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Geothermal Development Policy for an Isolated State: The Case of Hawaii

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ABSTRACT

Hawaii presents the case of an industrialized economy almost completely dependent on imported fossil fuel, but possessing potential indigenous energy sources. Publicly financed exploration for geothermal resources is under way, and the Hawaii state government is considering what actions should be taken to encourage and also regulate the resource should it be economically useful.

In determining the level and kinds of support to give geothermal development, the state should consider benefits going beyond the substitution of geothermal power for imported oil. These benefits may include: (1) insurance against the interruption of petroleum imports or additional increases in their price; (2) stimulation of local employment; (3) population decongestion, with encouragement of population growth near geothermal areas, away from Honolulu; and (4) environmental enhancement, with the institution of power production less polluting than burning oil. Methods of approximating the value of these spillover effects are shown using Hawaii data as an example.

INTRODUCTION

A happenstance of the industrial revolution created an energy paradox for Hawaii and many another island area across the Pacific. Islands in tropical waters, well warmed by the lingering sun, bathed by the tides and swept by the tradewinds, are generously soaked with energy. And yet, because the island economies have adopted the standard energy technologies of the industrial world, based on the electric generator and the internal combustion engine, they are hooked into the world demand for fossil fuels, a resource in which—aside from Indonesia, Australia, and the Philippines at the western margins of the Pacific—both the high and low islands of this ocean are completely deficient.

Given the political and economic uncertainties of the world oil markets, dependence on petroleum imports makes for great vulnerability. In the case of Hawaii that dependence is almost total, over 99% (Table 1), compared with a fuel import dependence level of less than 20% for the U.S. as a whole. The few indigenous sources of power currently exploited in the state are streams on the islands of Hawaii and Kauai which supply a small amount of hydroelectric power, and the bagasse from sugar mills—again mostly on the island of Hawaii—which is burned to generate electricity for the plantations. Sales by them of surplus power to the local utility company supply about 3% of the electricity sold in the state, and 0.3% of all energy consumed here.

If tankers did not bring in crude oil to the two refineries on Oahu and if imports of petroleum products were cut off for any reason, the highly mechanized, power-intensive economy of Hawaii would quickly be reduced to primitive agriculture, with limited fertilizers and few beasts of burden, incapable of supporting more than a small fraction of the 850 000 people now inhabiting the Islands.

ECONOMIC CONSTRAINTS

Even short of the social catastrophe which seemed to threaten Hawaii during the energy scare of early 1974, dependence on imported oil has been a tight constraint on the local economy. Throughout this century, energy has been expensive in Hawaii, when compared with other parts of the U.S., whether in the form of petroleum fuel, electric power, or gas. Since energy costs are major expenses in most industrial activities and in many service enterprises, Hawaii has been handicapped in its recent search for economic diversification by the high price it pays for oil and the electricity and gas produced from oil. Certainly there are other important reasons for Hawaii's inability to diversify in any large way from sales to the military establishment, tourism, and shrinking plantation agriculture. Among these reasons are the absence of minerals as well as fossil fuel, the limited size of the local markets, the costs of transportation to and from major markets, and high wage rates compared with most other Pacific areas; but among these causes the relatively high price of an energy supply system based on oil must also be listed.

Thus the cost of electricity on the island of Hawaii, among the highest in the U.S., was a factor in the closing of a wallboard plant in Hilo two decades ago. It seems also to be a factor in the reluctance of private enterprise to develop a lumber and wood-product industry on the island of Hawaii, which already has stands of hardwood trees. By many accounts this island has a potential for substantial production of commercial timber, but the drying of lumber requires large amounts of heat per unit of product, and hence large amounts of fuel to generate that heat. Other economic activities, either already in the state's limited list of industries (notably petroleum refining, steel fabrication, and sports clothes manufacture), or proposed for development here (such as the production of glass and plastic containers, or the extraction of metals from manganese

Table 1. Energy consumption in Hawaii: 1974 (civilian plus military commissaries, but excluding direct military use).

Fuel source	Energy consumed (10^{12} Btu)	Distribution (%)
Petroleum products	187.77	99.66
Hydroelectric	0.06	0.03
Solid waste burning for electricity generation	0.58	0.31
Total	188.41	100.00

Source: University of Hawaii and Department of Planning and Economic Development, 1975, Alternative energy sources for Hawaii, 1975: p. 25.

nodules) tend to be energy intensive and so would be significantly affected by the supply and price of electricity.

LOCAL ENERGY ALTERNATIVES

Both the State of Hawaii and its counties, as well as the private utility companies, have been aware of the need for developing local alternatives to the costly and politically unreliable importation of oil on which we have been depending. Locally supported research is currently underway, mostly in the early stages of demonstrating feasibility, into a variety of indigenous energy sources: the heat of the sun, the temperature differential between the surface of the ocean and its depths, the wind, and the burning of solid waste or its conversion by pyrolysis to fuel oil. A nuclear fission plant has been considered by the Hawaiian Electric Company from time to time, but discarded for several reasons, including the presently uneconomical large size of plant (and backup facility) required, as well as environmental and safety considerations.

Geothermal Energy

Of these potential new energy sources, the one on which research in Hawaii is most advanced is geothermal energy. Investigation is now being centered on the island of Hawaii, the newest and volcanically most active land mass in the archipelago. As far back as 1961, four shallow wells were drilled along the eastern rift zone of the Puna District by the Hawaii Thermal Power Company. Although two of the holes showed bottom temperatures at or near the boiling point, none of the wells was extended much below sea level, where in the opinion of geophysicists today it is more likely that commercially useful geothermal resources may be encountered. That project was abandoned. However, when the University of Hawaii received a $252 000 grant from the U.S. National Science Foundation in 1973 to investigate geothermal phenomena on Hawaii, the state legislature responded with a matching appropriation of $100 000 and the County of Hawaii added an equal amount from its portion of the capital improvement budget. With the receipt of these funds, Hawaii became established as one of the centers for geothermal research in the U.S., along with California and Montana.

With additional funding from the federal government (now the Energy Research and Development Administration) and the State of Hawaii, the Hawaii Geothermal Project plans to drill an exploratory well in the Puna area, at the eastern end of the island of Hawaii later this year to penetrate the earth some 4000 to 6000 ft below sea level. At that depth, the fresh water lens should be passed and the existence of an underlying body of geothermal water (or, less likely, steam) will be proven or disproven. Several geologists and geophysicists, connected both with government agencies and private industry, are of the opinion that a geothermal resource will be discovered.

PUBLIC GEOTHERMAL POLICY

The state government has begun to formulate a public policy on geothermal development for Hawaii. Already, the State Legislature acted in 1974 to establish a legal regime for the potential resource. By Act 241 it defined geothermal resources as "mineral," thereby placing them under a reservation on behalf of the Hawaii government which was generally applied on sales and leases of land going back to the original distribution made in the middle of the 19th century. Unless the statute is successfully challenged in the courts, it has the effect of making geothermal resources the property of the State of Hawaii in most of the land area.

Now under way are discussions between the state and county governments to establish a rationale for government action in geothermal development, a basic policy to guide the decisions already thrust upon the Hawaii Department of Land and Natural Resources by proposals to drill exploratory wells on two of the islands in the state. It is the purpose of this paper to identify the kinds of considerations which the state government may have in formulating its geothermal policy and to sketch the models of action available to the state for effectuating that policy.

Interruption of Oil Supply

A primary consideration is the vulnerability of the Hawaii economy to any prolonged interruption in the importation of oil, already noted. The armed forces based in Hawaii have provided for such emergencies by the construction of large storage facilities, and also have their own tankers, capable of penetrating barriers which either civil or military conflict may place in the way of ocean transport. These modes of supply are not available to the civilian economy, at least in significant scale, because they are so costly. However, it would be valuable to the economy to obtain the energy insurance which an indigenous source of energy would provide, and that value provides a social external benefit to be taken into account when the local community, through its government, determines how far and how fast geothermal development should proceed.

Closely related to this first consideration is the price of oil in Hawaii and the effect of that price on the local cost of living—highest in the U.S. second only to Alaska—and on Hawaii's ability to compete in the markets available to its enterprises, notably plantation agriculture, tropical fruits and ornamentals, tourism, sports clothes, and as a communication hub. Any significant reduction in the relative cost of electricity would be stimulating to Hawaii's economic growth and demand for labor, and would therefore help attract more people to the Islands.

Decongestion

This would be a mixed blessing, unless the economic growth were to be centered off the island of Oahu, which holds more than four-fifths of the state's population and already is one of the most densely populated parts of the

U.S. State policy supports the idea of holding the line on population in and around Honolulu, of encouraging—by means not yet devised or accepted—people to move instead to the wider spaces of the neighbor islands.

Geothermal development offers the possibility of an economic base for a policy of decongestion. At this juncture it is the only alternative to an expanded tourism, which is beginning to encounter resistance on some of the outer islands. If a geothermal field of large capacity—say with a generating capability of 100 MW or more, or possessing a comparable economic value in direct industrial utilization of the geothermal waters and from the extraction of by-products—were to be developed on the island of Hawaii, it would supply the base for a significant amount of local employment. The new jobs might attract people from overcrowded Oahu, or, to the same social effect, enable job-seekers living on the island of Hawaii to stay there, instead of moving into the job and housing markets of Honolulu.

Employment

The creation of employment opportunities by developing an indigenous energy source would have additional economic benefits. One is a reduction in welfare payments and unemployment compensation payments which have become large cost items to both the government and the private sector in Hawaii, as elsewhere in the U.S. during the protracted recession of the 1970's. Another benefit would be a check on the state's increasingly heavy fuel import bill, which is the heaviest charge by far in Hawaii's balance of payments with the U.S. mainland and the rest of the world. The import-substitution effects of geothermal development, replacing petroleum imports with locally produced power, over time could add some of the money now spent for foreign oil (in excess of $200 million annually) to the supply of investment funds in Hawaii. That investment might be made by the local utility companies, if cheaper geothermal energy brought down their costs and increased their profits, or by enterprises and households benefiting from lower power rates, should the lower costs be passed back to them.

Environment

The quantitative importance in Hawaii of a social benefit frequently attributed to geothermal power in contrasting it with the burning of fossil fuels is difficult to appraise beforehand. This is the reduction of air pollution, or other adverse effects on the physical environment. The uncertainty stems from the fact that the plant design of a generating station is yet undetermined—particularly if massive cooling towers will be required—and the difficulty of calculating the trade-offs between the visual intrusion of a geothermal field and generating plant out in an undeveloped area such as the Puna district and that of a conventional generating plant closer to the built-up areas. Given any reasonable concern for environmental factors and skill in minimizing pollutant effects, there should be a gain from substituting geothermal fluids for oil, but the gain would probably not be large as long as the local electric companies continue to burn low-sulfur oil.

State Revenues

A final consideration which the State of Hawaii may have in determining its policy on geothermal development is the revenues which would accrue to it if the development is commercially successful. Those revenues would come in two streams. The first would be royalties from the extraction of geothermal resources owned by the state. That revenue source may have to be defended in court, if the 1974 statute defining geothermal resources as "mineral" should be challenged; but, once established, the stream of royalties could continue for the life of the geothermal field, which would presumably be measured in decades.

Taxes would provide the second stream of government income from geothermal production. Directly affected would be the real property tax (as the value of land in the field was reassessed to reflect its increased worth); this in Hawaii goes to the county government. The state itself would receive general excise taxes at 4% of gross receipts from all sales of geothermal power, or its by-products, plus net income taxes on the corporations and individuals profiting from the sale of the new energy source. By application of a fiscal multiplier, one might estimate additional tax revenues which would be generated by the geothermal operation and would flow to the state from the employees, suppliers, and local stockholders of the geothermal enterprise.

Such calculations might be predicated on the grounds that the state seeks to maximize its royalty collections and tax yields from geothermal enterprises. However, the state might have as its objective, not the maximizing of its own revenues, but rather optimizing the size and tempo of geothermal development in order to obtain some of the social benefits from an indigenous energy source outlined above. Recapitulating, these include: (1) insurance against disruptions in oil imports, or continued increases in the price of petroleum; (2) stabilizing effects on local costs of living and producing; (3) improvement in balance of payments with the rest of the world, freeing funds for local investment; (4) employment stimulation; (5) reduction of public welfare and unemployment compensation costs; (6) decentralization of population; (7) possible reduction in the adverse environmental impact of oil-burning generating plants.

POLICY SELECTION

Depending on which of these objectives is considered more important, and depending on the time preferences of the policy makers, the state might want to adopt policies to stimulate the quickest possible development of whatever geothermal resources Hawaii possesses. Or it might want to maximize the value of output from the resources over time. Either goal might be constrained by a policy to minimize costs to the Hawaii government, either from direct subsidies or by foregoing state revenues which might be collected as royalty payments or taxes on the geothermal enterprise.

As a problem, the selection of state policy and actions with respect to geothermal development is an exercise in cost-benefit analysis. As is usual in such analyses in the public sector, it is easier to quantify the costs than the benefits. Once the size and productive capacity of a new field is ascertained, the annual value of the geothermal yield can be approximated, with assumptions as to the marketing of the output, for example as a substitute for oil, at specified prices of the fossil fuel, with or without by-product sales of the geothermal resource. After the productive life of the field is estimated, the value of the annual yields can be capitalized into an asset value for the field. This would distinguish between the value (at cost or replacement) of

the well equipment, gathering lines and other improvements and the value of the geothermal resource itself, which would be the residual value after the capital costs are accounted for. From an array of estimates of the asset value, calculated under various geologic and economic assumptions, one can estimate the limits of gross and net income from the operation of the field, royalty payments to the state (assuming the now-standard 10% rate, or any other) plus the additional real property, gross-income, and net-income taxes which would be generated.

These estimated state revenue potentials can be entered as possible cost items, were the state to consider waiving such receipts to stimulate geothermal resource development. More obviously, so would any subsidy by the government, such as paying for exploratory drilling, or providing access roads to the fields, or any other direct support of a development program. More difficult (but probably also less important because much smaller in amount) would be the calculation of how much the indirect support of a geothermal development operation, as through the provision of geological and engineering research and technical advice, safety inspection programs, land planning, a supply of fresh water, and so on would cost the state and county governments. If drilling were done on lands owned by the state or county governments, the opportunity costs of using the area for geothermal development rather than some alternative purposes would also have to be added in. In this instance, any present calculation of opportunity costs would result in a relatively small sum, since few public lands in the Puna district, aside from beach parks, are now being used or have a currently discernible use of much economic value.

On the benefit side is encountered the classic problem of rational, optimizing government budget making: what values are to be given to benefits which are not priced in the market? For few of the social returns from developing an indigenous power source are measures or proxies for valuation readily specified. Thus, the labor productivity associated with the creation of jobs by geothermal development gives only a first approximation of the net value to society of those jobs. (Labor markets in Hawaii are sufficiently competitive to justify using estimated wage payments as a measure of productivity.) Social values other than increases in product are also involved. The creation of jobs would result in the employment of some persons who had been receiving welfare or unemployment compensation, and who prefer receiving wages instead of these supportive transfer payments. Partial evidence of the size and prevalence of this preference can be gleaned from the experience of state agencies in placing recipients in jobs which reduced their net income, and similarly from the Social Security Administration with respect to persons who accept employment at the cost of lower retirement benefits. From this evidence, it may be possible to judge the magnitude of the nonpecuniary value attributed to employment by those involuntarily unemployed. This value, should it prove to be significant, would be added to the wage bill for geothermally related work in estimating the total social value of the new jobs. (To the extent that geothermal development displaces workers—such as those employed in local petroleum refineries—their wages would be subtracted, so that the calculation is of net increase of wages plus nonpecuniary benefits.)

Estimating the value of improvements to the environment which may be associated with a noncombustion energy technology also offers its own difficulties, but is amenable to at least proximate calculation. What is required is a specification of adverse environmental impact that compares the effects on water, soil, air and landscape of a geothermal operation with those of an oil-burning plant in a specified location. Landscape effects are difficult, perhaps impossible, to price out except in terms of each person's individual preferences, but as suggested earlier, they would probably not be major items in an area as little settled and utilized as most of the Puna district.

Most difficult of all in this calculus would be placing an economic value on the stimulus which geothermal development might provide to spreading out the population. How many dollars is it worth to the people living on Oahu to have somewhat less crowding in their neighborhood, in the shopping center, on the beach, in the park, in the parking lot? Obviously, the answer would be different, depending on whom one asked. There is no market, there is no voting process to measure the strength of individual preferences for more space, less crowding. Perhaps some tangential data could be compiled as to the incidence of crime, disease, traffic injuries and other manifestations of urban pathology, or of the increased costs of government per person as the population of a jurisdiction rises; but such information—even if completely valid for what it purports to say—does not address the esthetic question, how much is space worth to people collectively?

Since the market does not answer questions of this sort, governments have to. The budget process responds to social needs whose satisfaction is dependent on services or conditions of living (a salubrious environment, safety from violence) which must be made freely available to all in the community if any are to enjoy them fully. Until this moment, and despite energetic efforts at quantifying the outcomes of government programs (recently centered in the Program Planning Budgeting System), budget authorities remain without means of measuring the benefits of "social goods" such as open space. Nevertheless, the governor, legislature and other decision makers have to act as if they knew the worth of the services provided by the state. They do this by gathering what information is available about a proposed expenditure—how much it will cost, what kind of social good it will provide, what groups in the community will be served, who will be disadvantaged or opposed—and then obtain opinions as to the desirability of the expenditure. Finally, considering the information in the light of their experience, preferences and perhaps obligations to others, they make their voting decision to sign or to veto.

That is the complex process, stated simplisticly, by which state governments decide on programs and expenditures, and so it is the way in which an isolated state, such as Hawaii, will set its policy (meaning here action, not necessarily rhetoric) on geothermal development. To help determine their decision, the authorities can line up the costs of, say, a policy which tries to maximize geothermal production in the shortest time by waiving royalties, granting tax exemptions for a period of time, minimizing environmental safeguards, providing necessary infrastructure, lending or granting subsidies, or even by undertaking state development of geothermal fields.

On the benefits side would be arrayed the values listed above, plus others that may enter into the consideration of the policy makers, represented by the "ball park" estimations available to the deciders. Rational analysis would

require that the benefits which accrue over time (such as retaining open space and reducing dependence on oil imports) be reduced to present value by appropriate time discounting, as would be the recurring costs, such as the exemption of land which would otherwise be subject to taxation.

Since many of the valuations entering into the cost-benefit analysis must be gross approximations of the actual values, which are better represented by a range of estimated cash values than by a single figure, the policy makers are likely to be influenced by factors which do not enter into the analysis at all. Caution or enthusiasm for new technology would be one such factor; optimism or pessimism about the future of oil supplies would be another. A third would be policy maker's attitudes toward government intervention in economic development in Hawaii, whether it is desirable for the state to take an initiative in that development or wait for private industry to do the work. Also, opinion as to how well the operations of public utility companies in the state serve the public welfare may affect decisions concerning the development and application of geothermal power. For example, if policy-makers were persuaded that cost savings from geothermal power would not be passed on by the electric companies to consumers, then they might favor a larger role for the state, extending to distribution of the power derived from geothermal resources.

POLICY MODELS

State control lies at the end of a broad spectrum of possible roles of the Hawaii government in geothermal development, depending on its policy objectives and ideological preferences. Within that range, these models can be distinguished.

Minimal State Intervention

This model, which would also attempt to maximize output, 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.

Private Operation, Government Support

To maximize production while minimizing state control, 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), minimizing environmental impact statements, and 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 the benefits of geothermal power are shared between developer and utility company and not passed back to consumers in lower rates. (This is done at The Geysers, California, where the Pacific Gas and Electric Company pays the geothermal-steam supplier at a rate tied to the price of fuel oil.)

Private Operation for State Objectives

The means just listed above 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, and so on 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 achieved this purpose. If the state puts a high priority on environmental protection, the environmental impact statement would be held to a demanding standard of explicitness. If it wants to maximize production over time, the state would ensure that the resource had been adequately identified before permitting production drilling, that geothermal waters are reinjected after use, and so forth.

Joint Venture

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 set by the state, such as creation of employment, reduction of dependence on oil, and population decongestion. This possibility, in fact, is what would provide justification for the direct and indirect subsidization considered above.

Another approach is for the local 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 commensurately sharing in the profits (or losses) of the geothermal enterprise.

The joint venture might encompass the entire operation, from drilling to production of electricity of by-products of geothermal waters and minerals, or it might provide for a division of labor. One division would be for the state to drill and produce the steam and then sell the steam to the Hawaii Electric Light Company, 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 island of Hawaii. Other combinations of public and private enterprise, hooked together in series or in parallel, are readily imagined.

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 marketing of the electric power or other products of the resource. 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.