# The Hawaii Energy Strategy 2000
# Summary

## January 2000


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

## HAWAII ENERGY STRATEGY 2000 SUMMARY

This is a summary of the *Hawaii Energy Strategy 2000* (*HES 2000*), completed in January 2000 by the Energy, Resources, and Technology Division of the State of Hawaii Department of Business, Economic Development & Tourism. The full report is available in Hawaii State Libraries and on the worldwide web at http://www.hawaii.gov/dbedt/ert/hes2000.

The purpose of *HES 2000* is to assist State of Hawaii planners and policy makers, members of the Hawaii energy community, and Hawaii's people to better understand Hawaii's current energy situation. It developed and analyzed possible future energy scenarios and makes recommendations to enhance Hawaii's energy future.

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

- Increase diversification of fuels and the sources of supply of these fuels;
- Increase energy efficiency and conservation;
- Develop and implement regulated and non-regulated energy development strategies with the least possible overall cost to Hawaii's society;
- Enhance a system of comprehensive energy policy analysis, planning, and evaluation;
- Increase the use of indigenous renewable energy resources; and
- Enhance contingency planning capabilities to effectively contend with energy supply disruptions.

### 1. Hawaii Energy Strategy 2000 and the Hawaii Climate Change Action Plan

**State Energy Policy Objectives.** The Hawaii Energy Strategy program was designed to increase understanding of Hawaii's energy situation and produce recommendations to achieve the statutory energy objectives outlined in Section 226-18(a), Hawaii Revised Statutes (HRS), as amended by Act 96, Session Laws of Hawaii, 1994, of planning for:

- Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;
- Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased; and
- Greater energy security in the face of threats to Hawaii's energy supplies and systems.

**Hawaii Climate Change Action Program.** Hawaii is a Climate Change Partner in the U.S. Environmental Protection Agency (USEPA) State and Local Climate Change Program. The USEPA has involved individual states in its program out of recognition that "although problems such as global warming need to be addressed through cooperative national and international efforts, many of the critical responses can be initiated locally. If the adverse effects of climate change are to be avoided, states will need to take an active and immediate role in addressing greenhouse gas emissions."

### 2. Energy, the Economy, and the Environment

**The Need for Energy.** Energy is essential to modern life. Hawaii's citizens use energy for transportation, hot water, refrigeration, heating/air conditioning and ventilation, lighting, cooking, to operate office and industrial machines, to run appliances, and other essential uses.

**Energy and Hawaii's Economy.** Energy fuels Hawaii's economy. Energy is used by the jets bringing visitors to the islands; jets move them around the islands; and provides ground transportation, air conditioning, hot water, and lights to make their stay more comfortable. Energy supports Hawaii's military installations and the military's Hawaii-based operations. Energy is used to grow, harvest, and refine Hawaii's sugar and other agricultural products. Energy lights our stores, refrigerates our food, and provides myriad other services. Energy use by Hawaii's residents is a major component of economic activity. Energy-related companies make up a large segment of Hawaii's economy.

Hawaii's economy is overdependent on oil because oil is easy to transport and an oil-based infrastructure has evolved in Hawaii over the years. The system is supported by historically low real oil prices. From Hawaii's perspective, the system requires massive exports of money to pay for imports of crude oil and some refined products. This money is not used for further development of Hawaii's economy and does not have local multiplier effects. Much of Hawaii's energy demand is inelastic, so when energy prices rise, the effect is to use even more money that would have been spent in other sectors of the economy to meet energy needs. In addition, Hawaii's own renewable resources are not fully used and further energy efficiency measures could be adopted.

Renewable energy and energy efficiency offer the benefits of keeping money in the state and greater levels of employment per unit of energy. Such local employment would result in multiplier effects that would enhance the local economy.

Hawaii's residents and visitors use oil to meet almost 90% of their energy needs. Hawaii's dependence on oil poses risks to Hawaii's economy from sudden price increases or from supply problems as experienced in 1973, 1979, 1991, and 1992.

**The Link between Energy Use, the Economy and the Environment.** Hawaii enjoys a beautiful natural environment and many regard it as paradise. It provides pleasant living conditions for residents. Hawaii's economy is based upon its beautiful environment; the environment is the major reason tourists come to the Islands. The challenge is to protect Hawaii's environment while meeting the energy needs of Hawaii's people for jobs, income, and a growing economy.

**Energy Use, Greenhouse Gas Emissions, and Climate Change.** The earth's weather and climate are driven by energy from the sun. Water vapor, carbon dioxide, and other gases in the atmosphere trap some of the energy from the sun, creating a natural "greenhouse effect". There is strong evidence that, due to industrialization, energy use, other human activities, and population growth, greenhouse gas concentrations in the atmosphere have increased. The greenhouse gases, primarily carbon dioxide, methane, and nitrous oxide, add to the global warming of the earth's atmosphere. Climate change will have many potentially negative effects on health, coastal areas, water resources, agriculture, forestry, ecosystems, and the economy in Hawaii.

**Hawaii's Energy Sector Greenhouse Gas Emissions.** About 89% of Hawaii's greenhouse gas emissions in 1990 came from energy use. Figure 1 shows the relative contribution to Hawaii's global warming potential by energy end-use sector. Hawaii faces major challenges in reducing its future emissions.

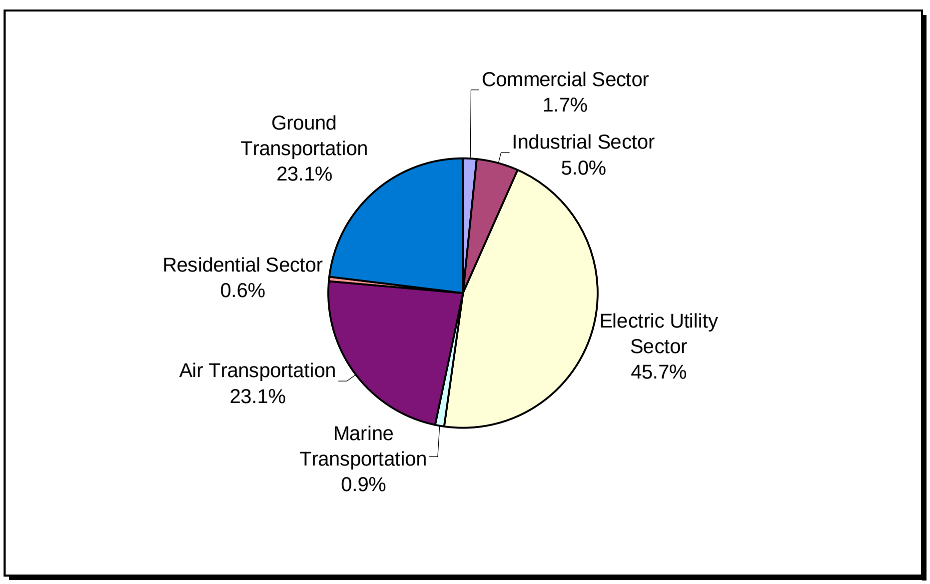


***Figure 1. Contribution to Hawaii's Global Warming Potential from Energy Use by Sector, 1990***

**Balancing Energy Needs, Economic Growth, and Environmental Protection.** How might energy needs, economic growth, and environmental protection be balanced? In general, efforts to improve energy efficiency can reduce energy costs and permit businesses and consumers to spend their money in ways more productive to the local economy. In addition, by investing in alternate energy resources within the state, expenses may not necessarily be reduced, but more of the money spent will remain in the local economy and less oil use will reduce economic and environmental risks to Hawaii.

## 3. Meeting Hawaii's Energy Needs

**Hawaii's Primary Energy Sources 1997.** Table 1 summarizes Hawaii's primary energy sources in 1997. Figure 2 shows percentages of energy use by sector in 1997.

**Table 1 Hawaii's Primary Energy by Fuel (Million Btu), 1997**

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

**Hawaii's Energy Use and State Energy Policy.** The following section will briefly look at Hawaii's energy use in terms of the major elements of the State of Hawaii energy objectives.

***Objective 1: Dependable, efficient and economical energy.*** Hawaii's energy supply and energy system remains dependable on the whole. Energy is used relatively efficiently in Hawaii. In 1970, Hawaii's per capita energy use was 86% of the national average, but by 1997, it was only 70% of the national average. Some of the reasons Hawaii is more efficient than the Mainland average include high energy prices that discourage energy use, little requirement for space heating, few energy-intensive industries, and short driving distances.

***Economical Energy.*** Figure 3 is a comparison of Hawaii's energy prices with those of other states in 1995. Hawaii's national rank is indicated for each category above the column showing Hawaii's prices compared to the U.S. average and the lowest U.S. prices. Note that the utility gas comparison is between synthetic natural gas manufactured in Hawaii and natural gas available at low prices on the Mainland and in Alaska.

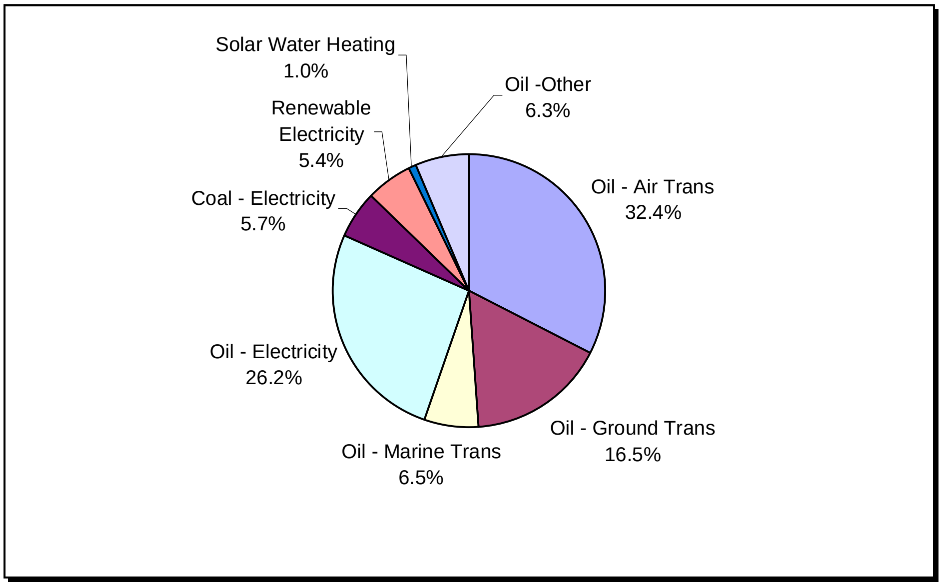


*Figure 2. Percentage Energy Use in Hawaii by Sector, 1997*

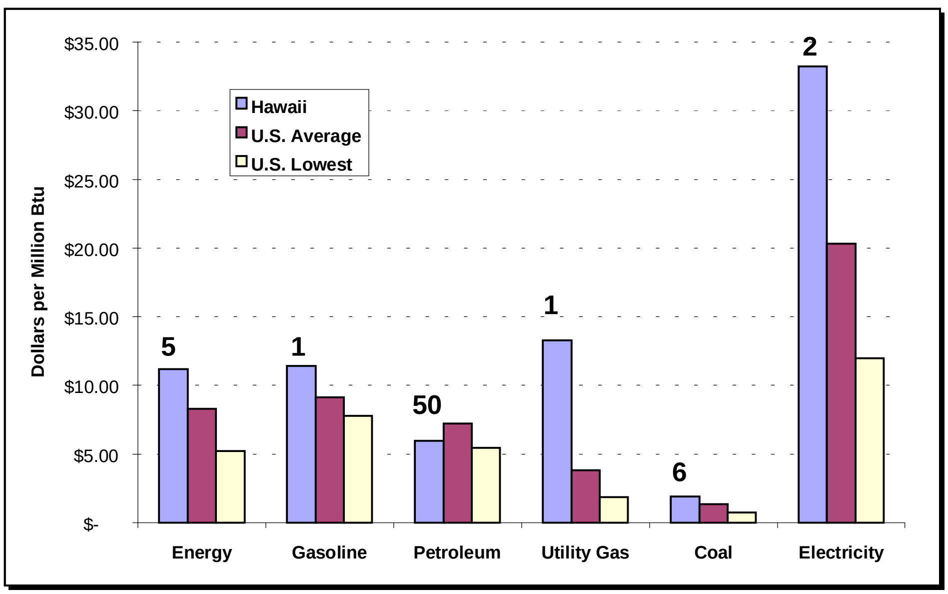


*Figure 3. Comparison of Hawaii Energy Prices with U.S. Average and Lowest U.S. Price per Million Btu, 1995*

***Objectives 2 and 3: Self-sufficiency and Diversification.*** In 1962, 18% of Hawaii's primary energy came from biomass-fired electrical generation and hydroelectricity produced by sugar plantations, which sold substantial amounts to the electric utilities. As Hawaii grew and rapidly developed, electricity needs were met by new oil-fired utility generation and little or no new sugar industry generation was added.

Even as oil prices rose dramatically in the 1970s, the proportion of energy from oil increased to 90.5% by 1980. Biomass, hydro, and solar water heating accounted for 9.5% of energy in 1980. Hawaii reached a peak in its dependence on oil in 1989 at 91.8% of total energy use. In the 1990s, the addition of the H-POWER municipal solid waste-to-energy plant, geothermal energy on the Big Island, and a new coal plant on Oahu helped offset declines in biomass electricity production. In 1994, oil use declined to 87.1%, the lowest level since 1969. By 1997, oil prices had declined further and oil use was up again to 87.9%. Sugar operations had closed entirely on the Big Island and Oahu and scaled back on Kauai. Wind operations on Oahu ended in 1986. This reduced the contribution of renewable energy, including solar water heating to 6.4% of 1997 primary energy consumption.

***Objective 3: Energy Security.*** Energy security includes supply security, price security or stability, and economic security. Supply security is ensuring that energy is available despite market disruptions elsewhere. Price stability is sought to protect against price fluctuations which reduce economic security. The use of indigenous, renewable energy and diversification of fossil energy sources both contribute significantly to all three forms of energy security, but there are other important measures.

Fuel substitution, energy efficiency, energy emergency preparedness, and oil stockpiles help provide supply security. Through the concerted efforts of Senator Akaka and the Hawaii Congressional Delegation, in 1998, Hawaii was granted priority access to the U.S. Strategic Petroleum Reserve in times of emergency.

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

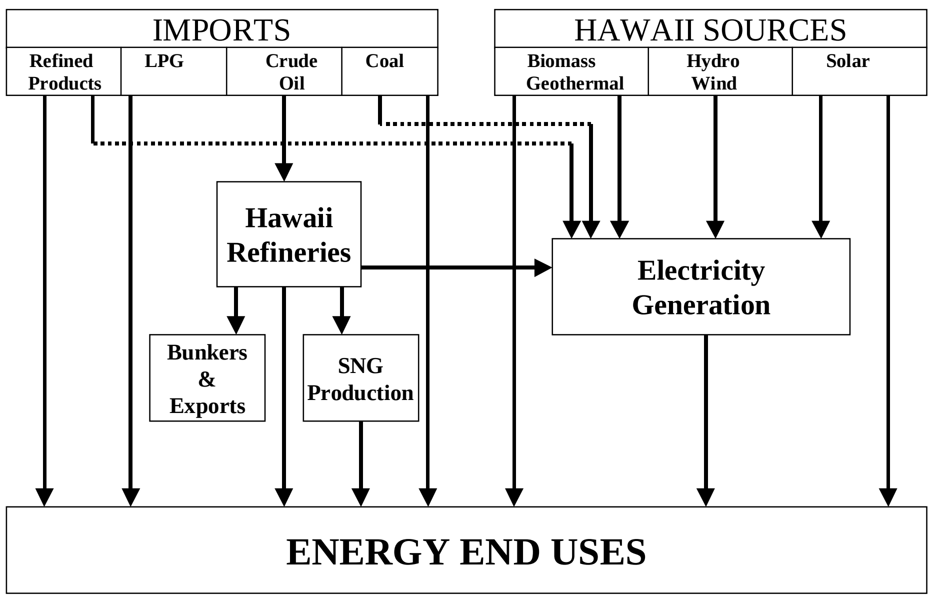


***Figure 4. Hawaii's Energy System***

**Hawaii's Energy System.** Figure 4 depicts Hawaii's energy system. Sources of energy are shown at the top of the graphic. Conversion of energy sources into refined products for export and local end uses, or into electricity is shown in the middle. The end uses in the residential, commercial, industrial, and transportation sectors depicted at the bottom of the chart.

- ***Crude Oil Imports.*** Hawaii has no fossil energy resources. In 1997, Hawaii imported 50.8 million barrels of crude oil, down almost 8% from a high of over 55 million barrels in 1994, but up 5% compared to 1990. About 71% came from foreign sources, and only 29% came from domestic sources, principally Alaska.
- ***Refined Oil Product Imports.*** In 1997, the total volume of refined product imports and exports was roughly in balance -- 6,662,722 barrels were imported and 6,835,388 were exported. Imports of refined product were 13% of the volume of crude oil imports.
- ***Oil Products Refined in Hawaii.*** The two local refiners, Chevron USA and Tesoro Hawaii, produced most of the refined products used in Hawaii. The Chevron refinery has a capacity of about 20 million barrels per year. Chevron maximizes gasoline production.

The Tesoro Hawaii refinery has a capacity of about 33 million barrels per year and maximizes production of jet fuel.

- ***Synthetic Natural Gas Production.*** The Gas Company (TGC) provides all utility gas service in Hawaii. The largest group of TGC customers are on the company's main Oahu distribution network which serves them with synthetic natural gas (SNG) produced at the TGC SNG plant in Kapolei, Oahu.
- ***Coal Imports.*** Very low sulfur (0.4%) and low ash (5%) coal for the AES Hawaii 180 MW AFBC power plant is imported under a long-term contract from Indonesia's Kaltim Prima mine. Coal for HC&S Puunene Mill and for Hilo Coast Power Plant is generally imported from Australia.
- ***Hawaii's Renewable Energy Sources.*** About 6.4% of Hawaii's primary energy came from indigenous, renewable energy sources in 1997. Biomass, geothermal, hydroelectric, solar, and wind energy were used to produce electricity. Biomass was also used to produce process heat and solar is used for drying and to heat water.

**Future Fossil Energy Supply for Hawaii.** Hawaii is far away from its sources of oil and remains dangerously dependent on oil for its energy needs. Hawaii is not now dependent on "insecure" sources of oil from politically unstable regions. Further, Hawaii had no oil and coal supply problems during the recent Asian economic crisis, despite considerable political and social unrest in Indonesia -- the source of 31% of Hawaii's oil imports in 1997. Nevertheless, increasing domination of the world oil market by Middle Eastern oil producers could raise the price of oil in the future.

**U.S. Energy Information Administration's (EIA) Outlook for Oil.** Figure 5 shows the late 1999 EIA forecast of world oil prices for the next two decades. Oil prices are driven by the relationship between supply and demand. Prices in early 1999 were low because of an oversupply created, in part, by reduced demand in developing nations, especially Asia. OPEC, especially the OPEC nations in the Persian Gulf region, was expected by EIA to be the "principal source of marginal supply to meet future incremental demand". In the EIA's low price case, OPEC production was assumed to be high, and in the high price case, production was assumed to be low. In March 1999, OPEC took action to reduce production and drove oil prices higher than estimated earlier, reaching about $24.75 per barrel by December 1999. For the short term, EIA estimated prices would rise another $5 per barrel in 2000 before moderating.

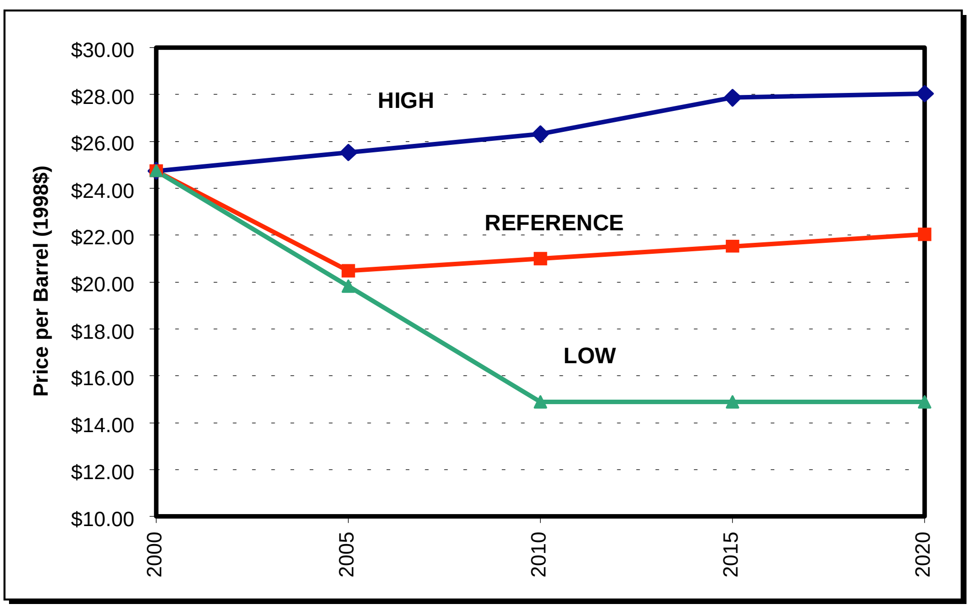


***Figure 5. U.S. Energy Information Administration Long-Term Forecast of World Oil Prices, 2000-2020***

The prospect is for OPEC to control an increasing share of the market. From EIA's perspective, greater OPEC market share would result from greater OPEC supply, reducing prices. Others are more concerned about the potential for higher prices arising from growing OPEC market dominance.

**International Oil Market Concerns – Are Oil Supplies Declining?** Some authors, such as Colin J. Campbell, argue that "within the next decade, the supply of conventional oil will be unable to keep up with demand", driving prices higher. Campbell believes OPEC production will peak in 2010 with radical increases in oil prices following as a result of the combined factors of declining supply and OPEC dominance of the market. Campbell calls for a transition to a post-oil economy through production of liquid fuels from natural gas for transportation fuel, safer nuclear power, cheaper renewable energy, and conservation programs that could help delay the decline of conventional oil.

**International Oil Market Concerns – Will the OPEC Cartel Again Drive Prices Higher?** On March 23, 1999, in an effort to boost oil prices, members of OPEC formally agreed to cut crude oil production and crude oil prices rose 20%. According to David Greene, of the U.S. Department of Energy's Oak Ridge National Laboratory, the main threat to U.S. energy security is economic scarcity, not physical or geologic scarcity. Monopolistic behavior or any of a variety of shocks to the world's oil producing regions could create economic scarcity. He noted that oil markets cannot adjust quickly to sudden changes in supply, thus, supply shocks could cause huge increases in oil prices. This would mean huge profits for oil producers and huge losses for consumers. The economies of the United States and Hawaii depend heavily on oil and are susceptible to these enormous economic losses as shown on Figure 6.

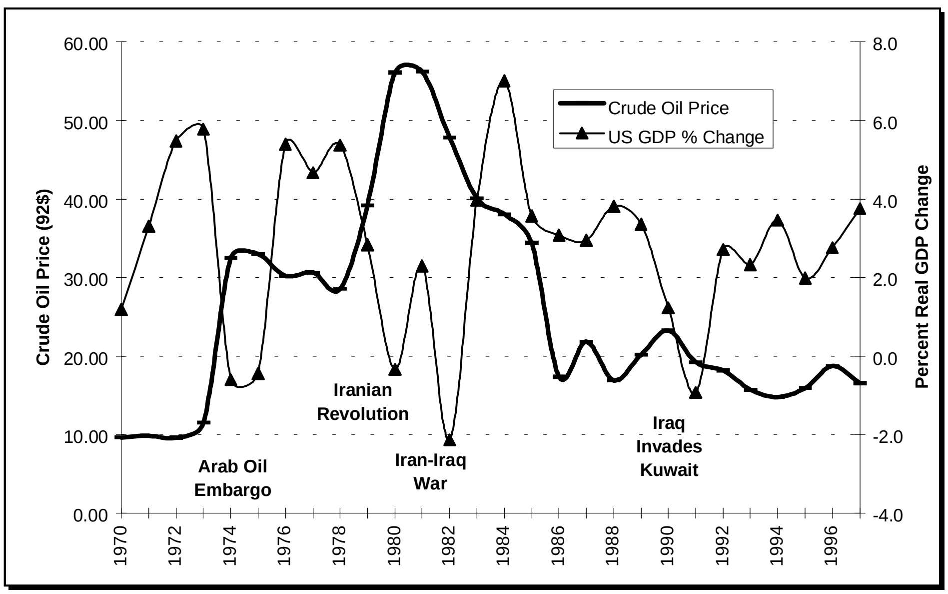


***Figure 6. Historical Shortages and Effects on World Oil Prices, 1972-1997***

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

**International Oil Market Concerns – Will Political/Military Crises Disrupt the Market?** Since 1970, oil price shocks have been triggered by political or military crises. At the end of the Nineties, conflicting claims by China, Vietnam, the Philippines, Taiwan, Brunei, Indonesia, and Malaysia for the Spratley Islands and other areas of the South China Sea are principally motivated by the potential for oil in the area. Domestic unrest in Angola and Algeria could affect oil supplies from those nations. Kurdish guerillas in eastern Turkey, continuing civil war in Afghanistan, potential unrest in the Middle East, and other areas offering potential pipeline access to Central Asian oil supplies may prevent or delay oil supplies from reaching the world market.

**International Oil Market Concerns – What Will Be the Effect of the Projected Decline in Alaska Production?** One factor that may increase Hawaii's dependence on foreign over domestic crude oil is the expected decline in oil production from Alaska. This situation may slightly reduce Hawaii's supply security, but given Hawaii's tiny demand in the context of the overall world oil market, it is expected that supplies of oil will be available in the future at some price. When supplies are tight, the price could be very high.

**The Outlook for Coal.** Coal is one of the most widely available sources of energy in the world. The United States, Australia, and Canada have about a third of world coal reserves and serve over half of seaborne coal trade. Exports from Australia and Indonesia are expected to grow. Should these countries remain as Hawaii's main suppliers, they should have little difficulty in meeting Hawaii's relatively small needs. However, coal emits 20% more $CO_2$ per energy unit than oil. It is possible that carbon taxes or other measures such as carbon trading schemes could raise the financial cost of using coal relative to oil and gas in the future.

**The Possibility of Importing Liquefied Natural Gas (LNG).** In its 1999 Integrated Resource Plan (IRP), The Gas Company (TGC) looked at importing LNG for use in the utility gas system. The main obstacle to LNG imports, besides cost, remains finding a site with sufficient size for necessary processing and storage and a safety buffer against accident.

## 4. Ground Transportation in Hawaii

**Current Ground Transportation Fuel Use.** Energy demand in the transportation sector is based upon the number and types of vehicles in use, and how many miles these vehicles travel. In 1997, there were 884,267 motor vehicles registered in Hawaii. Although there was a decline in the number of registered vehicles and a slight decline in estimated vehicle miles traveled in Hawaii over the period 1990-1997, gasoline use increased 6.7%, diesel use increased 21.6%, but LPG highway use declined 61%. The estimated average highway vehicle fuel efficiency of Hawaii's vehicles declined from 20 mpg in 1990 to 18.4 mpg in 1997, a 7.8% decline.

**Future Demand.** Highway gasoline use was estimated to grow from 51.23 TBtu in 2000 to 66.49 TBtu in 2020, a 30% increase. Over the same period, highway diesel use was estimated to decline by 7% from 4.12 TBtu in 2000 to 3.84 TBtu in 2020.

**Economic Effects of Ground Transportation Fuel Use.** Based upon the Bureau of Labor Statistics Honolulu Consumer Price Index, the average Honolulu resident expended 3.02% of his or her total expenditures on motor fuel. The EIA estimated this to be about $679 million in 1995. A significant portion of the monies spent left the state. If locally produced renewable fuels can supply a portion of that demand; expenditures for the locally produced fuels may contribute more to the growth of the state's economy.

## 5. Air Transportation and Hawaii

Air transportation is vital to Hawaii. Overseas air transportation is essential to Hawaii's tourism-based economy, providing transportation to millions of visitors annually. Overseas transportation is the only regular passenger connection to the mainland United States and international destinations for Hawaii's citizens. Interisland air transportation is equally critical. It is the only passenger connection between Hawaii's islands for residents and visitors alike. Hawaiian Airlines aptly noted in its *Annual Report* that, "One-third of this market is represented by residents of Hawaii who rely on Interisland flights in much the same way as mainland residents rely on a state highway system".

**Current Aviation Fuel Use.** In 1997, 8.442 million barrels of domestic jet fuel were used by civilian scheduled airlines on interisland flights and flights between Hawaii and the mainland United States. Piston-engine aircraft operating in Hawaii used about 32,000 barrels of aviation gasoline. Air carriers on international operations used 8.901 million barrels of bonded jet fuel. The military purchased 735,290 barrels of jet fuel from Hawaii refiners or distributors, but Hawaii-based military aircraft did not necessarily use that fuel in Hawaii.

**Future Aviation Fuel Requirements.** Using the ENERGY 2020 model, an estimate for future civilian jet fuel use for both domestic and international operations was developed. The base case efficiency estimate was based on the USDOE best estimate of an average efficiency improvement of 0.7% per year starting in 1998. Although efficiency improved over the 20 years, growth in traffic overcame efficiency improvements in the base case, resulting in a need for 112.3 TBtu in 2020, a 12% increase.

If maximum estimated efficiency improvements, on the order of 2.5% per year, occur jet fuel use declined from 93.9 TBtu in 2000 to 84.54 TBtu in 2020, a 10% decrease and a value only 75% of the base case. Greater aircraft efficiency than the base case could reduce civilian jet fuel demand in Hawaii by as much as 27.8 TBtu by 2020. This could have significant implications for Hawaii refiners that maximize jet fuel production and for consumers of other refined products.

**Cost of Aviation Fuel.** Hawaii's economy is highly vulnerable to increases in the cost of aviation fuel. In 1995, an estimated $250 million was spent in Hawaii on jet fuel. This amount does not include the cost of bonded fuel or fuel purchased elsewhere but loaded in Hawaii. Higher fuel prices would also increase the price of tickets, reducing the demand for air travel. This would be very undesirable for Hawaii's tourism-based economy and for its airline-based interisland transportation system.

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

## 6. Marine Transportation and Hawaii

Inter-island marine shipping is the analog of Mainland intrastate trucking, pipelines, and railroads. Inter-island vessels, primarily towed barges, transport most of Hawaii's cargo inter-island. Transportation of cargo from the Mainland and overseas is primarily seaborne. The only alternative is air cargo with its inherent cost, weight, and bulk limits. Air cargo is primarily used for high value, time-sensitive, or perishable items.

**Current Marine Fuel Use.** Most fuel used or sold in the marine transportation category was bonded fuel for use in international shipping or international fishing operations or loaded as cargo and exported from Hawaii. In 1997, such bonded fuel included 1.813 million barrels of residual fuel oil and 1.778 million barrels of diesel fuel oil. Sales for inter-island use were 130,742 barrels of residual fuel oil, 235,598 barrels of diesel, and 997 barrels of gasoline.

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

## 7. Generating Electricity for Hawaii

The four electric utilities, several non-utility generators, and the sugar industry generate Hawaii's electricity. Most of this electricity is sold to consumers by the utilities. Hawaiian Electric Company, Inc. (HECO) serves the City and County of Honolulu (Oahu); Hawaii Electric Light Company, Inc. (HELCO) serves Hawaii County; Kauai Electric Division of Citizens Utilities (KE) serves Kauai County, and Maui Electric Company, Ltd. (MECO) serves Maui and Kalawao Counties. MECO operates separate systems for the islands of Maui, Lanai, and Molokai.

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

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

**Growing Electricity Demand.** Electricity use grew faster between 1990 and 1997 than any other form of energy use. The slowdown in Hawaii's economy since 1991 was not evident in reduced electricity sales until 1997. Electricity sales increases outpaced growth in Hawaii's population and gross state product (GSP) during the period. By 1997, electricity sales were almost 13% greater than in 1990. Looking at each Hawaii utility: MECO sales grew most rapidly by 32%, HELCO sales increased 25%, Kauai Electric sales rose 11%, and HECO sales increased 9%.

During the same period, Hawaii's de facto population grew about 1.1%, while GSP grew 3.8%. Electricity sales per capita grew 11.3% and there was an 8.4% growth in electricity sales per real dollar of GSP. Despite this growth, Hawaii's electricity intensity is lower than the U.S. average. Hawaii's electricity intensity in 1997 was less than 0.3 kWh per dollar of GSP, approximately 70% of the 0.43 kWh per dollar of gross domestic product (GDP) for the nation as a whole.

Total statewide electricity demand grew 13% between 1990 and 1997. The 15% growth in residential demand outpaced the 12% increase in commercial/industrial demand.

**The Rapidly Rising Cost of Electricity**. Hawaii's average statewide electricity revenues per kWh were the highest in the nation in 1997. The average revenue per kWh in the United States was $0.069. Average revenues per kWh ranged from $0.11 for HECO to $0.213 for Kauai Electric. The statewide average was $0.125 per kWh. At over $1.17 billion, electricity revenues were 3.4% of Hawaii's estimated 1997 gross state product of $34.2 billion dollars.

Moreover, average electricity revenues for Hawaii utilities grew much faster than the U.S. average over the years 1990 to 1997. By 1997, they were 39.2% higher than 1990 while the U.S. average was only 4.2% higher. In comparison, between 1990-1997, the consumer price index for all urban consumers in Honolulu grew 24%. The overall U.S. consumer price index increased 23% during the same period.

**Changing Ownership of Electricity Generation.** In 1990, Hawaii's utilities produced 90.7% of the electricity sold to customers while NUGs and the sugar industry almost equally accounted for the rest. By 1997, the utility share declined to 62%, and sugar's contribution was down to 1.5% as several sugar plantations closed, including all on Oahu and the Island of Hawaii. Major power purchase agreements by HECO and HELCO raised the NUG share of net generation to 36.5% of the statewide total.

**Increasing Diversification of Fuels**. In this decade, Hawaii's electricity system became increasingly diversified, consistent with one of the State's energy objectives. As recently as 1991, over 92% of the electricity sold in Hawaii by the four electric utilities were generated using oil. In 1997, oil produced 76.5% of electricity, coal 16%, municipal solid waste 3.2%, geothermal 2.3%, sugar biomass 1%, hydroelectric 0.7%, landfill methane 0.2%, and wind 0.1%. Solar water heating is not included as a generation source, but its use reduces the need for generation.

**Integrated Resource Planning and Increased Efficiency.** Integrated Resource Planning (IRP) is an approach to regulated utility planning which evaluates all potential energy options, including supply-side (energy-production by conventional fuels and renewable energy resources) and demand-side management (energy conservation, efficiency and load management) as well as the social, environmental, and economic costs of these options. The goal of IRP is to meet consumer energy needs in an efficient and reliable manner at the lowest reasonable cost.

**Where Can Hawaii Build Its Future Power Plants?** Through the year 2020, Hawaii's electric utilities currently plan to build 1001 MW of new generation as follows -- HECO: 605 MW, HELCO: 101 MW, KE: 60 MW, and MECO: 235 MW. Kauai Electric and Maui Electric have identified future sites for generation and are involved in the permitting process. If both are successful, the facilities planned will provide siting for all new generation planned in the KE and MECO IRPs. HECO and HELCO will need additional sites to install their units planned for the future. While new technologies and reduced costs for renewable alternatives may significantly change the current IRPs, new fossil fuel generation will be need on all four systems. Early identification, approval, and permitting of such sites is the most efficient course for the long term, even if they are not fully built out. The existence of a site for a fossil fuel unit does not preclude use of renewable energy instead should renewable energy be cost-effective.

**Future Technology for Electricity Supply.** Hawaii's geographic isolation helped create its dependence on fossil fuel, especially oil. Developing technologies may provide new solutions to Hawaii's electricity supply problem. Technologies of interest include more efficient fossil fuel central station generation and various forms of distributed generation, such as microturbines, combined heat and power, and fuel cells.

## 8. Increasing Renewable Energy Use in Hawaii

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

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

Sugar bagasse, wind, hydroelectricity, geothermal, landfill methane, and municipal solid waste were used to generate 7.9% of the state's electricity in 1997. 1997 renewable energy production of electricity was 16% greater than in 1990. Although the sugar industry started the decade producing the largest percentage of renewable energy for utility sales, it was surpassed in 1991 by MSW and in 1994 by geothermal.

**Use of *HES 2000* Renewable Energy Recommendations.** *HES 2000* offers specific recommendations for renewable energy projects for consideration by utilities and independent power developers. The recommendations are based upon the *HES 1995* study recommendations and data for biomass, hydro, photovoltaic, and wind systems. Based upon available data, these projects appear to be the most promising. It is clear that updated cost data is needed (funds were not available to update *HES 1995* work) and that the interconnection feasibility of each intermittent system must be further evaluated.

## 9. Electricity Competition and Hawaii

**Electricity Competition.** Currently, Hawaii's four electric utilities are regulated monopolies with exclusive rights to sell electricity to retail customers. As of January 1, 2000, 24 states had enacted legislation or promulgated regulations establishing retail competition programs.

At the federal level, in April 1999, the Clinton Administration submitted a proposed *Comprehensive Electricity Competition Act* to Congress for consideration. Within Congress, a variety of other legislation has been proposed which either included: 1) mandated retail competition for all states, or 2) no mandate for retail competition, thus leaving it up to the states.

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

The Commission made the Consumer Advocate and the four electric utilities parties to the docket and invited all interested stakeholders to participate in the docket. A collaborative was established to discuss and narrow the issues. The Commission also granted intervention status to the Waimana Enterprises; the US Department of Defense; DBEDT, GTE Hawaiian Telephone; Hawaii Renewable Energy Alliance (HREA); Puna Geothermal Venture; Life of the Land; International Brotherhood of Electrical Workers Local 1260; County of Maui; County of Kauai; County of Hawaii; AES Hawaii; and Enserch Development Corporation.

Over the next year, the parties, meeting as the Competition Collaborative, attempted to discuss and narrow the issues, and, if possible, to reach consensus. Due to the diverse views and interests involved, reaching consensus proved impossible. As a result, the Collaborative ultimately decided to provide the Commission with a collection of position papers produced by each of the parties. Initial drafts were discussed at a meeting at the end of June 1998. Many parties provided comments on other parties' papers for their consideration. The papers were finalized and provided to the Commission on October 19, 1998. As of January 2000, the Commission had not yet taken further action.

**Potential Benefits of Electricity Competition.** Some objectives of electric competition include:

- Reduced cost of electricity and an improved economy;
- Stimulation of greater energy efficiency;
- Encourage the use of advanced, diverse generation technology;
- Greater use of renewable energy and diversity of supply; and
- Improved consistency with State energy policy.

DBEDT believes that electricity competition in Hawaii can and should be structured to comport with the state's statutory energy objectives.

**Hawaii's Current Competitive Situation**. There is limited competition in electricity generation in Hawaii under current law. Hawaii's utilities purchased about 40% of the electricity sold to customers from independent power producers (IPPs) and cogenerators in 1997.

**HECO Concept for Increased Competition.** The HECO companies do not believe competition is possible in Hawaii, primarily due to the small size of the six physically independent utility systems/markets. In the Competition Collaborative, the HECO Companies proposed three areas that "have the potential to provide many of the benefits of competition, while working within the existing regulatory system". These included 1) competitive bidding for new generation; 2) performance based ratemaking; and 3) innovative pricing provisions.

***Competitive Bidding for New Electricity Generation.*** The HECO Companies supported the use of competitive bidding "consistent with the unique structure of the electric power market in Hawaii". A similar process has already been used successfully in Hawaii. Kauai Electric selected its next increment of generation from proposals by IPPs in response to a request for proposals. KE did not compete to build the next unit.

***Performance Based Rate Making.*** HECO's performance based ratemaking proposal is complex and will not be described fully here. The plan included an index-based price cap, an earnings sharing mechanism, and a benchmark incentive plan. HECO stated that the plan is intended to strengthen incentives to enhance operations efficiency, lower barriers to market-responsive rates and services, and share the benefits of improved performance with customers.

***Innovative Pricing Procedures.*** HECO stated that their pricing proposals seek to achieve most benefits of competition, including "efficient pricing to provide accurate price signals, increasing customer choice, and lower energy cost to customers by offering them alternative rates that empower them to control their energy costs". A wide variety of rate options would be offered to customers who would theoretically select the option that provided the level of electricity service they wanted. This is intended to be similar to the options offered by electricity marketers under competition.

**Implementing Competition in Hawaii.** Competition could be undertaken by separating the vertically integrated utilities into their component parts. With changes in law, Hawaii's utilities could be split into separate generation, transmission and distribution, and customer service entities. Although additional study is required to determine the best option for Hawaii, this generally has been done through divestiture of all but the transmission and distribution functions of existing utilities so that each generation and customer service company would be owned by separate entities. The utility transmission and distribution functions would remain regulated.

On the Mainland, some states are establishing competition at the retail level. The availability of retail competition, and the promise for its expansion, has led to new market combinations on the Mainland. These combinations have included electric and natural gas companies, as well as energy efficiency providers, home security, telecommunications, and it has promise for home banking, computing, cable, fiber optic, home office programs, etc.

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

Some are concerned that electric utility restructuring may leave individual residential consumers behind. Any change in the current regulatory system must recognize the needs of residential consumers of all types of financial means. Facilitation of aggregation programs involving residential customers could be the most significant method for this class of customers to benefit through restructuring.

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

## 10. Utility and Bottled Gas for Hawaii

**Gas Use in Hawaii.** Since Hawaii does not have access to natural gas, other forms of petroleum-based gas met 2% of Hawaii's energy needs in 1997. Gas is piped to customers through utility systems on Oahu, Hawaii, Maui, Kauai, and Molokai owned by The Gas Company (TGC), a division of Citizens Utilities Company. For the southern portion of Honolulu, SNG is produced from refinery feedstock and provided to TGC customers via pipelines. In other areas of Oahu and on the neighbor islands, propane is stored in tanks and piped to customers through utility pipelines. LPG is also used in the form of bottled, non-utility gas on all islands.

**Utility Gas Supply.** TGC is a utility regulated by the Hawaii Public Utilities Commission. TGC provides SNG and LPG to its Oahu customers who receive their gas through pipelines. Areas outside the SNG grid on Oahu and on the islands of Hawaii, Kauai, Maui, and Molokai are served with propane. The propane is stored in tanks and sent to the customer through distribution pipeline networks. Total utility gas use in 1997 was 313.9 TBtu.

**Non-Utility Gas.** For customers not on utility pipelines, an option for water heating, cooking, drying, and other gas uses is non-utility bottled gas. In addition, a number of vehicles are fueled with propane, usually at fleet bases or at some gasoline stations. As noted above, in 1997, non-utility gas use was 2.86 TBtu. Non-utility gas is available from several different vendors in Hawaii.

## 11. Increasing Energy Efficiency in Hawaii's Buildings

Most of Hawaii's electricity, utility gas, and non-transportation uses of fuel are used to provide lighting, heating, ventilation, air conditioning, water heating, drying, cooking, and other end-uses in buildings. Federal, State, and local governments, the utilities, and public-private partnerships, such as the Rebuild America Program, carry out a variety of building energy efficiency programs in Hawaii.

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

**Current Building Efficiency Measures in Hawaii.** Current building efficiency measures include the Model Energy Code, utility demand-side management programs, and a variety of State, County, and Federal government efficiency programs.

***The Hawaii Model Energy Code.*** The code sets minimum requirements for the energy-efficient design of new buildings, provides criteria for energy-efficient design, and provides methods for determining compliance with these criteria. It sets standards for electric power; lighting; building envelope; heating, ventilating, and air conditioning systems and equipment; water heating systems and equipment; and energy management. All counties except Maui County have adopted the code. Honolulu and Kauai counties exempted low-rise residential buildings; Hawaii County exempted single family dwellings and duplexes.

***Utility Demand-Side Management Programs (DSM).*** DSM is defined as any utility activity aimed at modifying the customer's use of energy to reduce demand. It includes conservation, load management, and efficiency programs. DSM offers the potential for lower customer utility bills, deferral of major power plant investments, reduced environmental impacts, and potential diversification of resources. The four electric utilities have each developed DSM programs, which are detailed in the *HES 2000* report.

***State Government Efficiency Programs.*** The State of Hawaii is involved in a number of energy efficiency programs that reduce the need for electricity generation and reduce electricity demand. Hawaii government programs identify, initiate, and implement energy and resource efficiency programs through public/private sector partnerships and through existing resources and competitive grants awarded from federal agencies.

***County Government Energy Efficiency Programs.*** Hawaii's County governments are involved in a variety of energy efficiency programs in conjunction with the federal and state governments and independently.

***Federal Energy Efficiency Programs in Hawaii.*** The mission of the Federal Energy Management Program (FEMP) is to reduce the cost of government by advancing energy efficiency, water conservation, and the use of solar and other renewable energy. A key element of FEMP activities has been partnership with local electric utilities and use of demand-side management incentives offered by those utilities.

***New Technologies for Energy Efficiency***. In 1998, the American Council for an Energy-Efficient Economy examined more than 200 emerging energy efficiency technologies and practices that were defined as commercialized, but had not achieved more than 2 percent market penetration or would be "off-the-shelf" by 2005. DBEDT screened the list for applicability to Hawaii and selected six high priority measures and 12 medium priority measures for recommendation as part of *HES 2000*.

## 12. Energy Emergency Preparedness

**Hawaii's Potential for Energy Emergencies**. Hawaii's geographic isolation and dependence on imported oil make Hawaii's people critically vulnerability to serious energy shortages. The combination of oil overdependence, isolation from sources of supply, and the unpredictability of the world oil market create a great deal of energy security concern for Hawaii. The challenge for Hawaii is to be as prepared as possible to effectively contend with energy emergencies and threats to Hawaii's energy security. Energy emergencies can stem from oil market disruptions or from natural and man-made disasters. Such events could lead to an energy shortage.

**The State of Hawaii Energy Emergency Preparedness (EEP) Program.** The State's EEP Program is structured to address both market and disaster-related energy emergencies. The State's EEP Program is made effective only by the hard work and cooperation of Hawaii's private sector energy companies **--** the front-line energy emergency responders. The State's EEP Program to assist industry is only activated when the private sector is stretched beyond its capabilities.

**Recent Developments in the EEP Program.**

On May 6-8, 1998, the State of Hawaii conducted a regional energy emergency seminar and simulation exercise for Hawaii, the Western states, and Pacific Island Territories. This event exercised joint public/private sector energy emergency response coordination organizations and tested the concept of operations of the Energy Council (EC). The EC approach was examined as an application that may be applicable to other jurisdictions based on its demonstrated success in the aftermath of Hurricane Iniki in 1992 and in a statewide energy emergency simulation exercise in 1997.

On November 13, 1998, a new federal law (Public Law 105-388) was enacted to provide Hawaii and the insular U.S. Pacific and Atlantic Territories priority access to oil in the Strategic Petroleum Reserve (SPR) in the event of a draw down. This legislation was introduced by Senator Daniel Akaka and was supported by Senator Daniel Inouye and Hawaii's Congressional representatives. The legislation was based on policy analyses provided by DBEDT in cooperation with Hawaii's energy industry.

In January 1999, the U.S. Army Corps of Engineers (Corps) completed a supplemental study on coastal hazard mitigation. Also, in 1999, the State initiated a project to survey emergency and essential service facilities with generators for the purpose of documenting emergency power requirements and generator technical specifications.

The above programs are designed to prepare for a wide range of conditions and scenarios involving reduction in available fuel supplies and decreasing the hardships and inequities which energy shortages could cause.

No single solution or set of plans can entirely remove the vulnerability Hawaii faces. However, the State in seeking to reduce the impact of energy vulnerability works in concert with industry and the county governments to:

- Annually exercise EEP plans statewide,
- Encourage the diversification of energy usage,
- Utilize energy more efficiently,
- Plan and prepare for fuel shortages when they occur, and
- Conduct hazard mitigation measures.

## 13. Scenarios for Hawaii's Energy Future

Chapter 13 of *HES 2000* reports on the results of a number of scenario runs conducted to examine ways to improve Hawaii's energy future. The scenarios incorporated actions to increase the efficiency of Hawaii's energy system and to reduce the use of fossil fuels. The scenarios discussed in this chapter were compared on the basis of reductions in $CO_2$ emissions from energy used in Hawaii and for domestic air and marine transportation. The $CO_2$ emission reductions primarily represent fossil fuel energy savings, a principal objective of *HES 2000*.

The scenarios were compared to a Base Scenario designed, to the extent possible, to replicate the current Hawaii energy system and known plans for additions through the year 2000. The continued use of existing technologies was assumed and their costs were based upon utility Integrated Resource Plans (IRP plans) as of October 1999.

Any model must incorporate simplifications, but such simplifications do not negate its utility. The trends and patterns forecasted by the model can be used to examine a variety of possible futures. By applying policy or scenario alternatives, the estimated effects of options can be compared against the Base Scenario to determine estimated effectiveness. The model also yields estimates of economic effects to help evaluate cost or benefits of alternative measures. Scenarios that offer desirable outcomes warrant more detailed analysis and study by those organizations able to carry out the recommendations.

**Electricity Scenarios.** Three scenarios were modeled that were designed to increase renewable energy use, reducing future fossil energy use and greenhouse gas emissions. The Base Scenario is the current planned Hawaii energy system. The 20% Renewable Energy Scenario, was designed to deploy renewable energy systems totaling about 20% of all new generation added statewide during the 2000-2020 period. Renewable energy resources considered were selected from projects known to be under contract or under negotiation as of late 1999 and recommendations of *HES 1995*. Intermittent resources were added to the utility plans and were not assumed to displace fossil fuel generation, but to reduce fossil fuel use. The 10% Renewable Energy Scenario, E3, was designed to deploy renewable energy systems totaling about 10% of all new generation added during the 2000-2020 period.

Figure 7 shows the $CO_2$ emissions estimated by the ENERGY 2020 model for the period 1990-2020. None of the three scenarios reduced greenhouse gas emissions below the Kyoto target of 7% less than 1990 levels. By 2010, under the Base Scenario, forecast $CO_2$ emissions were about 3.7 million tons, or 23.3%, above the Kyoto target. The 20% Renewable Scenario offered the greatest reduction of $CO_2$, but it was estimated to be still 1.2 million tons, or 19.6%, above the target in 2010.

It should be kept in mind that these scenarios are presented to examine the effectiveness of various strategies in reducing electricity sector $CO_2$ emissions. Any decision for actual construction of the projects modeled in the scenarios would require extensive further analysis, including evaluation of updated cost information, technical feasibility of integration of the particular systems into the electricity system, site availability, the likelihood of obtaining necessary permits, etc.

**Transportation Energy Scenarios.** Transportation energy use produces the largest percentage of Hawaii's $CO_2$ emissions from domestic energy use. The scenarios were designed to examine potential ways of reducing transportation emissions. The Baseline Scenario for the transportation runs was the same as used in the electricity sector analysis above. Under the T2 Scenario, the use of a 10% ethanol/90% gasoline blend in Hawaii was projected to begin in 2000. It was assumed that the ethanol would be produced in Hawaii. The T3 Scenario assumed that Hawaii's citizens bought new vehicles 10% more efficient than 1998 purchases beginning in 2001. The T4 Scenario assumed that Hawaii's citizens bought new vehicles 100% more efficient than 1998 purchases beginning in 2006. The essential factor would be the availability of highly efficient automobiles now in the research and development phase. A combination of highly efficient conventional vehicles, hybrid vehicles, alternate fuel vehiclees, and fuel cell vehicles could be involved. Combination of efficient vehicles with transportation demand reduction measures could help achieve this level of improvement. The Department of Energy has estimated that aircraft efficiency could improve at a rate as high as 2.5% per year, and Scenario A2 modeled such improvements beginning in 1998, representing a nominal technical potential.

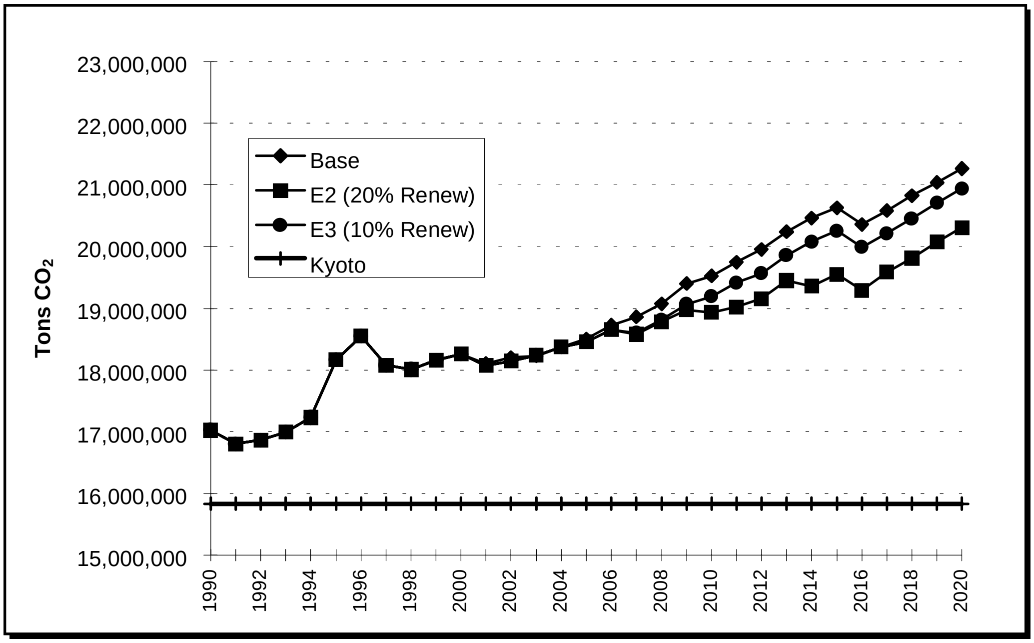


***Figure 7. Estimated Hawaii $CO_2$ Emissions under Electricity Sector Scenarios, 1990 - 2020***

Figure 8 depicts estimated $CO_2$ emissions for 1990 to 2020 under the transportation scenarios. As with the electricity sector, no single transportation sector scenario reduced $CO_2$ emissions to the target level. Scenario T4, the availability and use of increasing numbers of new, highly efficient vehicles beginning in 2006, produced the greatest emissions savings. Yet, overall emissions were 2.23 million tons, or 14.1% greater that the target in 2010. Greater civil aircraft efficiency (Scenario A2) yielded the second greatest savings, but resulted in $CO_2$ emissions 2.95 million tons, or 18.7%, greater than the Kyoto target in 2010. Scenario T2, 10% ethanol fuel reduced emissions by 3.04 million tons or 19.2% by 2010. Under Scenario T3, 10% increase in fuel efficiency beginning in 2001, emissions were 3.34 million tons, or 21.2% greater than the target.

**Carbon Tax Scenarios.** Carbon taxes, based upon the carbon content of fossil fuels, have been discussed as a way of internalizing the costs of fossil fuel use on the environment. They would increase the cost of fuels, discouraging their use. In the ENERGY 2020 model, it was assumed that the taxes were a cost to Hawaii's economy. Alternatively, a carbon tax could be used instead to offset other taxes, which would likely reduce the negative economic consequences of carbon taxes while still tending to reduce fuel use.

It is not clear whether the fuel use reduction would differ depending upon the ultimate payee of the tax and any offsetting deductions from other taxes. These considerations, in addition to the potential that negative economic consequences might be especially harsh for Hawaii, should be explored in detail before such a tax is considered or enacted. Two carbon tax scenarios were examined. They were applied to all fossil fuels and were implemented in 2005. They were as follows: CT1 -- $50 per ton; and CT2 -- $125 per ton. With CT1, the $50/Ton carbon tax, $CO_2$ emissions were estimated by the model to be 3.46 million tons or 21.9%

above the Kyoto target in 2010. The $125/Ton carbon tax modeled in CT2 still resulted in $CO_2$ emissions 2.67 million tons, or 18.1% greater than the target.

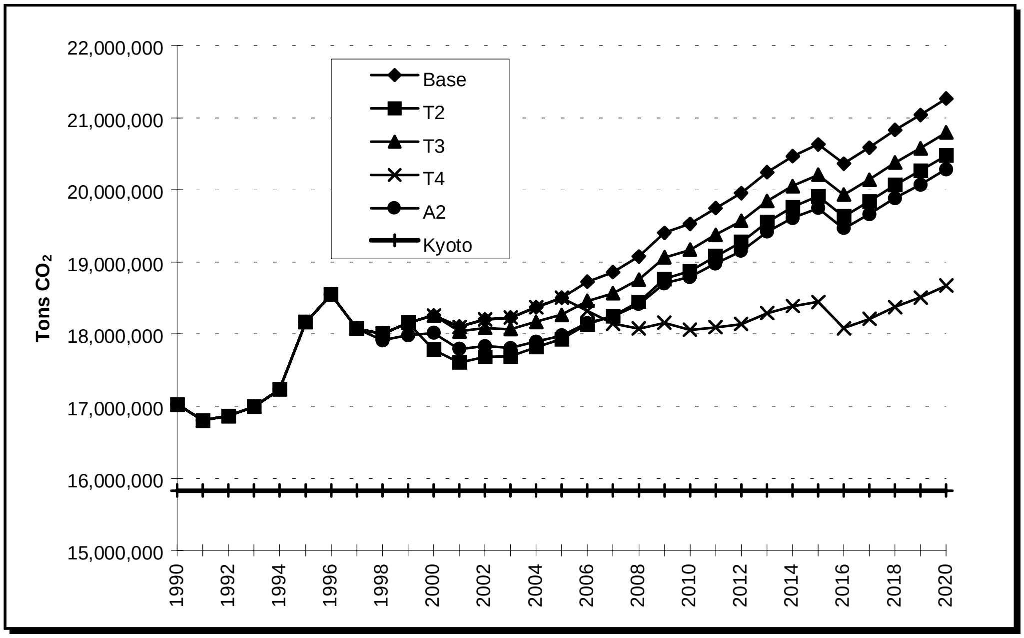


***Figure 8. Estimated Hawaii $CO_2$ Emissions under Transportation Sector Scenarios, 1990 – 2020***

**Combination Scenario Runs**. In developing the Combination Scenarios, the individual scenarios discussed above were ranked in order of year 2010 $CO_2$ savings. Three Combination Scenarios were created to group the scenarios that offered the greatest potential $CO_2$ reductions to further explore some of the options available to policy-makers and their effectiveness in reducing greenhouse gas emissions. These were:

- **C1 – Maximum Reduction Scenario with Maximum Carbon Tax.** Scenario C1 combined the electricity scenario with the greatest $CO_2$ reductions, E2 – 20% Renewable Energy, with four of the transportation scenarios. These included A2 – Aircraft Efficiency Improvements, T2 – 10% Ethanol-based Gasoline, and T4 – 100% Increase in New Vehicle Efficiency. The maximum carbon tax scenario, CT-2, at $125/ton of $CO_2$ was also included.
- **C2 – Maximum Reduction Scenario without Carbon Tax.** This scenario included all of the elements of C1, but without the $125/ton carbon tax (CT-2).
- **C3 – Hawaii-based Reductions Scenario.** C3 was intended to examine the emission reductions under the control of various entities in Hawaii. The scenario was also based on the E2 – 20% Renewable Energy electricity scenario. In the transportation sector, T2 – 10% Ethanol-based Gasoline, and T3 -- 10% Increase in New Vehicle Efficiency in 2001 were also included.

Figure 9 depicts the results of the three Combination Scenarios in comparison with the Base Scenario and the Kyoto target. The C1 Scenario, Maximum Reduction Scenario with Carbon Tax, reduced $CO_2$ emissions below the Kyoto target by 2009 and remained below there through 2020. The C2 Scenario, Maximum Reduction Scenario without Carbon Tax, achieved the next greatest estimated $CO_2$ emissions reduction, reaching a level only 3% above the Kyoto target in 2010, dipping below the target in 2016, and ending in 2020 2% above the target. The reader is reminded that these results depend upon transportation technology advances that are expected, but may not occur exactly as estimated. The C1 and C2 Scenarios also assume adoption of these technologies by Hawaii's people, businesses, and institutions. As Figure 10 shows, under both Scenarios, emissions growth began to overcome the improvements in efficiency and use of renewable energy about 2016, suggesting that additional measures will be required at that time to achieve further reductions. C3, the Hawaii-based Reductions Scenario, brought emissions down to within

15% of the Kyoto target by 2010, an 8% improvement over the Base Scenario. By 2020, emissions increased to 19% above the Kyoto Target, a 10% improvement over the Base Scenario.

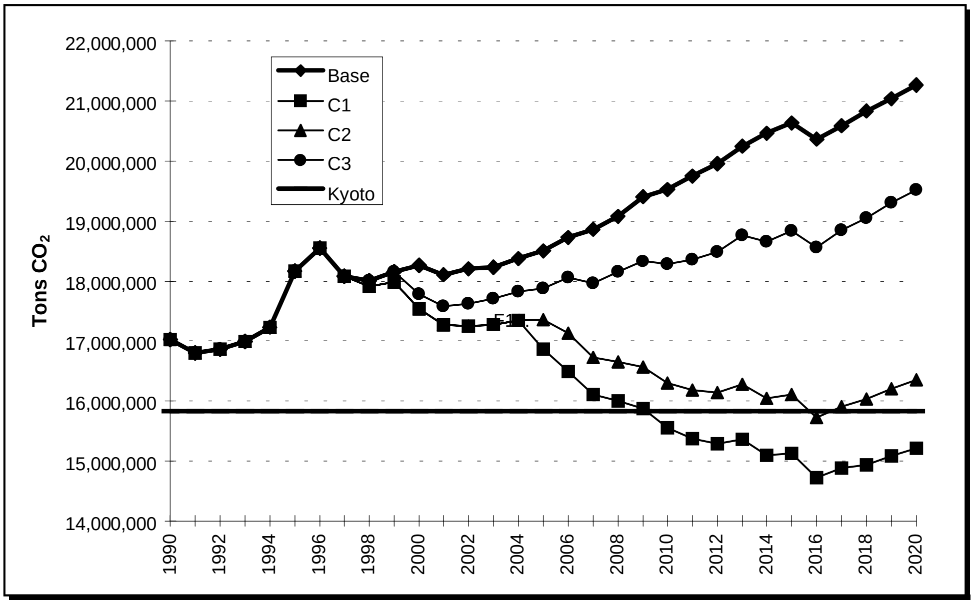


***Figure 9. Estimated Hawaii $CO_2$ Emissions under Combination Scenarios, 1990 – 2020***

**Estimated Economic Effects of Scenarios and Recommendations.** The estimated effects of implementing each scenario on gross state product (GSP), personal income, and employment were also evaluated. More detail is presented in the report, but Table 2 provides a summary. It ranks the scenarios by their estimated $CO_2$ savings in 2010 and their benefit or cost compared to the Base Scenario GSP, Personal Income, and Employment for the period 2000-2020.

Only four scenarios (C2, GT4, A2, and GT3) produced positive economic effects over the 2000-2020 period. Together, these further susggest the economic benefits of reducing the amount of money spent on imported oil. The next four scenarios, which did not include a carbon tax (E2, E3, GT2, and C3), had relatively small negative effects on GRP. Scenarios C1, CT1, and CT2, which contained a carbon tax had significant negative economic effects.

**Table 2 Scenario Rankings by Estimated $CO_2$ Savings in 2010, and by GSP, Personal Income, and Employment, 2000-2020**

| $CO_2$ Rank | Scenario | 2010 $CO_2$ Savings (Tons) | Effects on Economy 2000 - 2020: GSP (92$) Rank | GSP (92$) Amount | Personal Income (92$) Rank | Personal Income (92$) Amount | Job Years Rank | Job Years Number |
|---|---|---|---|---|---|---|---|---|
| 1 | C1 - Max Reduction w/ Tax | 3,975,836 | **10** | (2,494,800,000) | **10** | $(3,536,200,000) | **7** | (2,495) |
| 2 | C2 - Max Reduction w/o Tax | 3,227,055 | **1** | $ 1,612,300,000 | **1** | $ 4,583,000,000 | **1** | 32,818 |
| 3 | GT4 - 100% Vehicle Efficiency Improvemen | 1,465,366 | **2** | $ 1,136,000,000 | **2** | $ 3,267,400,000 | **2** | 23,229 |
| 4 | C3 - Hawaii-based Reductions | 1,247,184 | **8** | $ (248,800,000) | **7** | $ (641,600,000) | **9** | (5,490) |
| 5 | CT2 - $125/Ton Carbon Tax | 823,656 | **11** | (4,602,600,000) | **11** | $(9,486,200,000) | **11** | (75,123) |
| 6 | A2 - Improved Aircraft Efficiency | 735,281 | **3** | $ 711,100,000 | **3** | $ 1,913,900,000 | **3** | 14,789 |
| 7 | GT2 - 10% Ethanol Gasoline | 654,434 | **7** | $ (244,900,000) | **8** | $ (643,900,000) | **8** | (5,385) |
| 8 | E2 - 20% Renewable Energy | 590,867 | **5** | $ (18,900,000) | **5** | $ (52,900,000) | **5** | (470) |
| 9 | GT3 - 10% Vehicle Efficiency Improvement | 358,071 | **4** | $ 341,800,000 | **4** | $ 940,200,000 | **4** | 7,196 |
| 10 | E3 - 10% Renewable Energy | 330,490 | **6** | $ (27,400,000) | **6** | $ (69,300,000) | **6** | (580) |
| 11 | CT1 - $50 per Ton Carbon Tax | 232,687 | **9** | (817,600,000) | **9** | $(1,749,600,000) | **10** | (13,735) |

## 14. Facilitating Exports of Sustainable Technology to the Asia-Pacific Region

**Hawaii's Strategic Technology Marketing and Development Program.** Hawaii’s Strategic Technology Market Assessment and Development (STMAD) Program is designed to facilitate increased exports of U.S. energy, environmental and other sustainable technologies and related services into Asia/Pacific markets.

STMAD focuses on Asia-Pacific markets due to their high growth history and future potential. A key objective of STMAD is to facilitate sustainable, technology-related economic development for Hawaii, create higher valued jobs, and diversify the State's economy. Hawaii and U.S. exports of sustainable technology, especially renewable energy; energy efficiency; advanced, high-efficiency fossil-fueled energy; recycling, reuse, and remanufacturing; information technologies; health care; ocean science and technologies; and environmental management, control, protection, and remediation. The energy-related elements of STMAD will help reduce fossil fuel use and will also help to mitigate and reduce greenhouse gas emissions, which contribute to global climate change.

**STMAD Partnerships**. Partnerships with industry through business opportunity missions, government-to-government contacts throughout Asia, and business leads through workshops and conferences in Hawaii are the central component of STMAD. STMAD seeks to match commercial applications of sustainable technologies and related services to targeted demand in the Asia-Pacific region.

**STMAD Goal, Priorities, and Activities.** STMAD has the following major goals, priorities, and activities in these areas:

- ***Supply.*** Expand and diversify the export activities of Hawaii's existing sustainable technology and related service companies; and next priority: Attract Mainland technology firms to locate in Hawaii;
- ***Demand.*** Identify and develop strategic technology niche markets, which Hawaii companies can serve now or gain the capacity to serve, or that will attract Mainland technology enterprises to Hawaii;
- ***Technology Industry Development and Promotional Activities***;
- ***Specific Projects.*** Identify, and help facilitate development of specific projects to increase exports of U.S. technologies and services from Hawaii;
- ***Finance.*** Provide tailored sustainable infrastructure project finance training for potential client country decision-makers and facilitate financing arrangements for specific projects; and
- ***Market Analyses and Evaluation.*** Measure, analyze, and report technology-related economic development in Hawaii. This information is used to tailor future STMAD Program activities for greater efficiency and effectiveness.

**Opportunities in Environmental Technology Exports: Hawaii's Competitive Edge.** Unlike straightforward product exports, business and technical transactions inherent to development of environmental infrastructure in the Asia-Pacific require strong cross-cultural understanding. Hawaii has a strong Asian orientation, so there is an inherent and valuable knowledge of the various Asian cultures among its citizens. That could enhance the State of Hawaii's ability to fill the emerging need for individuals who can operate cross-culturally in supporting the delivery of hands-on environmental technologies.

**STMAD's Current Activities.** STMAD's Current Activities include the following:

***Center for Asia-Pacific Infrastructure Development (CAPID).*** The State of Hawaii established the CAPID as part of STMAD to promote exports of U.S. energy, environmental, transportation-related and other infrastructure technologies and related services to facilitate sustainable economic development throughout the Asia-Pacific region, while helping to diversify and strengthen the American economy.

***Hawaii/Philippines Energy Efficiency Technology and Policy Transfer Project.*** This project has four primary objectives:

- Introduce advanced Hawaii and U.S. energy efficiency technologies and policies to the Philippines;
- Introduce Hawaii and U.S. energy service companies to business development and partnering opportunities in that country;

- Provide policy advisory support on the refinement and enforcement of Philippine energy codes and standards; and

- Provide policy and technical assistance on designing and implementing utility demand-side management (DSM) programs, as well as energy efficiency performance contracting.

***Hawaii/Philippines Biomass-to-Electricity Assessment and Commercial Case Study Project.*** In partnership with Hawaii's ERTD and the Philippines Department of Energy, the UH-HNEI is conducting this project, which includes a complete inventory and future projections of the availability of Philippine biomass feedstocks for use as fuel for electricity generation. The project is developing recommendations for commercially applying the most economic, environmentally responsible energy conversion technologies to develop these biomass fuels. The database and networking that stem from this effort ultimately will help to identify opportunities and strategies for Hawaii companies to serve markets in the Philippines for commercial deployment of bio-energy technologies, products, and services.

***Technical and Market Assessments***. In addition DBEDT is involved in several technical and market assessments, including:

- Hainan Province, China, Energy and Environmental Infrastructure Assessment;

- Assessment of Potential for Biomass Electricity in Philippines, Thailand, Malaysia, and Indonesia; and

- Hawaii's Asia-Pacific Infrastructure Demand Profiles on the World Wide Web.

***Business Opportunities & Technical Exchange Missions.*** The following missions have been conducted:

- Business Mission to Hong Kong, May 31 - June 4, 1999;

- Hawaii Trade Mission to Vietnam, May 18-30, 1999;

- Trade & Sustainable Energy Technical Exchange Mission to Hainan Province, China, November 13-22, 1998; and

- Thailand Business Opportunities Mission, April 25 – May 4, 1997.

## 15. Future Technology and Energy in Hawaii

New technology is clearly needed to make major changes in Hawaii's energy system, to reduce energy costs, and reduce fossil fuel use and resultant greenhouse gas emissions. In the model runs and analysis, existing technologies were considered in developing and addressing options. This chapter discusses several research and development efforts currently underway in Hawaii that may allow use of indigenous energy resources or more efficient fuels such as hydrogen. These technologies could also contribute to greenhouse gas emissions reductions. It also examines a number of technologies under development that are expected to provide energy and transportation more efficiently and with reduced greenhouse gas emissions.

**Hawaii Research and Development Projects.** There are a number of current and recent research and development projects in Hawaii that offer potential contributions to Hawaii's energy system as well as greenhouse gas reduction and climate change mitigation.

***Hydrogen: Fuel of the Future.*** Hydrogen has been called the fuel of the future. It may be the ultimate energy carrier -- a versatile, transportable fuel that can be converted easily and efficiently to other forms of energy without producing harmful emissions. Hydrogen can be used as a fuel for transportation, electricity generation, cooking, and heating. It can be produced from renewable resources, such as electrolysis of water into hydrogen and oxygen using solar energy or wind energy, or direct conversion of biomass into hydrogen and other gases.

In the past, the cost of production, difficulties in storage, and lack of infrastructure have been obstacles to everyday use of hydrogen. The U.S. Department of Energy Center for Excellence for Hydrogen Research and Education at the University of Hawaii's Hawaii Natural Energy Institute (HNEI) is conducting research to address the cost and storage issues. Work is underway in the area of photoelectrochemistry, biomass gasification of hydrogen, and hydrogen storage technologies.

***New Technology for Charcoal Production.*** Charcoal has been made in virtually the same way for 6,000 years. The process is long, causes severe air pollution, and has low yields. An innovation by HNEI researcher Dr. Michael J. Antal, Jr., at the University of Hawaii offers the potential to greatly reduce production time to an hour or less, while reducing smoke and other pollution, and doubling or tripling yields. This technique could help slow deforestation and reduce pollution in the many developing nations that use large amounts of charcoal, reducing greenhouse gas emissions.

***Open-Cycle Ocean Thermal Energy Conversion (OTEC).*** The technology for generating electricity from different ocean temperatures is known as ocean thermal energy conversion, or OTEC. OTEC makes use of the difference in temperature between the warm surface water of the ocean and the cold water in depths below 2,000 feet to generate electricity. As long as a sufficient temperature difference (about 40 degrees Fahrenheit) exists between the warm upper layer of water and the cold deep water, net power can be generated.

Almost all of major U.S. OTEC experiments in recent years have taken place in Hawaii. The Natural Energy Laboratory of Hawaii Authority (NELHA) on the Big Island is recognized as the world's foremost laboratory and test facility for OTEC and OTEC-related research. The State of Hawaii funded the facility, with significant USDOE participation. The Pacific International Center for High Technology Research (PICHTR) in Honolulu designed, constructed, and operated a 210-kilowatt open-cycle OTEC plant. When it was operational, the plant set the world record for OTEC power production at 255 kilowatts gross. Testing ended in 1997.

OTEC continues to offer a way to generate greenhouse gas emission-free electricity. Additional research, component cost reduction, and funding of a utility-scale plant are needed to create a viable commercial technology.

**International $CO_2$ Ocean Sequestration Field Experiment.** During the Third Conference of the Parties of the Framework Convention on Climate Change at Kyoto in December 1997, agencies of the governments of the United States, Japan, and Norway signed a major international research agreement to develop technologies to sequester $CO_2$ removed from fossil fuel combustion from the atmosphere. Under the agreement, researchers from the three nations will test the feasibility of deep ocean sequestration of $CO_2$ via discharge from submerged pipelines.

The objective of the experiment is to identify safe and practical means of reducing $CO_2$ emissions while ensuring a stable and inexpensive energy supply. The first phase of the experiment will release a modest amount of $CO_2$ at depths of more than 3,000 feet over the period of a month. Data on the dissolution and dilution of the $CO_2$ will be obtained to assess any impacts on the deep ocean environment and to develop models of the discharge that can be used to predict and quantify changes in seawater chemistry. The first phase of the project will run through March 2002, with the experiments taking place in the summer of 2001.

The Pacific International Center for High Technology Research (PICHTR) of Honolulu is the general contractor. The experiment will take place in the ocean research corridor offshore of the Natural Energy Laboratory of Hawaii Authority at Kailua-Kona, Hawaii.

It should be noted that ocean sequestration is potentially well suited for fossil-fueled power stations in Hawaii. As noted in Chapter 7, Hawaii's power producers do not enjoy the option of switching to lower cost and lower carbon content fuels such as natural gas as is occurring with Mainland utilities. $CO_2$ removal from stack gases and sequestration in the deep ocean could be added to their other $CO_2$ reduction options of improved heat rate, energy efficiency programs, and use of renewable energy resources.

Hawaii's power stations probably have the best access to the deep ocean in the U.S. The U.S. Department of Energy, however, estimates that about 30% of U.S. power plants would have access to deep-water sequestration (USDOE 1997b). A pilot facility, which is being planned by the three nation consortium for development in the 2005-2010 time frame, could well be sited in Hawaii, possibly next to the Hawaiian Electric Company's Kahe station on Oahu (Masutani 1998).

**The Need for New Technologies.** Hawaii, and the rest of the world, will need new technologies to effect significant improvements in energy efficiency, increase use of renewable energy, and reduce greenhouse gas emissions necessary to reduce the consequences of global warming on climate change. In the context of

*HES 2000*, it is stressed that improvements in energy efficiency and use of renewable energy also offer economic and other environmental benefits.

The U.S. Secretary of Energy recently asked the Directors of the Department of Energy's national laboratories to identify technologies that could be used to meet this challenge nationally. The study was summarized in *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions*, published in October 1997. As the National Laboratory Directors stated, "Advances in science and technology are necessary to reduce greenhouse gas emissions from the United States while sustaining economic growth and providing collateral benefits to the nation".

**The Outlook for Technological Solutions.** The National Laboratories Directors pointed out that solutions available early are more effective in reducing emissions. They believe that, by 2030, a vigorous research, development, and demonstration program could result in a "wide array of cost-effective technologies that together could reduce the nation's carbon emissions by 400-800 million metric tons of carbon per year. This decrease represents a significant portion of the carbon emission reductions that may be targeted by the U.S. for 2030".

Looking ahead over the next thirty years, each decade was seen as distinct in the range of potential greenhouse gas reduction technologies. The technological pathways identified were energy efficiency, clean energy, and carbon sequestration.

In the first decade (2000-2010), advances in energy efficiency would reduce the energy intensity of the U.S. economy. Clean energy technologies would continue to grow, and carbon sequestration technologies could begin to emerge.

In the second decade (2011-2020), continued improvements in energy efficiency, and research-based advances in clean energy technologies would significantly reduce the amount of carbon emitted per unit of energy used. A wide variety of improved renewable, nuclear, and fossil energy technologies could be introduced.

During the third decade (2021-2030), clean energy technology reductions could begin to exceed the impact of increased energy efficiency by 2025. Success in the area of carbon sequestration is seen to be essential for the U.S. to continue its extensive use of fossil fuels without harming the global environment.

**National Goals for Research, Development, and Demonstration (RD&D).** The National Laboratory Directors suggested the following goals for a RD&D program. Many offer potential guidelines for Hawaii.

***National Energy Efficiency RD&D Goals.***

- Use energy efficiency more efficiently through the development of advanced technologies (e.g., intelligent building control systems, cost-effective refrigerators that use half as much electricity as today's models, and fuel cells for heat and power in commercial buildings).
- Reduce use of gas and oil for space and water heating through building efficiency measures (e.g., super insulation, gas-fired heat pumps that provide highly efficient space heating and cooling, and building envelopes that capture and store solar energy for later use). (Note: While Hawaii has minimal space heating requirements, some of these measures can reduce the need for air conditioning or be used to provide for cooling in large buildings. Solar water heating remains an important technology for Hawaii's residential and smaller commercial buildings.)
- Improve industrial resource recovery and use (e.g., develop and integrated gasification combined cycle power technology, which can convert coal, biomass, and municipal wastes into power and products) and industrial processes to save energy (e.g., advanced catalysts and separations technologies).
- Increase transportation efficiency through new technologies (e.g., a hybrid electric vehicle that is three times more fuel-efficient than today's standard model).

***National Clean Energy RD&D Goals.***

- Change the energy mix to increase use of sources with higher generating efficiencies and lower emissions -- increased use of natural gas, safer and more efficient nuclear power plants, renewable energy (e.g., solar and wind power; electricity and fuels from agricultural biomass), and hydrogen (to produce electricity through fuel cells).

- Develop "energyplexes" that would use carbon efficiently without emitting greenhouse gases for the integrated production of power, heat, fuels, and chemicals from coal, biomass, and municipal wastes.
- Distribute electricity more efficiently to reduce emissions (e.g., distributed generation using superconducting transformers, cables, and wires).
- Switch transportation to energy sources with lower emissions (e.g., trucks that run on biodiesel fuel, ethanol from cellulosic feedstocks, etc.).
- Remove carbon from fuels before combustion.

***National Carbon Sequestration RD&D Goals*.**

- Efficiently remove carbon dioxide from combustion emissions before they reach the atmosphere.
- Increase the rate at which oceans, forests, and soils naturally absorb atmospheric carbon dioxide.
- Develop technologies for long-term carbon storage in geological deposits, aquifers, and other reservoirs.

## 16. Recommendations

The table beginning on the following page summarizes the recommendations of *HES 2000* based upon the discussion in the preceding chapters. Recommendations are organized by chapter. For each recommendation, the organizations that are encouraged to take action are indicated in first column.

| Suggested Lead Organization (s) | Recommendation |
|---|---|
| **Chapter 1 The State of Hawaii Energy Program, Hawaii Energy Strategy 2000, and the Hawaii Climate Change Action Plan** | |
| DBEDT for consideration of Legislature | Propose a new State Energy Objective related to climate change to the 2000 Hawaii State Legislature. |
| DBEDT, appropriate State agencies, Counties, and interested stakeholders | Continue Hawaii Climate Change Action Program and participation in U.S. Environmental Protection Agency's State and Local Climate Change Partners' Program. |
| DBEDT, appropriate State agencies, Counties, and interested stakeholders | Set Hawaii Greenhouse Gas Reduction Goals with public input. |
| DBEDT, appropriate State agencies, Counties, and interested stakeholders | Identify future effects of climate change on Hawaii and plan adaptation measures. |
| **Chapter 4 Energy for Ground Transportation** | |
| City and County of Honolulu and other Counties | Continue efforts to increase use of mass transit to reduce energy use. |
| DBEDT | Encourage production and sale of 10% ethanol blend gasoline in Hawaii. |
| DBEDT | Continue to assist fleets in complying with EPACT requirements for alternative fuel vehicles. |
| DBEDT and Counties | Publicize incentives for alternate fuel vehicle ownership. |
| DBEDT, City and County of Honolulu, and other participants | Support the Honolulu Clean Cities Program |
| DBEDT, Counties, HEVDP, and electric utilities | Encourage early deployment of electric vehicles in Hawaii. |
| Legislature | Consider increasing the visibility of driving costs. |
| Legislature | Consider increasing information on the environmental costs of vehicle fuel use with a new Environmental Impact Information Sheet. |
| State DOT and Counties | Improve the bicycle transportation system. |
| State DOT, OMPO, and Counties | Reduce congestion through the use of transportation control measures. |
| State DOT, OMPO, and Counties | Develop estimates of energy- and emission-saving effectiveness of TCMs to help prioritize their potential use. |
| State Land Use Commission, DLNR, DOT, and Counties | Use land use planning to reduce traffic congestion and the need for transportation. |
| Vehicle dealers | Encourage purchase and use of fuel-efficient conventional vehicles and hybrid vehicles. |
| **Chapter 5 Energy for Air Transportation** | |
| Airlines | Maintain improved load factors and continue operational changes for fuel efficiency. |
| Airlines | Adopt additional operating measures suggested to increase fuel efficiency. |
| Airlines | Maintain high load factors while increasing overall overseas capacity. |
| Airlines and Department of Transportation | Use newer, more efficient aircraft on overseas routes. |

| **Suggested Lead Organization (s)** | **Recommendation** |
|---|---|
| **Chapter 5 Energy for Air Transportation (continued** | |
| Hawaii Congressional Delegation and Legislature | Insure proposals for Carbon Taxes on aviation fuels do not adversely affect Hawaii and take into account Hawaii's lack of alternatives to air transportation for interisland and overseas travel and potential effect on tourism of higher airfares. |
| Interisland airlines | Re-equip interisland airlines with newer, more efficient aircraft when economically feasible. |
| **Chapter 6 Energy for Marine Transportation** | |
| Hawaii Congressional Delegation and Legislature | Insure proposals for Carbon Taxes on marine fuels do not adversely affect Hawaii and take into account Hawaii's lack of alternatives to marine transportation for interisland and overseas cargo and potential effect on economy of higher shipping rates. |
| Shipping companies | Adopt technical improvements to ships for energy efficiency. |
| Shipping companies | Consider changes in operating procedures for energy efficiency. |
| **Chapter 7 Generating Electricity for Hawaii** | |
| Electric utilities, State Land Use Commission, Counties, and stakeholders | Identify, designate, and permit sites for future electricity generation consistent with Integrated Resource Plans. |
| Electric utilities and non-utility generators | Continue diversification of fuels used for electricity generation. |
| Electric utilities and non-utility generators | Continue to pursue greater efficiency in fossil fuel central generation. |
| Electric utilities and non-utility generators | Increase renewable energy use for electricity generation. |
| Electric utilities and non-utility generators, and large electricity users | Pursue greater efficiency through distributed generation (small cogeneration, microturbines, and fuel cells. |
| Public Utilities Commission and participants | Complete examination of electricity competition for Hawaii. |
| Public Utilities Commission and utilities | Review utility costs and require utilities to report on actions taken to reduce revenue requirements. |
| **Chapter 8 Increasing Renewable Energy Use in Hawaii** | |
| DBEDT, electric utilities, and renewable energy industry | Continue to assess need for renewable energy state income tax credits beyond 2003. |
| DBEDT, electric utilities, and solar water heating industry | Increase use of solar water heating. |
| Electric and Gas Utilities | Obtain accurate cost data for renewable energy options. |
| Hawaii Congressional Delegation | Encourage renewable energy use through federal tax credits. |
| HECO and renewable energy developers | Consider renewable energy options for Oahu. |
| HELCO and renewable energy developers | Consider renewable energy options for the Island of Hawaii. |
| KE and renewable energy developers | Consider renewable energy options for Kauai. |
| MECO and renewable energy developers | Consider renewable energy options for Maui. |

| Suggested Lead Organization(s) | Recommendation |
|---|---|
| **Chapter 8 Increasing Renewable Energy Use in Hawaii (continued)** | |
| Public Utilities Commission | Insure continued use and addition of renewable energy should Hawaii move to electric competition. |
| Public Utilities Commission and organizations as identified by report | Implement recommendations of renewable resource docket. |
| **Chapter 9 Electricity Competition and Hawaii** | |
| Public Utilities Commission | Consider restructuring Hawaii's electricity system. |
| **Chapter 10 Utility and Bottled Gas in Hawaii** | |
| DBEDT, The Gas Co., and distributed generation manufacturers | Encourage use of gas as a fuel for distributed electricity generation, cogeneration, and/or fuel cells where cost-effective and energy efficient. |
| DBEDT, The Gas Co., and renewable energy developers | Encourage cost-effective renewable energy substitution for synthetic natural gas and propane. |
| DBEDT, The Gas Co., Consumer Advocate, and Public Utilities Commission | Encourage substitution for electricity services by gas where cost-effective and energy-efficient. |
| **Chapter 11 Increasing Energy Efficiency in Hawaii's Buildings** | |
| Building industry | Design and construction of buildings appropriate to Hawaii's climate should go beyond the minimum standards of the Model Energy Code where cost effective. |
| Building industry | Encourage continued use HiLight software program to ensure Model Energy Code compliance in lighting design. |
| Counties | Adopt Model Energy Code for Maui County (currently under consideration) and adopt Residential Building Model Energy Code in all Counties. |
| Counties with DBEDT support | Continue and expand County government energy efficiency programs. |
| DBEDT | Continue energy efficiency market transformation activities. |
| DBEDT | Continue Solid Waste Reduction and Recycling Programs. |
| DBEDT and Counties | Continue to evaluate impact of and improve the rate of compliance with Model Energy Code. |
| DBEDT and partner organizations | Continue to support State participation in Public-Private Partnerships and alliances, such as Rebuild America, to improve resource efficiency. |
| DBEDT and State agencies | Increase State government efforts to improve energy efficiency by meeting State goals for reduction of energy use in State facilities. |
| DBEDT and State agencies | Expand Hawaii State government energy Performance Contracting and alternative financing activities. |
| DBEDT and utilities | New measures and practices for building energy efficiency should be investigated by the utilities for technical potential. |
| DBEDT, utilities, and building industry | Continue technology transfer of advanced building technologies and development of design guidelines |
| Federal agencies | Support energy efficiency programs in Federal facilities in Hawaii. |
| Utilities and DBEDT | Continue to support cost-effective utility Demand-Side Management programs. |

| Suggested Lead Organization(s) | Recommendation |
|---|---|
| **Chapter 12  Energy Emergency Preparedness** | |
| DBEDT | Continue to progress in hazard mitigation to reduce Hawaii's energy system vulnerability. |
| DBEDT | Continue to support the Hawaii's Energy Council's readiness and its application to other jurisdictions |
| DBEDT and Counties | Continue to work with Counties to complete administratively approved County EEP plans. |
| DBEDT and Energy Council | Develop an ESF-12 concept of operations for activating DBEDT staff during a disaster or market shortage. |
| DBEDT and USDOE | Continue to work with USDOE to provide for rule making to implement SPR priority access sales provisions. |
| DBEDT, State Civil Defense, and Young Brothers | Complete the Young Brothers' emergency generator hazard mitigation project. |
| DBEDT, State Civil Defense, Counties, and industry participants | Complete emergency generator inventories and database documentation of emergency and essential service facilities. |
| DBEDT, State Civil Defense, Counties, and industry participants | Continue to regularly exercise government and industry EEP plans. Emphasize preparedness on the local (first responder) level. |
| **Chapter 13  Scenarios for Hawaii's Energy Future** | |
| DBEDT, airlines, auto manufacturers, and Hawaii Congressional Delegation | Support efforts to increase aircraft and ground vehicle fuel efficiency. |
| DBEDT, electric utilities, non-utility generators, and renewable energy developers | Maximize renewable energy and Demand-Side Management in the electricity sector. |
| DBEDT, electric utilities, non-utility generators, and renewable energy developers, and Legislature | Consider implementing elements of Scenario C3, including Scenario E2, Maximize Renewable Energy in the electricity sector and, in the ground transportation sector, Scenario GT2, 10% Ethanol-based Gasoline and GT-3, 10% New Vehicle Energy Efficiency. |
| **Chapter 14  Facilitating Exports of Sustainable Technology to the Asia-Pacific Region** | |
| DBEDT | Continue to conduct market analyses and evaluation relevant to the needs of Hawaii firms interested in technology-based economic development |
| DBEDT | Continue to publish *The Hawaii Energy, Environmental, and Engineering Export Service Directory* |
| DBEDT | Strongly support and sustain the Millennium Workforce Development Initiative |
| DBEDT and partner organizations | Continue to conduct business and technical exchange missions, and reverse trade missions |
| DBEDT and partner organizations | Actively advise and promote Hawaii energy and environmental companies |
| DBEDT and partner organizations | Establish a Center for Asia-Pacific Infrastructure Development in Hawaii. |
| DBEDT, Federal agencies, and NGOs | Continue to take advantage of Federal and NGO support for State energy and technology export initiatives |

| Suggested Lead Organization(s) | Recommendation |
|---|---|
| **Chapter 14 Facilitating Exports of Sustainable Technology to the Asia-Pacific Region (continued)** | |
| East-West Center, UH-HNEI, and DBEDT | Continue to promote sustainability programs in cooperation with the East-West Center Asia-Pacific Economic Cooperation Program and UH-HNEI. |
| Hawaii State Legislature | Formalize the STMAD process. |
| **Chapter 15 Energy in Hawaii and Future Technology** | |
| UH HNEI, PICHTR, NELHA, USDOE, County of Hawaii | Support Deep-Ocean Carbon Sequestration Research and possible future installation of a pilot facility in Hawaii. |
| Electric utilities, renewable energy developers, and USDOE | Conduct RD&D on renewable energy technology using Hawaii's abundant renewable energy resources. |
| Electric utilities, renewable energy developers, and USDOE | Conduct building efficiency RD&D in Hawaii that yield rapid payback. |
| Vehicle manufacturers, electric utilities, Hawaii transportation companies, and USDOE | Conduct RD&D on clean energy and transportation energy efficiency to reduce Hawaii's overdependence on oil. |
| Electric utilities, NUGs, generator/ fuel cell manufacturers, and USDOE | Conduct RD&D on electricity system efficiency, distributed generation, and clean energy for electricity generation in Hawaii. |