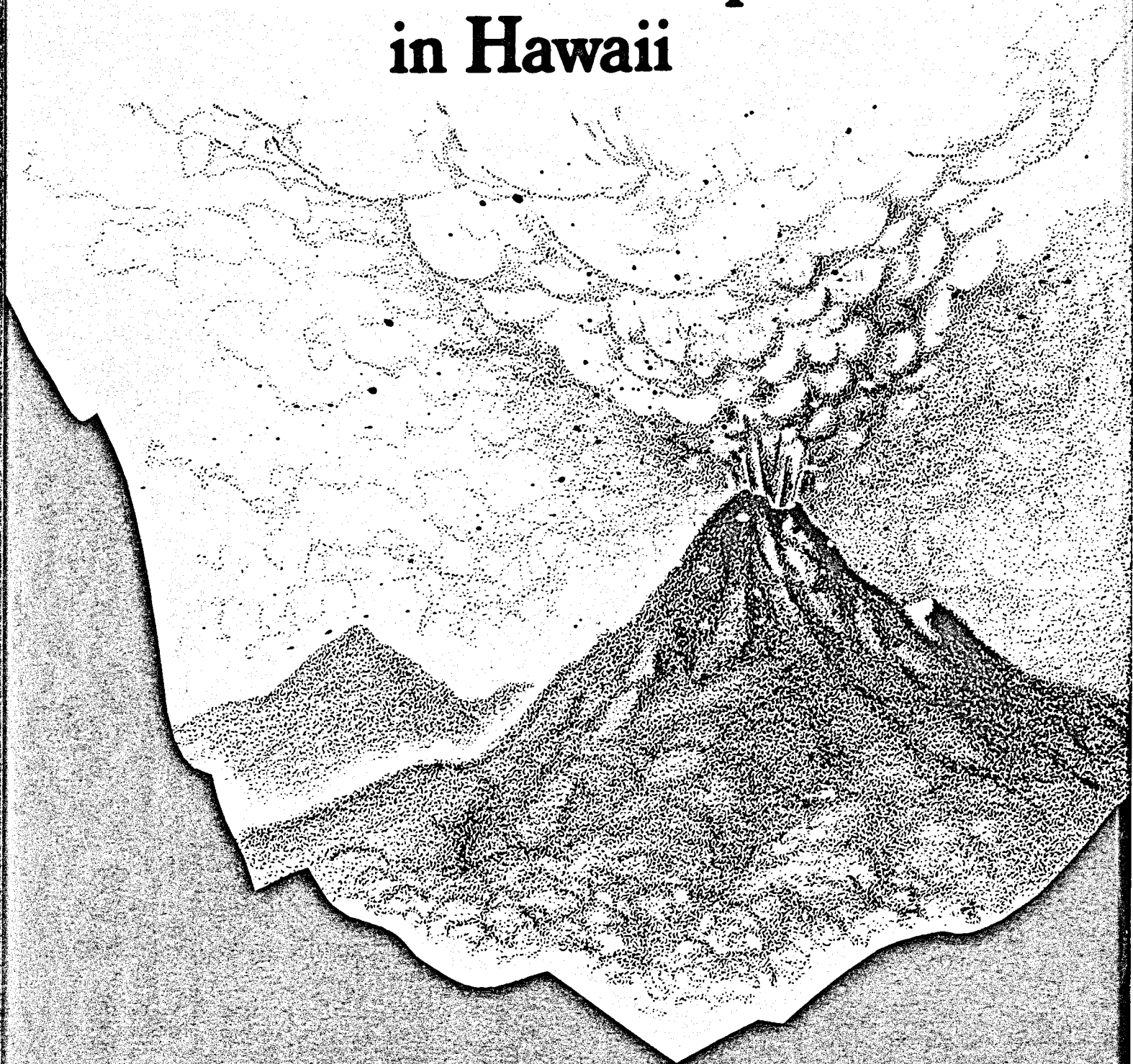


State Policy Considerations for Geothermal Development in Hawaii



* STATE POLICY CONSIDERATIONS *
* FOR *
* GEOTHERMAL DEVELOPMENT IN HAWAII *

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FOREWORD

This short paper was prepared in response to a request by Christopher Cobb, the Chairman of the State of Hawaii Board of Land and Natural Resources, and Hideto Kono, the Director of the Department of Planning and Economic Development, and State Energy Resources Coordinator. It is intended to be a short, opening statement on the various policy options which the State government and its Counties have in dealing with the geothermal resource potential now being investigated in Hawaii and therefore does not attempt to spell out in detail any of the policy issues it lists or the several institutional arrangements which are shown by way of example. The Department of Land and Natural Resources, under the Board, has the responsibility for the management of State mineral (including geothermal) resources, while the Department of Planning and Economic Development, the lead State energy agency, is responsible for general planning.

Robert Kamins, Professor of Economics, is co-principal investigator for Environmental and Socioeconomic Program of the Hawaii Geothermal Project at the University of Hawaii since its inception in 1973. The University project has also been concerned with geophysics and engineering, and has recently received a major grant from the Energy Research and Development Administration which will include drilling on the Island of Hawaii. Eugene Grabbe of the Department of Planning and Economic Development is Manager of a State Geothermal Energy Policy Project aimed at developing policy and action options in geothermal energy and is jointly funded by the State of Hawaii and the National Science Foundation. The State has also supplied substantial support for the Hawaii Geothermal Project. It is hoped that the policy and planning options which evolve will have general application to Hawaii's other energy resources such as ocean thermal energy conversion and wind as well as geothermal energy.

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I. The Potential Resource

- A. Physical characteristics. Hawaii's geothermal resources may be: (a) steam, (b) hot brines, (c) hot rocks and (d) molten magma. For (a) and (b) to be useful for electric power generation, hot volcanic or intrusive igneous rocks are needed with the right amount of water and a cap of sealed rock to form a reservoir. For (c) water would have to be injected, and reservoir conditions are also needed. In the longer range the extraction of energy from molten magma (d) may be possible but new technology will be needed.
- B. Legal characteristics. The Hawaii State Act 241 (1974) amends Chapter 182, Hawaii Revised Statutes, to define "geothermal resources" as a mineral. Such resources are said to be "...the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substances." Since most mineral rights in Hawaii belong to the State, the Department of Land and Natural Resources (DLNR), has the responsibility for establishing rules and regulations for exploration and development of geothermal resources (Ref. 1). The Department of Planning and Economic Development (DPED), as the lead energy agency, has been working with DLNR, the Attorney General and the University of Hawaii in formulating State policy options and plans for geothermal energy. Alternatives range from private to government development and exploitation.
- C. Locations of geothermal resources. In Hawaii, thermal activity is the best indication of geothermal resources. Wells have been drilled in many locations which produce warm or hot water and steam issues from some fissures. Areas of activity are most pronounced on

the Big Island, particularly the rift zones of Mauna Loa and Kilauea but also the region between Kamuela and Kawaihae. Other prospects are West Maui, West Molokai and the calderas of Waianae and Koolau volcanoes on Oahu (Ref. 2).

Hawaii's volcanoes are characterized by gentle eruptions of very fluid magma containing little gas. There are fountains of lava but little true explosion. The subsurface geology of Kilauea Volcano is well known, since it is the most investigated volcano in the world. The Puna flank was formed by numerous thin lava flows (Ref. 3). The Koolau Volcano has been thoroughly investigated by the Hawaii Institute of Geophysics. The size of the volcanic plug and the subsurface density distribution is known from gravity and seismic measurements (Ref. 3).

Kilauea is presently active while the last activity of Koolau Volcano is estimated to be 30,000 years ago. These represent two geological extremes and both should be explored as geothermal resources as well as those which lie between them.

II. Possible Uses of the Resource

While the chief motivation for finding and developing geothermal resources in Hawaii is to produce electric power, there are other possibilities. To provide a significant amount of electricity at a price competitive with oil-fueled generating plants, there must be a supply of water sufficiently hot (probably in excess of 350 F.), under sufficient pressure and of sufficient volume (say to energize a 10 megawatt plant for at least 20 years) to make commercial development economical. It is possible that geothermal resources will be discovered in Hawaii which do not meet these conditions, and yet are of economic use.

- A. Status of geothermal power in early 1975. Presently, there are only four major geothermal fields in the world producing electricity in relatively large

quantities. These are The Geysers, some 70 miles north of San Francisco, which now has an installed generating capacity approaching 500 Mw; the area around Larderello, north of Florence, Italy, which has a capacity of approximately 375 Mw; Cerro Prieto, near Mexicali, Mexico, where the installed capacity is about 125 Mw; and the geothermal areas at Wairakei and Kawerau on the North Island of New Zealand, where the combined capacity is 170 Mw.

In addition to these major fields, there is power production at the pilot plant level up to a moderate sized commercial operation--about 50 Mw--in many other areas, including Iceland, Japan, Kamchatka, Indonesia and the Imperial Valley of California. Exploration and development for geothermal power sources is underway in more than a score of other countries, on every continent. Under the Geothermal Steam Act of 1970, the Federal government has been auctioning off rights to explore and drill in many large "Known Geothermal Resource Areas" on public lands in the western mainland states. Electric companies in California are now either using geothermal power for their generating plants (Pacific Gas & Electric) or are trying to establish a geothermal source (City of Burbank Electric and San Diego Gas and Electric), (Ref. 4).

- B. Other industrial and commercial applications. Power production from geothermal resources has received the most attention in Hawaii, but there is a large and growing list of other applications. These range from space heating (as in Klamath Falls, Oregon); refrigeration (Rotorua, New Zealand); drying chemical products (Iceland); industrial applications, as in lumber and newsprint production (New Zealand); hot house agriculture (New Zealand, Japan, and Kamtchatka); drying crops (Hungary); extraction of minerals from geothermal water (Imperial Valley and Italy); production of distilled fresh water (under study in many areas); and providing bath water for hotels and spas (Japan, Hungary and many other places).

Some of these applications may have little relevance to Hawaii, but others could be important. Space heating is not important at elevations below a few thousand feet, but providing hot water for houses and commercial establishments is. A controlled-environment agriculture, such as that already used in growing flowers, could be energized by geothermal water, used to raise or lower the temperature, speed germination, sterilize soil, etc. Applied to aquaculture, geothermal water could help create an optimal environment for growing anything from prawns to algae--which could be of value as fertilizer or for its pharmaceutical elements.

It is quite possible that a geothermal water supply could be used as a tourist attraction. Spas are destinations for travellers in many parts of the world, and the mere existence of a geothermal station, even of a pilot plant, demonstration model scale, could be of interest to tourists.

III. Power--Possible Outcomes of Exploration & Development

Until one or more wells of sufficient depth to reach the levels at which geothermal waters are likely to occur have been drilled, there is no way of knowing if Hawaii has a geothermal resource of economic importance, and if so, how large that resource may be. As a power source for this State, geothermal may prove to be of major importance, of no importance--or anywhere in between. Only drilling can resolve this uncertainty.

If a small field is discovered and developed, it could have a modest impact on the area. For example, a field of four producing wells with sufficient pressure and temperature might supply a power plant with a capacity of about 20 or 25 Mw, enough wattage to take care of the expansion needs of the Hawaii Electric Light Co. on the Big Island for several years. This new supply could be fed into the island power network of HELCO, or used for some special purpose--as the pumping of water for agricultural irrigation, supplying a new industrial development, new subdivisions or hotels near the geothermal field, etc. The chief economic significance

would lie not in the geothermal plant itself, since it would be highly automated and employ few people once the installation was built. but in the new economic activity stimulated by the new, and presumably cheaper, power.

One particular economic consequence of a small geothermal field could be the facility itself. The plant could be a demonstration unit, at which equipment and techniques for dealing with the kind of geothermal steam or water discovered in Hawaii were used for research. Other research conducted at such a facility could look into by-products recovery from the geothermal water and direct use of the hot water in industry and agriculture. To provide new money for the State's economy, the demonstration plant would have to attract Federal or foreign funds, much as have the observatories on Mauna Kea.

A field capable of generating somewhat larger wattage, say up to about 100 Mw, which is the present installed capacity on the Big Island (excluding the generators of the sugar mills fed with bagasse to supply electricity to the plantations) would be of still greater economic importance. It could provide a substitute for much--or even all--of the expensive oil now imported by HELCO, whose cost helps make Big Island electric rates among the highest in the nation. It could support a modest amount of industrial expansion, or supply several new hotels, or give power to a considerable range of agricultural activities, etc. Jobs stimulated directly or indirectly by a 100 Mw geothermal generating plant would probably be in the range of 200 to 300.

A very large field in Hawaii would of course have a greater economic impact, since the low-cost electricity it generates might attract one or more new major industries--such as the processing of metals from manganese nodules. Alternatively, energy supplies surplus to the effective demand for electricity on the Big Island might be transported to Oahu and other islands by use of the so-called "hydrogen economy." The surplus electricity would be used to convert water to hydrogen (and oxygen) which could then be shipped to generating plants, factories, etc. on other islands as a fuel--the "hydrogen economy." A plausible range of employment supported by a major field would be from several hundred to a few thousand.

IV. Drilling for Geothermal Resources in Hawaii

Early exploration of geothermal resources in the State was carried out in areas which show thermal activity.

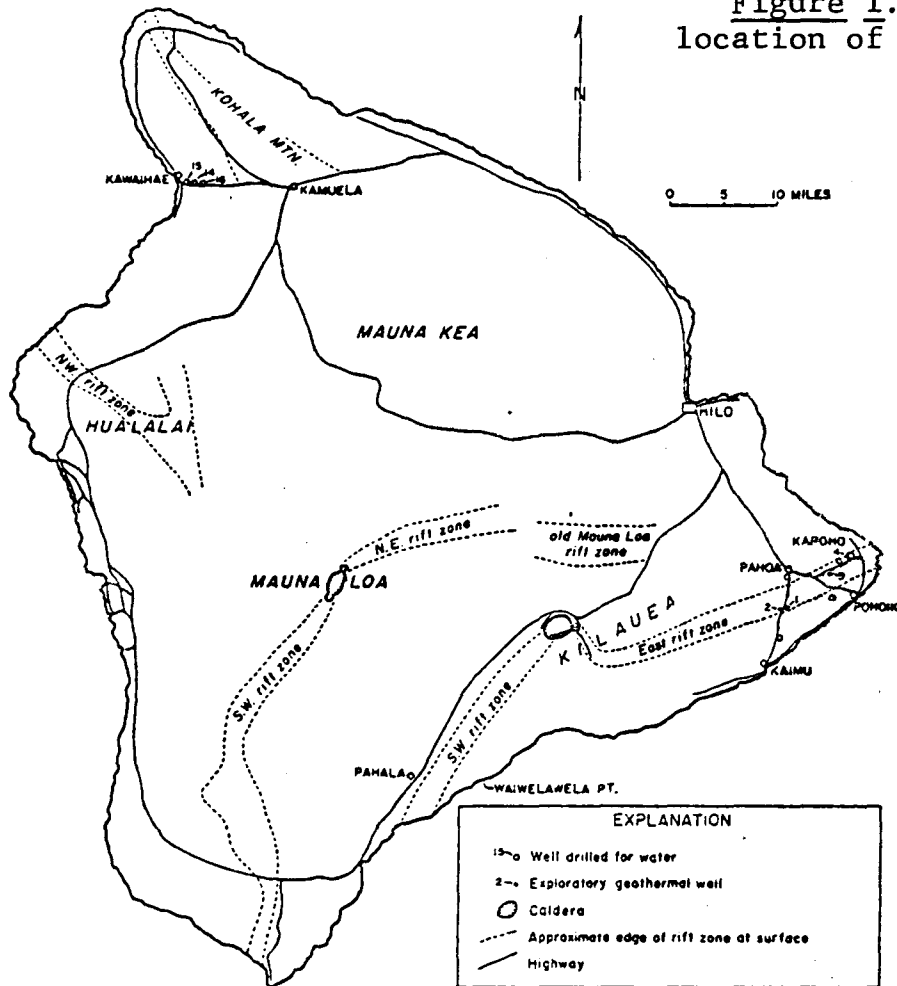
A. Commercial exploratory drilling of 1961. The highest thermal activity is along the east rift zone of Kilauea in Hawaii County and four wells were drilled in eastern Puna in 1961 by the Hawaii Thermal Power Company. Data on these wells is shown in the following Table, with the locations shown in Figure 1 (Ref. 2).

Well Number	Ground Elevation (feet)	Depth (feet)	Temperature At Bottom (°C)
1	1,009	178	54.5
2	1,035	556	102
3	563	690	93
4	250	290	43
Kilauea (1973)	3,615	4,141	137

Note: Data on Wells 1, 2, 3 and 4 supplied by A.T. Abbott.

Wells 1 and 2 were abandoned due to loss of drilling tools and did not reach sea level. Wells 3 and 4 went slightly below sea level. All the wells were drilled near areas of the eruptions of 1955 (Wells 1 and 2) and 1960 (Wells 3 and 4). The conclusion from the 1961 drilling and from water well temperatures is that the presence of a usable geothermal resource above sea level is unlikely.

Figure 1. Map showing location of drilling sites.



B. Scientific exploratory drilling of 1973. A scientific borehole was drilled to a depth of 4,141 ft. in the region of a marked resistivity anomaly thought to be due to a hydrothermal system. The gradient over the last 100 meters is about 400°C/kilometer and the hole bottom was over 500 ft. below sea level with a temperature of 137°C. (See Table for data.) (Ref. 5).

- C. Hawaii Geothermal Project drilling schedule. The Hawaii Geothermal Project (HGP) began in 1973 with geophysical, engineering and socio-economic studies. Late in 1974 a site was selected at the Pahoa anomaly on the east (Puna) rift zone of Kilauea and a proposal for \$995,000 for exploratory drilling has been made to the Energy Research and Development Administration (ERDA). The University of Hawaii has prepared a request for bids and has a bid list of mainland and local drillers. ERDA requested additional geophysical information which was supplied and HGP received notice of award on April 17, 1975. Drilling could be completed during 1975 (Ref. 6).
- D. Private industry proposals, 1975. The Geothermal Exploration and Development Company (GEDCO) has talked with DLNR and DPED about drilling in the Puna area of Hawaii and has requested drilling permits for two 2,500 acre sections along the Puna rift zone. Funding would come from private sources. Such risk capital would be contingent on lease arrangements which are attractive to the sponsor and acceptable to the State. It is anticipated that such commercial drilling would follow the University of Hawaii exploratory well.

A second organization call "Energy Resources Group Ltd." has recently been loosely organized and is seeking funding to investigate a longer range project of boring into the Koolau Plug on Oahu for geothermal resources.

Both groups are interested in cooperating with the University of Hawaii Project.

- E. Drilling requirements for geothermal field production.

Data on The Geysers in California give an indication of the drilling schedule for a 35 megawatt electric generating plant. Five megawatts (100,000 lbs. of steam per hour) is considered a minimum size well--the largest well is 11 Mw. On the average a 35 Mw unit will require 5 producing wells,

3 standby wells and 3 injection wells for a total of 11 wells. Before a plant is built, 4 to 5 wells are operated for 3 to 4 years to determine well stability. A well should last for 20 years. Spacing is 25 acres per well. A smaller plant would require fewer wells.

V. Constraints on Drilling on Hawaii

- A. National Parks do not permit commercial exploitation of natural resources within their limits. Volcano National Park was the site of Keller's bore hole. Many feel that a useful geothermal resource might have been found if Keller had continued drilling for several hundred meters more. Slant drilling to tap resources under the Park has been proposed but this might run into legal difficulties such as interference with the water regime, etc.

- B. The Board and Department of Land and Natural Resources have the responsibility for the management and disposition of government mineral rights as provided in Chapter 182, HRS. Chapter 182 covers exploration, leases, rights-of-way, drilling, rules and regulations, etc. The implementing organization of DLNR is the Water and Land Development Division. Existing rules and regulations were not written to cover geothermal resources. The Geothermal Officer of California visited Hawaii during March 1975, and assisted DLNR in drawing up rules and regulations for geothermal drilling. These regulations must be approved by the Board of Land and Natural Resources before they become effective.

A possible leasing arrangement has been outlined to conform with Chapter 182. The proposed arrangement is that a potential leasor must obtain a permit for exploration and would be required to present a plan for exploration of the area to be leased. The lease is then auctioned to the highest bidder for percent royalty on gross revenues when the geothermal field is developed, with an upset price established by DLNR.

- C. Environmental impact statements. An EIS will be required for exploratory drilling but it should be less stringent than for production drilling. Consideration should be given to historic, cultural, archeological, and environmental aspects of an area where drilling takes place. The regulations should provide that such an area be left as close to its original condition as possible, if the well is abandoned. For development of a field the original EIS should be amended to cover all factors such as noise, appearance, air pollution, water pollution, etc. Interference with the water regime is probably the most important aspect of EIS for Hawaii since the islands depend on the fresh water lens under each island for their water supplies.

For production well drilling, the scope of the EIS would be appropriately wider, including some estimate of the impact of geothermal development on industry, agriculture, employment and other socio-economic factors.

Baseline data on water and air quality would be very valuable to have.

- D. Right-of-entry to private land. This must be negotiated with the landowner. The State could condemn land if necessary but this should be avoided if possible.
- E. Monopoly on drilling. At present there is only one driller in Hawaii capable of drilling deep wells. The company's major activity is water well drilling to sea level. For deep geothermal drilling (6,000 ft. or so), the equipment may be pushed to its limit. With no competition, costs may be higher than reasonable--or what the market will bear.
- F. Other constraints. In November 1974 the Aboriginal Lands of Hawaii Ancestry Association (ALOHA) petitioned the President of the United States of America and his Secretary of Interior to declare a moratorium on the disposition of the mineral rights of the

"Hawaiian archipelago" and indicated a claim for such rights is being prepared for presentation to the U.S. Congress. The petition is directed toward ocean resources but is broadly worded in terms of the "territory of Hawaii."

The Congress of Hawaiian People was interested in the Keller drilling experiment and the University HGP has a member of the Congress on its Advisory Committee.

These organizations can be expected to show a strong interest in the development of geothermal energy in Hawaii.

VI. Possible State Policies Toward Geothermal Drilling and Development

Several considerations may affect the policy of the State and its counties towards developing its potential geothermal resources. The government may want to: lessen the State's almost total dependence on imported oil, reduce pollution from the burning of oil, hold down increases in electric bills, stimulate economic activity (employment, profits, rents, tax revenues), provide the economic base on the Big Island and elsewhere to support population dispersal and less crowding on Oahu.

Depending on which of these objectives is considered the more important, and depending on the time preferences of policy-makers, the State might adopt policies to stimulate the quickest possible development of whatever geothermal resource Hawaii possesses, or to maximize output from the resource over time. A hurry-up policy, for example, would encourage drilling for production even in advance of ascertaining the size and quality of the geothermal "deposit," while an output-maximization policy would require exploration in advance of production drilling--at least of any considerable number of wells--to ensure that the wells were spaced and exploited in a manner designed to get as much value out of the ground as known technology permits.

Ideology may also affect State policy toward geothermal development. Few people, including policy-makers, are neutral toward State involvement in economic activity and few do not have opinions about how public utility companies operate. If there is a general attitude, for example, that the government should stay out of business, it is likely that there will be a policy which sharply limits the State's involvement in geothermal development. Conversely, if policy-makers are persuaded that utility companies are so operated and regulated that cost savings are not passed on to consumers, the role of the State may extend to distribution of the power derived from geothermal resources.

VII. The Role of Hawaii's Government in Geothermal Development: Alternative Possibilities

There is a wide range of possible State roles in geothermal development, depending on its policy objectives and ideological framework. Within that range, these models can be distinguished.

- A. Minimal State intervention, secondary concern for maximizing output. This model would limit State action to what is required by law--but even this is considerable. Under Act 241 of 1974, the State government is steward for the people of Hawaii with respect to geothermal resources and the Department of Land and Natural Resources is delegated the responsibility for carrying out that stewardship--to see that it is not wasted but exploited in the public interest (however that may be interpreted), to set and collect royalty payments for the use of the publicly-owned resource, and carry out its other responsibilities as particularized in the next section of this paper. Similarly, the State Environmental Quality Commission must, under the law, ensure that the environmental impact of geothermal development is acceptable, and the Public Utilities Commission must regulate rates charged by a geothermal steam company, if it is set up as a public utility enterprise. In any case, the PUC would be concerned with the effects of geothermal power on the costs, profits and rates of an electric company using the power.

B. Private operation, government support model, designed to maximize production while minimizing State control.

To accomplish these policy objectives the State would accommodate all reasonable and mutually supportive efforts by private enterprise to develop the geothermal resources, as by:

1. Expediting drilling by cutting all corners in granting access to public lands (and helping to get access to private lands, if necessary, using its power to compel entry), in minimizing Environmental Impact Statements, in giving all assurances possible under the law that successful drillers would have production rights for long periods of time.
2. Direct subsidies: paying part of the costs of drilling development; minimizing or waiving royalty payments for geothermal wells; giving special tax benefits to drillers/producers.
3. Indirect subsidies: providing access roads, water supply, and other infrastructure needs of a geothermal field, regulating electric rates so that benefits of geothermal power are shared between developer and utility company and not passed back to consumers in lower rates. (This is how it is done in The Geysers, where the Pacific Gas & Electric Co. pays to the geothermal steam supplier a rate tied to the price of fuel oil.)
4. Loans: The State government could lend its funds, or its credit (by guaranteeing bank loans) to geothermal developers. However, the Federal government is in the better position to act as lender, and is authorized to do so under the Geothermal Energy Research Development and Demonstration Act of 1974.

- C. Private operation, government support model, designed to attain State objectives. The means just listed under "B" could be used to accomplish ends desired by the State government, by making the granting of permission to drill, the granting of subsidies or loans, etc. conditional on the geothermal development being carried out in a manner which would further those ends. For example, if the purpose of the State is to disperse population, it would support proposals to develop geothermal resources on the Neighbor Islands but not on Oahu. If its purpose is to reduce electric bills, it would support development likely to produce electricity and ensure that market forces, or rate regulation, were likely to achieve this purpose. If it puts a high priority on environmental impact, the EIS would be held to a demanding standard of explicitness. If it wants to maximize production over time, it would ensure that the resource had been adequately identified before permitting production drilling, etc.
- D. Joint venture between government and private industry.

Since drilling and geothermal resource development are highly risky and costly, private enterprise may not develop the resource to an optimal point to achieve public purposes which may be set by the State, e.g., creation of employment, reduction of dependence on oil, population decongestion. This possibility, in fact, is what would provide justification for the direct and indirect subsidization considered above.

Another approach to ensuring that geothermal development is sufficiently great or rapid is for the State or County government to enter into a joint venture with one or more private firms, furnishing some of the capital, technical knowledge and expertise and other necessary resources, sharing in the management perhaps, and sharing in the profits (or losses) of the geothermal enterprise.

The joint venture might encompass the entire operation, from drilling to production of electricity or by-products of geothermal waters and minerals, or it might provide for a division of labor. One division would be for the State to do the drilling and production of steam, selling the steam to the Hawaii Electric Light Co., or other private firm. Alternatively, a private firm could drill and produce (steam, electricity, distilled water or other by-products) and sell its production to the State or County government for distribution. Hawaii County, for example, might want to buy geothermally produced electricity to distribute to agricultural users on the Big Island. Other combinations of public and private enterprise, hooked together in series or in parallel, are readily imagined.

- E. Government monopoly. At the end of the spectrum of possible government roles in geothermal development is for the State or a County itself to undertake the development and perhaps also market the electric power or other products. Again, a variety of structures can be envisioned. One is the example of the Tennessee Valley Authority, where a special quasi-independent unit of government serves as producer and wholesale distributor, but not (generally) as retailer, leaving that function to other enterprises. Another model is the Honolulu Board of Water Supply, which operates rather independently within the County government to produce and distribute the potable water supply, of which it has a legal monopoly.

VIII. Possible Roles of State and County Government in Geothermal Development.

The major responsibilities and possible roles of the various government agencies are briefly outlined below:

- A. Department of Land and Natural Resources: Land and mineral resource management; controller of drilling and of geothermal steam production (other than rates). Rules and regulations, leasing, etc.

- B. Department of Planning and Economic Development: Planning for geothermal development in cooperation with county governments. Coordination of State alternate energy programs and State energy policy formulation.
- C. County Planning and Research & Development Departments: Planning geothermal development within each county, and cooperating with DPED in development of statewide planning and economic development.
- D. State Environmental Quality Commission: Coordinating and overseeing adequacy of environmental impact statements and otherwise checking compliance with environmental protection laws.
- E. Department of Regulatory Agencies: Regulation of rates charged by geothermal steam companies (if private enterprises) through the Public Utilities Commission.
- F. University of Hawaii: Research in geothermal phenomena and their economic, social, environmental impact. Results of such studies will provide valuable inputs for evaluating alternate State policies and for decision-making.
- G. New State Agency or Authority: For operation of geothermal field, if State decides to operate. Could also generate and distribute electric power. Alternately the agency could contract with private interests to carry out such functions.
- H. Attorney General's Office: Interpretation of existing statutes and advice on the establishment of State policies to implement rules and regulations relating to geothermal energy development.
- I. Hawaii State Legislature: The Legislature will play a key role in establishing geothermal energy policies such as funding of research and development, possible tax incentives, amendments to Chapter 182, funding of geothermal production, establishment of a new agency or authority and other policy matters.

- J. Federal Agencies: The Energy Research and Development Administration is responsible for funding of geothermal R&D at national laboratories, universities, industry, etc. The Federal government has legislation concerning geothermal resources.

Table I shows the responsibilities and possible roles of these various government organizations.

IX. Recommended Actions

1. Formulate State and County policies for geothermal exploration and development. Such policies should be applicable to other alternate energy sources such as wind, ocean thermal, solar, etc.
2. Draft and promulgate rules and regulations for geothermal exploration, drilling, operation, maintenance and abandonment of wells.
3. Ensure that exploratory drilling take place during 1975.

TABLE I

THE RESPONSIBILITIES AND POSSIBLE ROLES
OF GOVERNMENT AGENCIES
IN VARIOUS ASPECTS OF
GEOTHERMAL ENERGY POLICY AND PLANNING FOR HAWAII

O R G A N I Z A T I O N

<u>Activity</u>	<u>DLNR</u>	<u>DPED</u>	<u>Coun- ties</u>	<u>OEQC/ SEQC</u>	<u>AG</u>	<u>DRA/ PUC</u>	<u>UH</u>	<u>New State Agency</u>	<u>State Legis- lature</u>	<u>Federal Agen- cies</u>
Resource Management, Leasing, Drilling	X									
Energy Planning		X	X							
Energy Policy	X	X	X	X	X		X		X	
EIS	X	X		X						
Rates (Private Cos.)						X				
R&D		X					X			X
Resource Development	X							X		
Electricity Generation								X		X
Electricity Distribution								X		X

Abbreviations:

- DLNR - Department of Land and Natural Resources
- DPED - Department of Planning and Economic Development
- OEQC - Office of Environmental Quality Control
- SEQC - State Environmental Quality Commission
- AG - Attorney General
- DRA - Department of Regulatory Agencies
- PUC - Public Utilities Commission
- UH - University of Hawaii

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