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THE NATIONAL GEOTHERMAL ENERGY  
RESEARCH PROGRAMRichard J. Green  
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The continuous demand for energy and the concern for shortages of conventional energy resources have spurred the nation to consider alternate energy resources, such as geothermal. Although significant growth in the one natural steam field located in the United States has occurred, a major effort is now needed if geothermal energy, in its several forms, is to contribute to the nation's energy supplies. From the early informal efforts of an Interagency Panel for Geothermal Energy Research, a 5-year Federal program has evolved whose objective is the rapid development of a commercial industry for the utilization of geothermal resources for electric power production and other products. The Federal program seeks to evaluate the realistic potential of geothermal energy, to support the necessary research and technology needed to demonstrate the economic and environmental feasibility of the several types of geothermal resources, and to address the legal and institutional problems concerned in the stimulation and regulation of this new industry.

Geothermal energy is becoming a small but viable contributor to U.S. energy supplies. However, its development must be greatly accelerated if it is to contribute to meeting urgent domestic energy needs on a significant scale.

Geothermal waters have been used since ancient time; they have been used for municipal heating in Iceland since the 1930's and are being used to a small extent in the United States. Electric power production from geothermal energy began in 1904 at the Larderello Field in Italy. Today, somewhat more than 1000 MWe are being generated in the world. By comparison, single fossil-fueled or nuclear generators are now installed in units which often exceed the world's total geothermal capacity.

The U.S. geothermal resource base has been compared favorably with present oil and gas reserves. It is believed that the most readily exploitable geothermal resources are located in the western third of the U.S. Their development could have considerable impact on meeting the power requirements of the nation. For instance, it has been estimated that the Imperial Valley in California is capable of sustaining a generating capacity of as much as 100,000 MWe for 50 years.

Only one geothermal resource, dry steam, is presently being used to produce power in the United States, generating more than 400 MWe at the Geysers in California. There are no other known sources of dry steam in the U.S. except those in Yellowstone National Park. However, several other resource types show promise. They are: hot brines, moderate temperature/low salinity fluids, geopressed reservoirs, hot rock formations, and magmatic deposits.

It appears to me that the major problems inhibiting the growth of geothermal energy in the U.S. are: (1) a lack of confidence on the part of the energy utilization industry in geothermal reservoirs as reliable, long-term supplies of energy; (2) institutional, legal, and environmental problems associated with the development of such reservoirs; and (3) unsolved technical problems and economic uncertainties concerning the utilization of geothermal energy in an environmentally acceptable manner.

The goal of the National Program is to provide the knowledge and technology base to solve these problems.

There are several strategies which could be adopted to foster the growth of geothermal energy utilization in the United States. One is to give the government exclusive control over all phases from resource exploration to commercial power generation. This is clearly unacceptable. Another strategy would be no government involvement at all. This is undesirable in view of the high-risk nature of exploration, the need for advanced technology for the more marginal types of resources, and the urgency of our energy supply situation.

The strategy that makes most sense — and the one we have adopted — is based upon a short-term government involvement with the geothermal industry. The private sector is expected to assume an increasing role, and a greater share of the risk, as the National Research Program begins to pay off.

Thus, the National Geothermal Energy Research Program places major emphasis on a strong and continuous working relationship with the geothermal energy industry. This will ensure a rapid transfer of research results and, hopefully, achieve the acceleration of the development of U.S. geothermal resources.

The primary goal of the National Geothermal Energy Research Program is to stimulate the private sector to augment the commercial production of electric power by 20,000 to 30,000 MWe by 1985. This would save the equivalent of 1,000,000 barrels of oil per day. The corresponding production goals for 1990 and the year 2000 are 100,000 and 200,000 MWe, respectively. In addition, fossil fuels will also be conserved through the use of geothermal fluids for nonelectric purposes — space heating, process heat, production of minerals, and desalination.

Specifically, the National Program is directed to:

- (1) Provide the necessary technological advances to improve the economics of geothermal power production.
- (2) Expand the knowledge of recoverable resources of geothermal energy.

- (3) Provide carefully researched policy options to assist in resolving environmental, legal, and institutional problems.

The National Program is divided into four discrete areas:

- (1) Resource exploration and assessment.
- (2) Environmental, legal, and institutional problems.
- (3) Resource utilization projects.
- (4) Advanced research and technology.

Resource exploration and assessment is directed at appraising regionally and nationally all types of geothermal resources and identifying promising target areas for industry exploration and development.

The objectives are to improve geophysical, geochemical, geological, hydrological, and other techniques for locating and evaluating geothermal resources; to develop better methods for predicting the productivity and longevity of geothermal reservoirs; and to assess the nature and power potential of the deeper unexplored sectors of high-temperature geothermal convection systems.

Environmental, legal, and institutional research will investigate methods for improved waste disposal and evaluate surface and subsurface effects of geothermal production. The research will seek to improve the capability to predict environmental impacts, expedite preparation of environmental impact statements, and ensure compliance with standards and criteria. Social, legal, and economic problems will be identified. Policy alternatives will be developed to provide a socio-economic framework conducive to commercial utilization of geothermal resources.

Resource utilization projects will provide operational, technological, and economic data to establish the practicality of commercial electric and nonelectric uses of geothermal energy. Small scale, experimental research facilities or pilot plants of 1 to 10 MWe in size will be the vehicle to gain the data and experience. The pilot plants will provide data for use in determining the operating characteristics of commercial scale plants and the potential lifetime of different classes of reservoirs. The facilities will provide the capability to test and evaluate new components developed by industry and universities. The program is directed at involving engineers, analysts, technicians, and managers from industry so that they can gain "hands-on" geothermal power plant experience. Development of a cadre of trained geothermal engineers and technicians is another goal of this program.

The advanced research and technology efforts are directed at a variety of problems. Some examples are: the development of effective, efficient drilling methods for operation in the high-temperature geothermal regime; the development of predictive methods and control techniques for the extraction and reinjection of geothermal fluids; the development of rock fracturing techniques; the improvement of equipment and technology to extract fluids from reservoirs; the development of new energy conversion technology; and, lastly, the development of new and improved methods for controlling emissions and wastes from geothermal reservoirs.

The National Geothermal Energy Research Program involves the activities of many agencies: the National Science Foundation, the Atomic Energy Commission, the U.S. Geological Survey, the Bureau of Reclamation, the Bureau of Mines, the Environmental Protection Agency, the Council of Environmental Quality, the Federal Power Commission, and the Bureau of Land Management.

The National Science Foundation serves as the lead Federal agency for the formulation and execution of the National Program. An Interagency Panel for Geothermal Energy Research has been established to provide the foundation with a mechanism for coordinating the geothermal programs of the Federal agencies.

The panel, including representatives from the agencies listed below, serves as the focal point to ensure that all Federal efforts are properly integrated.

The Interagency Panel for Geothermal Energy Research includes representatives from:

- Atomic Energy Commission
- Bureau of Mines
- Bureau of Reclamation
- Council on Environmental Quality
- Department of Defense
- Department of Interior
- Environmental Protection Agency
- Federal Energy Agency
- Federal Power Commission
- National Science Foundation
- U.S. Geological Survey

Office of Management and Budget (observer)

Private sector involvement in the National Geothermal Energy Research Program will be accomplished through use of the following management approaches:

Industrial organizations and consortia thereof will be awarded contracts to design, construct, manage, and operate experimental research facilities. In these instances, a major benefit will be the flow of information and results directly to the private sector.

Secondly, national laboratories will award contracts to industrial firms for the completion of specific tasks associated with particular projects. Technical and management control will remain with the national laboratory.

I would like to note that in both cases cost sharing arrangements with industrial partners will be sought for the dual purposes of: (1) promoting early participation by the private sector on a "partnership" basis, and (2) reducing the government's cost.

In addition, through both solicited and unsolicited proposals, awards will be made to universities, industry and nonprofit organizations to conduct research in the areas discussed previously. This will ensure that the program will have a steady flow of innovative research ideas and project opportunities.

It is vital to the Federal geothermal effort that close ties with industry be established and maintained. One vehicle for accomplishing this will be the Geothermal Industry Liaison Group. The group will give advice regarding the scope, direction, and planned implementation of geothermal research conducted by Federal agencies.

It will be the means by which the Interagency Panel for Geothermal Energy Research can inform industry of the status of ongoing programs. It will provide the Interagency Panel with industry perspectives on the problems related to geothermal exploitation. Lastly, it will provide the Interagency Panel with recommendations relating to industry participation in the program.

The group will include representatives from:

- (1) Electric utilities.
- (2) Resource extraction organizations.
- (3) Engineering services.
- (4) Agriculture and mining.
- (5) Financial institutions.
- (6) State and local governments.

In addition to scientists and engineers, the group will include representatives concerned with rate base and marketing matters to ensure that the widest range of private sector attitudes and perspectives are available to the government.

The research budget for the national programs in fiscal year 1975 is shown below. We believe it provides for addressing, in a timely way, the problems which inhibit geothermal developments.

1975 Program Budget  
(millions of dollars)

	<u>NSF</u>	<u>AEC</u>	<u>DOI</u>	<u>Total</u>
Resource exploration and assessment	3.0	--	8.2	11.2
Environmental, legal, and institutional	2.3	--	1.1	3.4
Resource utilization projects	9.5	9.6	--	19.1
Advanced research and technology	<u>7.5</u>	<u>2.1</u>	<u>1.9</u>	<u>11.5</u>
Total	22.3	11.7	11.2	45.2

The 5-year projected budget for the program is \$314 million dollars. The degree that this is reduced will depend upon private sector cost sharing in the program.

In closing, I would like to say that in developing the National Program Plan we attempted to identify the problems to be overcome to bring geothermal energy to the market place on a large scale. We have attempted to design a program to help in solving these problems. It is based on optimism. We are optimistic that the resource base does in fact exist. We are optimistic that technology can be brought to bear to extract and utilize the resource. And we are optimistic that there are no insurmountable legal, environmental, and institutional problems.

Any program worth its salt is dynamic — it is subject to improvement and upgrading. To ensure that this occurs we need your help and active participation. I earnestly ask for it.