

**State  
Energy Resources Coordinator**



**Annual Report  
1998**

**State of Hawai'i  
Department of Business, Economic Development & Tourism**

**State  
Energy Resources Coordinator**

**Annual Report  
1998**

**State of Hawai'i  
Department of Business, Economic Development & Tourism**

This report was prepared as an account of work sponsored in part by the United States Government, grant # DE-FG51-97R020881. Neither the United States nor the United States Department of Energy, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been cataloged as follows:

Hawai'i. Energy Resources Coordinator.

Report—Hawai'i. Energy Resources Coordinator. Honolulu: Dept. of Business, Economic Development, and Tourism, State of Hawai'i, 1976-.

Annual.

1. Energy Policy—Hawai'i. I. Hawai'i. Dept. of Business, Economic Development, and Tourism.

HD9502.H383.1998

# Contents

1. Hawai'i's Energy Program	1
2. Energy and the Economy	3
3. 1998 Program Achievements	5
4. Trends and Recommendations	22
5. Appendix	25

## Figures and Tables

Figure 1. Petroleum Imports	1
Figure 2. Key Energy and Economic Indicators in Hawai'i, 1970 to 1997	3
Figure 3. Liquid Fuel Distribution by County, 1997	8
Figure 4. Primary Energy Sources in Hawai'i, 1962 to 1997, Selected Years	11
Figure 5. Trends in Transportation Energy Use	24
Table 1. ERTD Energy Program Budget, FY 97/98	5
Table 2. Primary Energy Consumption and Energy Consumption per Dollar of Constant Gross State Product, Hawai'i: 1960 to 1997	25
Table 3. Primary Energy Consumption and Per Capita Consumption, Hawai'i: 1960 to 1997	26
Table 4. Primary Energy Consumption by Source, Hawai'i (Trillion Btu)	27
Table 5. Primary Energy Consumption by Source, Hawai'i (Percent by Source)	28
Table 6. World Crude Oil & Natural Gas Reserves: Jan. 1, 1998	29
Table 7. Imports and Exports of Crude Oil and Petroleum Products: 1997	30
Table 8. Electricity Generation by Source: 1987 to 1997	30
Table 9. Electricity Production, by Source, by Islands: 1997	30
Table 10. Petroleum Consumption, Hawai'i	31
Table 11. Expenditures for Fuels and Electricity, by Source: 1985 to 1997	32
Table 12. Electricity Sales & Gross State Product, Hawai'i: 1960 to 1997	33
Table 13. Electricity Sales and DeFacto Population, Hawai'i: 1960 to 1997	34
Table 14. Electricity Sales, Hawai'i: 1960 to 1997	35
Table 15. Average kWh Use and Rates, Hawai'i: 1960 to 1997	36
Table 16. Wind Power in Hawai'i: 1997	37
Table 17. Hydroelectric Power Plants in Hawai'i: 1997	38

# Hawai'i's Energy Program

In 1974, as a response to the "Energy Crisis" generated by the OPEC oil embargo, the Hawai'i State Legislature created the position of Energy Resources Coordinator. The director of the Department of Planning and Economic Development (presently, the Department of Business, Economic Development & Tourism, or DBEDT) was designated as the Energy Resources Coordinator.

## Legislature defines the duties of the Energy Resources Coordinator

The oil embargo made Hawai'i's vulnerability to dislocations in the world oil market obvious, as have a number of other, more recent events, including the Persian Gulf War. Hawai'i is highly dependent upon oil, all of which is imported, primarily from foreign countries (see Figure 1). In 1997, petroleum supplied 88 percent of the state's total energy, more than in any other state.

Noting Hawai'i's wealth of renewable energy resources, the Coordinator was directed by the Legislature to coordinate energy conservation and alternative energy development efforts statewide.

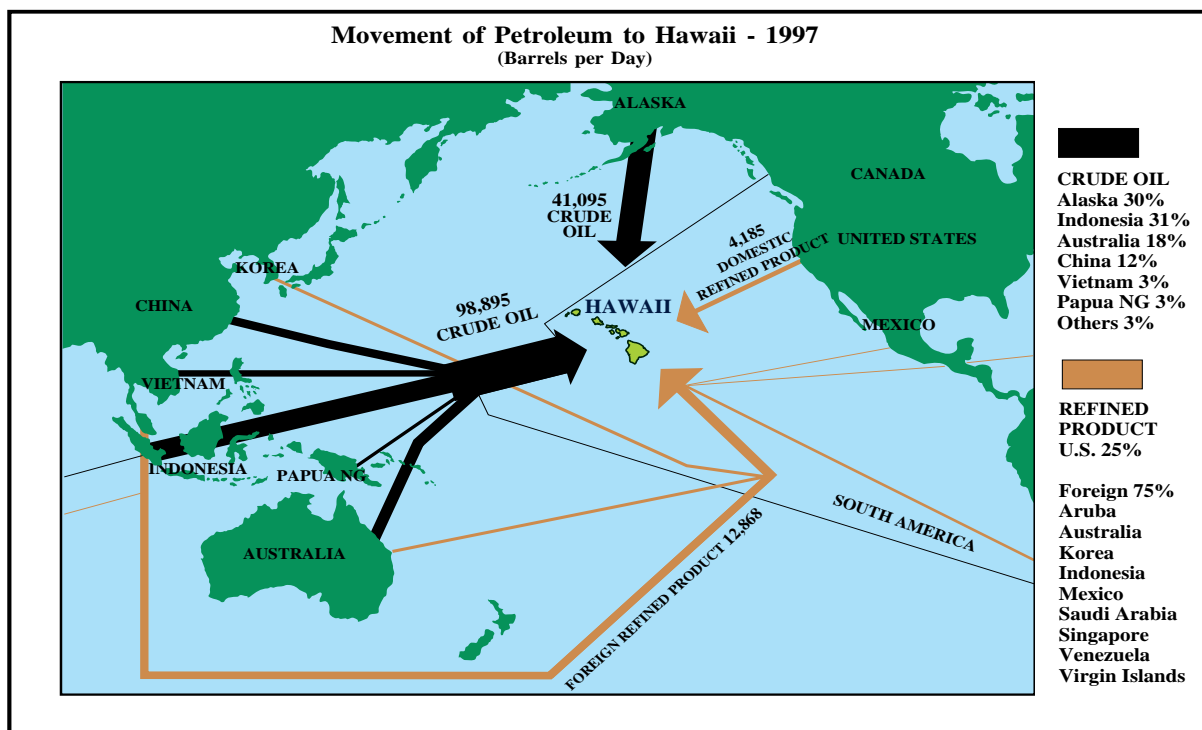


Figure 1. Petroleum Imports

## **State Plan provides statutory guidance for programs**

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

- ◇ dependable, efficient, and economical statewide energy systems capable of meeting the needs of the people;
- ◇ increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased; and
- ◇ greater energy security in the face of threats to Hawai'i's energy supplies and systems.

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

## **Energy, Resources, and Technology Division implements programs**

Assisting the Coordinator in implementing programs to meet the state's energy goals, the Energy, Resources, and Technology Division (ERTD) is pursuing the complementary objectives of increasing energy efficiency while diversifying energy sources. Additional goals include increasing public awareness of energy issues, preparing for energy emergencies, and developing resource-efficient businesses in the fields of recycling and remanufacturing. Also, ERTD planners are expanding opportunities for strategic economic development in the Pacific Basin, including the export of energy and environmental expertise.

# Energy and the Economy

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

## Efficiency Reduces Per Capita Energy Use

In 1997, overall energy use per capita (based on de facto population) held steady compared to the previous year (see Figure 2). Greater efficiency has resulted in a 13 percent decline in energy use per capita since 1970.

This decline has primarily been in the non-electricity sectors such as transportation, which represent about two-thirds of overall energy use. In contrast, electricity sales have generally continued to rise faster than the population has grown, and until recently have also risen faster than the Gross State Product (GSP).

In 1997, an estimated 316 trillion Btu of primary energy was consumed in Hawai'i. Petroleum consumption totalled 48.7 million barrels.

## Slight Decline in Per Capita Electricity Use and Sales

During 1997, as shown in Figure 2, electricity sales decreased slightly (0.36 percent) compared to GSP growth of 1.5 percent (with GSP calculated in constant

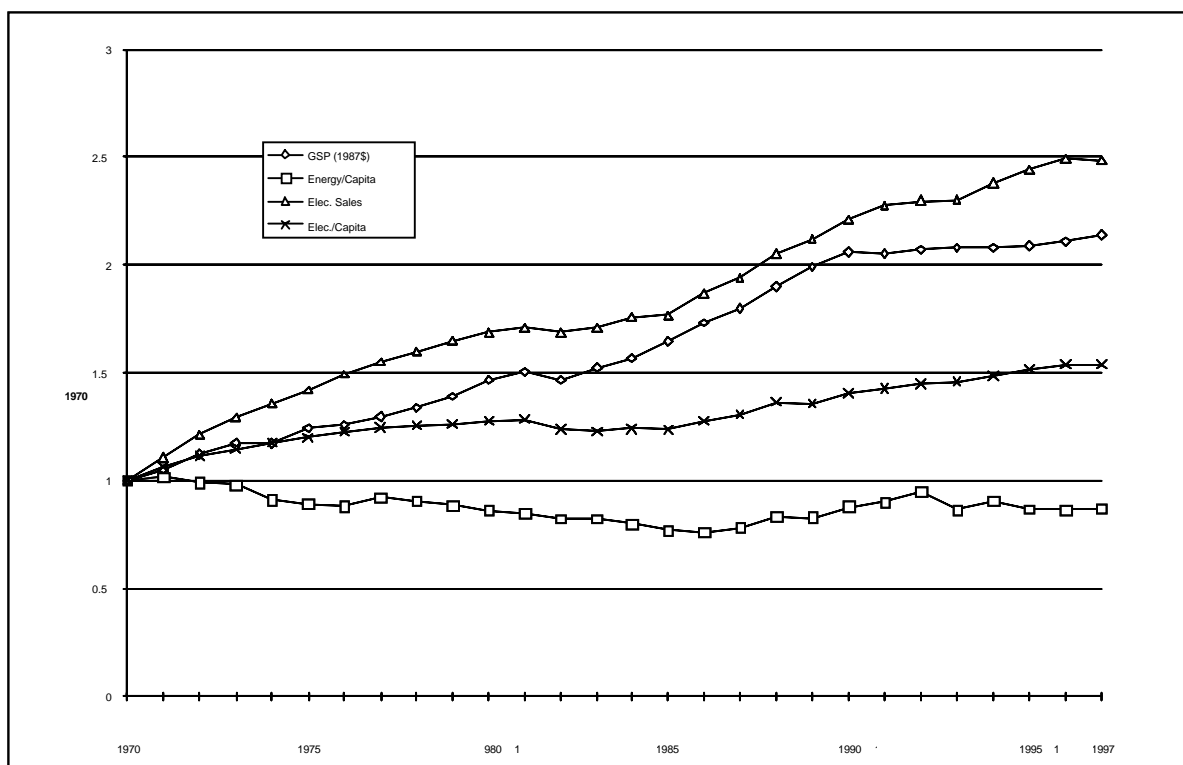


Figure 2. Key Energy and Economic Indicators in Hawai'i, 1970 to 1997

dollars). This corresponded to a slight decrease in per capita sales, less than the rate of de facto population growth for the first time since 1989.

Despite the drop in 1997, electricity sales have generally been growing strongly since 1970. Electricity sales in 1997 were two-and-a-half times 1970 levels.

In 1997, isle residents and businesses spent \$2.76 billion on energy, or about eight percent of the \$34.24 billion GSP (in 1997 dollars).

### **Programs Encourage Economic Diversification & Competitiveness**

DBEDT continues to attract significant out-of-state funds for energy and technology programs which benefit the residential, commercial and transportation sectors of the state's economy. In FY 1997/98, \$2.3 million in federal grants was authorized to encourage resource conservation, promote energy efficiency, expand alternative energy use, develop recycling, and continue energy planning.

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

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



# 1998 Program Achievements

The Energy, Resources, and Technology Division (ERTD) of DBEDT continued its efforts in a wide range of programs affecting policy development, energy efficiency, renewable energy, strategic planning, regional technological development, information dissemination, and remanufacturing ventures. The achievements during 1998 are outlined below.

## Programs and Efficiency Improvements Garner Awards

In March, the State received a U.S. Department of Energy's (USDOE) "Rebuild America State Innovator" award, recognizing ERTD's leadership in both marketing the program and working with the growing number of Rebuild America partnerships in Hawai'i. The State also received a Certificate of Environmental Achievement from Renew America for its previously-completed Hawai'i Energy Strategy.

Hawai'i's leadership was recognized by the U.S. Environmental Protection Agency (EPA) in June, when the State was awarded a Certificate of Recognition for the analysis which led to the State Climate Action Plan.

The EPA also presented the "1998 Challenge for Energy Excellence" certificate to the State for reducing energy consumption for lighting, saving \$9.2 million to date. The award was issued in October by EPA's Green Lights Program, a voluntary effort of private businesses and public agencies to retrofit their lighting systems, saving energy and improving the quality of light. ERTD played a key role by recruiting partners and sponsoring technical workshops.

Description	State Funds	Federal Grants	Total
<b>Education</b>	<b>0</b>	<b>20,181</b>	<b>20,181</b>
<b>Transportation</b>	<b>37,200</b>	<b>150,000</b>	<b>187,200</b>
<b>Buildings</b>	<b>0</b>	<b>854,210</b>	<b>854,210</b>
<b>Industrial</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Utilities</b>	<b>75,000</b>	<b>714,800</b>	<b>789,800</b>
<b>Strategic Technology</b>	<b>55,000</b>	<b>339,000</b>	<b>394,000</b>
<b>Recycling</b>	<b>50,000</b>	<b>236,000</b>	<b>286,000</b>
<b>TOTAL</b>	<b>217,200</b>	<b>2,314,191</b>	<b>2,531,391</b>

**Table 1. ERTD Energy Program Budget, FY 97/98**

In September, Governor Benjamin Cayetano recognized the University of Hawai'i at Hilo and 13 other State agencies for their efforts to reduce the cost of government by investing in energy efficiency.

Acknowledging his leadership in the Rebuild America initiative, Raymond Carr, energy coordinator for Hawai'i County, was nominated for the 1998 Energy Champion Awards offered by the USDOE. Carr leads the Rebuild Hawai'i Island program, which has the dual purpose of improving energy efficiency in government facilities and guiding a local community in its efforts to find "soft energy" solutions. The community group, Na Makani Energy Initiative, encompasses some 5,000 residents of North Kohala and has the goal of greater sustainability and self-sufficiency.

Rebuild Hawai'i, a statewide consortium of public sector organizations, private companies, and technical and business experts interested in energy efficiency, was recognized at the 1998 Efficient Electro-Technologies Expo and Conference in October. The consortium is led by ERTD staff. At the meeting, a Certificate of Appreciation was presented to Gov. Benjamin Cayetano for the state's commitment to the Rebuild Hawai'i program. Additionally, Gov. Cayetano proclaimed October 1998 to be "Rebuild America in Hawai'i Month."

Innovative energy efficiency projects on O'ahu were recognized by Hawaiian Electric Company (HECO) with its 1998 Energy Efficiency Awards, also announced during the Efficient Electro-Technologies Expo. ERTD staff served as judges and members of the steering committee. The Hawai'i Convention Center was named Energy Project of the Year, acknowledging the designers' "whole building" perspective in energy efficiency which includes an energy management system, flexible lighting options, and heat recovery.

## **Public Utility Issues Include Possible Increased Competition**

ERTD continued its participation in the integrated resource planning (IRP) process mandated by the Hawai'i Public Utilities Commission (PUC).

HECO filed its second IRP during January. ERTD staff attended advisory group meetings during the development of the second Hawai'i Electric Light Company (HELCO) IRP, which was filed in September. Staff are now participating in advisory groups for the second Maui Electric Company IRP and The Gas Company's second IRP, both of which are scheduled for completion in 1999.

As part of the IRP process, ERTD staff continue to monitor utility demand-side management (DSM) programs. These efforts attempt to modify customers' energy use, employing rebates and other incentives to achieve efficiency and reduce peak loads.

The DSM programs implemented by HELCO achieved a 1997 net reduction in capacity requirements of 0.776 megawatts and 5,095 megawatt-hours of energy savings. Although final figures are not available, 1998's goals were a capacity reduction of 0.991 megawatts and 5,413 megawatt-hours. ERTD has commended HELCO on the objectives and flexibility of its DSM programs.

In 1997, HECO's DSM programs resulted in 7.7 megawatts of capacity reduction and 38,400 megawatt-hours of energy savings. Projections for 1998 are 6.6 megawatts and 46,257 megawatt-hours.

Hawai'i continues its process of examining the structure of the electric utility industry. Anticipated benefits from restructuring, which has been initiated in some mainland states, include reduced electricity rates. A collaborative group examined the issues in 1997, but was unable to achieve consensus. Therefore, in early 1998, each party began to prepare independent position papers. The counties of Maui and Kaua'i prepared a joint paper, supported by Hawai'i County, which recommended a phased approach to competition, beginning with restructuring the retail energy services market. After a midyear clarifying meeting of the collaborative group, the participants submitted their position statements to the PUC in October.

### **Lack of Competition in Gasoline Prices Spurs Suit**

For a number of years, the State had investigated the price of retail gasoline sold in the islands because of concerns over the apparent lack of competition in the industry. Despite the recent decline of crude oil prices, which was reflected in savings at the pump on the mainland, Hawai'i prices remained high.

In 1998, a Petroleum Advisory Council was convened to advise the Coordinator of factors affecting statewide gasoline prices. The Council met between April and August to discuss pricing issues and the nature of the gasoline market in Hawai'i. In October, however, the collaborative nature of the process changed when the Attorney General decided to sue the industry for alleged overcharging and violation of antitrust laws. Action is pending on the suit.

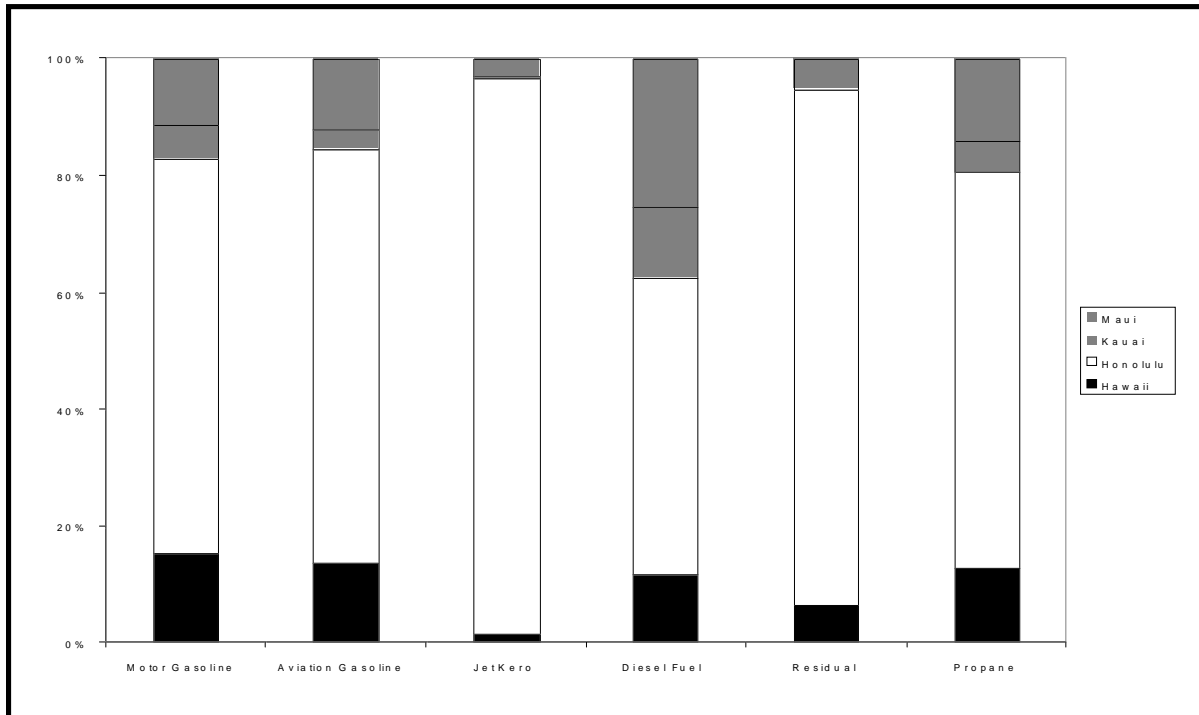
As a result of the 1997 law expanding the collection of data affecting all aspects of the petroleum industry, administrative rules are being prepared. This law will allow ERTD to collect monthly weighted average prices for gasoline, diesel, jet fuel and residual fuel, and tracking interisland transportation and storage of petroleum fuels. Figure 3 outlines the distribution of petroleum fuels among the counties.

### **Climate Study Produces Plan to Reduce Greenhouse Gases**

Supported by a grant from EPA, ERTD and the State Department of Health completed a Hawai'i Climate Change Action Plan in November 1998. Building on the previously-completed Greenhouse Gas Reduction Strategy, the action plan examines potential effects of climate change on Hawai'i, ways in which Hawai'i can reduce greenhouse gas emissions that cause climate change, and future technology which may further reduce emissions.

### **Preparing for Emergencies Means Applying Lessons Learned**

Modeling the impacts of another devastating hurricane, ERTD staff, industry representatives, emergency responders from the mainland, and energy



**Figure 3. Liquid Fuel Distribution by County, 1997**

coordinators from the counties and the U.S. Pacific Islands participated in "Makani Pahili 98," the annual State Civil Defense emergency preparedness seminar and exercise which was held in May. Following a declaration of an emergency by the Governor, a statewide Energy Council can be formed to prioritize the restoration of electrical and energy systems. The Council's recommendations are intended to support the actions of the private sector, which will be the initial respondent in an emergency situation. The seminar provided an opportunity to simulate the functions of the Council and support agencies, and introduced the participants to the capabilities of the Pacific Disaster Center.

Among the first items of concern in post-disaster confusion is the status of emergency backup power systems. ERTD is developing a database to document the technical specifications of backup generators in emergency and essential service facilities statewide.

Kaua'i, having been directly impacted by two hurricanes in recent decades, is taking emergency planning very seriously. A Kaua'i Energy Council began meeting on a monthly basis in 1998, offering an opportunity to coordinate the activities of the electric and gas utilities, communications companies, petroleum providers, and the county's Departments of Water and Public Works and its Civil Defense agency. Kaua'i County has also initiated a survey of critical and lifeline services facilities to determine their power loads, the status and specifications of backup generators, and other essential information. The findings will complement the state's emergency generator inventory.

In a related activity, the state's Energy Council is also discussing the potential impact of the "Y2K" situation, noting that computerized systems that do not recognize the calendar change to the year 2000 may impact energy companies. The State has already taken steps to bring its computer system into compliance.

### **Photovoltaic Projects Bring Solar Energy to Island Communities**

The Million Solar Roofs Initiative, announced by President Clinton in June 1997, will encourage additional photovoltaic (PV) and solar thermal installations statewide. Hawai'i County was selected as one of the first nine communities to participate; the County and HELCO are partners in this effort, which received a \$25,000 grant from the USDOE. A solar-powered circulating fountain and descriptive kiosk at Lili'uokalani Gardens in Hilo, designed to complement the ambiance of the formal Japanese setting, is planned.

A significantly larger private system, 100 kilowatts of PVs, was dedicated at the Mauna Lani Bay Resort in South Kohala in May with support from the Utility Photovoltaics Group. Expected energy production from the system is some 423 kilowatt-hours daily, and since the array is mounted on insulating panels, the roof of the hotel is also cooler by approximately 60°F.

Maui County celebrated the grand opening of its largest regional park and its first photovoltaic lighting system in September. Nineteen solar lights illuminate 1,900 feet of a jogging trail within Keopuolani Park in Wailuku. Each light will operate for six hours nightly. The system totals two kilowatts and has a four-day reserve capacity. It is designed to be vandal-resistant and can withstand 120-mph hurricane winds. The total installed cost was approximately \$77,000 (\$4,000 per fixture), \$15,400 less than the capital costs of a comparable system provided by the electric utility company. In addition, the solar lights will save Maui County about \$400 in electricity costs annually.

Use of solar electricity on military installations is accelerating. The 18-kilowatt PV system at Hickam Air Force Base continued to operate, although corrosion caused some leakage in the system's inverters. The University of Hawai'i (U.H.) School of Architecture plans to install a 2-kilowatt building-integrated photovoltaic system on the Ford Island Boat House in Pearl Harbor; roofing material containing PV cells will generate electricity.

The electric utilities' "Sun Power for Schools" program, financed in part by voluntary ratepayer contributions, resulted in two-kilowatt systems at McKinley and Waianae High Schools coming on line in January. A similar system was installed at Kaimuki High School in 1997, as was a one-kilowatt array at Baldwin High School. Additional installations at Waipahu, Mililani, Waiialua, Campbell, Moloka'i and Kealakehe High Schools are underway.

One of the state's larger PV installations, the 20-kilowatt PVUSA utility-connected system in Kihei, continues to generate electricity after an inverter replacement. The 15-kilowatt rooftop system on the public gymnasium in Kailua-Kona also continued to provide electricity to the grid and insulation to the gym. On a different scale, HELCO's off-grid residential PV pilot project completed six

months of data collection in April after three stand-alone systems were tested at Big Island homes. These systems had capacities of 600, 900 and 1200 watts, respectively.

PVs will also provide power to critical water supplies, sirens, and other essential services under a \$131,000 grant from USDOE in 1999. Among the projects will be a solar-powered Sensory Control and Data Acquisition (SCADA) system for six remote Kaua'i Water Department sites which will allow real-time monitoring of water supplies and an early warning of potential problems.

In order to promote acceptance of photovoltaic systems, ERTD continued to facilitate the PV4U (Photovoltaics for Utilities) group. Issues such as photovoltaics' role in a restructured utility market, local government opportunities to promote solar, and information resources were discussed.



**Governor Benjamin Cayetano is congratulated by Cully Judd, representing the Hawai'i Solar Energy Association, after extending the state's energy tax credits.**

---

## **Renewables Continue Contributions Statewide**

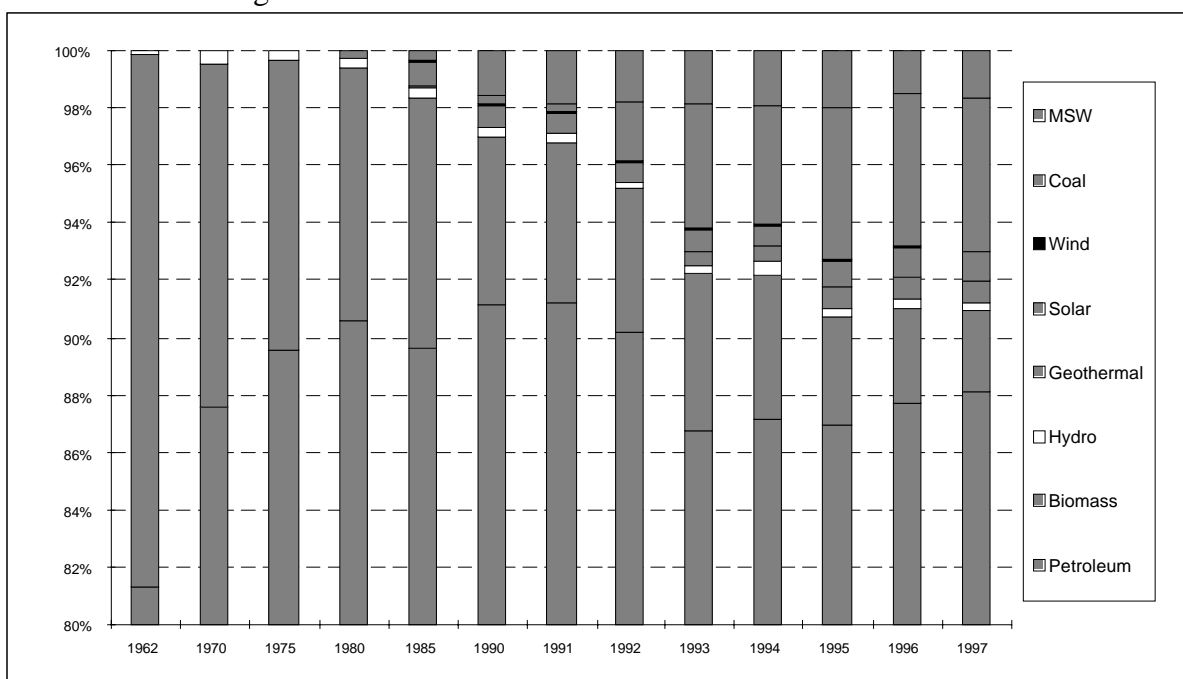
A noteworthy result of the 1998 legislative session was Act 163, which extended the energy tax credits until July 1, 2003. Coupled with ongoing utility rebate programs, which are part of the IRP process, the credits will encourage continued installation of this popular technology. Tax credits are presently at 35 percent for residential and commercial solar water heating and photovoltaic systems, 20 percent for heat pumps and wind systems, and 50 percent for ice storage systems. An estimated 60,000 homes have been solarized statewide.

Act 163 also established a task force to explore the most cost-effective means for supporting increased energy efficiency and sustainable energy.

To ensure that government facilities save energy and money, Governor Benjamin Cayetano issued a directive to all State agencies during April, establishing a policy to incorporate solar water heating in public facilities. Effective January 1, 1999, all plans for new or renovated facilities using State funds or located on State lands and incorporating the use of hot water shall compare the costs and benefits of solar versus conventional water heating. If the life-cycle analysis is favorable, solar water heating shall be installed. The policy further requires an analysis of solar preheating, if water heating entirely by solar energy is not cost-effective. The ERTD will develop guidelines for conducting these required cost-benefit analyses.

Although no new multimegawatt renewable energy facilities came on-line in 1998, existing plants utilizing geothermal steam, wind, biomass, municipal waste and hydropower continued to operate reliably. Municipal solid waste was the largest contributor, generating 371 million kilowatt-hours in 1997. Geothermal and biomass (primarily sugarcane bagasse) were responsible for 229 and 226 million kilowatt-hours, respectively. On the island of Hawai'i, geothermal resources continued to provide approximately one-fourth of the island's electricity. The contributions of renewable resources are shown in Figure 4.

Two major research projects wound down in 1998. Operations at the biogasifier at Pa'ia, Maui were terminated following persistent difficulties with the materials handling system. At the open-cycle OTEC facility, located at Keahole Point, Kona, USDOE funded additional research to demonstrate frequency control under varying power production and demand conditions. The facility will be dismantled in early 1999. Research and development at the adjoining closed-cycle OTEC project will continue with remanufactured heat exchangers.



**Figure 4. Primary Energy Sources in Hawai'i, 1962 to 1997, Selected Years**

## Partnerships Extend Programs' Effectiveness

The ERTD continued its Neighbor Island Assistance Program with funding from USDOE. In Fiscal Year 97/98, \$139,980 was budgeted for economic development projects involving energy efficiency and renewable energy technologies in the counties of Kaua'i and Hawai'i. The counties provided cost-sharing and services worth an additional \$118,307.

Opportunities to save energy are varied and numerous. For instance, computerized gas controllers are being installed statewide on swimming pool water heaters. The microprocessor-based devices constantly monitor total demand on the boiler, and proportionately adjust the burner's cycles for optimum efficiency. This technology reduces fuel consumption, extends equipment life, and reduces emissions. Maui County has found that one of its two retrofits has reduced gas consumption by 38 percent, saving some \$8,000 annually.

Technical assistance was provided by ERTD through its Motor Challenge program to the counties in order to improve the efficiency of large pumping systems. Each county is also participating in the USDOE's Rebuild America program, with technical support from ERTD. This effort focuses on community involvement and partnerships to implement energy efficiency projects.

## "Rebuild Hawai'i" Emphasizes Performance Contracting

The statewide program which promotes energy efficiency as a catalyst for development, Rebuild Hawai'i State, encompasses a number of cooperative endeavors. Its major thrust is the promotion of performance contracting: using private expertise and up-front investment to improve efficiency, paid back to the contractor from resulting energy and cost savings. ERTD has retained a technical consultant to assist with complex issues, and continues to update its *Guide to Energy Performance Contracting* by incorporating lessons learned.



The nine active Rebuild Hawai'i partnerships statewide have targeted over 9.3 million square feet of public facilities for efficiency retrofits which will save more than \$11.6 million annually. Over the past two years, ERTD has received \$198,000 in competitive grant awards from USDOE's Rebuild America Program. The funds support partners' participation in conferences and training workshops, as well as project implementation.

To create a focused effort, ERTD hosted a "Rebuild Hawai'i Retreat" in March for 18 program partners. Participants in the two-day event discussed ways



to support community programs, implement energy efficiency projects, and identify and leverage state resources. Rebuild Hawai'i participants include representatives from four counties, five state agencies, the University of Hawai'i, the Judiciary, five public utilities, the U.S. Department of Housing and Urban Development, and USDOE.

Among the cooperative efforts is the development of a data gathering and reporting system for all partners consistent with national programs. Rebuild Hawai'i is also developing, in cooperation with HECO, a program which will determine new market approaches for energy efficiency in the small commercial sector, examine ways to overcome barriers to the installation of efficient devices, and identify means to encourage participation in existing utility-sponsored energy efficiency programs.

The benefits of performance contracting are being documented by Hawai'i County, which obtained its first year of data from the retrofit of its main county building. So far, cumulative cost savings are \$69,207, which is above expectations. The County hopes to improve efficiency in the remainder of its facilities—totaling nearly 800,000 square feet in over 200 accounts—with a second performance contract, which was under negotiation at the end of 1998.

Savings have also been documented at the University of Hawai'i at Hilo, which completed \$2.9 million of performance contracting retrofits in 1997. Savings generated from the beginning of the construction period through June 1998 were \$804,000, exceeding the contract's guaranteed savings by \$83,000. Energy savings over the 10-year term of the contract are expected to be \$6.6 million. Lighting retrofits are being pursued by Kapi'olani Community College and Windward Community College.

Kaua'i County's performance contract for 29 public facilities is also producing data. Savings for the first six months after installation—including energy, operations and maintenance costs—totaled \$39,047, slightly above the guaranteed amount. Monitoring has proven to be a complicated matter at Vidinha Stadium and the War Memorial Convention Hall, two high-use public facilities where energy consumption fluctuates widely from year to year. Retrofit work in the remaining county facilities is being planned, including four main wastewater treatment plants for which energy audits have been completed. DBEDT is also providing funding for a technical analysis of the Kaua'i Water Department energy audit.

Maui County is hiring a consultant to provide technical assistance for performance contracting. Other performance contracts are being seriously pursued by the Hawai'i Army National Guard, the Judiciary, the State Library system, and several public schools.

## **Transportation Initiatives Promote Alternatives**

Another cooperative program, Clean Cities, is accelerating the use of alternative fuels in municipal and private vehicle fleets. The ERTD works with the Clean Cities consortium, providing outreach programs to recruit nontraditional

stakeholders and encourage wider acceptance of nongasoline-powered vehicles. This public/private partnership helps private fleets use alternative fuels to meet federal emissions requirements.

One of the alternative fuels available in Hawai'i is propane, already in use in a number of passenger and industrial vehicles, including some of the state government fleet. Propane engines for Class 8 trucks will be developed under a Clean Cities project with the City and County of Honolulu.

Other alternative fuels include alcohol mixes, electricity and biodiesel. Biodiesel, manufactured from used vegetable oils on Maui, is being used in heavy-duty trucks on that island.

Electric vehicles (EVs) have been in use by the state government, University of Hawai'i, and a number of private enthusiasts for years. Several dozen additional electric vehicles have been introduced through DBEDT's Electric Vehicle Demonstration Project, supported by the federal Advanced Research Project Agency. Addressing the need for daytime "refueling," a new rapid charger was unveiled in October at the EV demonstration project facility in Kaka'ako. Twenty additional chargers will be installed around O'ahu for public use. The device can charge an EV's batteries in less than nine minutes, at an estimated cost of less than \$2.00.

Overnight charging of EV batteries is a less expensive option due to HECO's recently-approved nighttime electricity rates of about 7.5 cents per kilowatt-hour on O'ahu, a significant reduction from existing residential rates. Other incentives include the waiving of state and municipal parking meter fees for EVs, special license plates, use of the high-occupancy vehicle lane on freeways, and waiving vehicle registration fees until June 30, 2002. Also, several electric vehicle manufacturers have announced plans to offer EVs for sale or rent to fleets and the general public in 1999.

## **Resource Conservation, Efficiency Promoted in Buildings**

The Advanced Building Technologies Program is training local residential building designers and contractors in the use of energy efficient, recycled, and nontoxic materials. Conducted by ERTD, the effort involves nearly one dozen partners, including the American Lung Association, the Building Industry Association of Hawai'i, the City and County of Honolulu, the State Department of Health, HECO, and the U.H. School of Architecture.

The program includes curriculum development, statewide workshops during 1999, and a mobile display of ways to make homes more comfortable, durable, healthier, affordable, and efficient. Complementing existing efforts, guidelines for designing and building energy-efficient residential buildings will be developed by the Honolulu Chapter of the American Institute of Architects.

In a complementary effort, ERTD is developing a program to evaluate the effectiveness of residential insulation by monitoring temperatures in at least four homes. Though not widely used in residential construction, roof insulation can improve comfort and reduce the need for air conditioning.

Assessing the progress attained by implementing the commercial buildings section of the State's Model Energy Code in three counties, ERTD undertook a two-week review of building permits on O'ahu and Hawai'i islands. After analyzing the data, a compliance report, believed to be one of the first in the nation, was prepared. The report documented excellent compliance with the Code in nearly all types of buildings, indicating progress toward the goal of reducing peak electricity demand by 50 megawatts in 20 years.

Hawai'i's HiLight software program, which helps lighting designers comply with the lighting section of the Model Energy Code, was further refined to be readily adaptable by any entity using ASHRAE 90-1-1989 as the basis for its lighting standards. The improved HiLight program was presented to the Federal Energy Managers (FEMP) conference in Bellevue, Washington, and to state and private sector professionals in Madison, Wisconsin, in August. The State of Wisconsin is considering incorporating HiLight into its own energy code. Additional training programs for the USDOE's Southeast and Midwest regions have been arranged.

### **Recycling and Remanufacturing Supported by Clean Hawai'i Center**

Established by the Legislature in 1994, ERTD's Clean Hawai'i Center (CHC) helps local businesses develop markets for their recycled and remanufactured products and encourages industry expansion. With funding support from EPA, the State Department of Health, and DBEDT, the Clean Hawai'i Center offers counseling related to business development, financing, product development,



**Chris DeSante (l) and Bernie Boltz, two of the principals of Intech, Inc., display the oil change boxes they manufacture using recycled newsprint.**

demonstration and marketing. CHC also sponsors workshops and exhibits, develops printed materials, and promotes the Buy Recycled in Hawai'i campaign.

An industry database of over 120 businesses has been compiled by the Small Business Development Center network under contract to CHC and is currently under review. The Small Business Development Center is also providing one-on-one consulting and technical assistance to approximately ten selected recycling businesses.

Based in part upon the success of previous efforts, CHC awarded three new remanufacturing product development contracts following a Request for Proposals in 1997. The recipients—Aloha Plastic Recycling, Inc.; Intech, Inc.; and Pacific Allied Products, Ltd.—are developing markets for plastic, pulverized cellulose, and polystyrene, respectively. A third Request for Proposals for remanufacturing product development was issued in the spring of 1998, and contracts are being negotiated.

To more thoroughly understand the nature of the state's waste materials, CHC is conducting a study of the composition of O'ahu's construction and demolition debris. Since this debris comprises almost one-third of the state's wastestream, CHC is focusing on market development for construction and demolition materials and processors, as well as workshops and forums for the industry. Also, to promote recycled, nontoxic, energy- and resource-efficient products in the workplace, CHC is developing a Green Office exhibit.

To facilitate the reuse of materials which might otherwise be discarded, ERTD is helping to establish a materials exchange facility on Kaua'i. After an August groundbreaking for the Kaua'i Resource Exchange Center, construction commenced; an operator for the facility will be selected in early 1999. Kaua'i County has already contracted with the Kaua'i Business Assistance Corporation to provide training classes for entrepreneurs associated with the Center. Assessments are underway for similar facilities on O'ahu and Hawai'i. On Maui, a paint exchange program is being developed.

On June 30, 1999, CHC will sunset in accordance with state law. Supported over the past five years by \$220,000 in state general funds, CHC has initiated programs which generated an additional \$1,550,642 in federal funds, private matching funds and state special funds to support recycling and remanufacturing business development. Six recycling/remanufacturing businesses received \$230,000 in contract support from CHC, generating private matches of cash and in-kind services totaling \$504,642, creating at least nine new full-time equivalent jobs, and increasing capital investments by \$506,230. In addition, 4,500 tons of recycled material were made into products annually, and the companies increased capacity by over 26,400 tons per year.

## **Helping Hawai'i Companies do Business in Asia & the Pacific**

Hawai'i's Strategic Technology Market Assessment and Development (STMAD) program was designed to facilitate increased exports of U.S. energy, environmental, and other sustainable technologies and related services into Asia-

Pacific markets. A key objective is to facilitate technology-related economic development in Hawai'i, concurrently creating high-value jobs and diversifying the state's economy.

This type of governmental facilitation of U.S. technology exports is a major component of USDOE's draft Comprehensive National Energy Strategy. STMAD involves a number of active partners, including the National Association of State Energy Officials, the Export Council for Energy Efficiency, and the National Association of Energy Service Companies.

To support STMAD, infrastructure profiles for 19 Asian countries have been completed. The summaries provide an assessment of basic infrastructure and technology needs, investment climate, and potential market opportunities. The countries profiled include Australia, Brunei, Cambodia, China/Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Myanmar, New Zealand, Papua New Guinea, Philippines, Russia, Singapore, South Korea, Taiwan, Thailand, and Vietnam. Internet access to the reports is at [http://www.hawaii.gov/dbedt/ert/stid\\_br.html](http://www.hawaii.gov/dbedt/ert/stid_br.html).

ERTD received a federal grant of \$141,500 to conduct an Energy Efficiency Technology and Policy Transfer Project for improving environmental protection in the Philippines. The award, one of only seven nationally, builds upon a grant of \$30,000 received last year to introduce Hawai'i's model energy codes and standards to the island republic. The current project promotes the use of performance contracting and demand-side management, and will contribute to the Philippines' efforts to reduce greenhouse gas emissions. A major conference on the project was planned and held in Honolulu in February 1999, with a follow-up workshop in Manila at the end of May.

Mainland and Hawai'i-based companies met with Philippine policy makers and business leaders at a June workshop in Manila to inform them of available technologies and services as well as policies to facilitate their commercial application. A second workshop is scheduled for May 1999, when government and company officials from the Philippines will visit Honolulu to see firsthand the advancement in energy efficiency technologies available in the State.

Also in June, work began on a biomass-to-energy project for the Philippines being conducted by the U.H. An inventory and projections of the availability of biomass feedstocks, plus an analysis of bioconversion technologies, will be produced, resulting in recommendations for commercial applications. Economic, social and environmental impacts will also be assessed.

A two-year analysis of the energy and environmental technology needs of Hainan Province, People's Republic of China, is underway. In November, in conjunction with the DBEDT-sponsored trade mission, a technical infrastructure assessment began. Hainan boasts progressive economic policies along with a rapidly growing demand for electric power; renewable energy resources, though plentiful, are underutilized. Among the expected outcomes is the identification of potential roles for Hawai'i firms.

Sixteen individuals from Hawai'i participated in the November economic

mission to Hainan, where they were introduced to key government and industry leaders. A one-day introductory seminar on business opportunities was attended by about 70 Chinese business and government officials. DBEDT hopes to match the capabilities of Hawai'i firms with the needs of the Chinese, particularly in the fields of energy development, environmental technologies, waste management, and education and training. In the coming decade, China will require at least \$700 billion in new infrastructure development to meet the needs of its people and growing economy.

### **Advice to USDOE Impacts National Budget and Policies**

At the invitation of former USDOE Secretary Federico Pena, the ERTD program administrator serves on the State Energy Advisory Board, a group formed to advise the federal government on its energy efforts. The Board has worked on federal budget matters, assisting the Assistant Secretary for Conservation and Renewable Energy in obtaining a \$130 million budget add-on. One of the achievements was the inclusion of the Million Solar Roofs program as a line item in the current annual budget.

Another noteworthy action by the Congress was the authorization of direct access to the strategic petroleum reserve for Hawai'i and the U.S. territories. In the case of an emergency drawdown of the national reserve, U.S. insular areas will get priority access and will be able to purchase oil at the average successful low bid price. The result of years of effort by the State, this decision recognizes the special risks faced by Hawai'i and other U.S. islands that have no internal sources of fossil fuel and which are isolated from other fuel suppliers.

### **Publications Promote Technology, Energy Savings, Partnerships**

The Hawai'i Advanced Building Technologies program developed the *Guide to Resource-Efficient Building in Hawai'i*. This 200-page resource book for professionals in the residential design and construction industry contains sections on planning, construction checklists, and marketing "green buildings." Also included is information on life cycle assessment, environmental approaches to termite control, and materials for environmentally safe homes.

Published in 1998, the *Hawai'i Energy, Environmental and Engineering Technology and Services Export Directory* promotes local businesses. Intended for use by potential overseas buyers of Hawai'i technologies and services, the directory lists 158 companies, their investment or partnership needs, and examples of completed projects. The 60-page reference includes a special focus on bioremediation sciences, and the entire text is written in English, Japanese and Chinese.

Another 1998 DBEDT publication, *Science and Technology—The Key to Hawai'i's Economic Future*, summarizes the technical and scientific resources available in the state, including energy research and technology.

ERTD's practical handbook, *A Guide to Energy Performance Contracting*, was updated to incorporate lessons learned from implemented projects. The



**Workshops offered opportunities for professional improvement in a variety of technical fields.**

*Guide* contains sample contract language and other information to assist with the selection of an energy service company.

Assorted factsheets on recycling and remanufacturing were published by ERTD's Clean Hawai'i Center, providing information to private businesses and interested citizens.

An updated brochure on residential ceiling insulation was also printed and distributed, as were brochures describing the Rebuild Hawai'i program and other initiatives.

A flyer describing the extended energy tax credits was updated.

Efforts to support energy-related classroom curricula resulted in the republication of several workbooks and activity guides for students, including the extremely popular *Hawai'i's Energy Coloring Book*.

Many ERTD publications are also presented on DBEDT's internet site: <http://www.hawaii.gov/dbedt/ert>.

The site, which is frequently updated, features the latest news on renewable energy projects, upcoming events, profiles of Asian countries having business expansion potential for Hawai'i enterprises, summaries of major technical programs, funding opportunities, and hotlinks to other key energy websites. Both major publications and brief technology factsheets are available, as are discussions of ERTD programs such as demand-side management, energy emergency preparedness and export opportunities in Asia and the Pacific.

**Sharing Information During Workshops & Conferences**

In February, DBEDT co-sponsored a workshop entitled, "The Value of Roof Insulation" with HECO, highlighting the importance of insulation in keeping homes cool. Information on window tinting, which can reduce the heat gain in both residential and commercial buildings, was also included. Approximately 30 contractors, engineers and architects attended the session.

Over 100 industry participants attended a Construction and Demolition Waste Management workshop in February, with more than 40 attending its associated development forum. Co-sponsors included DBEDT's Clean Hawai'i Center and half a dozen federal, state and private sector organizations. A follow-up workshop and planning forum were held in December, offering case studies, access to industry resources, and information on national trends.

Also in February, DBEDT, HECO, USDOE and the Illuminating Engineering Society of Hawai'i co-sponsored a two-day Lighting Efficiencies Workshop. More than 90 engineers, building managers and government representatives learned practical applications of efficient lamps in new construction and renovations. The focus was on commercial buildings such as hotels, retail establishments, offices and hospitals.

A Workshop on Water and Air-Side Air Conditioning Design, a follow-up to previous "Motor Challenge" workshops on motor efficiency and large pump systems, was held during two days in April. Co-sponsored by ERTD and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), the session attracted 60 participants, including consultants, contractors, vendors, utilities, technicians and building engineers.

An August Workshop on Measurement and Verification of Energy Savings helped building managers and facilities staff review measurement techniques and protocols for verifying the savings which result from installing efficient equipment. Co-sponsors were ERTD and other members of the Rebuild Hawai'i consortium. The one-day workshop was followed by a two-day technical seminar to discuss measurement and verification issues encountered during performance contracting. The 46 participants in the workshop included representatives from utilities, energy service companies, public agencies, and the government of the Philippines; 26 invitees participated in the technical seminar.

The two-day Efficient Electro-Technologies Expo and Conference, held during mid-October, offered technical sessions on lighting, refrigeration and other topics, as well as vendor displays. The conference was co-sponsored by HECO, DBEDT, and USDOE's Rebuild America initiative, among others. ERTD arranged for a session on the application of ground-source heat pumps in tropical climates. ERTD staff participated in a concurrent meeting with staff from the U.S. Pacific Islands and USDOE, bringing each other up to date on energy programs. The Rebuild Hawai'i consortium was also featured at the expo.

An October workshop at the U.H. School of Architecture trained eight local contractors and architects to deliver workshops on building energy- and resource-efficient homes. Nationally-recognized instructors delivered the curriculum. The trainees will hold statewide workshops in early 1999, which will be open to all residential building designers, developers and builders.

The Clean Hawai'i Center coordinated a Buy Recycled Products Show and Workshop with the City and County of Honolulu's Recycling Office for the November 1998 Partnership for the Environment Conference.

## **Educating Our Youth in Energy, Science and Technology**

ERTD provided assistance to educators and students via classroom presentations, primarily through the Hawai'i Energy Extension Service office in Hilo which offered guest lectures at the primary, secondary and college level. ERTD staff also served as organizers, judges and speakers for the state Science and Engineering Fair, held annually in April in Honolulu. Prizes were given for



superior projects in energy efficiency and alternative energy sources. Competing students were from intermediate and high schools statewide.

ERTD staff also assisted with the Hawai'i Science Bowl, a high school competitive event, helping with organization, logistics, and presenting awards. USDOE is a major cosponsor.

A summertime enrichment course in renewable energy, focusing on photovoltaics, was offered by HELCO for Hawai'i District teachers. The two-day workshop included presentations by the Hawai'i Energy Extension Service and participation by other ERTD staff.

Various public educational events were also on ERTD's calendar. For Earth Day, commemorated each spring, Clean Hawai'i Center staff assisted with activities at the Federal Building in Honolulu. In Hilo, the Hawai'i Energy Extension Service, with help from college student volunteers, demonstrated solar and other alternative energy technologies to visiting groups of elementary students.

# Trends and Recommendations

This section outlines trends identified by ERTD staff, and notes recommendations for continued progress toward energy policy goals.

## Diversification Must Continue

Hawai'i continues to make progress in its efforts to achieve greater energy diversification. Looking back over the last five decades, Hawai'i was least dependent on oil in 1962, when sugarcane bagasse met 18.5 percent of the islands' energy needs. Since then, the reduced acreage planted to sugar has resulted in steadily shrinking contributions from this energy resource, presently less than three percent.

However, a greater number of energy resources are now available to Hawai'i residents. Municipal solid waste, wind, solar, geothermal and hydroelectric resources are reliable segments of Hawai'i's energy supply picture. The use of petroleum peaked in the early 1990s when it rose above 90 percent of the state's energy supplies; it is presently at 88 percent. Oil has always contributed over three-fourths of the state's energy needs, but coal is becoming increasingly important, growing from a fraction of one percent in the mid 1980s to over five percent in 1997.

Although several alternatively-fueled power plants have been proposed, nearly all the future additions to the islands' power supply are expected to be fueled by petroleum or coal. It will be difficult to sustain the downward trend of oil use observed since 1990. However, locally-available renewable resources must continue to be developed to provide Hawai'i's citizens with secure, diversified energy.

## Efficiency Improvements Critical

Continued improvement in the efficiency with which Hawai'i's people use electricity is expected. Despite steady increases in population, electricity sales and economic activity, as measured by the Gross State Product, per capita energy use has been holding steady.

Barriers such as institutional unfamiliarity with efficient technologies and alternative financing opportunities are being overcome by public/private partnerships supported by ERTD. Investments in efficient equipment, as well as designing and building with savings in mind, will continue to have benefits in the short and long term.

Promotion of energy and resource efficiency will continue to be among the most critical activities of ERTD because of their related environmental and economic benefits. Low oil prices and ample supplies affect the use of efficient and renewable technologies. Energy-efficient new residences are most successfully promoted on the basis of occupant comfort, cost-containment and possible mortgage advantages, as well as energy savings.

## **National Building Efficiency Movement Reflected in Hawai'i**

A national movement toward constructing energy- and resource-efficient buildings, especially residences, has been growing steadily. This sustainable development trend is becoming more prominent in Hawai'i as well.

Across the nation, large public/private programs such as the City of Austin's Green Building Program, Metro Denver Home Builders Association's Built Green Program, Kitsap County, Washington's Build a Better Kitsap Program, and others, have shown that resource-efficient homes are more in demand and have higher resale values. Complementary national efforts such as EPA's Energy Star Homes, home energy rating systems, energy-efficient mortgages, and the American Lung Association's Healthy House project have focused attention on the value of "green built" homes.

Continued support for projects such as the Hawai'i Advanced Building Technologies Program and the Residential Energy Efficient Building Guidelines Project will help the state secure its energy future and reduce dependence on fossil fuels while reducing the cost of home ownership, operation and maintenance for Hawai'i residents.

Energy efficiency in the commercial sector will continue to be supported by public/private partnerships such as Rebuild Hawai'i and performance contracting initiatives. In order to further extend savings in the commercial building sector, the County of Maui should continue to be encouraged to introduce legislation to adopt the commercial portion of the Model Energy Code as soon as possible. The Code itself should be updated to reflect recent technological advances. Voluntary compliance with the residential portion of the Code should be encouraged through the Advanced Buildings program and the promotion of insulation.

## **Transportation Remains Dominant**

Energy for transportation accounts for about two-thirds of the state's total energy use, and will continue to do so. The largest single use of transportation fuel is by aircraft, a sector essential to the state's economy because of its dependence on tourism and interstate commerce.

As shown in Figure 5, the use of transportation fuels is holding steady or declining. In 1997, a reduction in ground transportation fuel consumption was noted for the first time in decades. These factors are causing the decline in per capita energy use despite increasing electricity consumption.

## **Sharper Focus on Emergency Planning**

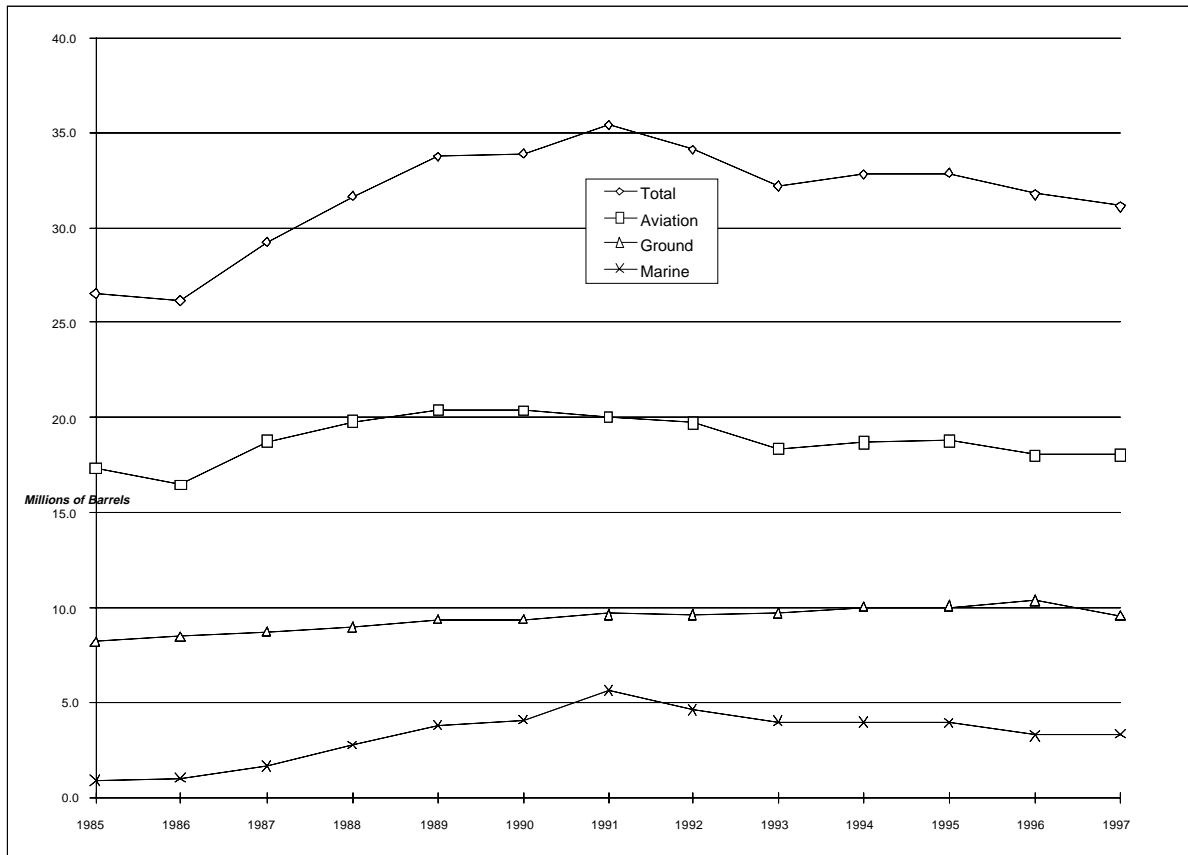
Continued cooperative exercising of emergency systems has led to a greater level of disaster preparedness among government entities. Assessments of backup generation options and the installation of photovoltaic and other alternatively-powered emergency systems will reduce the impact of power system disruptions. Improved interagency communications will ensure coordinated and rapid responses.

## Greater Role Seen in Pacific Rim Economies

Initial successful partnerships which provide technical expertise in energy and environmental protection from Hawai'i to Pacific Rim nations will lead to an increasing number of regional collaborations that, in turn, will lead to job opportunities for Hawai'i companies.

## Employment and Environmental Benefits Result from Remanufacturing

Replacement of imported commodities with products made of locally discarded resources is expected with sustained support for remanufacturing ventures statewide. Small but steady improvements in employment, and the concurrent reduction of materials sent to the landfill or incinerator, will continue.



**Figure 5. Trends in Transportation Energy Use**

# Appendix

Year	Energy Consumed (Trillion Btu)	Constant GSP (Thousands of 1987 \$)	Quantity (Thousand Btu per 1987 \$)	Annual Change (Percent)
1960	120.4982	6,271,500	19.214	
1961	141.3156	6,273,800	22.525	17.2
1962	137.1934	6,538,000	20.984	-6.8
1963	143.8698	6,699,400	21.475	2.3
1964	153.9604	7,370,200	20.890	-2.7
1965	160.6014	8,023,600	20.016	-4.2
1966	175.5990	8,464,800	20.745	3.6
1967	196.1247	8,758,600	22.392	7.9
1968	214.9613	9,479,300	22.677	1.3
1969	221.9387	10,642,200	20.855	-8.0
1970	225.2299	11,142,900	20.213	-3.1
1971	241.0916	11,718,800	20.573	1.8
1972	245.1282	12,505,100	19.602	-4.7
1973	250.5421	13,124,000	19.090	-2.6
1974	237.2659	13,083,500	18.135	-5.0
1975	238.3572	13,857,900	17.200	-5.2
1976	240.5195	14,036,900	17.135	-0.4
1977	254.5484	14,463,400	17.599	2.7
1978	259.1148	14,917,100	17.370	-1.3
1979	278.4501	15,501,700	17.963	3.4
1980	273.8809	16,360,100	16.741	-6.8
1981	273.3227	16,756,900	16.311	-2.6
1982	272.1129	16,360,700	16.632	2.0
1983	279.0303	16,981,100	16.432	-1.2
1984	276.3700	17,491,600	15.800	-3.8
1985	266.2178	18,336,500	14.518	-8.1
1986	271.0562	19,323,900	14.027	-3.4
1987	284.2042	20,027,300	14.191	1.2
1988	306.9212	21,206,100	14.473	2.0
1989	315.0842	22,213,900	14.184	-2.0
1990	312.1304	22,976,700	13.585	-4.2
1991	322.9524	22,887,700	14.110	3.9
1992	339.0912	23,095,100	14.682	4.1
1993	307.7465	23,180,100	13.276	-9.6
1994	327.4778	23,190,300	14.121	6.4
1995	315.1186	23,297,800	13.526	-4.2
1996	315.9492	23,504,400	13.442	-0.6
1997p	315.9927	23,859,700	13.244	-1.5

**Table 2. Primary Energy Consumption and Energy Consumption per Dollar of Constant Gross State Product, Hawai'i: 1960 to 1997**

**Energy Resources Coordinator's Annual Report 1998**

Year	Primary Energy Consumption (Trillion Btu)	De Facto Population (July 1)	Per Capita Energy Consumption	
			Millions of Btu	Annual Change (Percent)
1960	120.4982	651,200	185.040	
1961	141.3156	668,200	211.487	14.3
1962	137.1934	693,600	197.799	-6.5
1963	143.8698	694,500	207.156	4.7
1964	153.9604	711,200	216.480	4.5
1965	160.6014	715,400	224.492	3.7
1966	175.5990	724,600	242.339	8.0
1967	196.1247	742,600	264.105	9.0
1968	214.9613	758,800	283.291	7.3
1969	221.9387	778,800	284.975	0.6
1970	225.2299	798,600	282.031	-1.0
1971	241.0916	833,100	289.391	2.6
1972	245.1282	869,800	281.821	-2.6
1973	250.5421	901,300	277.979	-1.4
1974	237.2659	923,700	256.865	-7.6
1975	238.3572	943,500	252.631	-1.6
1976	240.5195	970,300	247.882	-1.9
1977	254.5484	992,300	256.524	3.5
1978	259.1148	1,014,300	255.462	-0.4
1979	278.4501	1,042,700	267.047	4.5
1980	273.8809	1,055,400	259.504	-2.8
1981	273.3227	1,062,600	257.221	-0.9
1982	272.1129	1,084,600	250.888	-2.5
1983	279.0303	1,109,200	251.560	0.3
1984	276.3700	1,130,500	244.467	-2.8
1985	266.2178	1,137,800	233.976	-4.3
1986	271.0562	1,167,500	232.168	-0.8
1987	284.2042	1,186,500	239.532	3.2
1988	306.9212	1,200,400	255.682	6.7
1989	315.0842	1,245,600	252.958	-1.1
1990r	312.1304	1,256,600	248.393	-1.8
1991r	322.9524	1,272,500	253.794	2.2
1992r	339.0912	1,265,800	267.887	5.6
1993r	307.7465	1,260,000	244.243	-8.8
1994r	327.4778	1,281,600	255.523	4.6
1995r	315.1186	1,287,300	244.790	-4.2
1996r	315.9492	1,292,900	244.372	-0.2
1997p	315.9927	1,288,700	245.203	0.3

**Table 3. Primary Energy Consumption and Per Capita Consumption, Hawai'i: 1960 to 1997**

Year	Total	Petroleum	Biomass	Hydro-Electric	Geo-thermal	Solar Hot Water	Wind	Coal	Municipal Solid Waste
1960	120.4982	98.8532	21.3450	0.3000	0	0	0	0	0
1961	141.3156	116.6716	24.3440	0.3000	0	0	0	0	0
1962	137.1934	111.5904	25.4030	0.2000	0	0	0	0	0
1963	143.8698	117.6498	26.0200	0.2000	0	0	0	0	0
1964	153.9604	126.0344	26.7260	1.2000	0	0	0	0	0
1965	160.6014	131.6284	27.8730	1.1000	0	0	0	0	0
1966	175.5990	146.7910	27.6080	1.2000	0	0	0	0	0
1967	196.1247	166.3587	28.6660	1.1000	0	0	0	0	0
1968	214.9613	185.2063	28.7550	1.0000	0	0	0	0	0
1969	221.9387	192.5367	28.4020	1.0000	0	0	0	0	0
1970	225.2299	197.2279	26.9020	1.1000	0	0	0	0	0
1971	241.0916	212.8486	27.3430	0.9000	0	0	0	0	0
1972	245.1282	218.3842	25.8440	0.9000	0	0	0	0	0
1973	250.5421	223.7861	25.7560	1.0000	0	0	0	0	0
1974	237.2659	212.2739	23.9920	1.0000	0	0	0	0	0
1975	238.3572	213.4572	24.0000	0.9000	0	0	0	0	0
1976	240.5195	215.5195	24.0000	1.0000	0	0	0	0	0
1977	254.5484	229.5889	24.0000	0.9000	0	0.0595	0	0	0
1978	259.1148	233.5357	24.4000	0.9000	0	0.2791	0	0	0
1979	278.4501	253.0344	24.0000	0.9000	0	0.5157	0	0	0
1980	273.8809	248.0109	24.2000	0.9000	0	0.7700	0	0	0
1981	273.3227	245.5086	24.0900	0.7356	0	1.1185	0	1.8700	0
1982	272.1129	244.3151	23.9200	1.0939	0.1572	1.3567	0	1.2700	0
1983	279.0303	250.6283	24.8500	0.8865	0.1886	1.5269	0	0.9500	0
1984	276.3700	248.4026	24.3650	0.7796	0.2075	1.7683	0	0.8470	0
1985	266.2178	238.6470	23.1430	0.9808	0.1886	2.1327	0.1697	0.9560	0
1986	271.0562	242.5857	23.9670	1.0562	0.1823	2.1644	0.6036	0.4970	0
1987	284.2042	256.4061	22.1840	0.9670	0.1446	2.1914	0.8236	1.4875	0
1988	306.9212	279.1052	22.7080	0.9826	0.1629	2.1931	0.4185	1.3509	0
1989	315.0842	289.2301	20.8020	1.0183	0.1435	2.3310	0.4189	0.8715	0.2689
1990	312.1304	284.4906	18.1200	1.0700	0	2.3400	0.2900	0.8900	4.9298
1991	322.9524	294.6222	17.9000	1.0000	0	2.3000	0.3060	0.8000	6.0242
1992	339.0912	305.7758	16.9840	0.7226	0.0168	2.3000	0.2573	6.9207	6.1140
1993	307.7465	266.9516	16.8310	0.8024	1.5988	2.3000	0.2352	13.2237	5.8038
1994	327.4778	285.5010	16.3660	1.5300	1.8060	2.3000	0.2251	13.5599	6.1898
1995	315.1186	273.9590	11.8232	1.0632	2.3045	2.8386	0.2364	16.5249	6.3688
1996	315.9492	277.1298	10.3994	1.1332	2.3566	3.1225	0.2244	16.9294	4.6539
1997p	315.9927	278.3480	8.9527	0.9544	2.3633	3.1225	0.1796	16.7772	5.2950

Table 4. Primary Energy Consumption by Source, Hawai'i (Trillion Btu)

Year	Petroleum	Biomass	Hydro-Electric	Geo-thermal	Solar Hot Water	Wind	Coal	Municipal Solid Waste	Total
1960	82.04	17.71	0.25	0.00	0.00	0.00	0.00	0.00	100.00
1961	82.56	17.23	0.21	0.00	0.00	0.00	0.00	0.00	100.00
1962	81.34	18.52	0.15	0.00	0.00	0.00	0.00	0.00	100.00
1963	81.78	18.09	0.14	0.00	0.00	0.00	0.00	0.00	100.00
1964	81.86	17.36	0.78	0.00	0.00	0.00	0.00	0.00	100.00
1965	81.96	17.36	0.68	0.00	0.00	0.00	0.00	0.00	100.00
1966	83.59	15.72	0.68	0.00	0.00	0.00	0.00	0.00	100.00
1967	84.82	14.62	0.56	0.00	0.00	0.00	0.00	0.00	100.00
1968	86.16	13.38	0.47	0.00	0.00	0.00	0.00	0.00	100.00
1969	86.75	12.80	0.45	0.00	0.00	0.00	0.00	0.00	100.00
1970	87.57	11.94	0.49	0.00	0.00	0.00	0.00	0.00	100.00
1971	88.29	11.34	0.37	0.00	0.00	0.00	0.00	0.00	100.00
1972	89.09	10.54	0.37	0.00	0.00	0.00	0.00	0.00	100.00
1973	89.32	10.28	0.40	0.00	0.00	0.00	0.00	0.00	100.00
1974	89.47	10.11	0.42	0.00	0.00	0.00	0.00	0.00	100.00
1975	89.55	10.07	0.38	0.00	0.00	0.00	0.00	0.00	100.00
1976	89.61	9.98	0.42	0.00	0.00	0.00	0.00	0.00	100.00
1977	90.19	9.43	0.35	0.00	0.02	0.00	0.00	0.00	100.00
1978	90.13	9.42	0.35	0.00	0.11	0.00	0.00	0.00	100.00
1979	90.87	8.62	0.32	0.00	0.19	0.00	0.00	0.00	100.00
1980	90.55	8.84	0.33	0.00	0.28	0.00	0.00	0.00	100.00
1981	89.82	8.81	0.27	0.00	0.41	0.00	0.68	0.00	100.00
1982	89.78	8.79	0.40	0.06	0.50	0.00	0.47	0.00	100.00
1983	89.82	8.91	0.32	0.07	0.55	0.00	0.34	0.00	100.00
1984	89.88	8.82	0.28	0.08	0.64	0.00	0.31	0.00	100.00
1985	89.64	8.69	0.37	0.07	0.80	0.06	0.36	0.00	100.00
1986	89.50	8.84	0.39	0.07	0.80	0.22	0.18	0.00	100.00
1987	90.22	7.81	0.34	0.05	0.77	0.29	0.52	0.00	100.00
1988	90.94	7.40	0.32	0.05	0.71	0.14	0.44	0.00	100.00
1989	91.79	6.60	0.32	0.05	0.74	0.13	0.28	0.09	100.00
1990	91.14	5.81	0.34	0.00	0.75	0.09	0.29	1.58	100.00
1991	91.23	5.54	0.31	0.00	0.71	0.09	0.25	1.87	100.00
1992	90.18	5.01	0.21	0.00	0.68	0.08	2.04	1.80	100.00
1993	86.74	5.47	0.26	0.52	0.75	0.08	4.30	1.89	100.00
1994	87.18	5.00	0.47	0.55	0.70	0.07	4.14	1.89	100.00
1995	86.94	3.75	0.34	0.73	0.90	0.08	5.24	2.02	100.00
1996	87.71	3.29	0.36	0.75	0.99	0.07	5.36	1.47	100.00
1997p	88.09	2.83	0.30	0.75	0.99	0.06	5.31	1.68	100.00

**Table 5. Primary Energy Consumption by Source, Hawai'i (Percent by Source)**



Country or region	Crude oil (Billion bbl)	Percent	Natural gas (Tril cu ft)	Percent
<b>North America</b>	66.8	6.55%	295.4	5.81%
Canada	4.8	0.47%	65.0	1.28%
Mexico	40.0	3.92%	63.9	1.26%
USA	22.0	2.16%	166.5	3.27%
<b>Central &amp; S. America</b>	86.2	8.45%	222.3	4.37%
Venezuela	71.7	7.03%	143.1	2.81%
Other	14.5	1.42%	79.2	1.56%
<b>Western Europe and North Sea</b>	18.1	1.78%	170.4	3.35%
<b>Mid East</b>	677.0	66.40%	1,726.1	33.93%
Abu Dhabi	92.2	9.04%	189.0	3.72%
Iran	93.0	9.12%	810.0	15.92%
Iraq	112.5	11.03%	109.8	2.16%
Kuwait	94.0	9.22%	52.4	1.03%
Saudi Arabia	259.0	25.40%	190.0	3.74%
Other	26.3	2.58%	374.9	7.37%
<b>Africa</b>	70.1	6.88%	348.6	6.85%
Libya	29.5	2.89%	46.3	0.91%
Nigeria	16.8	1.65%	114.8	2.26%
Other	23.8	2.33%	187.5	3.69%
<b>Far East, Oceania</b>	18.3	1.79%	279.6	5.50%
India	4.3	0.42%	17.4	0.34%
Indonesia	5.0	0.49%	72.3	1.42%
Malaysia	3.9	0.38%	79.8	1.57%
Other	5.1	0.50%	110.1	2.17%
<b>East Europe, China other Communist areas</b>	83.1	8.15%	2,044.2	40.19%
Russia	48.6	4.77%	1,700.0	33.42%
China	24.0	2.35%	41.0	0.81%
Other	10.5	1.03%	303.2	5.96%
Total OPEC	797.1	78.18%	2,175.2	42.76%
<b>World Total</b>	1,019.6	1.0	5,086.6	1.0

Source: Oil & Gas Journal , Dec. 29, 1997 .

**Table 6. World Crude Oil & Natural Gas Reserves: Jan. 1, 1998**

## Energy Resources Coordinator's Annual Report 1998

Product	Imports			Exports		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Crude Oil	51,096	15,000	36,097			
Distillates	63	63		679	668	11
Jet Fuel Kerosene	5,446	311	5,135	126	126	
Residual Fuel Oil				457	42	415
Naphtha				1,201		1,201
Other	1,154	1,154		4,372	2,663	1,709

Units = 1,000 Barrels  
Data are preliminary

**Table 7. Imports and Exports of Crude Oil and Petroleum Products: 1997**

Year	Total	Petroleum	Biomass	MSW 1/	Hydro-electric	Geo-thermal	Wind	Coal	PV 2/	Other 3/
1987 .....	8,368	7,577	605	-	93	14	79	-	-	-
1988 .....	8,952	8,115	681	-	98	16	42	-	-	-
1989 .....	9,280	8,511	614	-	100	14	41	-	-	(Z)
1990 .....	9,566	8,589	538	-	105	-	28	-	-	306
1991 .....	9,610	8,664	495	-	92	-	30	-	-	329
1992 .....	10,104	8,556	460	-	67	1	21	-	-	999
1993 .....	10,219	7,576	435	349	78	155	24	1,592	(Z)	10
1994 .....	10,341	7,793	423	379	148	175	22	1,382	(Z)	19
1995 .....	10,563	7,853	292	383	103	223	23	1,674	(Z)	12
1996 .....	10,740	8,026	270	326	110	228	22	1,739	(Z)	19
1997 .....	10,424	7,805	226	371	93	229	17	1,663	(Z)	20

Z Less than 500,000 kWh

1/ Electricity generated from Honolulu municipal solid waste plant.

2/ Electricity generated from photovoltaics.

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

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

**Table 8. Electricity Generation by Source: 1987 to 1997 (Millions of kWh generated)**

Island	Total	Petroleum	Biomass	MSW 1/	Hydro-electric	Wind	Geo-thermal	Coal	PV 2/	Other
State total..	10,422	7,805	225	371	92	17	229	1,663	-	20
Hawaii .....	1,028	608			51	17	229	123	(Z)	-
Maui .....	1,199	1,006	133		24	-	-	36	(Z)	-
Lanai .....	28	28	-		-	-	-	-	-	-
Molokai .....	37	37	-		-	-	-	-	-	-
Oahu .....	7,685	5,775	15	371	-	-	-	1,504	(Z)	20
Kauai .....	445	351	77		17	-	-	-	-	-

Z Less than 500,000 kWh

1/ Electricity generated from Honolulu municipal solid waste plant.

2/ Electricity generated from photovoltaics.

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

**Table 9. Electricity Production, by Source, by Islands: 1997 (Million kWh)**

Year	Total	Aviation Gas	Diesel	Jet Fuel	Kerosene	LPG/SNG	Motor Gasoline	Residual Fuel Oil	Other
1960	17,430	2,582	886	5,011	91	112	3,429	4,766	553
1961	20,474	2,994	1,663	5,558	69	140	3,546	5,926	578
1962	19,459	1,790	1,637	5,532	55	172	3,708	5,974	591
1963	20,444	1,084	1,362	6,892	49	232	3,756	6,431	638
1964	21,801	561	1,761	7,682	50	257	3,861	6,965	664
1965	22,777	626	1,612	8,275	49	219	4,082	7,230	684
1966	25,448	870	1,378	10,158	37	242	4,294	7,801	668
1967	28,785	477	1,208	12,802	33	285	4,526	8,818	636
1968	32,009	268	1,420	14,723	27	298	4,882	9,738	653
1969	33,469	195	1,601	14,834	29	912	5,176	10,056	666
1970	34,320	162	1,695	14,884	153	938	5,691	10,154	643
1971	37,047	165	1,709	16,939	80	963	5,872	10,701	618
1972	37,962	165	1,776	16,839	52	945	6,202	11,338	645
1973	38,922	153	1,837	17,043	41	942	6,608	11,575	723
1974	36,927	145	1,951	15,432	75	966	6,543	11,122	693
1975	37,106	133	1,948	15,363	76	872	6,766	11,255	693
1976	37,473	130	2,337	14,202	129	1,036	7,029	11,871	739
1977	39,823	147	2,865	14,875	169	877	7,406	12,695	789
1978	40,458	141	3,567	14,861	146	702	7,639	12,556	846
1979	44,115	152	6,567	15,276	40	1,583	7,506	12,167	824
1980	43,126	199	5,987	14,116	9	1,573	7,231	13,196	815
1981	42,680	55	4,604	16,451	-	1,285	7,033	13,223	29
1982	42,326	45	4,569	15,427	-	1,335	6,823	14,121	6
1983	43,400	215	4,853	14,724	-	1,360	7,274	14,958	16
1984	43,067	74	5,513	14,398	-	1,273	7,682	14,077	50
1985	41,787	65	4,262	17,297	-	1,292	7,528	11,293	50
1986	42,340	45	4,157	16,486	-	1,281	8,063	12,253	55
1987	44,837	29	3,124	18,775	-	1,333	8,911	12,606	59
1988	48,587	175	5,289	19,648	-	1,350	8,491	13,574	60
1989	50,484	51	4,749	20,399	-	1,476	8,755	15,054	-
1990	49,673	45	5,541	19,922	-	1,490	8,940	13,735	-
1991	51,242	45	5,355	19,598	-	1,490	8,958	15,796	-
1992	53,404	48	6,067	19,258	-	2,375	9,100	16,556	-
1993	46,750	37	5,007	17,990	-	1,648	9,154	12,913	-
1994	49,276	38	6,128	18,347	-	1,772	9,258	13,733	-
1995	47,960	37	5,291	18,462	-	1,609	9,441	13,119	-
1996	48,444	32	5,452	17,733	-	1,611	9,680	13,936	-
1997p	48,704	32	6,082	18,079	-	1,608	9,582	13,321	-

Table 10. Petroleum Consumption, Hawai'i (Thousand Barrels)

Year	Total energy expend.	Fuel expenditures			Less: electric utility fuel expend.	Plus: electric purch. by end-user
		Total	Electric utility	Other		
1970 .....	282.7	215.9	17.3	198.6	17.3	84.1
1971 .....	320.8	246.8	24.8	222.0	24.8	98.8
1972 .....	332.4	250.4	27.3	223.1	27.3	109.3
1973 .....	391.1	300.9	36.3	264.6	36.3	126.5
1974 .....	534.5	433.2	49.8	383.4	49.8	151.1
1975 .....	669.9	546.1	91.9	454.2	91.9	215.7
1976 .....	735.6	600.0	100.4	499.6	100.4	236.0
1977 .....	844.5	696.5	123.5	573.0	123.5	271.5
1978 .....	932.2	767.8	149.3	618.5	149.3	313.7
1979 .....	1,261.3	1,083.7	177.0	906.7	177.0	354.6
1980 .....	1,721.3	1,529.8	267.8	1,262.0	267.8	459.3
1981 .....	2,195.2	1,947.7	451.5	1,496.2	451.5	699.0
1982 .....	2,153.8	1,869.6	439.4	1,430.2	439.4	723.6
1983 .....	2,019.9	1,730.1	369.3	1,360.8	369.3	659.1
1984 .....	2,048.4	1,724.8	379.3	1,345.5	379.3	702.9
1985 .....	1,921.6	1,586.6	337.6	1,249.0	337.6	672.6
1986 .....	1,564.0	1,147.3	224.6	922.7	224.6	641.3
1987 .....	1,575.1	1,176.2	203.7	972.5	203.7	602.6
1988 .....	1,664.1	1,314.6	238.0	1,076.6	238.0	587.5
1989 .....	1,895.2	1,530.6	277.5	1,253.1	277.5	642.1
1990 .....	2,204.4	1,807.0	352.5	1,454.5	352.5	749.9
1991 .....	2,217.5	1,736.4	304.8	1,431.6	304.8	785.9
1992.....	2,340.3	1,760.0	238.2	1,521.8	238.2	818.5
1993.....	2,369.9	1,660.4	213.3	1,447.1	213.3	922.8
1994.....	2,397.0	1,642.5	201.4	1,441.1	201.4	955.9
1995.....	2,459.4	1,645.2	223.5	1,421.7	223.5	1,037.7
1996r.....	2,712.0	1,843.9	268.9	1,575.0	268.9	1,137.0
1997p	2,756.6	1,863.6	276.2	1,587.4	276.2	1,169.2

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

**Table 11. Expenditures for Fuels and Electricity, by Source: 1985 to 1997  
(Millions of Dollars)**

Year	GSP (Thousands of 1987 \$)	Total	Residential	Other	Total kWh Sales per \$1,000 of Constant GSP	Annual Change (Percent)
1960	6,271,500	1,602,197	580,849	1,021,348	255	
1961	6,273,800	1,766,031	624,730	1,141,301	281	10.19
1962	6,538,000	1,966,105	678,628	1,287,477	301	6.83
1963	6,699,400	2,078,571	730,317	1,348,254	310	3.17
1964	7,370,200	2,284,275	786,118	1,498,157	310	-0.11
1965	8,023,600	2,445,025	853,086	1,591,939	305	-1.68
1966	8,464,800	2,639,866	912,616	1,727,250	312	2.34
1967	8,758,600	2,832,469	989,785	1,842,684	323	3.70
1968	9,479,300	3,109,256	1,083,233	2,026,023	328	1.43
1969	10,642,200	3,426,052	1,174,502	2,251,550	322	-1.85
1970	11,142,900	3,758,094	1,270,732	2,487,362	337	4.76
1971	11,718,800	4,167,127	1,375,308	2,791,819	356	5.43
1972	12,505,100	4,562,568	1,493,840	3,068,728	365	2.61
1973	13,124,000	4,867,850	1,581,855	3,285,995	371	1.66
1974	13,083,500	5,113,906	1,635,978	3,477,928	391	5.38
1975	13,857,900	5,334,755	1,676,438	3,658,317	385	-1.51
1976	14,036,900	5,615,210	1,750,618	3,864,592	400	3.91
1977	14,463,400	5,831,610	1,779,314	4,052,296	403	0.79
1978	14,917,100	6,004,891	1,799,024	4,205,867	403	-0.16
1979	15,501,700	6,197,426	1,851,457	4,345,969	400	-0.69
1980	16,360,100	6,345,531	1,852,984	4,492,547	388	-2.98
1981	16,756,900	6,424,016	1,855,837	4,568,179	383	-1.16
1982	16,360,700	6,332,707	1,801,297	4,531,410	387	0.97
1983	16,981,100	6,425,578	1,814,336	4,611,242	378	-2.24
1984	17,491,600	6,606,255	1,837,954	4,768,301	378	-0.19
1985	18,336,500	6,635,158	1,879,027	4,756,131	362	-4.19
1986	19,323,900	7,025,739	1,959,447	5,066,292	364	0.48
1987	20,027,300	7,298,178	2,070,052	5,228,126	364	0.23
1988	21,206,100	7,719,029	2,148,275	5,570,754	364	-0.11
1989	22,213,900	7,970,360	2,239,356	5,731,004	359	-1.43
1990	22,976,700	8,310,537	2,320,550	5,989,987	362	0.81
1991	22,887,700	8,564,032	2,385,276	6,178,756	374	3.45
1992	23,095,100	8,643,562	2,430,152	6,213,410	374	0.02
1993	23,180,100	8,657,905	2,453,830	6,204,075	374	-0.20
1994	23,190,300	8,948,458	2,551,240	6,397,218	386	3.31
1995	23,297,800	9,187,429	2,597,010	6,590,419	394	2.20
1996	23,504,400	9,378,962	2,669,654	6,709,308	399	1.19
1997p	23,859,700	9,345,281	2,659,248	6,686,033	392	-1.84

**Table 12. Electricity Sales & Gross State Product, Hawai'i: 1960 to 1997**

Year	De Facto Population (July 1)	Total	Residential	Other	Total kWh Sales Per De Facto Population (kWh)	Annual Change (Percent)
1960	651,200	1,602,197	580,849	1,021,348	2,460	
1961	668,200	1,766,031	624,730	1,141,301	2,643	7.42
1962	693,600	1,966,105	678,628	1,287,477	2,835	7.25
1963	694,500	2,078,571	730,317	1,348,254	2,993	5.58
1964	711,200	2,284,275	786,118	1,498,157	3,212	7.32
1965	715,400	2,445,025	853,086	1,591,939	3,418	6.41
1966	724,600	2,639,866	912,616	1,727,250	3,643	6.60
1967	742,600	2,832,469	989,785	1,842,684	3,814	4.70
1968	758,800	3,109,256	1,083,233	2,026,023	4,098	7.43
1969	778,800	3,426,052	1,174,502	2,251,550	4,399	7.36
1970	798,600	3,758,094	1,270,732	2,487,362	4,706	6.97
1971	833,100	4,167,127	1,375,308	2,791,819	5,002	6.29
1972	869,800	4,562,568	1,493,840	3,068,728	5,246	4.87
1973	901,300	4,867,850	1,581,855	3,285,995	5,401	2.96
1974	923,700	5,113,906	1,635,978	3,477,928	5,536	2.51
1975	943,500	5,334,755	1,676,438	3,658,317	5,654	2.13
1976	970,300	5,615,210	1,750,618	3,864,592	5,787	2.35
1977	992,300	5,831,610	1,779,314	4,052,296	5,877	1.55
1978	1,014,300	6,004,891	1,799,024	4,205,867	5,920	0.74
1979	1,042,700	6,197,426	1,851,457	4,345,969	5,944	0.40
1980	1,055,400	6,345,531	1,852,984	4,492,547	6,012	1.16
1981	1,062,600	6,424,016	1,855,837	4,568,179	6,046	0.55
1982	1,084,600	6,332,707	1,801,297	4,531,410	5,839	-3.42
1983	1,109,200	6,425,578	1,814,336	4,611,242	5,793	-0.78
1984	1,130,500	6,606,255	1,837,954	4,768,301	5,844	0.87
1985	1,137,800	6,635,158	1,879,027	4,756,131	5,832	-0.21
1986	1,167,500	7,025,739	1,959,447	5,066,292	6,018	3.19
1987	1,186,500	7,298,178	2,070,052	5,228,126	6,151	2.21
1988	1,200,400	7,719,029	2,148,275	5,570,754	6,430	4.54
1989	1,245,600	7,970,360	2,239,356	5,731,004	6,399	-0.49
1990r	1,256,600	8,310,537	2,320,550	5,989,987	6,614	3.36
1991r	1,272,500	8,564,032	2,385,276	6,178,756	6,730	1.76
1992r	1,265,800	8,643,562	2,430,152	6,213,410	6,829	1.46
1993r	1,260,000	8,657,905	2,453,830	6,204,075	6,871	0.63
1994r	1,281,600	8,948,458	2,551,240	6,397,218	6,982	1.61
1995r	1,287,300	9,187,429	2,597,010	6,590,419	7,137	2.22
1996r	1,292,900	9,378,962	2,669,654	6,709,308	7,254	1.64
1997p	1,288,700	9,345,281	2,659,248	6,686,033	7,252	-0.03

**Table 13. Electricity Sales and De Facto Population, Hawai'i: 1960 to 1997**  
**Electricity Sales by Utilities (Thousand kWh)**

Year	Customer Accounts (No. at end of year)			Power Sold (Thous. kWh)			Revenues (Thous. \$)		
	Total	Residential	Other	Total	Residential	Other	Total	Residential	O
1960	157,578	132,440	25,138	1,602,197	580,849	1,021,348	39,284	17,265	
1961	162,452	136,788	25,664	1,766,031	624,730	1,141,301	42,137	18,153	
1962	167,101	140,661	26,440	1,966,105	678,628	1,287,477	46,282	19,603	
1963	171,832	144,638	27,194	2,078,571	730,317	1,348,254	48,499	20,733	
1964	177,684	149,547	28,137	2,284,275	786,118	1,498,157	52,133	21,971	
1965	183,723	154,822	28,901	2,445,025	853,086	1,591,939	55,472	23,519	
1966	190,276	160,784	29,492	2,639,866	912,616	1,727,250	59,362	24,905	
1967	196,417	166,256	30,161	2,832,469	989,785	1,842,684	63,685	26,763	
1968	202,167	171,346	30,821	3,109,256	1,083,233	2,026,023	69,599	29,034	
1969	210,330	178,569	31,761	3,426,052	1,174,502	2,251,550	75,417	31,181	
1970	219,003	186,282	32,721	3,758,094	1,270,732	2,487,362	84,096	34,068	
1971	226,514	193,043	33,471	4,167,127	1,375,308	2,791,819	98,829	38,824	
1972	236,309	201,903	34,406	4,562,568	1,493,840	3,068,728	109,213	42,560	
1973	246,255	210,740	35,515	4,867,850	1,581,855	3,285,995	126,454	48,674	
1974	255,901	219,633	36,268	5,113,906	1,635,978	3,477,928	151,188	57,145	
1975	263,816	226,836	36,980	5,334,755	1,676,438	3,658,317	215,678	76,881	
1976	270,035	232,070	37,965	5,615,210	1,750,618	3,864,592	235,999	83,957	
1977	275,616	237,557	38,059	5,831,610	1,779,314	4,052,296	271,553	92,917	
1978	284,064	244,863	39,201	6,004,891	1,799,024	4,205,867	313,722	105,846	
1979	293,061	252,898	40,163	6,197,426	1,851,457	4,345,969	354,595	118,862	
1980	301,544	260,358	41,186	6,345,531	1,852,984	4,492,547	459,251	146,397	
1981	305,927	265,042	40,885	6,424,016	1,855,837	4,568,179	699,031	214,584	
1982	313,009	270,712	42,297	6,332,707	1,801,297	4,531,410	723,622	222,423	
1983	319,449	276,194	43,255	6,425,578	1,814,336	4,611,242	659,089	205,889	
1984	324,384	280,518	43,866	6,606,255	1,837,954	4,768,301	702,899	217,447	
1985	330,407	285,117	45,290	6,635,158	1,879,027	4,756,131	672,600	213,478	
1986	337,563	291,222	46,341	7,025,739	1,959,447	5,066,292	562,344	182,110	
1987	347,086	299,758	47,328	7,298,178	2,070,052	5,228,126	602,835	195,277	
1988	354,887	306,375	48,512	7,719,029	2,148,275	5,570,754	587,528	189,689	
1989	362,290	312,347	49,943	7,970,360	2,239,356	5,731,004	644,789	207,296	
1990	370,952	320,215	50,737	8,310,537	2,320,550	5,989,987	749,845	238,103	
1991	380,963	328,899	52,064	8,564,032	2,385,276	6,178,756	785,896	251,553	
1992	385,055	332,863	52,192	8,643,562	2,430,152	6,213,410	818,525	265,667	
1993	394,825	340,932	53,893	8,657,905	2,453,830	6,204,075	922,797	302,054	
1994	403,595	346,977	56,618	8,948,458	2,551,240	6,397,218	955,907	317,984	
1995	409,983	352,589	57,394	9,187,429	2,597,010	6,590,419	1,037,702	346,359	
1996	413,830	356,205	57,625	9,378,962	2,669,654	6,709,308	1,137,045	381,011	
1997p	415,964	358,683	57,281	9,345,281	2,659,248	6,686,033	1,169,188	394,620	

Table 14. Electricity Sales, Hawai'i: 1960 to 1997 (Electric Utilities)

Year	Customer Accounts (No. at End of Year)		Average Power Sold (kWh per Customer)		Average Rate (\$ per kWh)		Average Rate (Constant Residential)	
	Total	Residential	Total	Residential	Total	Residential	Total	Residential
1960	157,578	132,440	10,168	4,386	0.0245	0.0297	0.0783	0.0950
1961	162,452	136,788	10,871	4,567	0.0239	0.0291	0.0743	0.0905
1962	167,101	140,661	11,766	4,825	0.0235	0.0289	0.0718	0.0881
1963	171,832	144,638	12,097	5,049	0.0233	0.0284	0.0697	0.0847
1964	177,684	149,547	12,856	5,257	0.0228	0.0279	0.0677	0.0829
1965	183,723	154,822	13,308	5,510	0.0227	0.0276	0.0660	0.0801
1966	190,276	160,784	13,874	5,676	0.0225	0.0273	0.0637	0.0773
1967	196,417	166,256	14,421	5,953	0.0225	0.0270	0.0619	0.0745
1968	202,167	171,346	15,380	6,322	0.0224	0.0268	0.0594	0.0711
1969	210,330	178,569	16,289	6,577	0.0220	0.0265	0.0559	0.0674
1970	219,003	186,282	17,160	6,822	0.0224	0.0268	0.0539	0.0646
1971	226,514	193,043	18,397	7,124	0.0237	0.0282	0.0549	0.0653
1972	236,309	201,903	19,308	7,399	0.0239	0.0285	0.0537	0.0639
1973	246,255	210,740	19,768	7,506	0.0260	0.0308	0.0557	0.0660
1974	255,901	219,633	19,984	7,449	0.0296	0.0349	0.0574	0.0678
1975	263,816	226,836	20,221	7,391	0.0404	0.0459	0.0718	0.0815
1976	270,035	232,070	20,794	7,543	0.0420	0.0480	0.0711	0.0811
1977	275,616	237,557	21,158	7,490	0.0466	0.0522	0.0750	0.0841
1978	284,064	244,863	21,139	7,347	0.0522	0.0588	0.0781	0.0879
1979	293,061	252,898	21,147	7,321	0.0572	0.0642	0.0770	0.0864
1980	301,544	260,358	21,043	7,117	0.0724	0.0790	0.0872	0.0952
1981	305,927	265,042	20,999	7,002	0.1088	0.1156	0.1187	0.1261
1982	313,009	270,712	20,232	6,654	0.1143	0.1235	0.1176	0.1270
1983	319,449	276,194	20,115	6,569	0.1026	0.1135	0.1033	0.1143
1984	324,384	280,518	20,366	6,552	0.1064	0.1183	0.1028	0.1143
1985	330,407	285,117	20,082	6,590	0.1014	0.1136	0.0949	0.1064
1986	337,563	291,222	20,813	6,728	0.0800	0.0929	0.0732	0.0850
1987	347,086	299,758	21,027	6,906	0.0826	0.0943	0.0719	0.0821
1988	354,887	306,375	21,751	7,012	0.0761	0.0883	0.0625	0.0726
1989	362,290	312,347	22,000	7,169	0.0809	0.0926	0.0629	0.0719
1990	370,952	320,215	22,403	7,247	0.0902	0.1026	0.0653	0.0743
1991	380,963	328,899	22,480	7,252	0.0918	0.1055	0.0620	0.0713
1992	385,055	332,863	22,448	7,301	0.0947	0.1093	0.0611	0.0705
1993	394,825	340,932	21,928	7,197	0.1066	0.1231	0.0666	0.0769
1994	403,595	346,977	22,172	7,353	0.1068	0.1246	0.0649	0.0758
1995	409,983	352,589	22,409	7,366	0.1129	0.1334	0.0672	0.0793
1996	413,830	356,205	22,664	7,495	0.1212	0.14272	0.0710	0.0836
1997	415,964	358,683	22,467	7,414	0.1251	0.1484	0.0733	0.0869

Table 15. Average kWh Use and Rates, Hawai'i: 1960 to 1997 (Electric Utilities)



Table 16. Wind Power in Hawai'i: 1997

Island	Location	No. of Units	Model	Capacity Each kW	Total Capacity MW	Gross Generation MWh	Annual Oil Equiv. (1000 Bbl)	Owner
HAWAII	Kahua Ranch	3	Bergey - Excel R-240	10	0.03	84.10	0.14	Kahua
	Lalamilo	26/55	Jacobs	17.5/20	1.56	3,248.40	5.41	HEI
	South Point	37	Mitsubishi	250	9.25	14,000.00	23.33	Apollo Energy
						49.11	0.08	Independents+
<i>Island Total:</i>		<i>121</i>			<i>10.84</i>	<i>17,381.61</i>	<i>28.97</i>	
<b>STATE TOTAL</b>		<b>121</b>			<b>10.835</b>	<b>17,381.61</b>	<b>28.97</b>	

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

Gross generation is approximate for calendar year 1997 and will vary with annual wind conditions.  
 Oil equivalent based on 600 kWh per barrel of oil. Totals are rounded.

## Energy Resources Coordinator's Annual Report 1998

Island	Location	Stream	MW Capacity	Gross Generation (MWh)	Annual Oil Equiv.* (1000 Bbl)	Owner
<b>HAWAII</b>	Hilo	Wailuku	1.50	9,281.48	15.47	HELCO Pu'ueo
	Hilo	Wailuku	0.75	2,963.91	4.94	HELCO Pu'ueo
	Hilo	Wailuku	0.75	5,234.66	8.72	HELCO Waiau
	Hilo	Wailuku	0.35	1,608.77	2.68	HELCO Waiau
	Hilo	'Ainako	0.07	27.63	0.05	Wenko Energy
	Hawi	Kohala Ditch	0.20	956.20	1.59	Hawi Ag & Energy
	Waimea	Waimea/ Waikoloa Pipeline	0.04	74.08	0.12	Hawai'i County
	Hilo	Wailuku	11.00	30,445.41	50.74	Wailuku River Hydro Power
	Waimea	Kahua	**	**	**	Kahua Ranch
	North Hilo		0.08	339.40	0.57	Ho'owaiwai Farms
<b>Island Total:</b>			<b>14.66</b>	<b>50,931.55</b>	<b>84.32</b>	
<b>KAUAI</b>	Waimea	Waiawa	0.50	7,050.00	11.75	AMFAC Sugar Kaua'i (West) <sup>1</sup>
	Waiawa	Kehaha Ditch	1.00			AMFAC Sugar Kauai (West)
	Lihu'e	Wailua Ditch	0.50	2,890.00	4.82	AMFAC Sugar Kaua'i (East) <sup>2</sup>
	Lihu'e	Wailua Ditch	0.80			AMFAC Sugar Kaua'i (East)
	North	Wainiha	3.80		0.00	McBryde Sugar
	Kalaheo	Alexander Res.	1.00		0.00	McBryde Sugar
	Kaunakakai	Makawili	1.25	7,430.00	12.38	Olokele Sugar
	<b>Island Total:</b>			<b>8.85</b>	<b>17,370.00</b>	<b>28.95</b>
<b>MAUI</b>	Kaheka	Wailoa Ditch	4.50	18,360.00	30.60	HC&S
	Pa'ia	Wailoa Ditch	0.90	5,920.00	9.87	HC&S
	Hamakua	Wailoa Ditch	0.50		0.00	HC&S
	Lahaina	Kaua'ula	0.50	110.00	0.18	Pioneer Mill Co., Ltd.
	<b>Island Total:</b>			<b>6.40</b>	<b>24,390.00</b>	<b>40.65</b>
<b>STATE TOTAL</b>			<b>29.91</b>	<b>92,691.55</b>	<b>153.92</b>	

\* Oil equivalent based on 600 kWh per barrel of oil. Totals are rounded.

\*\* Research facility.

1 Combined generation for AMFAC Sugar Kaua'i (West)

2 Combined generation for AMFAC Sugar Kaua'i (East)

**Table 17. Hydroelectric Power Plants in Hawai'i: 1997**