PROPOSED SCOPE OF PHASES II and III STATE COUPLED PROGRAM

RESERVOIR CONFIRMATION for LOW- AND MODERATE-TEMPERATURE GEOTHERMAL RESOURCES

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PROGRAM OBJECTIVES

The objectives of the proposed program are:

1. To foster economically viable use of low- and moderate-temperature geothermal resources by the industrial and private sectors by the year 1985, and
2. To develop an infrastructure of consultants, contractors, and equipment manufacturers that will facilitate increased economic use of low- and moderate-temperature geothermal resources beyond 1985.

It is believed that a program of the magnitude proposed herein will be required if both of these objectives are to be achieved.

INTRODUCTION

Most geothermal geoscientists agree that there are many more low- and moderate-temperature (30°C to 150°C) geothermal resources than there are high temperature (>150°C) geothermal resources. U.S. Geological Survey Circular 790, Assessment of Geothermal Resources of the United States--1978, documents the distribution of resources as a function of temperature down to 90°C, with the conclusion that there is an exponential increase in the number of known occurrences as temperature of the resource decreases. This means that the geographic distribution of lower temperature resources is wider and that the

possibility of co-location with a user is increased as temperature decreases. The above relationship has also been documented for a number of other natural resources. For example the quantity of copper ore above a certain cutoff grade is known to increase approximately exponentially as the cutoff grade is decreased, both within individual deposits and for the world's copper resource as a whole.

Considering the relationship stated above it is possible that direct heat utilization of low- and moderate-temperature geothermal resources will ultimately contribute more power on line than will electrical generation from high temperature geothermal resources.

There is very little use presently being made of low- and moderate-temperature geothermal resources. The main reason for this appears to be lack of enough knowledge of the resource itself to attract users. By contrast, utilization of a geothermal resource, once it is discovered and confirmed, consists of reasonably straightforward engineering.[1]

Lack of resource knowledge occurs on two levels of detail:

1. On a regional scale, the locations of low- and moderate-temperature resources are poorly known. Maps and compilations of such information are only now becoming available in preliminary form through the State Coupled Program;

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[1]Low-temperature geothermal resources generally have low salinities. Special high-temperature equipment and special techniques to handle high salinities are problems usually encountered only with high-temperature resources. Most direct heat geothermal applications can use off-the-shelf equipment and techniques.

2. On a site-specific scale, the lateral limits, depth, temperature, productivity, and longevity of very few low- and moderate-temperature geothermal reservoirs are known. Very little surface exploration and drilling have been done.

PRESENT DOE RESOURCE CONFIRMATION PROGRAMS

At the present time, DOE/DGE is supporting the State Coupled Program whose primary focus to date has been compilation and publication of maps and reports that identify potential low- and moderate-temperature geothermal resource areas on a regional scale. A smaller portion of this program has been addressed to detailed exploration and drilling of a few select sites. The program proposed herein concerns a change in emphasis of the State Coupled Program toward a much larger portion of reservoir confirmation activities. This is the next logical step in the State Coupled Program after regional data have been compiled and assessed (Phase I).

The Industry Coupled Program of DOE is a cost-sharing program with industry which has the objective of increasing the amount of exploration and reservoir assessment that industry is able to do for high-temperature resources suitable for electrical power production. In the process of exploration for high temperature resources, data on low- and moderate-temperature resources are automatically generated at specific sites. The number of sites where this program is active is small (about 15).

The DOE Geothermal Direct Application Field Experiment program, known as the PON program, has the goal of demonstrating direct heat use of geothermal energy at sites where the risk associated with reservoir confirmation is low

or where the reservoir is already confirmed. This program is currently active at 23 sites and future PON solicitations are planned. As it is currently operating, the PON is actually performing reservoir confirmation activities. This is being done without the benefit of appropriate geologic and exploration guidance. Because the purpose of the PON program is not reservoir confirmation and because few confirmed reservoirs are known today, the program proposed herein would not overlap the PON program but rather would replace inappropriate PON reservoir confirmation activities with an agressive, exploration-oriented program that would provide reservoirs needed for continuing the PON program.

It is not expected that the private sector will perform reservoir confirmation for low- and moderate-geothermal resources in the near future. Large developers such as the petroleum companies involved in geothermal activities are not interested because the typical direct heat use is much too small in scope to be attractive. On the other hand, few private individuals or small users could afford to take the substantial risks involved in exploration and confirmation of geothermal resources. The result is that at present very little is being done to develop the large low- and moderate-temperature resource base in the United States.

RECOMMENDED DOE PROGRAM

There is a clear need for a federal program to stimulate site-specific, detailed reservoir exploration and confirmation. This program must include funds for drill site selection and for sufficient drilling to confirm reservoirs where private capital would be available for full development.

Before considering the recommended DOE program and its costs, let us first estimate the program size in order to meet the Federal direct heat goal of 0.1-0.2 Quads of utilization by 1985.[2] We begin by making the following assumptions:

1) 0.15 Quads of utilization must be developed from this program. The remainder will be developed from projects in progress and from private development;
2) 25% of the Federally funded exploration and confirmation projects will be successful in the sense that sufficient flow of water at sufficient temperature will be achieved from the first production well(s) to warrant continued development using private capital;
3) 20% of the successful projects will be ultimately developed to a total production of 100 MWt each, using private money after the initial DOE funding;
4) 30% of the successful projects will be ultimately developed to a total production of 50 MWt each;
5) the remainder of the successful projects will be ultimately developed to a total production of 10 MWt each.

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[2]From the Geothermal Hydrothermal (Liquid-Dominated) Commercializaton Task Force Report; DOE/DGE, June 15, 1978.

Using these assumptions and the conversion factor 1 Quad = 33,430 MWt-yr we find:

If x = number of successful projects

$(0.20x)(100\ MWt) + (0.30x)(50MWt) + (0.50x)(10\ MWt) =$

$(33,430\ MWt\text{-}yr/Q)(0.15Q)$

x = 125 successful projects

and if y = total number of projects

x/y = 0.25

y = 500 total projects under this proposed program that must be initiated by, say, 1983 if the Federal direct heat power goals are to be met.

Let us now consider what the typical project would be expected to consist of and what its cost to DOE would be. First, it will be cost-effective to apply geoscientific exploration techniques before the drilling stage in order to increase chances of initial success and to select drill sites intelligently both for initial confirmation and for further development drilling. In addition to surface exploration, gradient drilling and confirmation well drilling will be required. For projects that are a success, reservoir engineering and hydrologic studies, and drilling of an injection well will be necessary.

Considering first the confirmation program, a typical program might be rather straightforward (Confirmation Program 1 below) or might be rather complex (Confirmation Program 2 below) depending on the exploration target concept, the amount of data required to select a confirmation well site, and the drilling difficulty.

Confirmation Program 1

Surface geology, geophysics, geochemistry	$ 60K
Temperature gradient holes (1,500 ft total)	30K
Production well drilling and testing (1500 ft)	90K
1500' x 250 holes = 375,000'	
	$180K

Confirmation Program 2

Surface geology, geophysics, geochemistry	$160K
Temperature gradient holes (4,000 ft total)	100K
Production well drilling and testing (2,000 ft)	120K
4000' x 250 holes = 1,000,000'	
	$380K

For those projects that meet success, further work will be necessary as estimated below:

Post-Confirmation Program

Engineering and hydrology	$ 20K
Injection well drilling and testing (1,500 ft)	$ 80K
	$100K

If we assume that half of the projects initiated will require Confirmation Program 1, half will require Confirmation Program 2, and that Post-Confirmation studies will be performed only on successful projects, the total estimated project costs would be:

Estimated Project Costs = (500/2)($180K) + (500/2)($380K)

+ (500/4)($100K) = $153M (million)

This money is needed for FY80, 81, 82, and 83 to meet the Nation's direct heat utilization goals by 1985, and it averages $38M per year.

1st YEAR - 100 projects

50 holes x 1500' = 75,000'

50 holes x 4000' = 200,000'

To these costs must be added implementation costs, which are considered below.

IMPLEMENTATION

The program proposed herewith is in every aspect an exploration program. It must be managed and performed by geoscientists who have an exploration background. An average of 125 projects must be initiated per year during FY80-83 inclusive. From what is presently known of the distribution of low- and moderate-temperature resources, the following 16 states have by far the best chance for contributing to success of the program (listed alphabetically): Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. The difficulty of a confirmation project would vary from area to area and from state to state. In addition, co-location of resources and users varies from state to state also. Therefore it is not presently possible to specify the proposed program on a state by state basis.

Management and performance of a program of the recommended scope will be complex. It is recommended that implementation be accomplished by a competitive procurement process directed at a team composed of a geoscience consulting or contracting firm and a potential resource developer (or a potential resource developer who has an in-house exploration capability). A second alternative would be to pass exploration and confirmation funds solely to the State Coupled Resource Assessment teams. This alternative is not favored because few of the state teams have an exploration background and because they generally do not have the management skills to handle a program

of this size. Participation of the State teams, however, is essential to insure the success of the program. Competitive procurements from the private sector confer several advantages, some of which are:

1. An industry-based infrastructure, for all aspects of direct heat applications from exploration through utilization, would result. This would help carry the program into future years with decreased need for federal support.
2. The amount of professional talent available to the program would be extended to all of the talent in geoscience and engineering consulting and contracting firms.
3. A modest cost-share requirement could be introduced to help ensure private committment and incentive for good performance.

DOE will need management assistance for the proposed program, and the biggest portion of this management assistance must come from explorationists. A management team must be assembled that can evaluate 300-500 proposals per year and can monitor 125 projects per year. An estimate of the size, composition and cost of such a team is as follows:

	Proposal Eval.	Proj. Monitor
Geoscientists with exploration experience	8	30
Utilization Engineers	4	4
Support Staff (sec., draft, legal, etc.)	3	12
Estimated Costs ($80K per professional-year)	$960K	$2700K

These costs do not include DOE staff who would be assigned to this program.

Assembly of the appropriate management staff should not be difficult. In fact, many of the required people are already available through the State Coupled Resource Assessment and Operations Research Teams, EG&G, Idaho, and the University of Utah/University of Utah Research Institute.

INTERFACE WITH OTHER DOE PROGRAMS

The program proposed here has parallels with but is not the same as the Industry Coupled Program. It is directed toward potential users of lower temperature resources which big developers are not considering. The proposed program uses the already established State Coupled Resource Assessment teams; the regional activities (Phase I) of the State Coupled program should continue at least through FY83 to provide a selection of specific sites for application of Phases II and III. The proposed program would be expected to generate excellent sites for application of the PON program.

SUMMARY

The Proposed program can be summarized as follows:

Program Purpose

By the end of FY83, exploration and reservoir confirmation at 500 sites will have to be initiated if an adequate infrastructure for development of low- and moderate-temperature geothermal resources is to be developed and if the Nation is to meet the goal of 0.1-0.2 Quads of direct heat utilization by 1985.

Anticipated Results

Anticipated results of this proposed program are:

1. An infrastructure to carry on economic geothermal development beyond 1985 will have been established in the private sector, and
2. Development of direct heat utilization at the following level will have been achieved:

Sites with ultimate successful direct heat development (25% success rate)	125
Sites with little or no direct heat development	375
	500

		Direct Heat Development, MWt	
	Sites	Per Site	Total
	25	100	2,500
	38	50	1,900
	62	10	620
Totals	125	---	5,020

Implementation

Function	Responsible Organization(s)
Management, procurements from Private Sector	DOE
Coordination, Management Assistance to DOE for Geoscience Aspects	UU/UURI
Management Assistance to DOE for Engineering Aspects	EG&G, Idaho
State-Level Proposal Review and Project Monitoring	State Resource and OR Teams

Management Assistance Team

Geoscientists	38
Engineers	8
Support	15

Estimated Costs

Item	Yearly Cost (Millions)
Procurements	$38
Management (non-DOE)	4
	$42

Spending Schedule