo, Hawaii, which provided 2.7 million kWh for HELCO's grid in FY 87/88.

The Kamaoa Wind Farm operated by Kamaoa Wind Energy Partners at South Point, Hawaii, went on line in July 1987. The wind farm has 37 250-kW Mitsubishi machines with a total capacity of 9.25 MW. The wind farm can furnish as much as 24.3 million kWh of electricity per year. About 50 other wind machines of various sizes located on Hawaii provide pumping power and/or electricity to private facilities.

In Maui, Zond Pacific, Inc. revised its plans for a wind farm of 40 250-kW machines to be built at Honolua Valley. The revised plans call for a wind farm to be built in two stages of 4.2 and 5.8 MW each.

Wind Research Projects

Several research projects in wind energy were initiated or continued during FY 87/88. HNEI completed the second year of its long-range wind energy program with SERI at the Kahua Ranch Wind Energy Storage Test (WEST) facility. Work continued on the battery storage project, focusing on adapting the project's computer model to reflect the utility's annual hourly demand profile and Kahua's hourly wind regime. Designs for a pumped storage hydroelectric test system at Kahua were evaluated and the system is being installed under a program supported by DBED, Bonneville Pacific and Bonneville Power Authority. This system will use the electricity generated by wind turbines to re-fill a reservoir that supplies a hydro-electric power plant thus providing more uniform and higher quality electric power from an intermittent energy source.

A study was initiated by Zond Pacific to determine the feasibility of using wind power to pump water on Maui and Molokai. The study was funded by DBED under a program administered by the U.S. DOE.

The State funded a study to investigate the technical and economic feasibility of a wind-diesel hybrid system on Maui. The system would use a wind machine for pumping water and/or generating electricity with a back-up diesel generator allowing the system to furnish firm power and operate during periods of low or no wind. The feasibility study will also consider the possibility of using hydrogen produced by surplus electricity from the wind turbine as an alternative fuel source for the diesel engine. If this concept proves feasible, funding of a demonstration wind-diesel and a hydrogen generation and utilization system will be considered.

Assistance to Windpower Projects

The State Legislature approved SB 2213-88 (Act 273-88) which authorized the issuance of $15 million in special purpose revenue bonds to assist International Pacific Energy Consortium, Inc. to establish a wind energy farm in Maui. This Act specifies that the electricity produced shall be made available to the general public through sale to MECO.

The Maui County EES provided assistance to wind farm developers in the permitting and financing processes. The Hawaii EES fielded more than 70 questions and requests for information on wind energy; conducted a tour of 64 persons to the Kamaoa Wind Farm at South Point; and presented talks to nearly 200 students at Konawaena High and Waiakaewaena Elementary Schools on wind and solar power.

Wind Power '88, the 18th National Convention of the American Wind Energy Association, agreed to co-sponsor the International Renewable Energy Conference (IREC) in September, 1988. Several papers on wind energy will be presented at IREC; field trips will be offered to wind farms on Oahu and Hawaii.

OTHER ALTERNATIVE ENERGY RESOURCES

Hawaii is exploring and using additional energy resources and technologies, including coal, hydrogen, fuel cells and superconductors.

Coal

Imported coal may be a possible substitute for petroleum in Hawaii, especially if the development of geothermal power and the undersea electrical transmission cable are long delayed or prove economically impractical. It could be an inexpensive and reliable substitute for petroleum in many applications. Coal has been already used as a substitute for bagasse and oil in some of the islands' sugar mills to generate power when extra fuel was needed to meet contractual power requirements. It has been estimated that sugar companies could replace most of their fuel oil consumption (350,000 barrels per year) by burning about 100,000 tons of coal annually. In the near term, however, only about five of the sugar companies could accommodate coal, due to equipment limitations. The delivered price of coal versus the price of petroleum remains a critical factor, and for this reason, during 1987 little or no coal was burned by the sugar plantations.

In 1987, HECO committed $100,000 in research and development funds to evaluate alternatives to oil as a fuel. Micronized coal was identified as the most viable, economical alternative to oil. Plans have been initiated by HECO to spend over $170,000 to demonstrate the performance of micronized coal in a boiler test facility to provide data demonstrating the feasibility of converting an oil-fired boiler to micronized coal with little or no derating of the boiler.

In April, 1988, HECO signed a contract to purchase 146 MW of coal-generated power from Applied Energy Services (AES) Inc. beginning in 1992. AES has begun construction of a plant at Campbell Industrial Park that will burn low-sulfur coal to produce electricity using modern combustion technology to meet stringent environmental standards. The electricity produced will be purchased by HECO.

Hydrogen

Although still in the research stages for commercial applications, hydrogen may be considered the fuel of the future. Hydrogen can be produced from many sources and used in many forms. Hydrogen combustion produces no carbon dioxide and practically no pollutants. It can be stored in liquid and gaseous forms and in metal hydrides which provide safety and convenience. Hawaii, with its abundant mix of indigenous renewable energy resources, is ideally situated to serve as a center of research and development of hydrogen as a commercial fuel.

At present, most hydrogen energy is used in chemical production and as fuel for sending rockets into space. In the future, many other applications may be hydrogen-fueled. Ultimately all commercial jetliners may use hydrogen. In Hawaii, almost one-third of the energy demand goes to power aircraft, so development of hydrogen has important implications for Hawaii's energy future.

For commercial development of hydrogen as a fuel, a cost-competitive method of producing the gas from water must be found. Considerable research in hydrogen production and storage is being carried on at the UH, U.S. DOE, PICHTR and in foreign countries. PICHTR hosted two hydrogen photoproduction workshops involving world research leaders in this field. Several papers on hydrogen have been scheduled for the IREC. A general agreement was signed between PICHTR and

the Material and Energy Research Institute, Tokyo (MERIT) concerning a comprehensive project on hydrogen generation and storage.

Fuel Cells

Fuel cells may be an important energy source in the future for both utility and industrial use. Once feasible only in limited situations such as the space program, fuel cells are now being used in utility applications and in demonstration units in commercial building. Fuel cells combine hydrogen and oxygen electro-chemically to produce electricity. The cells are energy-efficient and operate with negligible noise and emissions, which make them desirable for urban use.

A one-year test of a 40 kW demonstration fuel cell in a Honolulu building was conducted in 1985 and 1986. Results are currently being reviewed by the U.S. DOE. The HNEI is evaluating the possible use of fuel cells to power electric cars. DBED is funding a feasibility study and economic evaluation of an energy storage facility which will use wind energy as the power source for a 1.5 MW hydrogen fuel cell power plant.

Superconductors

Superconductors, materials which transmit electricity with little or no resistance loss, are being developed which will operate in temperature ranges far above the formerly required extremely low temperature of liquid helium (-459^{o} F). Research is being conducted on superconductors at HNEI through collaboration of the physics and chemistry departments of the UH and the Hawaii Institute of Geophysics. Applications of superconductors foreseen to have the greatest bearing on energy are the development of magnets for storing electricity

and the construction of transmission lines for sending electricity over great distances without the present five to 11 percent losses due to resistance.

HNEI initiated two research studies in FY 87/88 on superconductivity.

The ERC shall ... formulate comprehensive plans and specific proposals for ... energy conservation ...

ENERGY CONSERVATION

Energy conservation is Hawaii's least expensive, most accessible, largest and fastest growing energy alternative. Once commonly associated with voluntary "turn out the lights" programs, energy conservation has developed into an acknowledged technological field. A multi-faceted conservation industry has evolved based on technical innovation, state-of-the-art systems analysis and design, economic theory, product research, manufacturing and marketing.

The goal of energy conservation is to minimize the amount of energy used to meet private and public needs by: (1) reducing energy requirements by means of energy-efficient design; (2) maximizing the efficiency of energy consumption through the selection, design and operation of energy-efficient appliances, equipment and systems; and (3) providing financial programs which will allow the installation of energy efficient systems not otherwise affordable.

Hawaii has been a leader in the development and implementation of innovative energy conservation programs. The State continues to meet or exceed Federally targeted energy goals.

Energy conservation has had a significant impact on Hawaii's energy demand. Between 1980 and 1987, while Hawaii's population increased 14 percent and the gross state product increased an impressive 21 percent (adjusted for inflation), energy consumption actually decreased by 10 percent, demonstrating that it is not necessary to consume more energy to accommodate an improved lifestyle, and

that an increase in economic output does not necessarily require an increase in energy consumption. The average 1987 price of OPEC oil, adjusted for inflation, was 56 percent lower than the average 1980 price, indicating that high oil prices are not essential to reduce energy demand.

If the 1960-1972 trend of energy consumption per dollar of gross state product had continued to the present, Hawaii's 1987 energy consumption would have been 40 percent higher than the actual use reported. If the 1960-72 per-capita energy consumption trend had continued, the 1987 energy consumption would have been 70 percent higher than reported -- the equivalent of thirty 42-gallon barrels of oil or roughly $700 worth of energy costs per person. This is more than twice the energy now used to produce all of Hawaii's electricity. In addition, estimates have been made that at least half of the energy now used could be saved by utilizing presently available technology at less than the cost of the energy we are buying.

Two major forces in Hawaii's energy conservation success are: (1) the widespread knowledge of energy problems and energy economics which prompt responsible demand-side and supply-side decision-making; and (2) the increasing availability of energy-efficient designs, products and systems, which are largely the result of Federally-funded research and development and Federal regulations. Integral with these efforts are the broad range of State and commercial programs designed to proliferate energy information and energy conservation technologies.

The DBED is responsible for administering most Federal and State conservation programs for public and private sectors in Hawaii. It manages projects funded by the Federal government, disseminates conservation information, and promotes consumer awareness through publicity and education programs.

FUNDING FOR DBED ENERGY CONSERVATION PROGRAMS

The numerous energy conservation programs administered by DBED and other organizations are described on the following pages. Almost all of the funds for DBED programs are provided by the Federal government with State and County governments and private industry making supplemental contributions. Funding sources for major energy conservation programs are shown here.

- State Energy Conservation Program (SECP), $65,600 was funded by the U.S. DOE. In addition, $950,000 of Oil Overcharge Funds were expended for the Building Energy Efficiency Standards, Ridesharing Promotion, Consumer Information and Education, Commercial/Industrial Energy Conservation, Energy Audit Program for State Facilities and Commercial Buildings, and Energy Emergency Preparedness Planning programs. Since the beginning of the program in 1976, total State and Federal funding for the SECP exceeded $2.1 million.
- Institutional Conservation Program (ICP), $195,832 was funded by the U.S. DOE for energy-conserving retrofits to non-profit schools and hospitals. In addition, $350,000 in Oil Overcharge Funds have been expended for ICP projects in the State.
- Energy Extension Service (EES), $43,100 was funded by the U.S. DOE. In addition, $350,000 in Oil Overcharge Funds have been expended for the Hawaii Energy Assistance, Hawaii Agri-Energy Technical Assistance, and Energy Conservation Demonstration programs.
- Solar Energy and Energy Conservation Bank (Solar Bank), $20,000 was funded by the U.S. Department of Housing and Urban Development (HUD), for financial assistance to buyers of energy-conserving devices. Since the beginning of the program in 1983, total Federal funding

has been $211,500 of which $143,500 has been provided in loan subsidies to leverage a total of $365,596 in solar water heater sales.

- Oil Overcharge Funds, $1,094,400 was funded from the U.S. DOE Petroleum Violation Escrow Accounts. These funds, usually called "Oil Overcharge Funds," were used by DBED to initiate 23 cost-beneficial conservation projects which met Federal eligibility requirements. Oil Overcharge Funds were received by the State as a result of two U.S. District Court decisions on alleged oil pricing violations that occurred during the period 1975-1981. Over $23 million have been received since 1982. The funds are administered by DBED and are used for energy conservation projects which meet Federal eligibility requirements.

- Weatherization Assistance Program (WAP), received $161,591 in grants from the U.S. DOE and expended $729,044 from Oil Overcharge Funds. The WAP is administered by the State Department of Labor and Industrial Relations, Office of Community Services. Since the beginning of the program in 1981, about $1 million has been received from the U.S. DOE.

- Low-Income Home Energy Assistance Program (LIHEAP), $1,657,035 was administered by the State Department of Health, Family and Adult Services Division. LIHEAP funds assist with payment of utility bills for welfare recipients, the elderly, and the disabled. Since the beginning of the program in 1981, LIHEAP has received nearly $18 million from the U.S. Department of Health and Human Services.

- The State of Hawaii provided $70,000 from the State General Fund for energy conservation projects. The State also provides for three full-time energy conservation positions, and supplies capital improvement program funds to match Federal funds used for energy improvements to State facilities.

BUILDING TECHNOLOGY

Energy-efficient building design insures energy and cost savings throughout the life of a building. Several innovative programs promoting the design of energy-efficient building in Hawaii were initiated in FY 87/88.

A contract was awarded to the Hawaii Society, American Institute of Architects, to design a program to encourage and promote energy conservation in the design of new and renovated buildings in Hawaii. A secondary purpose of the proposed program is to help educate the building design industry on the way architectural design affects the energy performance of buildings.

Plans were initiated for a project involving the preparation of new energy-efficient building codes for Hawaii. A consortium of California and Hawaii firms received a contract to draft a new building code for the State. The code will incorporate results of research studies on the applicability of building envelope, lighting and other energy-related requirements of the State of California Building Code and ASHRAE Standard 90.1P to Hawaiian conditions. In connection with the project, a workshop on building energy standards was sponsored by DBED in November, 1987.

A research study analyzing roofing materials and building designs to provide energy efficiency for Hawaiian and other semi-tropical climates was

initiated in FY 87/88. Differences in building designs for Mainland and Hawaiian construction are a consideration in this study.

A Memorandum of Understanding was signed in June 1988 between the Energy Division, DBED, and the Housing Finance and Development Corporation (HFDC), concerning the provision of energy technical assistance for the approximately 5,000-unit Kapolei Village Housing Project on Oahu. A consultant team provided by DBED will investigate and recommend a variety of energy-savings measures to be incorporated into the plans for the roadways, bikeways, landscaping, schools, houses and other buildings which will be part of the proposed development. The State is especially interested in minimizing energy costs in Kapolei because it will be sharing the energy costs of many of the housing units.

A draft request for proposals covering energy saving options in site planning, building design and equipment selection was submitted to HFDC for review and concurrence.

EQUIPMENT AND APPLIANCES

The State conducts programs to promote the selection of efficient equipment for new buildings, as well as numerous retrofit programs that concentrate on replacing existing equipment with more energy-efficient options.

Lighting, Air Conditioning and Water Heating

An update of the thermal and lighting efficiency standards for new and existing buildings was initiated during FY 87/88. Several ICP projects were funded by approximately $455,000 in Federal grant dollars matched by an equal amount in private funds, to improve lighting and air conditioning systems. These projects will reduce energy costs by an estimated $162,000 per year.

Energy-saving ballasts, reflectors and lights were installed at Our Redeemer Lutheran School, Hawaii Baptist Academy (2 campuses), Hawaii School for Girls, the Kindergarten and Children's Aid Association (5 campuses), Sacred Hearts Academy, Star of the Sea School, and Trinity Lutheran School. Heat pump water heaters were installed at Brigham Young University, Hawaii Campus. High-efficiency air-conditioning chillers were installed at Kuakini Medical Center, Kapiolani Medical Center for Women and Children and St. Francis Hospital. A variable-speed drive was installed for the Iolani School library air conditioner cooling tower.

Appliance Efficiency

The State strongly supported the National Appliance Conservation Act, which sets minimum efficiency standards for most residential appliances entering the State after 1988. These appliances include air conditioners, refrigerators, water heaters, heat pumps, dishwashers, kitchen ranges, ovens and swimming pool heaters. DBED sponsored a National Appliance Conservation Act seminar to inform appliance dealers and distributors of the impact of the act.

Until the National Appliance Conservation Act takes effect, Hawaii law mandates that new water heaters entering the State meet ASHRAE standards. Information on this law is disseminated by the Energy Division, DBED.

Energy Management

During the past year, DBED continued to promote energy efficiency in government procurement practices. Highlights of this program are: the use of life-cycle costing methods which allow the State to concentrate on purchasing energy-efficient and cost-effective equipment and materials, and the institution

of additional energy-efficiency provisions in State and County government purchasing practices.

Energy Auditing

The State funds energy audit programs which analyze the energy usage in both private and public buildings to identify energy-conserving retrofit options and improvements in operation and maintenance procedures. In FY 87/88, the State funded projects through the UH College of Tropical Agriculture and Human Resources, to provide dairy operators with an energy audit package to evaluate the dairy audit program, and to adapt dairy energy audits to non-dairy enterprises.

Contracts were awarded for energy audits and analyses of nine sugar mill factories; wastewater treatment plants in Kailua-Kona and Kulaimano, Hawaii; water pumping stations in Olaa-Mt. View, Kona, and Hilo; the wastewater treatment plant in Lihue, Kauai; and an analysis of refuse disposal at Lahaina, Maui

A contract was awarded to the City and County of Honolulu to perform audits of water heating systems in the County's 57 police, fire and public works facilities, and to perform an energy analysis of the County's H-POWER project to determine possible uses for the waste heat.

A program was initiated to perform energy audits of most of the State Department of Corrections facilities. Audits of the Women's Correctional Center and Hawaii Youth Correctional Center in Kailua and the Wahiawa Correctional Facility in Mililani have been completed; audits of five additional facilities are in progress.

A major energy audit and energy-efficiency analysis began of lighting and water-heating systems in more than 200 public schools in the State. Planning

was done with the State Department of Education and the Department of Accounting and General Services on re-ballasting and re-lamping the fluorescent lighting systems of most public schools. In addition, 350 residential energy efficiency surveys were conducted for homeowners interested in reducing utility costs. These surveys are conducted in person using computerized forms and results.

Energy audits were performed in 330 public schools and 20 commercial buildings, such as Century Center, Yacht Harbor Towers and Windward Cove. These walk-through surveys are conducted by University of Hawaii engineering students who identify problem areas and opportunities for cost-effective, energy-saving improvements.

TRANSPORTATION

Because transportation accounts for more than half of Hawaii's energy needs, savings in transportation offer significant opportunities for overall savings in petroleum usage. In FY 87/88, DBED sponsored several programs in transportation fuel conservation and coordinated with other agencies and community groups in programs designed to implement fuel savings.

DBED funded a ridesharing program administered by the State Department of Transportation (DOT) to promote ridesharing/carpooling for residents of Mililani and Hawaii Kai. Travel mode surveys were conducted; computerized carpool matching programs were developed for State employees; and marketing materials such as brochures, newsletters and posters were developed.

In October, 1987, DBED conducted an automotive fleet energy management workshop to inform managers of public and private vehicle fleets about techniques and equipment available for energy savings. More than 60 representatives of automotive fleet organizations attended this one-day workshop. In conjunction

with the workshop, a 40-page manual, "Fleet Energy Efficiency," was prepared and published. The manual describes several strategies to reduce energy consumption in the operation of vehicle fleets in Hawaii, including delivery scheduling, vehicle maintenance, equipment purchasing, and performance monitoring.

DBED provided a grant to the Hawaii Bicycling League for a program encouraging the use of bicycles for transportation to and from work and school. Emphasis of this program will be on improving safety, as this issue is a major concern of potential bicycle users.

The use of electric-powered vehicles as a measure to conserve gasoline and other petroleum products continues to be evaluated, although many technical problems remain to be solved. Since 1979, HNEI has studied the operation, maintenance, testing and upgrading of more than a dozen electric trucks and cars under U.S. DOE funding. Improvements include low-maintenance gel-cell battery packs, more reliable battery cable connections, and transistorized controllers. Testing of electric vehicles has also been conducted by the Hawaiian Telephone Company and the Pearl Harbor Naval Shipyard. Current research on electric vehicles at HNEI includes the use of diesel engine-generators as range extenders. Future research under consideration includes the possible use of fuel cells in vehicles.

The EES sponsored Car Care Clinics providing free diagnoses of engine efficiency at Community College campuses on Hawaii, Kauai and Maui. The clinics were attended by more than 600 people during the year.

Assistance was given to the Staggered Work Hours Demonstration Project developed by the Lieutenant Governor's Office. Employees of DBED participated actively in the demonstration project. The State Legislature passed Act 286-88 which affirms that the policy of the State is to promote privately operated

public passenger vehicle service including taxi cabs and directs the Counties to promote these policies.

RECYCLING

Recycling common, energy-intensive materials is an effective way of reducing energy consumption. In FY 87/88, DBED granted funds to the Hawaii Automotive and Retail Gasoline Dealers Association to coordinate a Used Oil Recycling Program. The program included a workshop for service station operators, establishment of a network of used oil collection sites, surveys of do-it-yourself oil changers, public information efforts, and recommendations for appropriate legislative and regulatory initiatives.

DBED supported two bills concerning oil recycling; these bills were signed into law. Act 172-88 clarifies the definitions of used and recycled oil and makes administrative changes in permitting and record-keeping procedures. The changes are designed to save used oil for future use and to prevent improper disposal. Act 248-88 appropriates $50,000 for a study by the Legislative Auditor assessing the availability of markets for recycled materials, the economic viability of a recycling program in Hawaii, and means of encouraging service stations to collect used oil.

FINANCING

Owners and tenants of business and residential buildings often cannot afford to purchase energy-efficient equipment, even though the equipment may pay for itself in one to five years. DBED, using several innovative Federal and State programs, provides funding to assist with these purchases.

In FY 87/88 DBED initiated a program with the Hawaii Housing Authority (HHA) to provide solar water heating for 54 households in the Waipahu II project on Oahu, Waimea, Ho'me Nani on Kauai, and Waiakea Pomaikai project in Hawaii. Funding will be provided by the State and HUD by means of the Solar Bank program.

DBED also funded a project to facilitate performance contracting arrangements to install energy-efficient equipment in State facilities. Performance contracting is an arrangement whereby an energy service company or other investor agrees to install energy-efficient or energy-producing equipment in a facility at its own expense. In return, the investor is paid by the recipient out of energy cost savings generated over the term of the contract. Performance contracting has become fairly common as a means of providing energy-saving or energy-producing equipment for an agency or company which cannot afford to purchase or install such equipment until resultant savings or revenues are produced. The installing company may or may not operate and maintain the equipment. Payback terms are set forth by contractual arrangement.

DBED contracted with Pacific Energy Associates (PEA) of Portland, Oregon, to prepare an analysis of existing regulations and assist with proposed legislation authorizing performance contracting arrangements for State agencies. The proposed legislation (SB 3161-88) was adopted by the State House and State Senate but was not signed into law. PEA had designated two facilities, Kuhio Park Terrace Building B, and Makua Alii, as desirable for a performance-based transaction.

Funding for the installation of heat pumps, timers, and hot water heater jackets in low-income households throughout the State was provided through WAP funds. This U.S. DOE program, administered in Hawaii by the State Department

of Labor and Industrial Relations, Office of Community Services, provided energy-saving devices for more than 1,800 low-income, Hawaii households during 1987.

Direct payments to the elderly and disabled were provided to assist with payment of their utility bills through the Federally funded energy assistance program LIHEAP. During 1987, LIHEAP assisted 5,606 households in Hawaii. This program is administered by the State Department of Health, Family and Adult Services Division.

The Molokai Comprehensive Conservation Pilot Program was continued with the Molokai Community Federal Credit Union. The program provides no-interest and loan guarantees for residential solar heating installation. Since the program's inception in 1982, loans have been provided for a total of 187 solar and heat pump water heating systems for homes on Molokai.

The ERC shall ... conduct public education programs to inform the public of the energy situation ...

COMMUNICATION

Increasing public knowledge of energy alternatives, stimulating energy awareness, and providing access to energy information are fundamental to the State energy program. The State supports a broad scope of communication and education programs designed to bring energy information to every resident of Hawaii.

NATIONAL AWARDS PROGRAM FOR ENERGY INNOVATION

DBED coordinated local participation in the U.S. DOE's National Awards Program for Energy Innovation. All three Hawaii projects were winners of Governor's awards at the State level, and two projects were honored with National Awards:

A special national winner was "Naturally Ventilated Multifamily Housing" by the architect/engineering team of Benjamin S. Notkin/Hawaii and R.G. Wood & Associates. This naturally-ventilated, 17-floor high-rise building in Pearl Harbor was designed and oriented for minimum solar exposure of windows and optimum trade wind intake, which eliminated the need for air conditioning.

Eleven-Eight Corporation's $2.1 million privately-funded project titled, "Energy from Demolished Buildings," was one of the national winners. Due to the high cost of disposing of waste wood, Eleven-Eight developed a machine to process wood from demolished wooden buildings and convert it into a product that

is used by sugar companies as a high-Btu additive for biomass energy production. The project has resulted in a net energy savings of 41,350 million Btu per year, avoided capital costs of $400,000, and an $868,300 reduction in annual costs.

The third State winner was the Ala Moana Hotel, where installation of a centrifugal heat pump replaced a conventional water heating system. The overall energy cost savings were about $350,000 in the first year of operation and $285,000 per year at present energy costs.

ENERGY AWARENESS MONTH

October is National Energy Awareness Month and DBED's Energy Division coordinated the many public and private activities offered during the month. The Division prepared and published a newspaper tabloid supplement to Sunday newspapers which was distributed to more than 120,000 households in Hawaii. The supplement featured alternate energy technologies, energy conservation tips and messages, and a calendar of free energy workshops, exhibits, and tours.

During October, awards were presented by Governor Waihee to the winners of the National Awards Program for Energy Innovation; an energy exhibition was held at Ala Moana Center with games, prizes, gifts and energy displays. Seminars were held on Oahu and Hawaii on energy research, planning and strategies; fleet energy management; heat recovery; used oil recycling; building and appliance energy standards. A video, "Oil to Energy," and special energy teaching kits were presented to a group of educators by Pacific Resources, Inc. Exhibits and tours of generating plants and research facilities were held for the general public. Utilities presented special cooking classes featuring ethnic recipes and energy-efficient cooking methods.

Radio and television public service announcements encouraging the wise use of energy were produced featuring some of Hawaii's best known media artists. The spot announcements were presented on local radio and TV stations.

EDUCATION

Recognizing that the children of today are the energy consumers of tomorrow, DBED has assisted the State Department of Education and the UH with funding for new and innovative energy education programs for use in classrooms.

Curriculum Development

During FY 87/88, DBED funded the energy-related portion of the innovative elementary school curriculum entitled "Developmental Approaches in Science and Health" (DASH). This program integrates science, health and technology concepts into curriculum materials for kindergarten through the sixth grade. The University of Hawaii's Curriculum Research & Development Group (CRDG) is the lead agency handling this project.

DBED also assisted with the development of the computer program "Hawaii Energy Awareness Tutor" (HEAT) which enables high school students to learn about physical science principles and heat conversion devices that produce useful energy. The HEAT project utilizes computer-assisted instruction by developing and testing software for high school students which will help them learn the physical science and engineering principles behind heat conversion devices that produce energy. This project represents a joint effort by the Department of Education, CRDG, PICHTR, and the DBED.

A 30-minute energy play The Smartest Little Girl in the World was developed and staged for 40,000 elementary school children in 50 schools

statewide. The theme of the play reinforces the importance of energy conservation in our lives.

Seminars, Workshops and Community Meetings

During FY 87/88 DBED presented the following formal seminars and workshops: workshops on National Appliance Efficiency Standards for Appliance Dealers and Distributors; Fleet Energy Management Workshops for Fleet Owners and Managers; Heat Recovery Workshop for Restaurants; Used Oil Recycling Workshop for Service Station Operators and Fleet Managers; Building Energy Standards Workshop; Marketing Your Energy Program Successfully, a seminar for public information representatives; Teaching Energy in the Classroom, a credit course for teachers; and Simple Solar Maintenance, for the general public.

In addition, DBED coordinated senior citizens workshops on energy at Honolulu Community College and Leeward Community College. Department staff presented information on energy technologies and conservation programs to more than 1,000 people in community meetings and classrooms. Work began on the 1988 International Renewable Energy Conference to be held at the Sheraton Waikiki Hotel, September 18-24, 1988, in Honolulu.

INFORMATION SERVICES

Information services are developed and provided to provide students, the general public and the business community with information on alternate energy resources and technologies, energy conservation programs and measures, energy regulations and laws, and research sources.

Energy Extension Service

The Energy Extension Service (EES) of DBED provides personalized energy information and technical assistance to small-scale energy users on the Neighbor Islands. Offices are located in Hilo, Hawaii; Lihue, Kauai; and Wailuku, Maui.

During the past year, the Hawaii EES responded to more than 3,700 queries by telephone, mail and walk-in visitors. Information on energy technologies and conservation programs was presented to more than 1,000 persons in community meetings, classrooms and workshops. The Hawaii EES staff conducted tours of geothermal, OTEC, wind and biomass facilities for more than 500 persons. Help was provided to the Department of Educations's Science and Engineering Fairs, with Hawaii EES staff furnishing technical assistance, judging and prizes for energy-related projects. The Hawaii EES administers the Community Geothermal Technology Assistance Program at Noi'i O Puna, the geothermal research center in Puna. Wind farm developers were assisted in the permitting and financing processes through the Maui EES.

Energy Division Information Programs

The Energy Division of DBED provides backup support for the EES and also provides technical information and assistance to the public on Oahu. During the past year, the Energy Division has responded to over 6,000 inquiries by telephone, mail and walk-in visitors. It staffs the State Energy Hotline telephones, responding to public inquiries on alternate energy and energy conservation developments. It sponsored a Consumer Education and Information Association Fair at Pearlridge Shopping Center and an Energy Awareness Public Event at Ala Moana Center. These events were attended by more than 3,000 people and were supported with over 20 energy-related displays.

Energy Division staff educate and inform the public on current energy developments through a variety of media, including television and radio ads, bus advertisements, shopping mall ads, brochures, newsletter, and a statewide newspaper supplement. Residential energy surveys conducted by the Energy Division are advertised in the media.

The Division sponsored a statewide poster and essay contest on energy for elementary school students and used the winning posters as illustrations for an energy and tide calendar. More than 15,000 of these calendars were distributed to the State's congressional delegation, state energy offices throughout the nation, as well as to legislators, libraries, mayors, schools and Federal and County offices.

The Division continues to print and distribute a wide variety of energy information publications and brochures targeted toward the residential and commercial sectors.

DBED funded projects through the College of Tropical Agriculture and Human Resources, University of Hawaii, Manoa, to provide energy conservation assistance to dairy farmers. These projects provided technical assistance to livestock producers developing on-farm innovations in methane production from waste and waste by-product utilization and disseminated energy conservation information to farmers.

Utility Company Programs

Hawaii's utility companies have participated actively in consumer education programs. The newsletter Consumer Lines sent to all HECO, HELCO and MECO electric customers with their monthly bills, provides news items on alternate energy projects and suggestions for energy conservation measures.

HECO continued its efforts to educate both residential and commercial customers in using energy more efficiently and economically. A contracting division was established to handle new heat pump water heater projects. The company continued its marketing efforts in promoting ice storage as a means of limiting the demand for electricity used in air conditioning. In 1988, HECO participated in the State's Staggered Work Hours Demonstration project with 110 employees from HECO offices adjusting their work hours to assist with the project.

The Kauai Division, Citizen Utilities Company, provided extensive assistance in energy conservation projects for State and County agencies. In FY 87/88, a total of 2,608 consumer-oriented Kauai Electric radio spot announcements were aired by Kauai's three radio stations. These informational spots were targeted for the general residential audience on such subjects as the prompt repair of hot water leaks, energy consumption by refrigerators, and lighting tips for households.

Kauai Electric provided ongoing consultation, training and informational material to Kauai Economic Opportunity, Inc. (KEO) personnel for their various energy assistance programs. Over 300 low-income households received energy audits. Many of these households were subsequently provided weatherization installations of water heater timer switches and blankets or heat pump water heaters.

A variety of brochures, booklets and handouts covering energy and service-related topics are available to Kauai customers. During March, 1988, a new brochure on energy consumption, by household appliances was mailed to each of Kauai Electric Division's 21,000 customers. Assistance was provided to other agencies and organizations, including the EES.

> The ERC shall ... formulate comprehensive plans for the ... allocation and distribution of fuel ...

ENERGY EMERGENCY PREPAREDNESS

The petroleum shortages of the early '70s disrupted both the economy of the State and the lives of Hawaii's people. In order to prevent similar disruptions in case of future oil shortages or breakdowns of oil supply systems, the State administration continues to work with representatives of other state governments, Hawaii's county governments, the Federal government and private oil companies to ensure equitable distribution of supplies, the maintenance of essential public services, and preservation of the health and safety of its citizens.

DBED Actions for Preparedness

DBED is charged with carrying out this responsibility. The first task was to draft and adopt rules for set-aside quotas and retail sales of gasoline during an energy shortage. Public hearings were held on Maui, Kauai, Hawaii and Oahu on the establishment of rules governing the procurement, control, distribution and sale of petroleum products in the event of a fuel shortage. In February, 1987, the Governor adopted Chapter 15-10, Hawaii Administrative Rules for managing petroleum products during an energy emergency. These rules address the measures oil retailers must implement during a fuel shortage and the decision and authorization process for oil set-aside assignments. The rules were reviewed by DBED during 1988.

Training exercises were held to familiarize staff members with actions to be taken in case of an emergency situation. Coordination meetings were held with other State officials on actions to be taken in the event of a severe oil shortage.

In May 1988, Hawaii participated in a multi-state seminar on Emergency Planning/Preparedness, conducted by the U.S. DOE Office of Energy Emergencies, held in Sacramento, California. The seminar was attended by 42 energy and emergency officials from nine states, the Federal government and private industry. Simulation exercises were held on dealing with terrorist disruptions of local electrical systems as well as temporary and extended interruptions of supplies of oil from the Persian Gulf, and the possible use of the nation's Strategic Petroleum Reserve.

PADD V Workshop

Hawaii continued to participate in the activities of Petroleum Administration for Defense District V (PADD V), an organization of energy officials from seven states in the western region of the United States. This organization seeks coordination of efforts to deal with the resolution of common problems of fuel supplies and distribution in the event of an energy emergency.

A workshop held in California in May 1988, attended by Hawaii representatives, provided participating states with the opportunity to discuss energy emergency issues of mutual interest. The agenda included existing policies, energy infrastructure, sources of supplies, relative isolation of PADD V states from supply sources and types of energy data currently collected by the states.

Strategic Petroleum Reserve

At the present time, it is doubtful that the 500 million barrels of crude oil now stored in the salt caverns of Texas and Louisiana as part of the Strategic Petroleum Reserve (SPR) will be available to Hawaii in time of crisis. Under the current "open market approach" to purchases of SPR oil, Hawaii would have to compete against much larger states. In addition, the chances of small, American-flag tankers being available for the long trip through the Panama Canal to Hawaii in time to alleviate the damaging effects of a shortage are minimal.

Governor John Waihee submitted a resolution to the Western Governors' Association in 1988 expressing the belief that the Secretary of Energy should reconsider the current policies of the U.S. DOE with respect to the use of the SPR during an energy supply emergency in order to ensure that all regions are assured of equitable distribution of the reserve. The resolution also stated that the Secretary of Energy should consider the establishment of regional reserves as a means of providing equal access to the reserves by all regions. The Governors' Management Directive conveyed the Western Governors' Association position to the Secretary of Energy and appropriate congressional members.

The Governor also reappointed an Energy Emergency Preparedness Committee consisting of government officials and representatives of private companies, associations and unions. The function of the Committee is to advise the Governor on actions necessary to deal with sudden and severe shortages in the supply of oil and other issues concerning energy shortages.

To provide up-dated information on Hawaii's needs and resources during an energy emergency, the State initiated plans for a study of State options for protection against petroleum supply disruptions, with special emphasis on the

establishment of a regional petroleum reserve in Hawaii. The study will include the following topics:

1. Oil balances in the world, the United States, the seven PADD-V western states, the Pacific Basin and Hawaii.
2. Tanker availability during the 1990s, including Jones Act and foreign flag ships in the domestic and international trade.
3. Simulated drawdowns of the SPR Central Reserves and their effect on Hawaii.
4. Status of U.S. military fuel requirements with and without U.S. military involvement.
5. The endurance capability of Hawaii's petroleum industry during a prolonged energy shortage.
6. Options for dealing with such disruptions.
7. The cost associated with constructing and maintaining regional reserves.

The ERC serves as a consultant to the Governor, public agencies and private industry ... on matters related to energy ...

ENERGY CONSULTATION AND RECOMMENDATIONS

The ERC serves as a consultant to the Governor and Legislature on energy matters. The ERC also provides advice and assistance to private companies in securing permits and financing for energy resource development and conservation programs. In FY 87/88, the ERC assisted developers of geothermal, wind, hydropower and other alternative energy resources with permitting procedures and financing methods.

Legislation

During FY 87/88, the ERC and his staff reviewed 55 energy-related bills and 10 resolutions proposed during the 1988 regular session of the 14th State Legislature. Comments and recommendations, including testimony as appropriate, were submitted on these bills and resolution. A total of 18 bills were approved by the Legislature and signed into law by Governor Waihee; one bill approved by the Legislature was vetoed. Three concurrent resolutions were adopted by the Senate and House. These bills and resolutions are summarized in Appendix E.

Federal Rules and Regulations

Federal rules and regulations promulgated by the U.S. Congress and departments of the Federal government relating to energy are reviewed and

unusual significance for Hawaii where energy supply and consumption patterns differ so much from Mainland norms that some proposed rules could hurt rather than help our energy situation.

Western Governors' Association

Governor Waihee participates actively in the Western Governors' Association program on energy and other issues. In 1988 he submitted a resolution urging the Secretary of Energy to consider the establishment of regional oil reserves as a means of ensuring adequate emergency supplies for Hawaii and other Western states in case of a major interruption in oil supplies.

APPENDIX A. LEGAL BASIS FOR ERC ACTIVITIES

The position of Energy Resources Coordinator (ERC) was established by the State Legislature in 1974. In 1978, the Director of DBED was designated as the ERC by Chapter 196, Hawaii Revised Statutes (HRS), as amended. Among the powers and duties assigned to the ERC are the following:

- Formulating comprehensive plans and specific proposals for the optimum development of Hawaii's energy resources; the conservation of energy; and the allocation and distribution of fuel.
- Conducting systematic analysis of existing and proposed energy resource programs.
- Coordinating the State's energy conservation and allocation programs with those of the Federal government, other state governments, governments of nations with interest in common energy resources, and the political subdivisions of the State.
- Assisting public and private agencies in implementing energy conservation and related measures.
- Developing programs to encourage private and public exploration and research of alternative energy resources which will benefit the State.
- Conducting public education programs to inform the public of the energy situation and related government actions.
- Serving as consultant to the Governor, public agencies and private industry on matters related to the acquisition, utilization and conservation of energy resources.
- Submitting an annual report to the Governor and the Legislature on the implementation of this chapter and all matters related to energy resources.

Chapter 201, HRS, requires DBED to develop a Statewide program for energy planning and conservation. HCR 27-84 adopted the State Energy Fundamental Plan as a guideline to management decisions and policies and requires DBED to submit a progress report each year and conduct a comprehensive review of the Plan every two years.

APPENDIX B. ENERGY STATISTICS

World Energy Reserves and Resources

Estimates of the future availability of world crude oil and natuaral gas are based upon current estimates of world reserves and resources. Reserves as commonly defined are the "Proven Reserves", oil and natural gas that is known with a good degree of certainty to exist and can be recovered under present economic, operating and technical conditions. Resources are undiscovered recoverable oil and gas resources thought to exist in geologic strata favorable for crude oil extraction.

Because these data are based upon estimation and judgement, large shifts in these estimates occur as experts modify their estimates. Estimates of world crude oil and natural gas reserves made at the end of 1987 reveal the following: (1)

- More than 63 percent of world crude oil reserves and over 28 percent of world natural gas reserves are in countries surrounding the Persian Gulf.
- The 13 OPEC countries control over 75 percent of the world's crude oil and over 38 percent of the world's natural gas resources.
- The United States controls about three percent of the world's crude oil and five percent of its natural gas reserves.
- Western Europe has 2.5 percent and about 6 percent of the world's crude oil and natural gas respectively.
- The U.S.S.R. and Eastern European countries control almost 7 percent of the world's crude oil and about 39 percent of the world's natural gas reserves.

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(1) Data published by the Energy Information Administration, U.S. Department of Energy in Annual Energy Review 1987, P.263, May 13, 1988.

Table 1. **WORLD CRUDE OIL & NATURAL GAS PROVED RESERVES: 1987**

Country or region	Crude Oil (billion bbl)	Percent of total	Natural Gas (trillion cubic ft.)	Percent of total
North America	82.3	9.3	366	9.6
Canada	6.8	.8	98	2.6
Mexico	48.6	5.5	77	2.0
United States	26.9	3.0	192	5.0
Central & South America	65.7	7.4	150	3.9
West. Europe, incld. North Sea fields	22.4	2.5	218	5.7
Middle East	564.7	63.5	1,084	28.5
Iran	92.9	10.5	489	12.9
Iraq	100.0	11.2	26	.7
Kuwait	94.5	10.6	43	1.1
Saudi Arabia	169.6	19.1	146	3.8
United Arab Emerates.	98.1	11.0	204	5.4
Other	9.6	1.1	176	4.6
Africa	55.2	6.2	249	6.5
Libya	21.0	2.4	26	.7
Nigeria	16.0	1.8	84	2.2
Other	18.2	2.0	139	3.7
Far East, Oceania, Australia, Indonesia ..	37.8	4.3	256	6.7
China	18.4	2.1	31	.8
Other	19.4	2.2	225	5.9
Eastern Europe & USSR	60.8	6.8	1,479	38.9
USSR	59.0	6.6	1,450	38.1
Other	1.8	.2	29	.8
Total OPEC		.0		.0
Total world	888.9	100.0	3,802	100.0

Source: U.S. Department of Energy, Energy Information Administration, Annual Energy Review 1987.

Energy and Oil Consumption

The United States is the single largest consumer of energy in the world. It consumed in 1985 almost 36 percent of the energy used by the world's market economies. The U.S. used more than 32 percent of the petroleum, 47 percent of natural gas, over 40 percent of the coal and over 25 percent of the nuclear and other energy resources of the free world. The European countries were second to the U.S. in total free world use of energy.

PROPORTION OF WORLD ENERGY USE BY COUNTRY 1985
(Percent)

Country or region	Total	Petroleum	Natural gas	Coal	Nuclear & other
United States	35.9	32.5	47.1	40.7	25.7
Canada	4.7	3.2	5.5	2.8	11.3
Japan	7.6	9.3	4.2	6.7	8.0
Europe	28.1	27.7	23.7	27.2	36.3
Developing nations & OPEC ...	23.6	27.4	19.5	22.6	18.7
Total	100.0	100.0	100.0	100.0	100.0

U.S. Dept. of Energy, "International Energy Outlook 1986, Projections to 2000"

World and Oil Consumption

Except for Canada, oil continues to be the largest single source of energy for countries of the free world. Oil supplies 46 percent of the free world's total use. Japan, a major trading partner of the U.S. is over 56 percent dependent upon imported oil, a large proportion of which comes from the Persian Gulf region.

TYPE OF ENERGY USE BY COUNTRY 1985
(PERCENT)

Country or region	Total	Petroleum	Natural gas	Coal	Nuclear & other
United States	100.0	41.8	24.2	23.6	10.4
Canada	100.0	30.9	21.6	12.4	35.1
Japan	100.0	56.1	10.2	18.5	15.3
Europe	100.0	45.4	15.5	20.2	18.8
Developing nations & OPEC ...	100.0	53.4	15.2	19.9	11.5
Total	100.0	46.1	18.4	20.9	14.6

Source: U.S. Dept. of Energy, "International Energy Outlook 1986, Projections to 2000"

During 1987, the United States, Western Europe, Japan and Canada consumed 71 percent of the oil used by the market economies. The developing countries including OPEC consumed about 29 percent of the total. Between 1979 and 1987 the developing countries and OPEC consumed oil at a compounded annual rate of about 3.4 percent. Over the same period, the United States and Europe actually decreased their oil use and, in fact, in 1987 total oil use of market economies was less than in 1979. However, mainly due to the large decrease in oil prices in 1986 and continued over supply of product, consumption in the market economies increased by three percent in 1986 and by just under one percent in 1987.

FREE WORLD OIL CONSUMPTION
(Millions of barrels per day)

Region or country	1979	1980	1981	1982	1983	1984	1985	1986	1987 prelim
United States	18.5	17.1	16.1	15.3	15.2	15.7	15.7	16.3	16.5
Canada	1.9	1.9	1.8	1.6	1.5	1.5	1.5	1.5	1.5
Japan	5.5	5.0	4.8	4.5	4.4	4.6	4.3	4.4	4.4
Europe	14.7	13.6	12.5	12.1	11.8	11.8	11.6	12.0	12.0
Other	9.1	9.4	9.5	9.5	9.3	9.7	9.9	10.2	10.4
OPEC	2.4	2.7	3.1	3.3	3.3	3.4	3.6	3.6	3.6
Total	52.1	49.7	47.8	46.3	45.5	46.7	46.6	48.0	48.4

FREE WORLD OIL CONSUMPTION PERCENTAGE CHANGE
(Percent change from previous year)

Region or country	1979	1980	1981	1982	1983	1984	1985	1986	1987 prelim
United States	--	-7.6	-5.8	-5.0	-.7	3.3	.0	3.8	1.2
Canada	--	.0	-5.3	-11.1	-6.3	.0	.0	.0	.0
Japan	--	-9.1	-4.0	-6.3	-2.2	4.5	-6.5	2.3	.0
Europe	--	-7.5	-8.1	-3.2	-2.5	.0	-1.7	3.4	.0
Other	--	3.3	1.1	.0	-2.1	4.3	2.1	3.0	2.0
OPEC	--	12.5	14.8	6.5	.0	3.0	5.9	.0	.0
Total	--	-4.6	-3.8	-3.1	-1.7	2.6	-.2	3.0	.8

NATIONAL OIL USE AS PERCENTAGE OF FREE WORLD OIL USE
(Percent)

Region or country	1979	1980	1981	1982	1983	1984	1985	1986	1987 prelim
United States	35.5	34.4	33.7	33.0	33.4	33.6	33.7	34.0	34.1
Canada	3.6	3.8	3.8	3.5	3.3	3.2	3.2	3.1	3.1
Japan	10.6	10.1	10.0	9.7	9.7	9.9	9.2	9.2	9.1
Europe	28.2	27.4	26.2	26.1	25.9	25.3	24.9	25.0	24.8
Other	17.5	18.9	19.9	20.5	20.4	20.8	21.2	21.3	21.5
OPEC	4.6	5.4	6.5	7.1	7.3	7.3	7.7	7.5	7.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: "Free World" or Market Economies are defined as all countries other than the centrally planned economies of Eastern Europe, Soviet Union, Peoples' Republic of China, Kampuchea, North Korea, Laos, Mongolia and Vietnam.

Source: Energy Information Administration, U.S. Dept. of Energy, "International Energy Outlook 1987, Projections to 2000" May 1988.

International and National Energy and Oil Use Projections

Total Energy consumption

Projections of energy and oil demand have been published by the Energy Information Administration, U.S. Department of Energy up to the year 2000. Major assumptions used to generate the projections are economic growth rates, energy intensity of economic activity, supply availability, energy price change, demand response to price change, and projected growth of nuclear energy. The projections discussed here are base projections, those estimates which are in the middle of the high and low projections.

Energy consumption in Market Economies is projected to grow at a annual average rate of 1.85 percent between the base year of 1986 and the year 2000. The major industrialized nations of Europe, Japan and the United States are projected to use energy at about half the rate of the total market economy. The developing nations are projected to consume energy at 3.0 percent per year because of their rapidly increasing populations and rapid industrial and economic development.

Although the developing nations are growing at a rapid pace the United States is projected to continue to be the world's largest user of energy, consuming 35.5 percent in 1966 and projected to use over 33 percent in the year 2000. The developing nations will grow from a 20.3 percent share of energy use to almost 24 percent by the year 2000.

PROJECTED MARKET ECONOMY ENERGY CONSUMPTION
(Quadrillion Btu)

Region or country	1986 prelim	Projections 1990 Base case	1995 Base case	2000 Base case	Average annual growth rate 1986 to 2000 (percent)
United States	74.3	79.9	85.0	89.6	1.35
Canada	9.8	10.6	11.4	11.9	1.40
Japan	15.7	17.1	18.7	19.8	1.67
Europe	55.7	60.0	64.9	68.3	1.47
Other	42.5	48.9	56.7	64.3	3.00
OPEC	11.4	11.4	14.3	16.6	2.72
Total use	209.4	227.9	251.0	270.5	1.85

DISTRIBUTION OF ENERGY USE BY COUNTRY, MARKET ECONOMIES
(Percent)

Region or country	1986 prelim	Projections 1990 Base case	1995 Base case	2000 Base case
United States	35.5	35.1	33.9	33.1
Canada	4.7	4.7	4.5	4.4
Japan	7.5	7.5	7.5	7.3
Europe	26.6	26.3	25.9	25.2
Other	20.3	21.5	22.6	23.8
OPEC	5.4	5.0	5.7	6.1
Total use	100.0	100.0	100.0	100.0

Note: Market Economies or "Free World" are defined as all countries other than the centrally planned economies of Eastern Europe, Soviet Union, Peoples' Republic of China, Kampuchea, North Korea, Laos, Mongolia and Vietnam.

Source: Energy Information Administration, U.S. Dept. of Energy, "International Energy Outlook 1987, Projections to 2000" May 1988.

Oil and Other Fuel Projections

Oil has been and is projected to continue to be the major fuel source in market economies to the year 2000. Its relative importance is expected to decline from almost 47 percent in 1986 to around 40 percent by 2000. The assumption that changes in the structure of electricity production since 1973, that saw a shift to coal and nuclear fuels will continue, accounts for much of the relative decline of oil use in the market economies.

Although oil is expected to decline relative to other fuels, its use is expected to grow by 10.3 percent between 1986 and 2000 or over 1.4 percent per year to 1990, 0.9 percent per year between 1990 and 1995 and just over 0.23 percent per year between 1995 and 2000. This expected rapid growth during the early 1990's is expected to be driven by continued low world oil prices and continued economic growth especially among developing countries. Oil demand is expected to exceed supply sometime in the mid 1990's forcing prices up. Such price increases would encourage substitution, energy efficiency and conservation, the net result of which will be a decline in demand during the late 1990's.

Currently OPEC controls over 75 percent of the world's crude oil reserves and over 38 percent of natural gas reserves. Petroleum geologists do not expect this share to change appreciably in the future. The base case projections show the OPEC countries become once again the dominant oil producers in the world in the mid 1990's reversing the trend that started in the late 1970's. This is the projected period in which oil demand begins to exceed supply and when existing non-OPEC oil fields begin to be depleted. This trend is exacerbated by lack of exploration and oil development by non-OPEC nations due to low oil prices during the 1980's and projected for the early 1990's. In addition, low oil prices during this period have and will make it difficult to support development of energy efficiency and renewable energy programs.

ENERGY USE IN MARKET ECONOMIES BY FUEL
(Quadrillion Btu)

Energy source	1986 Prelim.	1990	1995	2000
Oil	98.00	103.00	108.00	109.00
Nat. gas	37.00	42.00	50.00	59.00
Coal	43.00	47.00	53.00	59.00
Nuclear	14.00	17.00	19.00	21.00
Other	17.00	19.00	21.00	22.00
Total	209.00	228.00	251.00	270.00

DISTRIBUTION OF FUELS, MARKET ECONOMIES
(Percent)

Energy source	1986 Prelim.	1990	1995	2000
Oil	46.89	45.18	43.03	40.37
Nat. gas	17.70	18.42	19.92	21.85
Coal	20.57	20.61	21.12	21.85
Nuclear	6.70	7.46	7.57	7.78
Other	8.13	8.33	8.37	8.15
Total	100.00	100.00	100.00	100.00

Source: Energy Information Administration, U.S. Dept. of Energy, "International Energy Outlook 1987, Projections to 2000", May 1988

Table 11. **PROJECTED "FREE WORLD" OIL CONSUMPTION**
(Millions of barrels per day)

country	prelim	Projections 1990 Base case	1995 Base case	2000 Base case	Average annual growth rate (percent)
CONSUMPTION					
United States	16.5	17.1	17.7	18.3	.74
Canada	1.5	1.6	1.7	1.6	.46
Japan	4.4	4.5	4.5	4.4	.00
Europe	12.0	12.4	12.7	12.0	.00
Other	10.4	11.2	12.1	12.6	1.38
OPEC	3.6	3.7	4.1	4.5	1.61
Total use	48.4	50.5	52.8	53.4	.70
PRODUCTION					
United States	10.6	9.9	8.8	8.4	-1.65
Canada	1.9	1.7	1.6	1.7	-.79
Europe	4.5	4.8	4.3	4.1	-.66
OPEC	19.3	21.2	26.1	27.8	2.64
Other	9.7	10.7	10.4	10.1	.29
Total produc	46.0	48.3	51.2	52.1	.89
Net CPE exports	.2	.3	.3	.3	--

Note: "Free World" or Market Economies are defined as all countries other than the centrally planned economies of Eastern Europe, Soviet Union, Peoples' Republic of China, Kampuchea, North Korea, Laos, Mongolia and Vietnam.

Source: Energy Information Administration, U.S. Dept.of Energy, "International Energy Outlook 1987, Projections to 2000" May 1988.

Energy and Oil Consumption

National and Hawaii

In 1987 the United States as a whole depended upon petroleum for just over 43 percent of its energy needs, proportionately about the same for the previous year. Coal and natural gas supplied 23.6 and 22.5 percent respectively. Nuclear supplied about 6.5 percent and hydroelectricity almost four percdnt.

In contrast to the national average, Hawaii in 1987 depended upon petroleum for over 90 percent of its energy needs. Biomass, used mainly by sugar plantations to generate electricity and industrial steam contributed about 8 percent. Solar water heeating, hydroelectricity, wind and geothermal made up the remaining 1.5 percent.

Hawaii is unique among the 50 states in that it is about 90 percent dependent upon oil for its energy. Geographically isolated, Hawaii cannot draw power from neighboring states, it has no conventional energy resources such as oil, coal or natural gas, but must import every barrel of oil it uses and must have the physical plant and means to meet all its energy needs.

On a state by state basis in 1986, the latest year for which individual state data are available, Hawaii had the highest dependence upon petroleum, about 90 percent. Ranking just below Hawaii in oil dependence were New Hampshire and Massachusetts at about 68 and 67 percent respectively. Typically the northeastern states tend to have the greatest oil dependency.

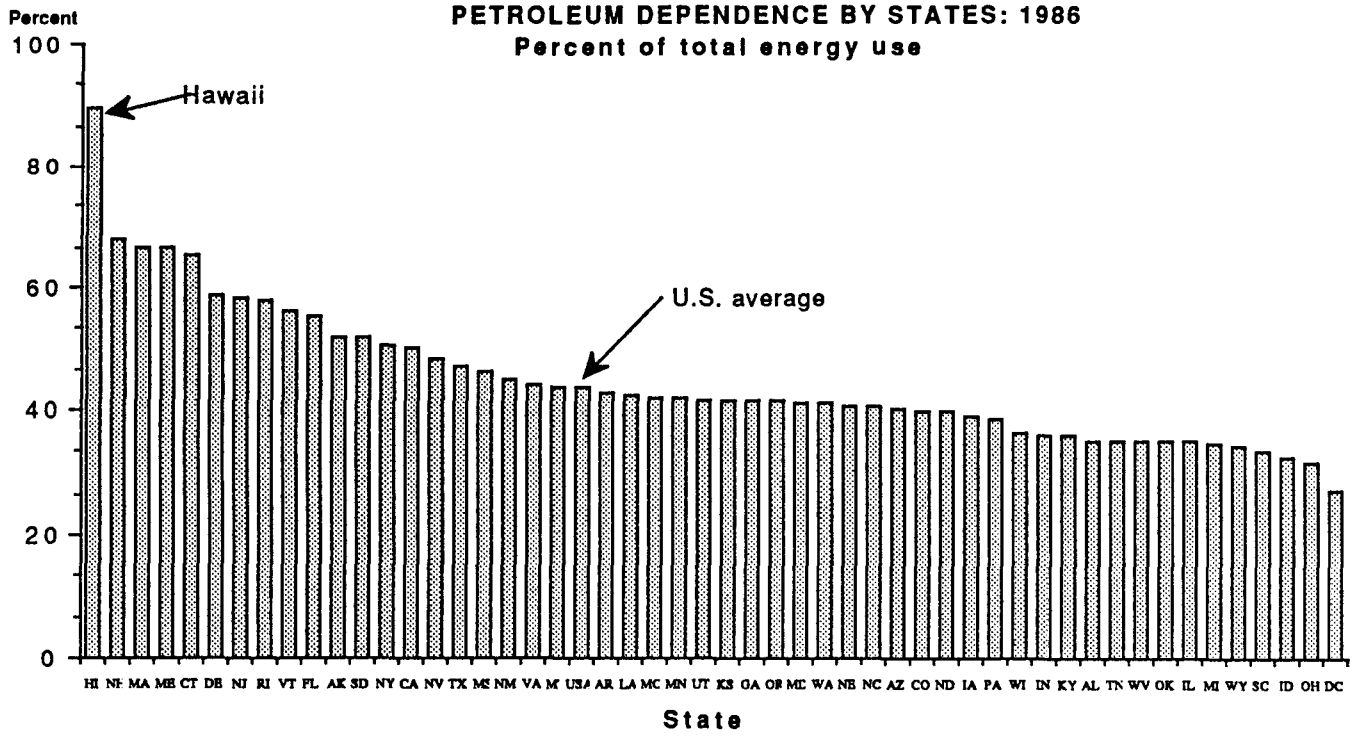

Table 12. **PRIMARY ENERGY USE, HAWAII: 1986 and 1987**
(Billion Btu)

Source	1986	Percent	1987	Percent
Petroleum	242,470	89.49	256,322	90.69
Biomass	23,967	8.85	22,184	7.85
Solar water heating	2,163	.80	2,191	.78
Hydroelectricity	1,056	.39	967	.34
Coal	497	.18	0	.00
Wind	604	.22	822	.29
Geothermal	182	.07	146	.05
Total	270,939	100.00	282,632	100.00

Note: Data for 1987 are preliminary.

Source: Department of Business and EconomicDevelopment, records.

PRIMARY ENERGY USE, UNITED STATES: 1986 and 1987
(Quadrillion Btu)

Table 13.

Source	1986	Percent	1987	Percent
Petroleum	32.196	43.37	32.865	43.09
Coal	17.262	23.25	18.020	23.63
Natural gas	16.708	22.51	17.180	22.53
Nuclear	4.471	6.02	4.916	6.45
Hydroelectricity	3.385	4.56	3.024	3.97
Other *	.215	.29	.253	.33
Total	74.237	100.0	76.259	100.0

* Includes biomass, wind, geothermal, PV and other sources.

Source: U.S. Department of Energy, "Monthly Energy Review" May 1988.

Table 14.

Imports and Exports of Crude Oil and Petroleum Products
Hawaii: 1986
(Thousand barrels)

Product	Imports			Exports		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Crude oil	40,560	15,085	25,475	0	0	0
Motor gasoline	240	240	0	227	13	214
Distillates	166	166	0	819	157	662
Jet fuel	3,781	1,116	2,665	0	0	0
Residual fuel oil	4,464	4,214	250	1,757	406	1,351
Total refined	8,651	5,736	2,915	2,803	576	2,227

Table 15.

Imports and Exports of Crude Oil and Petroleum Products
Hawaii: 1987
(Thousand barrels)

Product	Imports			Exports		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Crude oil	38,583	16,042	22,541	0	0	0
Motor gasoline	98	98	0	1,128	1,128	0
Distillates	112	67	45	1,807	639	1,168
Jet fuel	3,204	636	2,568	33	32	1
Residual fuel oil	2,795	821	1,974	2,301	677	1,624
Total refined	6,209	1,622	4,587	5,269	2,476	2,793

Source: DBED, Energy Division, records.

Electricity Use, National and Hawaii

In 1987, the United States depended upon oil for only 4.6 percent of its electricity generation. Coal was used to generate over 55 percent of the nation's electricity with nuclear, natural gas and hydroelectricity supplying 18, 11 and 10 percent respectively.

In stark contrast to the nation as a whole, petroleum was used for about 91 percent of Hawaii's electricity. Biomass, mainly use by the sugar plantations, was used to generate over 7 percent of the state's electric power while the remaining two percent came from hydroelectricity, wind and geothermal sources.

HAWAII ELECTRICITY PRODUCTION: 1986 AND 1987
(Thousand KWH)

Source	1986	Percent	1987	Percent
Petroleum	7,411,860	89.82	7,576,634	90.54
Biomass	645,640	7.82	605,403	7.23
Hydroelectricity	100,300	1.22	93,204	1.11
Coal	17,350	.21	0	.00
Wind	58,100	.70	79,200	.95
Geothermal	18,200	.22	14,106	.17
Total	8,251,450	100.00	8,368,547	100.00

Note: Data for 1987 are preliminary.
Source: Department of Business and Economic Development, records.

UNITED STATES ELECTRICITY GENERATION BY UTILITIES: 1986 AND 1987
(Million KWH)

Source	1986	Percent	1987	Percent
Petroleum	136,585	5.49	118,493	4.61
Coal	1,385,831	55.72	1,463,781	56.91
Natural gas	248,508	9.99	272,621	10.60
Nuclear	414,038	16.65	455,270	17.70
Hydroelectricity	290,844	11.69	249,695	9.71
Other *	11,503	.46	12,267	.48
Total	2,487,309	100.0	2,572,127	100.0

* Includes biomass, wind, geothermal, PV and other sources.
Source: U.S. Department of Energy, "Monthly Energy Review" May 1988.

When compared to other states, Hawaii, Rhode Island and the District of Columbia depend on oil as a fuel to supply practically all their electric utility needs. Massachusetts, fourth ranked, depends on oil for just under 58 percent of its electricity. The United States as a whole is only about 4.6 percent dependent on oil to supply its electricity.

Of 50 states and D.C., three including Hawaii are over 90 percent dependent on petroleum for electricity generation, eight are between ten percent and 60 percent dependent, 7 are between two and 8 percent dependent and the remaining 33 depend on oil for less than one percent of their electricity.

In general, most states rely on coal as the main fuel for electricity generation and in fact the United States as a whole used coal to generate about 57 percent of it electricity in 1987. In spite of low oil prices coal continued to supply over 56 percent of the nation's electricity during the first six months of 1988.

In 1987 electric utilities in Hawaii generated about 88 percent of the State's demand. Electricity generated by plantations and other private companies accounted for the remaining 12 percent, most of which was sold to the electric utilities under contract. Petroleum was used to generate almost 91 percent of Hawaii's electricity, biomass supplied over seven percent while the remaining two percent came from hydroelectric, wind and geothermal sources. This heavy reliance on oil varies widely from island to island ranging from about 100 percent on Molokai and Lanai to a low of 36 percent on Kauai.

Table 18. **ELECTRICITY PRODUCTION 1987**
(Kwh)

	Total	Oil	Biomass	Hydroelec	Wind	Geothermal
State total	8,487,453	7,695,540	605,403	93,204	79,200	14,106
Hawaii	649,769	402,299	172,360	18,004	43,000	14,106
Maui	859,371	650,261	184,600	22,710	1,800	0
Oahu	6,564,854	6,418,043	112,511	0	34,300	0
Kauai	413,459	224,937	135,932	52,490	100	0

Table 19. **ELECTRICITY PRODUCTION**
(Percent)

County	Total	Oil	Biomass	Hydroelec	Wind	Geothermal
State total	100.00	90.67	7.13	1.10	.93	.17
Hawaii	100.00	61.91	26.53	2.77	6.62	2.17
Maui	100.00	75.67	21.48	2.64	.21	.00
Oahu	100.00	97.76	1.71	.00	.52	.00
Kauai	100.00	54.40	32.88	12.70	.02	.00

Source: Department of Business and Economic Development, records.

Energy Consumption and the Economy

Hawaii's economy today is over 21 percent more energy-efficient than it was during the thirteen year period just before the OPEC oil embargo in 1973. Expressed in other terms, Hawaii uses 21 percent less energy per unit of constant gross state product. Constant or real gross state product is the best single measure of the state's economic condition.

Between 1960 and 1973, energy consumption and the GSP were in "lock step". On average, during this period, energy use increased by over 21 million Btus for every one thousand dollars of real gross state product generated. Then, in 1973/74 because of oil price increases brought about by the OPEC oil embargo this energy-to-GSP relationship was abruptly broken. Economic energy-efficiency increased by over ten percent in 1974 but decreased each year thereafter through 1979 the year of the Iranian Revolution and resulting large oil price increases.

This second oil price shock induced a concerted effort in conservation and energy efficiency programs which led to a structural change in the energy consuming infrastructure and to patterns of energy consumption. This economic energy-efficiency has continued to increase since 1980 (except for 1982/83 in which Hawaii suffered an economic downturn) to the present although the rate of increase has leveled off since 1986.

Table 20.

ENERGY CONSUMPTION & ENERGY CONSUMPTION PER CONSTANT DOLLAR OF GROSS STATE PRODUCT; HAWAII 1960 to 1987

Year	Energy Consumed (Trillion)	Constant GSP (Thous. of 1982 $)	Energy use per GSP: Quantity (thous Btu per 1982 $)	Energy use per GSP: Change from previous yr. (percent)
1959	--	--	--	--
1960	99.15316	5,224,929	19.0	--
1961	116.97162	5,229,222	22.4	17.9
1962	111.79039	5,459,636	20.5	-8.5
1963	117.84984	5,593,061	21.1	2.9
1964	127.23438	6,145,383	20.7	-1.7
1965	132.72839	6,677,279	19.9	-4.0
1966	147.99105	7,055,855	21.0	5.5
1967	167.45867	7,312,564	22.9	9.2
1968	186.50628	7,913,222	23.6	2.9
1969	193.83665	8,884,798	21.8	-7.4
1970	198.62790	9,309,703	21.3	-2.2
1971	213.94859	9,797,100	21.8	2.4
1972	219.48417	10,455,311	21.0	-3.9
1973	224.98611	10,975,563	20.5	-2.4
1974	213.57387	10,953,462	19.5	-4.9
1975	238.35719	11,601,888	20.5	5.4
1976	240.51954	11,747,134	20.5	-.3
1977	254.54840	12,105,930	21.0	2.7
1978	259.11475	12,491,630	20.7	-1.3
1979	278.45009	12,985,191	21.4	3.4
1980	273.88094	13,700,639	20.0	-6.8
1981	273.32263	14,028,215	19.5	-2.5
1982	272.11290	13,691,047	19.9	2.0
1983	279.03031	14,207,807	19.6	-1.2
1984	276.36995	14,635,599	18.9	-3.8
1985	266.21778	15,047,567	17.7	-6.3
1986	271.05620	15,703,100	17.3	-2.4
1987	282.71678	16,516,300	17.1	-.8
1988	--	17,026,700	--	--

Source: DBED records

Table 21. **ENERGY CONSUMPTION & STATE POPULATION**
Hawaii: 1960 to 1987

Year	Energy consumed (Trillion Btu)	Defacto population (July 1,)	Total resident population (July 1,)	Per Capita consumption (million Btu)	
				De facto	Resident
1959	--	630,479	622,087	N/A	N/A
1960	99.15316	651,185	641,520	152.3	154.6
1961	116.97162	668,224	658,684	175.0	177.6
1962	111.79039	693,634	683,513	161.2	163.6
1963	117.84984	694,503	682,241	169.7	172.7
1964	127.23438	711,158	699,858	178.9	181.8
1965	132.72839	715,428	703,804	185.5	188.6
1966	147.99105	724,581	710,325	204.2	208.3
1967	167.45867	742,639	722,528	225.5	231.8
1968	186.50628	758,839	734,456	245.8	253.9
1969	193.83665	778,848	750,228	248.9	258.4
1970	198.62790	798,566	771,647	248.7	257.4
1971	213.94859	833,103	801,644	256.8	266.9
1972	219.48417	869,825	828,331	252.3	265.0
1973	224.98611	901,330	851,595	249.6	264.2
1974	213.57387	923,730	867,978	231.2	246.1
1975	238.35719	943,479	886,160	252.6	269.0
1976	240.51954	970,323	904,191	247.9	266.0
1977	254.54840	992,285	918,259	256.5	277.2
1978	259.11475	1,014,304	931,584	255.5	278.1
1979	278.45009	1,042,689	953,306	267.0	292.1
1980	273.88094	1,055,810	968,865	259.4	282.7
1981	273.32263	1,064,538	980,200	256.8	278.8
1982	272.11290	1,088,335	997,600	250.0	272.8
1983	279.03031	1,115,209	1,018,600	250.2	273.9
1984	276.36995	1,138,604	1,036,000	242.7	266.8
1985	266.21778	1,149,300	1,051,500	231.6	253.2
1986	271.05620	1,179,100	1,064,700	229.9	254.6
1987	282.71678	1,198,800	1,082,500	235.8	261.2
1988	--	--	--	--	--

Source: DBED records

able 22. **ELECTRICITY SALES & GROSS STATE PRODUCT HAWAII:1960 TO 1987**

Years	GSP (Thous.of 1982 dollars)	Electricity sales by utilities (Thous. KWH)	Electricity sales per $1,000 of constant GSP	Annual change (percent)
1959	- -	- -	- -	--
1960	5,224,929	1,602,197	306.645	--
1961	5,229,222	1,766,031	337.723	10.135
1962	5,459,636	1,966,105	360.116	6.631
1963	5,593,061	2,077,571	371.455	3.149
1964	6,145,383	2,284,275	371.706	.068
1965	6,677,279	2,445,025	366.171	-1.489
1966	7,055,855	2,639,866	374.138	2.176
1967	7,312,564	2,832,469	387.343	3.529
1968	7,913,222	3,109,256	392.919	1.440
1969	8,884,798	3,426,052	385.608	-1.861
1970	9,309,703	3,758,094	403.675	4.685
1971	9,797,100	4,167,127	425.343	5.368
1972	10,455,311	4,562,568	436.388	2.597
1973	10,975,563	4,867,850	443.517	1.634
1974	10,953,462	5,113,906	466.876	5.267
1975	11,601,888	5,334,755	459.818	-1.512
1976	11,747,134	5,615,210	478.007	3.956
1977	12,105,930	5,831,610	481.715	.776
1978	12,491,630	6,004,891	480.713	-.208
1979	12,985,191	6,197,426	477.269	-.717
1980	13,700,639	6,345,531	463.156	-2.957
1981	14,028,215	6,424,016	457.935	-1.127
1982	13,691,047	6,332,707	462.544	1.006
1983	14,207,807	6,425,578	452.257	-2.224
1984	14,635,599	6,606,255	451.383	-.193
1985	15,047,567	6,635,158	440.946	-2.312
1986	15,703,100	7,025,739	447.411	1.466
1987	16,516,300	7,298,178	441.877	-1.237
1988	17,026,700	- -	- -	- -

Source: Dept. of Business & Economic Development;
Dept. of Commerce & Consumer Affairs, records.

Table 23. ELECTRICITY SALES AND POPULATION; HAWAII

Year	Electricity sales (1,000 KWH)	Defacto pop (July 1,)	Total resident pop. (July 1,)	Percapita elec. consumption (Kilo-Watt hours)		Annual change (percent)	
				Defacto	Resident	Defacto	Resident
1960	1,602,197	651,185	641,520	2,460	2,498	--	--
1961	1,766,031	668,224	658,684	2,643	2,681	7.415	7.353
1962	1,966,105	693,634	683,513	2,834	2,876	7.251	7.285
1963	2,077,571	694,503	682,241	2,991	3,045	5.537	5.866
1964	2,284,275	711,158	699,858	3,212	3,264	7.374	7.182
1965	2,445,025	715,428	703,804	3,418	3,474	6.398	6.437
1966	2,639,866	724,581	710,325	3,643	3,716	6.605	6.978
1967	2,832,469	742,639	722,528	3,814	3,920	4.687	5.484
1968	3,109,256	758,839	734,456	4,097	4,233	7.428	7.989
1969	3,426,052	778,848	750,228	4,399	4,567	7.358	7.872
1970	3,758,094	798,566	771,647	4,706	4,870	6.983	6.647
1971	4,167,127	833,103	801,644	5,002	5,198	6.287	6.735
1972	4,562,568	869,825	828,331	5,245	5,508	4.867	5.962
1973	4,867,850	901,330	851,595	5,401	5,716	2.962	3.776
1974	5,113,906	923,730	867,978	5,536	5,892	2.507	3.072
1975	5,334,755	943,479	886,160	5,654	6,020	2.135	2.178
1976	5,615,210	970,323	904,191	5,787	6,210	2.345	3.158
1977	5,831,610	992,285	918,259	5,877	6,351	1.555	2.263
1978	6,004,891	1,014,304	931,584	5,920	6,446	.736	1.499
1979	6,197,426	1,042,689	953,306	5,944	6,501	.397	.855
1980	6,345,531	1,055,810	968,865	6,010	6,549	1.117	.746
1981	6,424,016	1,064,538	980,200	6,035	6,554	.407	.066
1982	6,332,707	1,088,335	997,600	5,819	6,348	-3.573	.141
1983	6,425,578	1,115,209	1,018,600	5,762	6,308	-.979	.625
1984	6,606,255	1,138,604	1,036,000	5,802	6,377	.699	1.085
1985	6,635,158	1,149,300	1,051,500	5,773	6,310	-.497	1.043
1986	7,025,739	1,179,100	1,064,700	5,959	6,599	3.210	4.574
1987	7,298,178	1,198,800	1,082,500	6,088	6,742	2.171	2.170
1988	--	--	--	--	--	--	--

Source: Dept.of Business and Economic Development; Dept.of Commerce and Consumer Affairs, records.

Table 24. **ENERGY CONSUMPTION BY SOURCE, HAWAII**
(Trillions of BTU)

Year	Petro	Biomass	Hydro-electy	Geothr'm	Solar hot water	Wind	Coal	Total
1960	98.85316	.00000	.30000	.00000	.00000	.00000	.00000	99.15316
1961	116.67162	.00000	.30000	.00000	.00000	.00000	.00000	116.97162
1962	111.59039	.00000	.20000	.00000	.00000	.00000	.00000	111.79039
1963	117.64984	.00000	.20000	.00000	.00000	.00000	.00000	117.84984
1964	126.03438	.00000	1.20000	.00000	.00000	.00000	.00000	127.23438
1965	131.62839	.00000	1.10000	.00000	.00000	.00000	.00000	132.72839
1966	146.79105	.00000	1.20000	.00000	.00000	.00000	.00000	147.99105
1967	166.35867	.00000	1.10000	.00000	.00000	.00000	.00000	167.45867
1968	185.20628	.30000	1.00000	.00000	.00000	.00000	.00000	186.50628
1969	192.53665	.30000	1.00000	.00000	.00000	.00000	.00000	193.83665
1970	197.22790	.30000	1.10000	.00000	.00000	.00000	.00000	198.62790
1971	212.84859	.20000	.90000	.00000	.00000	.00000	.00000	213.94859
1972	218.38417	.20000	.90000	.00000	.00000	.00000	.00000	219.48417
1973	223.78611	.20000	1.00000	.00000	.00000	.00000	.00000	224.98611
1974	212.27387	.30000	1.00000	.00000	.00000	.00000	.00000	213.57387
1975	213.45719	24.00000	.90000	.00000	.00000	.00000	.00000	238.35719
1976	215.51954	24.00000	1.00000	.00000	.00000	.00000	.00000	240.51954
1977	229.58887	24.00000	.90000	.00000	.05953	.00000	.00000	254.54840
1978	233.53565	24.40000	.90000	.00000	.27910	.00000	.00000	259.11475
1979	253.03444	24.00000	.90000	.00000	.51565	.00000	.00000	278.45009
1980	248.01095	24.20000	.90000	.00000	.76999	.00000	.00000	273.88094
1981	245.50858	24.09000	.73560	.00000	1.11845	.00000	1.87000	273.32263
1982	244.31507	23.92000	1.09390	.15720	1.35673	.00000	1.27000	272.11290
1983	250.62827	24.85000	.88650	.18860	1.52694	.00000	.95000	279.03031
1984	248.40255	24.36500	.77960	.20750	1.76830	.00000	.84700	276.36995
1985	238.64696	23.14300	.98080	.18860	2.13272	.16970	.95600	266.21778
1986	242.58570	23.96700	1.05620	.18230	2.16440	.60360	.49700	271.05620
1987	256.40614	22.18400	.96700	.14460	2.19144	.82360	--	282.71678
1988	--	--	--	--	--	--	--	.00000

Note: Propane is naphtha plus propane from 1981 on.
Jet fuel equals jet kerosene plus jet naphtha from 1981 on.
Biomass mainly sugar plantation use not included from 1960 to 1974.
Small amounts shown are from U.S. source reference.

Source: U.S. Energy Information Administration, "State Energy Data Report 1960-1986":
Hawaii State DBED, Energy Division, from 1981 on, records.

Table 25. **PETROLEUM CONSUMPTION, HAWAII**
(Thousand Barrels)

Year	Avia gas	Diesel	Jet fuel	Kerosene	LPG	Mogas	Residual	Other	Total Oil
1960	2,582.0	886.0	5,011.0	91.0	112.0	3,429.0	4,766.0	553.0	17,430.0
1961	2,994.0	1,663.0	5,558.0	69.0	140.0	3,546.0	5,926.0	578.0	20,474.0
1962	1,790.0	1,637.0	5,532.0	55.0	172.0	3,708.0	5,974.0	591.0	19,459.0
1963	1,084.0	1,362.0	6,892.0	49.0	232.0	3,756.0	6,431.0	638.0	20,444.0
1964	561.0	1,761.0	7,682.0	50.0	257.0	3,861.0	6,965.0	664.0	21,801.0
1965	626.0	1,612.0	8,275.0	49.0	219.0	4,082.0	7,230.0	684.0	22,777.0
1966	870.0	1,378.0	10,158.0	37.0	242.0	4,294.0	7,801.0	668.0	25,448.0
1967	477.0	1,208.0	12,802.0	33.0	285.0	4,526.0	8,818.0	636.0	28,785.0
1968	268.0	1,420.0	14,723.0	27.0	298.0	4,882.0	9,738.0	653.0	32,009.0
1969	195.0	1,601.0	14,834.0	29.0	912.0	5,176.0	10,056.0	666.0	33,469.0
1970	162.0	1,695.0	14,884.0	153.0	938.0	5,691.0	10,154.0	643.0	34,320.0
1971	165.0	1,709.0	16,939.0	80.0	963.0	5,872.0	10,701.0	618.0	37,047.0
1972	165.0	1,776.0	16,839.0	52.0	945.0	6,202.0	11,338.0	645.0	37,962.0
1973	153.0	1,837.0	17,043.0	41.0	942.0	6,608.0	11,575.0	723.0	38,922.0
1974	145.0	1,951.0	15,432.0	75.0	966.0	6,543.0	11,122.0	693.0	36,927.0
1975	133.0	1,948.0	15,363.0	76.0	872.0	6,766.0	11,255.0	693.0	37,106.0
1976	130.0	2,337.0	14,202.0	129.0	1,036.0	7,029.0	11,871.0	739.0	37,473.0
1977	147.0	2,865.0	14,875.0	169.0	877.0	7,406.0	12,695.0	789.0	39,823.0
1978	141.0	3,567.0	14,861.0	146.0	702.0	7,639.0	12,556.0	846.0	40,458.0
1979	152.0	6,567.0	15,276.0	40.0	1,583.0	7,506.0	12,167.0	824.0	44,115.0
1980	199.0	5,987.0	14,116.0	9.0	1,573.0	7,231.0	13,196.0	815.0	43,126.0
1981	55.4	4,604.3	16,450.6	.4	1,284.6	7,033.3	13,222.7	29.2	42,680.5
1982	44.7	4,568.5	15,427.2	.2	1,334.5	6,823.3	14,121.0	5.5	42,324.9
1983	215.2	4,852.9	14,724.0	.0	1,360.2	7,273.6	14,958.2	15.8	43,399.9
1984	73.5	5,512.7	14,397.5	.0	1,272.8	7,681.8	14,076.5	50.2	43,064.9
1985	64.8	4,261.8	17,296.6	.0	1,292.0	7,527.5	11,293.2	50.4	41,786.3
1986	45.3	4,157.0	16,486.1	.0	1,281.4	8,063.4	12,253.3	55.0	42,341.4
1987	28.8	3,124.1	18,775.2	.0	1,332.8	8,911.3	12,605.6	58.8	44,836.7

Table 26. **PETROLEUM COMSUMPTION, HAWAII**
(Billion Btu)

Year	Avia gas	Diesel	Jet fuel	Kerosene	LPG	Mogas	Residual	Other	Total
1960	13.0	5.2	28.4	.5	.4	18.0	30.0	3.3	98.9
1961	15.1	9.7	31.5	.4	.5	18.6	37.3	3.5	116.7
1962	9.0	9.6	31.4	.3	.7	19.5	37.6	3.6	111.6
1963	5.5	8.0	39.1	.3	.9	19.7	40.4	3.8	117.6
1964	2.8	10.3	43.6	.3	1.0	20.3	43.8	4.0	126.0
1965	3.2	9.4	46.9	.3	.8	21.4	45.5	4.1	131.6
1966	4.4	8.1	57.6	.2	.9	22.6	49.0	4.0	146.8
1967	2.4	7.1	72.6	.2	1.1	23.8	55.4	3.8	166.4
1968	1.4	8.3	83.5	.2	1.1	25.6	61.2	3.9	185.2
1969	1.0	9.4	84.1	.2	3.5	27.2	63.2	4.0	192.5
1970	.8	9.9	84.4	.9	3.6	29.9	63.8	3.9	197.2
1971	.8	10.0	96.0	.5	3.7	30.8	67.3	3.7	212.8
1972	.8	10.4	95.5	.3	3.6	32.6	71.3	3.9	218.4
1973	.8	10.8	96.6	.2	3.6	34.7	72.8	4.3	223.8
1974	.7	11.4	87.5	.4	3.7	34.4	69.9	4.2	212.3
1975	.7	11.4	87.1	.4	3.3	35.5	70.8	4.2	213.5
1976	.7	13.7	80.5	.7	4.0	36.9	74.6	4.4	215.5
1977	.7	16.8	84.3	1.0	3.4	38.9	79.8	4.7	229.6
1978	.7	20.9	84.3	.8	2.7	40.1	78.9	5.1	233.5
1979	.8	38.4	86.6	.2	6.1	39.4	76.5	5.0	253.0
1980	1.0	35.0	80.0	.1	6.0	38.0	83.0	4.9	248.0
1981	.3	26.9	92.4	.0	5.8	36.9	83.1	.1	245.5
1982	.2	26.7	86.8	.0	5.9	35.8	88.8	.0	244.3
1983	1.1	28.4	82.8	.0	6.0	38.2	94.0	.1	250.6
1984	.4	32.3	81.1	.0	5.6	40.4	88.5	.2	248.4
1985	.3	24.9	97.0	.0	5.6	39.5	71.0	.2	238.6
1986	.2	24.3	92.8	.0	5.6	42.4	77.0	.2	242.6
1987	.1	18.3	105.8	.0	5.8	46.8	79.3	.2	256.4
1988	.0	.0	.0	.0	.0	.0	.0		.0

Source: U.S. Energy Information Administration, State Energy Data Report 1960-1986:
Hawaii State DBED, Energy Division, from 1980 on, records.

Table 27. **STATE ELECTRICITY USE: 1960 TO 1987**
Electric Utilities

Year	Customers (No. at end of yr.)			Power sold (1,000 kwh)			Revenues ($1,000)		
	Total	Residen	Other	Total	Residen.	Other	Total	Residen	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	2,077,571	730,317	1,347,254	48,499	20,733	27,766
1964	177,684	149,547	28,137	2,284,275	786,118	1,498,157	52,134	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	84,097	34,068	50,028
1971	226,514	193,043	33,471	4,167,127	1,375,308	2,791,819	98,828	38,824	60,005
1972	236,309	201,903	34,406	4,562,568	1,493,840	3,068,728	109,212	42,560	66,653
1973	246,255	210,740	35,515	4,867,850	1,581,855	3,285,995	126,453	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	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 28. AVERAGE KWH USE AND AVERAGE RATES: 1960 TO 1987
(Electric Utilities)

	Customers (No. at end of yr.)			Average power sold (KWH per customer)			Average rate ($ per KWH)			Average rate (Constant 1967 $ per KWH)		
Year	Total	Residen	Other	Total	Residen.	Other	Total	Residen	Other	Total	Residen	Other
1960	157,578	132,440	25,138	10,168	4,386	40,630	.0245	.0297	.0216	--	--	--
1961	162,452	136,788	25,664	10,871	4,567	44,471	.0239	.0291	.0210	--	--	--
1962	167,101	140,661	26,440	11,766	4,825	48,694	.0235	.0289	.0207	--	--	--
1963	171,832	144,638	27,194	12,091	5,049	49,542	.0233	.0284	.0206	--	--	--
1964	177,684	149,547	28,137	12,856	5,257	53,245	.0228	.0279	.0201	.0246	.0301	.0217
1965	183,723	154,822	28,901	13,308	5,510	55,082	.0227	.0276	.0201	.0240	.0291	.0212
1966	190,276	160,784	29,492	13,874	5,676	58,567	.0225	.0273	.0199	.0231	.0280	.0205
1967	196,417	166,256	30,161	14,421	5,953	61,095	.0225	.0270	.0200	.0225	.0270	.0200
1968	202,167	171,346	30,821	15,380	6,322	65,735	.0224	.0268	.0200	.0216	.0258	.0193
1969	210,330	178,569	31,761	16,289	6,577	70,890	.0220	.0265	.0196	.0203	.0245	.0181
1970	219,003	186,282	32,721	17,160	6,822	76,017	.0224	.0268	.0201	.0196	.0235	.0176
1971	226,514	193,043	33,471	18,397	7,124	83,410	.0237	.0282	.0215	.0199	.0237	.0181
1972	236,309	201,903	34,406	19,308	7,399	89,192	.0239	.0285	.0217	.0195	.0232	.0177
1973	246,255	210,740	35,515	19,768	7,506	92,524	.0260	.0308	.0237	.0202	.0240	.0184
1974	255,901	219,633	36,268	19,984	7,449	95,895	.0296	.0349	.0270	.0208	.0246	.0191
1975	263,816	226,836	36,980	20,221	7,391	98,927	.0404	.0459	.0379	.0261	.0296	.0245
1976	270,035	232,070	37,965	20,794	7,543	101,794	.0420	.0480	.0393	.0258	.0295	.0242
1977	275,616	237,557	38,059	21,158	7,490	106,474	.0466	.0522	.0441	.0272	.0305	.0258
1978	284,064	244,863	39,201	21,139	7,347	107,290	.0522	.0588	.0494	.0284	.0320	.0268
1979	293,061	252,898	40,163	21,147	7,321	108,208	.0572	.0642	.0542	.0280	.0314	.0265
1980	301,544	260,358	41,186	21,043	7,117	109,079	.0724	.0790	.0696	.0317	.0346	.0305
1981	305,927	265,042	40,885	20,999	7,002	111,732	.1088	.1156	.1060	.0431	.0458	.0420
1982	313,009	270,712	42,297	20,232	6,654	107,133	.1143	.1235	.1106	.0427	.0461	.0413
1983	319,449	276,194	43,255	20,115	6,569	106,606	.1026	.1135	.0983	.0375	.0415	.0359
1984	324,384	280,518	43,866	20,366	6,552	108,702	.1064	.1183	.1018	.0374	.0415	.0357
1985	330,407	285,117	45,290	20,082	6,590	105,015	.1014	.1136	.0965	.0345	.0386	.0328
1986	337,563	291,222	46,341	20,813	6,728	109,326	.0800	.0929	.0751	.0266	.0309	.0249
1987	347,086	299,758	47,328	21,027	6,906	110,466	.0826	.0943	.0780	.0261	.0298	.0246
1988												

Source: Hawaii State Dept. of Commerce & Consumer Affairs, records.

Table 29. HYDROELECTRIC POWER IN HAWAII

Island	Area	Stream	Megawatt Capacity	Annual Million KWh	Annual Oil Equiv. 1000 Bbl	Owner/Comment
HAWAII	Hilo	Wailuku	1.5	7.3	12.2	HELCO Puueo
	Hilo	Wailuku	0.75	5.5	9.2	HELCO Puueo
	Hilo	Wailuku	0.75	5.3	8.8	HELCO Waiau
	Hilo	Wailuku	0.35	1.0	1.7	HELCO Waiau
	Hilo	Ainako	*	0.1	0.1	Wenco Energy
	Hilo	Kaieie	*	0.2	0.3	Hoowaiwai Farm/Pacific
	Hawi	Kohala Ditch	0.2	1.5	2.5	Hawi Ag & Energy
	Waimea	Waikoloa Pipe	*	0.1	0.2	County Water Dept.
	Haina	Hamakua Ditch	0.5	2.5	4.2	Hamakua Sugar Co.
	TOTAL		4.05	23.5	39.2	4% of Hawaii demand
(P)	Hilo	Wailuku	9.0	27.0	45.0	Kahala Energy Dev.
(P)	Hilo	Honolii	14.6	20.4	34.0	Mauna Kea Power
	TOTAL + PROPOSED		27.65	70.9	118.2	10.5% of Hawaii demand
MAUI	Paia	Wailoa Ditch	1.0	3.0	5.0	HC & S
	Kaheka	Wailoa Ditch	4.5	19.0	31.7	HC & S
	Hamakua	Wailoa Ditch	0.5	2.2	3.7	HC & S
	Lahaina	Kauaula	0.3	0.9	1.5	Pioneer Mill
	TOTAL		6.3	25.1	41.9	3.6% of Maui demand
(P)	Wailua	Wailua Iki	2.7	7.9	13.2	Bonneville Pacific
	TOTAL + PROPOSED		9.0	33.0	55.1	4.7% of Maui demand
KAUAI	Waimea	Waimea	1.0	5.6	9.3	Kekaha Sugar Co.
	Waiawa	Kekaha Ditch	0.48	1.8	3.0	Kekaha Sugar Co.
	Upper Lihue	N.Wailua Ditch	0.48	3.1	5.2	Lihue Plantation Co.
	Lower Lihue	N.Wailua Ditch	0.76	4.3	7.2	Lihue Plantation Co.
	North	Lower Wainiha	3.6	30.0	50.0	McBryde Sugar Co.
	Kalaheo	Alexander Resrvr.	1.0	5.0	8.3	McBryde Sugar Co.
	Kaumakani	Makaweli	1.25	6.0	10.0	Olokele Sugar Co.
	TOTAL		8.57	55.8	93.0	16.2% of Kauai demand
(P)	North	Lumahai	4.0	23.7	39.5	Garratt Callahan Co.
(P)	Wailua	Wailua	6.6	17.5	29.2	Bonneville Pacific
(P)	North	Hanalei	6.0	29.0	48.3	Dominion Hydro
(P)	North	Upper Wainiha	3.8	20.0	33.3	McBryde Sugar Co.
(P)	Wailua	Upper Wailua	1.3	7.0	11.7	Bonneville Pacific
	TOTAL + PROPOSED		30.27	153.0	255.0	44.3% of Kauai demand
STATE TOTAL			18.92	104.4	174.1	1.5% of State demand
STATE TOTAL + PROPOSED			66.92	256.9	428.3	3.4% of State demand

Notes: (P) -- proposed hydroelectric developments
* -- less than 100 kW
kWh and oil equivalents may vary +/- 20% with annual water flow
Oil equivalent based on 600 kWh per barrel of oil

Table 30.

WIND POWER IN HAWAII

Island	Location	Number of Units	Model	Capac. Each kW	Total Capac. kW	Annual Million kWh	Annual Oil Equiv. 1000 Bbl	Owner/Comment
HAWAII	Kahua Ranch	198	Jacobs	17	3,366	8.8	14.7	HERS
	Kahua Ranch	3	Jacobs	17	51	0.2	0.2	Kahua Ranch
	Kahua Ranch	1	Carter	25	25	0.1	0.1	Kahua Ranch/HNEI
	Lalamilo	39	Jacobs	17	663	1.7	2.9	HERS
	Lalamilo	81	Jacobs	20	1,620	4.3	7.1	HERS
	South Point	37	Mitsubishi	250	9,250	24.3	40.5	Kamaoa Wind Energy Ptnrs.
	Residential	50	Various	5	250	0.7	1.1	
	TOTAL	409			15,225	40.0	66.6	6.7% of island demand
MAUI	Residential	20	Various	5	100	0.3	0.4	
	TOTAL	20			100	0.3	0.4	0.1% of Maui demand
(P)	Honolua Valley	40	Mitsubishi	250	10,000	26.3	43.8	Zond Pacific (1987)
(P)	Kahului	2	Windane	340	680	1.8	3.0	Sewage Treatment Plant
	TOTAL + PROPOSED	62			10,780	28.4	47.2	4.1% of Maui demand
MOLOKAI	Residential	3	Various	5	15	0.1	0.1	
	TOTAL	3			15	0.1	0.1	0.1% of Molokai demand
OAHU	Kahuku	1	MOD-5B	3,200	3,200	8.4	14.0	HERS
	Kahuku	15	Westinghouse	600	9,000	23.7	39.4	HERS
	Kahuku	4	Carter	25	100	0.3	0.4	HNEI
	Residential	5	Various	5	25	0.1	0.1	
	TOTAL	25			12,325	32.5	53.9	0.6% of Oahu demand
KAUAI	Residential	3	Jacobs	10	30	0.1	0.1	
	TOTAL	3			30	0.1	0.1	
STATE TOTAL		460			27,730	72.9	121.1	1.0% of State demand
STATE TOTAL + PROPOSED		502			38,410	101.0	167.9	1.4% of State demand

Note: (P) -- proposed wind power developments
Annual kWh are approximate, based on 0.3 capacity factor, and will vary with annual wind conditions
Oil equivalent based on 600 kWh per barrel of oil

APPENDIX C. ORGANIZATIONS INVOLVED IN ENERGY PROGRAMS

Department of Business and Economic Development (DBED)

DBED is the lead agency for the State in energy planning, commercialization, conservation, and information dissemination. With its Director serving as the Energy Resources Coordinator, the Department is actively concerned with the many energy-related programs being carried out by both public and private sectors in Hawaii.

Within DBED, the Energy Division has the primary responsibility for program activities in alternative energy research, development, demonstration and commercialization, energy conservation programs, energy planning and data management, energy emergency preparedness, and public awareness.

DBED's Energy Division coordinates its energy programs and activities with the Hawaii Natural Energy Institute of the University of Hawaii at Manoa, the Natural Energy Laboratory of Hawaii, the U.S. Department of Energy, County and Federal agencies, and other public and private organizations.

Address inquiries to: Mr. Roger Ulveling, Director, Department of Business and Economic Development, 250 South King Street, Honolulu, Hawaii 96813. Telephone (808) 548-3033, or use the Energy Hotline, (808) 548-4080.

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Hawaii Natural Energy Institute (HNEI)

The HNEI, University of Hawaii at Manoa, is the lead agency in the State for basic research activity on Hawaii's natural energy resources. HNEI was established as a research institute to provide focus, visibility and support for research and development activities directed toward converting Hawaii's natural energy resources to viable energy systems.

HNEI, in conjunction with the multidisciplinary research interests throughout the University of Hawaii, conducts research projects related to the development of geothermal, wind, solar thermal, photovoltaic, ocean thermal, biomass energy, synthetic fuels and electric vehicles. As part of HNEI, the Renewable Resources Research Laboratory conducts basic research related to the production of liquid and gaseous fuels from biomass. HNEI operates the Wind Energy Storage Test facility on the Island of Hawaii.

Address inquiries to: Dr. Patrick Takahashi, Director, Hawaii Natural energy Institute, University of Hawaii, Honolulu, Hawaii 96822. Telephone: (808) 948-8366.

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Michael Antal, Jr.

Natural Energy Laboratory of Hawaii (NELH)

NELH manages and operates specialized science and technology parks as sites for research, development, demonstration, and commercialization of natural energy resources and other compatible scientific and technological activities. Placed within DBED for administrative purposes , it has its own managing board consisting of officials from the State of Hawaii, the County of Hawaii, and the University of Hawaii.

NELH manages the Seacoast Facility, located on 328 acres of oceanfront property at Keahole on the Island of Hawaii. OTEC-related experiments have been conducted at the site since 1975, and the facility has been designated as the primary site for OTEC research in the United States.

NELH also manages the Puna Geothermal Facility, which includes the HGP-A geothermal well, the 3-MW wellhead generator plant and *Noi'i O Puna*, the Puna Research Center. All these facilities are sited on four acres near Pahoa on the Island of Hawaii.

Address inquiries to: Mr. Jack Huizingh, Executive Director, Natural Energy Laboratory of Hawaii, 220 South King Street, Suite 1280, Honolulu, Hawaii 96813. Telephone: (808) 548-7017.

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* Funded separately by the Hawaii Energy Extension Service

Pacific International Center for High Technology Research (PICHTR)

PICHTR was established by the Hawaii State Legislature and charged with the responsibility of building a research and development institution with an international focus. In keeping with its mandate to be an international research center in the Pacific region, PICHTR has reached beyond Hawaii's shores to the nations of Asia and the Pacific to promote cooperative high technology research and development.

PICHTR has four major divisions: Energy and Resources, Information Technology, Educational and International, and Biotechnology. Areas of expertise and research within these divisions include such diverse fields as open-cycle OTEC for the production of electricity and fresh water in remote regions, liquid hydrides for hydrogen storage and transport, a technology information network for the Pacific Islands, robotics, and artificial intelligence.

Significant support has come from the government of Japan, which in 1987 contributed $1 million to PICHTR for joint high technology research and development, with another $1 million to be contributed in 1988. This funding is being used to promote the development of a multi-product ocean energy conversion system and to assist with the exchange of information and technology transfer.

PICHTR will be working with the Pacific nations of American Samoa, Tonga and Western Samoa to help solve technological problems and strengthen their higher educational systems.

Address inquiries to: Adm. Ronald Hays (Ret.), President, Pacific International Center for High Technology Research, 2875 South King Street, First Floor, Honolulu, Hawaii 96826. Telephone: (808) 948-7850.

Pacific International Center of High Technology Research Staff

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James Woodruff
Researcher

In addition, PICHTR has professional and support personnel in its Information Technology Division, the Educational and International Division and the Biotechnology Divisions.

Note: Dr. Paul Yuen served as Acting President until the appointment of Adm. Ronald Hayes.

Research Corporation of the University of Hawaii (RCUH)

The RCUH was established to provide an effective mechanism for fostering research and development. RCUH provides fiscal and administrative services for a wide range of energy projects for DBED, HNEI, NELH and PICHTR. Attached to the University of Hawaii for administrative purposes, RCUH is a public, not-for-profit corporation, with its operating income derived from charges for its services.

Address inquiries to: Dr. Fujio Matsuda, Executive Director, Research Corporation of the University of Hawaii, 1110 University Avenue, Honolulu, Hawaii 96826. Telephone: (808) 955-6344.

U.S. Department of Energy (U.S. DOE) - Pacific Site Office

The U.S. DOE Pacific Site Office is a field office of the San Francisco Operations Office. Its primary mission is to represent the U.S. DOE in carrying out its programs and projects in the Pacific region. It serves as liaison agency for a number of DOE-funded programs administered by DBED.

Address inquiries to: Dr. John W. Shupe, Director, U.S. DOE, Pacific Site Office, P.O. Box 339, Honolulu, Hawaii 96809. Telephone: (808) 541-2563.

APPENDIX D. ENERGY COMMITTEES, BOARDS AND TASK FORCES

Representative of business, labor, public interest groups, and the general public have given generously of their time and expertise by serving on several technical and advisory committees together with representatives from Federal, State, and County agencies, and the military. Among these groups are:

The Governor's Geothermal Advisory Board on the Geothermal/Cable Project

The Board was appointed by Governor John Waihee in August 1987 to oversee the planning of the combined Geothermal/Cable Project, and to determine the feasibility of the project and the role the State government should play in the project. Members include top-level government, banking and labor officials. The Chairman is former Governor William F. Quinn, of the law firm Goodsill, Anderson, Quinn and Stifel.

Governor's Advisory Board on the Underwater Cable Transmission Project

Mr. William F. Quinn (Chairman)
Attorney-at-Law

Mr. Roger A. Ulveling, Vice Chairman
Director, Dept of Business and
Economic Development

Mr. John D. Bellinger
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and Chief Executive Officer
First Hawaiian Bank, Inc.

The Honorable Dante K. Carpenter
Mayor, County of Hawaii

Mr. Paul Finazzo
President and Chief Executive
Officer
Hawaiian Airlines

Mr. Sheridan C. F. Ing, General
Partner
Sheridan Ing Partners Hawaii

Dr. Fujio Matsuda, Executive Director
Research Corporation of the
University of Hawaii

Mr. Russell Okata
Executive Director
Hawaii Government Employees Assoc.

The Honorable William W. Paty
Chairman
Board of Land and Natural Resources

Mr. Howard Tasaka, Business Manager
and Financial Secretary
Sheetmetal Workers Union Local 293

Energy Emergency Preparedness Committee

The Committee was appointed in 1988 by Governor John Waihee to provide expert advice on health, safety and oil supply matters relating to the State Energy Emergency Plan. The 24-member committee includes top State and County officials and representatives from labor unions, utilities and oil refineries. The Chairman is Mr. Roger A. Ulveling, Director of DBED.

Proposed Energy Emergency Preparedness Committee Members

Mr. Roger A. Ulveling (Chairman)
Energy Resources Coordinator and
Director
Dept of Business and
Economic Development

Mr. James K. Ahloy, President
Aloha Petroleum, Ltd.

Mr. Richard S.Botti
Executive Director
Dealers'Hawaii Automotive Retail
Gasoline

Mr. Edward Y. Hirata, Director
Department of Transportation

Mr. Maurice H. Kaya (Staff)
Energy Program Administration
Department of Business and Economic
Development

Mr. George Kekuna, Administrator
Oahu Civil Defense Agency
City and County of Honolulu

Mr. Eddie Lapa, President
Local 142
International Longshoremen's and
Warehousemen's Union

Mr. Howard J.T. Lee, President
Gasco, Inc.

Mr. Alexis T. Lum, Adjutant General
Department of Defense

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Mr. Floyd Miyazono
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Union Oil of California

Mr. Robert L. Myrick, District Manager
Shell Oil Company

Mr. Yukio Naito, Chairman
Public Utilities Commission

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Hawaii Government Employees Assoc.

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Private Citizen

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Ms. Winona Rubin, Director
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Mr. Minoru Shintani, Director
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Dr. John W. Shupe (Observer)
Director, Pacific Site Office
U.S. Department of Energy

Mr. Harwood D. Williamson, President and Chief Operation Officer
Hawaiian Electric Company, Inc.

Mr. C.P. Woodland
Division Manager, Marketing
Chevron U.S.A., Inc.

Transportation Fuels Task Force

The task force provides advice and direction to research programs for the development of transportation fuels from indigenous resources. The nine-member task force includes University of Hawaii research institute administrators and program managers for HSPA, DBED and major oil companies. the Chairman is Dr. Michael Antal, Coral Industries Professor of Renewable Energy, University of Hawaii at Manoa.

Dr. Michael Antal, Chairperson
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University of Hawaii at Manoa

Mr. Robert L. Wilson
District Manager
Shell Oil Company

The Used Oil Advisory Committee

This 18-member committee provides advice on proposed legislation and implementation of programs for recycling used oil. the members are environmental, government and industrial representatives who share concern for the disposition and recycling of used oil in Hawaii. The Chairperson is Mr. Richard Botti, Executive Director, Hawaii Automotive and Retail Gasoline Dealers Association.

Used Oil Advisory Committee Members

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Hawaii Auto & Retail Gas Dealers Assn

Barry Helle
Energy Field Representative
County of Maui

Dr. Karl How
Environmental Specialist
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APPENDIX E. ENERGY LEGISLATION ENACTED BY THE 14TH STATE LEGISLATURE, REGULAR SESSION, 1988

Alternative Energy Resources

ACT 172-88 Clarifies the definitions of used and recycled oil and makes administrative changes in the permitting and record keeping procedures. Changes are designed to save used oil for future use and to prevent its improper disposal.

ACT 246-88 Authorized the PUC under certain conditions, to allow payments made by the utility to non-fossil fuel producers of firm capacity to be recovered through an interim increase in rates until the utility's next general rate proceedings.

ACT 301-88 Consolidates permitting procedures for geothermal and cable transmission projects and assigns responsibility to DLNR. Does not apply to applications filed prior to July 1, 1988.

ACT 378-88 Grants the surface owner the first right of refusal for a mining lease where BLNR has determined it appropriate to grant a geothermal lease on reserved lands. Prohibits geothermal development activities on the land within the mining lease until the area is designated a geothermal resource subzone.

Appropriations

ACT 116-88 Appropriates $3 million for a sugar research development program provided that HSPA provides a dollar for dollar match of funds.

ACT 248-88 Appropriates $50,000 for a study by the Legislative Auditor to include assessments of the availability of markets for recycled materials, the economic viability of a recycling program in Hawaii, and ways to encourage service stations to collect used oil.

ACT 311-88 Appropriates $220,000 to the University of Hawaii for a methanol-from-biomass research pilot plant feasibility study by HNEI. Requires matching funds from the Federal government. Also appropriates $2 million to the University of Hawaii for the plans and construction of a methanol-from-biomass research pilot plant.

Authorization for Special Purpose Revenue Bonds

ACT 142-88 Authorizes the issuance of up to $30 million in special purpose revenue bonds to assist Energy Conversion Devices, Inc. or Chronar Corporation in the generation of new capital for the manufacture of amorphous silicone, alloy photovoltaic products of devices in the State of Hawaii. Also requires DBED, with the assistance of HNEI, to do a technical and economic analysis of both corporations and recommend one of the to DBED to be assisted by the issuance of the bonds.

Authorization for Special Purpose Revenue Bonds cont.

ACT 224-88 Authorizes the issuance of special purpose revenue bonds not to exceed $5 million to assist Island Power Company in the construction and operation of the Upper Wailua Hydroelectric Project and related facilities on the Island of Kauai. Provides that the entire electrical output shall be made available for use by the general public through sale to the Citizens Utilities System.

ACT 273-88 Authorizes the issuance of $15 million in special purpose revenue bonds to assist International Pacific Energy Consortium, Inc. to establish a wind energy farm in Maui. Specifies that the electricity produced shall be made available to the general public through sale to Maui Electric Light Company.

ACT 277-88 Authorizes the issuance of special purpose revenue bonds not to exceed $164.4 million for multi-project capital improvement programs for the local furnishing of electric energy by HECO, HELCO, MECO and Kauai Electric Division of Citizens Utilities Company. Requires PUC approval of any project financed by the bonds. Prohibits the use of funds for nuclear fuel generating units.

ACT 299-88 Authorizes the issuance of special purpose revenue bonds in an amount not to exceed $10 million for the purpose of assisting Magnetics Research International Corporation of Hawaii in the generation of new capital for the establishment of a research and development facility to complete the commercial development of the company's base technology of its patented VRM brushless DC motor and sub-assembly products and to manufacture prototype units for the promotion of the VRM technology in commercial and industrial settings.

Studies

HCR 23-88 Requests DBED to identify the needs of Pacific Rim countries with regard to renewable energy needs and systems

HCR 82-88 Requests DBED to study the use of alcohol fuel as an alternative energy source and to address the issues of: (1) determining the feasibility of requiring all bulk purchases of fuel for state-owned vehicles consist of ethanol-blended fuel; (2) how much financial support should be provided for statewide marketing of ethanol or ethanol-blended fuel; (3) development of a program to encourage investors in the production and sale of ethanol and ethanol related products in Hawaii; and (4) developing a marketing strategy, including tax incentives to support an ethanol fuel industry in Hawaii.

HCR 85-88 Requests DBED assisted by hawaiian Sugar Planters' Association, the Department of Agriculture, the UH College of Tropical Agriculture and Human Resources, to continue research into the use of biomass to produce electricity, the development of new energy systems and

Studies cont.

sources to replace petroleum fuels, and the production of high value, co-product chemicals.

HCR 89-88 Requests the Legislative Auditor, assisted by the Legislative Reference Bureau, to conduct a comprehensive audit of Chapter 169 HRS [relating to the Public Utilities Commission] including the policies and procedures under which the PUC is operating and the identification of areas of regulations inhibiting the development of business.

Taxes

ACT 57-88 Exempts from the State Gross Excise Tax amounts arising from the sale and leaseback transaction of a solid waste processing, disposal and electric generating facility by a county.

ACT 64-88 Repeals the tax credit for the cost and installation of materials for insulating hot water heaters and pipes installed after Dec. 31, 1978 and before Dec. 31, 1984.

Other

ACT 43-88 Revised the exemption for gross proceeds from the sale of gasohol to the sale of alcohol fuel, which is defined as a neat biomass-derived alcohol liquid fuel mixed with at least 10 volume percent denatured biomass alcohol. Also clarifies the definition of motorized vehicles capable of being powered by the fuel to include aircraft, seacraft and spacecraft.

ACT 54-88 Grants Maui Electric Company, Ltd. a non-exclusive franchise to provide electric light, current or power in the Island of Lanai.

ACT 286-88 Affirms the policy of the State is to promote privately operated public passenger vehicle service including the pick-up and discharge of passengers by taxicabs. Directs the counties to promote these policies.

ACT 388-88 Requires retail dispenser of gasoline to post the price of gasoline in gallons both at the pump and in advertisements. Does not require that gasoline be sold by the gallon instead of liters.

APPENDIX F. GLOSSARY OF TERMS

AC	Alternating current.
Bbl	Barrel. A unit measure of bulk petroleum equivalent to 42 U.S. gallons.
Btu	British Thermal Unit. The measure of the quantity of heat needed to raise the temperature of one pound of water one degree Fahrenheit. Used to measure energy produced by various sources.
°C	Degrees Celsius, a unit of temperature measured on the Celsius scale, where 0°C is the freezing temperature of water and 100°C is the boiling temperature of water.
DC	Direct current
°F	Degrees Fahrenheit, a unit of temperature measured on the Fahrenheit scale, where 32°F is the freezing temperature of water and 212°F is the boiling temperature of water.
Gasohol	A mixture of ethanol and gasoline. By law, the mixture must contain at least 10 percent by volume of denatured biomass-derived ethanol.
HDWC	Hawaii Deep Water Cable. Proposed undersea electric transmission cable running between the islands of Hawaii and Oahu.
kW	Kilowatt, a unit of power equal to 1,000 Watts.
kWh	Kilowatt hour, a unit of work or energy expended by one kilowatt in one hour.
MSW	Municipal solid waste used as an energy source
MW	Megawatt, a unit of electric power equal to 1 million watts.
OTEC	Ocean thermal energy conversion
PV	Photovoltaic, referring to the direct conversion of solar radiation to direct-current electricity.
WECS	Wind energy conversion systems.