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HAWAII GEOTHERMAL PROJECT

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Hawaii's Geothermal Project is investigating the occurrence of geothermal resources in the archipelago, initially on the Island of Hawaii. The state's interest in geothermal development is keen, since it is almost totally dependent on imported oil for energy.

Geothermal development in Hawaii may require greater participation by the public sector than has been true in California. The initial exploration has been financed by the national, state, and county governments. Maximization of net benefits may call for multiple use of geothermal resources; e. g., the extraction of by-products and the application of treated effluents to agricultural and aquacultural uses.

A guiding role for the Hawaii Government is made the more likely by the 1974 statute which defined geothermal resources as "mineral," and so reserved ownership to the state. Under that law, the Department of Land and Natural Resources has immediate responsibility for fostering geothermal development, a task in which other public agencies necessarily will be involved if Hawaii strikes it rich in geothermal fields.

The State of Hawaii is totally dependent for energy on sea-borne petroleum. Hawaii has no known fossil fuel reserves; there is no coal coming into the State by rail; no natural gas by pipeline; and no regional electric grid to interconnect its electrical systems with those of other states or even with its separate islands. This complete lack of flexibility makes Hawaii particularly vulnerable to dislocations in the global energy market resulting from real or imagined shortages of petroleum.

This is most ironic, since the State is generously endowed with a variety and abundance of natural energy resources: geothermal, solar radiation, ocean temperature differential, wind, waves, and ocean currents — all potential non-polluting power sources. The candidate from among these natural energy sources which shows the highest promise for early power generation at commercial levels is geothermal energy.

The Hawaii Geothermal Project (HGP) was organized to focus the resources of the University, the State, and the County of Hawaii on the identification, generation, and utilization of geothermal energy on the Big Island of

Hawaii. Figure 1 shows the five volcanoes that form this largest island in the Hawaiian chain. Hawaii is also the youngest of the islands and is still experiencing growth from recent activity of the Mauna Loa and Kilauea volcanoes. Consequently, the Big Island was selected as the obvious site for initial geothermal exploration, but subsequent surveys will proceed up the island chain.

Whether a conventional geothermal resource exists — such as the vapor-dominated systems at Larderello, or at The Geysers, or a water-dominated system, as encountered in New Zealand — is subject to speculation. It is certain that enormous amounts of geothermal energy are present in the form of molten magma at 1200°C and in the adjacent hot rock. Ultimately, the HGP intends to look into conversion systems for utilizing this energy of the molten magma directly, but first efforts will be made to identify and develop a conventional geothermal resource.

Phase I of the Project was organized into three separate programs, encompassing the following research tasks:

Geophysical Program — Augustine S. Furumoto
Photogeologic (Infrared Scanning) Survey
Electromagnetic Survey
Electrical Resistivity Survey
Microearthquake and Microseismic Surveys
Geochemical Survey
Thermal Survey of Wells

Engineering Program — Paul C. Yuen
Reservoir Modeling
Well Test Analysis
Ghyben-Herzberg Lens Analysis
Energy Extraction From High Temperature Brine

Environmental-Socioeconomic Program — Robert M. Kamins
Regulatory and Legal Aspects
Land Use and Planning
Economic Analysis
Environmental Baseline Studies

The major emphasis of Phase I has been on the Geophysical Program, since the issue of if and where geothermal resources exist is crucial to the project. However, parallel studies were initiated in all supporting programs, so that some progress has been made in identifying and clarifying the technological, environmental, legal, regulatory, social, and economic problems that could obstruct the development of geothermal power in Hawaii.

Although the completion of surveys and interpretation of field data will continue through 1974, it has become obvious — both on the basis of preliminary results from Phase I and from complementary studies conducted on the Big Island over the past several decades — that an exploratory drilling program is essential to establish identity of the subsurface conditions predicated by the surveys.

Figure 2 is an organizational chart for Phase II of the HGP. In addition to continuing the three research programs from Phase I, an exploratory drilling program will be initiated under Dr. Agatin T. Abbott. Overall coordination and management is provided by Dean John W. Shupe. To assure that the Project has both local and national relevance and visibility, a 16-member Hawaii Advisory Committee and a 9-man National Liaison Board were appointed.

The HGP came into being when the 1972 Hawaii State Legislature allocated \$200,000 for geothermal research — \$100,000 to be administered through the County of Hawaii budget. This action was taken prior to the energy crisis and was a farsighted step for a state governing body to take. Additionally, a major source of funding for this Project has been the National Science Foundation. Total support for the HGP through December 31, 1974 is as follows:

National Science Foundation	\$ 252,000	Year 1
(Research Applied to National Needs)	335,000	Year 2
State of Hawaii	100,000	Year 1
(appropriated)	500,000	Year 3
County of Hawaii	100,000	Year 1
Other Public and Private Funds	39,000	
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	\$1,326,000	

Except for the \$500,000 appropriated by the 1974 State Legislature for exploratory geothermal drilling — contingent on additional federal matching funds for a research drilling program — essentially all of the above funds will be expended by the end of this calendar year on completing Phase I of the project. Referring again to Figure 1, tentative plans for Phase II call for initial drilling in the Puna Area along the Eastern Rift of Kilauea. A proposal has been submitted to NSF to assist with the drilling program, to get under way in early 1975.

With this overall picture of the Hawaii Geothermal Project in your mind I want to address a basic problem we are studying in the socioeconomic portion of the Project — how to establish rationally the level of investment in geothermal development appropriate to a limited area within the U.S. Most discussions of the economic rationality of energy development until now have been in national terms. How does it look at the state level? What factors are relevant to the calculation of optimal investment and how are they related to state policy?

Most of the factors which I will discuss derive in one way or another from uncertainty — that inability to ascribe probability values for success in action — which is such a key consideration in geothermal resource development anywhere in the world. The resource is so idiosyncratic in its occurrence that even in KGRA's, indeed, even within established productive fields, it is chancy that a well drilled at any given location will hit a useable geothermal supply -- and if it does, how productive the flow will be or how long it will last. Calculating the odds under such conditions is a major task for every management group concerned with investment in geothermal production in the State of California.

Now if uncertainty presents a problem for investment decisions here, among the best-proven geothermal fields of the nation, consider what a problem it is in Hawaii, where there are many good reasons for expecting that the resource exists, but where no production wells have yet been drilled. Given the inherent uncertainties, it is easy to understand why private industry has not yet been willing to invest much to find out if the resource exists in commercially exploitable conditions. There are much less risky investment opportunities here on the mainland.

However, despite the uncertainty, the State and County of Hawaii have appropriated scarce public funds to help finance the study and development of this chancy resource. Was this investment decision rational and in the public interest? I won't offer a categorical answer, but will suggest the considerations needed for one.

The primary consideration is that a geographically isolated state such as Hawaii faces conditions of uncertainty that in social context dwarf those pertaining to geothermal discovery. Consider what I have already said about Hawaii's small dot in the national energy picture. It is almost completely dependent on imported petroleum to light every room, cook every meal, and turn every motor in the state. The recent fuel shortage drove home the point that an oil embargo, shipping tieup or any other prolonged stoppage of the oil flow would quickly cripple the economy of the state. This kind of uncertainty is difficult to live with in a power-dependent society, and so the development of an indigenous power source becomes extremely valuable to the state as a kind of energy insurance.

Not only is the Hawaii government concerned with safeguarding the energy supply to maintain the local economy, it is also increasingly concerned with economic growth to provide more jobs. Unemployment is a problem in many parts of the U.S.; in Hawaii it is a bad problem, running over 8% — which is well above the national average — and still rising. Public welfare applications in Hawaii have doubled over the past 12 months and are also rising. Under these circumstances, a new energy source that provides a base for growth and jobs may have a social value far exceeding the profits which may be realized by firms engaged in producing and using geothermal power.

It is important to Hawaii that expansion of the energy supply be low in pollutants. The land mass is so small that geography as well as economics dictates that most generating plants be near residential or resort areas. It would be costly in many ways for Hawaii to accept high-sulfur oil or other polluting fuels, as is proposed to help the nation in the energy bind.

Another consideration in Hawaii's energy development policy is inflation. The brutal rate of price increases which Hawaii is experiencing, along with the rest of the nation, gives additional incentive to find indigenous energy sources which may be cheaper, as well as cleaner, than fossil fuel. Electricity rates and gasoline prices in Hawaii are among the very highest in the U.S., and they contribute to an overall cost of living that is second only to Alaska's. The development of geothermal power could not only bring some relief to family

budgets but could also help overcome the cost disadvantage under which Hawaii suffers in competition with other areas in attracting industries, other than in tourism.

Finally, the development of geothermal power on the Island of Hawaii could help the state government achieve another policy objective — to decentralize the population of the tiny state. Now, more than 80% of the population lives on Oahu (most of them in or near Honolulu), already one of the most densely occupied communities in the nation, with more people crowding in every year to be where the jobs are. Lacking constitutional means of turning away new residents, the state is seeking ways of encouraging them to move to the uncrowded outer islands; however, the economic base (the jobs) has been lacking there. However, if a major energy source were to be developed on the Island of Hawaii, that base could be created on the largest land mass in the archipelago. I might point out that such development could offer public economies as well as esthetic advantage in helping to preserve the last, unsubdivided valleys and open beaches of Oahu. Crowding costs more, the per capita costs of local government are higher in Los Angeles than in Honolulu, and higher in Honolulu than in Hilo. Decentralization should save tax dollars.

There are, then, several social benefits which a state in Hawaii's circumstances could receive from geothermal development: energy insurance, creation of a new economic base and more jobs, anti-inflationary help, environmental protection, and population dispersal. Attaining these benefits may be worth tens or hundreds of millions of dollars annually to overall Hawaiian society, yet worth much less to the private firms that would decide whether or not to invest in geothermal development. In the vocabulary of economics, this may be a case where externalities are of critical importance. There may exist a discrepancy between perceived private benefits and social benefits of a large order, so that when the difference is accounted for, total benefits would equal or exceed the total costs.

If analysis shows that the discrepancy does exist, and that by best judgment it is large, then the state may be justified to act to bring about a scale and pace of geothermal development greater than would result from private enterprises operating in the absence of government stimulation.

A broad cost-benefit analysis of the kind I have just sketched has not yet been made; we are just starting on it for Hawaii. And yet I think that its salient points have been intuitively understood by political leaders in the state for they have appropriated funds to support research and drilling programs for geothermal development, and additional funds for other alternative energy sources. And, if other social investments are indicated in order to stimulate geothermal development, this rationale and understanding may again be appealed to.

For example — returning again to the theme of uncertainty — it is quite possible that geothermal resources will be discovered in a corner of the Island of Hawaii, which in recent times has received lava flows from eruptions of Kilauea. This must be known to Lloyd's of London. The premium rates on insurance to cover a generating plant and other capital investments at a

geothermal field in Puna might be prohibitively high for a private enterprise and yet readily covered by the social benefits reasonably attributable to the development. In that case, it may be good and politically acceptable public policy for the Hawaii government to share some of the inherent uncertainty by subsidizing some or all of the extraordinary insurance that may be necessary for the geothermal developers who undertake the risk of working in an active volcanic area.

The Hawaii government has already acted to reduce a different kind of uncertainty in geothermal development by answering the question as to who owns whatever geothermal resources there may be in the state. Act 241 of the 1974 Legislature asserted that the State of Hawaii owns them, as successor in title to mineral reservations kept by the Kamehamehas when they reigned in the Kingdom and divided the lands more than a century ago. Like any statute, this declaration of ownership is subject to challenge in the courts, but unless it is overturned, parties interested in drilling for geothermal resources in Hawaii will have the certainty that they will deal with the State Department of Land and Natural Resources.

However the question of resource ownership is ultimately settled, it seems likely that in Hawaii's circumstances the government will retain a lively interest and play an active role in geothermal development in the Island State. I have tried to identify the basis of that interest and outline the factors to be considered in arriving at a rational policy for public investment in the potential new energy source. Whether public investment would most effectively be made by direct subsidies, by indirect subsidy through tax incentives, by providing roads and other facilities needed for geothermal field development, by loans or loan guarantees to private companies, or by the state entering into joint enterprises with them — or indeed undertaking geothermal development as a public enterprise — all these alternatives remain to be explored. In our research we are not attempting to determine what the role of government should be in Hawaii's geothermal future, but rather to lay out a rationale which decision-makers and the electorate may find helpful in making that judgment.

We are interacting with several state agencies — Planning and Economic Development, Land and Natural Resources, the Office of the Attorney General — and with the County of Hawaii in conducting our study. The results should have immediate applicability to the 50th State.

However, we also perceive that the public policy considerations we are trying to elucidate will be applicable to other parts of the nation, particularly those states which, like Hawaii, have strong incentives for developing indigenous sources of energy.

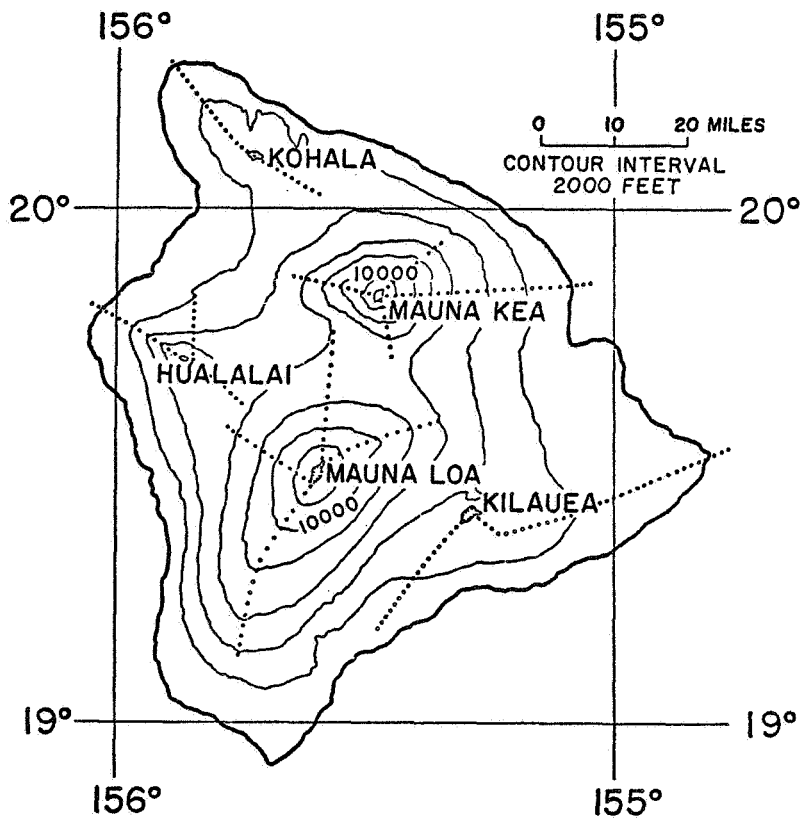


Fig. 1. Volcanoes and rift zones on the island of Hawaii

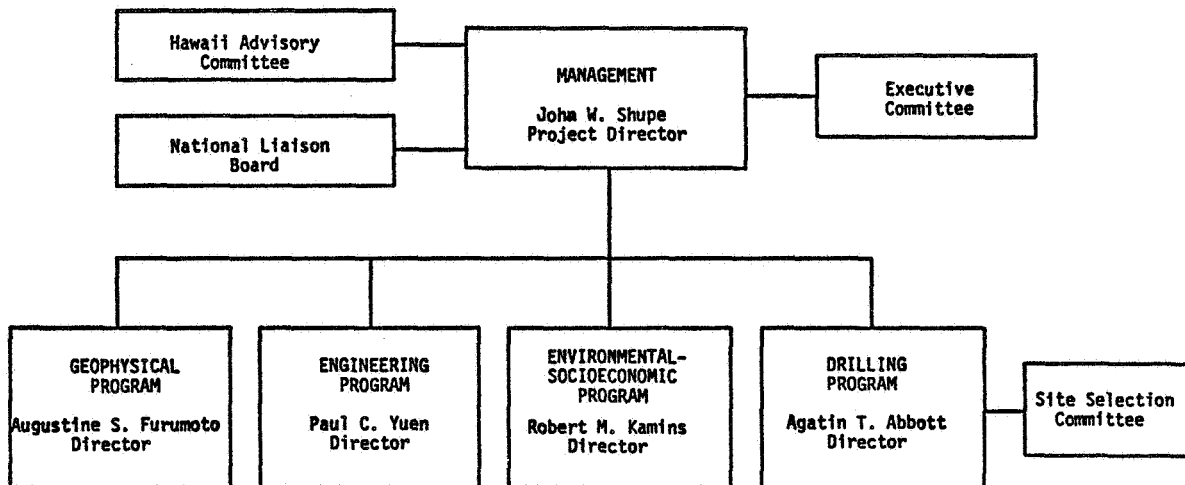


Fig. 2. Hawaii Geothermal Project, Phase II, organization chart