Energy-Efficiency Policies to Promote Sustainable Economic Growth in Hawaii:

Responses to Technological Change and Globalization

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Executive Summary

The revolution in information technologies in the past two decades promises (1) increased globalization of industry, (2) higher levels of economic growth, and (3) increased use of electricity. The question is whether this growth is sustainable from an environmental standpoint. In response to these phenomena, policymakers are making their electric industries more efficient to attract these global firms, while at the same time trying to make their electric industries more sustainable (i.e., minimize damage to the environment). Because of unique circumstances, Hawaii policymakers should take advantage of advances in energy-efficiency technologies, programs, and practices to promote sustainable economic growth.

Specifically, we recommend that:

- The State address the organization of the electric utility industry, its method of regulation, and utility-run energy efficiency programs.
- The State continue and expand the scope of its publicly run energy-efficiency progams.
- The State undertake activities with a longer-term view of energy and its relationship to the Hawaii economy.
- The State strengthen its energy services industry.

Advances in information technologies in the past 20 years have revolutionized how firms do business. New information technologies allow business firms the opportunity to become global, moving their activities from one country to another depending on local economic and political considerations. Moreover, these new technologies use electricity for their fuel. These developments promise to increase the productivity of the new global firms, promote economic growth, and, in the process, increase electricity demand growth.

The sustainability of economic growth fueled by electricity--especially electricity produced from fossil fuels--is a concern for policymakers. More reliance on fossil fuels to promote economic growth raises concerns about the environment--the local, regional, and global effects of producing electricity from fossil fuels. The use of fossil fuels to produce electricity worsens local health conditions and, by most accounts, contributes to global warming.

In response to these trends, national and regional policymakers are trying to (1) improve the efficiency of their electric industries and lower prices to attract the new global firms and (2) make those industries more sustainable.

With respect to *efficiency*, technology improvements in the electric industry afford policymakers a range of options to introduce competition in the industry and improve the efficiency of electric supply. Improved efficiencies in natural gas-burning power plants are the major driving forces that allow mainland policymakers to introduce competition into electric markets and break the vertical chain of production, transmission, and distribution of electricity controlled by a single firm.

With respect to *sustainability*, policymakers are approaching the issue in three ways, depending on local circumstances. First, they are introducing renewable portfolio standards for electricity generation. Under these standards, a pre-specified percentage of renewable-generated electricity must be part of the electric-generating supply mix, creating a secondary market" for electricity from renewable sources. Second, where coal is the fuel of choice, policymakers are promoting clean-coal technologies to generate electricity. Third, policymakers are aggressively pursuing programs to increase the efficiency of energy use.

Because of Hawaii's small power system, its insularity, and lack of low-cost natural gas supplies, the technologies, policies, and programs adopted in other regions to address the efficiency and sustainability of electric power industries may not be cost-effective or even applicable in Hawaii. With fewer options, Hawaii policymakers must become more innovative and aggressive. First, for the supply of electricity, the State should consider the introduction of a renewable portfolio standard in Hawaii's electric market. Second, radically restructuring the Hawaii electric industry to improve its efficiency may not be as appropriate an option in Hawaii as it is on the mainland. However, the State should consider performance-based ratemaking as an option. Finally, the State should focus more effort on energy-efficiency programs, both strengthening utility-run programs and adopting and expanding programs not run by electric utilities. Energy-efficiency programs improve the business climate to attract global firms by reducing their electricity bills. These programs are also instrumental in achieving other State goals such as affordable housing, efficient transportation systems, economic development, and job creation.

We recommend that the State adopt four policies to pursue this program. For each policy, we also recommend an action plan:

- The State should address the organization of its electric utility industry, its method of regulation, and utility-run energy efficiency programs.

    - ⇒ Investigate the cost-effectiveness of introducing time-varying (by hour, day, or season) electric rates in Hawaii.
    - ⇒ Investigate the applicability of performance-based ratemaking for Hawaii utilities to replace cost-based ratemaking.
    - ⇒ Investigate the potential impact of small-scale electric-generating technologies and distributed generation on Hawaii and its utilities.

- The State should continue and expand the scope of its publicly run energy-efficiency programs.

    - ⇒ Be a catalyst in developing a "green buildings" (or sustainable buildings) initiative.
    - ⇒ Be a catalyst in promoting the adoption of state-of-the-art building technologies that have proved energy savings and have the potential to be cost-effective in Hawaii.
    - ⇒ Expand the scope of Rebuild Hawaii to include sectors other than buildings.

- The State should undertake activities with a longer-term view of energy and its relationship to the Hawaii economy.

    ⇒ Be a catalyst in promoting life-cycle costing for state and county governments in Hawaii.
    ⇒ Sponsor a public-awareness campaign on the potential impacts of global warming, its consequences for Hawaii, how Hawaii policymakers can help ameliorate it, and the cost to individual residents of ameliorating it.
    ⇒ Investigate the harmful effects that imported energy has on the Hawaii economy.

- The State should strengthen its energy services industry.

    ⇒ Be a catalyst in strengthening Hawaii's energy service industry.
    ⇒ Be a catalyst in creating a Pacific energy services industry centered in Hawaii.

1. Introduction

1.1. Policy Responses to Technological Change and Globalization

Changes in technology are revolutionizing the global economy. Business firms are no longer confined to domestic borders to produce goods and services. In the new global economy, economic borders do not mirror political ones.

Technological change has already led to the introduction of a large number of information-related technologies and the innovation pipeline has not nearly been exhausted. The design and use of microelectromechanical systems (MEMS) are the direction in which information technologies are headed in the future. MEMS are tiny sensors, motors, and pumps built into microprocessors. MEMS will be deployed in networks, sensing one another and configuring themselves to perform information-processing tasks. In manufacturing, computer-aided design systems have already penetrated the market.

There are three consequences of these innovations. First, the new information technologies will make firms more efficient by improving the productivity of labor, leading to higher growth rates for many economies. Second, these new technologies require electricity as their fuel. The global demand for electricity, then, will be larger than it would have been without the technologies. Third, new information technologies afford business firms the opportunity to become global, moving their operations from one country to another on the basis of local economic and political considerations.

As a result of these developments, policymakers are focusing more attention on their electric industries. First, they are trying to make their electric industries more efficient to lower costs and prices to make their economies more competitive and to attract the new global firms. Second, they are trying to ameliorate the environmental consequences of producing more electricity.

1.1.1. EFFICIENCY OF THE ELECTRIC INDUSTRY

Policymakers are privatizing and introducing competition into their electric industries to make them more efficient. The advantages of competitive markets are well known: lower costs and prices, more product choices, better customer service, and less intrusive regulation by government agencies.

Technological innovation in the electric industry allows policymakers to introduce competition in the industry. On the mainland, the introduction of high-efficiency gas power plants has reduced the cost of producing electricity from these plants and has also reduced the minimum size of the plants needed to obtain the cost reduction.[1]

[1]The high-efficiency gas power plant is a combined-cycle gas turbine, using natural gas as the fuel source. Approximately two-thirds of the power generated from this type of plant comes

Whenever independent power producers can generate electricity at lower cost than incumbent regulated monopoly utilities, policymakers have the option of breaking apart the electric industry. The upstream production portion of the industry is competitive, allowing many firms other than the local utility to produce and sell electricity. The downstream distribution or "wires" portion remains a regulated firm but must now compete with other firms such as marketers to provide energy services to customers. The traditional electric "monopoly" no longer is the sole provider of electricity to customers.

In these restructured industries, electric prices are set in markets, not by state regulators. The sellers of electricity to ultimate customers will no longer produce it. They will purchase it from suppliers and re-sell it to customers. Unlike the past where state regulators required local electric utilities to run energy-efficiency programs, the regulators will no longer unfairly burden that local utility with running energy-efficiency programs if other marketers of electricity do not have to run them. If running energy-efficiency programs is a line of business that the utility wants to pursue, it is acceptable. But running these programs will no longer be mandated by state regulators.

1.1.2. ELECTRICITY AND THE ENVIRONMENT

These technology-driven changes are intensifying concerns about global climate change. Changes in climate allegedly result primarily from the greenhouse-gas emissions of electric power plants and other manufacturing processes. Global climate change refers to the phenomenon of trapped gases in the atmosphere--especially carbon dioxide--leading to a "greenhouse" effect, warming the earth's surface.

To address environmental concerns, one innovation used by policymakers is the renewable portfolio standard. Under this standard, a prespecified percentage of renewable-generated electricity must be used for every kWh of fossil electricity, creating a secondary "market" for electricity from renewable sources. In more advanced markets, electricity from renewable energy can be traded among suppliers who use fossil fuels to generate electricity.

In regions with plentiful supplies of natural gas, advances in gas generating technologies make them the cheapest generating source. Harmful environmental emissions are ameliorated to the extent that the natural gas turbines replace coal in the normal course of generating electricity.

In regions where coal is the predominant fuel, an option is to promote the use of clean-coal technologies. There are presently clean-coal technologies capable of (1) meeting rigid environmental performance standards and (2) the operational and economic performance necessary to compete in the era of deregulation and competition. Atmospheric and pressurized fluidized-bed combustion systems and integrated

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directly from the combustion of natural gas. The remaining power comes from a steam turbine, obtained by generating electricity in the combustion turbine.

gasification combined-cycle systems are examples. Further, advanced technologies are emerging that will enhance the competitive use of coal in the industrial sector, such as in steel-making.

On the demand side, "green pricing" is a viable option. Customer surveys nationally and in Hawaii have indicated that many people are willing to pay more for electricity from renewable sources. Improving the efficiency of the use of energy is another option that policymakers can consider to address the global climate change problem. Improving energy efficiency is an important policy tool in this regard because it also results in important income and employment benefits for local economies.

1.2. Implications for Hawaii Policymakers

Hawaii policymakers may not have the full range of options to address the efficiency of the electric industry, as do their Mainland counterparts. As we argue in Chapter 2, radically restructuring the Hawaii electric industry to improve its efficiency may not be as appropriate an option in Hawaii as it is on the Mainland. First, natural gas is not available in Hawaii. The high-efficiency gas power plant is the driving force behind restructuring on the mainland. Second, the electric market in Hawaii is small compared with its mainland counterparts. Introducing competition for existing utilities and deregulating the generation of electricity may be more harmful to competition than the status quo. Because of Hawaii's small size, one firm may eventually dominate the industry.

There are options for Hawaii, however, for increasing competition in generation such as competitive bidding to meet new generation needs. Kauai Electric has already employed this approach. In addition, in Chapter 4 we recommend that the State investigate the feasibility of introducing performance-based ratemaking (PBR) in the Hawaii electric sector. PBR is a middle ground between competition and the type of cost-of-service ratemaking presently used in Hawaii. If implemented properly, PBR can provide electric utilities with incentives to reduce costs and, hence, electric prices.

Hawaii policymakers also have options to address the sustainability of their electric industry. Because Hawaii does not have coal resources and the prospects for introducing more coal generating plants are not promising, clean-coal technologies are not currently as useful in reducing environmental emissions in Hawaii as they are on the mainland. However, adoption of a renewable portfolio standard in Hawaii is as relevant as it is for mainland policymakers. A renewable portfolio standard would allow the state to use its own energy resources, reducing energy imports and ameliorating the effect of electricity production on the environment in the process. The State should investigate that possibility.

Expanding the scope of existing energy-efficiency programs is one direction in which Hawaii policymakers can take to address both its business environment and sustainable growth. If size and energy resource base limit the ability of Hawaii policymakers to improve the efficiency of electricity supply in the State, they can still focus on reducing the cost of energy to the consumer. Energy efficiency programs not only reduce the cost of energy and improve the environment. They also have important economic benefits.

1.3. The Benefits of Improving Energy Efficiency

The short- and long-term effects of using energy more efficiently are well known and documented.

In households, improving the efficiency of energy use to provide a given amount of lighting, cooking, heating, cooling, and other services is equivalent to an increase in income. The expenditures formerly made on energy and water will be saved or used for other purchases. For low-income households, lower expenditures on energy make housing more affordable. In many cases where energy prices are high, the reduced costs of energy for low-income households often are the difference between ownership/rental and eviction. Over the long term, households adjust to lower expenditures on energy, choosing to consume more energy with their added income, increasing their comfort and well being in the process.

For commercial establishments and industrial enterprises, using energy more efficiently reduces the cost of producing goods and services. Depending on the types of markets that these enterprises operate in, this resource-cost reduction can translate into lower production costs, higher output, and more profits in the short term. Oftentimes, this also means that these commercial and industrial enterprises employ more workers to satisfy the increased demand for their products. The increased employment, of course, improves the performance of the local economy. In the long term, firms may choose to change the process they use to produce products because of lower energy bills, depending on the extent to which energy can substitute for other, relatively higher-cost inputs.

State and local governments also use energy and can benefit from energy-efficiency improvements. Local governments, for example, own buildings that use electricity, oil, gas, and water. They also light the streets. They run, maintain, and expand the local transport system that relies in large measure on gasoline and diesel fuel. They run wastewater treatment plants that typically consume large amounts of electricity. They dispose of solid waste. Any increase in the efficiency of using resources to provide these services will provide additional funds in the community. Local governments can use these funds to reduce taxes or increase spending on other goods and services. State governments perform many similar functions, have similar opportunities to improve energy and water efficiency, and can use the savings from increased resource efficiency in a similar manner.

Local and global environmental conditions can also improve if households, business enterprises, and governments use energy more efficiently. The degree of improvement depends on the type and amount of energy currently being used. Since Hawaii relies principally on oil and coal to produce electricity, for example, improving the efficiency of electricity use will have a marked impact on the local environment. Similarly, developing an effective mass transit system, encouraging of use of efficient vehicles, reducing congestion, and other measures can have a marked impact on local environmental conditions if a community currently relies on automobiles for local transportation. Global environmental conditions can improve to the extent that local energy-efficiency improvements will reduce consumption of energy forms that produce greenhouse gases.

Perhaps the most important, but least-discussed and appreciated, benefit of improving the resource efficiency of communities--and one that is especially important to the island environment of Hawaii--is the impact on local and state economies. Clearly, households, enterprises, and the government directly benefit by improving the efficiency of their use of energy. If they improve energy efficiency, they have more disposable income. However, there also is an important net benefit to local economies. This benefit depends on the degree to which local economies import their resource needs from surrounding communities or, in the case of Hawaii, other states and countries.

Local economies such as Hawaii's that are heavily dependent on other economies for their resources are likely to benefit the most from energy-efficiency improvements. By importing energy and other resources, these economies are "exporting" resource dollars to resource-producing regions. These dollars are no longer available in the community. If expenditures on resources are reduced, the savings will improve the performance of the local economy via the "multiplier effect" to the extent the savings are spent in the local economy. The multiplier effect is an economic phenomenon characteristic of all economies, relating the spending and re-spending effects of dollars on the output of local economies. Studies have found that the multiplier effects for renewable energy production and energy efficiency are greater than those for oil refining and fossil fueled electricity generation, in part due to greater labor requirements per unit of energy.

Also, the expenditures on energy-efficiency improvements themselves will improve local economic performance because the materials and labor for those improvements are likely to come from the local economy and not be imported from elsewhere. For example, the workers conducting energy audits on Hawaii enterprises are likely to be Hawaii residents. The workers installing energy-efficient lighting are also likely to be Hawaii residents.

2. Global Trends Affecting Hawaii and its Electric Sector

The New Economy brought about by the revolution in information technologies in the past two decades promises (1) increased globalization of industry, (2) higher levels of economic growth, and (3) increased use of electricity. The question is whether this growth is sustainable from an environmental standpoint.

In response to these three phenomena, policymakers are making their electric industries more efficient to lower electric prices and attract these global firms, while at the same time trying to minimize damage to the environment. This chapter explores these global trends and consequences in more detail.

2.1. Information Technologies

In the 1980s, many believed that the U.S. economy was "mature," an economy that could not sustain high rates of growth because of outdated industries, low productivity, and a large amount of government interference. In the 1990s, the reality is the opposite. A wave of innovation led by information technologies is transforming the U.S. economy. These advances in information technologies have not only increased the productivity of the U.S. economy, but also changed the location decisions of business firms around the world. Manufacturers and other businesses around the world are now free to move across countries and continents, seeking the best price and conditions for their labor, energy, and materials inputs.

Information technologies and other innovations are revolutionizing American industry. The productivity of the American economy increased dramatically during the 1990s. The productivity of nonfinancial corporations--corporations excluding small businesses and financial corporations--increased 2.5 percent annually during the 1990s, significantly above the 1.0 percent annual increase from 1973 to 1990. Manufacturing productivity increased even more. For example, productivity in durable goods manufactures increased at a rate of 5.9 percent annually since 1990 compared to 2.5 percent over the 1973-1990 period.[2]

And, the innovation pipeline is not nearly exhausted, suggesting that the U.S. economy can sustain high rates of productivity gains and growth well into the 21st century. With the potential of the Internet not fully exploited, there is no sign that the information revolution is ending. And, the information revolution is just the start of the technological revolution. The promise of products and production techniques currently in the innovation pipeline is overwhelming.

Microelectromechanical systems (MEMS) are good indicators of the direction in which the technological future is headed. MEMS are tiny sensors, motors, and pumps built into microprocessors. There are already many applications of MEMS in the economy. For example, an automobile accelerometer that triggers air bags in a crash is a MEMS application and is already mass-produced. Industrial sensors, another example, are also already being manufactured and used.

The promise of MEMS is that they will be deployed in networks, sensing one another and configuring themselves to perform information-processing tasks. Office networks, for example, could assemble themselves, rather than being configured manually. Laptop computers with built-in MEMS can connect to the nearest Internet link. In the telecommunications industry where much of the research is currently being undertaken, wave division multiplexing could reduce long-distance communications costs to near zero. This, of course, has implications for the globalization of economic activity. The applications go on and on.

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[2] U.S. Department of Labor, Bureau of Labor Statistics, "Major Sector Productivity and Cost Index," Washington, DC, 2000.

The future of nanotechnologies--or miniaturization of technologies--in which science mimics nature by teaching smart devices to assemble alone atom by atom is the real promise of technological innovation in the future.

2.1.1. IMPLICATIONS FOR GLOBALIZATION AND ELECTRICITY GROWTH

Technological change promises to improve the productivity of economies and increase economic output. Although the U.S. economy has perhaps taken the most advantage of these changes in technology, other economies are expected to benefit greatly in the future. This suggests larger world markets for goods and services.

Improved transport and communications technologies enable companies to shift production more easily around the world. Capital, labor, and goods are more mobile than they were even a decade ago, leading to fundamental changes in the ways in which industries now conduct business. Industries no longer confine their activities within the borders of individual countries. Rather, they seek market opportunities across international borders.

Larger world markets and enhanced mobility suggest more global competition for markets. Access to larger competitive markets spurs even more innovation. This process leads these new global firms to seek the cheapest source of inputs for their production processes.

There are two manifestations of globalization. First, electricity is becoming more and more the end-use fuel of choice in the world to fuel the new technologies. Despite continued improvements in the efficiency of electric power delivery systems and end-use efficiency, world electricity demand is expected to grow at a 2.5% annual rate until 2020. The growth in developing countries is expected to be 4.3% per year during this period.[3]

Second, this global competition has led policymakers in many countries to address inefficiencies in their economies. The less costly it is to do business in a state or country, the more attractive it is for the new global competitors. This is one of the driving forces for restructuring of the energy industries in the United States--especially the electric industry.

2.1.2. IMPLICATIONS FOR HAWAII

Electricity is expected to be the fuel of choice in Hawaii also, continuing the trends of the 1990s. The slowdown in Hawaii’s economy since 1991 was not evident in reduced electricity sales until 1997. Increases in the sales of electricity outpaced growth in Hawaii's population and gross state product until 1997. During the 1990-1997 period,

[3] Energy Information Administration, *International Energy Outlook 2000,* DOE/EIA-0484 (2000), Washington, D.C.

Hawaii's population grew about 1.1%, while gross state product grew 3.8%. Electricity sales per capita grew 11.3% during that period.[4]

The new global firms are attracted to locales most conducive to conducting business. Tax laws and the general business environment are important. The cost of doing business is just as important.

The implications for Hawaii's electric sector are obvious. The new global firms seek cheap and reliable energy sources. In this new, more global environment, Hawaii must work to reduce the cost of producing, transmitting, and distributing electricity and lower electric rates to attract these global firms. Recognizing that Hawaii's insularity and lack of cheap fossil resources is an impediment to competing with the supply cost of electricity on the U.S. mainland even if Hawaii had the most efficient electric industry, Hawaii can still do more to reduce the cost of electricity for customers.

Hawaii policymakers can work to reduce energy costs as well as make customers' use of energy as efficient as possible, thereby reducing customers' energy bills.

2.2. A Complicating Factor: Sustainable Growth

The concept of sustainable economic development has replaced that of economic development. The concept of sustainable economic growth has replaced that of economic growth. The concept of sustainable economic planning has replaced that of economic planning.

In its most simple form, the concept of sustainability refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept is currently part of many national and international policy agreements.

In a general, pluralist approach to sustainability, many economic, social, and environmental issues are lumped into the concept:

- higher per-capita income
- reduction of poverty
- public participation in the decision making process
- no environmental degradation

In a more narrow economic approach, sustainability simply incorporates the concept of "natural capital" in the decision making process. In contrast to man-made capital (e.g., plant and equipment, knowledge, skills, and social institutions), natural capital includes:

- material resources

[4] State of Hawaii, *Hawaii Energy Strategy 2000,* Department of Business, Economic Development, and Tourism, Energy Resources and Technology Division, January 2000.

- waste absorption
- other ecological functions
- aesthetic values

Sustainability is a major concern with the expanded economic development and growth promised by the information revolution in the 21st century. Will growth occur without damaging the earth's natural capital? Or, if damage does occur, can man-made capital replace or substitute for it?

The electricity sector is a concern of policymakers dealing with sustainable development and growth. If the economic and electricity growth promised by the information revolution materializes, the growth in fossil fuel-based electricity generation may not be sustainable. Moreover, if the phenomenon of global climate change due to man-made causes exists, the growth definitely is not sustainable.

2.2.1. GLOBAL CLIMATE CHANGE

Currently, the average atmospheric concentration of carbon dioxide (CO_2) is about 370 parts per million by volume (ppmv). Between the years 1000 and 1800, the CO_2 concentration averaged 280 ppmv, varying by only 10 ppmv around this mean over that 800-year period. Thus, since the beginning of the Industrial Revolution, the concentration of CO_2 in the atmosphere has increased by 90 ppmv. Some forecasts suggest that, under current emissions levels, CO_2 concentration will reach 800 ppmv by the end of the 21st century.

Increases in CO_2 concentration levels are caused by human activities. The primary activities are the burning of fossil fuels and deforestation in many parts of the world where trees are used for firewood and home construction. In the United States, electric power plants burning fossil fuels account for more than a third of all of the U.S. emissions of CO_2.

Proponents of the human-causality hypothesis claim that increased amounts of CO_2 in the atmosphere are causing global temperatures to rise. That is, trapped gases in the atmosphere--especially CO_2--are leading to a "greenhouse" effect, warming the earth's surface. This hypothesis suggests that, in a business-as-usual scenario, the average global temperature will rise by as much as five degrees in comparison with pre-industrialization levels.

The consequences of this temperature rise are potentially disastrous for many parts of the world. First, the sea level may rise as a result of the thermal expansion of the ocean and the melting of mountain glaciers. The most vulnerable parts of the globe to this change in sea level are populous river deltas such as the Ganges in Bangladesh, the Nile in Egypt, and the Mekong in Vietnam. Second, the temperature rise could affect agriculture. Crop production will likely decline in developing countries and increase in developed countries. On balance, however, agricultural output will likely decline.

The scientifically puzzling aspect of the global climate change hypothesis is the relationship between increased CO_2 concentration in the atmosphere and increases in global temperatures. Critics contend that there is no such relationship. And, no such relationship has been proved. However, the potentially disastrous effects of global climate change lead many to conclude that public policy must be formulated on the assumption that increased levels of greenhouse gases are causing changes in the earth's temperature. After reviewing hundreds of scientific papers, the American Geophysical Union (AGU), the leading society of U.S. earth scientists, recently concluded that the evidence to date warrants government action. In a carefully worded statement, the AGU concluded in part:[5]

> AGU recommends the development and evaluation of strategies such as emissions reduction, carbon sequestration, and adaptation to the impacts of climate change. AGU believes that the present level of scientific uncertainty *does not justify inaction* in the mitigation of human-induced climate change and/or the adaptation to it (emphasis supplied).

2.2.2. IMPLICATIONS FOR HAWAII

Global climate change is a phenomenon of the global commons: a transnational environmental, political, and economic problem. On one hand, acting alone, Hawaii cannot resolve this global problem. On the other hand, Hawaii has more to lose than many areas of the mainland. Sea level rise and the increased possibility of storms caused by global warming will erode beaches. This could reduce the availability of fresh water. Higher water temperatures and increased carbon dioxide levels are also likely to increase destruction of coral reefs.

At Honolulu, Nawiliwili, and Hilo, sea level has already increased 6 to 14 inches in this century and is likely to rise another 17 to 25 inches by 2100. The expected rise in sea level could cause flooding of low-lying property, loss of coastal wetlands, beach erosion, saltwater contamination of drinking water, and damage to coastal roads and bridges.

Hawaii's economy could also be hurt if the combination of higher temperatures, changes in weather, and the effects of sea level rise on beaches make Hawaii less attractive to visitors. Adapting to sea level rise could be very expensive, as it may necessitate the protection or relocation of coastal structures to prevent their damage or destruction.[6]

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[5] AGU Council, "Position Statement on Climate Change," National Press Club, Washington, DC, January 28, 1999.

[6] State of Hawaii, *Hawaii Energy Strategy 2000,* Department of Business, Economic Development, and Tourism, Energy Resources and Technology Division, January 2000.

2.3. Changing Electric Supply Systems to Promote Low-Cost, Sustainable Power

Globalization of industry and sustainability are the two driving forces for policymakers to radically restructure their electric industries. Advances in technology are the enabling forces to effect change in the electric industry.

Technological advances in clean-coal technologies and renewable energy technologies are important considerations in economies that have those resources. In Hawaii, recent experience of IPPs providing lower cost generation than the utilities suggests to policymakers that introducing competition in their electric industries may make them more efficient and reduce the price of electricity. In this section, we discuss this revolution in the electric industry.

2.3.1. TECHNOLOGICAL CHANGE IN THE ELECTRIC INDUSTRY

In the electric industry, changes are occurring at the generation, transmission, and distribution stages. Changes in the economics of generation technologies such as fuel cells, photovoltaics, and microturbines are revolutionizing the way in which electricity is being generated and delivered to utility customers and changing the incentives for customers to consider self-generation. Mini-generation is generally that within the 100 kW to 1 MW range, while micro-generation is considered below 100 kW.

On the mainland, an important change promoting convergence of the electric and gas industries is technological improvement in the production of electricity using natural gas. Although gas is not currently in Hawaii's generating mix, improvements in the efficiency of gas conversion could alter the incentives to import liquefied natural gas (LNG) into the islands if associated problems such as the high cost, scale, and siting of terminal facilities can be resolved.

Modular technologies from the medium-size aeroderivative combustion turbine in the 50-100 MW range to micro-technologies in the 1-5 MW range are becoming increasingly competitive with traditional, central-station steam generating plants.

Further improvements in electric-generating technologies could revolutionize the way in which electricity is supplied to both consumers on the mainland and in Hawaii. These technology changes lead to more efficient oil-fired combined cycle central station and distributed generation,[7] altering the vertically integrated structure in the electric industry. Table 1 summarizes a range of technologies that can be used for distributed generation on transmission/distribution systems.[8] Although some are not financially competitive with coal-fired steam plants or high-efficiency gas power plants at the moment, further

[7] Distributed generation refers to sources of electric-power supply that are placed near consuming centers, not having to rely on long-distance transmission. Conventional central-station plants require electricity to be transmitted long distances from supply sources to consuming centers.
[8] Henry R. Linden, "Operational, Technological and Economic Drivers for Convergence of the Electric Power and Gas Industries," *Electricity Journal*, 10(4): 14-25.

technical improvement and economies of mass production indicate that most will be competitive in the future.

Table 1
Distributed Generation Technologies

Technology	Size Range
Wind Turbine	10 kW- 1 MW
Photovoltaics	<1 kW - 1 MW
Battery Storage	500 - 5,000 kWh
Fuel Cells	
Commercial Phosphoric Acid	200 kW - 2 MW
Molten Carbonate	250 kW - 2 MW
Proton Exchange Membrane	1 - 250 kW
Combustion Turbine	1 - 50 MW
Internal Combustion Engine	5 kW - 2 MW
Diesel Engine	50 kW - 6 MW

Combustion turbines are already used in distributed transmission applications. Wind turbines are also used, producing power in the 5-6 cents/kWh range or less on the mainland. Fuel cells are continuous batteries that use natural gas to produce hydrogen as the power source. A 200-kW commercial fuel-cell plant presently in operation produces electricity at less than seven cents per kWh on the mainland. Although still expensive, photovoltaics have an opportunity to penetrate distributed markets with improvement in materials and mass production of thin-film, amorphous silicon segments.

Of course, cost conditions in Hawaii are different from those on the mainland. Because Hawaii's average total cost of producing fossil-fuel electricity is nearly double the mainland average, the relationship between the cost of producing electricity from the new, distributed generation technologies and the average total cost of production is nearly the same in Hawaii as the mainland. Over the last year, wind producers on Hawaii and Maui agreed to provide electricity at prices comparable to Mainland prices – and below the cost of equivalent fossil fuel generation.

The competitiveness of small-scale generating technologies with larger-scale central station plants looms as a potential competitive threat to existing utilities, whether these utilities have been restructured or not. Individual customers are expected to have increasing access to generating technologies whose electric output can compete on a cost basis with the power provided by existing utilities. Their efficiency is enhanced by their use of exhaust heat to produce hot water, air conditioning, and other uses. And, this is not necessarily limited to customers using large amounts of electricity. Small users in individual households could have access to miniature fuel cells that may be able to produce electricity as cheaply as that provided by their local utilities. This technological revolution in power production could lead to a large scale “bypass” of existing electric utilities by electric customers in some parts of the country.

Clearly, electric utilities that have high production costs and, consequently, charge high prices are in the greatest danger of bypass by their customers. Hawaii utilities are especially vulnerable to bypass. In an island environment, Hawaii utilities have very high production costs.

Possibly the most attractive form of distributed generation is small-scale cogeneration which can operate at twice the thermal efficiency of generating plants in many applications. For cogenerators, this means less oil burned, less emissions, and less oil imports.

To counter the move to distributed technologies, a utility could seek and obtain “customer retention” rates from the PUC which allows them to offer discounts to large users considering distributed generation. The long-term effect of this may be that in order for the utility to keep offering reduced rates to preferred customers, the electric rate for the rest of the ratepayers will go up.

For electric customers, technological change not only improves the prospects to bypass local electric utilities but also improves prospects for increasing the efficiency of energy use. In the industrial sector, for example, advances in membrane technology could revolutionize industries using separation processes and dramatically improve energy efficiency. Advances in sensor technology improve the performance of industrial processes, reduce waste, and improve energy efficiency.

2.3.2. MAINLAND RESPONSES TO CHANGING TECHNOLOGY

Policymakers recognize that energy--especially electricity--is an important input for the new global firms. The lower the price of electricity, gas, and other utility services, the greater the chances of attracting investment by these global firms, especially those firms using energy-intensive processes.

The combination of (1) technological advances and (2) the determination of policymakers to lower electric prices to attract foreign investment is leading to a global restructuring of electric industries. The goal of national government policymaking is to make electric industries more efficient. Where feasible, introducing competition into otherwise inefficient markets has been the tool used by policymakers to increase economic efficiency. The advantages of competitive markets are well known: they lead to lower costs and prices, more product choices, better customer service, and often the need for less regulation by federal and state agencies. In the short run, competitive firms that cannot produce at the market-clearing price are forced to leave the industry, ensuring that customers have the lowest price possible. In the long run, competition promotes innovation and lower costs.

Some countries have privatized their energy industries at the same time that they have restructured them. Although oftentimes done for philosophical reasons--the government is too pervasive, for example--privatization occurs because of the belief that government-owned enterprises are inherently more inefficient than private ones. Using this rationale, privatization promotes efficiency and lowers production costs, resulting in lower energy prices in the future.[9]

The United Kingdom, Australia, New Zealand, Chile, Argentina, Sweden, Norway, and Finland are examples of countries that have privatized and/or restructured their energy industries.

The United States is currently in the process of restructuring its energy industries. In the natural gas industry, the Natural Gas Policy Act of 1978 and the Natural Gas Wellhead Decontrol Act of 1989 decontrolled the supply price of natural gas. A series of orders by the Federal Energy Regulatory Commission (FERC) in the mid 1980s and early 1990s made interstate natural gas pipelines common carriers. The effect of this national activity is to make wholesale, interstate natural gas markets more competitive. Individual states are currently reshaping their local, retail distribution markets.

In the electric industry, the Energy Policy Act of 1992 (EPAct) required that interstate transmission-line owners allow all generators access to their lines. In effect, transmission lines became common carriers. In its Order 888 in 1996, FERC implemented EPAct with respect to electric transmission lines. The order required that all transmission-line owners post open-access tariffs. Any generator of electricity--utility-affiliated or independent--has access to transmission lines to transport their electric output. The objective of these initiatives at the federal level is to create competitive wholesale electric markets.

The final structure of electric markets depends on state legislation or state regulatory commission rulings. FERC has jurisdiction over interstate wholesale electric markets; states have jurisdiction over retail sales. State policymakers have two options:[10]

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[9] The evidence from the experiences of electric utilities in the United States does not confirm the hypothesis that publicly owned electric utilities are less efficient than privately owned ones. See Lawrence J. Hill, *Economic-Efficiency Considerations in Restructuring Electric Markets*, Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-436, December 1996.

[10] In its Utility Series, the National Conference of State Legislatures published a series of six *State Legislative Reports* on electric restructuring that were targeted for state legislators and their staffs: (1) Lawrence J. Hill and Matthew H. Brown, "Organization and Regulation of the Electric Industry," *State Legislative Report*, National Conference of State Legislatures, Denver, Colorado, The Utility Series-1, 20(18), December 1995; (2) Lawrence J. Hill and Matthew H. Brown, "Changing Electric Markets," *State Legislative Report*, National Conference of State Legislatures, Denver, Colorado, The Utility Series-2, 20(19), December 1995; (3) Lawrence J. Hill and Matthew H. Brown, "Strandable Commitments in the Electric Industry," *State Legislative Report*, National Conference of State Legislatures, Denver, Colorado, The Utility Series-3, 20(20), December 1995; (4) Matthew H. Brown and Lawrence J. Hill, "Competing Utilities and Energy Efficiency, Renewable Energy and Low-Income Customers," *State Legislative Report*, National

- Allow the industry's structure to evolve, ensuring open access to transmission lines for any potential entrant in the generating stage of the industry and letting competitive forces emerge over time. Modest policy changes such as substituting performance-based for cost-of-service ratemaking could also be considered.[11]

- Restructure the industry more radically, (1) facilitating competition in the generating stage of the industry by creating a spot market and independent system operator and (2) allowing retail customers direct access to electric suppliers of their choice.

Other than the aforementioned changes in technology, the primary motivation for state policymakers to radically restructure their industries is differences in electric prices across states. States with high prices relative to others are more inclined to restructure with the expectation of improving efficiency and lowering costs and prices. Lower energy prices attract investment and industry.

Table 2 provides the status of state-level restructuring, dividing states between those whose legislatures have enacted legislation and those whose regulatory commissions have issued sweeping restructuring orders.[12] Twenty-three states have enacted legislation restructuring their electric industries. Two state regulatory commissions have issued orders requiring restructuring of their electric industries. Most other states have either a legislative or regulatory commission investigating restructuring.

Thus, of the 50 states, one-half remain without legislation or a commission order restructuring their electric industries. In anticipation of a "patchwork" industry in which generally higher-priced states restructure while lower-priced ones delay, several federal bills have been introduced in the U.S. Congress since 1996 mandating national restructuring. The bill proposed by the Clinton Administration in June 1998, and amended in April 1999, the Comprehensive Electricity Competition Act, would require retail competition--i.e., direct access by customers to sources of electric supply--for all customers by January 1, 2003. However, the proposed legislation would allow states to

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Conference of State Legislatures, Denver, Colorado, The Utility Series-4, 20(21), December 1995; (5) Lawrence J. Hill and Matthew H. Brown, "Performance-Based Regulation in the Electric Industry," *State Legislative Report*, National Conference of State Legislatures, Denver, Colorado, The Utility Series-5, 20(22), December 1995; and (6) Lawrence J. Hill and Eric Sikkema, "Retail Wheeling and Direct Access: Customer Choice for Electricity," *State Legislative Report*, National Conference of State Legislatures, Denver, Colorado, The Utility Series-6, 20(23), March 1996.

[11] Cost-of-service ratemaking allows an electric utility to recover all prudently incurred costs in its rates, plus a fair return on investment. Performance-based ratemaking severs this price-cost relationship, providing more incentives for a utility to cut costs. For a lengthier description of ratemaking, see Lawrence J. Hill, *A Primer on Incentive Regulation for Electric Utilities*, Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-422, October 1995.

[12] Energy Information Administration, "Status of State Electric Industry Restructuring Activity as of March 2001," Washington, DC, March 2001.

"opt out" of the provisions of the legislation if they felt that consumers would be harmed.[13]

Table 2
Status of State Electric Restructuring

State Legislation		**State Regulatory Order**	
State	Date Enacted	State	Date Ordered
Arizona	May 98	New York	May 96
Arkansas	Apr 99		
California	Sep 96		
Connecticut	Apr 98		
Delaware	Mar 99		
D of Columbia	Jan 00		
Illinois	Dec 97		
Maine	May 97		
Maryland	Apr 99		
Massachusetts	Nov 97		
Michigan	Jun 00		
Montana	May 97		
Nevada	Jul 97		
New Hampshire	May 96		
New Jersey	Feb 99		
New Mexico	Apr 99		
Ohio	Jul 99		
Oklahoma	May 97		
Oregon	Aug 99		
Pennsylvania	Nov 96		
Rhode Island	Aug 96		
Texas	Jun 99		
Virginia	Mar 99		
W. Virginia	Mar 00		

The outcome of this legislative/regulatory morass on restructuring is difficult to predict. However, there are three undeniable trends in the mainland electric industry: (1) de-integration, (2) convergence, and (3) globalization. We discuss them in turn.

[13] In its "savings clause," EPAct left retail competition up to state policymakers. One of the reasons is the constitution. The federal government has jurisdiction over interstate electric sales; states have jurisdiction over retail sales.

2.3.2.1. De-Integration

The electric industry is increasingly becoming vertically de-integrated by state legislation, commission orders, and state policymaking. In California, for example, the three large investor-owned utilities are in the process of selling their generating assets. The same is true of electric utilities in Massachusetts. Electric-restructuring legislation in Maine and New Hampshire requires vertical divestiture of generating assets to prevent vertical market power. Other state restructuring legislation or commission orders are likely to follow this pattern.

Given these developments at the state level and FERC's requirement of open access to transmission lines, electric markets and the electric utility of the future will look dramatically different than the markets and utilities today. Electric markets will become more like gas markets with a futures market, a spot market, and many different types of financial arrangements. Many electric utilities will be national or international energy companies. Although they may own only the transmission/distribution system in any one region, they will be actors in multiple markets as they purchase generating facilities and the wires in other markets. Pacific Gas and Electric's purchase of a portion of New England Electric's generating assets is an example.[14]

These new electric "utilities" will be selling the energy form preferred most by ultimate customers. To illustrate, electricity's share of total U.S. energy use is now approaching 40 percent, nearly double the amount of the late 1950s.[15] The share is expected to increase markedly in the future because of the information revolution's reliance on electricity and the introduction of new electricity-using technologies in other sectors. The latter include developments in space conditioning, industrial processes, and transportation.

2.3.2.2. Convergence

The electric distribution utilities will face intense competition from marketers in purchasing reliable supplies of electricity and attracting customers. Technological progress in development of the distributed-generation technologies shown in Table 1 will provide incentives for local distribution electric firms to merge with gas distribution firms. Besides the obvious advantage of economies in joint operation such as those realized from joint metering, a merged electric-gas distribution utility could use the gas infrastructure as a storage system for its electric operations. Although the merged utility will be indifferent to how energy reaches the customer, electricity is the fuel of choice by customers and, as discussed above, is likely to remain so as new electro-technologies enter the market.

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[14] Public Utility Reports, Inc., *PUR Utility Weekly*, Vienna, Virginia, September 4, 1998.
[15] Energy Information Administration, "Electricity Overview: 1949-1998," *Annual Energy Review,* December 1999.

Because it has no economic supplies of natural gas and very limited gas infrastructure, the phenomenon of convergence as it is known on the mainland is unlikely in the Hawaii energy sector. However, the introduction of distributed-generation technologies by Hawaii's electric customers is just as likely as that on the mainland with similar implications for load loss and financial performance.

The implications of this convergence for competition, regulation, and energy customers are significant. Consider the two grids--electric and gas--of large- and small-volume gas and electric lines overlaying the country, bringing electricity and gas from production areas to population centers. In cases where both small-volume gas and electric lines extend to the point of consumption, will a merged electric-gas utility have the incentive to keep both parts of the energy infrastructure when the economics suggest that the utility may be better off using its gas network for the production and storage of electricity?

As marketers expand from supplying electricity or gas exclusively to sales of both electricity and gas and local electric and gas distribution companies become energy transporters exclusively, what is to keep the marketers from pricing energy at profit-maximizing prices?

Moreover, there is a possibility for convergence to extend beyond gas and electricity into other utility services such as telephony, Internet, cable, and even water. The introduction of fiber-optic cable is one possible conduit for this broader convergence of services.

Fiber optics is a broad-band cable that offers multiple uses. It is not a new technology in the electric industry. It is currently used by many electric utilities in their transmission systems for communications purposes. It theoretically can be used for communications in real-time pricing programs.

A drawback to using fiber-optic cable for communications purposes in utility-customer applications such as real-time pricing is that only a small portion--roughly two percent--of the band will be used. However, this drawback provides an additional incentive for mergers of existing utility companies. Besides the convergence of electricity and gas, there are incentives for the convergence of telephony, Internet, and cable utilities with the energy industries. Others have argued that electric utilities are naturals for the introduction of fiber-optic cables to build the information superhighway because of the network character of their industry and their need for advanced communications.

Many electric utilities are already getting into the communications business. For example, Potomac Electric Power Company entered into a joint venture to provide Internet and telephone service in the District of Columbia.[16] Southern California Edison became the first electric utility in California allowed to offer telecommunications services.[17]

[16] Public Utility Reports, Inc., *PUR Utility Weekly*, Vienna, Virginia, October 30, 1998.
[17] Public Utility Reports, Inc., *PUR Utility Weekly*, Vienna, Virginia, January 1, 1999.

2.3.2.3. Globalization

EPAct broke down the barriers to globalizing the electric industry. U.S. electric utilities that were formerly restricted to a single service territory--or a holding company in multiple service territories in contiguous states--can now purchase utility assets anywhere in the world. By the same token, foreign interests can also purchase U.S. electric utilities.

The globalization of the electric industry in the aftermath of EPAct's enactment is impressive. Many U.S. electric utilities have purchased foreign utility assets and many have also been sold to foreign interests. Recently, there were two significant foreign purchases of U.S. electric assets. National Grid in the United Kingdom, the world's largest privately owned transmission company, announced the purchase of New England Electric system for $3.2 billion.[18] Scottish Power in the United Kingdom announced that it would pay $12.8 billion for PacifiCorp, creating one of the ten largest utilities in the world.[19]

2.3.3. IMPLICATIONS FOR HAWAII

Hawaii utilities have an opportunity to use technology to improve their efficiency and make the islands more attractive for the new global firms. However, mainland experiences are not necessarily transferable to Hawaii utilities. Hawaii policymakers must take a different approach to improving the efficiency of Hawaii utilities because of important differences between conditions on the mainland and those in Hawaii. We first discuss four major characteristics differentiating Hawaii utilities from those on the mainland. Then, we turn to the implications those differences have for policy toward the Hawaii electric industry and the future of energy-efficiency programs in the state.

2.3.3.1. Characteristics of the Hawaii Electric Sector

First, Hawaii utilities are not subject to the same type of regulatory jurisdiction that their counterparts on the mainland are. FERC has jurisdiction over interstate sales of electric power. Because of the nature of electrons flowing through a transmission grid, a Supreme Court decision interpreted "interstate" sales to mean any electron flowing through a transmission line that is interconnected with an interstate grid.[20] Because Hawaii utilities are not interconnected with utilities in other states, they are not subject to the regulatory jurisdiction of FERC. The State of Hawaii's Public Utility Commission regulates all of Hawaii's electric transactions--both wholesale sales and those sold to ultimate customers.

Second, because they are not connected to any other contiguous power grids, the six power systems on the islands of Hawaii are operated differently than those on the

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[18] Public Utility Reports, Inc., *PUR Utility Weekly*, Vienna, Virginia, December 18, 1998.
[19] Public Utility Reports, Inc., *PUR Utility Weekly*, Vienna, Virginia, December 11, 1998.
[20] Florida Power and Light vs. the Federal Power Commission (1972).

mainland. The lack of connections to other grids requires that Hawaii electric utilities maintain higher reserve margins than their mainland counterparts to ensure reliability. In the event that a power plant malfunctions and is shut down, Hawaii utilities cannot purchase power from a neighboring control area. They must have sufficient excess capacity themselves to replace the power from an inoperable plant. Higher reserve margins, of course, translate into higher costs and prices. Other important reasons include less diverse fuel supply sources (more reliance on oil) and the cost of living and doing business in Hawaii. In 1997, the average price of electricity in Hawaii was 12.5 cents per kilowatt-hour (kWh), nearly double the average for the United States as a whole. The average for all U.S. states was 6.9 cents per kWh.[21]

Third, relative to most mainland utilities, Hawaii's power systems are small because of the small populations they serve. To illustrate how small, compare the wholesale power markets of Hawaii's utilities and their mainland counterparts. For reliability reasons, wholesale power--or "bulk power"--markets are organized as "control areas" on the mainland.[22] The Pennsylvania-Jersey-Maryland power pool is the largest control area in the country with 46,450 megawatts (MW) of capacity. The tenth largest, Commonwealth Edison, has 18,600 MW.[23] In comparison Hawaii Electric Company's generating assets consist of 1,263 MW of capacity. Including Oahu's independent power producers (AES Hawaii, Kalaeloa, and H-Power), Oahu's total installed capacity is 1,669 MW.[24]

The power systems on Hawaii, Maui, Molokai, Lanai, and Kauai are appreciably smaller than that of Oahu's.

Fourth, as noted above, a major thrust of restructuring on the mainland is the convergence of gas and electric utilities because of expected economies of scale in supplying both commodities. This is the first phase in what many believe will be the convergence of all utility services: electricity, gas, water, telephony, cable, and the Internet. Natural gas is not available in Hawaii. However, synthetic natural gas and propane could play an increasing role, particularly as a fuel for distributed generation and fuel cells.

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[21] Energy Information Administration, *Electric Power Annual, 1998*, Washington, DC, 1999.

[22] A control area is a . . . "system that regulates its generation in order to maintain its interchange schedule with other systems and contributes its frequency bias obligation to the interconnection." Control areas must meet the reliability requirements of the North American Electric Reliability Council. Control areas consist of "tight" power pools, holding companies, individual utilities, or multiple utilities with one functioning as the control-area operator. At the present time, control areas are consolidating and being run by independent system operators (North American Electric Reliability Council, *Operating Manual,* Princeton, New Jersey, June 1995).

[23] North American Electric Reliability Council, *Operating Manual,* Princeton, New Jersey, June 1995.

[24] State of Hawaii, Department of Business, Economic Development, and Tourism, *Hawaii Energy Strategy 2000,* Honolulu, Hawaii, January 2000.

2.3.3.2. Hawaii Restructuring

In December 1996, the Public Utilities Commission opened a docket initiating an investigation into the possible restructuring of the Hawaii electric industry.[25] While the Commission asked parties to the docket to seek consensus, this proved impossible, and the parties submitted position papers to the Commission on October 19, 1998. The Commission has yet to take further action.

The differences between Hawaii's electric utilities and those on the mainland suggest that policies to improve the efficiency of Hawaii's electric industry should proceed differently from those on the mainland.

With a small electric system such as that in Hawaii, the opportunity to effectively introduce competition in wholesale power markets is reduced considerably. If policymakers decide to de-integrate the industry by requiring existing vertically integrated utilities on Hawaii, Maui, Oahu, and Kauai to divest themselves of generating assets, there could be too few participants in the generating stage of the industry for workable competition.[26] This is the case for the largest electric system on Oahu. Restructuring with too few generating companies runs the risk of institutionalizing market power without regulatory review, in effect replacing a monopoly firm with an oligopolistic market structure.

There are other ways to cut costs at the wholesale level without introducing competition. For example, GDS Associates concluded that electric costs on Oahu could be reduced through the following measures:[27]

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

There also could be competitive bidding for new generation. In addition, Hawaii utilities could be provided proper incentives to reduce costs through performance-based ratemaking.[28]

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[25] Hawaii Public Utilities Commission, 1996, *Instituting a Proceeding on Electric Competition, Including an Investigation of the Electric Utility Infrastructure in the State of Hawaii,* Order Number 15285, Docket Number 96-0493, Honolulu: State of Hawaii Public Utilities Commission.

[26] See, for example, Severen Borenstein, James Bushnell, and Christopher R. Knittel, "Market Power in Electricity Markets: Beyond Concentration Measures," *Energy Journal,* 20(4):65-88.

[27] GDS Associates, 1998, *Oahu Power Market Study,* Marietta, Georgia: GDS Associates, Inc.

Allowing retail competition--direct access to suppliers by all customers--in small retail electric markets such as those in Hawaii also poses problems. On one hand, if only large users of electricity are allowed direct access, they will leave the remaining captive customers to pay all of the fixed costs of the system. On the other hand, if all customers are allowed direct access to electric suppliers, the results may be the same: small customers pay for more fixed costs. The reason? Large customers have more resources than small ones to seek out alternative electric supply sources. And, the transaction costs of that search for large customers are much smaller on the basis of percentage of total electric bill than for smaller customers.[29]

To assume that aggregators and marketers will enter the market to match small customers with supply sources is also folly. For example, Enron, perhaps the most aggressive participant in U.S. restructured electric markets, withdrew as a marketer from New Hampshire and California because of the lack of interest by small customers in seeking out alternatives to their local utility for electric supplies.

Based on the foregoing arguments, it seems likely that the structure of Hawaii's electric industry--i.e., vertical ownership and control by a franchise monopoly purchasing some of its power requirements from independent power producers--will remain the same in the foreseeable future. If this is the case, an alternative to a radical restructuring of Hawaii's electric markets is a change in ratemaking for Hawaii utilities. The goal would be to change the incentives that Hawaii's regulated utilities have to reduce costs.

Utility-run energy-efficiency programs do not necessarily have to be victims of this change in ratemaking philosophy. State regulatory commissions on the mainland have combined new ratemaking approaches such as performance-based ratemaking with powerful incentives for utilities to run energy-efficiency programs.

For example, under Central Maine Power's (CMP's) performance-based ratemaking approach before Maine's electric industry was restructured,[30] the Public Utility Commission penalized CMP for not attaining energy-efficiency savings targets defined in its annually updated Electric Resource Plan. To its benefit, if CMP saved more than its target in any given year, a $1.0 million deferred credit was created to offset penalties that it would incur if it did not attain its DSM goals in other periods. CMP attains the target if it achieves at least 90 percent of it. If it falls short of its goals, the following penalties applied:

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[28]Lawrence J. Hill, *A Primer on Incentive Regulation for Electric Utilities*, Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-422, October 1995.
[29]*Economic-Efficiency Considerations in Restructuring Electric Markets*, Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-436, December 1996.
[30] Maine Public Utilities Commission, 1994, "Central Maine Power Company: Proposed Increase in Rates," Phase II, Docket No. 92-345, Maine Public Utilities Commission, Augusta, Maine, October 14.

Savings	Reduction in Revenues
85-89%	$1.5 million
80-84%	$2.0 million
75-79%	$3.0 million
<75%	$5.0 million

A regulatory commission, of course, can make these targets as lax or as stringent as it desires to achieve its public-policy goals.[31]

In their PBR filing, Hawaiian Electric Co., Hawaii Electric Light Co., and Maui Electric Co. proposed a traditional PBR scheme.[32] The plan includes a price cap, incentives to cut costs, and a mechanism to share savings (i.e., reduced costs) between the utilities and their ratepayers. Unlike the Central Maine Power PBR plan, however, there is no financial incentive to achieve energy savings by running energy-efficiency programs. If approved without amendment, utility-run energy-efficiency programs would ostensibly be eliminated according to the utility filing.[33]

3. Using Energy-Efficiency Technologies, Programs, and Practices to Promote Sustainable Economic Growth

As technology in the electric industry advances, the historical distinction between technologies used in the supply of electricity and its consumption is becoming increasingly blurred. Instead of focusing exclusively on the efficiency of electric supply, Hawaii policymakers should focus more attention on the efficiency of electricity consumption.

In this section, we first discuss advances in technologies in energy-efficient goods and services. We then address six delivery mechanisms that Hawaii policymakers should consider when developing a comprehensive energy-efficiency program for the State.

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[31] For more details on the integration of energy-efficiency programs with performance-based ratemaking, see Alan G. Comnes, Lawrence J. Hill, Steven Stoft, and Nathaniel Greene, *Performance-Based Ratemaking for Electric Utilities: Review of Plans and Analysis of Economic and Resource-Planning Issues*, Berkeley, CA: Lawrence Berkeley Laboratory, LBL-37577, UC-1320, November 1995.

[32] Hawaiian Electric Co., Hawaii Electric Light Co., and Maui Electric Co., *In the Matter of Hawaiian Electric Co., Hawaii Electric Light Co., and Maui Electric Co for Approval to Implement Performance-Based Ratemaking in their Next Respective Rate Cases*, Docket 99-0396, Honolulu, Hawaii, December 13, 1999.

[33] GDS Associates reviewed the PBR filing and indicated that the plan could be improved to promote lower costs in the Hawaii electric sector. See GDS Associates, *Analysis of HECO's Proposals for Electricity Restructuring*, January 2000.

3.1. Advances in Energy-Efficient Goods and Services

There have been marked improvements in the energy efficiency of goods and services in recent years. For example, the energy efficiency of consumer goods such as clothes washers, driers, refrigerators, and air-conditioners has improved dramatically in the past decade. Much of that improvement is attributable to nationally mandated appliance efficiency standards.

There is also a revolution in the energy efficiency of industrial technologies. Nearly 70 percent of electricity use in the manufacturing sector is attributable to motors. The energy inefficiency of motors has been cut in half in the past decade with introduction of variable-speed drives. Also, recent advances in membranes, sensors, and materials promise to revolutionize energy use in American industry.

However, the industrial sector is not a large portion of Hawaii's economy. Because of its service and tourism orientation, energy efficiency in the buildings sector may be the area in which Hawaii can derive the most benefit from energy-efficiency programs. New technologies have been proved cost-effective or are under development in the buildings sector. Advanced roof, window, and wall systems and more effective moisture control strategies are increasing the energy efficiency of U.S. buildings. Some promising commercial-building technologies include:[34]

- Advanced wallboard and insulation incorporating change-of-state material technology.
- Advanced reflective window films
- Combined cooling, heating and power systems
- Desiccant dehumidification
- Engine-driven chillers and refrigeration equipment
- Gas refrigeration and cooling
- Ground-coupled (geothermal) heat pumps
- Heat pump water heaters
- High-efficiency chillers and air conditioners
- High-efficiency distribution transformers
- Horizontal-axis clothes washer
- Hybrid electric/gas chillers and refrigeration plants
- Hybrid lighting
- Integrated cooling and hot water systems
- Integrated photovoltaic roofs
- Massive refrigerated warehouses
- One kWh/day refrigerator freezer
- Reflective roofing materials
- Thermal storage

[34] Source: Oak Ridge National Laboratory report to State of Hawaii, Department of Business, Economic Development, and Tourism.

- Waste heat utilization

We describe these technologies in greater detail in Appendix A.

The concept of a "green building" is also gaining momentum nationally and internationally. A green building uses all inputs efficiently--energy, water, materials, and labor--and minimizes the building's contribution to the waste stream. However, the Green Building concept places just as much importance on the people inhabiting the building as the physical structure itself. It addresses indoor air quality, toxicity, the amount of daylight used in the building, and the overall comfort of the building.

The existence of energy-efficient technologies is not the major impediment to an energy-efficient economy in Hawaii. The technologies exist. The major problem is delivering these technologies to consumers or, in other words, using effective energy-efficiency delivery mechanisms.

3.2. Six Types of Energy-Efficiency Delivery Mechanisms for Hawaii to Consider

Policymakers have become more innovative in obtaining the economic and environmental benefits of energy-efficiency programs as traditional utility-created, funded, and administered programs wane in restructured electric markets. Funding sources, administrators, implementers, and strategies are changing in the new era of energy efficiency. Taxpayers, commercial banks, private businesses, and even charitable foundations are replacing ratepayers as primary funding sources. Government agencies, non-governmental organizations, and energy service companies are replacing utilities as administrators of energy efficiency programs. Policymakers increasingly emphasize market transformation programs as a strategy to improve energy efficiency because of their long-lasting effects.

Hawaii policymakers can learn from the experiences of their mainland counterparts to not only strengthen existing State and utility-run energy-efficiency programs, but also to supplement them with more innovative programs.

Although there are many combinations of funding sources, administrators, implementers, and strategies for Hawaii policymakers to consider, we discuss six relevant delivery mechanisms in the remainder of this chapter.

3.2.1. UTILITY-RUN ENERGY-EFFICIENCY PROGRAMS

From the early 1980s to the present, electric and gas utilities ran the majority of programs to improve the efficiency of a community's use of energy. These programs were typically mandated by state law or required by an order of a state regulatory commission. Utilities were required to create, fund, and administer programs aimed at improving the efficiency of their customers' use of energy. As in most other states, Hawaii's energy-efficiency programs were developed--and their cost-effectiveness estimated--as part of demand-side management programs in an integrated resource planning (IRP) process.

Policymakers typically invoked six reasons for requiring electric and gas utilities to run energy-efficiency programs when those programs first originated in the late 1970s and 1980s. These were (1) deferral of new power plants, (2) production cost relationships (marginal higher than average cost), (3) lack of codes and standards; (4) oil-dependence concerns, (5) acquiring energy efficiency resources cheaper than building new power plants, and (6) environmental consequences. Although they vary by local conditions, most of these reasons are no longer valid for most U.S. mainland utilities. However, four of the six reasons can still be used to justify utility-run programs in Hawaii: electricity production cost relationships (marginal higher than average cost); dependence on foreign oil; efficiency programs relatively cheaper than constructing new power plants; and the environmental costs of producing electricity from fossil fuels.

First, policymakers believed that utilities could defer construction of new power plants by implementing energy-efficiency programs. Deferring construction of plants was important at the time, since the cost of building a new power plant was excessive because of high rates of inflation, high interest rates, and long construction lead times. This is no longer a valid reason for U.S. energy utilities--including those in Hawaii--to run energy-efficiency programs. Rates of inflation are at historic lows. However, in Hawaii, as in many other states, deferring construction of new power plants has other benefits such as avoiding land-use conflicts.

Second, consumers were not getting adequate information on the cost of producing electricity because the marginal cost of producing electricity was higher than its average cost of production.[35] Because most consumers were paying an average price rather than a marginal one at that time, consumers used too much electricity during peak periods when the utilities' production costs were high. In general, this rationale for utility-run DSM programs no longer applies for mainland utilities. The marginal cost of production is lower than the average and customers of mainland utilities are now more and more paying the actual cost of producing electricity through time-of-use rate programs.[36] In Hawaii, however, this rationale still applies. The marginal cost of producing electricity is not lower than the average cost in Hawaii and Hawaii utilities are not as progressive in offering time-of-use tariffs as many of their mainland counterparts.

Third, policymakers wanted to compensate for the lack of energy standards on appliances and the lack of energy codes for buildings. At the time, implementing codes and standards was a hotly debated political issue in Congress and in state governments. That situation has changed. Most U.S. communities have developed building codes. Hawaii, for example, developed a model building code for new commercial and residential construction that has been adopted in three out of its four counties, Maui being the

[35] The average cost of production is the ratio of total cost to total electric output during the course of a year. The marginal cost of production is the additional cost of producing a unit of output at any point during the year.

[36] Although time-of-use rates have been used by utilities in the industrial sector for years, they are now being introduced more and more for residential and commercial customers.

exception. And, national appliance standards have been adopted after a series of legislative initiatives in the 1970s, 1980s, and 1990s. Presently, a sophisticated mechanism is in place to periodically change the standards and the tests required to develop those standards.

Fourth, utility-run energy-efficiency programs originated in the aftermath of the first oil embargo in the 1970s. As a result of the embargo, national policymakers wanted electric utilities to reduce their use of foreign oil in the production of electricity. Presently, mainland utilities use oil for less than five percent of their electricity production. Imports of foreign oil are no longer a major concern for power production on the mainland. Therefore, this rationale for utility-run DSM programs no longer applies to mainland utilities. However, the rationale still applies for Hawaii utilities to run DSM programs. Hawaii energy supply remains much less diversified than that of the United States as a whole. In 1997, 88% of Hawaii's total energy came from oil (75% of its electricity production from oil), 5.7% from coal, 4.5% from biomass and municipal waste, and 1.8% from other sources. In comparison, in 1997 the nation relied on petroleum to produce only 37% of its energy, while natural gas supplied 22%, coal 22%, nuclear power 7%, and hydroelectricity and other 12%.[37]

Fifth, related to deferring construction, utilities wanted to acquire resources that were cheaper than building power plants. At the time when utility-run energy-efficiency programs were conceived in the late 1970s and early 1980s, the country was in the midst of a nuclear-construction frenzy. High interest rates and long lead times for constructing nuclear plants because of safety concerns drove up their construction costs. Although today there are many energy-efficiency opportunities that make financial sense, the financial attractiveness of these opportunities are increasingly threatened because technological advances are making it more and more economically attractive for utilities to produce electricity than help their customers improve the efficiency of its use.

Sixth, policymakers wanted to mitigate the adverse environmental consequences of producing electricity from fossil fuels. Improving energy efficiency--and thus reducing the amount of electricity to be produced--was a better environmental policy option than producing more electricity. This reason for running energy-efficiency programs is, of course, still currently valid today for both mainland and Hawaii utilities and the urgency has even been exacerbated by (1) increasing concerns about global climate change from producing electricity from fossil fuels and (2) the introduction of new, electricity-using electro-technologies. Because of these recent developments, many state and national policymakers are now calling for the use of more renewable energy resources to generate electricity in conjunction with running more energy-efficiency programs.

For Hawaii policymakers, then, four of the six original reasons for requiring utility-run energy-efficiency programs have not changed appreciably. Although (1) deferral of new power plants, (2) cost effectiveness, (3) oil-dependence concerns, and (4) environmental

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[37] Data provided from State of Hawaii, Department of Business, Economic Development, and Tourism.

consequences are a solid foundation for continuing utility-run resource-efficiency programs in Hawaii, changing circumstances caused in large measure by rapid technological innovation are forcing policymakers to consider delivery mechanisms other than energy utilities to increase energy efficiency.

At one time, policymakers and analysts believed that utility-run energy-efficiency programs would dominate the resource efficiency landscape. Policymakers also hoped to implement resource conservation policy through the integrated resource planning (IRP) processes of energy utilities, especially electric utilities.

In an IRP process, energy-efficiency programs and renewable-energy technologies "compete" with conventional generating plants for the resource investment expenditures of electric and gas utilities. In an IRP process, the price of electricity is determined in a regulatory proceeding. At its peak in the early 1990s, more than 33 states mandated the use of IRP processes. These mandates came either from state legislation or state regulatory commission orders.

Hawaii has a long history with utility-run energy-efficiency programs.[38] In 1988, Governor John Waihee requested the Public Utility Commission (PUC), with assistance from DBEDT, to implement a program encouraging all utilities in the state to comply with an IRP process. In January 1990 the PUC issued Order No. 10458 instituting a proceeding "to require energy utilities in Hawaii to implement integrated resource planning." A collaborative consisting of all Hawaii public utilities, the Division of Consumer Advocacy, DBEDT-Energy Division, and environmental and other interested groups was formed to address various issues in IRP. As a result of the collaborative sessions, a consensus was reached on a number of principles to guide the development of a utility's IRP. A consensus document was filed with the PUC.

The PUC then held hearings that concluded in September 1991. In March 1992 the PUC issued a Decision and Order requiring the utilities to develop IRPs in accordance with a Framework attached to the Order. Subsequently, some parties requested clarification of certain portions of the Order and Framework, which was accomplished in Decision and Order No.11630, issued in May 1992.

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

- Commercial and Industrial Energy Efficiency Program, promoting more efficient air conditioning, lighting, refrigeration, and motors;

[38] The discussion of Hawaii's utility-run DSM programs in this chapter is based on State of Hawaii, *Hawaii Energy Strategy 2000,* Department of Business, Economic Development, and Tourism; Energy, Resources, and Technology Division, January 2000.

- Commercial and Industrial New Construction Program, providing design and technical assistance for more efficient air conditioning, lighting, motors, and other end uses;
- Commercial and Industrial Customized Rebate Program, providing for cost-sharing arrangements to fund customer-proposed energy efficiency opportunities;
- Residential Efficient Water Heating Program, promoting the use of high-efficiency water heating technologies such as solar water heating, heat-pump water heaters, and high-efficiency resistance water heaters; and
- Residential Efficient Water Heating Program (New Construction), promoting solar water heating, heat-pump water heaters, and high-efficiency resistance water heating to developers of new housing.

In its second IRP, HECO reviewed the Hawaii Demand-Side Management Opportunity Report, produced by DBEDT as part of HES 1995 and concluded that it could be used by HECO as an assessment of the potential for DSM in Hawaii. HECO elected to maintain and further develop the five DSM programs established in their first IRP and to add two load management programs. The two load management programs are:

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

The two load management programs are intended to defer the need for new capacity by reducing peak demand, a strategy known as "peak shaving." The five original DSM programs also offer some peak demand savings. The estimated 168 MW peak demand savings expected to be deferred during the period is comparable in size with a planned 107 MW combustion turbine or the 180 MW atmospheric fluidized bed coal plant planned for installation late in the planning period.

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

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

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

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

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

There are two reasons why IRP and utility-run energy-efficiency programs are threatened in many jurisdictions throughout the country. First, as the electric industry undergoes reorganization, the retail price of electricity will be determined more and more in markets with multiple energy suppliers that do not themselves generate electricity. The "wires" portion of utilities that historically ran energy-efficiency programs argue that they are unfairly burdened by running these programs if their competitors are not also obligated to do so. With energy prices determined in markets--not regulatory proceedings--utility-run energy-efficiency programs are becoming less and less common.

Second, restructuring of the electric industry is supposed to lower the price of electricity to consumers. Lower prices make energy-efficiency improvements less attractive. If prices decline far enough, even the most potentially cost-effective programs will not be financially attractive.

In Chapter 4, we recommend that Hawaii look more closely at its electric utilities and study the feasibility of implementing time-of-use (TOU) pricing and an innovative ratemaking approach based on performance rather than costs. TOU pricing is a fundamental energy-efficiency program. An innovative ratemaking approach will lower production costs and retail prices of Hawaii utilities. We also recommend that Hawaii study the potential impacts of distributed generation on its utilities.

3.2.2. PUBLICLY RUN PROGRAMS

Publicly run energy-efficiency programs are created, organized, funded, and administered by various levels of government--national, state, and local. They are implemented by staff at government agencies, contractors, and non-governmental organizations. There are different reasons why governments run energy-efficiency programs, examples being to improve the environment or reduce government outlays on energy. The programs can be created by statute or implemented as a matter of public policy.

The most far-reaching federal program relates to energy conservation standards and labeling. In 1975 after the first oil price shock, Congress enacted the Energy Policy and Conservation Act (EPCA) that mandated the U.S. Department of Energy to develop test procedures and standards for residential appliances. In 1987, Congress amended EPCA with the National Appliance Energy Conservation Act which set the first national efficiency standards for appliances and created a schedule for regular updates. EPAct expanded coverage of the standards to include certain commercial and industrial equipment (including commercial heating and air-conditioning equipment), water heaters, incandescent and fluorescent light bulbs, distribution transformers, and electric motors. The legislation also created maximum water flow-rate requirements for plumbing products and provided for voluntary testing and consumer information programs for office equipment and luminaires.

EPAct also created the Federal Energy Management Program (FEMP). This program requires that the U.S. Department of Energy coordinate a program to have all federally owned buildings reduce energy consumption by 20 percent by the year 2005. An Executive Order by President Clinton increased the stringency of the law to 30 percent by the year 2010. Although the legislation does not apply to federally owned military buildings, the Department of Defense has a similar energy-efficiency program.

The federally funded Weatherization Assistance Program, supplemented by other funds, has helped low-income families install insulation jackets and timers on water heaters, provided new heat pump water heaters, and offered advice on improving energy efficiency.

There are other publicly run federal programs in the United States not administered exclusively by the U.S. Department of Energy. The U.S. Environmental Protection Agency's Energy Star Programs for both buildings and consumer appliances are examples.

USDOE also works with states to run energy-efficiency programs. The USDOE's State Energy Program, originally created in 1976, provides funds for states to originate projects that are most beneficial for their states. Under this program, there are numerous examples of successful, cost-effective, energy-efficiency programs in the buildings, transportation, industry, education, agriculture, and utilities sectors.[39] The programs range from direct energy-efficiency retrofits in commercial, industrial, and educational buildings, to technical and financial assistance, and to educational programs.

Individual states also run energy-efficiency programs. For example, many states run FEMP-type programs for state-owned buildings. Hawaii established an Energy Management and Efficiency Program for State Facilities in 1994 to moderate the growth in energy demand through conservation and energy efficiency. An Executive Memorandum in 1996 urged all departments and agencies to use public funds judiciously by making energy efficiency a priority.

Besides State buildings, Hawaii is very active in promoting resource efficiency in other sectors.[40] Specific programs include:

- Residential building efficiency. The Honolulu Chapter of the American Institute of Architects was contracted to develop and implement voluntary residential building guidelines to support and extend the State's Model Energy Code. This project included training materials and training sessions and the planning and building of at least one model demonstration house.
- Commercial building efficiency. Participants in the project will work toward the development of the next-generation building code for new and renovated commercial developments and buildings.
- Performance contracting. The Energy, Resources, and Technology Division of DBEDT is providing technical assistance to interested facility and agency managers throughout the performance contracting process, from developing the RFP through monitoring and verifying savings. Construction on the first energy savings performance contract for State of Hawaii facilities, 50+ buildings on the University of Hawaii and Hawaii Community College Campus at Hilo, was completed in December 1996, and, as of June 1999, had produced over $1.4 million in savings. The $2.9 million investment in energy efficiency retrofits is projected to produce over $6.6 million in energy and other cost savings during the term of the 10-year contract. In addition, $200,000 in maintenance savings are being achieved annually.
- Training. The State is very active in market transformation through its educational and training programs. DBEDT promotes renewable energy and energy efficiency through educational and promotional projects such as workshops and technical seminars, science and engineering fairs, exhibits, and energy-efficiency publications.

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[39] U.S. Department of Energy, *State Energy Program Results: More Projects that Work*, Washington, DC, December 1998.

[40] The discussion of Hawaii's state and county energy-efficiency programs in this chapter is based on State of Hawaii, *Hawaii Energy Strategy 2000,* Department of Business, Economic Development, and Tourism; Energy, Resources, and technology Division, January 2000.

Local governments are also involved in running energy-efficiency programs. The energy awareness educational programs run by local school districts in many states are examples of local initiatives. Recognizing that energy accounts for as much as 75 percent of the cost of operating a water system, many municipalities have initiated energy-efficiency programs for their water distribution systems. The city of Fresno, California, for example, saves $725,000 per year after installing a supervisory control and data acquisition system in their water distribution system. In 1990, Portland, Oregon enacted the Portland Energy Policy. This policy mandates the city to improve energy efficiency in municipal buildings, commercial and industrial plants, and the transport sector.

Hawaii's County governments are involved in a variety of energy efficiency programs, not only independently, but also in conjunction with the federal and State governments. County governments have programs and projects that contribute to reducing energy costs and improving Hawaii's economy, as well as reducing environmental pollution. County initiatives include building and lighting programs and performance-based contracting. Construction on the first county performance contract, the Hawaii County building, was completed in March 1997. To date, Hawaii County has retrofitted an additional 27 fire and police stations for a total investment of $877,000. Cumulative energy savings to date are $242,100. By November 2000, the County plans to complete a retrofit of all public safety buildings, an estimated investment of $1.2 million. Kauai County has retrofitted 29 county facilities/buildings with energy savings equipment. Total investment was $525,000 and $680,000 in energy and operational cost savings are projected over the 10-year project period (1998-2007).

In Chapter 4, we recommend that Hawaii consider three additional state-run programs. First, we recommend that Hawaii consider using life-cycle costing in its purchasing decisions. Second, we recommend that Hawaii implement a "green buildings" program. Finally, we recommend that the state be a catalyst for adoption of new, energy-efficient buildings technologies.

3.2.3. PUBLIC-PRIVATE PARTNERSHIPS

The national government often has the expertise, research capabilities, and access to technologies dealing with energy efficiency. However, information about specific energy-efficiency problems often exists at state or local levels or with individual commercial enterprises. To bridge this gap, national governmental agencies are forging alliances with subnational organizations to improve resource efficiency.

The U.S. Department of Energy's (USDOE's) Rebuild America Program is an example of one such alliance. This program's mission is to build partnerships among communities, states, and the private sector to improve building performance, and to provide a gateway connecting people, resources, ideas and practices for energy solutions to community needs.

The State of Hawaii has joined Rebuild America as a community partnership and DBEDT is a catalyst for the program in Hawaii, providing funding and technical assistance to participating groups. In 1998 DBEDT established the Rebuild Hawaii Consortium as a forum for Hawaii Rebuild America partnerships, utilities, community and private business groups to share information on energy and resource development. By sharing experiences with energy efficiency projects and learning about new energy efficiency technologies, practices and products, the Consortium finds connections that help leverage the many resources of the members to effect better, bigger results in energy efficiency projects. In Chapter 4, we recommend that the state expand its Rebuild Hawaii program to include other sectors.

USDOE also works with private industry to improve the energy efficiency of existing industrial processes and those that are likely to be adopted in the future. In its Industries of the Future Program, for example, USDOE works in partnership with industry and non-governmental organizations in eight energy- and waste-intensive industries--steel, chemicals, aluminum, metal-casting, glass, petroleum refining, renewable bioproducts, and forest products--to develop and deliver advances in energy efficiency, renewable energy, and pollution-prevention technologies and practices. USDOE offers assistance in leveraging government resources, coordinating industry participation, providing access to national laboratories, and disseminating software and information.

USDOE also works in partnership with individual industries through its "challenge" programs, including motor, compressed air, and steam challenges. The programs are collaborative processes between (1) the USDOE and its resources (national laboratories, computer software, information) and (2) private firms using motors, compressed air, or steam in their industrial processes. The goal of these partnerships is to increase the resource efficiency of industrial processes.

3.2.4. MARKET TRANSFORMATION PROGRAMS

Markets consist of producers, consumers, and intermediaries such as wholesalers/ distributors, lending institutions, and a futures market. At any one time, producers may manufacture goods that consumers do not want. However, markets tend to equilibrate over time. Producers ascertain the revealed preferences of consumers and will discontinue production of those goods not demanded in the market place. If consumers choose to purchase energy-efficient goods, producers will manufacture them. Similarly, if producers and distributors supply only energy-efficient equipment, consumers will purchase it.

Changing--or "transforming"--a market as an energy-efficiency policy option involves changing the production and distribution of energy-using goods--or, alternatively, changing consumer preferences for energy-efficient goods—to ensure that only energy-efficient appliances and equipment reaches consumers in the long term. Oftentimes, a problem with this policy approach is the higher up-front costs of more energy-efficient goods. However, changing consumer preferences to purchase more energy-efficient goods may lower their production costs and prices to the extent that there are scale economies in manufacturing the energy-efficient goods.

A "green pricing" program can be viewed as a market transformation activity. Consumers pay a premium for electricity generated from renewable resources such as the sun. More renewable technologies will be used to produce electricity, lowering production costs to the extent scale economies are present.

Large-scale market transformation programs are currently under consideration in many states. Multiple states have also entered into partnerships to form regional alliances to transform markets.

In the Northwest, for example, public and private organizations in Montana, Idaho, Oregon, and Washington collaborated in October 1996 to form the Northwest Energy Efficiency Alliance. The Alliance's creation reflects support of organizations in the region for market transformation in those four states, believing that broad-based, coordinated support for market transformation will be more effective than individual utility programs. The Alliance has a budget of $65.5 million over the 1997 through 1999 period, funded by the Bonneville Power Administration (57.3 percent) and six investor-owned utilities (42.7 percent): Idaho Power, Montana Power, PacifiCorp, Portland General Electric, Puget Sound Energy, and Washington Water Power.[41]

A similar collaborative, the Northeast Energy Efficiency Partnerships, was created in the Northeast. NEEP coordinates energy efficiency programs in New England, New York, and the Mid-Atlantic region.

The State of Hawaii is very active in market transformation through its educational and training programs and the Rebuild Hawaii Consortium. First, DBEDT promotes renewable energy technologies and energy efficiency through workshops, educational and promotional projects such as technical seminars, science and engineering fairs, energy-efficiency publications, and cooperative efforts with the utilities.

Second, DBEDT partners with other entities through the Rebuild Hawaii Consortium to implement energy efficiency projects. The Consortium recently provided support to the HECO Small Business Market Transformation Project that investigated issues and solutions to the barriers to implementing energy efficiency in small business. Under this project, 21 small business were aggregated into one project in order to take advantage of economies of scale and bulk purchase.

Third, DBEDT provides information on renewable energy technologies and Hawaii's renewable energy resource potential to students, teachers, decision makers, investors, and government agencies interested in assessing, developing, and funding renewable energy projects in Hawaii. DBEDT supports diversification of energy supplies and increased

[41]See the Northwest Energy Efficiency Alliance's web site (www.nwalliance.org) for more details.

use of locally available energy resources such as wind, solar, ocean, hydro, geothermal, and biomass.

Fourth, DBEDT provides information on alternative transportation fuels and vehicles to public and private fleet managers. DBEDT administers federally funded and state- and private-funded joint demonstration and development projects. DBEDT supports increased use of transportation energy options such as alcohol fuels (ethanol and methanol), electric vehicles, liquified petroleum gas, and biodiesel.

In Chapter 4, we recommend that Hawaii expand its market transformation activities to include a public awareness campaign on global climate change and a study of the economic effects of importing energy that could also be included in a public awareness campaign.

3.2.5. PUBLIC BENEFIT FUND

The electric industries in the United States are undergoing dramatic structural change. The industries are increasingly becoming de-integrated with vertically integrated electric utilities selling their generating assets and placing their transmission assets under the control of an independent system operator. Many policy analysts are now pressing for an independent transmission company (Transco) that would further de-integrate the industry. The gas industry has already been de-integrated by legislation and orders of the Federal Energy Regulatory Commission. There are incentives for gas and electric distribution utilities to merge. Because of advances in metering, there are also incentives for gas, electric, and water utilities to merge. At the extreme, it is conceivable that marketers and companies will sell all electric, gas, water, telephony, cable, and internet services together, a one-stop provider of utility services.

Although the future structure of distribution utilities cannot be predicted with certainty for every region of the country, it is clear that the delivery of energy-efficiency services, renewable energy, low-income energy programs, and research and development on energy--so called "stranded benefits"--will change dramatically in the future. The question is how? In its Order No. 888 implementing EPAct's electric transmission access provision, FERC stated:[42]

> Through their jurisdiction over retail delivery services, states have authority not only to assess stranded costs but also to assess charges for stranded benefits, such as low-income assistance and demand-side management. Because their authority is over services, not just the facilities, states can assign stranded costs and benefits based on usage (kWh), demand (kW), or any combination or method they find appropriate.

[42] Federal Energy Regulatory Commission, Order No. 888, 61 Federal Register 21540, 21626, Washington, DC, May 10, 1996.

Thus, FERC advocated the use of a “wires charge” to collect funds for stranded benefits. The Clinton Administration’s proposed legislation to restructure the electric industry contains a similar proposal. The wires charge is, in essence, a “tax” on electricity.

If enacted, a wires charge would create a pool of funds to be used for energy-efficiency programs, the increased penetration of renewables in electric markets, low-income energy programs, and research and development. These funds would not necessarily be administered by the utility owning the electric distribution lines. All of the funds are being raised by a non-bypassable charge on electric distribution services.

In Hawaii, the political and economic climate does not seem amenable to a public benefit fund. A tax on electricity transmission and distribution would increase rates in a state that already has the highest electric rates in the country.

3.2.6. ENERGY SERVICE COMPANIES

Energy service companies (ESCOs) began in the United States in the late 1970s, originating in the aftermath of the oil price shocks. Recognizing the potential market for energy conservation, the first ESCOs used “shared savings” mechanisms to finance (1) the loans required for up-front energy-efficiency retrofits; (2) the operating costs of the ESCOs; and (3) a share or profit for the organization undergoing the retrofit. Recognizing their potential profitability, utilities entered the industry, forming their own ESCO subsidiaries.

By 1983, the “shared savings” mechanism originally used by ESCOs to conduct energy-efficiency projects was abandoned in favor of new types of performance-based agreements using bonds, and commercial and tax-exempt leasing for financing. Current practice in Hawaii is not shared savings, but “guaranteed savings” by the ESCO. If the guarantee is not met, the ESCO pays the facility the difference.

The State of Hawaii is active in promoting guaranteed-savings performance contracting. The Energy, Resources, and Technology Division's activities in performance contracting are increasing through the Division’s efforts to educate interested parties in the State about the technical merits of such contracts and through supportive legislation passed by the Hawaii State Legislature. DBEDT's role is to provide information and technical assistance to interested facilities managers and agency managers, from developing the request for proposals, negotiating the contract, performing technical reviews of energy audits, and through monitoring measurement and verification performed by the ESCO.

Some issues arose during the early years of the industry. First, interest rates increased dramatically in the 1980s. Higher interest rates translate into higher transaction costs and resulted in fewer retrofits being cost-effective.

Second, U.S. energy prices were relatively high when the first ESCOs were formed on the mainland and the projection for the future was higher and higher prices. At that time, the price of oil was projected to increase to more than $100 per barrel within a decade.

Conventional wisdom suggested that the United States was running out of natural gas. Of course, none of this materialized.

Third, the operating costs of ESCOs became higher as the number of their employees increased. The energy-efficiency business does not bring a steady stream of projects or revenues. With highly skilled technicians on the payroll and no bankable projects, many ESCOs ran into financial trouble because of a fixed-cost burden. Today, the industry is fairly stable, dominated by larger companies with multiple lines of business. As the industry matures in a given location, the operating costs of ESCO's actually go down because of scale economies. As customers get more familiar with performance contracts, a steady flow of projects can result.

Fourth, there were many government, organizational, and institutional barriers to implementing energy-efficiency programs even where the potential for energy efficiency was high. At the outset, negotiations take a long time because of the novelty of the contracts and the need for innovative financing. Many states did not have legislation authorizing performance contracting. Many public-sector facilities cannot borrow money without voter approval to finance energy-efficiency retrofits. Recently this has changed with the understanding of the customers that the risk of an energy performance contract lies with the ESCO that has to guarantee savings. More recently, public-housing authorities are being encouraged to implement performance contracts in their facilities to lower costs of energy bills to occupants of public housing.

We recommend below that Hawaii strengthen its energy services industry in both the State and Pacific region.

4. Recommendations

As we discussed in the previous chapter, the State of Hawaii currently has a large portfolio of energy-efficiency programs. And, it is considering a wide range of other supply- and efficiency-related initiatives as part of its Climate Change Action Plan.[43] However, as we discussed in Chapter 2, technological advances are revolutionizing the global economy. This revolution promises higher economic growth, more electricity production, and even more concern about global climate change. With these changing circumstances, delivering resource-efficiency services in the future will be more compelling for Hawaii policymakers.

On the mainland, electric utilities will be more reluctant to run energy-efficiency programs because the monopoly-franchise structure of the electric industry is evolving into a structure based on market principles: electric prices are increasingly set in markets, not regulatory proceedings. Policymakers on the mainland are emphasizing market-transformation alliances such as the Northwest Energy Efficiency Alliance created in the states of Montana, Idaho, Oregon, and Washington. As more states impose "stranded-

[43] Steven Alber *et al.*, *Climate Change Action Plan,* Department of Business, Economic Development, and Tourism, State of Hawaii, December 1998.

benefits charges" on electric customers and generate funds for resource-efficiency programs, policymakers will also rely more on administrators or trusts to oversee the funds and deliver energy-efficiency services to electric customers.

The situation in Hawaii is much different. Radical restructuring of the electric industry is unlikely and electric prices are likely to stay higher than the national average because of, if nothing else, Hawaii's insularity. Therefore, Hawaii policymakers will encourage more utility-run energy-efficiency programs than other states from the six delivery mechanisms discussed in Chapter 3:

- utility-run energy-efficiency programs
- publicly run programs
- public-private partnerships
- market transformation programs
- public benefit fund
- energy service companies

However, all of the burden to tap the economic and environmental benefits of energy-efficiency programs must not be placed on the utilities. We recommend a comprehensive program aimed at improving energy efficiency in Hawaii's economy. The program is based on four policy directions:

- The State should address the organization of its electric utility industry, its method of regulation, and utility-run energy efficiency programs.
- The State should continue and expand the scope of its publicly run energy-efficiency programs.
- The State should take a longer-term view of energy and its relationship to the Hawaii economy.
- The State should strengthen its energy services industry.

We recommend 11 initiatives to implement this comprehensive program to improve energy efficiency in Hawaii's economy, using the delivery mechanisms discussed in Chapter 3.

The benefits of undertaking these initiatives are so large that Hawaii policymakers would be remiss if they did not consider them. Although time and resources do not permit us to quantify the benefits of the 11 initiatives, the experiences of other states suggest that, if implemented, they would result in significant employment, income, and productivity benefits in Hawaii. For example, one study concluded that California's energy-efficiency programs resulted in marked income growth resulting from energy-efficiency programs (on the order of $1,000 per-capita since 1977), a 40% reduction in air pollution, and an increase in disposable income for low-income households.[44]

[44] Mark Bernstein, Robert Lempert, David Loughran, and David Ortiz, *The Public Benefit of California's Investments in Energy Efficiency*, Santa Monica, CA: RAND, MR-1212.0-CEC, March 2000.

In the remainder of this chapter, we discuss the recommendations in more detail.

4.1. Policy to Address the Organization and Regulation of the Electric Industry

4.1.1. TIME-OF-USE PRICING

We recommend that the State investigate the cost-effectiveness of introducing time-varying (by hour, day, or season) electric rates in Hawaii.

An energy-efficiency strategy used by many utilities is innovative electricity pricing, both alone and as a financial incentive for other energy-efficiency measures. Higher-voltage commercial and industrial customers are the most appealing targets for these pricing strategies because of lower administrative costs. However, smaller-voltage electricity users are also targeted by some electric utilities because of their poor load shapes. As incomes rise and air-conditioning loads increase, seasonal peaks are magnified for many utilities.

The most widely adopted pricing strategy to manage this type of load is diurnally varying rates--time-of-day (TOD) pricing--which is a specific form of the more general class of time-of-use (TOU) rates which vary over the course of a year: hour by hour, day by day, or season by season. TOD rates are theoretically appealing: consumers causing daily peaks bear the burden of paying for the higher running costs during those periods. Likewise, consumers contributing to seasonal peaks--such as using air-conditioners--bear the cost of building the capacity needed to meet the peaks.

TOU pricing has proved effective in shaping load and reducing energy consumption for electric utilities. In fact, although it is a behavioral energy-efficiency program rather than a technology fix, it is the foundation of --or necessary for--running effective technical energy-efficiency programs. The amount of energy savings that can be realized by utilities adopting TOU pricing depends on the annual amount of consumption by its customers and the types of load they have. In the residential sector, response to TOU rates depends on household size, income, weather, and the types of appliances being used. For some utilities, peak residential energy consumption declined by a third after TOU rates were implemented. In the industrial sector, energy-intensive mechanical production processes whose loads are easily curtailed such as cement producers respond more to TOU rates than continuous-process industries that find it more difficult to curtail production during peak periods.[45]

[45] We refer the interested reader to: Lawrence J. Hill, "Large Power Users and Capacity Shortages in Developing Countries: The Role of Innovative Pricing," *International Journal of Global Energy Issues*, 3(2):86-96; Lawrence J. Hill, "Residential Time-of-Use Pricing as a Load Management Strategy: Effectiveness and Applicability," *Utilities Policy*, 1(4):308-318; and Lawrence J. Hill, *Electricity Pricing as a Demand-Side Management Strategy: Western Lessons for Developing Countries*, Oak Ridge, TN: Oak Ridge National Laboratory, ORNL-6620, December 1990.

Electric utilities can easily implement TOU rates. If effective, these rates can improve the load factor of the utility, increase its productivity, and reduce oil consumption for Hawaii utilities during peak periods. TOU rates are an effective resource-efficiency program.

Advances in metering and communications technology now afford utilities the ability to transmit prices to customers and to read meters in real time. This "real-time TOU pricing" is one of the most important aspects of many of the restructuring efforts to date, providing customers "virtual direct access" to competitive electric markets.

The State should investigate the feasibility of implementing static TOU pricing and the more dynamic real-time pricing for Hawaii utilities. A portion of the study should address the appropriate metering and communication technologies for real-time pricing in the Hawaii situation. The result of the investigation would be a proposal to the Hawaii PUC on the coverage, feasibility, and expected effects of both static and dynamic TOU pricing.

4.1.2. INNOVATIVE RATEMAKING

We recommend that the State investigate the applicability of performance-based ratemaking to Hawaii utilities.

Rates are the most controversial of all regulatory areas: How are electricity rates to be determined, and at what levels should they be set? To address the rate challenge, cost-of-service ratemaking (COSR) has been historically adopted by most state regulatory commissions, including Hawaii's PUC. Concisely, COSR allows electric utilities to recover all prudently incurred operating costs plus a reasonable opportunity to earn a fair return on their investment in electric plant. Three features of COSR make it attractive for regulators. First, rates are based on accounting costs, information that utilities gather as a matter of course. Second, because utilities are allowed to recover their costs, they are likely to maintain and even improve service quality. Third, the regulatory process allows a fair return on the franchise monopoly's investment in plant and equipment, neither confiscating it over time nor allowing an excess return.

Then, why replace COSR with another approach based on performance? The problems with the cost-of-service approach are the incentives and opportunities given to electric utilities. They are not the type of incentives that characterize a competitive market, and that balance the additional risk of operating in a competitive market. Under COSR, the incentives to *operate* "efficiently" in the sense of an unregulated firm are minimal.

Incentives and opportunities to *invest* wisely in utility plant and equipment are also distorted under COSR. In contrast to a competitive market, COSR does not generally reward utilities with a higher return for making an especially good investment in plant and equipment, or penalize them for making an especially bad investment. The return that a utility earns on a highly successful investment is generally the same as its return on a less-successful one. The opportunity to prosper--or, alternatively, to go bankrupt--is generally not part of COSR.

Some states have attempted to correct the distorted incentives resulting from COSR by introducing variants of performance-based ratemaking (PBR). More recently, state regulators have targeted energy-efficiency programs, providing financial incentives for electric utilities to invest in these types of conservation and load management programs in their PBR plans. Depending on local conditions, PBR may be the best bridge between COSR, in which rates are determined in a regulatory proceeding, and a situation in which rates are determined in unregulated markets.

The State should be a catalyst for exploring alternative ratemaking approaches for Hawaii utilities to see if local conditions warrant implementation of some type of PBR approach. Because of Hawaii's unique situation, implementing an innovative, performance-based approach to ratemaking may be more effective than restructuring the electric industry. Again, any conclusion on future ratemaking approaches in Hawaii awaits the results of a study on the net benefits of alternative ratemaking approaches.[46]

4.1.3. DISTRIBUTED GENERATION

We recommend that the State investigate the potential impact of small-scale electric-generating technologies on Hawaii and its utilities.

In the discussion of emerging technologies in the electric industry in Chapter 2, we identified some micro-technologies that are close to being commercially competitive on a cost basis with central-station generating plants. Mass production of these micro-technologies in the future will lower their production costs and further enhance their attractiveness to potential users. The technologies include wind turbines, photovoltaics, battery storage, fuel cells, combustion turbines, and internal combustion and diesel engines. These technologies can be deployed near consuming centers. In the not too distant future, they will make up a significant percentage of the total U.S. electric generating capacity.

For two reasons, the State should investigate distributed generation technologies themselves, their applicability to Hawaii, and their expected market penetration.

First, some of the technologies have a direct bearing on energy-efficiency programs because they can be used most effectively by tying them directly to the programs. For example, strategically placed photovoltaic panels can be used with load management programs to service a customer's electric load, irrespective if the customer uses large or small amounts of electricity. The impact on energy consumption is difficult to predict, but can be significant if the load is an air-conditioner on a hot day.

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[46] Local conditions and policymaking priorities dictate the specific features of a PBR plan. See, for example, G. Alan Comnes, Lawrence J. Hill, Steven Stoft, and Nathaniel Greene, "Six Useful Observations for Designers of PBR Plans," *Electricity Journal* 9(3):16-23.

Second, electric utilities can deploy these technologies on their distribution lines *or* consumers can also deploy them. To the extent that consumers deploy these technologies and "bypass" a utility's distribution system, the utility will lose sales and revenues. The utility's financial condition will deteriorate, requiring it to raise prices to spread its fixed costs over fewer customers.

The potential for customers to bypass an existing utility to satisfy its own load is greater in states with high electric prices. Hawaii has the highest electric prices in the nation. Therefore, Hawaii utilities are especially vulnerable to bypass. If this happens to any significant degree, the high cost of electricity could be an impediment to Hawaii attracting new investment, having an adverse affect on savings, employment, and state income.

4.2. Policy to Continue and Expand the Scope of Public Energy-Efficiency Programs

4.2.1. A "GREEN BUILDINGS" PROGRAM

We recommend that the State be a catalyst in developing a "green buildings" initiative.

Initially, the State could be instrumental in setting up a demonstration building, highlighting the energy and other resource savings and amenity enhancements of "green buildings." It could then use this building as a promotion for others like it in the islands.

Where constructed properly, "green buildings" have enhanced the performance of buildings greatly. Energy savings approach 50 percent, compared with a base-line scenario. The building envelope is optimized. Sun shading devices are used. Atrium configurations are employed with natural ventilation. Lighting is configured not only to save energy but also to enhance lighting for occupants. Daylight is used optimally. Waste and wastewater is 30 percent lower. Materials have 20 percent recycle content. The air and aesthetic quality of the indoor environment increases. The productivity of workers has improved by 10 percent in some cases.

4.2.2. NEW ENERGY-EFFICIENT BUILDING TECHNOLOGIES

We recommend that the State be a catalyst in promoting the adoption of some of the state-of-the-art building technologies that have proved energy savings and have shown to be cost-effective in other applications.

Demonstrations of the technologies could possibly be undertaken in conjunction with HECO, the University of Hawaii, or the technology's user. From the list presented in Section 3.1 and discussed in detail in Appendix A, three technologies seem the most promising for immediate application in Hawaii:

- *Integrated photovoltaic (PV) roofs*. Because of Hawaii's climate, integrated PV roofs in which PV panels are integrated with metal roofs can be very financially attractive. DBEDT could expand on the integrated photovoltaic roof project demonstrated on Ford Island.
- *Thermal storage*. Cool storage systems allow buildings to shift heating, ventilation, and air conditioning (HVAC) loads from peak to off-peak times. It is beneficial to coordinate storage systems in multiple buildings served by one substation and monitor substation and feeder loading. This requires communications with the local utility's dispatch systems. This project would be ideal to coordinate with HECO.
- *Desiccant dehumidification*. Desiccant dehumidification technology provides a method of drying air before it enters a conditioned space. Desiccant systems save energy by using low-grade thermal sources to remove moisture from the air and to eliminate the overcooling and reheat step necessary in conventional vapor-compression cooling systems.

4.2.3. EXPANSION OF REBUILD HAWAII

We recommend that the State expand the scope of Rebuild Hawaii to include sectors other than buildings.

Because of financing considerations, an important trend in energy-efficiency programs is to have governments partner with the private sector to implement these types of programs. National and state governments can provide significant resources and expertise to the private sector in running energy-efficiency programs in the household, commercial, industrial, and transport sectors in their jurisdictions.

The Rebuild America Program is an example of such a partnership. It marries national expertise and resources in the buildings sector with local building conditions and local solutions provided by community leaders. It is an example of how energy efficiency programs and the principles of economic development and community building can be used together for economic development.

Through Rebuild Hawaii, the State has already taken advantage of the resources provided by the Rebuild America Program. Rebuild Hawaii facilitates implementation of energy efficiency in buildings by creating a partnership with the public and private sector. However, the State should extend coverage of its Rebuild Hawaii effort to sectors other than buildings and take advantage of the strengths of its public-private partnership. The advantages of such a partnership are rooted in economic development: limiting the import of energy into a community, the economic multiplier, economic growth, and increases in productivity.

4.3. Policy to Undertake Activities with a Longer-Term View of Energy and the Economy

4.3.1. LIFE-CYCLE COSTING IN PURCHASING DECISIONS

We recommend that the State take the lead in promoting life-cycle costing for state and county governments in Hawaii.

The net costs of producing goods--and distributing their waste after consumption--extend beyond the financial costs that consumers confront in markets. The additional net costs above market prices are called externalities and are not generally internalized in the market prices of products. These costs refer either to (1) the net additional costs of using a product over its lifetime or (2) the net additional costs associated with using inputs in the production of a product.[47]

To illustrate the former, any good that is more energy-efficient than a comparable one is more likely to cost more. If a consumer purchases a good based on the lowest market price, he will pick the cheaper, more energy-inefficient product. If he analyzes the decision over the life of the product, the lower energy costs may offset the higher capital costs and make the higher-priced product more financially attractive at the time of purchase.

To illustrate the latter, compare the cost of using electricity and natural gas to heat a building. If one looks simply at financial market prices for the two fuels, electricity may be cheaper on a unit heating-value basis. However, if one takes into account the upstream costs of getting the electricity to the building, a different conclusion may emerge. If the electricity were generated from coal, for example, there may be external coal mining costs and environmental costs (greenhouse gases) that are not internalized in the cost of producing electricity. On a financial cost basis, then, electricity may be cheaper than natural gas, but more expensive on a life-cycle basis.

The State should promote life-cycle analysis for the purchasing decisions of Hawaii and its counties. The State could be a catalyst for educating state and county purchasing agents on life-cycle analysis. In considering the large number of purchases made by the state and counties in Hawaii, the energy savings and environmental effects could be substantial. The reliance on imported oil would decline as well.

4.3.2. PUBLIC AWARENESS CAMPAIGN

We recommend that the State sponsor a public-awareness campaign on the potential impacts of global warming, its consequences for Hawaii, and how Hawaii policymakers can help ameliorate it.

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[47] See, for example, Lawrence J. Hill, Donald B. Hunsaker, and T. Randall Curlee, *The Principles of Life-Cycle Analysis,* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/TM-13178, May 1996.

As a market transformation tool, there often is not a better strategy than educating the public about the adverse environmental consequences of burning fossil fuels and, therefore, the benefits of energy conservation. In Hawaii, a promotional campaign based on the potential effects of global warming and its consequences for island environments is especially appealing. Promotional campaigns in other states and localities have produced positive results. Studies show that many people are aware of large problems such as the consequences of global warming but have a "what can I do as one small consumer?" attitude.

The State should use this characteristic of the population and Hawaii's special vulnerability to global warming as the basis of a public-awareness campaign promoting energy efficiency, riding The Bus, and the like.

The amount of energy savings realized from such programs is difficult--if not impossible--to estimate. The effects of a promotional campaign are oftentimes so intertwined with other effects on a population's energy consumption that one cannot disentangle individual effects.

4.3.3. ECONOMIC EFFECTS OF IMPORTING ENERGY

We recommend that the State investigate the harmful effects of imported energy on the Hawaii economy.

Energy security is oftentimes couched exclusively in physical and emergency terms. That is, as the argument goes, economies with limited energy resources are vulnerable to energy-supply disruptions such as those that occurred in the 1970s. When it is couched in economic terms, the discussion on oil disruptions centers on "the cost of energy security," an "oil-vulnerability premium," or the large effects of energy-supply disruptions on the local economy.

An equally important phenomenon due to an economy's lack of energy supplies is the economic effect of importing energy during normal--not crisis--times. The "energy dollars" leaving an economy are not spent and re-circulated locally within the economy. The multiplier effect on income is negated.

The State should undertake a systematic, scientific investigation of the effect of importing energy on Hawaii and its county economies. The results could be an important part of the promotional campaign suggested earlier. The results could also be used to educate local policymakers on the important economic effects of resource-efficiency programs.

The study can highlight the macroeconomic effects of promoting energy efficiency, not just the microeffects on productivity. For every kWh saved, there is a reduction in oil imports. The import reduction keeps dollars in the local economy with its attendant multiplier effects. Employment increases and productivity rises.

This study complements earlier efforts by the State to investigate the effects of high oil and electric prices on the State's economy. For example, in the 1995 Hawaii Energy Strategy, investigators modeled an oil price spike scenario and found that an oil price increase from $19.42 per barrel to $45.00 per barrel (1996 dollars) for a one-year period results in considerable short-term economic dislocation. Employment drops 2% and the economy takes two years to regain former employment levels.[48]

4.4. Policy to Strengthen the Energy Services Industry

4.4.1. HAWAII'S ENERGY SERVICE INDUSTRY

We recommend that the State be a catalyst in strengthening Hawaii's energy service industry.

One way to accomplish this is for the state and counties to require improvement in the energy efficiency of their buildings by creating a FEMP-type program at the state and county level. There are numerous energy-efficiency retrofit opportunities in Hawaii, excluding federal buildings and military facilities. They include state and county office buildings, schools, and hospitals. Oftentimes, one of the problems in taking advantage of these energy-efficiency opportunities is institutional: there is no easy mechanism for suppliers of energy-efficiency services to make cost-effective investments. The barriers oftentimes include the small size of potential investments (e.g., small buildings) and the administrative difficulties for contractors making energy-efficiency investments.

The State could facilitate this market-based process by helping to remove some of the barriers. For example, the State could facilitate the "aggregation" of small facilities (i.e., small investments) into larger ones to make them more attractive to ESCOs that have a minimum threshold investment level. The State could also facilitate advanced approval of ESCOs for certain types of facilities. The ESCOs could then identify cost-effective energy-efficiency investments with the understanding that an individual ESCO has the exclusive right to make the investment unfettered by competition.

The effects on local economies of using ESCOs are well known. The ESCOs create jobs, increase incomes, and stimulate economic growth.

4.4.2. PACIFIC ENERGY SERVICES INDUSTRY

We recommend that the State be a catalyst in creating a Pacific energy services industry centered in Hawaii.

Of all the states, Hawaii is the most likely base for creation of an Asia-focused energy services industry. The United States has been the world leader in developing an energy

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[48] State of Hawaii, *Hawaii Energy Strategy*, Department of Business, Economic Development, and Tourism, Energy Division, October 1995.

services industry and is the leading producer of many of the energy-efficient products used by ESCOs. The State should be the catalyst for the state to use its geographical advantage to be the center of a Pacific energy services industry.

One place to start is China. China's State Power Corporation (SPC) was created in 1997 as a result of restructuring the government. SPC formed the DSM Instructional Center in 1998. One of the thrusts of the Instructional Center is to develop an energy services industry in China similar to the National Association of Energy Service Companies (NAESCO) in the United States. The State could work through existing Hawaii institutions to develop that industry in China. One option is to work through HEI Power, a subsidiary of HEI Industries, which has ties to China.

Appendix A: Energy-Efficient Commercial Building Technologies

- *Advanced wallboard and insulation incorporating change-of-state material technology. Advanced reflective window films. Reflective roofing materials, particularly on commercial low-slope roofs.* These products are typically evaluated by looking at the energy (kWh) they will save each year by reducing cooling energy requirements. Credit may also be taken for reduced demand charges; demand charges in tariffs reflect capacity credits for deferring construction or reinforcement of generation, transmission, and distribution facilities. These products produce the most energy savings during the few hours that system-operating reserves are likely to be low. Reflective roofs consist of coatings (applied over conventional dark roof membranes usually on un-vented low-sloped roofs); single-ply membranes (these are typically rolled out products, which are made reflective in the factory); metal roof systems (used in both slope and low-sloped configurations and on commercial and residential structures). A study is underway at Oak Ridge National Laboratory (ORNL) with 60 highly reflective roofs' thermal performance being compared side by side. This three-year study is examining the service life performance requiring a 3-year time frame. In the Oak Ridge area the average reflectivity decay is about 30%. With the Hawaii climate the benefits of reflective roof systems are that it could reduce the heat flow into buildings during the warmest time of day. Increasing the thermal comfort inside the building, potentially leads to longer service life due to less expansion and contraction as the roofing materials remain at a more constant temperature throughout the day when highly reflective compared to black surfaces.

- *Combined cooling, heating and power systems.* Combined cooling, heating, and power systems (CCHP) improve overall energy utilization by employing waste heat from power generation for space heating and/or cooling. Distributed power generation using micro-turbines or fuel cells provides opportunities for CCHP by placing power-generating equipment close to buildings requiring heating and cooling. Waste heat from power generation is distributed to customers in the form of low-pressure steam that can be used in radiators for heating or as the primary energy input to absorption chillers. Alternatively, an absorption chiller powered by waste heat can be situated beside the generating equipment to produce chilled water for distribution to customers for space cooling. Employment of energy that would otherwise be rejected to the environment boosts thermal efficiencies significantly. A local energy exchange entity could be structured to enhance these district energy benefits.

- *Desiccant dehumidification.* Desiccant dehumidification technology provides a method of drying air before it enters a conditioned space. Desiccant systems save energy by using low-grade thermal sources to remove moisture from the air, and to eliminate the overcooling and reheat step necessary in conventional vapor-compression cooling systems. Hawaii has most of the economic conditions that suggest cost-effective applications of desiccant systems; high latent load fraction (greater than 25%), high fresh air intake (greater than 20%), high summertime electric demand and energy costs. This technology has been proven in industrial environments, there is limited field test data to evaluate the long-term performance in commercial buildings. In addition to energy savings desiccants provide IAQ benefits resulting from low microbial growth. The types of buildings where desiccants hold great promise are: dry storage warehouses, supermarkets, hospital operating rooms, schools, and fast food restaurants.

- *Engine-driven chillers and refrigeration equipment.* Large commercial buildings typically use electric motors to drive compressors for chilled water systems to provide comfort cooling or refrigeration systems for supermarkets, cold storage warehouses, and food preparation and packaging industries. The electrical load of these systems increases as the outdoor temperature increases, contributing to distribution system peaks and high operating costs. Alternative chiller and refrigeration systems employ natural gas engines to drive compressors in place of electric motors; the only electrical load is the relatively level requirement for blowers, fans, and pumps. Sales of engine-driven chillers and refrigeration systems have remained low because of higher equipment and maintenance costs relative to electric systems. The potential of gas-driven systems under deregulated energy prices has not been well developed or demonstrated.

- *Ground-coupled (geothermal) heat pumps.* Ground-coupled heat pumps and air conditioners represent one of the most efficient electric heating and cooling technologies available. Conventional heat pumps and air conditioners use outdoor air as a heat source or sink; they operate at their lowest efficiencies when heating and cooling loads are highest. In contrast, deep ground temperatures are relatively constant and do not experience the freezing winter temperature or very high summer temperatures. As a result, the ground is a better heat source or sink and contributes to high system efficiencies. Reductions of electrical load and energy consumption of 20% and higher are possible.

- *Gas refrigeration and cooling.* Absorption chillers and engine-driven chillers and refrigeration systems burn natural gas to provide air conditioning and refrigeration. Efficiencies can be higher than comparable electric-driven systems, and carbon dioxide emissions can be lowered, depending on the fuel source and generation equipment used to provide electric power. The gas-fired systems require electricity for only pumps and blowers and consequently have a dramatically lower demand than electrical-driven systems. Historically, fuel-cost ratios between gas and electricity and the higher first-cost of gas equipment have favored use of electrical chillers and refrigeration. Electric deregulation changes the economic comparisons; energy consumers need both rate information and energy use simulation tools to make informed decisions between gas and electric equipment. With high electric prices in Hawaii, cooling of large buildings with absorption chillers may be quite attractive. The triple-effect chiller now under development at ORNL operates using LiBr/H2O fluids and has a coefficient of performance (COP) of 1.4, a 30% improvement over the best double-effect chillers currently on the market.

- *Heat pump water heaters.* Approximately 50% of the residential and light commercial water heaters nationwide use electrical resistance heat. While these systems are relatively simple and inexpensive, they are inefficient compared with electric heat pump water heaters. Heat pump water heaters are similar to conventional air conditioners in operation; air conditioners absorb heat from where it is not wanted (a hot room) and reject it to the outdoor environment; heat pump water heaters take the heat out of the room and reject it to a tank of water. While an electric resistance water heater has an annual efficiency between 0.8 and 0.9

(useful heat delivered divided by total energy input), heat pump water heaters have annual efficiencies of 1.4 to 1.5 or higher. Current R&D activities sponsored by DOE and other organizations are expected to raise efficiencies even higher.

- *High-efficiency chillers and air conditioners.* Cooling equipment is commercially available that is 20% to 40% more efficient than that which is commonly installed in commercial buildings. New centrifugal chillers to produce cold water for cooling large buildings use on the order of 0.65 kW/ton of air conditioning; significantly less electricity than the 0.85 to 1.0 kW/ton systems available in 1987. State of the art systems in 1999, however, require only 0.49 kW/ton, a 25% reduction. Building model unitary air conditioners have seasonal efficiencies of 10 Btu/Wh; systems are on the market with efficiencies of 12 to 14 Btu/Wh (20% to 40% higher). Historic energy tariffs have discouraged building owners from investing in high efficiency chillers and air conditioners. Deregulation with real-time price rates and price spikes alter the economic evaluation considerably. Building owners, architectural and engineering firms, and contractors need information in an easy to use form to make decisions about investing avoided energy costs in high-efficiency, conventional equipment.

- *High-efficiency distribution transformers.* Transformers located in buildings (dry-types) have the potential of saving large cumulative electric energy costs. An ORNL study conducted for DOE found that the percent maximum operating efficiency of commercial and industrial transformers is 98.4 yet the cost effective efficiency using national average kWh prices which are 30% lower than those found in Hawaii is 99.2%. TP-1 transformers are cost effective; dry-type transformers that are used in buildings have a rate-of-return of approximately 30%, based on 6.92 cents/kWh. The average simple payback for TP-1 transformers for the nation is 2.8 years. These transformers are presently available from at least three major manufacturers: Square D Company, Federal Pacific Transformer Co., and ACME Electric Corporation. Activities that are needed to accelerate the adaptation of this technology in Hawaii are: (1) change state commercial buildings standards; (2) change government buildings standards; (3) change military standards; (4) an information-brief on the economic benefits of transformers for utility purchases; and (5) an information brief for other purchasers distributed through A&E firms, the American Institute of Plant Engineers, the American Physical Plant Association, and other industrial and manufacturing organizations.

- *Horizontal-axis clothes washer.* Energy savings of 60% and water savings of 40%. On average today's new vertical-axis clothes washers consume 924 kWh/year. In Hawaii that offers a savings potential of $70 per day. The cost premium for this advanced commercially available unit varies from $250 to $650. That is a simple payback of 3 to 9 years using only the energy savings. Additional water, sewage and clothes savings will accelerate these paybacks enormously.

- *Hybrid electric/gas chillers and refrigeration plants.* Large businesses employ air conditioning or refrigeration plants using multiple electric chillers or compressors in parallel to meet base and peak cooling requirements. The substitution of one or more gas-fired absorption or engine-driven chillers or compressors creates opportunities to use natural gas to make substantial reductions in peak electrical demand. Immediate communication of real-time price charges between the LEX and building EMS enable the building energy manager to deploy the gas and electric systems in a manner that minimizes energy costs. "Price spikes" in deregulated electric rates provide both the incentive and economic means to install hybrid plants.

- *Hybrid lighting.* Fiber optics can be employed to efficiently deliver daylight from rooftops of multi-story buildings into interior zones away from windows for task lighting. When natural light is not available, ultra-efficient artificial lighting can provide a remote source to be transmitted into the fiber optic distribution system.

- *Integrated cooling and hot water systems.* Virtually every mechanical device has to reject unwanted heat in order to provide useful cooking (evaporative cooling is a notable exception). Typically, this energy is rejected to the outdoor air either directly or through a cooling tower; in some instances it is rejected to groundwater in lakes, streams, ponds, or aquifers or to the ground itself. Integrated cooling and hot water systems reject all or part of the heat removed for space cooling to a hot water tank where it can be used by laundry, dish washing, or other applications of domestic hot water. This use of waste heat can reduce energy consumption for cooling and water heating substantially in buildings with significant hot water loads (e.g., hospitals, restaurants, hotels); the efficiency of the air conditioning process itself may be increased depending on air and water temperatures. The ability of a local energy exchange entity to manage and coordinate waste heat production and utilization among several buildings will enhance the economic feasibility of this technology.

- *Integrated PV Roof.* Metal roofs are easily equipped with integrated PV Panels, which are hardly discernible to the eye. Several of these systems are under study at the ORNL Buildings Technology Center in Oak Ridge, TN. These systems are dark in color, meaning some heat may penetrate the roof into the conditioned space compared to highly reflective systems.

- *Massive refrigerated warehouses.* Warehouses integrated with combined vapor compression and evaporative coolers. Advanced control systems can also be coupled with weather forecast and power rate projections and real time energy costs. A potential demonstration site should be identified in Hawaii for this technology.

- *One kWh/day refrigerator freezer.* ORNL along with the Association of Home Appliance Manufacturers (AHAN) conducted a joint research project that redesigned a cost-effective refrigerator-freezer, which used 0.93 kWh/day. This was a standard 20 cubic foot unit with a top-mounted freezer and no icemaker. This unit achieved this goal which is 40% below the current federal minimum efficiency standard of 1.36 kWh/day by using a 5.73 EER compressor, a low-wattage condenser fan, and adaptive defrost cycle; vacuum panel insulation, extended surface heat exchangers.

- *Thermal storage.* Cool storage systems allow buildings to shift HVAC loads from peak to off-peak times. Real-time communication with the Power Exchanger will allow storage charge/discharge strategies to be responsive to real-time pricing and its attendant price volatility. It is also advantageous to coordinate storage systems in multiple buildings served by one substation, and monitor substation and feeder loading in order to prevent or reduce overloads of electric distribution equipment. This requires communications with the local utility's SCADA and dispatch systems, and the building owners should receive some credit for the utility's ability to reduce overloads, downsize equipment, or defer reinforcements through distribution load-leveling with thermal storage. Full recognition of the system operating benefits of thermal storage, and a mechanism to schedule the systems in response to real-time systems needs, may affect design economics, to justify full storage systems where otherwise only partial storage would be justified.

- *Waste heat utilization.* On-site power generation using micro-turbines or fuel cells provide opportunities for waste heat utilization resulting in thermal conversion efficiencies that are nearly twice what is achievable without waste heat utilization. Power generation provides high quality waste heat that can be used by bottoming equipment to reduce the power requirements of the generator itself or to produce steam for use in industrial processes, in radiators to provide space heating, or in absorption chillers to provide space cooling.