

ENERGY SELF-SUFFICIENCY

FOR THE

COUNTY OF KAUAI

1991

for

COUNTY OF KAUAI

OFFICE OF ECONOMIC DEVELOPMENT

4444 Rice Street
Lihue, Kauai 96766

by

ECM, INC.

485 Waiale Drive
Wailuku, HI 96793
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INTRODUCTION

PURPOSE

This report replaces a two volume report published in 1979 and 1980 entitled "*Energy Self Sufficiency for the County of Kauai*", produced by the Hawaii Natural Energy Institute at the University of Hawaii at Manoa. That report presented environmental, geographic, and demographic data and described the existing (1978) energy situation. This included identification and quantification of potential natural energy resources, estimation of future economic trends and requirements, and consideration of the potential energy scenarios Kauai County might face if oil prices continued to escalate.

The County of Kauai, under Mayor JoAnn Yukimura, commissioned this follow-up report out of concern for Kauai's continually growing dependence upon fossil fuels. This report takes a distinctive approach; its goals are to provide specific recommendations which can be implemented by ordinance within a two year period and to provide an analytical framework for County decision-making. **The scope of the recommendations and analysis is specific to the political domain of the County of Kauai and the range of options available at the county level. Options not available to the County are not included within this report.**

This report illustrates how promotion of energy conservation, efficient use through innovative demand side management initiatives, and renewable energy development will allow Kauai County to promote increased energy security and energy self-sufficiency.

This report was prepared by ECM, Inc. with support and assistance provided by Glenn Sato, Energy Coordinator for the County of Kauai and the members of Kauai's Energy Advisory Committee: John Harder, Randall Hee, Kelvin Kai, Suzanne Marinelli, Marshall Mock, Nick Phillips, Iraj Siedas, and Francis Takahashi. Within ECM, Inc., the Principal-in-Charge was Hilton H. Unemori, P.E., the Project Manager was James M. Brock, P.E., and the authors were Charles E. Willson and James M. Brock. Consultant reports were prepared by Keith Avery and Robert Mowris to update the statistical data and examine potential energy development and consumption scenarios. Production assistance was provided by Cecilia A. Vista and Hilda A. Austin.

security"² is used as an appropriate interim goal. Only resources and interventions within the County's political reach and administrative "window of opportunity" are discussed in depth. Additional information (including an inventory of resources, summary data, and high/low consumption scenario data) is available under separate cover ("Reference Material"); this includes consultant reports updating information from the 1979 plan and other information of possible utility. This information is not critical to understand this report and is specifically excluded to prevent a diffusion of focus and a reduction in the clarity of report conclusions and recommendations.

PERSPECTIVE

The "energy problem" is often characterized as a crisis ready to destroy the nation and the economy. This report takes a substantially different perspective. **There is no energy problem.** We are awash in an **abundance** of energy. Harnessing energy provided the impetus for the phenomenal advancement of civilization; we are the beneficiaries of that abundance. Energy has historically been part of the solution, not part of the problem.

But abundance can lead to problems. One problem is an over-reliance on and over-consumption of stored (non-renewable) energy resources -- that is, **dependence upon the wrong kind of energy.** Another problem is an **addictive pattern of energy consumption.**

Significant remedies are available. These remedies -- far from being a "bitter pill to swallow" -- present opportunities which could result in significant economic and social returns for the County, for its residents, and for Kauai Electric Division of Citizens Utilities Company.³

² Energy security means insuring sufficient energy resources to sustain the lifestyle and economic prosperity enjoyed by Kauai residents, while minimizing the County's vulnerability to supply disruption. This implies short-term actions to promote efficient use, reduce growth in consumption, and diversify energy supply resources and establishing long-term policies to continue such improvement over time.

³ Kauai Electric (abbreviated KE in this report) is a division of Citizens Utilities Company, and its proper name is Kauai Electric Division of Citizens Utilities Company. KE and Citizens Utilities are occasionally referenced separately where it is important to distinguish the functionally distinct roles, capabilities, and restrictions of the publicly-held parent from its regulated subsidiary.

As the cost of whale oil continued to increase, the first U.S. oil well was drilled in 1859 to develop a less expensive source of crude oil to supply kerosene for lighting. The kerosene produced was shipped worldwide within ten years. Fifty years later, in 1909, the U.S. was producing 500,000 barrels of oil a day, more than half the world's production.

ELECTRICITY

Invention of the incandescent bulb in 1878 provided a superior means of lighting, an impetus to promote electric power generation,⁶ and increased the demand for fossil fuels. The first central electric generation for public use began in London and New York City with direct current systems in 1882. However, transmission over any significant distance was not possible until the advent of alternating current. The first three-phase system was built in 1891 to supply Frankfurt, Germany, and by 1896 a 22-mile system was supplying hydroelectric power to Buffalo, New York. New insulators invented in 1907 made high voltage transmission practical, and increases in transmission voltages in the 1920's allowed wide-scale electrification.

ENERGY USE ON KAUAI

The decline of whaling was accompanied by an increase in agriculture as the new resource base, and plantations became the mainstay of the Hawaiian economy, society, and energy development between the mid-1800's and mid-1900's. Electric power was introduced on Kauai with bagasse fired electric generators on plantations in the early 1890's. Hydroelectric generation was also a significant source of early electric power, as it is today. McBryde Sugar Company still maintains the Wainiha plant -- a 4000 kW hydroelectric plant originally installed in 1905 to supply electric power to irrigation pumps for West Kauai sugarcane lands. This unit provides an example of the longevity and reliability of hydroelectric installations. Like Kauai's six other hydroelectric plants, this unit provides year-round power, with excess power feeding the electric utility grid, although output varies with water flow.

⁶ Originally, light was sold instead of power, but it became easier for the utility to measure and bill for kWh of power used than for lighting. The report's recommendations will be more understandable if the customers' desire for light or heat (the products of energy) -- not kWh -- is understood. Restricting utilities to the sales of kWh is part of the situation "locking us in" to the problem.

PETROLEUM CONSUMPTION

In the continental U.S., coal was the dominant energy source for early industrialization. At the beginning of the 20th century, over 90% of U.S. energy requirements were met by coal. The advent of the automobile in the early 1900's created a growing demand for petroleum fuels. This, combined with the convenience and low cost of oil and natural gas, led to a decline in coal use, down to half of U.S. energy needs by the 1946 coal strike.⁷ By 1972, this had dropped to slightly over 17%. Official U.S. fears over increasing dependence on oil, the potential inadequacy of domestic oil reserves, and the importance of maintaining reliable supplies led to congressional action to promote control of world oil production by U.S. companies.⁸

The U.S. remained a net oil exporter until 1948, when imports overtook exports. Imported oil offered significant economic advantages over U.S. crude. U.S. production peaked in 1970 at 11.3 million barrels a day, and declined thereafter. Excess production capacity also disappeared in 1970, leaving the U.S. without reserve capacity and most producing countries (except Saudi Arabia and Iran) extracting at or near full production capacity.

From the late 40's to the early 70's, British and American oil companies controlled Mid Eastern and North African oil production and dictated oil prices to producer nations without negotiation. Competition from independents in the late 1950's led to a series of price decreases -- with corresponding decreases in payments to producer nations. Late 1969 prices hit lows of \$1.00 to \$1.20 per barrel (US dollars). In September 1960, the oil exporting nations, attempting to restore and stabilize prices, formed the Organization of Petroleum Exporting Countries (OPEC), but were unable to assert significant control over their assets until February 1971, when a fifty cent per barrel increase was negotiated in Tehran.

⁷ Fossil fuel extraction and transportation involves risks and costs; this leads to the possibility of supply disruption, which was a problem even for coal users in 1946.

⁸ The major portion of the historical information in this section is drawn from the report of the Energy Project at the Harvard Business School, published as Energy Future, (Robert Stobaugh and Daniel Yergin, eds., Ballantine Books, New York, 1979). For price data, cf. Adelman, M.A., The World Petroleum Market, Johns Hopkins Univ. Press, Baltimore, 1972. Other dates from Encyclopædia Britannica, *passim*.

Oil price volatility was further exemplified by two recent events. Despite the minimal effect on world oil supply, gasoline prices rose significantly following the Exxon Valdez oil spill. Then in late 1990 and early 1991, the short-lived war with Iraq reemphasized the tendency of oil prices to change abruptly -- despite the fact significant shortages never materialized. These increases illustrate the effect of market psychology, as perceptions of shortage on the oil futures market bids up the price of oil for future delivery. Price oscillation then results from market self-correction: prices fall as perceptions adjust to market realities.

PREDICTABILITY, PERCEPTION, AND BEHAVIOR CHANGE

The abrupt appearance of oil shortage periods and significant price jumps may have surprised consumers and policy-makers, but these changes were not unforeseen. The potential for problems was recognized early in this century. The director of the U.S. Geological Service wrote: "The U.S. position can best be described as precarious" in 1920, prior the discovery of major Texas oil deposits. Secretary of State Robert Lansing expressed concerns about the adequacy of U.S. supplies in 1919.¹⁰ Worldwide, the combined effect of resource depletion, increasing per-capita use, population increase, and increased use by developing nations has long been forecast by environmentalists. Early computer models, such as the Limits to Growth¹¹ study, also predicted supply shortages well before the end of the century.

The disruptive effects of rapid price escalation are due more to the rapidity of change rather than actual cost. (This is beneficial -- it gets our attention.) During the 50's and 60's, oil

¹⁰ Energy Future, op. cit., p. 18.

¹¹ Meadows, Donella H., Dennis L. Meadows, Jorgen Randers, and William W. Behrens, III. The Limits to Growth. Universe Books, New York, 1972. This was a system-dynamics computer program ("World3" -- developed by Jay Forrester and funded by the Club of Rome) which interactively modeled population growth, resource depletion, capital growth, pollution, and several other systemic variables on a global basis. Computer models were effective in "sounding the alarm", but have proven inadequate to modeling oil depletion, as the consequences of increased costs are increased exploration (increasing known reserves) and extraction improvements. Periods of increased prices are likely to increase known "recoverable reserves" as it becomes cost-effective to extract oil from wells of declining production, heavy oils, bitumen, and shale oil, but higher prices are likely to be required to support this production. (cf. "Dirt Cheap" from the "Energy and the Environment" special section in The Economist, Aug. 31, 1990, p. 3 - 30, especially p. 4 - 5.)

The consequences of this waste and addictive dependence are difficult to assess. According to Amory Lovins, national energy savings improvements instituted since 1973 resulted in current energy savings of about \$150 billion per year (\$430 billion instead of the expected \$580 billion annual expense) -- money which would otherwise be flowing to oil exporting nations. Bringing U.S. efficiency up to the level of its competition in Europe and Japan would produce additional savings of \$200 billion per year, he estimates.¹³ This is a significant -- and growing -- competitive disadvantage for U.S. business enterprise. "In 1986, a dollar of Japanese gross national product (GNP) used 36% less electricity than a dollar of American GNP. Official projections show this gap widening to 45% by 2000."¹⁴ The Japanese auto industry, which produced about 9% of the number of cars and trucks of the U.S. in 1960, overtook U.S. production within 20 years.¹⁵

Could the energy-inefficiency -- and therefore higher costs -- of the tourist industry and island economy result in a similar loss of competitiveness? This is clearly implied by Lovins' analysis. How would this decline affect Kauai's economy? How would alternative policies affect the economy? Lovins offers the analogy of a leaky bathtub in his description of the implications of energy inefficiency to Hawaii's economy: money spent on energy keeps leaking out. We can put more in, we can do without, or we can plug the leak -- keeping the money which would have been spent on energy in the local economy. The **multiplier** effect of money kept in local circulation goes far beyond the value of the savings themselves.¹⁶ These small changes are often cumulative, and can be magnified by the passage of time. The long-term economic consequences of these alternative energy policies merit consideration.

¹³ These figures are presented in Amory Lovins' July 26, 1989 address to the Enhancing Renewable Energy Development in Hawaii (EREDH) Workshop (reprinted in Proceedings of the Enhancing Renewable Energy Development in Hawaii Workshop, *op. cit.*, overhead IX - X, p. 88 - 89. Efficiency improvements and implications for Hawaii's economy are discussed on p. 81).

¹⁴ *ibid.*, p. 88.

¹⁵ Energy future, *op. cit.*, p. 185.

¹⁶ Lovins, EREDH Proceedings, *op. cit.*, p. 81.

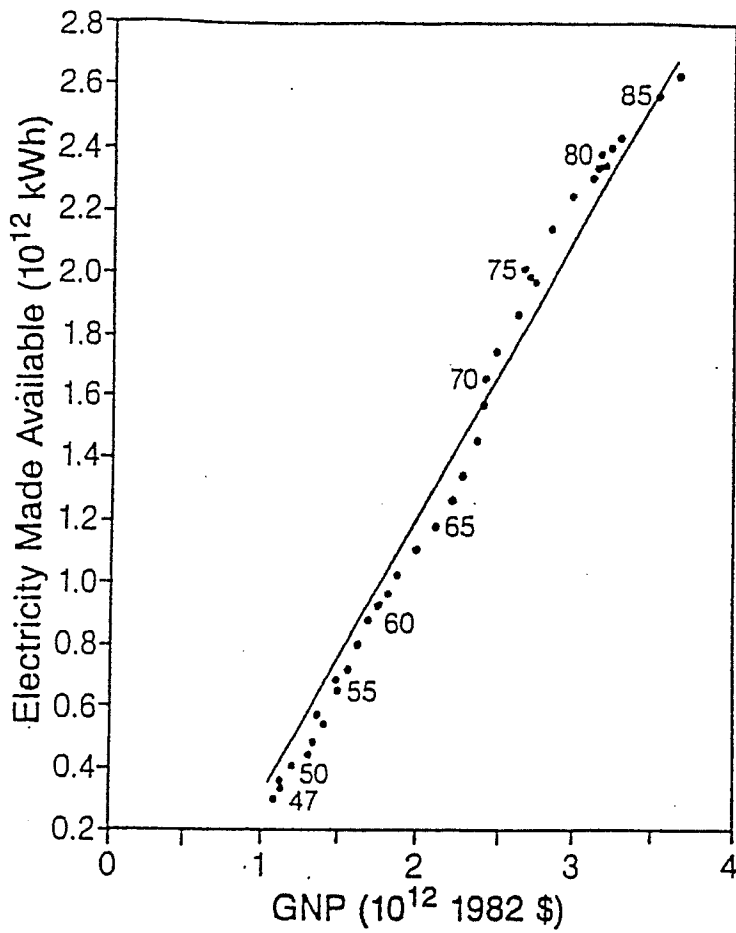


FIGURE 1: Gross National Product (GNP) and National Electrical Energy Consumption
(Electric Power Research Inst., Palo Alto, CA.)

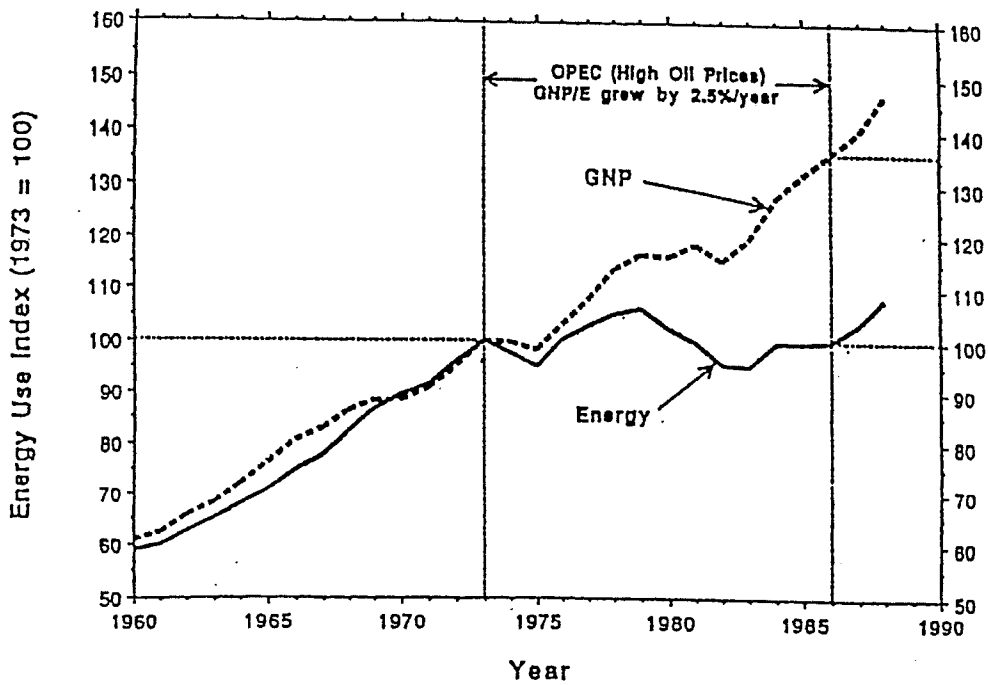


FIGURE 2: Growth in National Energy Use and GNP, 1960 - 1990
(from a presentation by Alan S. Lloyd of HECO)

FIGURE 3

Gross State Product and Total Energy Consumption

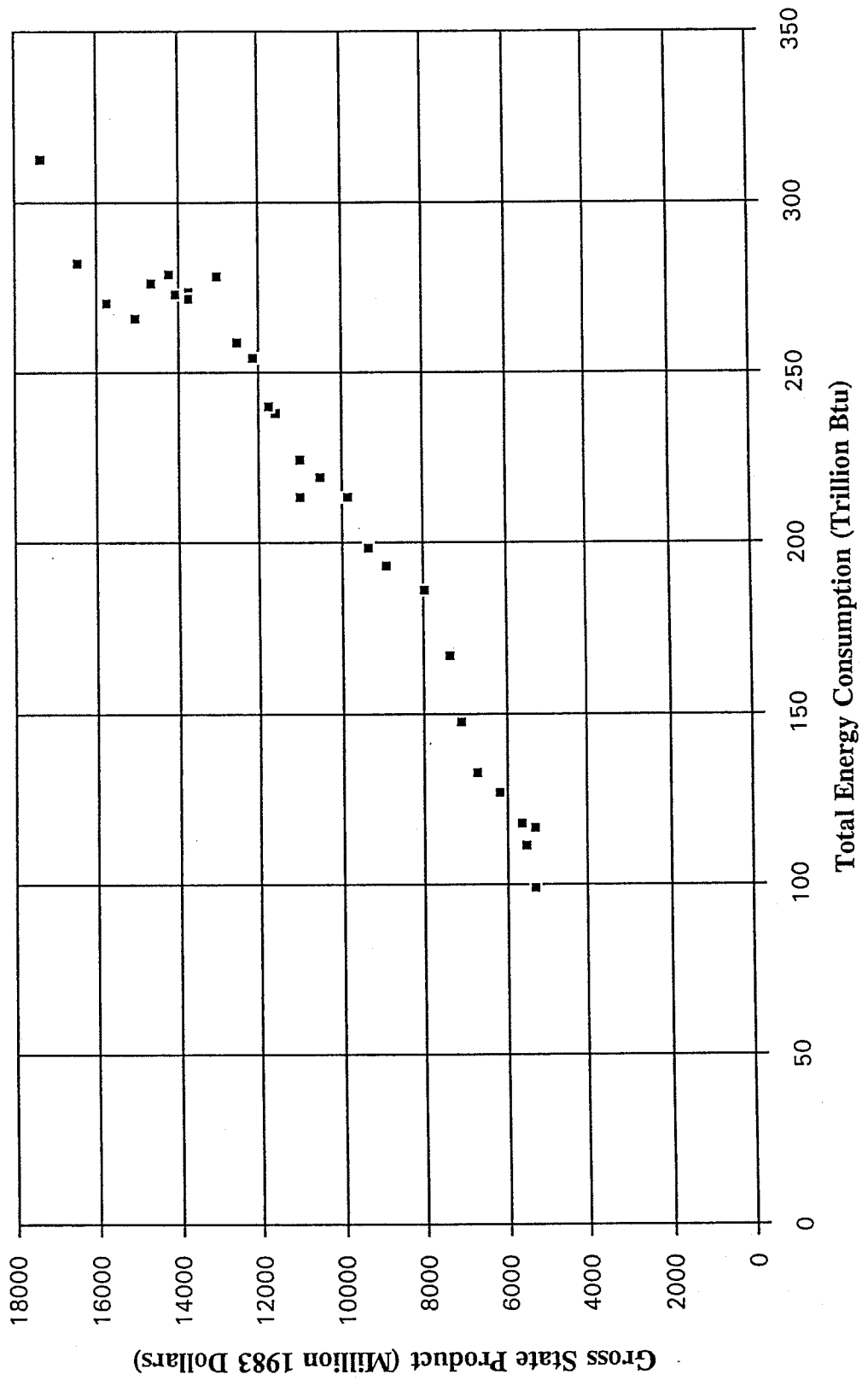
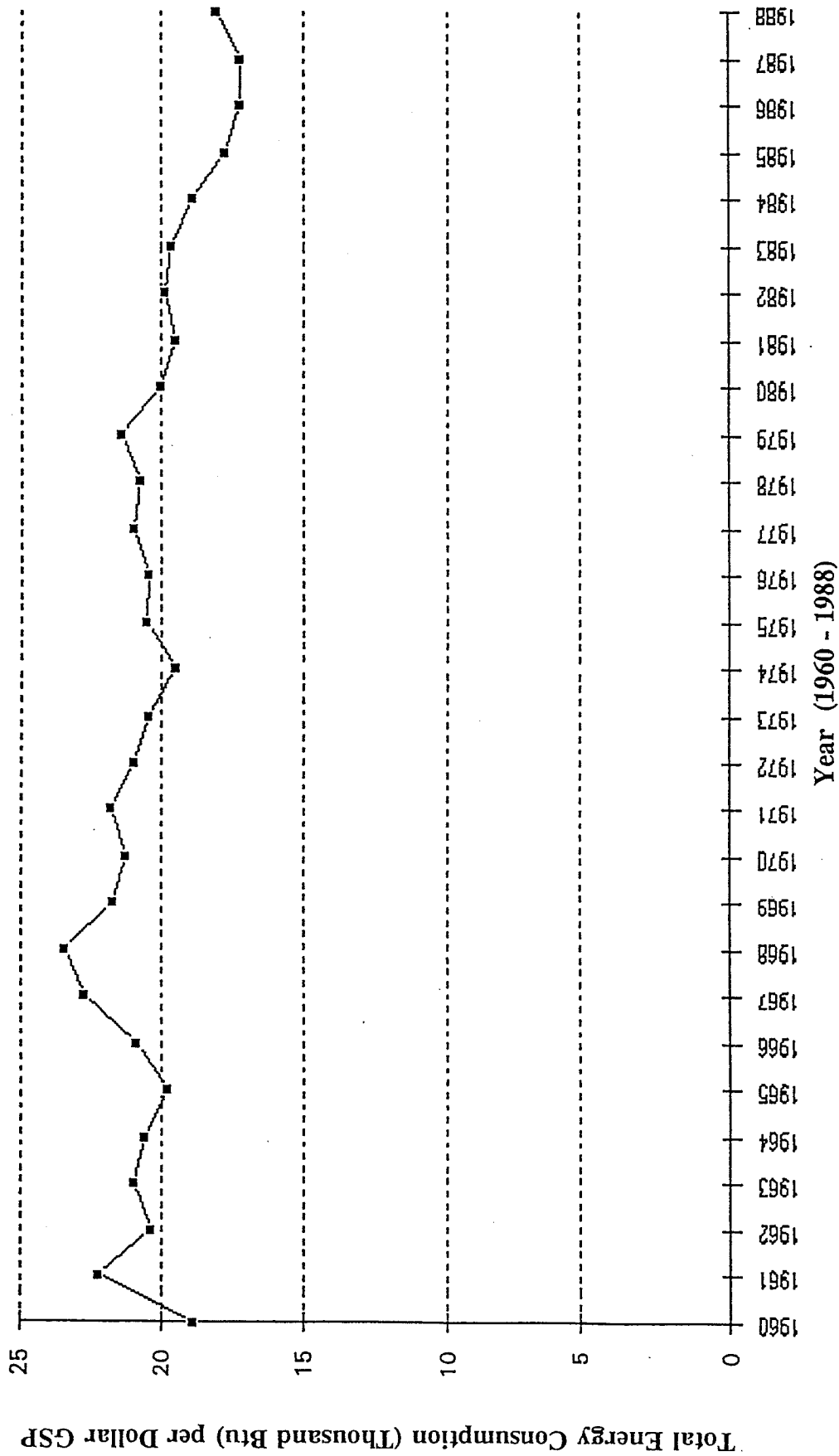


FIGURE 5

Total Energy Consumption (Thousand Btu) per Constant (1982) Dollar GSP Produced



U.S. ENERGY POLICY, PETROLEUM, AND DEVELOPMENT

Nationally, energy and transportation have been heavily subsidized since World War II. A portion of this subsidy took the form of the federal highway system, justified on the grounds of national defense. Government policy also promoted credit to boost home sales and create sufficient demand to allow the WWII wartime manufacturing sector to convert to production of civilian goods. Manufacturers of military vehicles, tanks, aircraft, and materiel were needed to employ returning soldiers, and tax collections from a healthy economy were important to pay off wartime debt. Automobile manufacturing, road building, and production of new housing were important elements in transforming the economy from pre-war depression to the prosperity of a rapidly-expanding post-war economy. As the population spread out, supported by the world's most extensive highway system, automobiles became necessities, and the American "car culture" was born. This was promoted by artificially low fuel¹⁷ prices, which did not reflect the real costs of this expansion. Highway infrastructure was budgeted from federal funds, and energy producers were given tax advantages such as depletion allowance to keep energy prices down.

THE REAL PRICE OF ENERGY

Current energy prices do not, therefore, reflect the real (fully accounted) costs of energy. A substantial portion of these costs are hidden, or "externalized". "Energy costs society billions of dollars more that its users pay directly for oil, coal, gas, or electricity. Other hidden costs of energy include tax credits, environmental degradation, increased health care expenditures and lost employment. Estimates for the U.S. alone range between \$100 billion and \$300 billion per year..."¹⁸ These costs must eventually be borne by users -- or paid by future generations, as these costs end up in the federal deficit, and are shifted into the future.

¹⁷ Artificially low petroleum prices also lead to lower prices for rubber, steel, automobile production, road construction, and many other factors contributing to this change.

¹⁸ Externalities are "costs borne by people who are not parties to the transaction that imposes them." Both quotes from Hubbard, Harold M. *The Real Cost of Energy*. Scientific American, Vol. 264, No. 4, April 1991, p. 36.

Table 2

Kauai Electric Renewable Energy Purchases, 1980 - 1989

YEAR	TOTAL SYSTEM GENERATION	K.E. GENERATION (MWH)	K.E. PERCENT OF TOTAL	RENEW. ENERGY PURCHASES (MWH)	RENEWABLE PERCENT OF TOTAL
1980	211,126	184,395	87.3%	26,731	12.7%
1981	218,665	124,610	57.0%	94,055	43.0%
1982	217,000	97,739	45.0%	119,261	55.0%
1983	224,834	118,877	52.9%	105,957	47.1%
1984	247,141	164,219	66.4%	82,922	33.6%
1985	248,842	150,099	60.3%	98,743	39.7%
1986	271,655	167,508	61.7%	104,147	38.3%
1987	292,531	185,914	63.6%	106,617	36.4%
1988	332,613	213,685	64.2%	118,928	35.8%
1989	347,611	235,159	67.6%	112,452	32.3%
TOTAL	2,612,018	1,642,205		969,813	

Sources: Kauai Electric. Alternate Sources of Energy Production, 1980 - 1989.
 Kauai Electric. Purchased Power Energy, 1981 - 1989.
 Kinoshita, C.M. (HSPA). "Energy Inventory of Hawaiian Sugar Plantations, 1981 - 1990".

Continued delays in approval for proposed new hydro construction have also been damaging to energy self-sufficiency. Hydroelectric power is particularly well suited to satisfy Kauai's energy needs, and -- if developed in an environmentally-sensitive manner with predetermined, mutually agreed-upon conditions to address community concerns -- could contribute substantially to energy self-sufficiency goals. This is a known and proven technology, and the resolution of present impediments should be given a high priority.

ANALYTICAL CONCEPTS

Energy, as discussed in this report, is the capacity to perform work. It can be present in kinetic, potential, or physical forms.²⁰ Energy is also embodied in matter. It is present in stored form in all plant and animal life.

Energy is essential for life. Living things constantly seek foods containing energy, which is used to fuel muscles for movement and for growth. Direct mechanical energy was the form familiar to early humans, employing their own muscle power to accomplish work. Much later animal power was harnessed, and "beasts of burden" supplied energy for development of early agriculture and transportation. The source of this energy -- solar energy stored in food -- was not well understood. Humans learned to use energy derived from the movement of air (wind) and water (hydro), although these are ultimately derived from solar energy as well. Air movement is due largely to heating and cooling by the sun, and hydro power begins with the evaporation of water which condenses, falls as rain, and collects in rivers and streams, the flow of which provides a significant source of energy. These sources formed the basis of ocean transportation systems and provided power for pumping water and grinding grains.

Chemical energy was (and is) also important, primarily in the conversion of biomass to thermal energy through combustion. This heat was used for cooking, heating, and (later) smelting. Burning biomass also provided energy to produce steam, which could be converted to mechanical energy to power the first railroads, opening an era of rapid and convenient transport. Steam could also produce mechanical energy to turn generators and produce electrical energy. Later, the stored (solar) energy of coal and petroleum supplanted biomass as the fuel of choice due to the energy concentration and conveniences of these sources.

²⁰ Energy can be in mechanical, thermal, electrical, radiant, chemical, or nuclear forms. It is a property of objects possessing mass and/or velocity (kinetic energy), of a mass raised to an elevation (or charged, stretched, compressed, or composed of such matter) which permits release of stored energy (potential energy), of radiation from the electromagnetic spectrum (radiant energy, such as heat, light, or x-ray energy), or of the release of energy from matter by combustion (chemical energy) or by decomposition or decay (chemical/nuclear energy). This transmutation is bidirectional, and energy can also be stored by matter, as seen in photosynthesis.

efficient because extraction, processing, and transportation are not required.²² A three-way comparison of efficiencies would look like this:

	Petroleum		Coal		Hydroelectric	
	Process	Cumulative	Process	Cumulative	Process	Cumulative
Extraction	35%	35%	66%	66%		
Processing	88%	31%	92%	61%		
Transportation	95%	29%	98%	60%		
Power Generation	31%	9%	38%	23%	90%	90%
Transmission	91%	<u>8%</u>	91%	<u>21%</u>	91%	<u>82%</u>
Net energy Remaining		8%		21%		82%

Thus, only 8% of the petroleum energy available in the ground is available by the time electric power reaches the end-user's meter. This is not an ideal energy resource from this perspective. A balanced perspective, however, recognizes it does have other advantages which merit serious consideration for other purposes.

A key strategy is to match appropriate technologies to specific needs. If the end use is for water heating (40% of residential electric use), this task can be carried out on-site with none of these losses by the direct use of the sun's energy using a solar water heater.

Thus the complex and inefficient conversions involved in the growth of plant matter by collecting solar energy, the extraction, refining, and transportation of the fuel, the generation and transmission of electricity, and conversion into heat are **avoided entirely**.

The difference between the total efficiency losses of the technology employed and the losses of the best (most appropriate) technology is waste. This waste represents a **permanent** loss -- an avoidable loss which can never be recovered. Although the price of fossil fuels does not represent the true, fully-accounted social costs of resource consumption costs, these externalized costs should be included when analyzing the consequences of this waste.

²² Hydroelectric power requires significant infrastructure investment for dams and/or penstocks and tunnels to transport water to the generation site. These are, however, one-time expenses for passive, low maintenance systems, and are amortized over the life of the facility. Thus, operating costs are held low and the efficiency of the system is high.

changes over time. A constellation of options are necessary to stabilize demand. Energy self-sufficiency is unlikely to occur through grandiose technological quick-fixes, but by many small steps to nibble away efficiency losses, exploit appropriate scale sources, and create efficient use patterns.

ENERGY NEEDS AND REAL NEEDS

Energy is a "means to an ends", not an end in itself. Energy is used to accomplish work. It is harnessed to multiply productivity -- and produce comfort. Changes in society at the time of the agricultural revolution were largely due to harnessing animal power for clearing, plowing, and transportation. Advancements during the industrial revolution were largely due to harnessing the stored energy in wood, coal, oil, and nuclear sources, and our ability to store, convert, and transmit that energy.

Yet it is the **products** of energy we desire, not energy itself. Similarly, the products themselves are not the final ends, but our quality of life, individually and as a society, and other ends which become progressively more difficult to quantify and influence directly.²⁴ The tendency of studies -- out of convenience and the desire to limit the scope of inquiry -- is often to treat such means as ends in themselves. This can lead to false conclusions.

WHAT ARE KAUAI COUNTY'S REAL NEEDS?

At some point in the planning process it is desirable to ask "What do we really want? What do we really need?" Perhaps the ultimate ends -- the health, happiness, security, comfort, and quality of life of Kauai's citizens -- should be considered directly. Finally, we would ask: "By what means may these desired ends be assured -- and undesired ends avoided?"

²⁴ Amory Lovins suggests the question "...should be not how to expand supplies to meet the postulated extrapolative needs of a dynamic economy, but rather how to accomplish social goals elegantly with a minimum of energy and effort..." (Soft Energy Paths, Harper/Colophon, NY, 1977, p. 13).

through" then becomes the predominant method of operation. Increased development, being planned, is likely. Increased discontent is also likely if planning-intensive enterprises have greater influence and, as a result, must be controlled by increased regulation and/or public pressure.²⁷

These choices require realistic assessments of desirable levels of population and economic activity. The energy necessary to support these levels is a secondary calculation, and the best mix of energy policies and resources to provide this energy is a tertiary consideration. These choices should be made in appropriate order. Energy policies which significantly reduce jobs, significantly increase costs or taxes, reduce property values, or otherwise produce severe economic consequences are unlikely to be wise policies, yet could occur as the unintended consequences of a failure to consider the larger system.

DEMOGRAPHIC AND CONSUMPTION TRENDS

Realistic energy forecasts require realistic population estimates. Resident population rose from 29,800 in mid-1970 to 51,000 in mid-1989, a 71% increase in 19 years. De facto population²⁸ rose from 32,300 in mid-1970 to 69,300 in mid-1989, more than doubling (114% increase) in the same 19 years.

Straight-line extrapolation using the same rate of growth for another 19 years yields a year 2007 de facto population estimate of nearly 150,000 and a resident population of about 87,000. This estimate is likely high, as limited land is available for new residential or resort development. Interpolating population projections from DBED figures yields about 110,000 de facto residents and 79,000 full-time residents in year 2007, increasing to 120,300 and

²⁷ While voters in Kauai may not have a clear vision of what they want, many have a sense of what they don't want, and this may be expressed at the polls. Because of the time lags involved in voting, it may be too late for their views to be represented, or to remedy the source of discontent.

²⁸ DBED population data from The State of Hawaii Data Book, 1990, Tables 5, 7, & 18, pages 16, 18, & 36. De facto population includes residents, military personnel, and number of visitors physically present on the island on an average day during the specified year. Presented data is for July 1st of each year. Projections to year 2010 are from Population and Economic Projections for the State of Hawaii to 2010 (Series M - K), DBED, November 1988, passim. (esp. p. 3 - 5 and 12) and are based on likelihood, not desirability of indicated population levels.

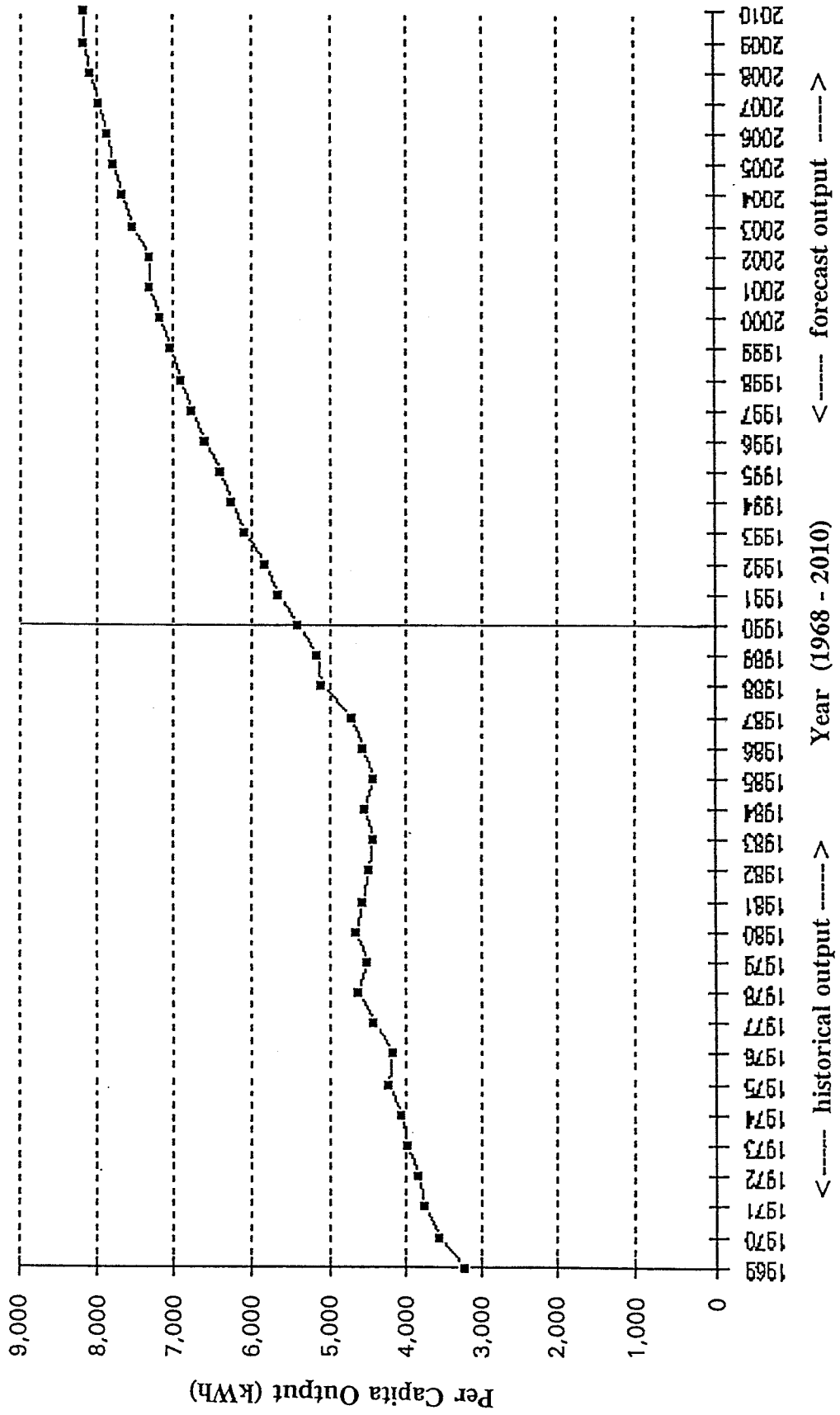
TABLE 3

Kauai Electric Population and System Output Forecasts

YEAR	Resident Population	Defacto Population	System Output (MWH)	Sales (MWH)	Per Capita* Output (kWh)
1968			86,390		
1969	29,500	32,000	102,732		3,210
1970	29,800	32,300	114,527		3,546
1971	30,900	34,000	127,422		3,748
1972	31,900	35,800	137,049	121,226	3,828
1973	32,900	36,900	147,072	131,556	3,986
1974	32,600	36,800	149,460	135,587	4,061
1975	33,400	38,100	161,196	148,533	4,231
1976	34,900	40,100	167,638	155,834	4,180
1977	35,500	41,300	183,230	167,035	4,437
1978	36,800	43,600	201,011	179,299	4,610
1979	38,100	45,200	204,214	184,459	4,518
1980	39,400	46,400	211,126	188,798	4,550
1981	40,500	47,500	218,664	199,451	4,603
1982	41,600	48,500	216,999	200,865	4,474
1983	42,500	50,700	224,834	209,712	4,435
1984	43,500	54,600	247,142	228,951	4,526
1985	44,600	56,200	248,842	231,008	4,428
1986	45,400	60,500	271,656	252,509	4,490
1987	46,900	62,000	292,533	270,163	4,718
1988	48,100	65,000	332,613	308,094	5,117
1989	49,700	67,000	345,027	321,256	5,150
1990	51,200	68,800	369,337	342,857	5,368
1991	52,235	70,575	399,192	367,747	5,656
1992	53,270	72,350	420,884	382,289	5,817
1993	54,305	74,126	449,834	411,039	6,069
1994	55,339	75,901	474,184	433,289	6,247
1995	56,374	77,676	498,534	455,539	6,418
1996	57,409	79,451	522,884	477,789	6,581
1997	58,444	81,226	547,234	500,039	6,737
1998	59,479	83,002	571,584	522,289	6,886
1999	60,514	84,777	595,934	544,539	7,029
2000	61,548	86,552	620,284	566,789	7,167
2001	62,583	88,327	644,634	589,039	7,298
2002	63,616	90,103	668,984	611,289	7,425
2003	64,653	91,878	693,334	633,539	7,546
2004	65,688	93,653	717,684	655,789	7,663
2005	66,723	95,428	742,034	678,039	7,776
2006	67,757	97,203	766,384	700,289	7,884
2007	68,792	98,979	790,734	722,539	7,989
2008	69,827	100,754	815,084	744,789	8,090
2009	70,862	102,529	839,434	767,039	8,187
2010	71,897	104,304	863,784	789,289	8,281
2011	72,932	106,079			
2012	73,966	107,855			
2013	75,001	109,630			
2014	76,036	111,405			
2015	77,071	113,180			
2016	78,106	114,956			
2017	79,141	116,131			
2018	80,175	118,506			
2019	81,210	120,281			

FIGURE 8

Projected Per Capita System Output (kWh) (from Kauai Electric data)



KE system output projection summary:

1970 114,500 MWh, or 3,545 kWh per de facto resident.

1990 369,337 MWh, or 5,408 kWh per de facto resident (152.55% increase 1970 - 90).

2010 853,750 MWh, or 8,185 kWh per de facto resident (151.35% increase 1990 - 2010 and 230% increase 1970 - 2010 based on a 2010 de facto population of 104,300).

Energy self-sufficiency cannot be a realistic goal unless this increase is eliminated. In fact, per-capita consumption must be cut by one-third simply to keep demand from increasing. Reducing total consumption by half in the face of a 50% population increase would require a two-thirds reduction in per capita consumption. This is a realistic goal before year 2010 -- if we choose it. Improvements are not likely to be made "all at once", but over a period of years. A projected 4% annual growth in power demand need only be met by a 4% annual improvement in efficiency -- this will keep demand approximately constant. Greater improvement would result in declining demand. Adding renewable resources shifts an equal percentage of dependency to self-sufficiency. Improvements are incremental, but cumulative. Again, there are linked choices, costs, and consequences.

ENERGY AND LIFESTYLE CONSIDERATIONS

In perspective, in 1778 Captain James Cook estimated Kauai's population at 30,000 residents on the first visit of the *Discovery*; on the second visit, Captain King (replacing Cook) estimated a population of 54,000 residents.³⁰ Both estimates indicate a population of the same order of magnitude as de facto 1970's (or resident 1980's) population. This population was sustained without energy or food imports.

If the County desires real self-sufficiency, this example illustrates that the "energy crisis" threatens lifestyle, not life support: Kauai has sufficient land, sun, and water to sustain a population of this magnitude. More could be sustained with contemporary crops. But other

³⁰ Fornander, Abraham. An Account of the Polynesian Race: Its Origins and Migrations. Tuttle: Rutland, VT / Tokyo, original publication 1880, Vol. 2, p. 165. Fornander references Cook's Voyages, Vol. ii, p. 230 and Vol. iii, p. 128 for these estimates, but feels they may be high. Other recent works use higher estimates.

will need) may foster increased dependence and over-reliance on these resources -- a "brittle" system,³² inflexible and subject to the possibility of breakdown.

An alternative analysis might consider this dependency a systemic form of addiction,³³ where what was once a comfort, convenience, and a productivity multiplier has become a need we cannot live without. An analogy to drugs with comforting and performance-enhancing qualities may be valid. If so, long-term planning should consider if the severity of our energy craving (our "energy crisis") is indicative of systemic health or a signal of early (and still treatable) pathology -- and how this addiction might be controlled.

One indicator differentiating a responsible from an irresponsible relationship with a drug is how well the user can function in its absence. What would happen if electric power were not available for one to two weeks? How many offices would shut down because they are unnecessarily dependent on air conditioning and artificial lighting? If only reduced quantities of energy were available, could we get along without most air conditioning and artificial lighting? This information might provide a useful measure of our vulnerability. The County should consider what best meets Kauai's real needs -- and insures long-term security.

In earlier times, reducing demand meant getting by with less or doing without. This has lifestyle impacts. The availability of efficient, modern energy technology means this is no longer necessary. Kauai's future energy security -- avoiding the pathological consequences of excessive dependence -- can best be met by increasing efficiency ("doing more with less") and capturing the untapped resources of solar and hydro power.

³² The vulnerability of large, centralized power systems and the design of resilient systems is discussed by Amory Lovins and L. Hunter Lovins in Brittle Power: Energy Strategy for National Security, Brick House, 1982, *passim*.

³³ The addiction analogy is discussed by Gregory Bateson in Steps to an Ecology of Mind. Ballantine, New York, 1973, *passim*.

changeover will occur. It is a question of timing. Secondary questions include **which** technologies will be used, **how** these will be implemented, and **who** will supply the products and profit from this change.

This changeover will be accompanied by consequences. The earliest possible transition may have real advantages for some sectors, and disadvantages for others. It is appropriate then, to ask which demand sectors and which supply sources would provide the greatest benefits from early transition -- and should therefore be slated for aggressive implementation -- and which should be promoted later.³⁴

This determination has many facets, since there are many levels (and criteria) of analysis (i.e.- social, economic, environmental/ecological, political, etc.) and time perspectives in which a particular position could be justified or opposed. Conflicts arise even within a single frame of analysis, such as the tradeoff between environmental costs of constructing new hydroelectric generation facilities to achieve the environmental benefits of reduced oil-fired generation, pollution, CO₂, power transmission lines, and so on. These conflicts have political consequences, since **present costs must be borne to receive future benefits.**

Since taxpayers (and voters) are unlikely to consider the extraction of additional taxes as an investment, the employment of an intermediary with the perspective of an investor merits serious consideration. Investors are, in effect, paid for securing capital and taking risks. Since investors expect a return commensurate with the risk involved, it is in the best interest of the county and rate-payers to minimize risk. The predictability of the cost recovery -- and ability to generate a secure profit -- is a key consideration in implementing a program where the county and rate-payers avoid up-front costs.

The time frame required for **planning** is also important, as longer lead times are often required for alternative technologies. Delaying decisions on alternative energy diminishes or forecloses those options, requiring additional generation to be supplied by a known technology (such as oil) with shorter lead times. Again, failing to choose results in a choice by default.

³⁴ The Recommendations which follow are based on this consideration.

Since demand reductions are the best source of available capacity, efficiency and conservation efforts should be given precedence over supply-side increases. Accordingly, these recommendations primarily aim at producing a significant reduction in electric demand. Electrical energy consumption is about 30% of all energy consumption; a reduction in electric power consumption reduces petroleum imports and dependence on outside resources. Between 1973 and 1990, Kauai Electric recorded an average annual kWh sales growth of 5.6%, increasing from 121 GWh to 343 GWh³⁵ in this period. KE sales forecasts project 3.9% average growth to 2010, with sales of 789 GWh in that year. This growth in electrical demand is one segment of the energy equation where significant results and discernable savings are possible within a realistic time frame.

An energy self-sufficiency program should approach the problem systematically, by:

- 1.) eliminating per-capita demand growth,
- 2.) eliminating absolute demand growth,
- 3.) establishing a basis for ongoing demand reduction,
- 4.) facilitating the development of proven alternative energy technologies,
- 5.) replacing existing fossil fuel generation with preferred energy technologies.³⁶

These should be approached in order. By the time demand growth has been brought under control -- which is likely to take several years -- promising technologies such as solar-thermal, photovoltaic and OTEC will have had additional time to mature, and retirement of oil-fired generation should be based on renewable sources. Present planning, however, should employ proven, reliable technologies with predictable cost recovery.

³⁵ Figures supplied by Kauai Electric indicating capacity expansion from 1972 - 1990 and resource projection 1991 - 2010, rounded to nearest gigawatt-hour (GWh). A gigawatt (GW) is 1,000 megawatts (MW).

³⁶ This is not to deny the value of fossil fuels, but to preserve it. If fossil fuels can be reduced to reasonably sustainable (non-addictive) levels, they may provide cost-effective energy for some transportation, peak load, and emergency generation needs well into the next century. This flexibility would have significant value.

CONSTRAINTS: FINANCING

The first problem (and opportunity) is financing. Implementation of these recommendations involves up-front investment to gain long-term savings.

Most **individuals** replace equipment such as light bulbs, water heaters, and refrigerators when a crisis demands immediate attention; this is a problem when high-efficiency equipment is not often available locally "off-the-shelf". Where efficiency is available, prices are often at a premium. This often deters residents of limited economic means. The value of these improvements is often unclear even to those who can afford the products. Many people prefer not to change -- or not to consider the need for change. On their own, people are likely to replace failed bulbs, water heaters, and refrigerators with items which are both available and sell at a competitive price.

An **investor's** perspective is different. Investments are evaluated on the basis of security, stability, return on investment, and -- for growing numbers of investors -- the social responsibility of the investment. Energy efficiency improvements are both exceptionally sound investments and rate prominently on social responsibility. To answer to the question: "Where does the money come from?", it is clear that near-term capitalization of the process should come from investors, who are likely to supply ample capitalization in return for a profitable return on their investment.

The logical place to look for investors is Citizens Utilities, the owner of Kauai Electric and a highly-regarded, triple-A rated public utilities company. The *1990 Citizens Utilities Annual Report* (p. 11) states:

"...we are talking to our customers and our regulators about conservation and, with them, are developing a strategy that will, in the long run, benefit us all."

Under the heading "**INVESTING IN CONSERVATION**", they state:

"Part of this planning requires demand-side management, which entails investing in programs to help customers reduce their consumption of electricity by installing, for example, energy-efficient light bulbs, motors, or heating units in their homes or businesses."

hours, and other measures. These would be considered on a least-cost³⁷ basis, with consideration given to externalized costs and intangibles such as the social value of resource diversification and local economic impacts. IRP will be mandatory, and requires development of a DSM plan expected to produce results over time. It is in the best interests of the County to support KE's DSM planning and agree on a plan of mutual benefit which can be supported vigorously by the County and will be profitable for KE.

The described program will be easy to kill. If the County, the utility, the rate-payers, the environmentalists, and the PUC adopt adversarial positions, little good will be accomplished. This is a classic "non-zero sum game": all participants makes some small sacrifice in the short-run, and all reap long-term benefits as the efficiency program bears fruit. Any of these interests can be a spoiler for the others, so it is important to form a partnership mentality at the outset. Initially, this would be between the County and Kauai Electric/Citizens' Utilities to establish a common set of goals. Next, representatives would be drawn in from, perhaps, the Sierra Club, a consumer advocate, a large power user, a business group, a resort, an alternative energy provider, an efficiency provider (representing a solar and heat pump business), and (once formed) a PUC advisor. The public would be kept informed through the media, and through a public information campaign. Representatives will not be asked if they "like" the program, but how they can help make the program work for them -- to define the win-win scenario they could support -- and how the program can be improved. This program should be well-developed and have broad-based community support before asking for special consideration from the PUC. It should be, as much as possible, a "done deal".

If regulatory issues prove to be a barrier to program implementation, the County should facilitate the ability of Kauai Electric/Citizens' Utilities to form a **non-regulated** energy services company for the purpose of carrying out the objectives of this program.

³⁷ As discussed in previous sections, the real cost of petroleum is not reflected in the U.S. purchase prices, so "least cost" needs careful examination. The upcoming section entitled "**Promote Secure Environment for Alternative Energy Development**" (page 44) discusses cost considerations.

contrast, the customer would have used about 12 incandescents (\$8.40 assuming \$0.75 each) over the same 10,000 hours. Thus savings of around \$54 per installed bulb are possible, less costs of supplying these to the customer. Different customers use lighting in different amounts with different patterns, but the economics and energy savings are clear.

An electric lighting energy audit would first be used to compute which bulbs to upgrade, with priority given to high-use fixtures for entryway or constantly-lit areas. Little used bulbs (such as those in closets and garages) would not be upgraded if the hours of operation or duty cycle proved uneconomic. Implementation could be by one of several means:

- Bulbs could be upgraded by KE with cost recovery through the (average) energy savings, with the customer "owning" the bulb after payback; -- or --
- Kauai Electric could supply CFLs to all customers and agree to replace any burned out CFL with a new bulb on an exchange basis. Electric rates would be increased to adjust for required paybacks and lower sales due to savings in electric lighting costs.

The second option may be preferable (if this is a stand-alone energy initiative) due to simplicity, and because customer perception of "no charge" bulbs but higher electric rates without the bulbs (regardless if they upgrade or not) will provide upgrade incentive. This should be emphasized by a County-sponsored educational campaign. This seems preferable to county-enacted requirements which may be unenforceable.

Utility customers could have a choice of how they would receive their bulbs, as some may prefer not to allow entry to their homes. Kauai Electric could (probably through subcontractors) send a van to every home with a variety of sizes, shapes, and ratings to assure the proper item is installed, or customers could come to an office of KE (or designated subcontractors, which could include retail chains) and receive bulbs.

- The 35% State Tax Credit could be handled in several ways:
 - a.) Go directly to the consumer in the normal way refunds are handled. This would be the simplest program, and would provide significant incentive for early homeowner involvement, as solar installation would provide about \$1050 in credits on a \$3000 installation -- a positive cash flow on installation.
 - b.) Go directly to the consumer and be turned over (by contractual agreement) to Kauai Electric / Citizens Utilities when received. This would substantially reduce outstanding costs to be recovered.
 - c.) Be credited to KE (IF this can be worked out with the PUC and the State Tax Office) either as cash refunds or by transfer of tax credits to KE.

- PUC approval would be required (unless run as an unregulated subsidiary), since KE would own energy efficiency equipment on the customer side of the meter until payoff of the lease-purchase agreement.

- Energy efficiency improvements should be excluded from property tax assessment to prevent additional tax burden -- which would tend to discourage such improvements.

- Kauai Electric (or other efficiency provider) would be able to recommend and provide, in agreement with owners, high-efficiency air conditioning and heat pump systems (in addition to or in place of solar installations) where appropriate.

REQUIRE ENERGY EFFICIENCY AUDITS OF EXISTING COMMERCIAL STRUCTURES

This proposal would affect all metered facilities (primarily non-residential structures) not included in the lighting and water heating retrofit programs described above. This energy audit would provide these enterprises with sufficient information to make independent determination of the cost-effectiveness of energy-efficiency improvements. It is to provide the impetus -- and information -- to examine energy use, face problems where they exist, and promote efficiency upgrades. The County, Kauai Electric, or other parties could provide comparative data to assess probable saving and payback periods. Possession of this information also provides a basis for energy-efficiency contractors to submit proposals for energy upgrades in a comparable format.

This recommendation is based on the assumption that businesses are likely to do what makes economic sense, if they have sufficient information available. While compliance and submission should be required by ordinance within a two year period, any improvements would be voluntary to prevent unnecessary bureaucratic involvement. Data would be considered confidential if requested by the business. This information would otherwise be available to energy-efficiency contractors, and would foster the growth of these beneficial enterprises. Information held confidential would have to be submitted to at least one efficiency contractor for proposal. No other actions would be compelled until the effect of such a voluntary program can be assessed by the County.

The County should initiate this program by auditing its own buildings first. This will provide needed experience for those overseeing the program. The County should then follow through with energy-efficient retrofits of its buildings, and publicizing the program and the anticipated paybacks. This way the County gains experience, long-term savings, good public relations, and educates the public about the program with the same tax dollars.

AMEND VEHICLE/FUEL TAX SYSTEM TO PROMOTE EFFICIENCY; use funds for road efficiency improvements and public transportation

Focusing early efforts at automobile, aircraft, and marine fuel consumption could drain limited resources -- more progress can be made by devoting the same resources to more productive areas. Policy choices in the transportation fuels area are likely to be made on a national level. However, certain policy initiatives could prove beneficial:

- The motor vehicle tax system should be amended to reward efficiency. This could be increased over time. Raising fuel costs with an additional county tax would have a similar effect (this is a regressive tax, but is needed to reduce consumption). Earmarking tax monies to eliminate traffic bottlenecks which contribute to excess consumption would increase the political palatability of such a tax.
- Long-range planning should consider a public transportation system to present an alternative to private automobiles. This should be funded from tax monies, not fares. Fares should be minimal, with inexpensive monthly or yearly passes, to encourage use and minimize additional roadbuilding as population increases.³⁸
- Cars undergoing yearly inspection should be checked for possible efficiency-related problems (tire inflation, etc.) and efficiency-related information (e.g.- DOE, *Energy Conservation for Vehicle Owners*, (DOE/CE-0297P), January 1991) should be distributed to car owners at that time.

Long Term:

- Continuing improvements in photovoltaic and battery technology could make electric vehicles practical on Kauai before many areas on the mainland. Acquiring test vehicles for county use would keep the desirability of such vehicles in the public eye. Hydrogen could also be a major transportation fuel in the future, and may merit consideration for county test vehicles.

³⁸ Federal funding is available for mass transit capital equipment expenses. The City and County of Honolulu has staff and expertise devoted to acquiring Urban Mass Transit Authority (UMTA) funding, which could be solicited for advice. However, the County may wish to forego UMTA funding, as regulatory and reporting requirements may exceed grant monies received, and severely restrict autonomous control. Mass transit vehicles should be from a single manufacturer to minimize maintenance and spare parts expense, and would ideally be powered by alternative fuels. Alternatively, transit services could be subcontracted to a private contractor, which might provide additional efficiency of scale by allowing vehicles to be used in the tourist industry in off-peak hours.

PROMOTE SECURE ENVIRONMENT FOR ALTERNATIVE ENERGY DEVELOPMENT

The long-term energy security of Kauai County depends upon development of additional renewable energy supplies to meet the demands of a growing population. These supplies are unlikely to appear without encouragement. Capital investment will be required. Risk needs to be minimized -- and profitability secure -- to attract investment capital. This will require clear signals of county support to potential suppliers.

At the same time, a favorable pricing scheme for purchase of renewable energy is needed. The real value of energy from these sources needs to be reflected in purchase prices. **This should include the actual avoided costs of this energy** -- that is, the cost to replace this energy (including construction, staffing, operation, and overhead) if existing resources were shut down, **NOT** just the fully-allocated cost of running an existing generator an incremental number of hours to supply this amount -- plus an additional amount designed to reflect the real societal costs of petroleum-fired generation (including mitigation of environmental and health effects, social, political, and economic disruption, externalized costs, and so on). This formula could allow higher purchase prices for emission-free sources such as hydro and solar-thermal generation, as preferred over important, but less ideal sources such as biomass. These prices could be adjusted to promote a diversified and balanced⁴⁰ mix of sources over time.

Across-the-board rate increases are not required to promote renewable energy development. For instance, 1990 per capita energy sales averaged slightly over 5000 kWh⁴¹ at a cost of

⁴⁰ The reliability of baseload generation could be increased by balancing, for example, solar thermal against hydro sources. Periods of high rainfall are likely to have ample water for hydroelectric generation, but less sunlight for solar thermal generation. Sunny periods will permit ample solar thermal generation, but reduced hydroelectric generation. Carefully balanced diversification can contribute significantly to energy security.

⁴¹ This figure takes total system sales for 1990 and divides by *de facto* population -- this may seem deceptive, because this divides all power use (including commercial, large power, and street lighting) by all people present on the island (not just those having a meter). This shows total costs which would be shared by all consumers, although this would not be equally shared. Computing residential rates by meter illustrates the effect on an average residential electric bill: averaging 14,733 single family dwellings (at 511 kWh/mo.) with 4,130 condo/apartment units (at 491 kWh/mo.) yields an average 506.6 kWh per meter per month at \$0.11887 kWh for a bill of \$60.23 per month. Adding \$0.01 per kWh would increase a typical 1990 residential electric bill by \$5.07 per month, or 8.4%.

shortage -- can cause wild price swings and other disruptions. The most painless method of increasing supply is by providing incentives to promote alternative energy development. While alternative energy development by private enterprise may be promoted with little more than a rate adjustment (subject to PUC approval), purchase prices will have to be commensurately higher if risk is high. It would be advisable for the County to improve the climate for alternative energy development, as private investment is unlikely to be forthcoming if uncertainty and risk outweigh the expectant value of profit. Losses suffered by potential alternative energy vendors are likely to reduce the willingness of investors to promote these desirable community investments.

The technology which traditionally provides the least expensive power at the least environmental cost is hydro. The County should improve the consistency of the approval process to allow hydroelectric generation sites to be developed, consistent with water availability and long-term environmental responsibility. In this regard, it is important all groups look at the "big picture". Responsible community decision-making requires involved parties to be informed of needs, time horizons, and the range of options available -- not just seemingly discrete and isolated decisions as they arise. Win - win strategies are difficult unless common goals are defined in advance and reasonable conditions are set to protect the interests of all parties -- and, hopefully, to enlist their support.

CONCLUSION

Many long term issues need to be addressed by the county. Energy self-sufficiency is prominent among these, but is not a separate or isolated issue. A coherent vision of the future is important in determining the role energy plays within that future. Options discussed in this report have been sharply restricted to short-term energy policy actions available at the county level. These should not be treated as discrete decisions, but components of a larger strategy. Policy means "a plan or course of action ... designed to influence and determine decisions, actions, and other matters"⁴³; it is a "means to an ends", or goal. Policy without clearly-defined goals is likely to be misdirected.

As the year 2000 approaches, a process of "visioning" the desired future for Kauai County is important for residents, business enterprises, and county government. Kauai has followed a different path than most of the state, has a separate identity, and needs to make its own choices. The choices available constrain other choices, and are codeterminants of Kauai's long-term future. Many choices are unilateral (by individuals, businesses, or government agencies), leading to a future which evolves willy-nilly, sweeping everyone along, rather than as a result of agreement and shared goals. Problems borne of disagreement and divergent goals are likely to be magnified by the passage of time. **Unresolved energy policy creates an inappropriate battleground where opposing forces attempt to determine development, population, environmental, lifestyle, and other *a priori* issues.**

This report necessarily suffers from an inability to address the larger, *a priori* goals underlying energy planning. As a compromise, it suggests policies designed to maximize resilience, flexibility, adaptability, and freedom. Some recommendations will be controversial, especially county policies designed to avoid electric utility expansion using petroleum-fueled generators. But some things are clear: petroleum fueled and sustained the prosperity of western society for the last hundred years; it cannot sustain prosperity for another hundred years. The security of systems relying on petroleum resources has changed markedly within the last twenty years; within the next twenty years, it will change as much

⁴³ American Heritage Dictionary of the English Language, Houghton Mifflin, Boston, 1970, p. 1014.