

Noise Generation

Noise has been identified as a factor in public health. During construction and operation of facilities both on-site workers and occupants of nearby buildings can be affected. The acceptable levels and duration of noise generation depend on location. The standards are much more rigorous in a residential area than in an area of concentrated heavy industry.

Soil Erosion and Nutrient Removal

Agricultural activities have been a major contributor to soil erosion and sedimentation problems. In environmentally sensitive areas, the normal rates of erosion have been accelerated and the amount of sediment carried away from the land and deposited in coastal waters has exceeded natural tolerances. Valuable topsoils, along with fertilizers and nutrients, may be removed by soil erosion; this is detrimental not only to the receiving waters, but also to the lands which have lost the high-quality soils.

Safety

In mechanized operations of any kind, the incidence of injury or death must be minimized. Compliance with Occupational Safety Hazard Act (OSHA) regulations and suitable training for employees will ensure safety.

Wildlife and Plantlife

Plant and animal life has evolved and radiated into many species that are endemic to Hawaii due to Hawaii's unique ecosystem. The ecological balance between species may be threatened by the introduction of new, competitive species. The 1973 Endangered Species Act, designed to protect species of fauna and flora that are rare and in danger of extinction, has many applications on Kauai. The protection of the watersheds also has aided the preservation of the sensitive ecosystem. Extensive research is necessary to identify the initial factor of habitat for the protection of endangered or endemic species.

Aesthetic Considerations

Aesthetic considerations usually include visual intrusion, traffic congestion, and odor. These do not directly threaten public health, but rather public well-being. Kauai's scenic resources are highly valued by visitors and residents alike. The severity of traffic impacts should be minimized through careful siting. Obnoxious odors should be acknowledged and contained as much as possible.

E. Research, Development and Demonstration Planning

Ongoing Projects

Lihue Plantation Company Project [4-20]

Work has begun on the construction of a new, single 20 MW electrical generating unit that will replace the Lihue Plantation's present aging nine boilers and three turbogenerators. This high-efficiency steam generator will not only satisfy processing requirements (8 MW) but will generate substantial quantities of electricity (12 MW) for sale to the local utility, Kauai Electric.

Firm power will be provided 11 months out of the year, seven days a week, 24 hours a day regardless of bagasse fuel availability. The steam generator will be able to burn bagasse, No. 2 oil, and No. 6 oil in varying proportion. It will also be able to burn other fibrous fuels--prepared and dewatered cane leaf trash, wood chips, and prepared municipal refuse (20,000 combustible tons per year available). The project is scheduled to be completed in late 1980.

G. N. Wilcox Memorial Hospital Energy Self-Sufficiency [4-20, 4-21]

Wilcox Hospital, with its rapidly rising energy cost, has decided that it should, in the public interest, attain energy self-sufficiency. Conservation measures have already reduced the total energy requirements by 23 percent. In addition, four plans were developed to take advantage of natural sources of nonpolluting energy.

The plans include:

- 1) Utilizing solar flat plate collectors to heat water
- 2) Generating electric power through the use of solar photovoltaic technology.
- 3) Generating electric power with a wind energy conversion system.
- 4) Generating methane from solid waste to be burned in the hospital's boilers.

Thirty-six solar collectors have been donated to the out-patient department by local and mainland solar companies. A proposal to the U.S. Department of Housing and Urban Development (HUD) for solar collector panels for the long-term care facility is in the final selection stage.

The Department of Energy has recently awarded \$1.4 million (with 0.4 million State matching funds) to Wilcox Hospital for the construction of a solar photovoltaic facility.

The field of parabolic trough solar concentrators will produce about 75 KW and one million BTUs of thermal energy for the hospital.

Plan three, which is in the preliminary stages, will result in a proposal to the Department of Energy for the installation of a 200 KW wind generator to be located roughly one mile away from the hospital on Kalepa Ridge. Plan four has had further funding of \$40,000 by the Department of Energy for the design and construction of a methane gas plant.

Proposed and Suggested RD&D

Solar Thermal Repowering Project

A proposal was submitted to the U.S. Department of Energy for a project to develop a solar central receiver system for repowering applications at Kauai Electric Company's Port Allen generating station. The present utility system offers an excellent opportunity to study the options of solar repowering of the gas turbine versus the steam turbine to derive maximum benefits from the energy conversion systems at the power station.

As Kauai Electric Company has plans for an additional 18 MWe steam turbine unit in 1986, a molten salt (heat transfer fluid) central receiver system could be used as the baseline approach to repower 10 MWe from the new steam unit during the day and over six hours in the evening on the peak summer day at the same 10 MWe level. No significant technical risk is foreseen in applying available technologies to repower the station by 1985 to supply steam at the relatively low temperature and pressure conditions of 835°F (446°C) and 675 psig, respectively. Approximately, 565 billion BTU of No. 6 oil would be replaced annually.

The proposal was not funded, although it was considered technically sound. Action is continuing to find funds for the project.

Kauai County Biomass Program

A careful study should be made of land availability, especially with respect to maximizing biomass growth and optimizing species mix; and the sociological consequence, environmental impact, and financial requirements should be examined.

Kauai's Sugar Plantations

The Kauai sugar plantations produce a large block of electrical power in addition to steam to run their processing plants. Factories that presently burn fuel oil in conjunction with bagasse

are working towards the elimination of the use of fuel oil by improving plant efficiencies and capacities.

Numbers given in Section II, Kauai Energy Use Pattern, for generation of electricity from bagasse indicate an average boiler efficiency of 57 percent. If this were to be increased to the 67 percent, already achieved by Kekaha Sugar Company, total electric output would be increased by approximately 16 percent. Additional energy would be available if the excess bagasse and trash from the cane cleaners were also burned. The use of trash normally burned in the field is being investigated—in this case the value of energy gain must be balanced against the resulting increased capital and operating costs, and increased difficulty of pest control.

Kauai plantations could further increase their plant efficiencies by installing more efficient multi-stage turbines, modifying evaporation stations and pan-boiling systems, and instituting just plain good housekeeping.

The biomass output could be significantly increased by decreasing are-of-harvest and by other changes in agronomic practice. The Hawaiian Sugar Planters' Association is presently investigating ways to optimize energy production, as opposed to present practice, designed to optimize sugar production.

Ethanol Production Program

For years, the sugar companies have been shipping molasses out of Kauai. The cost of shipping has been escalating and the price of molasses has been fluctuating. Approximately 65,300 tons of molasses are produced annually, which could potentially produce 4.6 million gallons of ethanol. An automobile can operate normally with a mixture of up to 20 percent ethanol/80 percent gasoline before any adjustments have to be made on the engine. In 1977, about 14.5 million gallons of gasoline could have been replaced by ethanol, with the remaining 1.7 million gallons of ethanol possibly being ignited in Kauai Electric's gas turbines. These numbers are certainly intriguing. This project would require the construction of a large-scale fermentation/distillation facility.

Tree Farm Program

A 15,000-acre eucalyptus tree farm could provide about 2.55×10^{12} BTU of electricity or 25.8×10^6 gallons of methanol. A lot this size can no doubt be easily accommodated on Kauai. The Big Island has a eucalyptus tree cutting and chipping operations that sells its wood chips to Japan. C. Brewer, also on the Big Island, has started a eucalyptus plantation to study the various species and their potential in Hawaii. The Division of Forestry has a parallel program of

growing eucalyptus seedlings which may result in future biomass energy farms. Giant koa haole trees are about to be examined on Molokai. The findings from these operations will be beneficial to Kauai's venture towards energy self-sufficiency.

Solid Waste Program

Studies are presently underway to investigate the economic feasibility of burning solid waste in Lihue Plantation's new boiler. It is estimated that 22,000 tons of combustible solids from Kauai's animal production or solid waste will be able to produce approximately 176×10^9 BTU of energy. Another possibility that should be investigated in this study is processing cane trash with the solid waste.

Kauai County Hydroelectric Program

Kauai's abundant (and usually consistent) rainfall over the windward and interior parts of the island has proven to be a valuable resource for hydroelectric generation. Beginning in the early 1900's, streamflow has been diverted via a number of open ditches and pipelines to drive generators for several of the island's sugarcane plantations. Although each of these units is relatively small, their success is unquestionable. They have paid for themselves many times over, and have provided an inexpensive energy supply to their owners for decades. In contrast to the success of these "run-of-the-river" hydropower plants, one early study and two other recent studies portrayed a more pessimistic view of the potential hydroelectric areas that they evaluated.

The Kokee Water Project study was culminated in 1964 by the State of Hawaii's Department of Land and Natural Resources in cooperation with the U.S. Department of the Interior, Bureau of Reclamation. The proposed construction called for a 32,000 acre-foot storage reservoir impounded by a 240-foot-high earthfilled dam on the Kawaikoi Stream, a tributary of Waimea River. The power generation capacity was rated at 10 MW. The project included the multi-purpose features of power, irrigation, fish and wildlife enhancement, and recreation. Approximately 59 percent of the project first cost of \$19 million was allocated for power. The project has since been deferred, principally because of lack of Federal funding [4-14].

The Wailua River basin study, completed for the State Department of Land and Natural Resources in 1978, depicted rather dismal economic prospects for a major dam development in that basin. The Corps of Engineers' study examined both dam and run-of-the-river generating configurations for numerous watersheds throughout the State and arrived at the same conclusion—that the economics of hydropower, even in this era of rapidly rising costs of electricity, do not presently justify its development in Hawaii.

In view of the findings of these two recent and independent studies, is yet another hydroelectric feasibility investigation warranted? Perhaps surprisingly, the answer is yes, and for two very important reasons. The first is that neither of the recent studies considered hydropower on a seasonable basis, to be run at a maximum rate in winter when water is typically abundant, and run only a little or not at all for the drier part of the year. This approach to deal with the water as it naturally occurs could avoid the economic constraints of either a substantial investment in storage capacity (as shown by the State study) or energy generation limited by dry season flow-rates (a finding of the Corps of Engineers' study).

The second reason that hydropower might deserve another look on Kauai evolves from the first. If its most efficient development would produce energy primarily on a seasonal basis, then it would have to be integrated with other generating modes in a system which would be able to produce electricity when hydropower would not be available. Bagasse-fired steam generation has always been the ideal complement to achieve this, since it is only available in the mill-grinding season, which, by necessity, is the drier nine to ten months each year. Until now, the limited capacity and poor condition of the existing bagasse units have been impediments to their greater utilization. This outlook will be substantially changed, however, with the installation of the new and much larger bagasse-burning unit at Lihue Mill. It will create the possibility of integrating bagasse and hydropower to produce electrical energy year round, perhaps at a cost which will be of benefit to electricity consumers on Kauai.

Because of this, an investigation of the hydropower opportunity posed by the new bagasse plant in Lihue is proposed. This study would take advantage of work done in the two recent studies, but would look at the integrated development scheme which neither considered. The several most promising watersheds on Kauai would be evaluated by comparing computer simulation analyses of potential performance against the cost development. Because recent studies have developed the computer programs to do the bulk of this work, the total cost of the study would be minimal.

A number of run-of-the-river hydroelectric projects appear promising. The rivers of interest are the Wailua, Hanalei, Wainiha, Waimea, Lumahai, Makaweli, and Hanapepe. For the Wailua river alone, rough estimates indicate a single 6500 KW machine could produce about 18×10^6 KWH per year, two-thirds of this between November and April. The total is equivalent to about 36 thousand barrels of oil. Contrary to preliminary findings of hydroelectric potential as listed on Table 4-5, the committee feels that a far greater potential exists.

The possibility of using low-head hydro plants with large existing dams or reservoirs which would require rehabilitation or expansion should be investigated. These include: Waita, Alexander, Kapaia, Koloko, Wailua, and Puu Lua reservoirs. A rough estimate of the power potentially available from the above reservoirs is about 4000 KW.

Kauai Solar Photovoltaic Program

The Coast Guard station on Kauai is a radar station located in an area with good insolation just a few minutes' walk away from the popular Poipu Beach. The installation of a solar photovoltaic unit in a salty, corrosive environment will provide useful operational information. Other potential solar photovoltaic sites include the Waimea Canyon elementary school, Sheraton-Kauai Hotel, and Up-to-Date Cleaner.

Kauai County Wind Energy Program [4-14]

Wind speed survey conducted by the University of Hawaii's Department of Meteorology indicated that the areas that are the most promising for power generation are Kilauea Point in the north and the strip along the southeast coast between Makahuena Point and Kawelikoa Point. A wind energy conversion system located at Kilauea Point could provide the power necessary to operate the lighthouse facilities. Also, pumped storage systems on Kauai are promising since there are large reservoirs available near the potential wind sites. Other sites and projects of major attention are: at Anahola, water pumping of existing Department of Water Supply water tank; plantation field pumps for field irrigation; Alexander Reservoir water pumping; and Lihue Plantation required as a result of a new Lihue Airport runway.

Kauai County Hydrogen Fuel Program

Kauai County should keep abreast of research and development in hydrogen fuel storage, distribution, and utilization technologies, seeking opportunities to participate in experiments and demonstrations. Concurrently, studies could be made of energy requirements and cost of production, possible sources of energy other than oil, and of the economic and other benefits to be realized when hydrogen technology is commercially feasible.

Kauai Community College Energy Self-Sufficiency

Kauai Community College is an educational institution committed to provide two-year college transfer and general education programs, including semi-professional, technical, vocational, continuing education, and other educational programs and services appropriate to such an institution. The electrical consumption of Kauai Community College is primarily for lighting, water heating, and air conditioning. Solar flat plate collectors, solar air conditioning, and a wind energy conversion system could help reduce this consumption.

Kauai County Ocean Energy Program

Although most of the present work has been directed at Ke-Ahole Point on the Big Island of Hawaii, Kauai should begin to develop the baseline information that is necessary for an ocean thermal facility.

Also, information should be collected on wave action if a wave energy unit is contemplated on the South shoreline. Close contact with the Japanese and British should be made, since they are the leaders in this field.

Kauai County Geothermal Program [4-18]

Recent literature reviews have uncovered anomalies in the Mana and Wailua areas. This is surprising since Kauai is considered the oldest island in the State and therefore should be devoid of any residual subsurface heat. Field surveys will be necessary to further explore this discovery.

Appropriate Energy Technology Program

The U.S. Department of Energy conducted a small grants program in support of small-scale, energy-related technologies. Individuals, local non-profit organizations and institutions, state and local agencies, small businesses, and native American groups are eligible to receive grants.

Appropriate energy technology will not contribute in a major way to the total energy consumption on Kauai; however, it can contribute to meeting the needs of local communities and enhance individual and community self-reliance through the use of locally available resources. Some examples of alternate energy devices include solar technologies, energy conversion systems, small hydroelectric systems, methane digesters, waste heat recovery, aquaculture, and wood-burning stoves and heaters.

To support and encourage such activities Kauai County should prepare a Kauai Energy Self-Sufficiency Manual—a compilation of do-it-yourself information into a manual for anyone interested in individual energy self-sufficiency. This manual would include basic theory, basic design criteria, and recommended complete plans for different alternatives. A Kauai Appropriate Energy Technology Office, with a complete library and technical staff to assist in the design and building of energy alternatives should be established. The office also could be equipped to do simple measurements and simulations and sponsor Kauai Energy Self-Sufficiency Workshops—

a workshop series on how to become more energy self-sufficient. It could be a monthly series that would teach basic design of systems, aimed at answering questions. The Appropriate Technology Office would be available to assist the individuals between workshops.

V. ENERGY SUPPLY SCENARIO

A. Supply Development

In Section III energy demand projections were developed under three sets of assumptions. The baseline scenario, "Business as Usual," is an extrapolation into the future of population and economic growth trends of the past few years. To establish reasonable bounds within which to plan for development of alternative sources of energy to meet demand, a "Controlled Growth" scenario and a "Stimulated Growth" scenario were also developed.

No matter what rates of economic growth or decline may actually occur in the future, it is assumed for analysis that in all cases energy conservation will be practiced. Actions that can and should be taken to eliminate waste and improve the efficiency of energy utilization are summarized in Table 5-1 for the "Business as Usual" future, under the headings Government (i.e., County), Business and Industry, and Community for the following three time periods: near-term (the present through 1982), mid-term (1983 to 1990), and far-term (beyond 1990). The overall effects of these actions, along with other economic considerations discussed in Section III, are reflected in the energy demand projections for this postulated future course of events. In the "Stimulated Growth" and "Controlled Growth" demand projections, larger conservation savings are assumed, the result of increased motivation or necessity. Correspondingly, some of the actions listed in Table 5-1 for far- or mid-term would be initiated earlier, in the mid- or near-term.

For the present analysis only one projection is made for the future development of alternative energy sources to replace petroleum. It is based on what is the judgment of the authors is a reasonable set of assumptions. First, immediately available resources are applied (e.g., increased use of bagasse) for electricity generation, improvement and expansion of hydroelectric facilities, and increased use of solar water heaters. These are accompanied or followed by initiation of work to bring other sources on line as the necessary technology becomes available. Thus, wind energy is a near- and mid-term possibility, followed later by direct solar energy for solar thermal and photovoltaic generation of electricity. Ocean energy does not become commercially available until the 1990's.

It is recognized that the rate at which alternate energies become available can be increased or decreased, depending upon the availability of capital. Future study should investigate this issue.

TABLE 5-1
ACTIONS TO CONSERVE ENERGY

Source	Near-Term Present to 1982	Mid-Term 1983 to 1990	Far Term 1990 on
Govt.	<p>Establish county energy office, with energy commission made up of local representatives from industry, community, etc.</p> <p>Initiate carpooling program</p> <p>Initiate bikeway network</p> <p>Revise current interior lighting standards</p> <p>Require timers and water heater jackets on all electric and gas water heaters</p> <p>Market energy conservation to community (workshops, seminar, fair. . .)</p> <p>Push to revise permit schedule to encourage energy efficient construction</p> <p>Initiate const. and monitoring of Kauai energy house</p> <p>Design new county buildings for total energy efficiency</p> <p>Restrict zoning changes on projects which require excessive energy supply and distribution systems</p> <p>Government commitment to conservation in procurement practices</p>	<p>Raise office to Departmental status</p> <p>Continue to promote carpooling program</p> <p>Continue bikeway network</p> <p>Continue</p> <p>Continue</p>	<p>Continue</p> <p>Continue</p> <p>Initiate islandwide mass transit</p>

TABLE 5-1 (cont'd)

Source	Near-Term Present to 1982	Mid-Term 1983 to 1990	Far Term 1990 on
Business & Industry	<p>Encourage energy audits to all island residences</p> <p>Encourage energy audits to small businesses</p> <p>Push for state legislation on tax incentives for raising energy efficiency in power generation</p> <p>Promote carpooling by employees</p> <p>Reduce commercial lighting</p> <p>Practice conservation methods at work</p> <p>Promote use of bikes by employees (install showers)</p> <p>Stress conservation to employees</p>	<p>Continue</p> <p>Continue</p> <p>Retrofit existing structures/energy effic. lighting</p> <p>Purchase vans for Van-Go program - lease to employees</p>	
Community	<p>Improve driving habits</p> <p>Purchase more efficient appliances</p> <p>Promote energy conservation develop energy advisory groups</p> <p>Develop and Participate in public education programs - conservations, alternative systems, vocational training</p> <p>Participate in carpools</p> <p>Purchase fuel efficient cars</p> <p>Increase walking and use of bikes</p> <p>Participate in energy conservation at home and work</p> <p>Participate in energy seminars</p> <p>Install timers and jackets on all electric and gas water heaters</p>		Utilize mass transi

Table 5-2, similar to Table 5-1 for energy conservation, shows possible actions by government and by business and industry to accelerate alternate energy development.

B. Computer Analysis

Computer program KESS determines the year energy self-sufficiency can be attained given varying energy growth rates and availability of indigenous resources. Figure 5-1 displays the general flow chart of computer program KESS. The letters refer to reference points in the narrative.

Population and energy growths (A) are calculated using the following first-order growth equation.

$$p_n = p_o e^{k(t_n - t_o)}$$

where p_n = future population in year, t_n
 p_o = initial population in year, t_o
 k = annual growth rate, fractional
 t_n = future year
 t_o = initial year

Table 5-3 summarizes the annual population and energy growth rate scenarios evaluated: Stimulated, Business as Usual, and Controlled. The three sectors examined in each scenario are electrical generation, transportation, and other (includes residential and industrial/commercial non-highway use). The Stimulated scenario shows the electrical generation sector keeping its present pace, while the transportation sector increases during the 1980's and slows down in the 1990's. The other sector increases in the 1990's. The Business as Usual scenario follows a pattern similar to the Stimulated scenario except the growth rates are lower. The Controlled scenario shows a negative growth rate in the transportation sector which eventually increases with time. The electrical sector has the lowest growth as does the other sector compared to the rest of the scenarios. The demand scenarios already take into account conservation measures.

Table 5-4 shows the year the various indigenous energy resources become operational and the amount of energy generated (B). The units are interchanged between BTU, a unit of energy, and megawatts (MW), a unit of power. The matter of mixing power and energy is avoided because the megawatt power rating is implicitly multiplied by 365 days per year times 24 hours per day to convert to energy. In the computer calculations, the units are converted to BTU per year and the tabulated values in the electrical sector are treated as primary figures (i.e., the number amount of BTU's necessary to produce one kilowatt-hour—the state average figure used was 11,150 BTU per KWH).

TABLE 5-2

ACTIONS TO ACCELERATE ALTERNATE
ENERGY DEVELOPMENT

Source	Near-Term Present to 1982	Mid-Term 1983 to 1990	Far-Term 1990 on
Govt.	Establish a county energy office, with energy commission made up of local representatives from industry, community, etc.	Total utilization of gasohol in county vehicles	Continue
	Pass added gas tax (20% of existing tax). Utilize for alternate energy development	Test use of electric vehicles for county fleet	Continue
	Push for tax credit on all natural energy resource use in power generation and liquid fuel production	Increase non-gasohol fuel tax to 50% of existing county rate	Continue
	Push for tax exemption on liquid fuel from indigenous resources		
	Push to require solar hot water in all new large-scale use (600 gal.) construction	Require solar hot water in all new const. where applicable	Continue
	Retrofit energy systems in public buildings	Continue retrofit	Continue retrofit
		Require energy efficient concepts in all public housing	Continue
	Promote R&D of small scale appropriate technologies	Participate with business in developing small-scale appropriate tech. markets	Continue
	Solar water heating workshop on building your own solar collectors cheaply		
	Seek funding for construction of pilot/demo large-scale wind systems		
	Island-wide conversion of municipal waste	Continue	
Business & Industry	Push for state legislation on tax incentives for use of natural indigenous resources in power generator or liquid fuel production		
	Push for state legislation on property tax break on land using natural energy resources		
	Initiate retrofit of existing hot water to solar		

TABLE 5-2 (cont'd)

Source	Near-Term Present to 1982	Mid-Term 1983 to 1990	Far-Term 1990 on
	<p>Initiate design and const. of commercial ethanol plant</p> <p>Initiate research into alt. use of sugar cane</p> <p>Initiate construction of large-scale wind systems (1 MW)</p> <p>Retrofit current hydro efficiencies and add hydro units (3 MW total)</p> <p>Increase bagasse conversion efficiencies by renovating systems or bringing in new systems</p> <p>Lihue-plantation renovated energy efficient - more power production (25×10^6 kwh)</p> <p>Promote and develop commercial energy farms (tree farms)</p> <p>Feasibility study on converting sugar industry to energy farms</p> <p>Use of municipal waste for power generation at Lihue plantation</p> <p>Initiate study of solar re-powering of electric utility</p> <p>Initiate study of use of solar photovoltaic cells for power generation</p> <p>Initiate co-generation project-waste heat recovery at electric utility</p>	<p>Expand energy conserving businesses - solar, etc. 2000 new solar installations</p> <p>Experiment with adaptation of diesel to ethanol</p> <p>Market gasohol & pure ethanol to public</p> <p>Initiate design and construction of commercial methanol plant</p> <p>Install additional large-scale wind systems (5 MW)</p> <p>Install run-of-river hydro units (5 MW total)</p> <p>Total utilization of bagasse and trash for power generation</p> <p>McBryde plant renovated energy efficient - more power production (25×10^6 kwh)</p> <p>Initiate commercial power from energy tree farms (15,000 acres)</p> <p>Convert Sugar Industry to energy farms - maximize fiber to 30% more (switch to 1 year crops, high fiber content)</p> <p>Use of all island municipal waste for power generation at sugar power plants</p> <p>Install solar thermal unit for repowering at electric utility (2-10 MW units total)</p> <p>Feasibility study on ocean energy use for Kauai County</p> <p>Install solar photovoltaic units for power generation (3 MW total)</p>	<p>Total switchover from diesel to ethanol</p> <p>Use of methanol fuel</p> <p>Develop local plastics industry from sugar</p> <p>Install additional large scale wind systems (98 MW Total)</p> <p>Install run of river hydro units (10 MW total)</p> <p>Additional 15,000 acres to energy tree farms</p> <p>Install additional solar thermal electric units (3-10 MW units total)</p> <p>Install additional solar photovoltaic units (3-5 MW units total)</p>

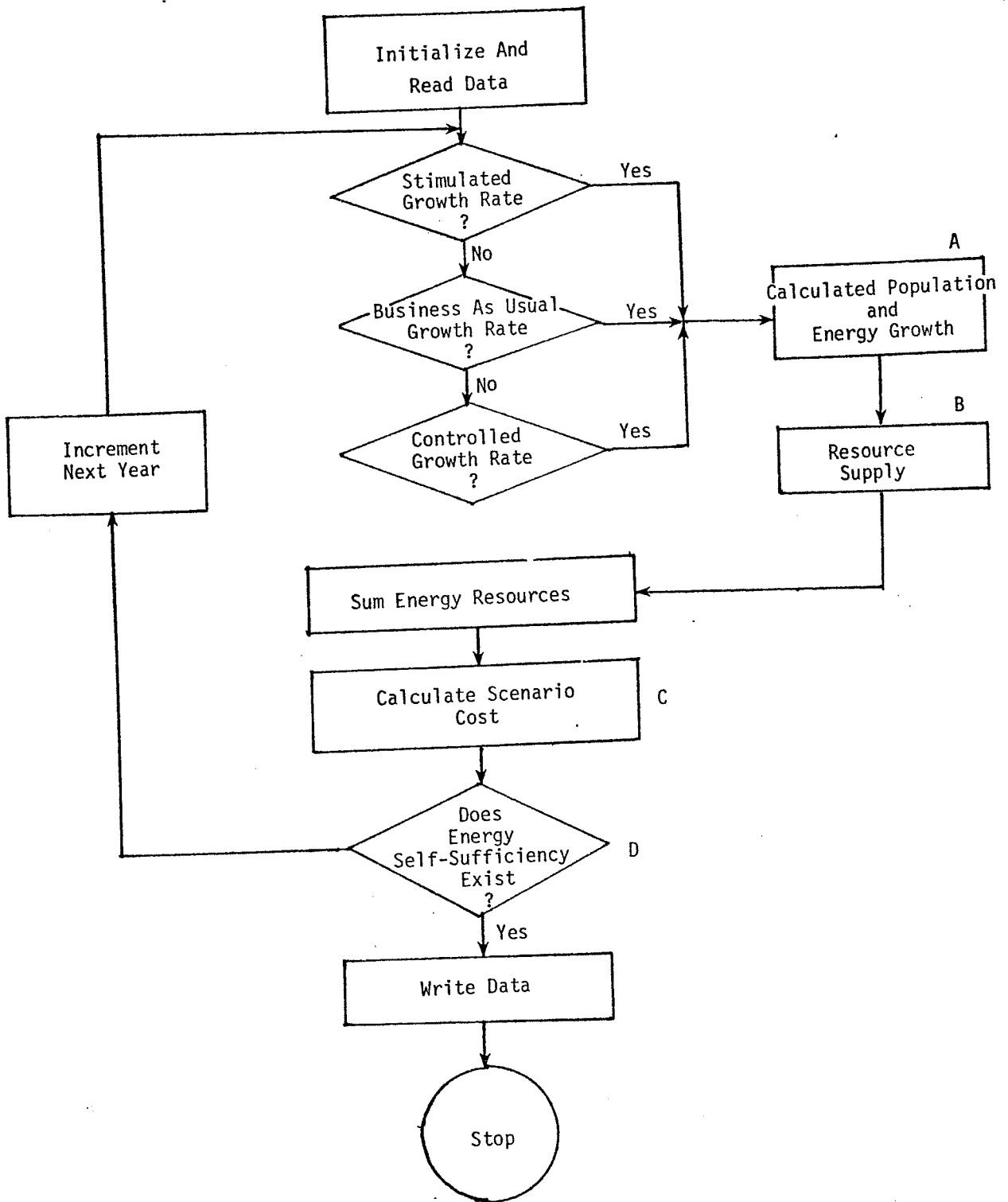


Figure 5-1. Flow Chart of Computer Program - KESS

TABLE 5-3. Growth Rates Examined, Fractional

<u>Year</u>	<u>Population</u>	<u>Electrical</u>	<u>Transportation</u>	<u>Other</u>
<u>Stimulated</u>				
1978 - 1980	0.04	0.065	0.017	0.020
1981 - 1990	0.03	0.065	0.058	0.020
1991 - 2000	0.03	0.065	0.029	0.020
<u>Business As Usual</u>				
1978 - 1980	0.025	0.053	0.037	0.015
1981 - 1990	0.025	0.053	0.050	0.015
1991 - 2000	0.025	0.053	0.020	0.020
<u>Controlled</u>				
1978 - 1980	0.025	0.040	-0.047	0.010
1981 - 1985	0.025	0.040	-0.010	0.010
1986 - 1990	0.025	0.040	0.012	0.010
1991 - 1995	0.025	0.040	0.013	0.015
1996 - 2000	0.025	0.040	0.030	0.015

Source [see section III]

TABLE 5-4. Projections For Natural Energy Resource
Production Levels

Year	Sector	Primary Energy	Comment
<u>Sugar Cane</u>			
1981	Electrical	456 x 10 ⁹ BTU/yr	Sugar companies update present facilities which will increase efficiencies
1983	Electrical Other	100 x 10 ⁹ BTU/yr 900 x 10 ⁹ BTU/yr	Burn trash fiber Burn trash fiber
1987	Electrical Other	231 x 10 ⁹ BTU/yr 1218 x 10 ⁹ BTU/yr	Sugar industry switches to 1-year crop--increases bagasse output by 30% 30% increase
<u>Municipal Waste</u>			
1985	Electrical	Function of population	0.59 tons of combustible waste per year per capita
<u>Co-Generation</u>			
1980	Electrical	8 MW	Kauai Electric use waste heat for energy production.
<u>Hydroelectric: Capacity factor ~ 32%</u>			
1983	Electrical	3 MW x 0.32	Installation of hydropower at various rivers on island
1987	Electrical	5 MW x 0.32	Installation of hydropower
1991	Electrical	5 MW x 0.32	
1995	Electrical	5 MW x 0.32	
<u>Pineapple: No resources</u>			
<u>Hay - Grass: No resources</u>			
<u>Trees</u>			
1988 1993	Electrical Electrical	1335.0 x 10 ⁹ BTU/yr 1335.0 x 10 ⁹ BTU/yr	15,000 acre tree farm of which 50% of trees go for electrical production
1988 1993	Transportation Transportation	735 x 10 ⁹ BTU/yr 735 x 10 ⁹ BTU/yr	
<u>Geothermal: No resources</u>			

TABLE 5-4. Projections For Natural Energy Resource
Production Levels (cont'd)

Year	Sector	Primary Energy	Comment
<u>Wind: Capacity factor ~ 35%</u>			
1983	Electrical	1 MW x 0.35	Install a total of 1 MW wind machine (wind survey limited to coastal areas)
1985	Electrical	1 MW x 0.35	
1987	Electrical	2 MW x 0.35	
1989	Electrical	2 MW x 0.35	
1990	Electrical	2 MW x 0.35	
1991-1994	Electrical	4 MW x 0.35	
1995-2002	Electrical	10 MW x 0.35	
<u>Solar Thermal Electric: Capacity factor ~ 50%</u>			
1990,1994, 1998,2002	Electrical	10 MW x 0.50	Install a total of 10 MW units at year specified
<u>Solar Photovoltaic: Capacity factor ~ 20%</u>			
1982	Electrical	0.1 MW x 0.20	Wilcox Hospital installation
1987	Electrical	1.0 MW x 0.20	
1991,1995	Electrical	2.0 MW x 0.20	
1999,2003	Electrical	5.0 MW x 0.20	
<u>Ocean Energy: Capacity factor ~ 70%</u>			
2000	Electrical	10 MW x 0.70	
2005	Electrical	25 MW x 0.70	
<u>Solar Hot Water</u>			
1980	Other	1% of electrical power	
1985	Other	2% of electrical power	
1990	Other	3% of electrical power	
1995	Other	4% of electrical power	
2000	Other	5% of electrical power	
2005	Other	6% of electrical power	
<u>Hydrogen: No resource</u>			
<u>Low Btu gas: No resource</u>			
<u>Intermediate Btu gas: No resource</u>			
<u>Methanol: Taken into account with Tree Resource</u>			
<u>Ethanol</u>			
1983	Transportation	350 x 10 ⁹ BTU	Ferment all available molasses on island to ethanol = 4.6 x 10 ⁶ gal

The energy technology costs (C) are given in Table 5-5. The majority of the costs were adapted from a recent Stanford Research Institute (SRI) study [4-20] and represent the total cost (capital plus operation and maintenance). These costs are inflated each year by an annual average rate of 8 percent. At this time no consideration has been given to the fact that technological breakthroughs should reduce the capital cost on various resources: wind, solar thermal electric, solar photovoltaic, and ocean energy. This reduction, coupled with the ever-increasing cost of petroleum, may make the resource unit cost-competitive. These figures are compared with the total cost of two types of diesel electrical generators: small peaking and large scale. The capital cost is inflated each year by 8 percent, while fuel cost increases by 10 percent (2 percent over inflation includes annual petroleum increase).

Energy self-sufficiency (D) is achieved when the total energy from indigenous resources is equal to or greater than the calculated required energy. Therefore, it is feasible to achieve energy self-sufficiency by transferring to the deficient sectors.

C. Discussion of Results

The three demand scenarios were examined with a supply of potential indigenous resources on the island of Kauai. Both the Stimulated (1) and Business as Usual (2) scenarios failed to achieve 100 percent energy self-sufficiency, while the Controlled (3) scenario was able to meet this goal in 1993. Table 5-6 shows a summary of the degree of self-sufficiency by each sector. Scenarios 1 and 2 reveal that the high growth rates in the electrical and transportation sectors make it difficult to reach self-sufficiency. The controlled scenario has the lowest electrical growth rate compared to the other two scenarios, and its transportation sector is the only one with a negative growth rate. This is due to the assumption of having more efficient cars on the road.

Figures 5-2 through 5-5 display the percent of energy imported per year of each scenario by individual sectors. The saddle effect on each plot is due to insufficient resource supply as the energy demand continues to grow. This points out the fact that to maintain some degree of self-sufficiency with time, either energy demand will have to be kept at a steady pace or additional resources will have to be developed to meet the increasing demand.

The amount of resource supply used in this study is that shown in Table 5-4; however, there is still room in various resources for additional units if cost considerations are ignored. These resources are trees, solar thermal electric, solar photovoltaic, and ocean energy. Therefore, the saddle effect can be eliminated by increasing or adding more units of the above technologies in each scenario. One should note also that the total cost will also rise with each additional unit.

TABLE 5-5. Total Cost of Natural Energy Resources by Sectors
 [\$/MM BTU]

Resource	Electrical Sector			Transportation Sector			Other Sector		
	CAP	O&M	T	CAP	O&M	T	CAP	O&M	T
Sugar Cane			6.2						2.1
Municipal Waste			6.7						
Co-Generation			7.8						
Hydroelectric			13.6						
Pineapple	8.8	10.6	19.4				1.6	2.4	4.0
Hay/Grass	8.8	10.6	19.4				1.6	2.4	4.0
Trees	8.8	10.6	19.4				1.6	2.4	4.0
Geothermal	15.5	5.0	20.5				2.2	0.7	2.9
Wind	30.8	2.9	33.7						
Solar Thermal Electric	37.2	1.8	39.0						
Solar Photovoltaic	59.2	0.6	59.8						
Ocean Energy	116.0	2.0	118.0						
Solar Hot Water							6.0	2.3	8.3
Hydrogen									
Low BTU Gas				2.5	3.0	5.5			
Intermediate BTU Gas				4.0	2.6	6.6			
Methanol				9.4	6.4	15.8			
Ethanol				3.6	14.9	18.5			
Improve Efficiency									
Electric									
Small Peaking	8.2	12.6	20.8						
Large Scale	2.9	9.7	12.6						

CAP = Capital Cost/Yr.

O&M = Operation & Maintenance Cost/Yr.

Source [4-19, 4-20]

TABLE 5-6. Year For Energy Self-Sufficiency
For Kauai County

Scenario	Year	Degree of Self-Sufficiency (Percent)			
		Electrical	Transportation (2)	Other	Total
Stimulated	2005 (1)	39	32	113	55
Business as Usual	2005 (1)	54	37	112	67
Controlled	1993	87	93	118	100

(1) Calculations carried out to year 2005

(2) Assumes all alcohol burning vehicles are commercially available

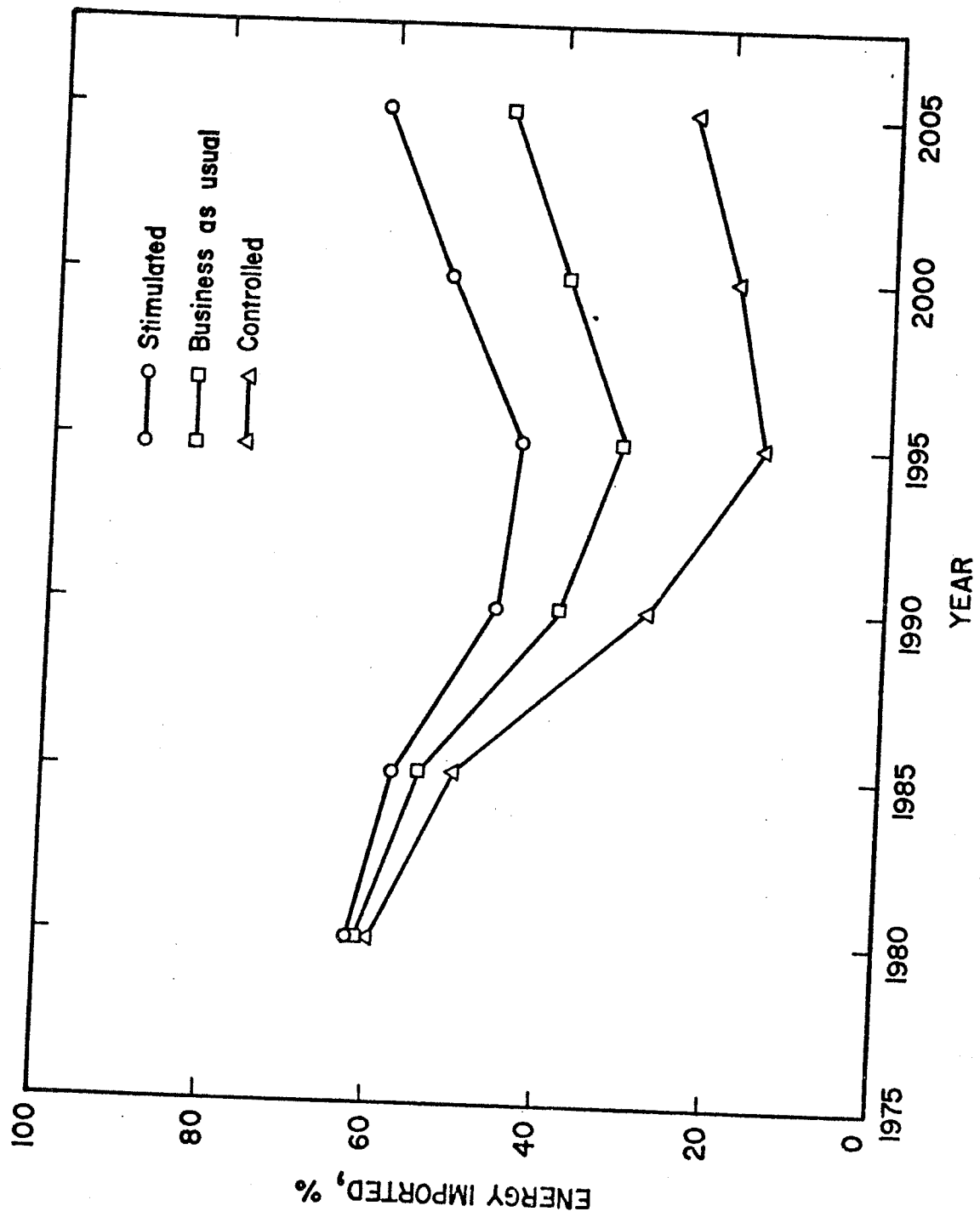


Figure 5-2. Percent of Energy Imported - Electrical Sector

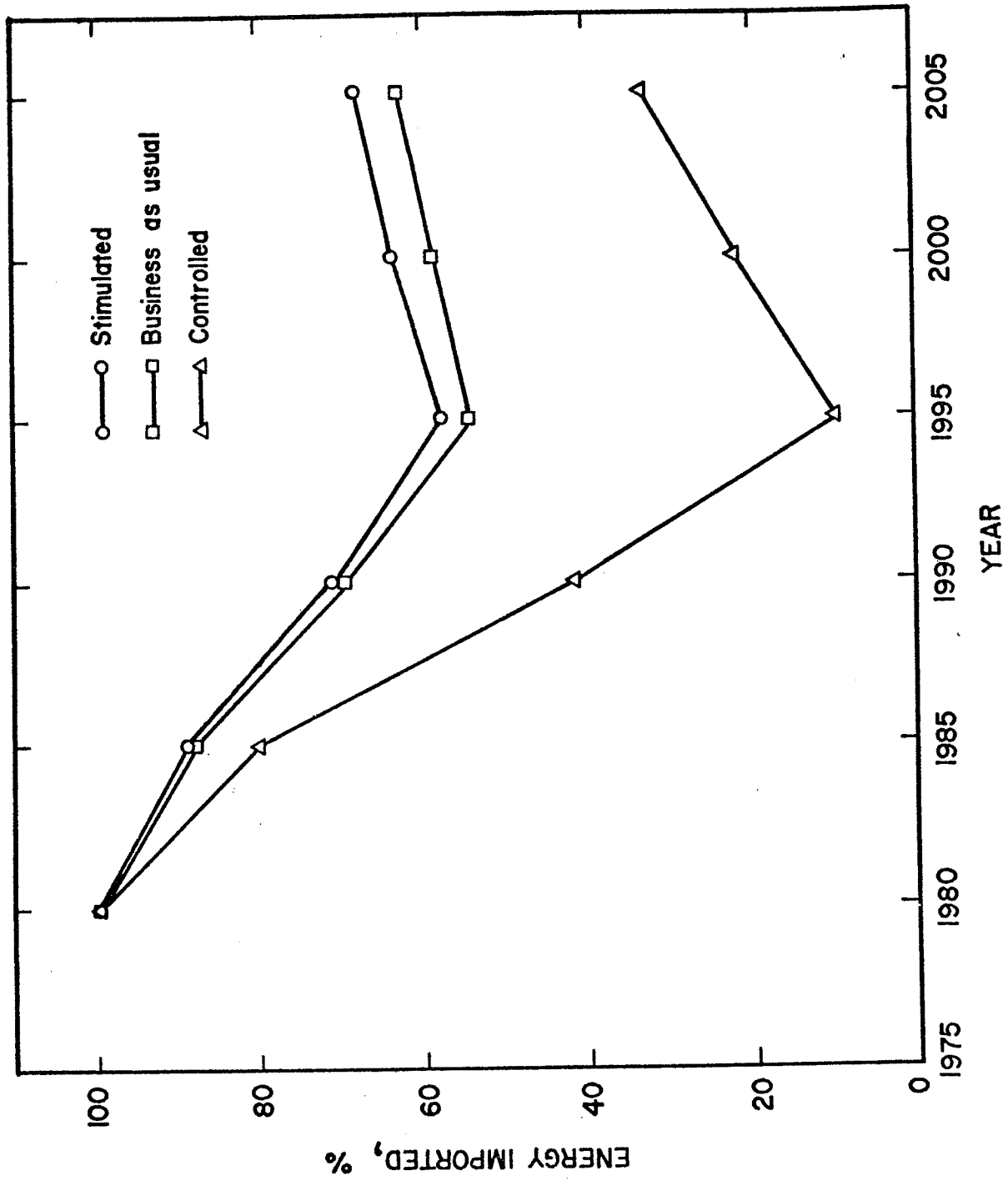


Figure 5-3. Percent of Energy Imported - Transportation Sector

Figure 5-3. Percent of Energy Imported - Transportation Sector

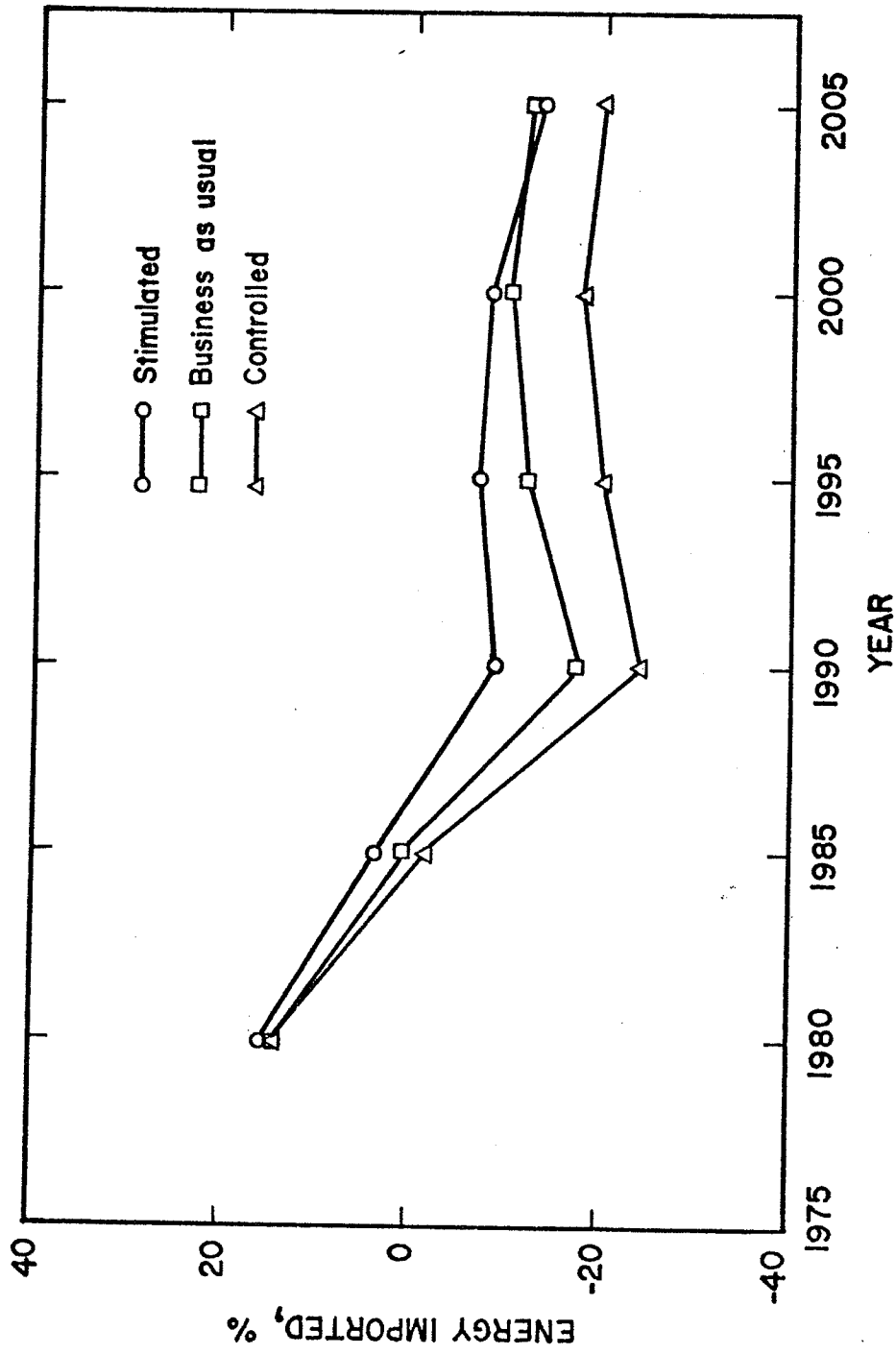


Figure 5-4. Percent of Energy Imported - Other Sector

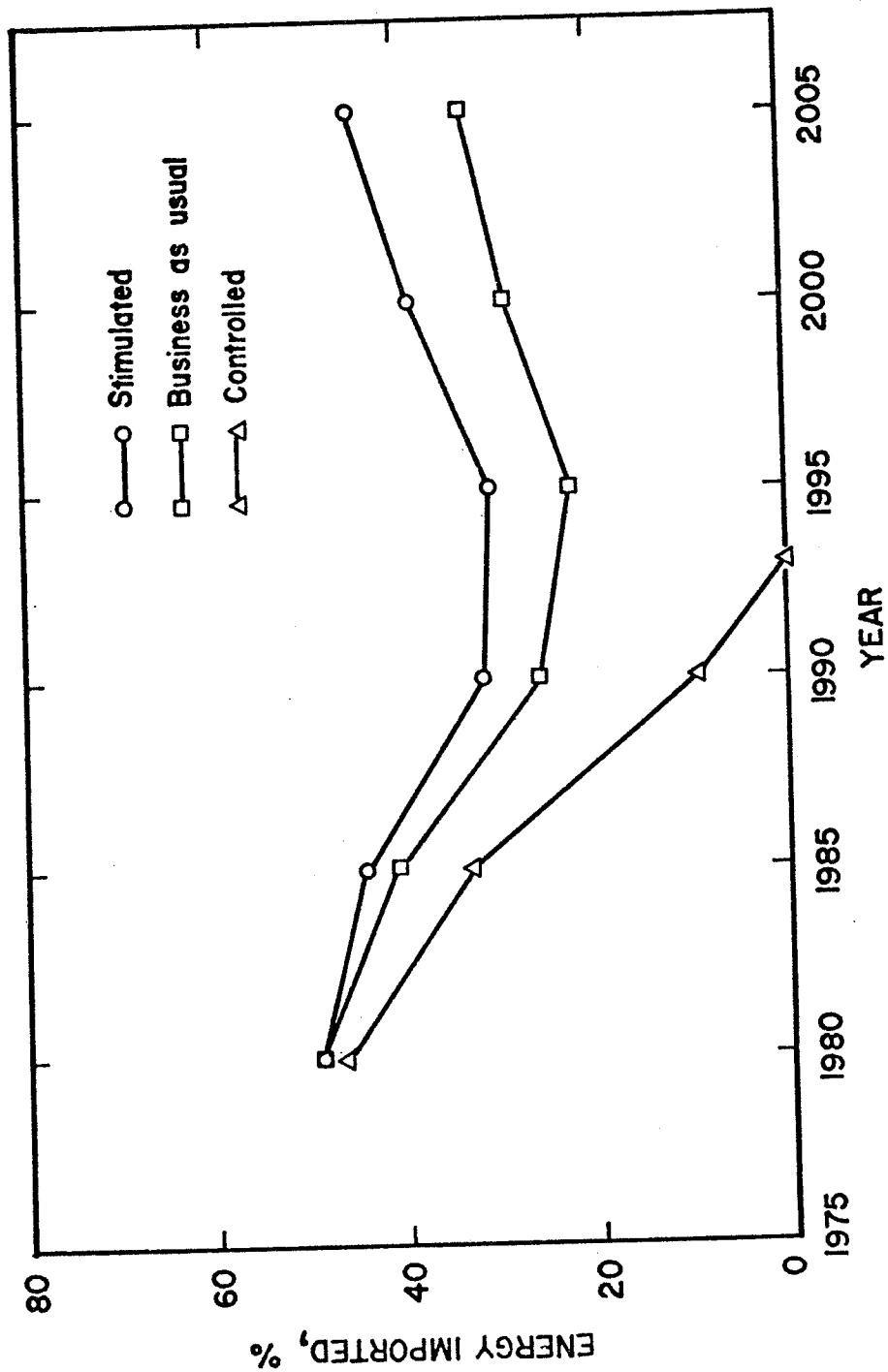


Figure 5-5. Percent of Total Energy Imported

Tables 5-7 through 5-9 present the final energy supply and demand scenarios at the end of the computer analysis. The Stimulated case shows that sugarcane is used predominantly as a resource supply—contributing about 22 percent of the total required energy. Solar water heating, trees (wood chip burning), methanol production (from trees) and wind follow as the next productive resources. In the electrical sector, trees, sugarcane, and wind are major factors while methanol and ethanol contribute to the transportation sector. Sugarcane and direct solar provide more than sufficient energy to satisfy the other sector.

In the Business as Usual scenario, the resources follow a pattern similar to Scenario 1, except the percentage contribution may be higher because of the lower energy demand.

In Scenario 3, Controlled Growth Rate, sugarcane contributes roughly 55 percent of the total required energy. The next major contributors are trees and methanol, with 19 and 10 percent, respectively. Trees, sugarcane, and hydroelectric power stand out in the electrical sector, while the other two sectors follow the same type of pattern stated earlier.

As mentioned earlier, the supply of various resources has not been fully developed, therefore additional units can be added to achieve at least electrical energy self-sufficiency. The Controlled Growth scenario, because it is only 13 percent away from electrical energy self-sufficiency, would be easy to achieve while the other two scenarios would require a much more vigorous campaign to reach this goal.

By expanding the tree farm by another 7500 acres, 1335×10^9 BTU/year will become available (trees would then account for 60 percent of the indigenous resources), thus making Kauai County electrically energy self-sufficient in 1993. A combination of solar thermal units, solar photovoltaic units and a smaller acreage of trees would certainly create the same results. Thus, electrical energy self-sufficiency is a viable goal that can be obtained in the Controlled Growth Scenario with slightly increased development.

Table 5-10 presents the total cost for achieving the degree of energy self-sufficiency shown in Table 5-6, along with the total oil equivalent cost and net savings by developing these resources. Scenarios 1 and 2 show that to attain 55 percent and 67 percent energy self-sufficiency, respectively, in the year 2005, it's going to cost roughly \$2.2 billion, while only \$352 million is needed in Scenario 3 to achieve 100 percent self-sufficiency. The cost for resource development appears very high, but in comparison to the total oil equivalent cost for that particular year, it is actually cheaper to develop the indigenous resources than to pay for foreign oil as presented in the final column in Table 5-10. The savings from natural energy development ranges from \$815 million in Scenario 1 to \$105 million in Scenario 3, although only partial energy self-sufficiency is met in Scenarios 1 and 2.

TABLE 5-7. Stimulated Growth Rate - Energy Scenario

2005 ENERGY SCENARIO FOR KAUAI COUNTY

STIMULATED GROWTH RATE

ELECTRICITY GROWTH RATE, EK = 0.0650

TRANSPORTATION GROWTH RATE, EK = 0.0280

OTHER GROWTH RATE, EK = 0.0200

POPULATION GROWTH RATE, PK = 0.0300

POPULATION = 85666.

ENERGY PER CAPITA (BTUx10**9) = 0.407

MODE	ELECTRICITY		TRANSPORTATION		OTHER		TOTAL	
	RESOURCE (BTUx10**9)	CUMULATIVE PERCENT	CUMULATIVE PERCENT	PERCENT	CUMULATIVE PERCENT	PERCENT	CUMULATIVE PERCENT	PERCENT
SUGAR CANE		1567.	0.	0.	6180.	77.	7747.	22.
MUNICIPAL WASTE		505.	0.	0.	0.	0.	505.	1.
CO-GENERATION		239.	0.	0.	0.	0.	239.	1.
HYDROELECTRIC		683.	0.	0.	0.	0.	683.	2.
PINEAPPLE		0.	0.	0.	0.	0.	0.	0.
HAY OR GRASS		0.	0.	0.	0.	0.	0.	0.
TREES		2670.	0.	0.	0.	0.	2670.	8.
GEOTHERMAL		0.	0.	0.	0.	0.	0.	0.
WIND		1088.	0.	0.	0.	0.	1088.	3.
SOLAR THER ELEC		747.	0.	0.	0.	0.	747.	2.
SOLAR PHOTOVOL		90.	0.	0.	0.	0.	90.	0.
OCEAN ENERGY		733.	0.	0.	0.	0.	733.	2.
SOLAR HOT WATER		0.	0.	0.	2864.	36.	2864.	8.
HYDROGEN		0.	0.	0.	0.	0.	0.	0.
LOW BTU GAS		0.	0.	0.	0.	0.	0.	0.
INTER. BTU GAS		0.	0.	0.	0.	0.	0.	0.
METHANOL		0.	1470.	25.	0.	0.	1470.	4.
ETHANOL		0.	350.	6.	0.	0.	350.	1.
IMPROVE EFF.		0.	0.	0.	0.	0.	0.	0.
TOTAL INDIGENOUS		8323.	1820.	32.	9044.	113.	19187.	55.
ENERGY REQUIRED		21098.	5768.	68.	7983.	-13.	34849.	45.
ENERGY IMPORTED		12774.	3948.	61.	-1061.	-13.	15661.	45.

TABLE 5-8. Business as Usual Energy Scenario

2005 ENERGY SCENARIO FOR KAUAI COUNTY

BUSINESS AS USUAL

ELECTRICITY GROWTH RATE, EK = 0.0530

TRANSPORTATION GROWTH RATE, EK = 0.0200

OTHER GROWTH RATE, EK = 0.0200

POPULATION GROWTH RATE, PK = 0.0250

POPULATION = 66385.

ENERGY PER CAPITA (BTUX10**9) = 0.417

MODE RESOURCE (BTUX10**9)	ELECTRICITY		TRANSPORTATION		OTHER		TOTAL	
	CUMULATIVE	PERCENT	CUMULATIVE	PERCENT	CUMULATIVE	PERCENT	CUMULATIVE	PERCENT
SUGAR CANE	1567.	10.	0.	0.	6180.	82.	7747.	28.
MUNICIPAL WASTE	392.	3.	0.	0.	0.	0.	392.	1.
CO-GENERATION	239.	2.	0.	0.	0.	0.	239.	1.
HYDROELECTRIC	683.	4.	0.	0.	0.	0.	683.	2.
PINEAPPLE	0.	0.	0.	0.	0.	0.	0.	0.
HAY OR GRASS	0.	0.	0.	0.	0.	0.	0.	0.
TREES	2670.	17.	0.	0.	0.	0.	2670.	10.
GEOTHERMAL	0.	0.	0.	0.	0.	0.	0.	0.
WIND	1088.	7.	0.	0.	0.	0.	1088.	4.
SOLAR THER ELEC	747.	5.	0.	0.	0.	0.	747.	3.
SOLAR PHOTOVOL	90.	1.	0.	0.	0.	0.	90.	0.
OCEAN ENERGY	733.	5.	0.	0.	0.	0.	733.	3.
SOLAR HOT WATER	0.	0.	0.	0.	2213.	29.	2213.	8.
HYDROGEN	0.	0.	0.	0.	0.	0.	0.	0.
LOW BTU GAS	0.	0.	0.	0.	0.	0.	0.	0.
INTER. BTU GAS	0.	0.	0.	0.	0.	0.	0.	0.
METHANOL	0.	0.	1470.	30.	0.	0.	1470.	5.
ETHANOL	0.	0.	350.	7.	0.	0.	350.	1.
IMPROVE EFF.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL INDIGENOUS ENERGY REQUIRED	8210.	54.	1820.	37.	8393.	112.	19423.	67.
ENERGY IMPORTED	15259.		4915.		7518.		27692.	
	7050.	46.	3095.	63.	-875.	-12.	9270.	33.

TABLE 5-9. Controlled Growth Rate Energy Scenario

1993 ENERGY SCENARIO FOR KAUAI COUNTY

CONTROLLED GROWTH RATE

ELECTRICITY GROWTH RATE, EK = 0.0400

TRANSPORTATION GROWTH RATE, EK = 0.0130

OTHER GROWTH RATE, EK = 0.0150

POPULATION GROWTH RATE, PK = 0.0250

POPULATION = 49179.

ENERGY PER CAPITA (BTUX10**9) = 0.287

MODE	ELECTRICITY		TRANSPORTATION		OTHER		TOTAL	
	RESOURCE (BTUX10**9)	CUMULATIVE PERCENT	CUMULATIVE PERCENT	PERCENT	CUMULATIVE PERCENT	PERCENT	CUMULATIVE PERCENT	PERCENT
SUGAR CANE	1567.	24.	0.	0.	6180.	113.	7747.	55.
MUNICIPAL WASTE	269.	4.	0.	0.	0.	0.	269.	2.
CO-GENERATION	239.	4.	0.	0.	0.	0.	239.	2.
HYDROELECTRIC	635.	10.	0.	0.	0.	0.	635.	5.
PINEAPPLE	0.	0.	0.	0.	0.	0.	0.	0.
HAY OR GRASS	0.	0.	0.	0.	0.	0.	0.	0.
TREES	2670.	40.	0.	0.	0.	0.	2670.	19.
GEOTHERMAL	0.	0.	0.	0.	0.	0.	0.	0.
WIND	209.	3.	0.	0.	0.	0.	209.	1.
SOLAR THER ELEC	149.	2.	0.	0.	0.	0.	149.	1.
SOLAR PHOTOVOL	19.	0.	0.	0.	0.	0.	19.	0.
OCEAN ENERGY	0.	0.	0.	0.	0.	0.	0.	0.
SOLAR HOT WATER	0.	0.	0.	0.	313.	6.	313.	2.
HYDROGEN	0.	0.	0.	0.	0.	0.	0.	0.
LOW BTU GAS	0.	0.	0.	0.	0.	0.	0.	0.
INTER. BTU GAS	0.	0.	0.	0.	0.	0.	0.	0.
METHANOL	0.	0.	1470.	75.	0.	0.	1470.	10.
ETHANOL	0.	0.	350.	18.	0.	0.	350.	2.
IMPROVE EFF.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL INDIGENOUS	5758.	87.	1820.	63.	6493.	118.	14071.	100.
ENERGY REQUIRED	6647.		1961.		5486.		14074.	
ENERGY IMPORTED	889.	13.	141.	7.	-1006.	-18.	23.	0.

TABLE 5-10. Total Cost For Energy Self-Sufficiency For Kauai
[Million Dollars]

Scenario	Year	Cost For Self-Sufficiency (Degree of Self-Sufficiency)				Total Cost Oil Equivalent (2)	Net Savings By Developing Natural Resources
		Electrical	Transportation	Other	Total		
1. Stimulated	2005 (1)	2024.0 (39)	74.1 (32)	159.0 (113)	2257.1 (55)	3072.3	815.2
2. Business as Usual	2005 (1)	2020.6 (54)	74.1 (37)	121.8 (112)	2216.5 (67)	2407.0	190.5
3. Controlled	1993	262.8 (87)	74.1 (93)	15.1 (118)	352.1 (100)	457.3	105.2

(1) Calculations carried out to year 2005

(2) 1979 oil cost at \$22/bbl inflated at 10 percent per year and other O&M cost at 8 percent per year plus capital cost at \$1000/kw inflated at 8 percent per year in electrical sector

The net cost for achieving energy self-sufficiency in the electrical sector is presented in Table 5-11. The final column shows that net costs of achieving 39 and 54 percent electrical self-sufficiency in Scenarios 1 and 2 are \$826 and \$720 million, respectively. In Scenario 3, however, an actual savings of \$135 million is realized by developing natural resources for 87 percent electrical self-sufficiency. As stated earlier, 100 percent electrical self-sufficiency by additional acreage in tree farming in the Controlled Growth Scenario is obtainable. The extra cost for the development wouldn't exceed the net savings. Figure 5-6 shows the projected fuel cost for each scenario examined. As is to be expected, the larger the energy demand, the greater the energy cost will be.

Tables 5-12 through 5-14 present the total cost of achieving some degree of energy self-sufficiency. As mentioned earlier, approximately \$2.2 billion will be needed to reach 55 percent net self-sufficiency in Scenario 1. The most expensive resources are ocean energy, wind, solar thermal electric, solar hot water, and trees—totalling \$2.0 billion. However, these resources contribute only 23 percent of the total required energy, while the remaining 22 percent costs only \$0.2 billion. These resources are sugarcane, municipal waste, and hydroelectric. Scenario 2 reflects this same basic pattern.

Trees for electrical generation and methanol production appear outstanding in Scenario 3. Of the \$352 million needed to achieve net energy self-sufficiency, trees cost \$208 million or almost 60 percent of the total cost, while contributing almost 30 percent of the total required energy. The next highest cost resources are wind and solar thermal electric—\$85.2 million or 24 percent of the total cost, while supplying only 2 percent of the total required energy. Therefore, 68 percent net energy self-sufficiency can be met for a total cost of \$99 million.

It should be pointed out again that the cost figures are inflated at an annual rate of 8 percent and hence represent current dollars. Most of these technologies (wind, solar thermal electric, solar photovoltaic, and ocean energy) are currently in the developmental or pilot stages; thus the costs are high. This analysis does not take into account an anticipated decrease in capital cost with mass production of these technologies in the future. Figure 5-7 presents an example of this case. The cost of oil is rising at an annual rate of 10 percent or 2 percent petroleum price increase over inflation rate, while the solar photovoltaic cost is rising at an 8 percent inflated rate. If these two solid line plots were correct, solar photovoltaic technology would never enter the energy scene because it would never be cost competitive with petroleum, unless government subsidies or some other incentives are introduced to close the gap between the plots. The dashed line represents a possible cost reduction with technological breakthrough which shows solar photovoltaic technology may be cost competitive in the year 2014 (plots cross over). This figure represents only the conditions stated previously. The cross over point may appear sooner or even later, depending on a number of factors beyond our control: inflation varies from 8 percent

TABLE 5-11. Net Cost of Achieving Energy Self-Sufficiency in Electrical Sector, Kauai
 [Million Dollars]

(1)	Year Year	Total Cost of Alternate Energy Demand	% Electrical Self-Sufficiency Achieved	Total Cost Oil Equivalent of Alternate Energy	Net Costs of Achieving % Self-Sufficiency
	(2)	(3)	(4)	(5)	(6) = (3) - (5)
Stimulated Growth Demand	2005	2024.0	39	1198	826.0
Business as Usual	2005	2020.6	54	1300	720.8
Controlled Growth	1993	262.8	87	397	(-135.0)

- (3) Estimated total cost of developing alternative energy
- (5) Oil equivalent alternative energy evaluated at 10 percent increase per annum
- (6) Additional costs necessary to achieve respective degree of self-sufficiency

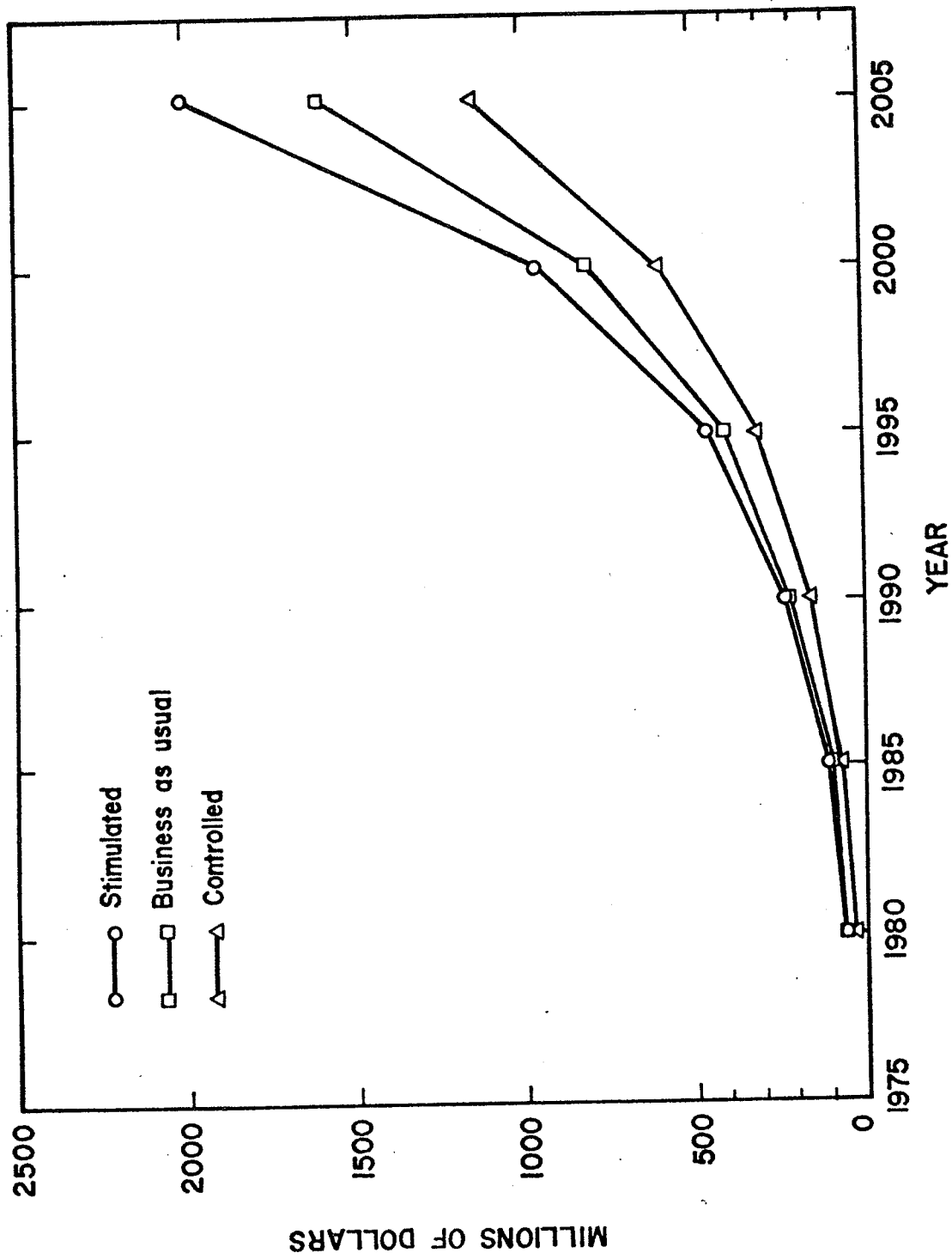


Figure 5-6. Cumulative Cost of Oil Equivalent for Total Energy Required*
 *1979 oil cost \$22/bbl inflated at 10%

TABLE 5-12. Stimulated Growth Rate Energy Scenario Cost

2005 ENERGY SCENARIO COST FOR KAUAI COUNTY

INFLATION GROWTH RATE, AFLA = 0.0800

PETROLEUM COST GROWTH RATE, BPET = 0.0200

ENERGY SOURCE	\$/MM BTU				ELEC	TRANS	OTHER	ELEC	TRANS	OTHER	INCR TOTAL
	ELEC	TRANS	OTHER	(MILLION DOLLARS)							
SUGAR CANE	53.8	0.0	21.7	7.5	0.0	9.6	17.1				
MUNICIPAL WASTE	58.1	0.0	0.0	11.9	0.0	0.0	11.9				
CO-GENERATION	67.6	0.0	0.0	2.2	0.0	0.0	2.2				
HYDROELECTRIC	117.9	0.0	0.0	19.7	0.0	0.0	19.7				
PINEAPPLE	168.2	0.0	34.7	0.0	0.0	0.0	0.0				
HAY OR GRASS	168.2	0.0	34.7	0.0	0.0	0.0	0.0				
TREES	168.2	0.0	34.7	143.6	0.0	0.0	143.6				
GEOTHERMAL	177.8	0.0	25.1	0.0	0.0	0.0	0.0				
WIND	292.2	0.0	0.0	491.7	0.0	0.0	491.7				
SOLAR THERMAL ELECTRICITY	338.2	0.0	0.0	283.1	0.0	0.0	283.1				
SOLAR PHOTOVOLTAIC	345.1	0.0	0.0	94.5	0.0	0.0	94.5				
OCEAN ENERGY	1023.2	0.0	0.0	969.8	0.0	0.0	969.8				
SOLAR HOT WATER	0.0	0.0	72.0	0.0	0.0	149.4	149.4				
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
LOW BTU GAS	0.0	47.7	0.0	0.0	0.0	0.0	0.0				
INTERMEDIATE BTU GAS	0.0	57.2	0.0	0.0	0.0	0.0	0.0				
METHANOL	0.0	137.0	0.0	0.0	0.0	0.0	0.0				
ETHANOL	0.0	160.4	0.0	0.0	64.4	0.0	64.4				
IMPROVE EFFICIENCY	0.0	0.0	0.0	0.0	9.7	0.0	9.7				
TOTAL COST				2024.0	74.1	159.0	2257.1				
FUEL COST: ENERGY REQD	58.0			1224.3	334.7	463.3	2022.3				
FUEL COST: ENERGY IMPORT	58.0			741.3	229.1	-61.6	908.8				
SMALL PEAKING: DIESEL	258.6			1196.3							
LARGE SCALE: DIESEL	169.5			768.9							

TABLE 5-13. Business as Usual Energy Scenario Cost

2005 ENERGY SCENARIO COST FOR KAUAI COUNTY

INFLATION GROWTH RATE, AFLA = 0.0800

PETROLEUM COST GROWTH RATE, BPET = 0.0200

ENERGY SOURCE	\$/MM BTU			ELEC	TRANS	OTHER	ELEC	TRANS	OTHER	INCR TOTAL
	ELEC	TRANS	OTHER							
SUGAR CANE	53.8	0.0	21.7	7.5	0.0	9.6	7.5	0.0	9.6	17.1
MUNICIPAL WASTE	58.1	0.0	0.0	8.5	0.0	0.0	8.5	0.0	0.0	8.5
CO-GENERATION	67.6	0.0	0.0	2.2	0.0	0.0	2.2	0.0	0.0	2.2
HYDROELECTRIC	117.9	0.0	0.0	19.7	0.0	0.0	19.7	0.0	0.0	19.7
PINEAPPLE	168.2	0.0	34.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAY OR GRASS	168.2	0.0	34.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TREES	168.2	0.0	34.7	143.6	0.0	0.0	143.6	0.0	0.0	143.6
GEOTHERMAL	177.8	0.0	25.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	292.2	0.0	0.0	491.7	0.0	0.0	491.7	0.0	0.0	491.7
SOLAR THERMAL ELECTRICITY	338.2	0.0	0.0	283.1	0.0	0.0	283.1	0.0	0.0	283.1
SOLAR PHOTOVOLTAIC	345.1	0.0	0.0	94.5	0.0	0.0	94.5	0.0	0.0	94.5
OCEAN ENERGY	1023.2	0.0	0.0	969.8	0.0	0.0	969.8	0.0	0.0	969.8
SOLAR HOT WATER	0.0	0.0	72.0	0.0	0.0	112.2	0.0	0.0	112.2	112.2
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOW BTU GAS	0.0	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INTERMEDIATE BTU GAS	0.0	57.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
METHANOL	0.0	137.0	0.0	0.0	64.4	0.0	0.0	64.4	0.0	64.4
ETHANOL	0.0	160.4	0.0	0.0	9.7	0.0	0.0	9.7	0.0	9.7
IMPROVE EFFICIENCY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL COST				2020.6	74.1	121.8	2020.6	74.1	121.8	2216.5
FUEL COST: ENERGY REQD	58.0			885.5	285.2	436.3	885.5	285.2	436.3	1607.0
FUEL COST: ENERGY IMPORT	58.0			409.1	179.6	-50.8	409.1	179.6	-50.8	537.9
SMALL PEAKING: DIESEL	258.6			1182.4			1182.4			
LARGE SCALE: DIESEL	169.5			759.9			759.9			

TABLE 5-14. Controlled Growth Energy Scenario Cost

1993 ENERGY SCENARIO COST FOR KAUAI COUNTY

INFLATION GROWTH RATE, AFLA = 0.0800

PETROLEUM COST GROWTH RATE, BPET = 0.0200

ENERGY SOURCE	\$/MM BTU				ELEC	TRANS (MILLION DOLLARS)	OTHER (MILLION DOLLARS)	INCR TOTAL
	ELEC	TRANS	OTHER					
SUGAR CANE	20.6	0.0	8.3					
MUNICIPAL WASTE	22.2	0.0	0.0		7.5	0.0	9.6	17.1
CO-GENERATION	25.9	0.0	0.0		3.3	0.0	0.0	3.3
HYDROELECTRIC	45.2	0.0	0.0		2.2	0.0	0.0	2.2
PINEAPPLE	64.4	0.0	0.0		11.7	0.0	0.0	11.7
HAY OR GRASS	64.4	0.0	13.3		0.0	0.0	0.0	0.0
TREES	64.4	0.0	13.3		0.0	0.0	0.0	0.0
GEOTHERMAL	68.1	0.0	13.3		143.6	0.0	0.0	143.6
WIND	111.9	0.0	9.6		0.0	0.0	0.0	0.0
SOLAR THERMAL ELECTRICITY	129.5	0.0	0.0		54.7	0.0	0.0	54.7
SOLAR PHOTOVOLTAIC	132.1	0.0	0.0		30.5	0.0	0.0	30.5
OCEAN ENERGY	391.8	0.0	0.0		9.3	0.0	0.0	9.3
SOLAR HOT WATER	0.0	0.0	0.0		0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	27.6		0.0	0.0	5.6	5.6
LOW BTU GAS	0.0	18.3	0.0		0.0	0.0	0.0	0.0
INTERMEDIATE BTU GAS	0.0	21.9	0.0		0.0	0.0	0.0	0.0
METHANOL	0.0	52.5	0.0		0.0	0.0	0.0	0.0
ETHANOL	0.0	61.4	0.0		0.0	64.4	0.0	64.4
IMPROVE EFFICIENCY	0.0	0.0	0.0		0.0	9.7	0.0	9.7
TOTAL COST					262.8	74.1	15.2	352.1
FUEL COST: ENERGY REQD	17.5				116.2	34.3	95.9	246.3
FUEL COST: ENERGY IMPORT	17.5				15.5	2.5	-17.6	0.4
SMALL PEAKING: DIESEL	83.7				310.9			
LARGE SCALE: DIESEL	53.1				195.3			

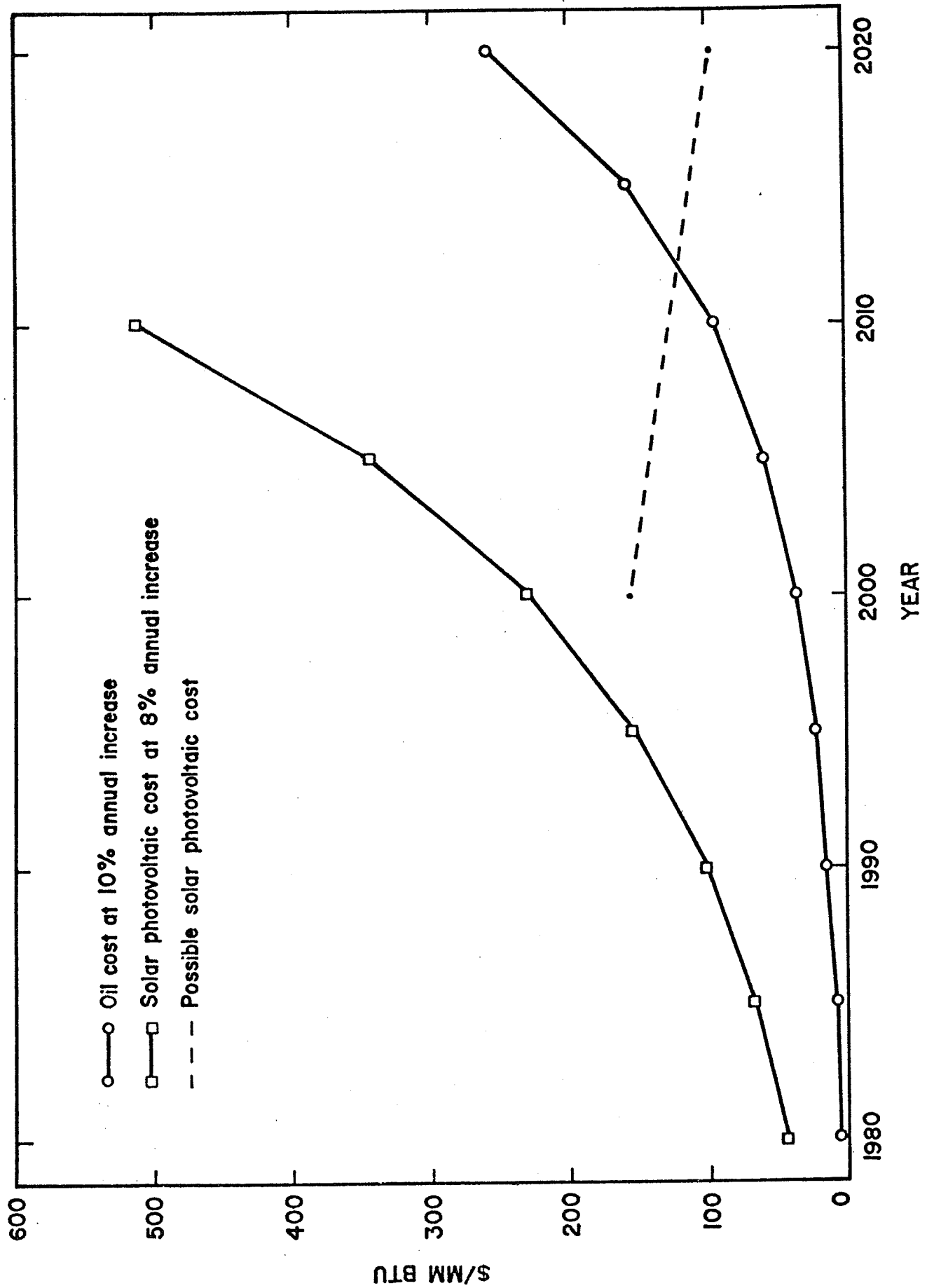


Figure 5-7. Cost Effectiveness of Solar Photovoltaic Unit

used, petroleum price varies from 2 percent used, or technological breakthrough is realized. Therefore, the total cost figure should be considered to be the upper limit in each of the scenarios examined.

As presented in Scenario 3, although energy self-sufficiency is met, the electrical and transportation sectors are still importing petroleum products. Increased supply in trees, solar thermal electric, solar photovoltaic, or ocean energy could easily place the electrical sector as an energy supplier; however, the transportation sector proves to be more difficult to satisfy. There is hope in the way of electric vehicles, hybrid vehicles (electrical-internal combustion option), or hydrogen vehicles. None of these technologies have been included in the analysis but do deserve mention since their application on Kauai could be very critical.

Electric vehicles are being used in various areas. The main problem seems to be battery storage, which affects driving range and acceleration. Work is now being concentrated in the high energy density batteries which may be the hope for the future. Hybrid cars are in the developmental stage but may prove helpful in the future. Hydrogen vehicles are in operation also but are still considered to be in the developmental stage. The fuel of the future may be the answer to the petroleum crisis which we now face; however, its full development is considered to be near the turn of the century.

Thus far, only the costs of providing energy from alternative sources have been considered. It was concluded that replacing conventional petroleum-based energy will certainly not be cheap, although by so doing hundreds of millions of dollars can be saved over the next two decades or so. These savings are realized primarily because of reduced dependence on petroleum. This fact is clearly demonstrated in Tables 5-10 and 5-11.

There are at least two additional considerations that must be taken into account in assessing the merits of developing alternative energy resources. They are the associated income and employment impacts. In 1978, Kauai County had approximately 14,000 civilian jobs which earned a total income of \$220 million. In the same year Kauai imported about \$15.0 million worth of petroleum for non-electrical use and an additional \$6.7 million for electrical generation. The total of \$21.7 million spent represented \$630 per person. This cost would have risen to over \$35 million, or \$1000 per person in 1979 fuel prices. And there is no end in sight. Another way of looking at this is that nearly 18 cents of every dollar taken home by Kauai residents leaked out of the County to pay for the fuel they used.

The leakage of the \$21.7 million is permanently lost to the island economy and thus fails to create jobs. If the same amount of money were spent developing indigenous resources within

Figure 5-7. U.S. ELECTRICITY CONSUMPTION

the County, more than \$33 million income would be generated, and at the same time in the order of 1000 to 1500 jobs would be created [5-1].

Natural energy development, no matter what degree of self-sufficiency may be achieved, means income and jobs for the residents. In fact, every one million dollars spent on renewable resource development in Kauai will create one-and-a-half million dollars of income and 65 jobs. More specifically, Kauai could conceivably spend any amount from \$250 million to over \$2 billion in energy development over the next 25 years. This not only would afford the island a greater degree of energy independence, but, perhaps more importantly, would provide a new industry with an opportunity of maintaining full employment throughout the period.

These economic impacts should be given serious consideration, along with the cost estimate provided in this study, in assessing alternative energy development strategy.

VI. CONCLUSIONS

As this study shows, achieving energy self-sufficiency will require considerable time, effort, and expense, but the initial steps must be taken now if we are ever to realize success. The first step should be to establish a county energy office to coordinate local efforts toward energy self-sufficiency. This office would aid in the development and implementation of local, state, and federal energy programs, assist and expedite the actions of local business and industry, and provide consultation, educational information and design assistance to local residents. One of its first tasks would be to prepare an implementation plan, expanding and refining the present study to improve the economic and financial analyses, prepare in-depth analyses of social, environmental, and legal issues, and develop specific hardware requirements.

In the face of diminishing supplies of petroleum and increasing costs of energy, the most immediate, and prudent, actions to be taken are to eliminate as much waste as possible, to reduce consumption by avoiding excessive or unnecessary uses of energy, and to improve the efficiencies of energy-using devices. Conservation of fuels from presently available sources will alleviate difficulties until increased supplies of energy from Kauai's own natural resources can be developed. Suggested actions for energy conservation by government, business and industry, and the community are given in Section 5 of this report.

Development and application of alternative sources of energy is much more a financial issue than a technological one. If the necessary capital can be found, present technology can provide a substantial portion of Kauai's energy needs, for example, through increased use of solar

water heaters, increased use of bagasse, expansion of hydroelectric facilities, and installation of wind machines for electricity generation, and production of ethanol for automotive fuel. Solar thermal and solar photovoltaic generation of electricity and synthetic fuels from cellulose for transportation require further development but should become available by the latter part of this decade. What is most needed now is a well thought out plan and initiation of its implementation.

Kauai County possesses an abundance of indigenous resources which could be developed to meet most of its energy needs. From the results of this study, it appears that the cost of achieving a moderate to high degree of energy self-sufficiency will be less than the equivalent oil cost. Developing the natural energy resources will permit the use of funds for new energy generating industries that would otherwise have gone out of state to pay for imported petroleum. The alternative to non-development could be economic disorder from depending upon an unstable and escalating cost commodity—petroleum.

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