GEOTHERMAL RESEARCH AND DEVELOPMENT PROGRAM OF THE U. S. ATOMIC ENERGY COMMISSION

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Within the overall federal geothermal program, the Atomic Energy Commission has chosen to concentrate on development of resource utilization and advanced research and technology as the areas most suitable to the expertise of its staff and that of the National Laboratories. The Commission's work in geothermal energy is coordinated with that of other agencies by the National Science Foundation, which has been assigned lead agency by the Office of Management and Budget. The objective of the Commission's program, consistent with the goals of the total federal program is to facilitate, through technological advancement and pilot plant operations, achievement of substantial commercial production of electrical power and utilization of geothermal heat by the year 1985. This will hopefully be accomplished by providing, in conjunction with industry, credible information on the economic operation and technological reliability of geothermal power and use of geothermal heat.

The Atomic Energy Commission's program for development of geothermal energy was first funded in 1973 at a level of $4.7 million. Funding for the current government fiscal year is $10.8 million.

At the outset, the Commission's program was developed largely through its National Laboratories. On June 18, 1974, a Geothermal Power Development Conference was held in Berkeley, California, for the purpose of describing the program as currently formulated and to solicit comments, recommendations and criticisms regarding it. Results of this meeting showed, in part, that much closer communication with and involvement of industry must be achieved, and that the Commission's program should be more responsive to ongoing industrial activities. It is hoped that the NSF-sponsored Conference on Research for the Development of Geothermal Energy Resources will assist in achieving these goals.

In addition, informal workshops are being planned on specialized topics, and a solicitation of interest is being prepared relating to joint projects with industry which would involve both industrial facilities and knowhow.

The Commission's resource utilization program is directed toward economic utilization of geopressured, convective hydrothermal, and dry geothermal resources for production of power and for nonelectric uses. A program concept definition study currently is underway to identify prospects for economical use of geothermal heat for nonelectric uses and to define further technical development which may be required. Advanced research and technology studies are planned in the areas of advanced drilling, reservoir modeling, downhole instrumentation development, low-temperature heat conversion, heat exchanger development and materials development. In order to better define the role of geothermal energy in relation to competing resources and to evaluate cost/benefit aspects of exploitation of various resource types, plant designs and development strategies, an economic modeling study is being performed. Also, a geothermal utilization systems analysis has been started for the purpose of providing a milestone and decision-point-oriented national activities network. It is hoped by this means to facilitate the formulation of quantitative goals and milestones for the government-sponsored aspects of the national program and to ensure that results needed to reach national goals are achieved in a timely fashion. It is apparent that successful development and application of these objectives can only be achieved with the fullest support and participation by industry, and the AEC wishes to reemphasize the importance it attaches to incorporation of industry in all phases of its geothermal program.

The United States Atomic Energy Commission's work in geothermal energy is coordinated with that of other agencies through the National Science Foundation which has been assigned lead agency by the Office of Management and Budget. The objective of the Commission's program, consistent with the goals of the total federal program is to facilitate, through technological advancement and pilot plant operations, achievement of substantial commercial production of electrical power and utilization of geothermal heat by the year 1985. This will hopefully be accomplished by providing, in conjunction with industry, credible information on the economic operation and technological reliability of geothermal power and use of geothermal heat.

Inasmuch as construction of commercial utilization facilities is obviously a voluntary decision on the part of industry the strategy adopted by the AEC is to attempt to stimulate that decision through performance of essential research and development work particularly in areas where industry lacks near-term profit motivation or lacks appropriate staff and facilities to perform such work.

It is intended to develop information in cooperation with industry, in part, as an adjunct to industrial activities having similar overall objectives, but principally as a means for advancing geothermal utilization technology beyond that currently available. The strategy adopted for achievement of program objectives thus involves cooperative demonstration programs with industry in addition to longer term research and development work.

At the outset the AEC program was developed largely through activities of its staff and the National Laboratories beginning in late 1972.

The AEC program finally came into being in December 1973 after the passage by Congress of legislation which provided funding at a level of $4.7 million for geothermal work and the apportionment of these funds by the Office of Management and Budget.

In December 1973 the staff began laying plans for formally integrating the AEC program with industrial and other nonfederal interests. As a first step, the staff proposed that public notice be given of the conduct of AEC's Research and Development activities in geothermal energy and that there be held a public information meeting for the purpose of describing the program as then formulated and soliciting comments, recommendations and criticisms regarding its content. Such a notice was eventually published in the Federal Register June 11, 1974 and a meeting known as the Geothermal Power Development Conference was held on June 18, 1974 in Berkeley, California. Registered attendance was in excess of 200 people.

The Proceedings of that conference have been published and can be obtained from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia, at a nominal cost.

Insofar as the purposes of the geothermal conference at the California Institute of Technology correspond with the purposes of the Berkeley Conference it may be of interest to summarize briefly the results of the Berkeley meeting, and the responses to the notice published in the Federal Register.

Each attendee at the Berkeley meeting was asked to respond to a questionnaire. The total number of respondents was 17, and the composition of these respondents according to affiliation was as follows:

(1)	Energy Companies	7
(2)	Engineering Companies	3
(3)	Universities	3
(4)	Utilities	2
(5)	Public Power Groups	1
(6)	State Government	1

The major comments received were as follows:

(1) 14 respondents described the Berkeley meeting as useful or very useful.

(2) 11 respondents urged similar meetings in the future, most commonly suggesting semiannually or annually.

(3) 10 respondents emphasized the need to involve industry much more closely in the design and implementation of the program.

(4) 9 respondents stated that they would consider participating in AEC projects on a cooperative, joint support basis.

(5) 2 respondents commented adversely on the apparent duplication between AEC and NSF programs.

(6) One respondent stated AEC had a serious credibility problem in the sense that AEC's objective appeared to be to establish a geothermal TVA.

In addition a number of miscellaneous comments were received:

(1) 2 respondents urged greater involvement of universities in the program.

(2) 2 respondents recommended that greater attention be given to nonelectric applications.

(3) One respondent emphasized the need to resolve the institutional problems inhibiting geothermal energy.

(4) Several respondents identified particular areas of R&D they felt needed attention.

For the most part we were gratified by this response and agree that many of these suggestions have merit. I would like to call attention to a few recent actions taken in the government programs which are related to some of those comments.

First, the need for closer coordination of the federal agency programs is being achieved through the Interagency Panel for Geothermal Energy, chaired by the National Science Foundation as lead agency. This Panel is now meeting frequently and shows good promise of being an effective instrument for program coordination, and dealing with matters such as duplication of effort among government agencies.

Second, industry has been requested to participate in top level review and planning of federal geothermal programs through establishment of a blue ribbon Geothermal Industry Liaison Panel, the members of which have been invited by the National Science Foundation in consultation with the Interagency Panel to serve in this capacity. It is believed that this will be a very important mechanism for industrial involvement in the design and implementation of government programs.

Third, informal workshops are being planned by AEC, NSF, and the U. S. Geological Survey to provide in-depth evaluations of specialized technical topics. AEC has tentatively scheduled a workshop on energy conversion systems for November 4-5, 1974. It is proposed to invite a limited number of industrial and government people who are actively working in power cycle development and applications to participate in a review of current status of this field, of development work in progress, and needs for additional research and development.

Fourth, a number of informal visits to industries have been made during August and September by representatives from the three agencies: NSF,

Department of Interior, and AEC. The purpose is to become better familiar with and to evaluate the status of industrial work and interests in geothermal energy as it relates to the role which federal programs should fill in the national effort.

Fifth, with respect to technical and operational aspects of our program, the AEC has been reexamining the objectives and general approach of its program particularly as it relates to ongoing industrial activities in order to ensure the most effective contribution to the national program. As a result of this reevaluation there may be other modifications to the program in the near future.

The impetus for these actions has, of course, come from a number of sources, but it is fair to state that constructive criticism and suggestions such as those we received from the Conference participants have been of great benefit in reassessing our objectives.

We have reason to hope, I believe, that the NSF-sponsored Conference on Research for the Development of Geothermal Energy Resources will further assist in achieving these goals.

I would like to turn now to a discussion of the AEC's technical program. This will be brief inasmuch as there will be detailed presentations from members of the National Laboratories in which three of the principal programs will be described.

The geothermal research and development program funded by the federal government is generally described under four categories: (1) Resource Exploration and Assessment; (2) Environmental, Legal and Institutional; (3) Resource Utilization; and (4) Advanced Research and Technology.

Within the overall federal program the Atomic Energy Commission has chosen to concentrate on development of resource utilization and advanced research and technology as the areas most suitable to the experience and expertise of its staff and that of the National Laboratories.

This is not to suggest that the first two categories of the program are in any way less important, but only that it is believed that the greatest contribution by AEC can be made in the categories of resource utilization and advanced research and technology.

The principal objectives of the geothermal resource utilization program are as follows:

(1) Develop economic utilization systems and components for generating electric power and for providing heat for other purposes such as space heating and cooling;

(2) Demonstrate these systems and components in test facilities;

(3) Gain experience in reservoir assessment and management;

(4) Acquire operational and cost experience with several different types of utilization systems and resources;

(5) Develop trained geothermal engineers and technicians; and

(6) Participate with industry in research and development leading to early industrial exploitation of geothermal resources of all types.

The program encompasses the major types of geothermal resources, namely hot dry rock, convective hydrothermal and geopressured systems, and near-normal or tectonic heat-gradient formations.

Programmatic responsibility for each of these resource types has been assigned to one of the AEC Laboratories. These assignments and the fiscal year 1974 and 1975 budgets are shown in Table 1.

In addition to resource utilization programs, advanced research and technology development common to all geothermal systems will be required for full development of the potentialities of the several types of geothermal energy resources. The ultimate goal of this effort is to solve technical problems inhibiting the full commercial utilization of geothermal resources. The objectives of the advanced technology program are to:

(1) Develop new methods for drilling in high temperature "hostile" geothermal environments rapidly and economically;

(2) Develop or test component hardware for handling and utilization of geothermal fluids, e.g., advanced heat exchanger designs.

(3) Develop improved methods for recovery of geothermal fluids and for converting the energy into electrical power and other applications;

(4) Design new and improved equipment, including downhole instrumentation capable of operation at high temperatures and in corrosive fluid media.

The programs supported by the AEC in this area and the fiscal year 1974 and 1975 budgets are shown in Table 2.

There will be presentations at this Conference on hot dry rock and convective hydrothermal systems, so perhaps a few comments would be appropriate concerning some other aspects of the program.

We have become quite interested in the possible uses of geothermal heat for nonelectric purposes. It is well known that geothermal water has been used successfully for many years for heating homes in Iceland, Hungary, France, and to a more limited extent the United States. There is also extensive use of geothermal energy in other countries for heating greenhouses, and to some extent for industrial process heat. Two complementary studies on nonelectric uses in which the AEC is participating are concurrently underway. One of these is sponsored by the NATO Committee on Challenges of Modern

Society. These studies can be expected to identify promising applications and areas for further technological development. A number of examples of thermal energy uses have been identified as shown below.

Residential and Commercial:

(1) Space heating and cooling
(2) Domestic water (potable, hot/cold utility)
(3) Waste treatment (disposal, bioconversion)
(4) Refrigeration
(5) Deicing
(6) Total energy systems (cascade utilization)

Agriculture and Related Areas:

(1) Crops (greenhouses, hydroponics, heated soil)
(2) Animal husbandry (cattle, pigs, chickens)
(3) Aquatic farming (fish rearing)
(4) Processing of agricultural products (drying)

Industrial Processes:

(1) Chemical production
(2) Pulp treatment
(3) Mining (heat, water)
(4) Drying (cement, diatomaceous earth)
(5) Water desalination/distillation
(6) Mineral recovery from geothermal brines

In each of these cases the technology to be assessed or developed would depend upon features of the specific resource being considered and the possible applications in that locality. In general, areas of technology development could include: thermal energy transport and storage; heat exchange systems; fluid/mineral separators; low temperature turbines; and heat pumps. In addition there would be areas of development peculiar to the specific applications including interactions with other energy systems.

If the program definition study is favorable, selected projects will be funded during FY 1975.

In order to better define the role of geothermal energy in relation to competing resources, an economic modeling study is being performed. This model will evaluate cost/benefit aspects of exploitation of various resource types, plant designs and development strategies.

There are two principal objectives: (1) to define the role of geothermal energy in relation to competing resources and (2) to further the optimum development of geothermal energy. In accomplishing these objectives, a model will be constructed which will provide an economic basis for performing benefit-cost analyses of Government-sponsored research and development programs. The model will also provide the basis for economic comparisons between geothermal power programs and programs in other energy technologies.

During this year the program will be concerned with (1) the completion of deterministic economic cost models and sensitivity analyses for all geothermal resource types, (2) a macroeconomic (logistics) analysis for geothermal energy, (3) development of an economic optimization model for geothermal energy development, and (4) an analysis of the national benefits of geothermal energy.

In addition, a geothermal systems analysis is being performed for the purpose of providing a milestone and decision-point oriented national activities network. It is hoped by this means to facilitate the formulation of quantitative goals and milestones for the government-sponsored aspects of the national program, and to ensure that results needed to reach national goals are achieved in a timely fashion. It is apparent that successful achievement of these and other program objectives can only be accomplished with the fullest support and participation by industry, and the AEC wishes to reemphasize the importance it attaches to involvement of industry in all phases of its geothermal program.

Table 1. Resource utilization program assignments and budget

Resource	Laboratory	FY 1974 ($1,000)	FY 1975 ($1,000)
HDR	Los Alamos Scientific Laboratory	2,970	3,800
HT/LS	Lawrence Berkeley Laboratory	800	1,000
HT/HS	Lawrence Livermore Laboratory	420	2,200
MT/LS	Idaho National Engineering Laboratory	245	950
Geopressured	Lawrence Livermore Laboratory	25	600
Near-Normal Gradient	Los Alamos Scientific Laboratory	0	100
		4,470	8,650

Table 2. Advanced research and technology budget

Program	FY 1974 ($1,000)	FY 1975 ($1,000)
Advanced drilling	0	400
Heat exchanger development	0	250
Low temperature heat conversion	250	250
Nonelectric uses	35	400
Materials development	0	100
Other	0	450
Economic study	200	300
	485	2,150
Grand total (approximate)	5,000	10,800