PROPOSED DOE PROGRAM IN RESERVOIR CONFIRMATION for LOW-AND MODERATE-TEMPERATURE GEOTHERMAL RESOURCES

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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 resouce decreases. This 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 cut off grade is decreased, both within certain individual deposits and for the world's copper resource as a whole.

Although it appears likely 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 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. 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 not readily available in useful form;
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, which has as a primary goal the compliation and publication of maps and reports which identify potential low-to moderate-temperature geothermal resource areas on a regional scale. An additional portion of this program is addressed to detailed exploration and drilling of a few select sites, but the present thrust of the program is regional scale resource assessment.

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

The DOE Geothermal Direct Application Field Experiment program, known as the PON program, has the goal of demonstrating ~~desert~~ 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. Because the purpose of the PON program is not reservoir confirmation and because few confirmed reservoirs are known today, the new proposed program contained herein will not overlap the PON program but rather will provide needed reservoirs for continuing the PON program.

It is clear that there is no federally funded program for confirming a low- and moderate-temperature geothermal resource once a potential site has been generated. This lack of reservoir comfirmation is the single largest barrier to development of low- and moderate-temperature geothermal resources.

It is not expected that private industry will perform reservoir confirmation for these resources in the near future. Large companies are not intested because the typical direct heat use of a low- to moderate-temperature resource is much too small in scope to attract them. On the other hand, few private individuals or small companies 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 potentially 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, for sufficient drilling to confirm the reservoir, and for preliminary analysis of an appropriate utilization system and of project economics. Once a reservoir is confirmed, it is expected that 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.[1] Assume that:

1) 0.15 quads of utilization must be developed from this program, the remainder being developed from projects in progress and from private development.

25%, too high?

2) 25% of the Federally funded exploration and confirmation projects will be successful in the sense that sufficient flow of water at sufficient temperature is achieved from the first production well(s) to warrant continued development using private capital,
3) 10% of the successful projects are ultimately developed to a total production of 100 MWt, using private money after the initial DOE funding,
4) 25% of the successful projects are ultimately developed to a total production of 50 MWt,

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

5) the remainder of the successful projects are ultimately developed to a total production of 10 MWt.

Using these assumptions and the conversion factor 1 Quad = 31,600 MWt-yr we find:

If x = number of successful projects

$(0.10x)(100\ MWt) + (0.25x)(50MWt) + (0.65x)(10\ MWt) =$

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

x = 170 successful projects

and if y = total number of projects

x/y = 0.25

y = 680 total projects under this proposal 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 its cost to DOE. First, it will be cost-effective to apply geoscientific exploration techniques before the drilling stage in order to increase chances of initial success and intelligently to select drill sites both for initial confirmation and for further development drilling. In addition to surface exploration data acquisition, gradient well drilling, and confirmation hole drilling will be required. For projects which are a success, drilling of an injection well and preliminary analysis of a total utilization system will be necessary.

Considering first the confirmation program, a typical program might be rather straight forward (Program 1 below) or might be rather complex (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)	25K
Production well drilling and testing (1500 ft)	75K
	$160K

Confirmation Program 2

Surface geology, geophysics, geochemistry	$160K
Temperature gradient holes (3,000 ft total)	60K
Production well drilling and testing (2,000 ft)	100K
	$320K

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

Post-Confirmation Program

Engineering, Hydrology and Environmental Studies	$ 40K
Injection well drilling and testing (1,500 ft)	$ 60K
	$100K

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

Estimated Project Costs = (680/2)($160K) + (680/2)($320K)

+ (680/4)($100K) = $180M

This money is needed for FY80, 81, 82, and 83 to meet the Nation's direct heat utilization goals by 1985, and it averages $45M per year.

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 170 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 ~~15~~ 16 states have by far the best chance for contibuting to success of the program (listed alphabetically): Alaska, Arizona, California, Coloardo, Hawaii, Idaho, Montana, North Dakota, Nevada, New Mexico, Oregon, South Dakota, ~~Utah~~ Texas, Utah, Washington, and Wyoming. Therefore an average of 11 projects per state per year must be initiated.

Management and performance of a program of this 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 poor alternative would be to pass exploration and confirmation funds solely to the State Coupled Resource Assessment teams. This alternative is poor because few of the state teams have an exploration background and because they generally do not have the management experience to handle a program of this size. ~~a massive increase in size of state teams would be required.~~ Participation of the state teams, however, is essential to the success of the project. Competitive procurements from the private

sector has 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, and
3. A modest cost-share requirement could be introduced to help ensure private commitment 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 which can evaluate 300-500 proposals per year and can monitor 170 projects per year. An estimate of the size, composition and cost of such a team is as follows:

	Proposal Eval.	Proj. Monitor
Geoscientist with exploration experience	8	30
Utilization Engineers	4	10
Support Staff (sec., draft, legal, etc.)	3	12
Estimated Costs ($80K per professional-year)	$960K	$3200K

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

(25% success rate)

Sites with little or no direct heat development	510
	680

	Sites	Direct Heat Development, MWt Per Site	Total
	17	100	1,700
	43	50	2,150
	110	10	1,100
Totals	170	---	4,950

Implementation

Function	Responsible Organization(s)
Procurements from Private Sector	DOE
Coordination, Management Assistance to DOE for Geoscience Aspects	UURI
Management Assistance to DOE for Engineering Aspects	EG&G, Idaho
State-Level Proposal Review and Project Monitoring	State Teams
Management Assistance Team	
Geoscientists	38
Engineers	14
Support	15

Estimated Costs

Item	Yearly Cost (Millions)
Procurements	$45

Spending Schedule