ENERGY SELF-SUFFICIENCY FOR THE COUNTY OF KAUAI

VOLUME 2: GENERAL ENERGY PLAN

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I. INTRODUCTION

The Kauai Energy Self-Sufficiency Committee was authorized by the Kauai County Council and appointed by Mayor Eduardo E. Malapit to conduct an energy self-sufficiency study for the County of Kauai. The study objective, as given by Resolution No. 164 of the County Council, County of Kauai, was to develop a comprehensive energy self-sufficiency plan, including both energy conservation and alternative sources development, to assist the people of Kauai to meet their future energy needs in ways which will significantly reduce their present dependence on imported petroleum.

The study results are reported in three volumes, Volume 1: Energy Data, Volume 2: General Energy Plan, and Volume 3: Committee Task Force reports.

A. Summary of Volume 1: Energy Data

The counties of the State of Hawaii follow a general pattern in sources of energy—high dependency on petroleum products, with some bagasse burning and hydroelectric power. The differences among counties are found in the distribution of these energy resources. Nearly 50 percent of the energy originates from petroleum products on Kauai.

The chief consumers of petroleum are the electrical generation and ground transportation sectors--namely, boiler fuel, diesel oil, and gasoline. Together they comprise almost 90 percent of the total petroleum used on Kauai. Indigenous energy resources contribute over 50 percent of the rest of the energy sources on Kauai. This is directly due to the sugar companies' practice of burning bagasse and use of irrigation waterways for hydroelectric power. The present contribution of indigenous resources represents a downward trend of the total sources of energy, since these figures have been relatively constant throughout recent history, while petroleum consumption has been increasing [1-1].

Kauai's population and hotel room growth indicate increases in residential population as well as tourism. Positive-growth trends for total petroleum consumption, electricity usage, and petroleum cost are also anticipated. More energy will therefore be needed in the future, undoubtedly, at higher cost. This shows a definite need for natural energy development and energy conservation.

Kauai, like the other counties, possesses an abundance of indigenous natural energy resources. Expanded utilization of biomass, along with solar and wind applications, provide Kauai with various routes to attain island energy self-sufficiency. Mount Waialeale, one of the wettest spots in the world, offers a large hydroelectric potential, while OTEC, wave action and quite possibly geothermal may also contribute to the sources of energy available sometime in the future.

B. Introduction to Volume 2: General Energy Plan

Volume 1 of the study, summarized above, presented background information concerning the environment, the economy, past trends in the use of energy, and potentially available natural energy resources of Kauai. In Section II of this volume present energy use patterns are described, updating the data of Volume 1 through 1978. Based upon past trends, three plausible scenarios of future economic growth and the corresponding projections of future energy demand are developed in Section III.

Potential sources of energy to meet projected demands are discussed in Section IV, including conservation and indigenous energy resources. The present state of energy technology and its implications for Kauai are reviewed, economic factors and environmental impact issues that will influence selection of sources are discussed, and current and planned research, development, and demonstration programs are described.

Section V presents an energy supply projection to be used in subsequent analysis. It represents a reasonable growth pattern in which sources available immediately and in the near future, conservation, biomass, solar water heating, and wind, are utilized in earlier years, augmented by solar power generation and ocean energy conversion, as they might be expected to become available. The results of analysis of the impact of this supply projection on each projected demand are discussed, including some economic impacts and alternatives that might increase future supply when projected supplies fall short of demand. Some general conclusions are drawn in Section VI.

II. KAUAI ENERGY USE PATTERN

Kauai's energy use pattern has changed somewhat within the last 10 years. One major change has been the shift of electrical production from the sugar plantations to the local utility (Kauai Electric). The reason for this is that the electrical demand for Kauai increased to a point where it exceeded the generating capacity of the sugar plantations. Due to the uncertainty of the sugar industry at that time, the sugar plantations decided not to invest capital funds into expanding their generating plants. As a result, Kauai Electric constructed its own generating facilities. Another major change in Kauai's energy use pattern was the large increase in the use of avaiation fuel and highway gasoline due to the growth of the tourist industry.

One significant fact was discovered after the Kauai Energy Self-Sufficiency Committee (KESCO) completed its investigation. In terms of primary energy used, approximately 50 percent was in the form of indigenous resources--mainly hydroelectric and bagasse, however, over 957,000 barrels of petroleum was still needed at a cost of approximately $21.7 million. Figure 2-1 presents the flow diagram of energy consumption on Kauai for 1978.

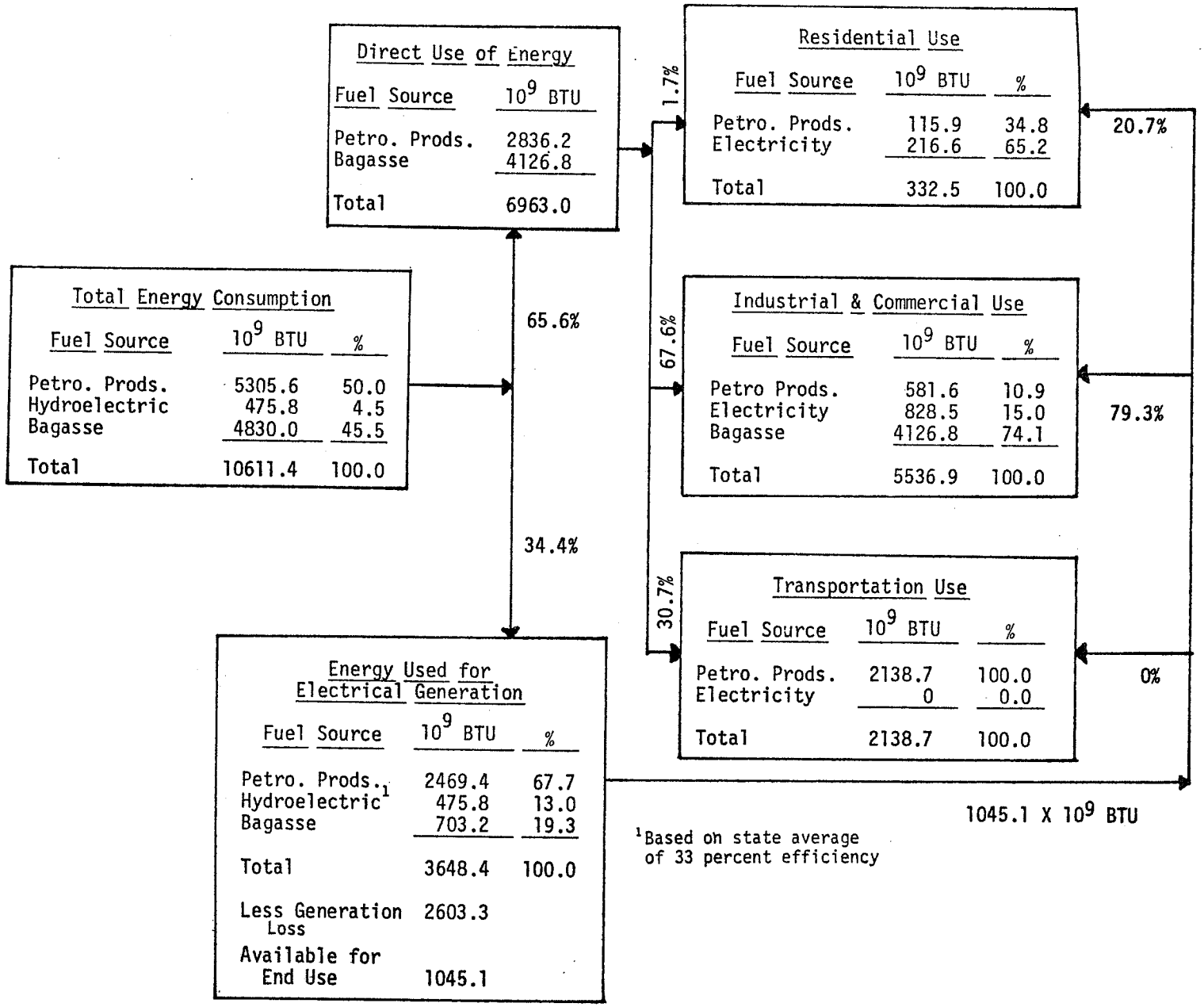

Figure 2-1. Kauai Flow Diagram of Energy Consumption, 1978
Source [2-1 to 2-10]

As shown in Figure 2-1, about two-thirds of the total energy went to direct use while the remaining third towards electrical generation (by Kauai Electric Company, the sugar companies and the federal installations at Barking Sands and Kokee).

Table 2-1 shows the primary and end use of energy on Kauai for the period from 1975 through 1978. Although the total primary energy consumption has risen at an average annual growth rate of only 1.3 percent per year, the consumption of petroleum-based energy has risen at an average annual growth rate of 7.0 percent, while biomass energy has declined at an average annual growth rate of (-1.3 percent). The decline in biomass energy could probably be attributed to less cane land and the decrease in tons of cane per acre. The consumption of hydroelectric power has fluctuated depending upon the rainfall. The total electricity generated has been rising at an average annual growth rate of 5.3 percent, reflecting the corresponding increase in energy demand. With the installation of Kauai Electric's new waste heat boiler (an energy conservation project) the energy required to produce the same amount of electricity should decrease.

A. Energy Consumption by Source

Petroleum

The trend of petroleum products consumed on Kauai is presented in Table 2-2. These fuel types include: motor gasoline, jet fuel, diesel oil, residual oil, and LPG. Although the average annual growth rate for the period from 1975 through 1978 was 7.0 percent, consumption growth rates for each product are vastly different.

The consumption of gasoline, used primarily for transportation with a small amount for off-highway needs by the construction industry, has grown at an average annual growth rate of 6.5 percent. The three types of motor gasoline—premium, regular, and unleaded—are received by the three petroleum companies, stored at their facilities in Nawiliwili and Port Allen, and sold to the County, State, and Federal governments, as well as the 41 service stations located around the island. The total petroleum for transportation requirements, including jet fuel, constitutes 40 percent of the total consumption.

Although the practice of both Hawaiian and Aloha Airlines is to fuel on Kauai only when necessary, the consumption of jet fuel by these local airlines, and the helicopters, has grown at a rate of 20.9 percent. This figure also includes consumption of aviation gas by the small planes.

The use of diesel has grown at a 25.0 percent average annual rate. Of the total 442.9×10^3 barrels of diesel oil consumed in 1978, 20 percent was consumed by the transportation sector and the industrial sector, while the remainder was used for the generation of electricity. Smaller

TABLE 2-1. Primary and End Use Consumption of Energy, Kauai, 1975 - 1978

	1975	1976	1977	1978	Average Annual Growth Rate
PETROLEUM					
10^3 BBL	784.2	889.1	904.6	957.8	7.0
10^9 BTU	4375.6	4992.8	5064.9	5305.6	
HYDROELECTRIC					
10^6 KWH	46.9	57.1	46.3	45.8	2.7
10^9 BTU	487.2	593.2	481.0	475.8	
BIOMASS					
10^3 BBL	611.3	575.8	571.3	586.3	-1.3
10^9 BTU	5170.0	4668.0	4670.0	4830.0	
TOTAL PRIMARY ENERGY USED					
10^9 BTU	10032.8	10254.0	10215.9	10611.4	1.3
ELECTRICAL POWER GEN.					
10^6 KWH	262.5	277.2	286.2	306.3	5.3
10^9 BTU	895.7	945.8	967.5	1045.1	
ENERGY USED TO GENERATE ELEC. POWER					
10^9 BTU	3245.7	3405.7	3627.2	3648.4	
TOTAL END USE					
10^9 BTU	7682.8	7794.1	7556.2	8008.1	1.4

Source [2-1 to 2-10]

TABLE 2-2. Use of Petroleum Products, County of Kauai, 1975-1978

Petro. Type	1975	1976	1977	1978	Average Annual Growth Rate
Motor Oil					
10^3 BBL	307.0	327.0	350.3	370.6	
10^9 BTU	1627.1	1733.1	1856.6	1964.2	6.5%
% BTU	37.2	34.7	36.7	37.0	
Jet Fuel					
10^3 BBL	9.1	10.9	13.3	16.1	
10^9 BTU	50.2	60.1	73.3	88.7	20.9%
% BTU	1.2	1.2	1.5	1.7	
Diesel					
10^3 BBL	263.9	291.1	282.2	442.9	
10^9 BTU	1537.2	1695.7	1643.8	2579.9	25%
% BTU	35.1	34.0	32.4	48.6	
Residual					
10^3 BBL	150.3	202.4	199.1	69.7	
10^9 BTU	944.9	1272.5	1251.7	438.2	-10.7%
% BTU	21.6	25.5	24.7	8.3	
LPG					
10^3 BBL	53.9	57.7	59.7	58.5	
10^9 BTU	216.2	231.4	239.5	234.6	2.8%
% BTU	4.9	4.6	4.7	4.4	
TOTALS:					
10^3 BBL	784.2	889.1	904.6	957.8	
10^9 BTU	4375.6	4992.8	5064.9	5305.6	7.0%
% BTU	100.0	100.0	100.0	100.0	

Source [2-1 to 2-10]

amounts, which are still significant, are used by the construction industry and the diversified agriculture industry. The sharp increase of diesel fuel from 1977 to 1978 (282.2 to 442.9 thousand barrels) is mostly due to the installation of a gas turbine at Kauai Electric. The gas turbine uses diesel oil as fuel for producing electricity. Also in 1978 a waste heat boiler was installed at Kauai Electric. This unit uses the exhaust heat from the gas turbine to produce steam. This steam is used to drive an existing steam turbine which produces electricity. Normally, the steam used to drive the steam turbine is generated by a power boiler that burns residual fuel. Use of diesel oil accounts for nearly 50 percent of all the petroleum products consumed.

This explains the sharp decrease in residual oil consumption—an average annual rate of -10.7 percent. The large drop occurred in 1978, when the gas turbine/waste heat boilers were installed at Kauai Electric. The three major uses include resurfacing of highways, electricity production by the sugar plantations, and producing industrial heat by the Brewer Chemical Company.

The consumption of LPG has risen at a 2.8 percent average annual growth rate, slightly less than the growth of the other petroleum fuels. The LPG on Kauai is stored, sold and delivered by the Gas Company, Kauai Division, whose storage facilities are located at Nawiliwili. Approximately 3 percent of the gas is piped in through utility pipelines.

Biomass

Biomass in the form of bagasse, or sugarcane waste, has contributed almost 46.7 percent of the total primary energy consumption. In 1978 the five sugar companies burned their bagasse for the production of both electricity and in-house steam required for sugar processing (Gay and Robinson is a grower whose cane is processed by the Olokele Sugar Company).

Table 2-1 showed that bagasse produced an equivalent 586.3×10^3 barrels of oil. This does not include the 42.0 wet tons of excess bagasse, or 53,000 dry tons of trash fiber.

Table 2-3 shows the total sugarcane bagasse produced for boiler fuel, excess bagasse, and the heat produced from the burning of the bagasse which was used for boiler fuel. Approximately 93 percent of the bagasse was burned in 1978, while 7 percent was disposed of as excess. It is interesting to point out that 4830×10^9 BTU (gross heat) produced only a net heat value of 2780×10^9 BTU. This represents an average plantation boiler efficiency of only 57.5 percent and indicates that a lot more bagasse power could be made available by improving boiler efficiency.

Table 2-3 also shows the fluctuations from year to year of total sugarcane bagasse produced, depending on the size of harvest, the rainfall, and other factors. Generally, the average

TABLE 2-3. Biomass Energy Production and Consumption, County of Kauai, 1975 - 1978

	1975	1976	1977	1978	Average Annual Growth Rate
Bagasse Boiler Fuel (10^3 Wet Tons)	611.3	575.3	571.3	586.5	-1.3%
Excess Bagasse (10^3 Wet Tons)	45.8	38.1	38.7	42.0	-2.3%
Total Bagasse (10^3 Wet Tons)	657.1	613.9	610.0	628.5	-1.4%
Gross Heat Value (10^9 BTU)	5170.0	4668.0	4670.0	4830.0	-2.1%
Heat Produced (10^9 BTU)	3063.0	2671.0	2666.0	2780.0	-2.9%
Trash Fiber Disposed (10^3 Tons)	50.9	56.2	54.1	53.0	-1.6%
Gross Heat Value (10^9 BTU)	851.0	883.0	854.0	847.0	-0.12%

Source [2-2 to 2-5]

annual growth rate has been slightly negative. The biggest change in the biomass picture is the Lihue Plantation bagasse plant presently under construction. It is being designed to burn bagasse, wood chips, county trash, and if needed, residual oil. It will be a highly efficient system that will provide a peak 12 MW of power into the utility system over its own in-house use. The new boiler/generator will be able to generate 87 million KWH of electricity per year from 259,600 wet tons of bagasse. Fifty-five million KWH will be sold to the electric utility. The remainder will be used for in-house factory use. The generating capacity of the unit is larger than the 87 million KWH it can produce on bagasse. The extra capacity of the unit will allow for production of electricity by wood chips, municipal waste, or other biomass material—an idea the Big Island has already put into use.

Hydro Power

In 1978, there were seven hydroelectric plants with a combined 7,900 kilowatts (KW) generating capacity and producing 45,850,000 KWH of electricity contributing to 15 percent of the total electricity requirements and 4.6 percent of the total primary energy.

All of the hydroelectric power plants ate operated by the sugar companies, which use a portion of the electricity in-house and a portion for sale to Kauai Electric. The amount of hydroelectric power available has been relatively constant since 1975—about 2.7 percent annual average growth rate.

Since Kauai is an island of abundant rainfall and many rivers, it has significant potential for hydroelectric power. The large dam on the east fork of the Wailua River has a potential to contribute up to 20 percent of Kauai's electrical needs today. The economics of developing the system on line today utilizing the resources are not too encouraging; nevertheless, it is a viable alternative in the near future.

Another possibility is the tying in of run-of-the-river type hydroelectric power which peaks with winter rainfall, and bagasse power which peaks with summer production. These options will have to be further investigated. An expanded discussion is included in Section IV, Sources of Energy Supply.

B. Energy Consumption by End-Use Sectors

Table 2-4 shows petroleum consumption by the end-use sectors. The two major end-use sectors are transportation and electrical generation, which account for the majority of total barrels of petroleum consumed in the county in 1978. The third petroleum-consuming sector

TABLE 2-4. Petroleum Consumption by Economic Sectors, County of Kauai, 1975-1978
[10^3 BBL]

Sectors	1975	1976	1977	1978	Annual Average Growth Rate (Percent)
Total Transportation	334.3	354.3	380.4	402.9	6.4
Highway	325.2	343.4	367.1	386.8	6.0
Aviation	9.1	10.9	13.3	16.1	20.9
Electrical Generation	331.4	368.7	417.2	418.4	8.2
Industrial[1]	70.0	109.6	48.0	78.7	21.4
Commercial[2]	22.0	28.1	29.6	28.9	10.2
Residential[3]	26.5	28.4	29.4	28.9	2.9
TOTAL	784.2	889.1	904.6	957.8	7.0%

[1] Mainly diesel consumed by sugar plantations and construction sectors.

[2] Estimated difference between total petroleum consumed and other economic sectors except commercial sector.

[3] Mainly LPG (both bottled and piped) used by residential sector.

Source [2-1 to 2-10]

was the commercial-industrial sector, primarily LPG for restaurants, heating oil and off-highway use of diesel by the construction industry and plantation trucks.

Electrical Generation Sector

The petroleum used to generate electricity totaled 418.4 x 10^3 barrels in 1978, taking 44 percent of the total. The average annual growth rate for the period between 1975 and 1978 was 8.2 percent, as shown in Tables 2-4 and 2-5.

Table 2-5 also presents the gross electricity generated during the same time period. An average annual growth rate of 5.3 percent is indicated. While Kauai Electric's gross electricity generation has increased 11.5 percent, the sugar companies have shown a decrease of -1.4 percent, indicating a definite shift of electrical production from the sugar plantations to Kauai Electric. However, the sugar companies' use of petroleum for electrical generation has ballooned to 48.0 percent from 1975 to 1978. On closer examination, the sugar petroleum consumption had peaked in 1976 and 1977 and in 1978 dropped to its 1975 level. The Federal electrical production has shown an average growth rate of -3.7 percent.

Table 2-6 shows that during the period from 1975 through 1977, bagasse production declined, and in order for the sugar plantations to provide the necessary electrical sales to Kauai Electric, the use of petroleum oil had to be increased. This table also points out that between 1977 and 1978 there was a sizable reduction in petroleum use by the plantations for electrical production. The reason for this reduction is a change in the Purchased Power Agreements between the sugar plantations and Kaui Electric. The contract basically shifted from a firm power contract to an interruptible type contract.

To further point out the change in the Purchase Power Agreement, Table 2-5 showed a rather large decrease between 1977 and 1978 in the sale of electrical energy sold to Kauai Electric, resulting in the electrical share of the plantations decreasing from 34.6 million kilowatt-hours in 1977 to 21.9 million kilowatt-hours in 1978—a decrease of 36.7 percent.

Non-Electrical Generation Sectors

The transportation sector, including aviation, small boats, trucks, and automobiles, consumed 402.9 x 10^3 barrels of oil in 1978 or an equivalent of 2128.7 x 10^9 BTU of heat, claiming 40 percent of the total petroleum. This figure includes federal cars and trucks (official and non-official) and diesel-powered federal target boats. The JP-4 and JP-5 aviation gasolines used by Barking Sands have not been included, however, because they are shipped to Kauai by the military. The rest of the federal fuels are purchased through the oil companies located on Kauai.

TABLE 2-5. Gross Electricity Generated and Petroleum Used for Electrical Generation by Producers, County of Kauai, 1975-1978

Producer	1975		1976		1977		1978		Average Annual Growth Rate	
	10^6 KWH	10^3 BBL	10^6 KWH	10^3 BBL	10^6 KWH	10^3 BBL	10^6 KWH	10^3 BBL	for KWH	for BBL
Kauai Electric	133.4	302.6	137.0	311.1	153.5	366.8	183.8	398.1	11.5%	9.7%
Sugar Plantations	125.0	13.9	135.7	45.7	128.9	40.5	118.9	10.8	-1.4%	48.0%
Own Use	90.8	-	98.0	-	94.3	-	97.0	-	2.3%	
For Sales	34.2	-	37.7	-	34.6	-	21.9	-	-11.9%	
Federal	4.1	14.9	4.5	11.9	3.8	9.9	3.6	9.5	-3.7%	-12.4%
TOTAL	262.5	331.4	277.2	368.7	286.2	417.2	306.3	418.4	5.3%	8.2%

Source [2-1 to 2-5, 2-10]

TABLE 2-6. Use of Bagasse and Oil by Sugar Plantations, County of Kauai, 1975-1978

Energy Source	1975	1976	1977	1978	Average Annual Growth Rate (Percent)
Bagasse					
10^3 tons	611.3	575.8	571.3	586.6	-1.3
10^9 BTU	5170.0	4668.0	4670.0	4830.0	
Residual Oil					
10^3 BBL	13.9	45.7	40.5	10.8	8.0
10^9 BTU	88.0	265.0	228.0	64.0	
Total Energy 10^9 BTU	5248.0	4864.0	4820.0	4894.0	-3.0
Bagasse as a Percent of Total Energy Input	98.5	95.9	96.9	98.9	0.2

Source [2-1 to 2-5]

Highway demand has grown at an average annual growth rate of 6.0 percent, while aviation fuel has increased sharply at 20.9 percent.

The industrial sector consumed 78.7 x 10^3 barrels of oil in 1978. The bulk of this was used by the sugar plantations for heavy equipment used in the fields and for hauling of sugarcane. Another high user is the construction industry. This petroleum sector has increased at an average annual growth rate of 21.4 percent.

Direct use of petroleum by the commercial sector was limited primarily to LPG, amounting to 28.9 x 10^3 barrels in 1978. Commercial use of LPG is primarily for water heating and food preparation. The average annual growth rate is 10.2 percent for the period examined. The industrial and commercial sector together accounts for 11 percent of the total petroleum used.

The use of petroleum by the residential sector is a small amount compared to the total use of petroleum in 1978. The direct use of petroleum by the residential sector at 2.9 percent average yearly increase has not kept pace with the increase in Kauai's total petroleum consumption. The main petroleum product in this sector is LPG.

III. ENERGY DEMAND PROJECTIONS

A. Methodological Notes

Needless to say, attempting predictions for an event including future energy demands is a treacherous business at best. We plan those events subject to our control and we predict events that we cannot control. Forecasting future energy demands comes somewhere between planning and predicting; it falls into a category where some events are beyond the control of individuals but are controllable by society as a whole via planning. To a considerable degree, society can shape future needs of energy by means of various policy measures, if such actions are deemed necessary. However, "policy actions" are not justifiable unless policy makers can predict aggregate behavior of people under various circumstances. It is these various unknown circumstances that are subject to prediction rather than aggregate behavior under a known circumstance.

This brief methodological note sets the tone for the objective of this portion of the study. What is attempted here is to arrive at three different levels of energy needs or demands for the next two decades. The circumstances or the key events that are assumed to occur, either as a result of deliberate policy action or through external forces, constitute energy demand scenarios.

There are numerous variables that determine the amounts of energy used by individuals or by a community; however, they are reduced to only those few variables that are most important and together contribute to determination of the level of energy use. The following variables are considered to be the most relevant determinants of energy use:

- Population
- Real per capita income
- Real price of petroleum
- Changes in economic structure
- Status of conservation technology and implementation

Table 3-1 is a summary of the criteria by which three scenarios with differing levels of energy demand are defined. Tables 3-2 and 3-3 provide additional pertinent data that help us in making some rational assumptions about the variables.

B. Business as Usual Scenario: The Base Case

The Business as Usual Scenario is developed to serve as a reference point. As such, events assumed to occur in this scenario follow closely the historical trends. Although it is conceptually difficult to see how historical trends would behave in the future, one has little choice but to assume that those important variables that determine energy use will follow the past trends. Five important variables, therefore, are carefully examined to form rationales for specific quantitative judgments about them.

Population

The resident population of Kauai County has been rising at an annual average rate of 1.9 percent from 1970 to 1978. The growth rate for somewhat longer periods has been lower: from 1960 to 1978, it was only 1.3 percent; and from 1975 to 1978, it was 1.8 percent. The population growth pattern is very closely related to the general economic activities, and the slow growth rate beginning in 1960 reflects a steadily declining economic base on Kauai with a stagnant sugar industry and a dying pineapple industry as the chief causes. It has been only relatively recently that the population growth rate has increased due to the rapid growth of the tourist industry during the late sixties and throughout most of the seventies.

The role of tourism in Kauai is very important in many respects. The most immediate impact is in the size of the de facto population of the island. It should be noted that although the resident population has been increasing at a rather slow rate, the de facto population (residents, tourists, and military personnel) has been rising at a much faster rate—registering a 3.2 percent average annual rate for the past eight years.

TABLE 3-1. Assumptions about the Important Variables That Affect Energy Demand Scenarios for Kauai County, 1980 - 2000

Scenario	Population Growth[1] (Compounded Rate)	Real Per Capita Income (Compounded Rate)	Real Price of Petroleum (% above Inflation Rate)	Conservation	Changes in Economic Structure and Activities
Business as Usual: (Past Trend)	1970-1978 Res: 1.75% De facto: 3.2% 1980/2000: 2-3%	1970-1976: 1.3%	1970/1973: -20% 1974/1977:+6.4% 1976/1979:+5.8%		Steady in agriculture; rapid growth in tourism.
Controlled Growth, Conservation (Intermediate)	De facto: 2.5%	1970-1976: 1-0%	2%[2]	15-20%	No change in agr. activity and slow growth in tourism.
Stimulated Growth (High)	De facto: 3-4% 1980/1990: 4% 1991/2000: 3%	1970-1976: 2-3%	2%[2]	5-10%	Increase in agr. activities; much stepped-up tourism; expansion of biomass-related industry.

[1]Population growth rate is the annual average growth rate. Tourist arrivals grew at an annual average rate of 12.3% from 1970 to 1978.

[2]Estimated real price of oil from 1980 to 2000.

TABLE 3-2. Selected Economic Indicators, County of Kauai

Variable	1978	Av. Ann. Growth Rate Percent	
		1970/1978	1975/1978
Population			
Residential	34,500	1.9	1.8
De facto[1]	40,713[3]	3.2	2.9
Per Capita Personal Income			
$	$5,791[2]	9.4[2]	4.9[2]
CPI			
Honolulu	191.2	9.6	12.1
Electricity Consumed			
Total Sales (10^6 KWH)	179.3	9.3	10.9
Per Capita			
De facto, KWH	4,404	4.9	3.7
Petroleum/Transportation			
Gallon Per Capita (De facto)	344.9	---	3.1
Gallon Per Automobile	562.9	---	0.3
Tourist Arrival, thousands	844.8	12.3	11.2
Autos Registered	27,716	5.6	5.6
Building Permits	---	---	---
Construction			
(10^6 $)	59.9	34.4	16.7

[1]De facto population includes military personnel and tourists.
[2]Figure is for 1976.
[3]Preliminary estimates.

Source [3-1]

TABLE 3-3. Population & Employment Projections Sector, County of Kauai, 1975-2000

	(in thousands)					
	1975	1980	1985	1990	1995	2000
Primary Industries						
Sugar Field	1.4	1.2	1.0	0.9	0.7	0.6
Sugar Processing	1.1	1.0	0.9	0.8	0.8	0.7
Pineapple Field	0.0	0.0	0.0	0.0	0.0	0.0
Pineapple Processing	0.0	0.0	0.0	0.0	0.0	0.0
Other Agriculture	0.2	0.2	0.2	0.3	0.3	0.3
Food Processing	0.1	0.1	0.1	0.1	0.1	0.2
Hotels	1.1	1.8	2.5	3.2	3.8	4.1
Government						
State-Local Government	2.1	2.5	3.1	3.9	4.8	5.6
Federal Government	0.2	0.3	0.3	0.3	0.3	0.4
Construction	0.6	0.4	0.4	0.4	0.4	0.4
Other Industries						
Misc Manufacturing	0.2	0.2	0.2	0.2	0.2	0.2
Transportation	0.5	0.7	0.8	0.9	0.9	0.9
Comunication-Utilities	0.5	0.4	0.4	0.4	0.4	0.4
Trade	1.6	1.7	2.1	2.4	2.8	3.0
Eating-Drinking Food	0.9	1.3	1.7	2.1	2.5	2.8
Bank, Finance, Real Estate	0.4	0.4	0.5	0.7	0.9	1.1
Services	1.5	1.8	2.3	3.0	3.8	4.5
Jobs by Sector	12.3	13.8	16.6	19.6	22.7	25.1
Self-Employed	1.3	1.5	1.9	2.3	2.7	3.0
Total Civilian Jobs	13.6	15.3	18.5	21.9	25.4	28.1
Civilian Population	32.7	35.6	39.8	45.0	50.0	53.7
Resident Population	32.7	35.6	39.8	45.0	50.0	53.7

Source [3-2]

Rapid growth in tourism means that the total energy needs for the island also grow rapidly. In fact, in terms of per capita energy consumption, the tourist population is a far greater consumer of energy than the resident population [3-3]. Since the tourist population constitutes nearly 20 percent of the Kauai resident population, the population variables must be defined using de facto numbers.

Table 3-1 showed that the population growth rate assumed for this scenario is between 2 percent and 3 percent per annum. Whether the actual growth rate would tend to gravitate toward upper or lower limits depends largely upon future tourism development efforts. Tourism, specifically number of visitor arrivals and length of stay, depends largely in the economic conditions of the U.S. Mainland, and to some extent on Japan, other Asian nations, and other foreign countries. The growth of tourism in Hawaii in the past well reflects this relationship. We believe that cyclical fluctuations in tourism, at least to 1990, would probably result in the de facto population growth rate chosen for this scenario.

Real Per Capita Income

Energy use is closely intertwined with how the economy functions. The real personal income that measures the economic activities net of price change for the island has been rising at around 1.0 to 1.3 percent per annum for the last ten years.

Unless drastic changes occur in terms of introduction of new industries and/or steady decline in agriculture activities, mainly sugar production, it is likely that the island's economy would expand at the same rate that has been recorded in the past, perhaps in the range of 1 to 2 percent per annum.

Assumptions made regarding the population and real income together determine the various assumptions made about energy projections for this scenario. For example, in examining energy demand in the transportation sector, we assume that the number of automobiles on highways increases 7 percent per annum. This reflects the general increase in de facto population, plus additional increases from industrial and commercial expansion, including tourist-oriented activities. Another example is the commercial sector, where energy demand for the sector is set at 3.2 percent per annum. Again, this reflects the anticipated de facto population growth over time, increase in real income, and adjustments for potential improvement in conservation practices.

Growth rates of 1.5 percent to 1.75 percent per annum until 1990 are assumed for the industrial and residential sectors, respectively. These reflect expected growth rates for the economy as a whole and tourism in particular.

Real Price of Petroleum and Conservation

The formation of and change in price of petroleum are enormously complex matters. There are different sets of prices for each type of petroleum-based fuel (e.g., motor, diesel, residual oil). These prices vary from region to region and from retailer to retailer within the same geographic location. Determination of price structures themselves are enormously complex, with various government regulations covering all phases of production, processing, and distribution to the consumer. These regulations are further complicated by the increasing dependence on imported oil from foreign countries.

It does not serve any purpose to conjecture the magnitude of future prices of various petroleum products. What is important, however, is to recognize that it is the relative price of energy vis-a-vis other goods and commodities that determines the magnitude of energy demand. For example, the real price (constant) of petroleum in the United States steadily declined from 1960 to 1974. 1974 was the year of the oil embargo in the United States. For Hawaii, the decline in the real price of petroleum was even more pronounced during that time. During 1961 to 1973, the real price of fuel declined 2 percent per annum, and it was not until 1974 that the rate turned around and accelerated at a rate of 6.4 percent. Table 3-4 shows the retail price movement in Hawaii.

Long-range price forecasting for the United States western region, including Hawaii, puts the constant dollar price of oil rising at an average of 2 percent per year until 1990 and higher rates after 1990 [3-5].

We assume that the constant dollar price rise for petroleum until 1980 is approximately 5 percent per annum. This assumption is based on the difference between current domestic oil price (weighted average) and the world price, plus the expected rise of 2 percent per annum of the world price itself. In other words, we assume the U.S. price would rise more rapidly than the world price during the eventual catch-up period. These assumptions are built into Tables 3-5 through 3-8. We believe that the rapid rate of increase of the real price of oil would have a more visible impact on conservation efforts (e.g., fleet fuel economy, vehicle miles driven). Conservation efforts measured by the total energy that can be saved in the range of 5 percent to 10 percent is a reasonable goal to achieve. Again, this assumption is built into residential, commercial, and transportation sector energy use projections.

Changes in Economic Structure

If business does continue as usual, it is realistic to expect that the economic base of Kauai County will remain relatively unchanged. This means that for the next decade, agriculture and

TABLE 3-4. Index and Actual Prices of Average Retail Leaded Regular, Unleaded Regular, and Premium Gasoline. Honolulu, Hawaii, 1974 - 1979

Subject	Indexes			Prices		
	Leaded Regular	Unleaded Regular	Premium	Leaded Regular	Unleaded Regular	Premium
Index: October 1973=100.0						
December 1974	132.5	--	129.2	59.9¢	--	62.9¢
June 1975	149.0	--	145.8	67.3¢	--	71.0¢
December 1975	152.9	--	150.5	69.1¢	--	73.3¢
Index: January 1976=100.0						
June 1976	99.8	99.4	99.1	68.4¢	69.2¢	72.0¢
December 1976	102.5	102.6	102.2	70.2¢	71.4¢	74.3¢
June 1977	105.5	106.1	105.1	72.3¢	73.8¢	76.4¢
December 1977	105.4	106.8	105.7	72.2¢	74.3¢	76.8¢
June 1978	108.1	109.7	109.8	74.1¢	77.2¢	79.8¢
June 1979	127.3	129.9	126.5	88.3¢	92.8¢	93.1¢

Source [3-4]

TABLE 3-5

Transportation. Assumptions for Business as Usual Scenario

Base Year - 1978	Baseline Assumptions
. Number of autos registered: (1) 27,716 . Average miles driven per automobile: 7,862 . Fleet fuel economy: 14.0 mpg . Auto sales mix: Passenger Cars: 79.5 4-seater : 33.4 6-seater : 46.1 Trucks & Other: 20.1 . Auto Registrations 1965 to 1978: Annual Average: 7.0% Compound Growth: 6.7% . Total New Car Sales (Percent of total registered) 7.2	. Annual miles driven per vehicle remains at 1978 level. . The number of automobiles on the highway increases slightly faster than that of the de facto population until 1990, then remains unitary thereafter. . Auto sales mix: The number of trucks/ trailers rises to 20%; 6-seater passenger cars drop to 10% by 1990. . Fleet mpg improves to 17.0 by 1990 and to 19.0 by 2000.

(1) Includes all types of vehicles

Source [3-1]

TABLE 3-6. Estimated Number of Vehicles, Travel Miles, and Consumption of Gasoline Assumed for Business as Usual Scenario, County of Kauai -- 1978-2000

Year	No. of Autos (1)	Annual Miles Per Vehicle	Total Vehicle Miles (10^6)	Miles Per Gallon	Total Gas Consumption (10^6 Gal.) (2)	Gallons Per Vehicle
1978	27,716	7862	217.9	14.0	15.6	562.9
1980	33,351	7862	262.2	15.0	17.5	524.7
1985	45,860	7862	360.6	16.0	22.5	490.6
1990	62,860	7862	494.2	17.0	29.1	462.2
1995	73,582	7862	578.5	18.0	32.1	436.2
2000	86,133	7862	677.2	19.0	35.6	413.3
Increase: 1978 - 19	126.8%	0%	126.8%	+21.4	86.5%	-17.8
Increase: 1978 - 2000	210.8%	0%	210.8%	+28.6	128.2%	-26.6

(1) Based on de facto growth rate of population of 3.2% per annum and per capita auto ratio of 0.681 for 1978, 0.727 for 1980, 0.854 for 1985, and 1.00 for 1990 and thereafter.

(2) There is a slight descripancy between the actual consumption of petroleum for highway use and the Total Consumption shown here. The latter is based on the estimates for miles per gallon and the annual miles per vehicle.

TABLE 3-7. Projections for Energy Demand in Barrels by Economic Sectors, Business as Usual Scenario, County of Kauai, 1978 - 2000

[10^3 BBL]

	1978	1980	1985	1990	1995	2000
Non-Electrical Energy						
Transportation						
Highway (1)	386.8	416.7	535.7	692.9	764.3	847.6
Aviation (2)	16.1	19.5	31.4	50.5	64.5	82.3
Total	402.9	436.2	567.1	743.4	828.8	929.9
Industrial (3)	1001.2	1031.5	1111.2	1196.9	1321.6	1459.3
Commercial (4)	28.9	30.8	36.0	42.2	46.6	51.4
Residential (5)	28.9	29.9	32.6	35.6	38.8	42.3
Total	1461.9	1528.4	1746.9	2018.1	2235.8	2482.9
Electrical Energy						
Electrical Generation (6)	607.4	673.4	872.0	1128.8	1461.3	1891.8
(10^6 kWh)	(306.3)	(339.6)	(439.7)	(569.2)	(736.9)	(954.0)
Total Energy Demand	2069.3	2201.8	2618.9	3146.9	3697.1	4374.7

(1) See Table 3-6
(2) 10 percent per annum until 1990 and 5 percent thereafter
(3) 1.5 percent per annum until 1990 and 2 percent thereafter
(4) 3.2 percent per annum until 1990 and thereafter
(5) 1.75 percent per annum throughout to 2000
(6) 5.3 percent per annum throughout to 2000

TABLE 3-8. Projections for Energy Demand in BTU by Economic Sectors, Business as Usual Scenario, County of Kauai, 1978 - 2000

[10^9 BTU]

	1978	1980	1985	1990	1995	2000
Non-Electrical Energy						
Transportation						
Highway (1)	2050.0	2208.5	2839.2	3672.4	4050.8	4492.3
Aviation (2)	88.7	108.3	178.6	294.5	378.1	485.6
Total	2138.7	2316.8	3017.8	3966.9	4428.9	4977.9
Industrial (3)	4592.5	4732.4	5100.9	5498.2	6076.5	6715.5
Commercial (4)	115.9	123.4	144.5	169.1	198.0	231.8
Residential (5)	115.9	120.0	130.9	142.7	155.7	169.8
Total	6963.0	7292.6	8394.1	9776.9	10,859.1	12,095.0
Percent of Total Energy Demand	(65.6)	64.3)	(61.6)	(59.1)	(55.3)	(51.6)
Electrical Energy						
Electrical Generation (6)	3648.4	4045.0	5237.4	6779.9	8777.4	11,363.3
(10^6 kWh)	(306.3)	(339.6)	(439.7)	(569.2)	(736.9)	(954.0)
Total Energy Demand	10,611.4	11,337.6	13,631.5	16,556.8	19,636.5	23,458.3
Percent of changes from 1978		(6.8)	(28.5)	(56.0)	(85.1)	(121.1)

(1) See Table 3-7
(2) 10 percent per annum until 1990 and 5 percent thereafter
(3) 1.5 percent per annum until 1990 and 2 percent thereafter
(4) 3.2 percent per annum until 1990 and thereafter
(5) 1.75 percent per annum throughout to 2000
(6) 5.3 percent per annum throughout to 2000

tourism together will continue to serve as the backbone of the economy. It is conceivable in the years beyond 1990 that an energy-intensive industry such as mineral processing can be introduced to the island. However, major changes can come about within the agriculture sector (e.g., sugar processing industry) when ethanol or methanol alcohol production and expanded sylviculture industries become more economically competitive alternatives to sugar as the major crop. These potential developments will be treated in the Stimulated Growth Scenario later in this study.

In terms of overall primary energy demand, using 1978 as a base year, we expect it to grow 28.5 percent by 1985, 56.0 by 1990, and 121.1 percent by 2000. Tables 3-6 and 3-7 indicate that the non-electrical energy demand including the transportation sector would steadily decrease from 65.6 percent in 1978 to 59.1 percent in 1990, and this trend will continue until 2000 with the non-electrical sector's share accounting for only 51.6 percent. Electric energy use, on the other hand, increases from 34.4 percent to 40.9 percent in 1990 with a further increase to 48.4 percent in 2000.

C. Controlled Growth Scenario with Emphasis on Conservation

The assumption for the Controlled Growth Scenario with Emphasis on Conservation are presented in Tables 3-9 through 3-12. The Controlled Growth Scenario with Emphasis on Conservation would provide the best chance for the islanders to obtain energy self-sufficiency. This is largely so by virtue of the traditional relationship between economic growth (implying that population and other general economic activities will rise quite slowly) and the energy use that such growth inevitably requires.

Combined with a slow economic growth, any rapid introduction of conservation technology certainly would reduce the magnitude of energy use and thus bring the island closer to realizing energy self-sufficiency. It can correctly be argued that a smaller amount of energy use does not necessarily mean a slowdown in economic activity or a reduction in living standards of the general populace. This is true, however, only if two things occur: 1) rapid technological breakthrough in improving efficiency of using energy, and 2) voluntary adoption of conservation practices without the feeling of sacrifice. If it appears that neither of the above is likely to occur in any meaningful way in the next decade, then the lower levels of energy demand will probably come about only as a consequence of less than desirable circumstances, such as chronic recession, unmanageable inflation, or higher energy prices. More than likely it would probably be all events occurring simultaneously.

TABLE 3-9

Transportation. Assumptions for Controlled Growth Scenario with Emphasis on Conservation

Base Year - 1978	Baseline Assumptions
. Number of autos registered: (1) 27,716 . Average miles driven per automobile: 7,862 . Fleet fuel economy: 14.0 mpg . Auto sales mix: Passenger cars: 79.5 4-seater : 33.4 6-seater : 46.1 Trucks & other: 20.1 . Auto Registration 1965/1978: Annual Average: 7.0% Compound Growth: 6.7% . New car sales (percent of total registered) 7.2	. Annual miles driven per vehicle is assumed to decline 2% per annum until 1985 and remains constant thereafter. . The number of automobiles on the highway increases approximately 3 per cent per annum; this rate is assumed to be the de facto population growth. . Auto sales mix is such that fleet mpg improves to 18.0 by 1990 and 19.5 by 1995 and thereafter.

(1) Includes all types of vehicles.

Source [3-1]

TABLE 3-10. Estimated Number of Vehicles, Travel Miles, and Consumption of Gasoline Assumed for Controlled Growth Scenario with Emphasis on Conservation, County of Kauai, 1978 - 2000

Year	Number of Autos (1)	Annual Miles Driven per auto (2)	Total Vehicle Miles (10^6)	Miles Per Gallon	Total Gas Consumption (10^6 Gal.)	Gallons per Vehicle
1978	27,716	7862	217.9	14.0	15.6	562.9
1980	29,404	7551	222.0	15.0	14.8	503.3
1985	34,087	6826	232.7	16.5	14.1	413.6
1990	39,516	6826	269.7	18.0	15.0	379.6
1995	45,810	6826	312.7	19.5	16.0	349.3
2000	53,106	6826	362.5	19.5	18.6	350.2
Increase 1978 to 1990	142.5%	-13.2%	123.7%	28.5%	-3.8%	-67.4%
Increase 1978 to 2000	191.6%	-13.2%	166.3%	39.3%	19.2%	-62.2%

(1) Based on de facto population growth rate of 3% per annum.
(2) Annual miles driven is assumed to decrease 2% per annum until 1985, and remain constant thereafter.

(2) Annual miles driven is assumed to decrease 2% per annum until 1985, and remain constant thereafter.

TABLE 3-11. Projections for Energy Demand in Barrels by Economic Sectors, Controlled Growth Scenario, County of Kauai, 1978 - 2000

[10^3 BBL]

	1978	1980	1985	1990	1995	2000
Non-Electrical Energy						
Transportation						
Highway (1)	386.8	352.4	335.7	357.1	380.9	442.9
Aviation (2)	16.1	17.7	22.7	28.9	36.9	47.1
Total	402.9	370.1	358.4	386.0	417.8	490.0
Industrial (3)	1001.2	1021.3	1073.4	1128.2	1215.4	1309.3
Commercial (4)	28.9	30.4	34.4	38.9	42.9	47.4
Residential (5)	28.9	29.8	32.1	34.6	36.7	38.6
Total	1461.9	1451.6	1498.3	1587.7	1712.8	1885.3
Electrical Energy						
Electrical Generation (6)	607.4	657.0	799.0	972.5	1183.2	1439.5
(10^6 kWh)	(306.3)	(331.3)	(403.1)	(490.4)	(596.6)	(725.9)
Total Energy Demand	2069.3	2108.6	2297.6	2560.2	2896.0	3324.8

(1) See Table 3-10
(2) 5 percent per annum throughout to 2000
(3) 1 percent per annum until 1990 and 1.5 percent thereafter
(4) 2.5 percent per annum until 1990 and 2 percent thereafter
(5) 1.5 percent per annum until 1990 and 1 percent thereafter
(6) 4 percent per annum throughout to 2000