U. S. DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY

USER COUPLED CONFIRMATION DRILLING PROGRAM

a new program to provide

FEDERAL COST-SHARING

for

EXPLORATION, DRILLING AND TESTING

to confirm

HYDROTHERMAL RESERVOIRS

for

DIRECT HEAT APPLICATIONS

THE ENERGY SITUATION TODAY

This country is embroiled in an energy crisis. The United States produces only about three-quarters of the energy that it consumes. Approximately 48% of our energy consumption is in the form of petroleum products. Petroleum products are also important in the manufacture of many consumer goods such as plastics. Approximately one-half of the total petroleum consumed in the U.S. comes from foreign countries. The $80 billion the U.S. spends yearly in foreign markets for petroleum has a highly detrimental effect on the U.S. economy. Alternative sources of energy that can be used to decrease our dependence on foreign petroleum are needed. Energy use forecasts for the year 2000 and beyond indicate that all feasible alternative energy sources will be needed and that conservation measures will have to be practiced as well if our standard of living is to be maintained. The energy crisis is real!

HYDROTHERMAL ENERGY -- A VIABLE ENERGY ALTERNATIVE

Of the undeveloped alternative sources of energy, hydrothermal energy is probably closest to being economically feasible. Hydrothermal energy is geothermal energy in the form of hot water and steam that occurs naturally at many locations beneath the earth's surface. Studies by the U.S. Geological Survey indicate that hydrothermal energy forms a very large energy reserve in the United States. The potential for development of hydrothermal energy in the U.S. is estimated to be 2400 Quads (2400 x 10^{15} BTU), compared to today's yearly total energy use of about 80 Quads. Little of this large resource has been developed in the past due to the availability of relatively inexpensive energy in other forms. But today, energy costs are increasing world-wide and hydrothermal energy is becoming cost competitive with more traditional sources. Hydrothermal energy is truly a viable energy alternative.

NATURE OF HYDROTHERMAL ENERGY

Hydrothermal energy can be used either for generation of electricity or by direct application of the heat in industrial processing, space heating, and other uses. High energy, high temperature geothermal steam is currently being used to generate electricity at The Geysers steam field in northern California, which provides enough electrical power to supply a city the size of San Francisco. Hydrothermal electrical power is also generated in other countries, including Italy, Mexico, El Salvador, New Zealand, Japan, and the Philippines. Direct geothermal uses are also important in the United States. Since before the turn of the century, Klamath Falls, Oregon and Boise, Idaho have had district heating systems to heat houses and public buildings with hydrothermal energy. In Iceland, a volcanically active island that is part of the mid-Atlantic ridge, much of the space and industrial process heat is geothermal. Extensive use of direct applications is also being made in France, where many of the homes and other buildings in the Paris basin are geothermally heated; in New Zealand, where industrial uses of direct heat are on line; in Japan, where geothermal fluids find many uses including raising poultry and fish; and in Hungary, where large greenhouse complexes are geothermally heated.

The temperature of geothermal fluids ranges from over 300°C (572°F) down to shallow groundwater temperature, which averages about 15°C (59°F). High temperature hydrothermal resources (>150°C = 302°F) are relatively rare--much more common are low- and moderate-temperature resources. Figure 1, taken from U.S. Geological Survey Circular 790, "Assessment of Geothermal Resources in the United States--1978"[1], shows the relationship between number of known occurrences and resource temperature down to 90°C. Little at all is known about resources with temperatures lower than 90°C.

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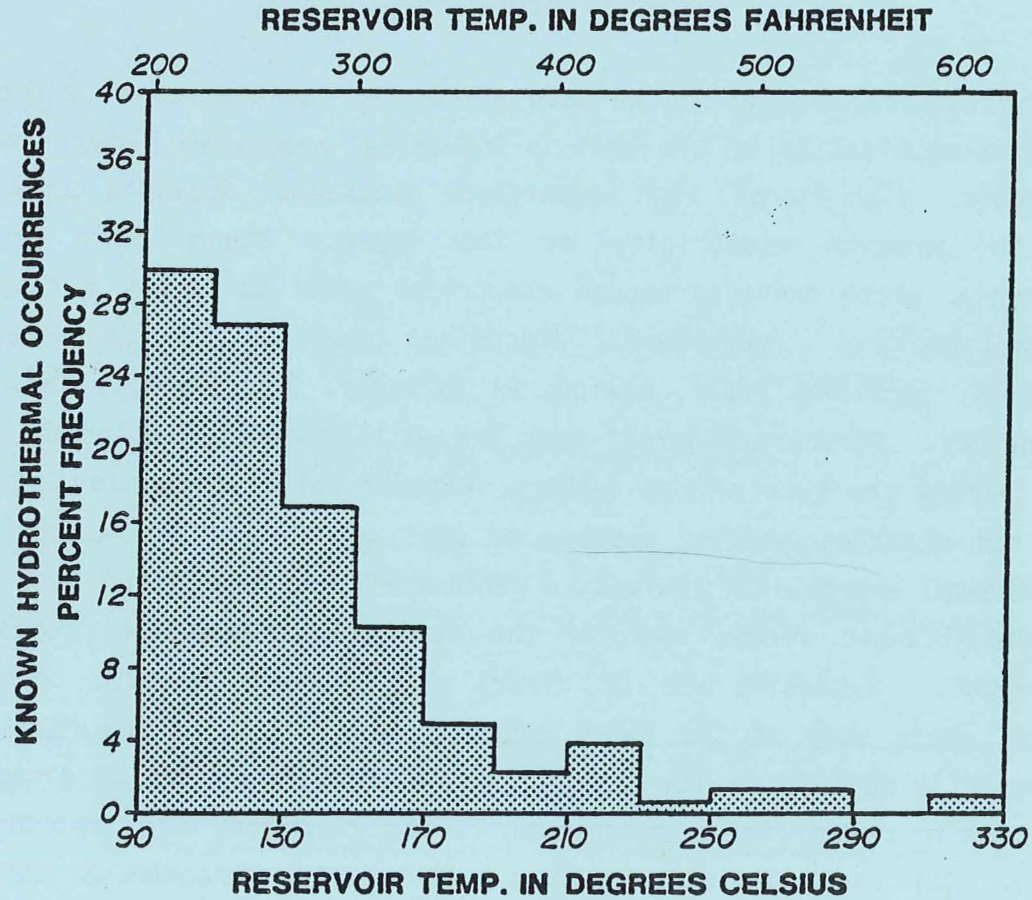
1 Available free by written request to Branch of Distribution, U. S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202.



Geothermal resources are comprised of three main geological components: 1) a source of heat, 2) a fluid (water or steam) to carry the heat to a drill hole from which it flows or can be pumped to the surface, and 3) a permeable system of pores or fractures in the rock through which the fluids can circulate. The heat source is sometimes a shallow body of molten or recently solidified hot rock. Alternatively, the shallow heat may result simply from very deep circulation of groundwater to hotter regions two to three miles down where the water is heated and rises buoyantly to the surface.

Hydrothermal resources occur throughout the United States, although the West has the largest share of presently known resources. Such hydrothermal surface manifestations as hot springs and hot wells are abundant in the West. Figure 2 shows the location of many of the known hot springs and wells in the United States. Although many occurrences and areas favorable for occurrence of hydrothermal resources are shown on Figure 2, little is known in detail about individual areas. This is because little exploration and drilling of geothermal areas has been done to date. Thus, although the large number of occurrences indicates a widespread and substantial resource base, there are few confirmed reservoirs. Drilling and flow testing of resource areas to determine temperature and productivity will be required for reservoir confirmation before development can take place.

DEVELOPMENT OF HYDROTHERMAL ENERGY

Hydrothermal energy is not widely recognized by the public as an energy resource. The past common use of hot springs has been for spas, and little thought has been given to other application of the heat energy. Therefore, there has been virtually no industry built up around direct hydrothermal uses. We lack good exploration and drilling techniques and experience, and, as mentioned before, there is little detailed knowledge of the resource base--few confirmed reservoirs. Few states have adequate geothermal use laws at present. There is little economic data on direct geothermal uses, and this makes economic feasibility studies uncertain and financing difficult to obtain. In short, there is no private sector infrastructure adequate to develop direct geothermal uses at the rate that the relatively large resource base indicates as possible and that this country's needs indicate as being desirable.

Exploration for hydrothermal reservoirs is a high risk enterprise. To insure that a suspected reservoir will be economic, the developer must drill into the resource at depth, measure the temperature and flow rate, and use sophisticated analysis techniques to estimate the productivity and longevity of the resource. The present high risk level for reservoir confirmation stems partly from the lack of resource knowledge stated above and partly from the fact that present surface surveying techniques are not well enough developed to ensure a high level of probability that a drill hole will intercept a resource. Hydrothermal reservoirs are never uniform or continuous, and unproductive holes are sometimes drilled in the middle of the best of resources. Better techniques for and more experience in siting wells are needed to decrease the risk of drilling an unproductive well.

Present developers of electrical power generation from high-temperature reservoirs are generally large resource companies that can finance reservoir confirmation by spreading the high risk and cost over many projects. However, these large companies are usually not interested in development or utilization of lower-temperature reservoirs because of the relatively small scale of such projects. Smaller developers, the ones most likely to be interested in low- and moderate-temperature geothermal resources, are often unable to spread risk and cost in the same way that a large company can. A single unproductive well can mean financial disaster for them. In addition, many prospective developers and users of direct heat hydrothermal energy are not resource companies and therefore are not accustomed to the techniques and risks of resource development. In some companies risk money for geothermal development can not be obtained from management. For these reasons, it is not expected that the direct heat user in the private sector will be able to perform needed reservoir confirmation of significant magnitude for direct heat hydrothermal resources by himself in the near future. Without federal assistance there will continue to be very little use of the large hydrothermal resource base that exists in the United States.

The User Coupled Confirmation Drilling Program will speed hydrothermal industrialization by absorbing some of the high risk and cost while at the same time developing an experienced industry in the private sector that will reduce future risk and that can carry on without federal aid in the future.

USER COUPLED CONFIRMATION DRILLING PROGRAM

Summary Program Description

The U.S. Department of Energy, Division of Geothermal Energy is sponsoring a new program that absorbs a portion of the high front-end risk and cost of development by providing cost-sharing of hydrothermal reservoir confirmation for direct heat applications. The User Coupled Confirmation Drilling Program will cost-share expenses for exploration to site drill holes, drilling, flow testing, reservoir engineering, and injection well drilling (if required). Cost-sharing or financing for the utilization system to be installed once the reservoir is confirmed are not covered under this program. The federal percentage of cost-share will be determined by a negotiated formula based upon usability of the thermal fluids intersected by the drilling. For a completely successful project, the DOE cost-share will be 20 percent, whereas for a completely unsuccessful project the DOE cost-share will be 90 percent. The degree of success and the corresponding DOE cost-share are expected to range between these extremes for individual projects.

The new program will be initiated by a DOE Solicitation for Cooperative Agreement (SCA), to be issued in May 1980. A 90-day period will be available thereafter for preparation and submission of proposals. It will be required that proposals detail, among other things, 1) the geologic evidence that a resource exists at the site of interest, 2) the direct heat use to be made of geothermal fluids if discovered and confirmed, 3) an adequate exploration, drilling, flow testing and data analysis program, and 4) an acceptable cost-share plan based on degree of success of the project. Proposals will be reviewed and awards made in accordance with applicable federal regulations. Successful proposers will negotiate a contract with DOE. The contractor's funds can be used to perform the project, or alternatively a loan can be obtained from a commercial financial institution, using the DOE contract as evidence that project risk has been substantially reduced. The project will then proceed under contractor management. After flow testing, the degree of success will be determined through analysis of flow testing results and by application of provisions for this purpose that have been negotiated in the contract. The DOE cost-share is then determined, and DOE pays this amount to the contractor, completing the agreement.

Program Objectives

The objective of the User Coupled Confirmation Drilling Program is to foster economically viable use of direct heat hydrothermal energy in the United States by the industrial and private sectors by:

1) getting direct heat utilization started by absorbing a portion of the risk associated with confirmation of hydrothermal reservoirs, while at the same time;
2) developing an experienced infrastructure of exploration, confirmation and utilization engineering consultants, contractors and equipment manufacturers who will reduce reservoir confirmation risks in the future.

This federal program is scheduled to phase out as private industry begins to grow on its own.

We must anticipate that some unproductive wells will be drilled. The extent to which successful reservoir confirmation will occur will depend upon 1) probability of occurrence of the resource, 2) probability that a well will be sited properly to intercept the resource, and 3) probability that the well will be drilled and tested properly. Petroleum and minerals resource developers understand and accept these probabilities and do not become discouraged when unproductive holes are drilled. This same attitude must be adopted by the new direct heat geothermal industry and by others associated with this program.

Proposals to DOE

A 90-day period will be available for development of a proposal after DOE issues the Solicitation for Cooperative Agreement in late May 1980. Those who write proposals can be users or developers of direct heat hydrothermal energy. Proposals must contain evidence that:

1) there is a user who intends to use the resource if discovered;
2) the user or developer has or can obtain rights to required land and geothermal fluid and/or heat;
3) other required permits can be obtained, and
4) environmental considerations can be handled.

The proposal must detail a project that the proposer intends to carry out to confirm a hydrothermal reservoir for direct heat application. Reservoir confirmation requires flow testing of a hydrothermal well and analysis of the results in terms of temperature, producibility and longevity of the resource. The proposal can be to test an existing well or to drill a new well for testing. The original contract will generally be for the drilling of a single reservoir test or confirmation well, although contract modification to allow more drilling is feasible depending on initial drilling results.

The proposal must document the geologic evidence that a reservoir exists at the site proposed. Proposals with good geologic evidence for existence of a reservoir will be favored over those with poor evidence. The best geologic evidence would be direct evidence consisting of known thermal springs or wells or of thermal spring deposits. All geological, geophysical, geochemical, and hydrological evidence should be given that bears upon existence of the suspected reservoir, and negative evidence should be given as well.

The end use(s) to be made of geothermal fluids should be given along with an analysis of the engineering and economic feasibility of the project. The end use(s) will specify the temperature and quantity of geothermal fluid required, and this will bear on determination of degree of project success. Engineering items to be discussed include process energy requirements (temperature, flow, load factor) and system design. Economic data to be furnished include capital requirements, replacement costs, annual costs and taxes for the follow-on utilization system as well as detailed costs for the cost-shared portion of the project.

If a well is to be drilled, the proposal must justify the well site selection and must show the data and analysis used in siting the well, or alternatively the proposal must specify an exploration program to develop data for use in well siting. Geological, geophysical, geochemical, hydrological and other data generation and analysis are encouraged. Shallow drilling for thermal gradient determination may also be a useful tool to help select a test well site and will be cost-shared. The proposal should also contain a drilling prognosis that briefly describes preliminary drilling plans. Later in the project, before actual drilling begins, a more detailed plan will be required.

A preliminary plan for reservoir testing and analysis of the results must be presented. This plan can be modified later depending upon drill results. The plan must be grounded in modern-day hydrology and reservoir engineering and must basically determine usability of the geothermal resource for the purpose intended. Items to be specified include testing methods, duration, flow rate, measurements to be made and accuracy and techniques to analyze test data.

A method must be proposed for determining degree of success of the project. This method should depend upon results of the flow testing and upon the intended or other possible end use(s). It is recognized that even though the quantity or temperature of fluids discovered may not support the entire primary intended end use, these hydrothermal fluids are likely to be usable at some level or to be worth something in a sale. This should be accounted for in determining degree of success. The degree to which each project is successful will vary from site to site and it is not possible for DOE to specify a certain formula for determining degree of success. Rather it will be up to each proposer to specify degree of success for his particular project as a function of properties of the fluids intersected. The proposed method for determining DOE's cost-share should be addressed in the proposal and should be based upon and tied to the proposed method for determining degree of success.

The proposal should give evidence that the proposer has a method of financing and carrying through the project if an award is made. Financing can be either internal or external (bank loan, stock, bonding, limited partnerships, etc). There is the possibility that up to 20 percent of the DOE cost-share could be invoiced as expenses occur, but the major portion of financing must be arranged by the proposer. At the time of the proposal it will not be necessary to have these financial arrangements complete, but evidence should be given that financing can be arranged.

Proposals that address projects to develop a large amount of hydrothermal direct heat use and therefore to displace a relatively large amount of conventional energy, will be favored over those that address only a small amount of direct heat development.

Proposers are advised and encouraged to obtain the services of reliable and competent consultants and contractors for exploration, drilling, reservoir testing, utilization, financing, legal, and other aspects of their proposed project for which they lack specific expertise. Projects that are to be carried out by a competent staff will be favored.

Once proposals are evaluated, notification will be made to those proposers that are successful. A contract between the proposer and DOE will then be negotiated, and the project can begin.

The Project

The basic project work flow is visualized as follows:

Proposal
↘ Contract with DOE
↘ Financing
↘ Exploration
↘ Drill Site Selection
↘ Drilling and Logging of Reservoir Confirmation Well
↘ Flow Testing
↘ Injection Well (if needed)
↘ Degree of Success
↘ DOE Pays Cost-Share
↘ Construction or Retrofit
↘ Energy Use

Once a contract is negotiated, the successful proposer will finance his project either internally or with a loan, as discussed previously. This proposed method of funding has advantages over full federal funding in that it develops contacts between users and bankers that will continue once the federal government has stepped out of the program. It also decreases substantially the total cost to DOE, which means that more projects can be funded for the same program budget. Once financing is obtained, exploration will begin, followed by drill site selection, drilling and logging, flow testing, and if needed an injection well. At each step, data will be sent to DOE, and from analyses of those data a joint decision will be made by DOE and the proposer as to how to proceed. When the well is tested, the degree of success will be determined as agreed in the initial contract, and DOE will pay its share, concluding the project. Follow-on installation of equipment to use the geothermal fluids will be the responsibility of the user or developer. Financial assistance for this may be available through the Geothermal Loan Guaranty Program.

At several stages in the program, more detailed plans will be required than were submitted during the proposal and contract negotiation stages. Before test well drilling, a detailed drilling plan describing procedures, anticipated problems and methods to abide by regulations will be needed. A detailed plan for well testing will be required before this testing begins. Similarly, more detailed, DOE-approved environmental plans will be needed before test drilling, before flow testing and for site restoration. The most sensitive environmental issue will probably be fluid disposal during flow testing and during subsequent operation. DOE will assist in the environmental reporting process by issuing a generic environmental document that will be useful to some users who can simply attach environmental considerations for their individual projects and the report will meet regulatory requirements.

Who is Eligible

Private individuals or companies and state and local government agencies can offer proposals under this program. The proposer will be required to demonstrate that he has included adequate geological, drilling, engineering, and other expertise in the proposed project. Consultants and contractors can be used to provide this expertise as needed.

Schedule

The first SCA will be issued in the last part of May, 1980. Response period will be 90 days. Successful proposers will be notified about September 1980 and then contract negotiations will begin. It is anticipated that some projects can begin in November 1980. Present plans call for follow-on solicitations on about a 6-month cycle. A prospective proposer who misses the first solicitation period would thus have later opportunity to propose a project.

Management

The User Coupled Confirmation Drilling Program will be managed for DOE Headquarters by the Idaho Operations Office of DOE with assistance from the Earth Science Laboratory of the University of Utah Research Institute and from EG&G, Idaho, Inc.

Technology Transfer

In order quickly to develop a knowledge and experience base in the private sector, much of the resource and exploration data for the project will be publicly available on open-file. In addition, selected case studies will be published. Although it is very important to make data, techniques and results widely available, it is also important to protect proprietary processes and techniques. Propriety of information can be protected, if desired and provision to do so will be negotiated in the contract.

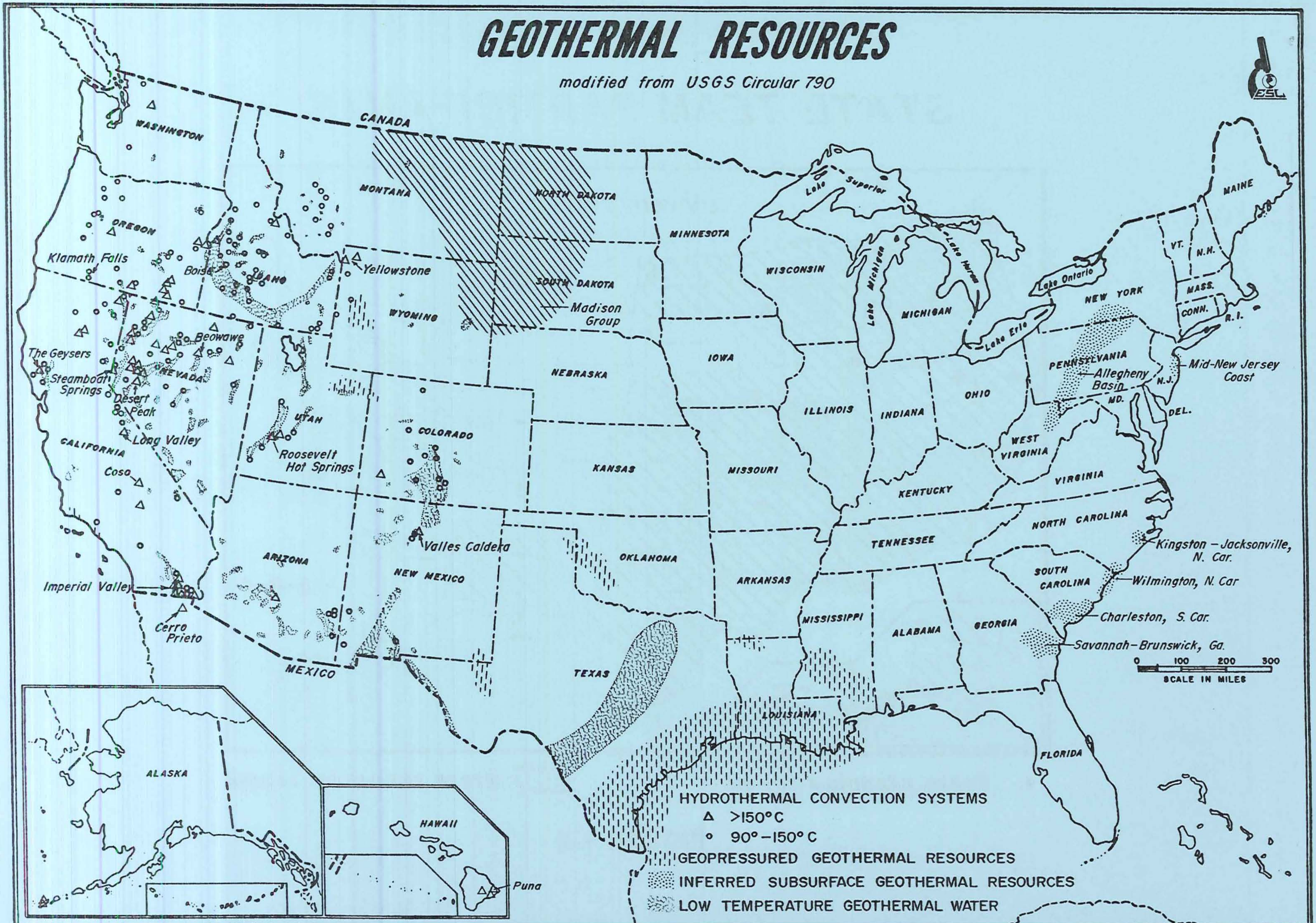
Interface With Other DOE Programs

The User Coupled Confirmation Drilling Program has important interfaces with other DOE programs. Among the most important of these is with the Geothermal Loan Guaranty Program (GLGP). Assistance with financing for installation and operation of utilization equipment will not be part of the User Coupled Confirmation Drilling Program. The resources of the GLGP, however, will be available for this purpose. Details are still being worked out with the intention of making it as easy as possible to move into the GLGP once the reservoir has been confirmed.

Two other important DOE programs exist that can offer help to proposers to the User Coupled Confirmation Drilling Program. These are the State Coupled Resource Assessment Program and the State Commercialization Planning Program. Figure 3 shows states in which there are teams working to assess geothermal resources and to facilitate all aspects of industrialization of geothermal energy. Prospective users and developers of hydrothermal energy in these states are encouraged to contact state teams for assistance. More information on these programs can be obtained from DOE-Idaho Operations Office in Idaho Falls, Idaho.

Anticipated Program Results

It is anticipated that this program will result in an increased utilization of direct heat hydrothermal energy that will decrease our dependence on foreign petroleum and aid in mitigating the energy crisis. The extent to which this will be possible will depend critically on the amount of funding that Congress authorizes for this program. It is estimated that for a federal expenditure of $250 million in 1980 dollars that direct heat uses as a result of this program would result in an annual petroleum savings of about 28 million barrels per year by the year 1987. For an oil price of $26 bbl, this represents an annual savings in payments for foreign petroleum of over $700 million per year.


GEOTHERMAL RESOURCES
modified from USGS Circular 790
CANADA
MEXICO
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEVADA
UTAH
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
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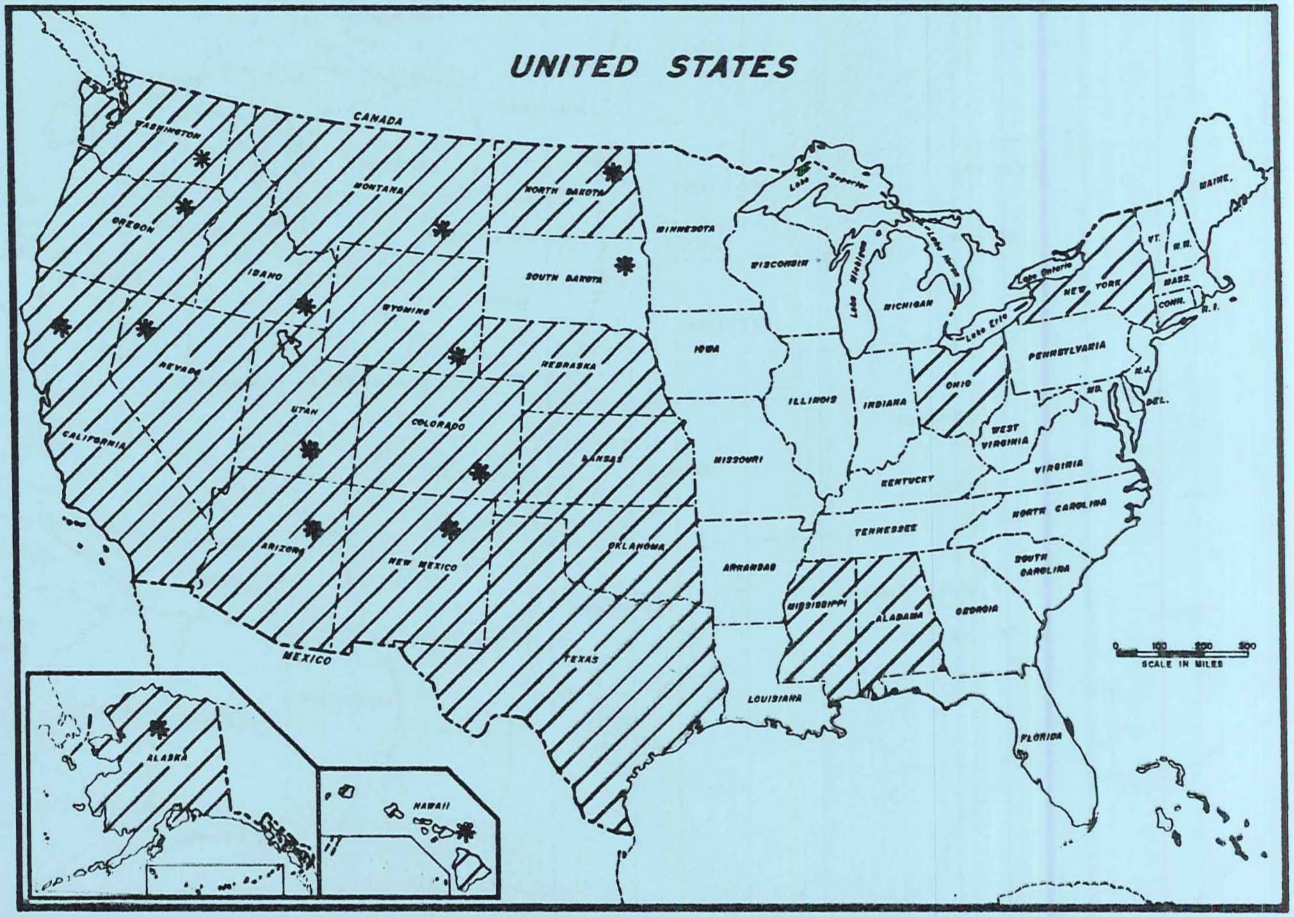
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MD.
DEL.
N.J.
CONN.
R.I.
MASS.
VT.
N.H.
MAINE
ALASKA
HAWAII
Lake Superior
Lake Michigan
Lake Huron
Lake Ontario
Lake Erie
Klamath Falls
Boise
Yellowstone
Madison Group
Beowawe
The Geysers
Steamboat Springs
Desert Peak
Long Valley
Roosevelt Hot Springs
Coso
Imperial Valley
Cerro Prieto
Valles Caldera
Allegheny Basin
Mid-New Jersey Coast
Kingston - Jacksonville, N. Car.
Wilmington, N. Car
Charleston, S. Car.
Savannah-Brunswick, Ga.
Puna
0 100 200 300
SCALE IN MILES
HYDROTHERMAL CONVECTION SYSTEMS
Δ >150°C
○ 90°-150°C
GEOPRESSURED GEOTHERMAL RESOURCES
INFERRED SUBSURFACE GEOTHERMAL RESOURCES
LOW TEMPERATURE GEOTHERMAL WATER
ESL

FIGURE - 2

STATE TEAM PARTICIPANTS



* State planning teams

State resource teams

FIGURE - 3