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EXPANDED RESOURCE BASE -- THE KEY TO FUTURE GEOTHERMAL DEVELOPMENT

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ABSTRACT

According to analyses by the Department of Energy's Energy Information Administration (EIA), geothermal electric power capacity could nearly quadruple over the next 20 years, and there is a tremendous potential for growth in the direct uses of geothermal energy. However, for a high rate of development to occur in either of these applications, the identified resource base must be expanded. To this end, the Department is supporting R&D efforts to 1) share with industry the costs and risks of evaluating promising new resource prospects with power potential; 2) reduce the costs of exploration to enhance industry's cost-competitive posture; and 3) assess the location and characteristics of low-temperature resources.

This paper describes DOE's new cost-shared industry-coupled exploratory drilling program to be initiated with a solicitation by the Idaho National Engineering Laboratory, field manager of DOE's reservoir technology activities. Proposals will be requested for drilling either core holes or full-size wells on prospects from which some information had already been gathered, such as surface geophysics or shallow heat flow.

The paper also discusses the status of the project designed to demonstrate whether a geothermal reservoir can be identified and adequately evaluated to meet investment requirements with slimholes rather than the much more costly production-size wells. Results to date of testing at the Far West 24 MWe plant site at Steam Boat Hills, Nevada, are reported, and plans for related technology development to make slimhole exploration accessible even to small developers are described.

In addition, the paper describes the components of a Low-Temperature Assessment Program and its objectives and identifies the state resource assessment teams.

It is concluded that the successful execution of each of these projects will help to ensure a secure future for geothermal energy in this country, thus enhancing the environment wherever geothermal energy substitutes for the combustion of fossil fuels.

INTRODUCTION

According to analyses by the Department of Energy's Energy Information Administration, geothermal electric power capacity could nearly quadruple over the next 20 years. It is also estimated that, if the new DOE/industry cooperative program, tentatively called GEO - PACT (Geothermal Program to Accelerate Commercialization of Technology) is funded at requested levels, earlier increases in both power capacity and direct use applications could result by the year 2000:

- 1,200 MWe capacity in the U.S.
- 2,000 MWe capacity in the rest of the world
- 40 trillion BTUs per year in direct heat
- 700,000 geothermal heat pump units.

Accomplishment of this degree of growth in geothermal use alone will offer dramatic support to President Clinton's Climate Change Action Plan, which calls for a reduction of greenhouse gas emissions in the U.S. to 1990 levels by 2000, and to similar worldwide efforts for a healthier future environment. It is estimated that a geothermal response of this magnitude would reduce carbon dioxide emissions by nearly 100 million tons per year, of sulfur dioxide by one million pounds per year, and of nitrogen oxides by 330,000 pounds per year. (These quantities were determined by comparison of emissions from clean geothermal power plants with those from the average coal-fired plant in the U.S. using 1990 data from EIA). Since coal is one of the most polluting fuels, it is expected that accelerated geothermal development would have greatest impact on coal among all competing fuels, and would lead directly to reduced coal use.

Before growth of the magnitude suggested above can occur, however, a greatly expanded resource

data base is necessary. Acquiring the knowledge needed to assure continuing growth in power capacity will involve 1) exploration to confirm that currently unknown reservoirs are present at commercially viable temperatures and quantities at economically accessible depths, and 2) more detailed characterization of promising reservoirs in order to design strategies for their production. These development steps are the particular province of the participants in the Stanford Reservoir Engineering Workshop whose contributions to the current resource data base and to exploration and resource assessment techniques are recognized worldwide. Thus, it is not necessary to elaborate here on the details of the great costs involved in discovering and evaluating reservoirs. It is only emphasized once again that with current technology these functions are beyond industry's economic means, and government assistance appears essential if geothermal energy is to make a substantial contribution to the President's climate change plan.

Concomitantly, accelerated development of low-temperature geothermal resources in direct uses of the magnitude suggested above hinges to a large extent on compilation and characterization of reservoirs suitable for these applications, particularly those within five miles of population centers.

EXPANSION OF GEOTHERMAL RESOURCE DATA BASE

As one of the coordinated initiatives envisioned by the GEO-PACT program, planning is underway in the Geothermal Division to establish a government/industry cooperative exploratory drilling project. The objective of this project is to increase the inventory of known U.S. geothermal resources and to assist industry in determining the feasibility of economic development of particular resource areas in order to accelerate development and investment decisions.

As planned, the mechanics of this project will be very similar to the Industry-Coupled Cost-Shared Program initiated in the 1970s when a working data base for geothermal resources did not exist. The only source of this information at the time was the energy companies themselves who regarded it as proprietary.

The program was initiated to: 1) stimulate industry exploration through cost and risk sharing; 2) make data generated from the program available for unrestricted use; 3) develop case histories of geothermal exploration in various geologic environments for determining optimum exploration techniques; and 4) confirm resource potential at selected geothermal sites. The program included 21 deep exploratory wells with an average depth of about 7,000 feet, numerous shallow thermal gradient test holes, and geoscience investigative surveys. These efforts are summarized in Exhibit 1.

Nine major data packages were developed and are still available through the Earth Science Laboratory of the University of Utah Research Institute, and excellent results were achieved, with eight of the 14 sites investigated in commercial production today.

While development has not yet reached the full estimated megawatt capacity of any of the eight reservoirs, their remaining potential is not enough to support major industry growth. The sites are as follows:

Nevada	Utah
Beowawe	Roosevelt Hot Spings
Desert Peak	Cove Fort
Dixie Valley	
San Emedio	
Soda Lake	
Stillwater	

If the new project is funded as proposed, it will be open to all interested companies for geothermal exploration anywhere in the U.S. Core holes or exploratory wells may be proposed, and bidders will be requested to provide any knowledge of a proposed prospect area already gained through activities such as surface geophysics or shallow heat flow measurements. An indication of the ultimate user -- utility or independent producer -- of sites deemed suitable for development will also be requested. The proposer must agree to pay 50 percent of the drilling cost and provide estimates of the depth to the resource and of the total drilling costs.

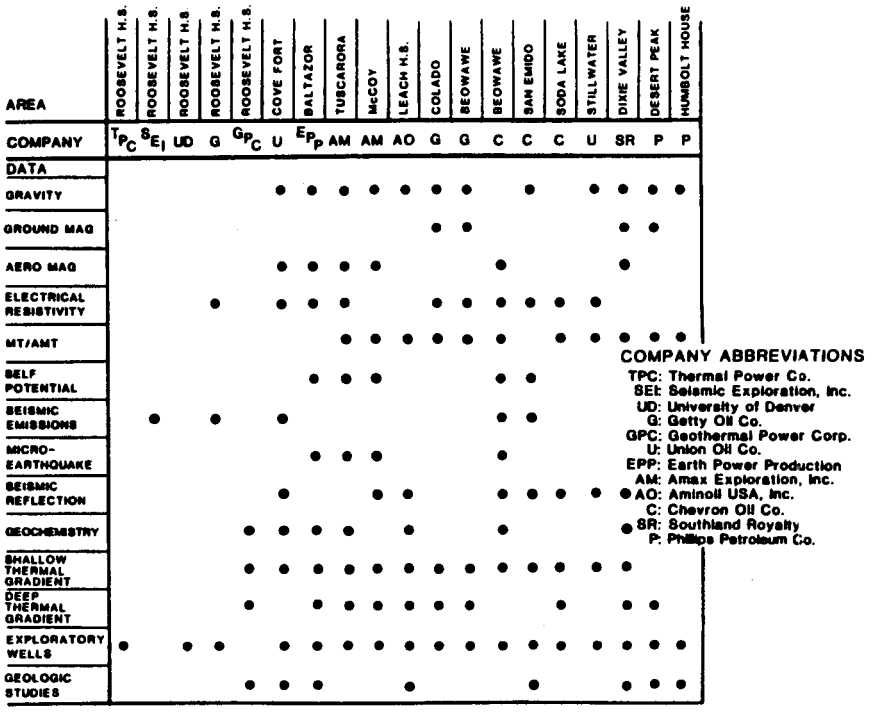
REDUCED FIELD DEVELOPMENT COSTS

Industry has expressed strong interest in technology advancements to reduce exploration costs so that industry can conduct more aggressive exploration programs on its own. As a result, a project was designed to investigate whether slimholes, rather then full-sized exploratory wells, can provide adequate information on a reservoir to satisfy investor requirements.

Slimholes are cheaper than wells because lost circulation zones can be drilled through without loss of drilling fluid, smaller rigs and crews as well as smaller drill sites are needed, road and permit requirements and environmental impact are reduced, and problems can be predicted and fixed

EXHIBIT 1

SUMMARY OF INDUSTRY-COUPLED PROGRAM EFFORTS



more easily. The cost analysis of a test of an existing core hole at the Far West Capital site at Steamboat Hills, Nevada, indicated the cost at $151/foot for the slimhole compared to $377/foot for an adjacent production well.

The project is under the direction of the Sandia National Laboratories which is working with a group that includes personnel from Sandia, Lawrence Berkeley Lab, University of Utah Research Institute, U.S. Geological Survey, independent consultants, and geothermal operators. This group is involved to a greater or lesser extent in all decisions affecting the direction of the research. Specific tasks, as outlined by John Finger of Sandia at last year's geothermal program review, include:

- Correlation of fluid flow and injection tests between slimholes and production size wells.
- Transfer of slimhole exploration drilling and reservoir assessment to industry so that slimhole drilling becomes an accepted method for geothermal exploration.
- Development and validation of a coupled wellbore-reservoir flow simulator which can be used for reservoir evaluation from slimhole flow data.
- Collection of applicable data from commercial wells in existing geothermal fields.
- Drilling of at least one new slimhole and using it to evaluate a geothermal reservoir.

The initial tests, on coreholes at Far West, a well-characterized field, yielded flow data which were in excellent agreement with results obtained by using measured downhole conditions as input for wellbore simulator codes. Further intensive testing is planned. Investigation of existing wellbore and reservoir codes indicates that they can be combined and/or slightly modified to produce a useful tool for analysis of reservoir parameters from wellbore flow data.

Plans to drill slimholes at two other well documented sites -- Coso Hot Springs and Wendell-Amedee, both in California -- this year are pending continued funding for this project. Its ultimate goal is to develop tools that will make slimhole exploration accessible even to the small, independent geothermal developer. These include, among others:

- guidelines for drilling and completing exploration slimholes
- recommended test procedures and strategies, including data requirements
- improved downhole instrumentation
- data interpretation techniques, possibly in the form of a PC-compatible flow simulator which could be distributed at a nominal expense to independent developers.

ASSESSMENT OF LOW- AND MODERATE-TEMPERATURE GEOTHERMAL RESOURCES

The objectives of the ongoing low- and moderate-temperature resources assessment is to promote accelerated use of these non-polluting resources in lieu of fossil-fuels for heating, and, in some climates, cooling. According to the Geo-Heat Center at the Oregon Institute of Technology, space heating in the 50-82°C (120°-180°F) range is by far the largest single U.S. energy use, representing 45 percent of all energy uses below 260°C (500°F). Customers of geothermal district heating systems commonly realize a 50 percent saving over the use of natural gas, with the payback period for initial installation determined by variations required by site-specific conditions.

Geothermal heat pumps represent similar operations cost savings over most alternatives, and the Environmental Protection Agency has found that they are the least polluting of all alternatives in most areas of the country. The Department of Defense has concluded, as enunciated in a military handbook on energy use, that the GHP is "the most efficient method of using electric power for heating." Thus, DOD has embarked on a program to accelerate the installation of GHPs at its facilities "to contribute to modernization and energy efficiency by reducing power consumption and maintenance costs." The circle of GHP proponents also includes utilities which are seeking the benefits of GHPs through reduced peak demand and higher annual load factors by offering various incentives to their customers to offset the upfront installation costs.

Thus, increased use of geothermal direct heat technologies will not only make a major contribution to reductions in greenhouse gas emissions, but will increase energy efficiency and cost savings, all of which are major objectives of DOE. It is believed that the products to result from the low- and moderate-temperature resource assessment will hasten the achievement of these objectives.

One product, which is nearly finished, is a nationwide set of maps indicating the potential locations for GHP installation. These are being prepared by the various state water resources research institutes.

Another product, also nearing completion, is an updated and refined inventory of the low- and moderate-temperature resources of the western states. Maps prepared for 18 of these states under the DOE State-Coupled Resource Assessment program of the late 1970s provided an excellent starting point for the current work. They identified wells and springs with anomalous temperatures and, along with supporting reports, have been very useful.

The current effort is focused on "cleaning up" the data base to provide good and usable data without errors. Drilling records and other information are being reviewed to identify new resources and verify temperatures and flow rates which may have changed substantially since the earlier State-Coupled program.

The Geo-Heat Center has selected the preliminary data base from the Utah Geological Survey as a model for the digital data base in table format. Information to be contained in the tables is as follows:

Table 1. Location: ID number, source name, county code, latitude and longitude.

Table 2. Description: ID number, source name, type of source, temperature (°C), flow rate (L/min), depth of wells (m), current resource use, and references to relevant studies (geology, geophysics, geochemistry, hydrology) completed for the site.

Table 3. Geochemistry: ID number, source name, pH, TDS, major cations, major anions, cation-anion balance, chemical species that may cause scale and corrosion products, and light stable isotopes.

Resource maps at a scale of 1:1,000,000 are also in preparation.

Program participants include, in addition to the Geo-Heat Center, the University of Utah Research Institute, the Idaho Water Resources Research Institute and agencies of state governments or universities in most of the western states.

CONCLUSION

The highest levels of experience and expertise in the U.S. geothermal community are being brought to bear on each of these projects. It can thus be expected that they will be executed with a maximum degree of success. To that end, they will enhance geothermal development, for both power generation and direct use applications, in this country and abroad, and, in turn, enhance the environment worldwide.