HAWAII HYDROTHERMAL MARKET

PENETRATION ANALYSIS

Prepared for

Department of Energy
Region IX
San Francisco, California

By

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EXECUTIVE SUMMARY

Introduction

- Over 90% of Hawaii's energy needs are supplied by foreign imports of fossil fuels.
- The State's governments and businesses are aggressively seeking alternatives to the dependence on foreign supplies.
- Over the past year and still continuing, a number of research projects on geothermal resource locations, economic and engineering feasibility of electricity generating and direct applications of hydrothermal fluids have been taking place.
- Based on potential resources and need, Hawaii is a prime candidate for direct applications of hydrothermal fluids in industrial and agricultural processing.
- The State's limited heavy industrial activity, the climatic conditions, and its island formations are considered to be limiting factors associated with the commercialization of direct application.

Key Assumption

- Geothermal reservoirs were assumed to be at great depths (over 5,000 feet) and high temperature (greater than 150^{o} C).
- High exploration and development costs and the costs of transmission, royalties, and other infrastructure costs combined with retrofit and backup system costs will prevent geothermal energy from being dramatically cheaper than other energy sources.
- Institutional, legal, political, environmental, and ownership barriers will be overcome.
- Private industry will have the primary responsibility for the commercialization of industrial direct applications.
- Potential users will connect to available hydrothermal fluid resources if made available.
- Electricity generation will be the primary force behind development of geothermal reservoirs and direct applications will follow.

- Hawaii's location, present economic base and water shortage concerns will tend to dissuade new, large energy intensive industrial operations from locating Hawaii.

  -(Comment: This is a controversial assumption, but is derived from a consensus of opinion by industry and government persons interviewed.)

- Hawaii's sugar factories will utilize geothermal for both direct applications and electricity generation.

- Alternative energy sources will eventually compete with each other and may slow development.

  (Comment: The State is currently conducting research projects in solar, OTEC, biomass, wind, and geothermal energy resources.)

Methodology

- Baseline data was developed for all non-transportation and non-military energy consumption in 1975 by County and by SIC classification.

- Direct industrial heating and water heating energy consumption were considered the potential market for geothermal direct application.

- Space conditioning was not considered a primary potential due to the lack of space heating and the availability of data on air conditioning consumption.

  (Comment: Air conditioning is generally confined to office buildings, retail outlets, hotels, and high rise condominiums.)

- The 20 potential sites identified by the Hawaii Institute of Geophysics were used as the State's reservoir base.

- Growth estimates for potential geothermal applications were based on the State's energy, population, and tourism projections and a survey of industry. (The estimates were made by County and by resource.)

- Market penetration projections were derived by assigning a rate of retrofit activity and new market penetration. The rates vary by County and in some cases, by industry.

Conclusion

- Tables A and B summarize the estimates for potential geothermal use and the projected geothermal capture. (The formulas for deriving the forecast are attached to the tables.)
- All four of Hawaii's counties have potential geothermal resources.
- Over 80% of State's population, commerce and industry are within potential geothermal markets.
- By 2020, 40% of the industrial energy requirements could be provided by geothermal.
- Geothermal estimated captures is 10% of the State's forecasted total non-electric energy usage excluding transportation and electricity generation.

TABLE A

INDUSTRIAL PROCESS HEAT

HAWAII

	1975 ENERGY USE BTU X 10^{12}/YR	1985 ENERGY USE BTU X 10^{12}/YR	2000 ENERGY USE BTU X 10^{12}/YR	2020 ENERGY USE BTU X 10^{12}/YR
POTENTIAL GEOTHERMAL USE				
4 counties evaluated	45.015	51.179	69.232	101.762
(of 4 counties total)	'A'	'D'	'D'	'D'
Total	45.015	51.179	69.232	101.762
FORECAST GEOTHERMAL CAPTURE				
Retrofit 'B'	-0-	1.506 'B'	12.643 'B'	17.232 'B'
New Growth Capture 'C'	-0-	-0-	1.527 'C'	4.319 'C'
Total	-0-	1.506	14.170	21.551

TABLE A

'A' Energy Use in Hawaii. County and consumption by end user data.

'B' Energy from expected retrofit of co-located sugar companies plus:

Honolulu - 20% retrofit beginning in 1985 of Campbell Industrial Park by 2000. 1% per year of all other potential retrofit starting in 1985 through 2020.

Hawaii - 1% per year beginning in 1985 through 2020.

Kauai - 1% per year beginning in 2000 through 2020.

'C' 50% of new growth beginning in 1985 for Honolulu, Hawaii, and starting in 2000 for Kauai.

'D' 1975 x growth factors.

TABLE B

RESIDENTIAL/COMMERCIAL WATER HEATING

HAWAII

	1975 ENERGY USE BTU X 10^{12}/YR	1985 ENERGY USE BTU X 10^{12}/YR	2000 ENERGY USE BTU X 10^{12}/YR	2020 ENERGY USE BTU X 10^{12}/YR
POTENTIAL GEOTHERMAL USE				
4 counties evaluated	60.63	88.59	158.93	293.23
(of 4 counties considered)	'a'	'b'	'b'	'b'
Total	60.63	88.59	158.93	293.23
FORECAST GEOTHERMAL CAPTURE				
Retrofit 'c'	-0-	1.506	2.945	8.720
New Growth Capture 'd'	-0-	-0-	2.394	10.589
Total	-0-	1.506	5.339	19.309

Table B

'a' Energy Use in Hawaii. County and consumption by end user data.

'b' Growth rates taken from projections by the Hawaiian Electric Company and State population projections.

'c' 1% per year retrofit rate for all counties beginning in 1990 except Kauai which starts in 2005 at a 1% retrofit rate.

'd' Step increases for all counties except Kauai, starting in 1985, to a maximum of 30% of the new growth by 2000. Kauai begins in 2000 up to a maximum of 30% by 2015.

I. INTRODUCTION

Ever since the OPEC embargo of 1973, Hawaii's governments, businesses, and residents have been very concerned about the State's vulnerability to foreign fossil fuels. The State legislature, the administration, the local governments, the University and businesses have been very aggressive in their efforts to achieve energy self-sufficiency. Currently, the State is actively promoting a state-wide energy conservation program, conducting research on various types of alternative energy resources and reviewing legal, political, and institutional barriers to the development of commercialization of various alternative energy resources. With the support of the federal government, Hawaii is rapidly gaining a great deal of expertise in alternative energy development.

Of the several alternative energy resources suited to Hawaii's climate, location, and geology, geothermal development has been viewed as one of the most promising and feasible alternatives. The successful drilling of Hawaii's first geothermal well, and the quality of the resource, have encouraged government and business to attempt to accelerate the development of this resource. The State has an active Geothermal Advisory Committee comprised of State government personnel, researchers, potential users, and community leaders who are seeking to find ways to promote geothermal development and overcome barriers. Appendix A contains a list of recommendations composed by this body to be presented to the State legislature for consideration.

To date, most of the research in Hawaii for measuring geothermal potential as an alternative energy resource has been focused on resource location and electricity generation. This study focuses on the potential for geothermal in

Hawaii as a direct energy source. The results are intended to provide a benchmark and guide for future studies and development of a Regional Plan by DOE to accelerate commercialization of hydrothermal resources in the State.

The primary purpose of this study has been to estimate the potential existing and future markets for direct applications of hydrothermal resources in Hawaii on a county level. Both industrial process applications and water heating applications for residential and commercial sectors were considered. Hydrothermal applications were factored out of total energy demand and annual growth estimates were developed for both existing and future energy demand. Estimated market penetration factors were developed on a county level and in some cases, by industry.

Several key assumptions were made during the development of the growth and penetration estimates. It was assumed that the geothermal resources in Hawaii would share many of the characteristics of Hawaii's only geothermal well, HGP-A at Puna, Hawaii. This resource has a very high temperature ($572^{O}F$) and is considered highly suitable for electricity generation. The well is 6,450 feet deep and required new state-of-the-art drilling and casing technology. It is not known at this time whether all geothermal reservoirs are as high temperature or as deep as HGP-A. It would be beneficial to the commercialization of geothermal reservoirs in Hawaii if future wells prove to be shallower. The costs of exploration and development would decline appreciatively. Also, for the purposes of direct heat applications, low and intermediate temperature wells would be suitable for a large percentage of the potential users. However, due to the expected depth of the wells, the geological formations to be drilled through, and the exploration costs, it was assumed that the development costs would be quite high. As a consequence of these

high capital costs, and the added costs of pipelines, royalties, and other infrastructure costs, the assumption was made that geothermal will not be dramatically cheaper than other alternative energy resources.

If the benefit to the overall community dictates, it was assumed that institutional, legal, political, environmental, and ownership barriers would be overcome. The potential impact that these barriers would have on the commercialization of geothermal cannot be underestimated.

For the purposes of estimating the potential geothermal market and forecasting the market penetration, it was assumed that private industry would have the major responsibility of commercializing geothermal. If government assumes the major role for commercialization, the forecasts presented in this report would most likely change.

A recent study conducted by the Hawaii Institute of Geophysics, "Hawaii Geothermal Resource Assessment Program," was used as the basis for geothermal resource location. The report list 20 sites that have anomalies indicating a probability of geothermal reservoirs. As the report states, this listing is not exhaustive of all potential geothermal sites, but rather, is the first priority for additional testing and investigating.

Potential market growth was derived through a combination of forecasting projection based on the state of Hawaii's Department of Planning and Economic Development projections for energy demands, population, and tourism and industry surveys.

The potential for space conditioning was not included in the market penetration estimates for future use of hydrothermal fluids. Hawaii's climate exempts the need for space heating and eliminates the need for residential air conditioning except in high rise residential buildings. Many of these high rise units have unit air conditioners. Commercial establishments such as

hotels, restaurants, retailers, and office buildings are heavier users of central air conditioning. In recent years, improved efficiency and operating improvements have been instituted. As a result, accurate data on air conditioning energy consumption is not readily available at this time. A valid assumption to make is that if hydrothermal fluids were available and absorption air conditioning technology was available for economical applications, that new commercial establishments would use the resources. However, it was not possible within the scope of this survey to develop the necessary data to forecast potential usages for air conditioning.

For industrial applications, geothermal potential was based on steam and preheat applications. Excluded from the potential was energy consumed in the form of electricity for industrial motors, lighting, etc., and energy required for direct electricity generation.

Market penetration by geothermal energy was estimated separately for industrial applications and residential/commercial application. It was assumed that because of existing plans, geothermal penetration would not begin until 1985. Estimates were developed on a county and resource location basis. Penetration factors for retrofit and new growth were developed based on the assumption that if hydrofluids were made available to potential users, these users would retrofit or design accordingly.

The penetration of geothermal sources presented in this report reflects the consensus of the business and government persons interviewed. Judgmentally, it is a realistic view of Hawaii's potential, but does not set either upper or lower limits on the potential development. It assumes that Hawaii will not experience a dramatic change in its economic activity. Hawaii has never been an industrial state, and its distance from markets, lack of raw materials, industrial infrastructure, and the cost of living all strongly suggest that Hawaii will not have a substantial growth in industrial activities.

Hawaii has, and is being evaluated as an industrial site by several energy intensive industries, but the feeling among government and business leaders contacted is that the probability of large energy users locating in Hawaii is relatively low. Most reason that the same conditions and factors that have kept large industry away from Hawaii will prevail in the future. Additionally, the major attraction of a dependable, inexpensive energy source is associated with a relatively high risk geological area. The sites being considered for these industries are near the Puna Geothermal Reservoir and, are active geological areas and the plants would be subject to risks such as lava flows, landslides, earthquakes, and other hazards associated with volcanic areas. Specifically, the prospects of a magnesium nodules processing plant and/or an aluminum refinery are considered to be less than fifty percent.

Industry growth considered in this survey will be in those segments where the major consumers are located in Hawaii or the raw materials are locally available in Hawaii. Examples for the former growth market are food and feed processes and for the latter, sugar factories and canneries.

In summary, Hawaii's geothermal resources appear to be substantial and suitable for direct heat hydrothermal applications. Its vulnerability to embargoes, shipping strikes and other uncontrollable factors, makes the development of geothermal very desirable for the community at large. Also, the prospects of a dependable, cheaper than fossil fuels alternative have aroused the interest of Hawaii's businesses. Hawaii's lack of energy intensive industry, its low probability of attracting new major industry, and the cost of exploration, development, and transmission may retard the commercialization of geothermal. However, on a selective basis, in the industrial park areas, and agriculture processing factories, there appears to be a relatively high potential for the commercialization of direct geothermal use.

Hawaii's sugar factories account for almost 27% of the State's total non-transportation energy consumption. Their industrial process energy consumption is 38% of the State's industrial non-electrical energy use. As an industry, they offer one of the best potential for geothermal commercialization and a recent study by Puna Sugar Company indicates that it is economically feasible for a company to drill its own well and transport the hydrofluids via pipeline. However, the economic model included the production of electricity for sale to the local utility on a firm power basis and the value of extracted sulfur dioxide.

The estimates for the State's potential geothermal market show that by the year 2020, 40% of the State's industrial energy consumption could be provided by geothermal. Penetration by geothermal in the industrial sector is projected to be 50% of the potential. This is based on the assumption that geothermal colocated sugar factories will use geothermal for their industrial energy needs.

In the residential/commercial sectors, (R/C) potential geothermal applications are projected to be 25% of the State's R/C usage. Penetration is expected to be 25% of the total potential. The competition from other alternative energy sources is expected to be greater in the residential/commercial sectors and penetration is very dependent on state and local government's involvement.

By the year 2020, geothermal is projected to supply Hawaii with 10% of the total non-transportation energy usage, under the assumptions that resources are developed, barriers are overcome, and that geothermal's cost is competitive with other energy sources.

II. METHODOLOGY AND ASSUMPTIONS

A. Baseline Market Size Demand

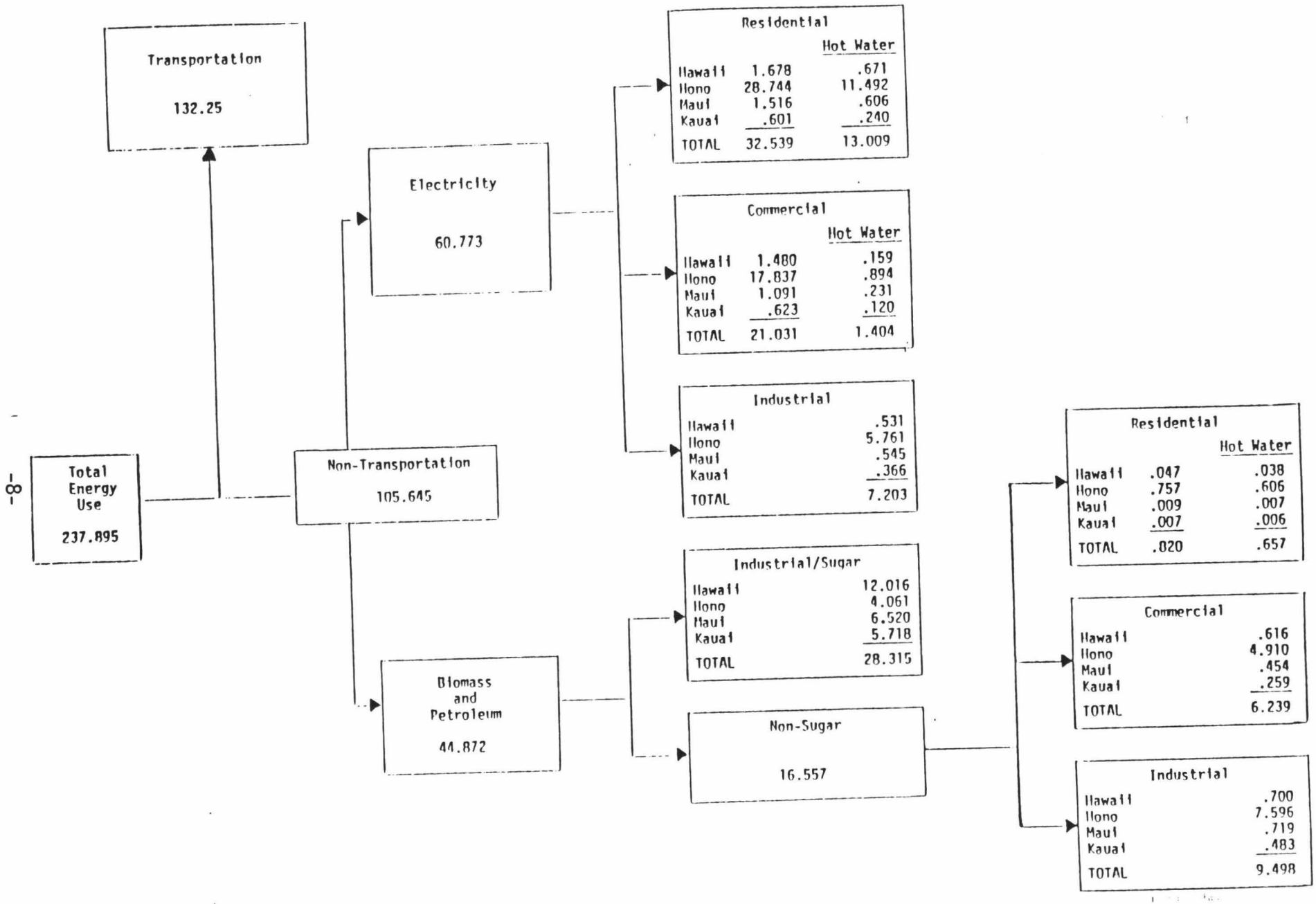
The State's total gross BTU consumption for 1975 was determined. The consumption was then segmented by county. Exhibit I illustrates the segmentation for non-transportation usage. Roughly 58% of the State's non-transportation BTU consumption is in the form of electricity. The remaining consumption is either petroleum products such as residual oil or diesel fuel and biomass created steam. Several assumptions were made in deriving this data. First, all residual fuel not being used for electricity generation was allocated to industrial usage. All non-transportation diesel fuel was allocated to the commercial sectors such as construction and agricultural field operations. Appendix B shows a breakdown of petroleum consumption by use and by county. An analysis of the sugar factories energy consumption was then conducted. Appendix C shows the energy source mix and energy consumption by sugar factories in each of the counties. The sugar factories for the most part are not dependent on utility electricity, and in fact, are net sellers of electricity. Sugar factories consume approximately 40% of their total BTU usage for electricity generation. A portion of this electricity is put into the various counties' electrical grids and used by utility customers.

The above analysis resulted in a breakdown of gross BTU consumption by residential, commercial and industrial sectors for each county. Residential and commercial consumption were then combined and industrial treated separately.

The 20 potential geothermal sites identified by the Hawaii Institute of Geophysics were used as the resource base. These potential reservoir sites were located on county maps. 12-mile radius circles were drawn around each of the sites and the enclosed areas were considered potential geothermal market

EXHIBIT I

ENERGY CONSUMPTION BREAKDOWN
HAWAII, 1975
10^{12} BTU's



areas. Major physical barriers such as high mountain ranges and the ocean were located and the potential market areas adjusted. Next, the latest published land use, zoning, and state plan information was applied to the areas to determine what future development might take place in the various potential geothermal market areas. The county maps in Appendix D show the present designated land use for each of the counties. It was taken under consideration that land use and zoning status are subject to change.

Each of the 4 counties were surveyed for industrial plants. Over 600 companies were identified as industrial establishments, according to the Standard Industrial Classification, (SIC). However, only 125 of these companies had 50 or more total employment and the average number of employees was 38.

From the list of 125 companies, those having industrial processes that require direct heat applications or preheat requirements were selected. The resulting 79 companies were classified by SIC and location. 64 of the companies were co-located with the 20 potential geothermal resource sites. 48 of the companies, including at least 1 from each SIC, were contacted to obtain data on energy consumption, company and industrial growth estimates and attitudes, perceptions, and understanding of and about hydrothermal usage in industrial processes. Several of the companies declined to give information for a number of reasons, but representative data was obtained for all industries.

The data acquired through the survey was measured against data available through the State's Department of Planning and Economic Development, the electrical utilities, and previous energy studies. In most cases, the data had a high correlation. Where large discrepancies existed, industrial sources were reinterviewed to determine which data was in error.

For companies where specific data was not available, factors for industrial process BTU consumption were developed. These factors were based on employee

counts and the energy intensity of respective product mixes.

87% of the State's industrial energy consumption was identified by company. The remaining 13% was allocated to smaller companies and secondary usages. Also, an error factor of 20% was applied to industry data because of the translation of source consumption into gross BTU consumption.

The resulting baseline data was then tabulated by county. A similar analysis was conducted to determine gross BTU consumption by the residential/ commercial sector. Through data provided by the electrical utilities and Hawaii's Department of Planning and Economic Development, per capita energy consumption factors was determined and multiplied by the various county populations to determine residential consumptions. To convert KWH into gross BTU's, a factor of 11,150 BTU's was used. This is the State's average level of efficiency.

The commercial sector was difficult to break down by type of usage. Energy consumption for hotels (one of Hawaii's major business segments), office space and retailing space were identified. This accounts for less than 60% of the total energy consumed by the commercial sectors. However, electrical and gas utility data confirmed the size of the commercial market. The potential market for geothermal applications was determined to be primarily water heating. Space conditioning was considered, but excluded from the potential market. There is practically no space heating in the State and a high percentage of the central air conditioning units are located in the heavy urban areas and would require a great deal of disruptive activity to get hydrothermal fluids piped to them. Also, because the larger systems are used year round, most operators have invested in equipment and engineering to gain operating efficiencies and several have retrofit heat exchangers to provide hot water.

Baseline data for industrial consumption by county and site and residential and commercial consumption by county are shown in Exhibit II.

EXHIBIT II

1975 GEOTHERMAL POTENTIAL BY RESOURCE LOCATION

County / Resource Location	Industrial		Residential/Commercial	
	Standard Industrial Code (SIC)	Energy Use (BTU/yr x 10^{12})	Total Energy Used (BTU/yr x 10^{12})	Energy Used For Space Conditioning And Water Heating (BTU/yr x 10^{12})
Hawaii				
1. Puna*	201	.007		
	2061	1.506		
	2065	.049		
	209	.004		
2. Ka'u	2061	1.430		
4. Hualalui	209	.009		
	327	.012		
5. Kawaihae	201	.003		
	327	.002		
6. Keaau	201	.004		
	202	.002		
	203	.010		
	204	.006		
	2061	3.347		
	287	.007		
	327	.015		
	329	.015		
	Subtotal	6.428	3.82	1.484
Honolulu				
15. Lualualei	204	.014		
	249	.001		
	281	.234		
	287	.024		
	291	.721		
	324	3.612		
	327	.030		
	331	.291		
16. Honolulu Volcanic Series	201	.010		
	202	.009		
	203	.573		
	205	.005		
	2065	.001		
17. Haleiwa	2061	1.525		
19. Pearl Harbor	201	.010		
	202	.007		
	203	.005		
	204	.014		
	205	.002		
	2061	1.555		

*Locations correspond to the sites identified in "Hawaii Geothermal Resource Assessment Program."

EXHIBIT II
(cont'd)

1975 HAWAII ENERGY USE BY COUNTY

County / Resource Location	Industrial		Residential/Commercial	
	Standard Industrial Code (SIC)	Energy Use (BTU/yr x 10^{12})	Total Energy Used (BTU/yr x 10^{12})	Energy Used For Space Conditioning And Water Heating (BTU/yr x 10^{12})
Honolulu (cont'd.)	2062	.228		
	2065	.001		
	209	.025		
	265	.080		
	307	.024		
	327	.002		
	Subtotal	9.003	52.25	17.902
Kauai				
20. Post Erosional Volcanic Series	205	.001		
	2061	1.688		
	287	.001		
	327	.013		
	Subtotal	1.703	1.49	.625
Maui				
10. Pauwela	203	.120		
	2061	3.370		
	327	.002		
11. Lahaina	2061	.870		
	Subtotal	4.362	3.07	1.298
State Total		21.496		21.309

B. Market Growth Projection Development

Potential market growth was derived through a combination of forecasting projection based on the state of Hawaii's Department of Planning and Economic Development projections for energy demands, population, and tourism and industry surveys. A summary is given in Exhibit III.

Industrial growth rates were developed for each of the SIC categories from company interviews, industry projections, and state projections. Growth projections were made on an annual compounded rate for the periods 1985-2000 and 2000-2020. These figures were not adjusted for efficiencies that might occur due to rapidly rising energy costs.

The sugar factories were not expected to show growth. Foreign competition has suppressed the price of sugar and many companies are looking for alternative uses of the land. Historical data indicates that the industry is consolidating and that a number of smaller inefficient factories have been shut down. Countering these trends is the increasing value of sugar by-products such as electricity generation.

The other two large energy SIC categories, refinery and cement, were given growth rates based on company projections. Food processors and agriculture processors, other than sugar, were given growth rates equal to population projections. In construction related industries, growth rates were based on projected construction activity in the housing and tourism industries.

The potential geothermal market growth was projected to be lower than the general growth for industry. This reflects the no-growth trend of the sugar factories' energy consumption. Where the sugar factories were subtracted out of the data, the potential geothermal growth rate is higher than the growth rate for industry in general. This can be expected as new industries locate near geothermal resources. It was assumed that in-place industries would not

EXHIBIT III

HAWAII GROWTH PROJECTION CALCULATIONS

Standard Industrial Code (SIC)	Growth Rate (%/Year)	1975 Energy Use (BTU/Yr x 10^{12})	1985 Energy Use (BTU/Yr x 10^{12})	2000 Energy Use (BTU/Yr x 10^{12})	2020 Energy Use (BTU/Yr x 10^{12})
201	Based on population growth	.034	.080	.195	.339
202	"	.018	.045	.117	.226
203	"	.708	1.666	3.975	4.861
204	"	.034	.084	.224	.421
205	"	.008	.019	.045	.091
2061	No growth	15.294	15.294	15.294	15.294
2062	"	.228	.228	.228	.228
2065	Based on population growth	.051	.070	.095	.134
209	"	.038	.095	.201	.379
249	Construction projections	.001	.001	.013	.026
265	Population	.080	.088	.110	.134
281	Industry sources	.234	.300	.434	.875
287	Agriculture projections	.032	.040	.055	.067
291	Industry sources	.721	.793	.793	.793
307	Industry sources	.024	.012	.024	.048
324	Construction projections	3.612	3.612	4.516	6.711
327	"	.076	.162	.253	.332
329	Industry sources	.015	.030	.039	.052
331	"	.291	.355	.355	.675
TOTAL PROCESS HEAT		21.499	22.974	26.966	31.686

relocate to geothermal resources. Also assumed was a continuation of Hawaii's pattern of attracting smaller scale industrial processes rather than large manufacturers.

It should be noted that if the State if successful in attracting an energy intensive process such as manganese nodules or aluminum refinery that the industrial energy growth rates and geothermal growth rates would change dramatically. For example, a three product manganese nodule plant requires 150 MW capacity and a four product plant or aluminum refinery requires a 300 MW capability. However, as previously stated, it was assumed that these industries would not locate in Hawaii for a number of non-energy reasons.

Growth rates for R/C were based on energy use projections by the State Department of Planning and Economic Development based on per capita consumption, population growth, and tourism growth. Over time, these rates decline. Population growth for the State declines from a high of 1.87 average annual percentage growth in the 1977 to 1980 period to a low of 1.05% in the 2000 to 2005 period. This growth rate was assumed to continue through year 2020. These forecasts assume a middle fertility level of 2.1 births per woman. The State's economy, growth rate, and commercial activity is very dependent on the tourism industry State projections for tourism growth starting at 7% per annum in the 1977 to 1979 time frame and declining to 1% in the 1996 to 2000 period.

The State's projections assume a constant growth rate of 4% for electricity generation. This rate includes a growth in per capita energy consumption. The projections also assumed a continuing dependence on petroleum products and did not consider the importance of alternative energy sources.

New discovery factors were not applied to potential geothermal growth since all major population, commercial, and industrial areas of the State are

located within potential geothermal market areas. Several sugar factories are not in these areas and new discoveries within this area (which cannot be predicted at this time) would increase the potential growth.

C. Market Capture Potential Estimate Development

The market capture potential estimates were developed on a county basis. Present plans indicate that the earliest possible direct application of geothermal to be 1983. All co-located sugar plants are projected to convert to geothermal by year 2000. Other major retrofit applications were projected to start in 1985 in Honolulu at the Campbell Industrial Park. By the year 2000, a 20% retrofit is estimated. All other retrofit is projected at a rate of 1% per year until the year 2020. Kauai County's retrofit is not projected to start until year 2000, because of the current size of its population and commercial/industrial base. However, for Hawaii, Honolulu, and Maui, geothermal is projected to capture 50% of new growth beginning in the year 1985 and starting in 2000 for Kauai. These rates were assumed constant through year 2020.

Potential capture for R/C was based on an assumed 1% per year retrofit rate for all counties beginning in 1990 for Hawaii, Honolulu, and Maui, and 2005 for Kauai. Starting in 1985, step increases for new growth in Hawaii, Honolulu, and Maui were estimated to a maximum of 30% of the new growth by 2000, Kauai's capture of new growth is assumed to start in 2000 up to a maximum of 30% by 2015.

Exhibit IV summarizes by county the baseline data, market potential projections, and the forecasted geothermal capture.

EXHIBIT IV

HYDROTHERMAL FORECAST FOR HAWAII

County	1975 (BTU/Yr x 10^{12})		1985 (BTU/Yr x 10^{12})			2000 (BTU/Yr x 10^{12})			2020 (BTU/Yr x 10^{12})		
	State Energy Use	Potential Geothermal Use	State Energy Use	Potential Geothermal Use	Forecasted Geothermal Capture	State Energy Use	Potential Geothermal Use	Forecasted Geothermal Capture	State Energy Use	Potential Geothermal Use	Forecasted Geothermal Capture
Hawaii											
Industrial	13.240	9.943	13.657	9.980	1.506	14.500	10.027	6.634	15.600	10.097	7.283
Residential/ Commercial	3.82	1.484	6.39	2.456	-0-	11.54	4.116	.537	20.91	7.449	2.017
TOTAL	17.060	11.427	20.047	12.436	1.506	26.04	14.143	7.171	36.51	17.546	9.300
Honolulu											
Industrial	17.421	10.676	21.384	12.025	-0-	34.734	14.978	3.555	64.364	20.450	8.102
Residential/ Commercial	52.25	17.902	71.75	24.076	-0-	125.35	34.645	4.238	240.85	55.035	14.841
TOTAL	69.671	28.578	93.134	36.101	-0-	160.084	49.623	7.793	305.214	75.485	22.943
Kauai											
Industrial	6.568	4.860	6.918	4.864	-0-	7.628	4.867	-0-	9.158	4.869	1.971
Residential/ Commercial	1.49	.625	2.72	1.084	-0-	5.36	1.993	-0-	10.71	3.589	.809
TOTAL	8.058	5.485	9.638	5.948	-0-	12.988	6.860	-0-	19.868	8.458	2.780
Maui											
Industrial	7.780	4.963	9.22	5.021	-0-	12.37	5.073	3.981	12.640	5.112	4.195
Residential/ Commercial	3.07	1.298	7.73	2.528	-0-	16.68	4.144	.564	20.760	6.108	1.642
TOTAL	10.850	6.261	16.95	7.549	-0-	29.05	9.217	4.545	33.400	11.220	5.837
State											
Industrial	45.015	30.442	51.179	31.890	1.506	69.232	34.945	14.170	101.762	40.528	21.551
Residential/ Commercial	60.63	21.309	88.59	30.144	-0-	158.93	44.898	5.339	293.23	72.181	19.309
TOTAL	105.645	51.751	139.769	62.034	1.506	228.162	79.843	19.509	394.992	112.709	40.860

III. RESOURCE OVERVIEW - DIRECT HEAT

The State of Hawaii consists of a chain of five major islands and several minor islands. The islands were formed by volcanic activity and are relatively young land masses. The island of Hawaii still has an active volcano which erupted as recently as 1977. The geological and hydrological conditions of Hawaii are substantially different from those found on the Mainland.

An assessment of potential geothermal resource areas in the state of Hawaii was recently completed by the Hawaii Institute of Geophysics. This evaluation was based on geological, geophysical, geochemical data. The report appraises the probability of low temperature and high temperature resources. The appraisals were based on surface tests. More intensive site investigation is planned for the future.

Unlike many geothermal resources around the world, it is believed that Hawaii's resources are at a great depth. The cost of reaching these resources may prevent individual companies from drilling their own wells for direct heat applications in the near and intermediate future.

It was assumed for purposes of estimating market potential that direct heat applications would be a secondary application after electricity generation. In other words, it is not anticipated that the geothermal resources will be developed unless the primary objective is to generate electricity.

IV. MARKET OVERVIEW - DIRECT HEAT

Most of the publicity on geothermal development in Hawaii has been on its potential for generating electricity. The consensus of the business executives surveyed was that they had not even considered the possibility of applying hydrothermal fluids to their companies' direct heat needs. Most stated that their companies did not have plans for researching the feasibility of hydrothermal usage. However, most allowed that this could change if geothermal resources and quality were known to be located near their plants.

Hawaii's island economy, unique climate, and geological formation limits the potential of hydrothermal energy as a substitute for fossil fuel generated direct heat. The lack of space heating needs, the size of the economy and its various participants lessen the probability of widespread usage by individual companies or communities unless it is developed and distributed by a utility.

The present development of geothermal has been confined to one site on the island of Hawaii in an agricultural area. This area is subject to volcanic activity and there are a number of risks associated with this activity. Concurrent to the development of geothermal as an alternative energy resource, Hawaii is actively pursuing the development of other alternative energy resources.

A pilot Ocean Thermal Energy Conversion (OTEC) project was recently launched and results to date appear promising. The State's major utility recently announced plans to apply to the U.S. government for a grant to build an OTEC generating plant off the island of Oahu. They have also announced plans to build a windmill farm.

Hawaii's proximity to the equator makes it a high potential candidate for

solar energy resources. Already, many homeowners are using solar for their water heating and the market is growing. Several hotels have recently installed solar collectors to meet a portion of their hot water requirements and plans for future homes, condominiums and hotels often include solar.

When and if solar cell technology makes direct conversion from solar to electricity economically competitive, it is likely that this technology will gain widespread use in Hawaii.

In the meantime, other technologies and resources are being investigated by Hawaii's businesses. One of the major cement factories recently announced that it was converting to coal. A pre-stressed concrete manufacturer is seriously considering converting from steam curing to chemical curing and indicated that it will most likely be an industry-wide change.

The impact that the development of other alternative energy sources and the activities of businesses to decrease their consumption of petroleum products will have on geothermal development is impossible to measure at this time because of unknown economics. But business and government leaders throughout the State have indicated that geothermal's major potential will be in electricity generation, rather than direct heat. These attitudes are not firm, and additional insights into direct heat applications, the economics involved, and the time frame for development could have a positive effect.

At this time, the largest potential user of hydrothermal fluids appear to be the sugar factories. They have both process heat requirements and electricity generation capabilities, and many are located in potential geothermal resource areas. Other strong potentials exist at Campbell Industrial Park and Puna area in Hawaii County. Most of Hawaii's heavy non-sugar industry are located in or near the Campbell Industrial Park. If the Laulaulie reservoirs (owned by the Department of Defense) is developed and made available to commercial users via a utility pipeline, new industry may be attracted to that

location because of the availability of hydrothermal fluids.

The Dillingham Company, one of Hawaii's leading companies and a major developer is conducting "An Engineering and Economics Studies for Direct Application of Geothermal Energy in an Industrial Park at Pahoa, Hawaii." This study is being sponsored by the DOE. The results of this study and the development efforts by Dillingham may accelerate the industrialization of Hawaii County faster than this study has estimated.

APPENDIX A

Hawaiian Dredging & Construction Company

August 28, 1979

Dr. John Shupe
University of Hawaii
College of Engineering
Holmes Hall #240
2540 Dole Street
Honolulu, Hawaii 96822

Dear John:

The chairman of the Geothermal Advisory Committee has asked me to furnish you our legislative recommendations for the forthcoming session of the State Legislature. The Legislative Subcommittee's recommendation to the full committee listed the issues related to the commercialization of Geothermal Energy as follows:

	Issue	Priority
1.	Incentives	high
2.	Community, Social, Environment	high to medium
3.	Resource Assessment	medium to high
4.	Risk Insurance	medium to high
5.	Barrier Removal	medium
6.	Resource Ownership	medium to low
7.	Technical, Scientific	low

A DILLINGHAM COMPANY
BOX 3468 HONOLULU HAWAII 96801 CABLE BARDREDGE TELEX 723-8795 TELEPHONE (808) 735-3211

Within the context of these issues, the several legislative proposals which have been discussed and endorsed by the committee and recommended for consideration by the committee are:

1. "Forgive state royalty payments for first ten years production of wells and provide gradual reduction and elimination through sunset provision."

Discussion: The need for additional wells to prove the extent of Hawaii's geothermal resource is of prime importance. In order to attract the necessary investment to undertake the drilling and development of future wells with application for both electric and non-electric commercial ventures the forgiving of state royalty payments can be a key incentive. We doubt that investors will act without this incentive and we do not believe the state will lose any direct benefit. Certainly, without the development there could be no royalty payment and after ten years the royalty payments and other direct benefits will flow from producing wells.

However, the legislature may wish to differentiate between an exploratory well and a producing well. We believe the greatest incentive in Hawaii at this time is needed to encourage and support the drilling of "exploratory" wells. Therefore, we believe the full ten years forgiveness is necessary to get these wells drilled and developed. Then, after several exploratory wells have been placed in operation the Legislature may determine that the succeeding "production wells" drilled in that reservoir could have a reduced period of time for forgiveness of the royalty payments.

2. "Pass a resolution instructing the PUC to permit public utilities to make a higher rate of return on investments in non-fossil fuel generating facilities."

Discussion: Because Hawaii government and private interests probably will benefit from the avoidance of sending money out of the state for every barrel of oil that is replaced by alternative energy generating facilities, the public utilities should be encouraged with proper incentives to invest in these alternative facilities. It is recommended that the Legislature consider a "higher rate of return on investment", that is, markedly higher reflecting the long range benefit to the rate payers of the state that may result from the development of these alternative resources.

3. "Establish a 3 mills per kwh tax credit for generation of electricity for all new or improved plants using 'alternate' forms of energy."

Discussion: Whereas the cost of imported fuel oil has drastically increased in cost approximately 60% since January 1969, the best interests of the State of Hawaii and its residents can be served by the early development of alternative electricity generating facilities using non-fossil fuel energy including geothermal, ocean thermal and bio-mass energy. To encourage private and public utility investment, the recommended 3 mills per kwh tax credit is believed to be necessary. Existing state funds will not be expended and neither will future funds be reduced because the new and improved alternate energy generating plants may not be constructed without such an inducement as the 3 mills per kwh tax credit.

4. "Pass a resolution to the Department of Land and Natural Resources to provide for a reduced royalty payment for the direct use of geothermal energy applications such as the production of ethanol, sugar, etc."

Discussion: Direct use application of geothermal energy can enhance the development of Hawaii's geothermal resource. Acceptance of the use of geothermal energy by residents and others can be facilitated through diverse direct uses in commercial processes which are currently being studied. Because of the many unknowns associated with such a new business venture, extra incentives will be necessary. Furthermore, any "direct use" business would be an additional business activity which would not require payment of existing funds.

5. "Provide 15% differential to increase geothermal loan guarantee from federal support of 75% to a full 90% support."

Discussion: Geothermal loan guarantees have proven very valuable in the mainland western states for geothermal developments. However, the 75% level has also proven an inadequate amount for many businesses that are unable to provide the 25% required funding. Thus, the additional 15% state supported geothermal loan guarantee will reduce the risk of businesses investing in the exploration, drilling and end use applications of Hawaii's geothermal resource.

However, one way DOE assesses a geothermal loan guaranty application is based on the amount of the borrower's investment. With a 25% investment by the borrower, DOE

considers that his risk will be sufficient to encourage him to do his utmost to assure success of the development. With a reduction to 10% there may be some hesitancy by DOE. Even so, we believe that in Hawaii there is a need for this additional 15% loan guarantee assistance to make the geothermal development attractive.

It is noted that there would be no reduction in the Federal Loan Guarantee of 75% with the State's provision for an additional 15%.

6. "Provide funds for 'affected' communities, such as the Puna District, to do socio-economic research that can develop and protect the interests of residents in an objective and realistic manner."

Discussion: The cooperation of near-by residents of any commercial development should be encouraged. The amount of funds required to provide for reimbursement of costs of the residents representatives to follow activities such as hearings, conferences and meetings can be considered a modest investment not only for the awareness of the people of Hawaii directly involved, but also to assure acceptance of a project before sizeable funds are committed.

It is contemplated that socio-economic research would be conducted by representatives of the community in conjunction with some assistance by professionals from industry or academia. Also representatives of the community at some stage of development would expect to participate in critical decision making by the businesses.

7. "Forgive for a period of five years after commercial production commences, state sales taxes on all construction and equipment purchased for geothermal exploration and development until a positive revenue flow for the project is attained."

Discussion: This is an incentive to attract investors so that geothermal energy can be developed. Once the 'positive revenue flow' is established, the State will realize an income from the development of a geothermal industry.

8. "Provide general support in a resolution for federal geothermal energy omnibus legislation."

Discussion: In July, Dr. Eugene Grabbe participated with other state government representatives in a review of two proposed bills in the U.S. Senate. The list of recommendations of that group are attached.

Two additional items, which are considered to be of high priority relate to 'Risk Insurance'. They will be handled separately as an administrative manner. They are:

1. Alleviate uncertainties of risks associated with volcanic, seismic and 'acts of God' activities by providing state risk insurance at early date pending provisions by Federal legislation at level's required to stimulate electric and non-electric applications of geothermal energy.

2. Provide early depletion reservoir insurance to compensate geothermal production companies investing in direct use applications in the event of premature failure of the geothermal supply.

If there is additional information you may require, please do not hesitate to call me.

Very truly yours,

Lloyd Jones

W. Lloyd Jones
Manager, Energy Projects

WLJ:JWM:p

Attachment as indicated

Attachment

GEOTHERMAL ENERGY OMNIBUS LEGISLATION

July 10, 1979
Economic Sub-group Concurrence
Seattle

All parties present agreed:

1. That the program establishing direct forgivable loans for for exploratory drilling, which is a part of S1388, would be extremely beneficial and should be strongly supported.

2. That a limit be established in the legislation to preclude a single company from obtaining a large percentage of the loans issued under the exploratory drilling loan program.

3. That the limitation on the size of the loan for a single well currently in S1388 be increased from three million to ten million.

4. That the reservoir insurance in S1330 should be implemented provided that this does not preclude adequate funding for loans supporting reservoir exploration.

   a. That S1330 Sec 1149 Sub Sec (B) Paragraph 3 (pg. 36) should be ammended to read:

      . . . . . risk means a hazard that a reservoir of geothermal resources will cease to provide sufficient quantities of geothermal resource shown to exist at the time of application at minimum conditions required to maintain an economically (or technically) viable operation for utilization of the geothermal resource:

   b. That the regulations covering reservoir insurance should include risks associated with:

      seismic risks
      volcanic risks
      other acts of God

   c. That S1330 Sec 1149 Sub Sec (F), be ammended to include the sentence:

      The insurance shall be for a period not to exceed the expected life of the project or 30 years, whichever is less.

5. That the legislation should add provisions which are not currently incorporated in either S1330 or S1388, to eliminate the royalties charged under the Geothermal Stam Act for applications utilizing resources not exceeding 150 degrees centidrage or any non-electric applications.

6. That it is important for Congress to set a time limit within which applications under the Geothermal Loan Guarantee Act must be processed. Such a time limit is currently in S1330.

7. That the Geothermal Loan Guarantee program for municipals, cooperatives, and small businesses should be increased to 90%.

8. That an increase in the acreage limit should be made along with increased diligence requirements. Both of these are important and it may be advantageous to combine them to assure that companies holding larger lease areas will not tie up the resources in a particular area.

9. That the 90% forgivable loans for feasibility studies and the 75% construction loans currently in S1330 should <u>not</u> be included in the final Omnibus legislation.

10. That the SBA, HUD, REA and Fm HA should be encouraged to support geothermal loans. No consensus was reached whether the Geothermal Loan Guarantee Program is the best mechanism for accomplishing this.

11. That the definition of geothermal reservoir in S1388 needs to be changed. The definitions under Title III of S1330 would be acceptable.

12. That the economic incentive portions of the Omnibus legislation have a sunset clause similar to what is currently in Section 104 of Title 1 of S1388.

PETROLEUM USE
1975
BTU/yr. x 10^{12}

	Hawaii	Honolulu	Kauai	Maui	Total
Electric Utilities	4.7	50.6	2.2	3.9	61.4
Cement		1.5			1.5
Other Non-commercial		1.1			1.1
Gas Marketing & Distributing	.7	3.4	.2	.3	4.6
Agriculture & Ag. Processing	2.1	4.0	——	1.4	7.5
Construction	.2	2.2	——	.1	2.5
Commercial/Industrial	.1	2.5	——	——	2.6
Refinery Use		3.7			3.7
	7.8	69.0	2.4	5.7	84.9

APPENDIX B

APPENDIX B
SUGAR FACTORIES
ENERGY PRODUCED FOR FACTORY PROCESSING AND ELECTRICITY GENERATION
1975

County	Biomass BTU/yr. x 10^{12}	Fuel Oil BTU/yr. x 10^{12}	Hydro	Total BTU/yr. x 10^{12}
Hawaii	9.912	2.084	.02	12.016
Honolulu	3.840	.221	——	4.061
Kauai	5.170	.088	.46	5.718
Maui	4.873	1.427	.22	6.520
State	23.795	3.820	.7	28.315

APPENDIX C

APPENDIX C
ENERGY USE - SUGAR FACTORIES
1975

County	Industrial Process BTU/yr. x 10^{12}	Electricity Generation BTU/yr. x 10^{12}	Total BTU/yr. x 10^{12}
Hawaii	7.889	4.122	12.016
Honolulu	2.176	1.885	4.061
Kauai	3.650	2.068	5.718
Maui	3.116	3.404	6.526
State	16.831	11.484	28.315

APPENDIX D

APPENDIX D

KEY TO LOCATION OF GEOTHERMAL SITES

Location

Hawaii
1. Puna
2. Ka'u
3. South Point
4. Hualalai-North Kona
5. Kawaihae
6. Keaau
7. Kohala

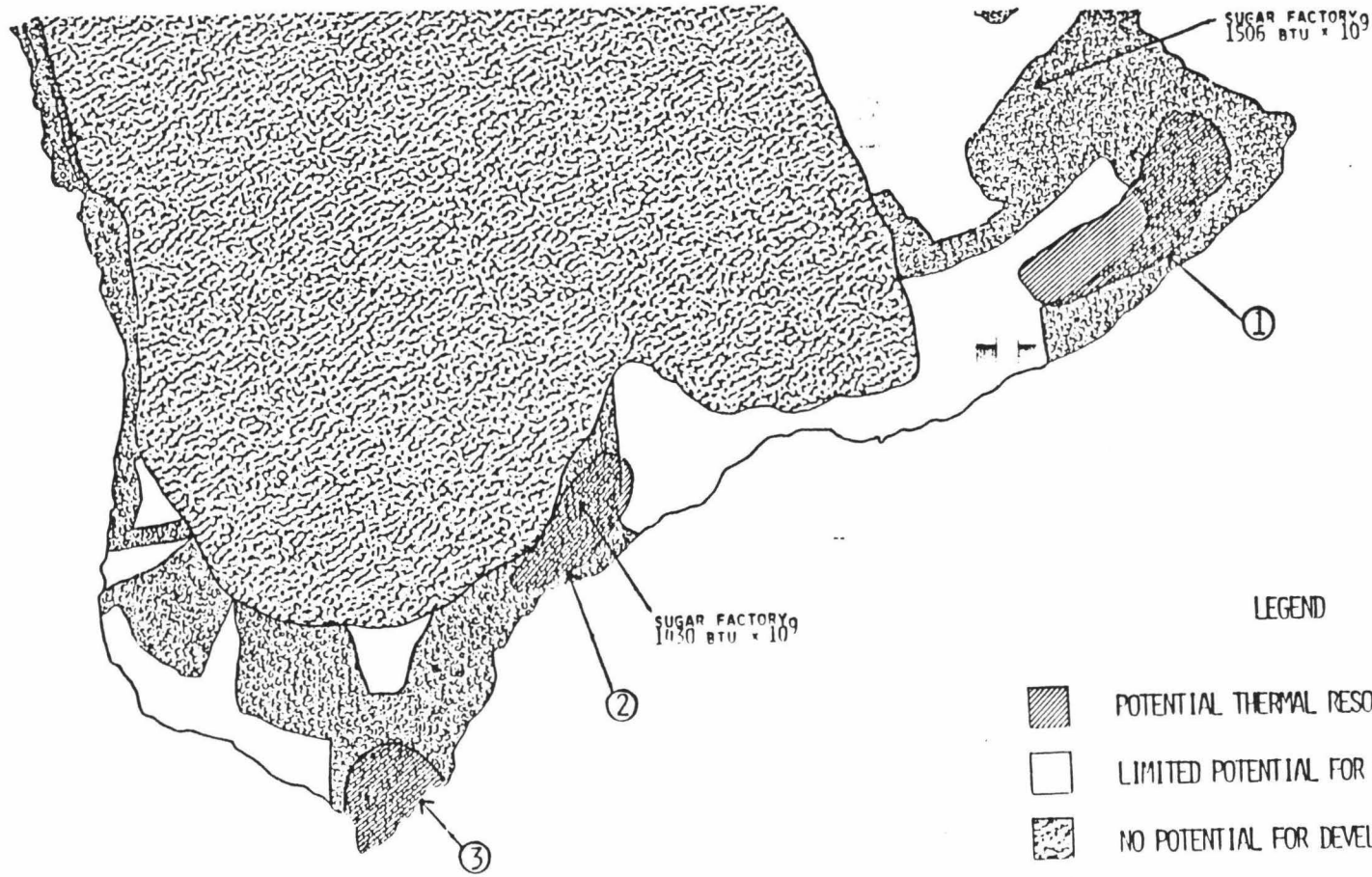
Maui
8. Haleakala-Southwest Rift
9. Haleakala- East Rift
10. Pauwela
11. Lahaina
12. Olowalu- Ukumehame
13. Honokawai

Oahu
14. Waimanalo
15. Lualualei
16. Honolulu Volcanic Series
17. Haleiwa
18. Laie
19. Pearl Harbor

Kauai
20. Post erosional Volcanic Series

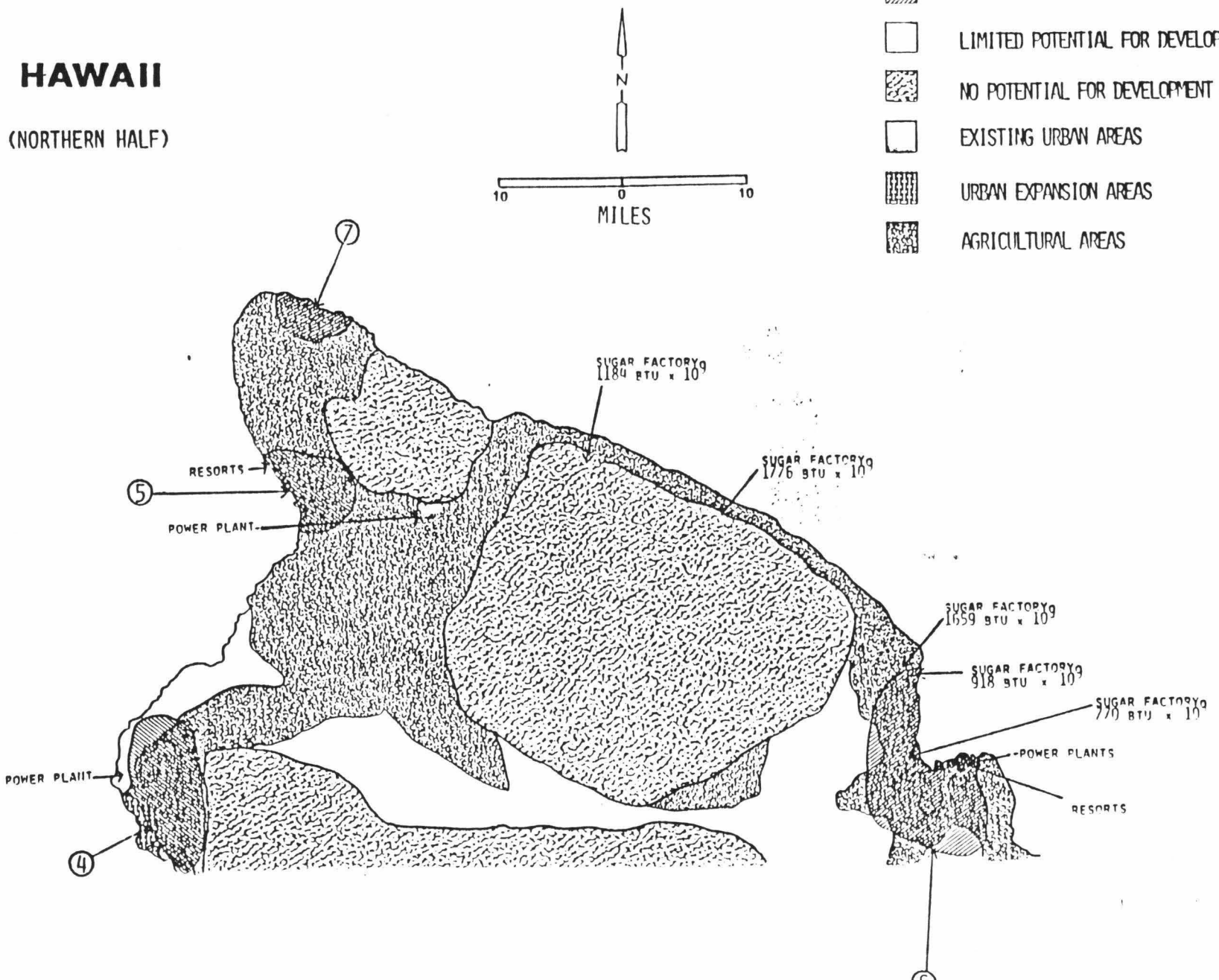
HAWAII

(SOUTHERN HALF)

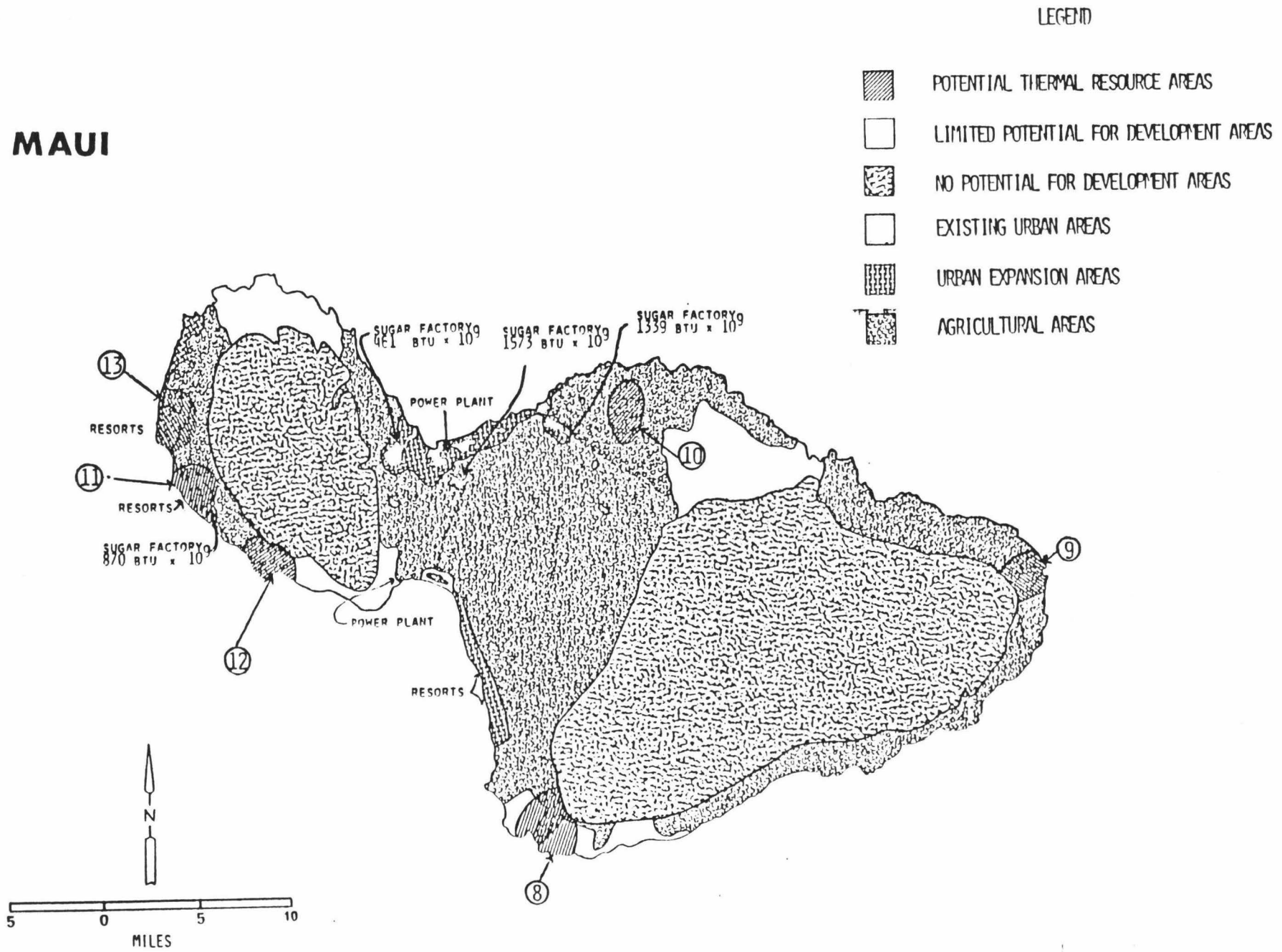


HAWAII

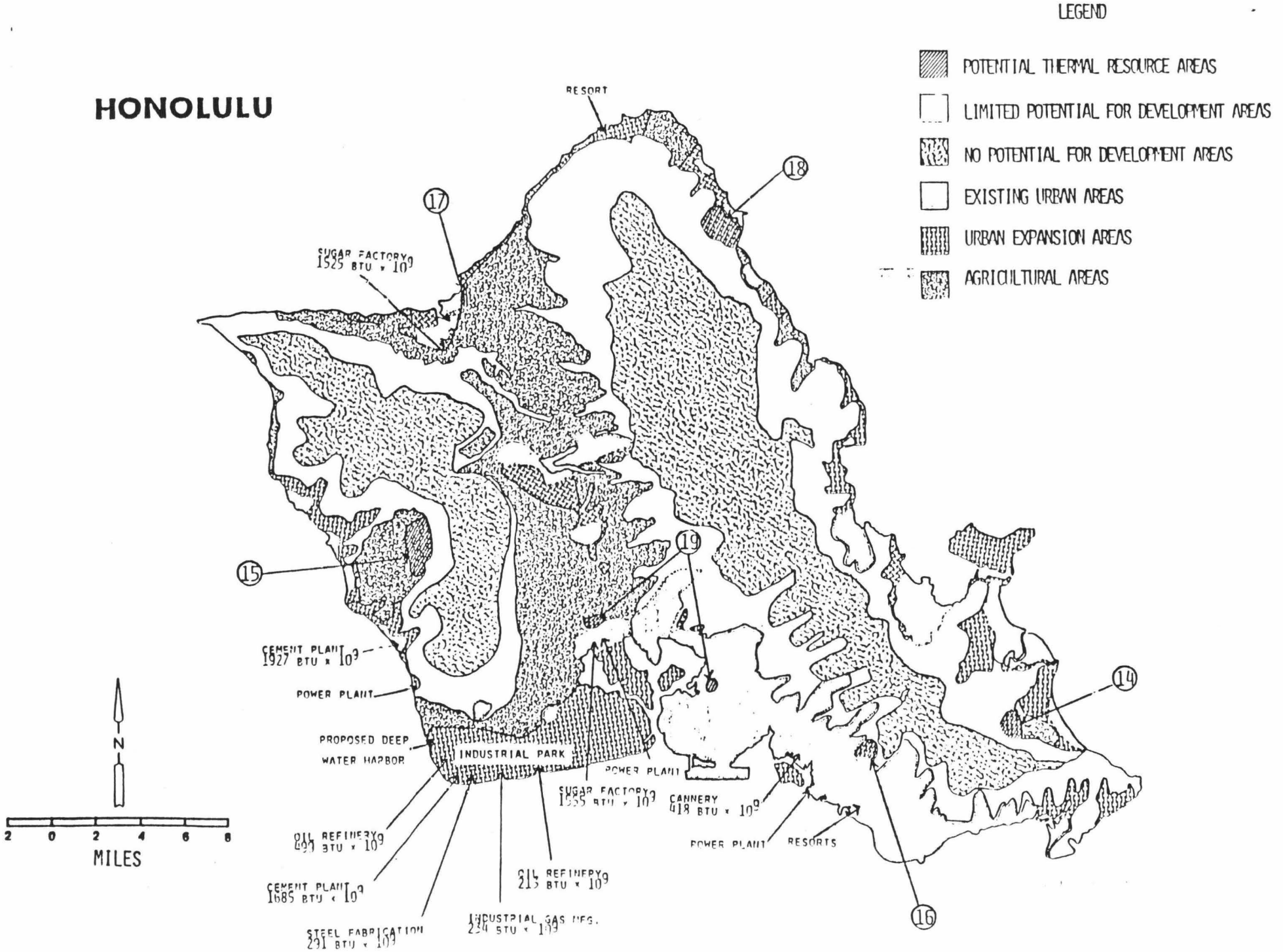
(NORTHERN HALF)



MAUI


LEGEND
POTENTIAL THERMAL RESOURCE AREAS
LIMITED POTENTIAL FOR DEVELOPMENT AREAS
NO POTENTIAL FOR DEVELOPMENT AREAS
EXISTING URBAN AREAS
URBAN EXPANSION AREAS
AGRICULTURAL AREAS
SUGAR FACTORY
461 BTU x 10^9
SUGAR FACTORY
1573 BTU x 10^9
SUGAR FACTORY
1339 BTU x 10^9
POWER PLANT
RESORTS
RESORTS
SUGAR FACTORY
870 BTU x 10^9
POWER PLANT
RESORTS
13
11
12
10
9
8
N
5
0
5
10
MILES

HONOLULU


LEGEND
POTENTIAL THERMAL RESOURCE AREAS
LIMITED POTENTIAL FOR DEVELOPMENT AREAS
NO POTENTIAL FOR DEVELOPMENT AREAS
EXISTING URBAN AREAS
URBAN EXPANSION AREAS
AGRICULTURAL AREAS
RESORT
17
18
19
15
14
16
SUGAR FACTORY
1525 BTU x 10^9
CEMENT PLANT
1927 BTU x 10^9
POWER PLANT
PROPOSED DEEP
WATER HARBOR
INDUSTRIAL PARK
POWER PLANT
SUGAR FACTORY
1525 BTU x 10^9
CANNERY
418 BTU x 10^9
POWER PLANT
RESORTS
REFINERY
BTU x 10^9
CEMENT PLANT
1685 BTU x 10^9
STEEL FABRICATION
291 BTU x 10^9
INDUSTRIAL GAS MFG.
REFINERY
213 BTU x 10^9
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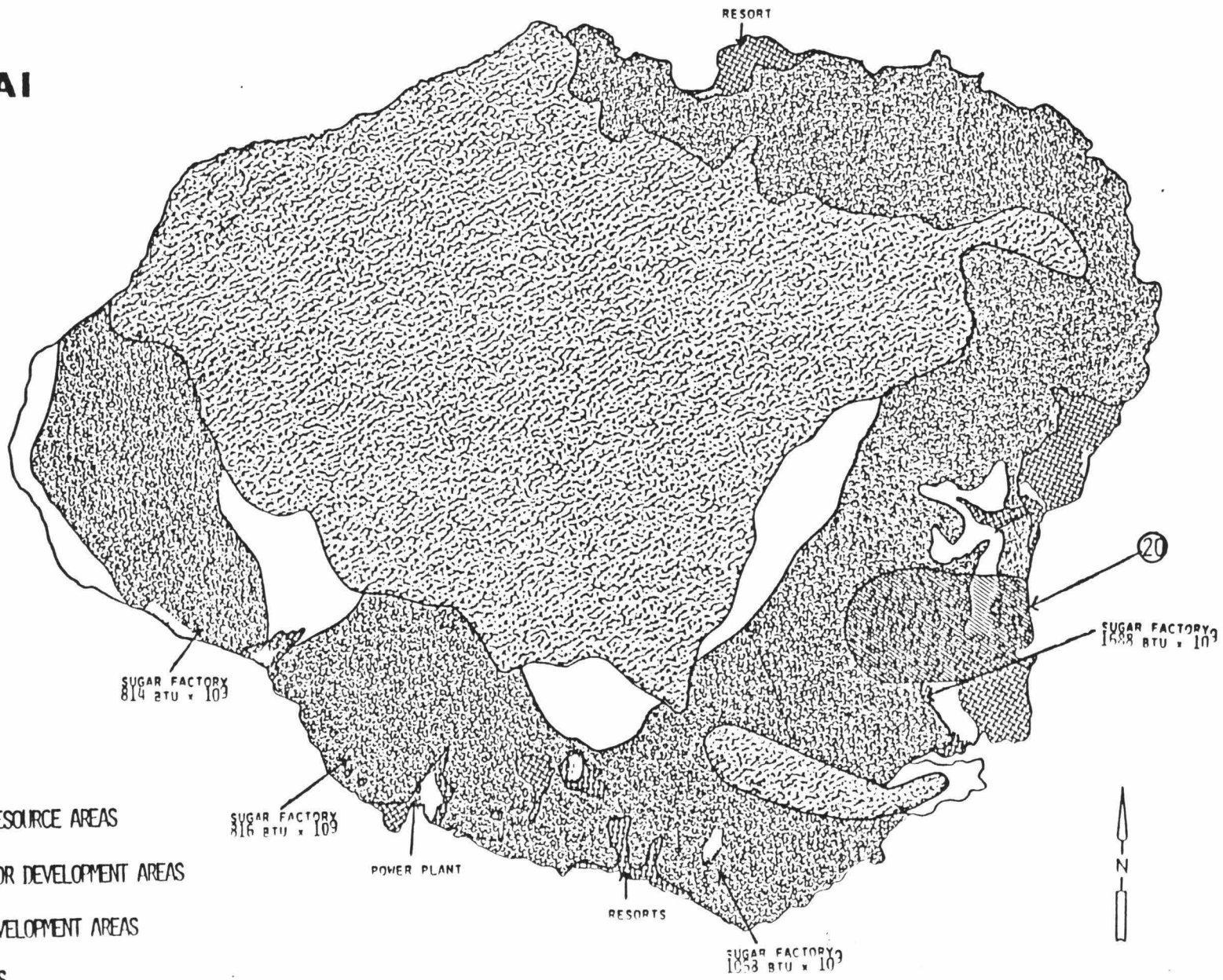
KAUAI



LEGEND

- POTENTIAL THERMAL RESOURCE AREAS
- LIMITED POTENTIAL FOR DEVELOPMENT AREAS
- NO POTENTIAL FOR DEVELOPMENT AREAS
- EXISTING URBAN AREAS
- URBAN EXPANSION AREAS
- AGRICULTURAL AREAS

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