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**INTERAGENCY GEOTHERMAL  
COORDINATING COUNCIL ANNUAL REPORT  
FOR  
FISCAL YEAR 1989**

**JANUARY 2, 1990**

**Prepared by the:  
Budget and Planning Working Group  
of the  
Interagency Geothermal Coordinating Council**

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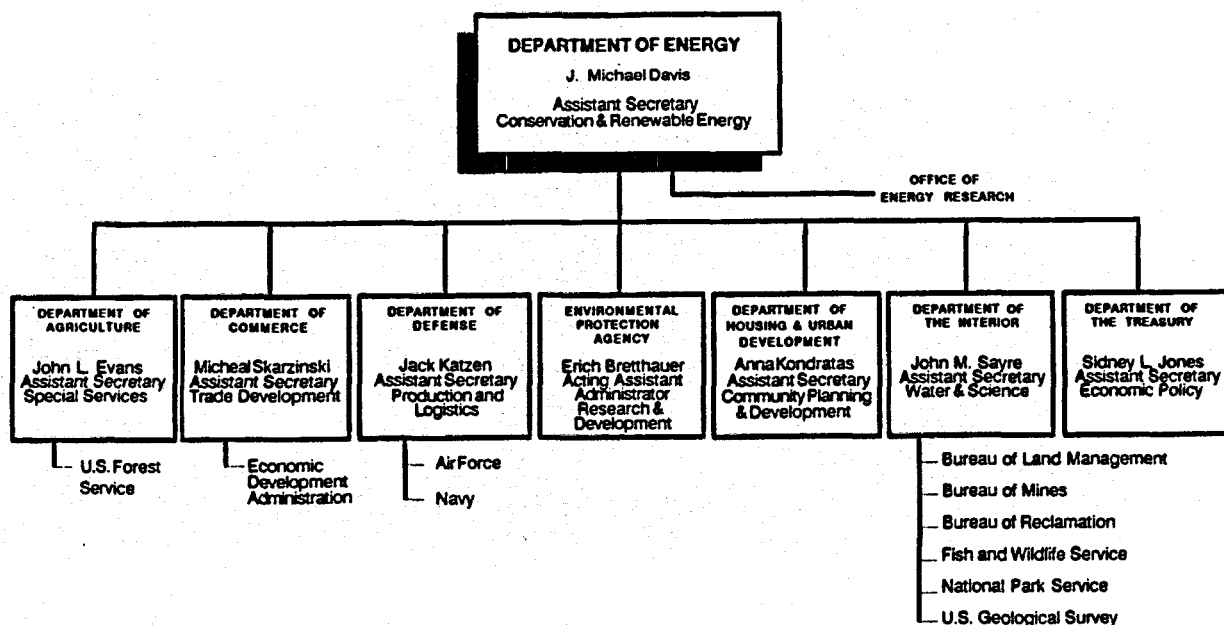
## I. INTRODUCTION

The Interagency Geothermal Coordinating Council (IGCC) was established in accordance with the provisions and intent of Public Law 93-410, the *Geothermal Energy Research, Development and Demonstration Act of 1974*, as amended by Public Law 95-238, and Public Law 95-91, the *Department of Energy Organization Act*. Council membership is composed of an assistant secretary from the Departments of Energy, Interior, Treasury, Agriculture, Defense, Commerce, and Housing and Urban Development, and the assistant administrator from the Environmental Protection Agency, and an assistant secretary from the Department of Energy, currently the Assistant Secretary, Conservation and Renewable Energy, is Council Chairperson. A membership organizational chart is shown in Figure 1.

The Council's objective is to coordinate a national geothermal energy research, development and demonstration program and to serve as a forum for discussion of those federal plans, activities, and policies which are related to or impact geothermal energy, including ancillary activities of agencies not represented by Council membership. Such other agencies may be represented as appropriate on working groups and panels assigned the responsibility for specific efforts on problems, policies, or programs in which those agencies are involved or have an interest. The Council, through the Chairperson, may make recommendations to the appropriate agencies and the President with regard to alternative policies or actions considered necessary or desirable to expedite research and development of technologies leading to the development and utilization of geothermal energy resources.

Figure 1

### INTERAGENCY GEOTHERMAL COORDINATING COUNCIL MEMBER AGENCIES



The federal government has been actively involved in the development of geothermal energy since 1970, when the *Geothermal Steam Act* was passed. It has been engaged in the leasing of federal lands for geothermal exploration and development, and conducts numerous research, development, and demonstration programs to investigate the use of geothermal energy. The provisions of section 302 of Public Law 93-410, require that the Council must prepare and submit to the President and Congress by June 30 of each year a report on federal activities and programs in geothermal energy. This report summarizes the accomplishments of the federal government during fiscal year 1989, and describes federal geothermal energy programs. Table 1 (pp. 3-4) presents a chronological history of significant, domestic geothermal energy developments. The federal geothermal activities budgets of the member agencies are presented in Table 2.

## II. LEASING

The goal of the federal geothermal leasing program is to make federal lands available to industry for exploration and development in an environmentally acceptable way. Leasing is administered by the Interior Department's Bureau of Land Management (BLM), with the consent of the Agriculture Department's Forest Service (FS) where National Forest System lands are involved. In addition, BLM and FS must consult with the U.S. Geological Survey (USGS) and the National Park Service (NPS) whenever federal lands offered for leasing are located adjacent to units of the National Park System listed under Public Law 100-443 as containing significant thermal features.

Interim final geothermal regulations amending existing regulations were issued on April 6, 1989, to implement the Geothermal Steam Act Amendments signed into law on September 22, 1988, as Public Law 100-443. This law provides new opportunities for qualified lessees to extend their leases for up to 10 years beyond their primary terms. The lessees are required to demonstrate bona fide efforts to produce or utilize geothermal resources and agree to either make payments in lieu of commercial quantities production or make significant expenditures during the period of extension. Thirteen leases were extended in FY 1989 under the new Act. All but one of the lessees chose the option of the \$3 payment per acre in lieu of production in commercial quantities. Many more leases will be eligible for extension in the next 2 years; for example, about 50 in California will be coming to the end of their primary term.

The law also allows nonproducing leases with wells capable of production to remain in good standing beyond their primary term as long as lessees make diligent efforts toward utilization. This would allow a lease to be in effect for a total of 40 years beyond the primary term. It further provides protection for significant thermal features in the 16 listed units of the National Park System from the effects of geothermal leasing. During FY 1989, these features were fully protected through the cooperation of the agencies involved, using the procedures prescribed in a cooperation of the agencies involved, using the procedures prescribed in a December 1987 Interagency Agreement between BLM, NPS, FS, and USGS. The Interagency Agreement was developed to implement requirements of Section 115 of the General Provisions of the Department of

**Table 1**

**SIGNIFICANT EVENTS IN THE DEVELOPMENT  
OF GEOTHERMAL ENERGY IN THE UNITED STATES**

- 
- 1884 • District heating implemented in Boise, Idaho
  - 1900 • Hot water provided in homes in Klamath Falls, Oregon
  - 1916 • Power generation at The Geysers resort
  - 1927 • First exploratory geothermal wells drilled in Imperial Valley, California by Pioneer Development Company
  - 1959 • Small pilot plant operated near Niland, California on Sinclair No. 1 well
  - 1960 • Commercial electricity generated from dry steam at The Geysers, California
  - 1970 • Geothermal Steam Act passed (Public Law 91-581)
  - 1973 • NSF became lead agency for Federal Geothermal Programs
    - USGS, AEC, NSF prepared the first Federal Geothermal Program Plan
  - 1974 • Geothermal Energy RD&D Act (Public Law 93-410) passed which included the establishment of the Geothermal Loan Guaranty Program (GLGP)
  - 1975 • ERDA formed; Division of Geothermal Energy (DGE) formed primarily from NSF and AEC staff to manage an RD&D program
    - USGS released first national geothermal resource estimates and inventory
  - 1977 • Issued the first loan guaranty to Republic Geothermal, Inc. for field development at East Mesa, California
    - DOE formed; DGE continued to manage the RD&D program
    - Bureau of Reclamation successfully completed desalting tests to produce fresh water from geothermal brines
  - 1978 • Energy Tax Act (Public Law 95-618) passed
    - Public Utility Regulatory Policies Act (Public Law 95-617) enacted. EPA issued pollution control guidelines for geothermal energy development
    - Successful hot dry rock experiment conducted in New Mexico
    - First geothermal crop-drying plant built in Nevada
  - 1979 • USGS released updated national geothermal resource estimates and inventory
    - Streamlining task force recommended measures to IGCC to speed federal leasing
    - U.S. Navy awarded a contract to develop 75 MWe at the Coso KGRA on the Naval Weapons Center, China Lake, California
    - First geothermal electricity produced from federal lands, at The Geysers, California
    - World's first experimental binary-cycle plant (10 MWe) built by industry at East Mesa, California
  - 1980 • FERC issued regulations (18 CFR 292) establishing hydrothermal geothermal resources as renewable resources and geothermal facilities as qualifying facilities
    - World's largest single geothermal power unit (132 MWe) generated electricity at The Geysers, California
    - 10 MWe flash-steam plant built by industry at Brawley, California
    - First electric power from a hot dry rock resource produced at Fenton Hill, New Mexico
    - First geothermal ethanol plant began production at La Grande, Oregon under private funding
    - First five DOE-sponsored field demonstrations of direct heat applications became operational
    - First deep geothermal reservoir confirmation well drilled in Atlantic Coastal Plain near Crisfield, Maryland
    - Crude Oil Windfall Profits Tax Act (Public Law 96-223) passed, providing tax credit increase for geothermal equipment
-



**Table 1 (Continued)**

**SIGNIFICANT EVENTS IN THE DEVELOPMENT  
OF GEOTHERMAL ENERGY IN THE UNITED STATES**

- 
- Energy Security Act (Public Law 96-294), containing Title VI, "The Geothermal Energy Act of 1979," passed
  - 1981 ● First U.S. geothermal electric generation plant outside the 48 contiguous states brought on-line in the Puna resource area in Hawaii
  - 1981 ● The Insurance Company of North America began offering insurance against the financial risk of reservoir failure
  - The practical demonstration of generating electricity from moderate-temperature geothermal fluids was accomplished at Raft River, Idaho
  - A mobile well-head generator with a net output of 1.6 MWe was installed at Roosevelt Hot Springs, Utah
  - USGS research drilling at Newberry Volcano, Oregon indicated for the first time that temperatures (265°C at 3,057 ft) sufficient for electrical production existed in the Cascade Range
  - FERC issued amendments to its regulations for qualifying small power production facilities incorporating the provisions of the Energy Security Act relating to non-utility geothermal facilities
  - 1982 ● A 10 MWe flash plant utilizing hypersaline brine began operation at the Salton Sea KGRA, California
  - An 80 MWe geothermal electric power plant to be constructed by Occidental Geothermal, Inc. in Lake County, California and a 49 MWe geothermal electric power plant to be constructed by Republic Geothermal, Inc. and the Parsons Corporation in the Imperial Valley, California were certified by the FERC as qualifying facilities. Magma Power Company and Magma Development Corporation issued a public notice of self-qualification for an existing 11 MWe geothermal power plant located in East Mesa, California
  - In an effort by DOI to accelerate the geothermal leasing program, a record 16 competitive lease sales were held in which 578,656 acres were offered
  - USGS completed the first quantitative national assessment of low-temperature (<90°C) geothermal resources of the United States
  - 1983 ● Federal leasing regulations were rewritten, resulting in the deletion of burdensome, counterproductive requirements
  - 1984 ● The first commercial electrical power from federal lands outside California was generated, with 20 MWe brought on-line by Phillips Geothermal in the Roosevelt Hot Springs KGRA in Utah
  - 1985 ● Lease acreage limit increased by DOI from 20,480 to 51,200 acres per state
  - 1986 ● The Salton Sea scientific well was drilled and cored to 10,564 ft; cuttings, fluid samples and geophysical well logs were obtained, and preliminary flow tests conducted
  - Congress acted to preclude geothermal leasing where, in the judgment of the Secretary of the Interior, development would result in significant adverse effects to significant thermal features in national parks
  - 1987 ● DOE cost-shared with industry the drilling of three deep thermal gradient test wells within the Cascades volcanic area of the Pacific Northwest -- which demonstrates the utility of this technique in identifying underlying hydrothermal features such as those beneath the Cascades
  - Navy Geothermal Plant Number One, Unit Number One, at Naval Weapons Center, China Lake, California, began delivering power to the public utility grid. Unit One is rated at 25-megawatts capacity. NWC's peak power demand is 20 megawatts. Negotiations are underway for an additional 135 megawatts at planned Units Two through Six
  - 1988 ● Geothermal Steam Act Amendments of 1988 were signed into law (Public Law 100-443). This law significantly modifies the geothermal leasing program by providing two 5-year extensions of the primary term of a geothermal lease if geothermal steam has not been produced in commercial quantities by the end of the primary term. The Act further provides protection for significant thermal features in units of the National Park System from the effects of geothermal development.
  - Navy Geothermal Plant Number One, Naval Weapons Center, China Lake, California was completed with the three generating units capable of generating 80 MWe. Construction started on a second 80 MWe plant with production scheduled for early 1990.
  - 1989 ● Eight plants were put on line with a combined total of 295 MWe including Unocal's Salton Sea Unit Three plant which utilizes the crystallizer clarifier process developed initially by the Department of Energy.
  - Operation and testing of a joint DOE/EPRI heat/methane hybrid power system (HPS) was begun at the Pleasant Bayou, TX well site. Electricity from the 980 kW unit is sold to a local utility.
  - The first exploratory well to be sited directly over a suspected magma body was spudded and drilled to a depth of 2,568 feet by DOE. A corehole was then drilled as part of the Continental Scientific Drilling Program.
-

**Table 2 FEDERAL FUNDING FOR GEOTHERMAL ENERGY (a)**

| ORGANIZATION UNIT                                      | Actual<br>1979 | Actual<br>1980 | Actual<br>1981 | Actual<br>1982 | Actual<br>1983 | Actual<br>1984 | Actual<br>1985 | Actual<br>1986 | Actual<br>1987 | Actual<br>1988 | Actual<br>1989 | Estimated<br>1990 | Requested<br>1991 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------|-------------------|
| <b>Department of Agriculture</b>                       |                |                |                |                |                |                |                |                |                |                |                |                   |                   |
| U.S. Forest Service                                    | 780            | 750            | 700            | 600            | 500            | 525            | 946            | 1,081          | 966            | 900            | 900            | 900               | 900               |
| <b>Department of Defense</b>                           |                |                |                |                |                |                |                |                |                |                |                |                   |                   |
| Navy   | 300            | 230            | 930            | 848            | 863            | 1,100          | 1,260          | 1,380          | 621            | 440            | 755            | 1,757             | 1,820             |
| Air Force  | 0              | 200            | 1,010          | 182            | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0                 | 0                 |
| DOD Total  | 300            | 430            | 1,940          | 1,030          | 863            | 1,100          | 1,260          | 1,380          | 621            | 440            | 755            | 1,757             | 1,820             |
| <b>Department of Energy</b>                            |                |                |                |                |                |                |                |                |                |                |                |                   |                   |
| Conservation & Renewable<br>Energy                     | 152,990        | 149,870        | 142,521        | 43,713         | 79,939         | 32,615         | 33,511         | 25,200         | 20,630         | 20,725         | 19,321         | 18,077            | 18,000            |
| Office of Energy<br>Research (b)                       | 2,100          | 3,102          | 3,305          | 2,650          | 2,500          | 2,400          | 2,600          | 2,800          | 2,930          | 3,000          | 2,700          | 2,000             | 2,000             |
| Environment  | 2,820          | 1,950          | 723            | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0                 | 0                 |
| GLGP (Program Direction)                               | 0              | 181            | 193            | 134            | 120            | 101            | 121            | 72             | 72             | 100            | 75             | 75                | 80                |
| DOE Total  | 157,910        | 155,103        | 146,742        | 46,497         | 82,559         | 35,116         | 36,232         | 28,072         | 23,632         | 23,825         | 22,096         | 20,152            | 20,080            |
| <b>Department of Interior</b>                          |                |                |                |                |                |                |                |                |                |                |                |                   |                   |
| National Park Service                                  | (c)            | (c)            | (c)            | 100            | 50             | 250            | 250            | 250            | 225            | 250            | 250            | 250               | 1,000             |
| Fish & Wildlife Service                                | 200            | 200            | 70             | 100            | 50             | 0              | 0              | 0              | 0              | 0              | 0              | 0                 | 0                 |
| Bureau of Land Mngt.                                   | 3,340          | 3,410          | 3,548          | 4,055          | 3,861          | 3,197          | 3,227          | 2,639          | 2,475          | 2,200          | 1,613          | 1,613             | NA                |
| Bureau of Reclamation                                  | 550            | 910            | 60             | 60             | 30             | 0              | 0              | 0              | 0              | 0              | 0              | 0                 | 0                 |
| Bureau of Mines  | 1,050          | 800            | 400            | 384            | 300            | 0              | 0              | 0              | 0              | 0              | 0              | 0                 | 0                 |
| USGS, Geothermal<br>Research Program                   | 12,043         | 10,047         | 7,889          | 7,953          | 7,090          | 7,215          | 7,314          | 5,601          | 5,841          | 5,943          | 5,908          | 5,949             | 4,954             |
| DOI Total  | 17,183         | 15,367         | 11,967         | 12,652         | 11,381         | 10,662         | 10,791         | 8,490          | 8,541          | 8,393          | 7,771          | 7,812             | 5,954             |
| <b>Environmental Protection<br/>Agency</b>             | 920            | 850            | 1,550          | (d)            | (d)            | (d)            | (d)            | (d)            | (d)            | (d)            | (d)            | (d)               | (d)               |
| <b>TOTAL FEDERAL<br/>GEOTHERMAL<br/>PROGRAM BUDGET</b> | <b>177,093</b> | <b>172,500</b> | <b>162,899</b> | <b>60,779</b>  | <b>95,303</b>  | <b>47,403</b>  | <b>49,229</b>  | <b>39,023</b>  | <b>33,760</b>  | <b>33,558</b>  | <b>31,522</b>  | <b>30,621</b>     | <b>28,754</b>     |

(a) Budget authority rounded to nearest thousand.

(b) Best estimate based on the portion of Basic Energy Sciences research related to geothermal activities.  
The estimate represents the applicable portions of a number of research tasks.

(c) Not available.

(d) While the EPA budget since 1982 has not targeted resources specifically for geothermal, other  
R&D at EPA (e.g., disposal of liquid effluents) or programmatic activities (e.g., permitting assistance  
to states) may be applicable to geothermal energy.

the Interior and Related Agencies Appropriation Act of 1987, the precursor of the Geothermal Steam Act Amendments of 1988.

### **Competitive Leasing**

At the end of FY 1989, there were 211 competitive leases in effect on 359,025 acres (California, 130 leases on 215,839 acres; Idaho, 2 leases on 3,061 acres; New Mexico, 3 leases on 2,861 acres; Nevada, 51 leases on 90,434 acres; Oregon, 8 leases on 16,565 acres; and Utah, 17 leases on 30,265 acres).

### **Non-Competitive Leasing**

At the end of FY 1989, there were 468 noncompetitive leases in effect on 730,564 acres (Arizona, 11 leases on 18,146 acres; California, 111 leases on 158,386 acres; Colorado, 3 leases on 2,751 acres; Idaho, 1 lease on 640 acres; New Mexico, 16 leases on 26,816 acres; Nevada, 158 leases on 269,873 acres; Oregon, 159 leases on 235,920 acres; and Utah, 9 leases on 18,032 acres).

### **Utilization**

At the end of FY 1989, there was a total geothermal production of 1059.6 MW on or from Federal lands. In California, 725 MW from The Geysers, 107 MW from East Mesa, 78 MW from Coso Hot Springs, and 8 MW from Wendel-Amedee. In Nevada, 70 MW from Dixie Valley, 16 MW from Beowawe, 15 MW from Steamboat, 10 MW from Desert Peak, 4.8 MW from San Emidio\*, and 3.6 MW from Soda Lake. In Utah, 20 MW from Roosevelt Hot Springs and 2.2 MW from Cove Fort.

\* San Emidio was previously mistakenly reported at 9.8 MW.

## **III. HYDROTHERMAL RESOURCE IDENTIFICATION, ASSESSMENT, AND EXPLORATION**

The Department of Energy (DOE) and the USGS have several programs designed to evaluate the geothermal energy potential in the United States. These programs are complementary in nature, focusing on different aspects of this goal. USGS activities emphasize geothermal resource inventory and assessment work; DOE activities focus on the technologies for more detailed study of specific resource areas. The main objectives of the USGS programs are to: (1) characterize the geological, hydrological, geochemical, and geophysical nature of the various types of geothermal resources; (2) estimate the location, distribution, and energy content of both the presently identified and the undiscovered geothermal resources of the U.S.; (3) develop resource assessment technology; (4) conduct regional resource assessments and national resource inventories; and (5) contribute to the confirmation of selected specific geothermal reservoirs. The programs also address geoenvironmental effects and issues dealing with the longevity of geothermal systems.

Selected accomplishments of the U.S. Geological Survey's Geothermal Research Program in FY 1989 were:

- Preparation of new geologic maps of the Long Valley/Mono Craters area, California; Medicine Lake Volcano, California; the San Francisco volcanic field, Arizona; and the island of Hawaii. Such maps, representing tens of man-years of work, are fundamental in defining the size, geometry, and likely state of magmatic heat sources, and the potential for their interaction with groundwater.
- Seismic imaging that defined a large body of low-velocity material beneath Medicine Lake Volcano, probably magma or partially-molten rock.
- Determination of the ages of hot spring deposits in Long Valley, California, for comparison with new geophysical and geochemical data from drill holes. The comparison will be used to check an hypothesis that water is being heated in the west part of the caldera and flowing east, in contrast to a previous interpretation from helium isotope ratios that magma lies beneath the east part of the caldera.

#### **IV. GEOTHERMAL ENERGY R&D PROGRAM**

Since the inception of the Geothermal Program in 1971, the federal government and private industry have developed an extensive geothermal knowledge base, and industry has succeeded in establishing an industrial infrastructure capable of applying research results in the marketplace. This accumulation of technical information has provided a basis for identifying the critical technical barriers to cost-competitive geothermal power generation and for assessing long-term research options. Private sector cooperation in planning and prioritizing geothermal program elements contributes to the process by indicating desirable improvements in technology. This input is critical in a balanced, logical strategy for the Program which is designed to maintain industrial momentum in geothermal resource development.

In accordance with legislative mandates and policy guidance, the Geothermal Program sponsors research and development in geothermal energy technology which will result in a technology base from which private enterprise can choose options for further development and competitive application in electric power markets. The Geothermal Energy R&D Program contains four categories that parallel the resource types: Hydrothermal, Geopressured, Hot Dry Rock, and Magma. Accomplishments of FY89 in each of these categories are summarized below.

## **Hydrothermal Research**

Development of hydrothermal technology constitutes a large portion of the overall geothermal R&D program. The hydrothermal research is conducted in three project areas: reservoir technology; hard rock penetration technology; and conversion technology.

Significant accomplishments in the Reservoir Technology project included demonstrations of new techniques of fracture mapping using combined seismic and electromagnetic methods. An innovative government/industry injection test of tracer performance was performed using multiple tracers in multiple wells. New techniques for determining stress in geothermal reservoirs and predicting fluid flow were also developed in 1989. The Geothermal Technology Organization continued cost shared DOE/industry research in 1989.

The Hard Rock Penetration Technology project develops technology for reducing drilling costs by discovering new techniques for locating lost circulation zones and using materials to plug them. The project also includes other research to lower well completion costs. Notable 1989 achievements in this research area include the successful use of ground tire rubber for plugging loss zones which developed while drilling the magma exploratory well. Researchers on this project also improved downhole instrumentation and designed and fabricated a full-scale transducer for drill strings. The Geothermal Drilling Organization jointly funded with DOE four research projects, largely involving heat-resistant hardware.

The Conversion Technology project is designed to increase the effectiveness of geothermal power conversion systems and to improve the possibilities of developing geothermal reservoirs uneconomical with today's technology. In 1989, researchers developed a brine equilibrium model that predicts the solubility of selected chemicals in brines. Achievements were also made in the use of microorganisms to leach toxic metals from sludge. FY 1989 research also included field testing of heat-exchanger tubing and the development of high-temperature elastomeric components for downhole drilling motors.

## **Geopressured-Geothermal Research**

Research in this category is aimed at developing geopressured resources and is divided into three main projects. The Well Operations project verifies the reliability of geothermal reservoirs through long-term research testing. The Geoscience and Engineering Support project involves the development of predictive models for reservoir performance. Energy Conversion research supports the construction and operation of the Pleasant Bayou Hybrid Power System in Texas.

During FY 1989, flow testing at the Pleasant Bayou well in Texas produced data for scientists to better understand reservoir performance. Also at Pleasant Bayou, operation of a demonstration plant began in FY 1989 utilizing a heat/methane hybrid

power system. The plant, the first of its kind in the world, will determine the feasibility of producing electricity from geopressed reservoirs. Long-term pressure build up testing continued at another design well, the Gladys McCall well in Louisiana.

### **Hot Dry Rock Research**

Research in the Hot Dry Rock (HDR) program is focused on finding a practical, economic technology for extracting energy from man-made hot dry rock reservoirs. Research is organized around two projects. The Fenton Hill Operations project in FY 1989 involved preparation for the Long-Term Flow Test of the reservoir at Fenton Hill, New Mexico. A one-million-gallon storage pond adjacent to the production well was cleaned and repaired. Scientific and Engineering Support research is aimed at providing support to meet the HDR objectives. Activities during FY 1989 included the use of improved mapping methods to study microearthquakes and the automated analysis of collected seismic data.

### **Magma Research**

The Magma research category is focused on extracting energy from accessible magma bodies. The program is organized around two projects. Researchers working under the Long Valley Operations project began drilling the world's first magma exploratory well in 1989, the first to be sited directly over a magma body. It will provide researchers valuable information about the feasibility of tapping energy from this large resource. Phase I drilling was completed to a depth of 2,568 ft.

Research to provide the scientific basis for developing magma energy falls under the second division within the magma program, Laboratory and Engineering Support. Activities during FY 1989 included research using direct-contact heat transfer to better understand the physical properties of extracting energy from magma. The project also encompassed the design of engineering materials to survive drilling, collecting downhole data, and extracting energy in the magma environment.

### **Basic Geosciences Research**

The Basic Geosciences Research activities of the Department of Energy's Office of Energy Research include the conduct of basic research and associated technology development for the study of geology, geophysics, geochemistry, and dynamics of thermal regions in the earth of long-term relevance to geothermal, fossil and mineral resources and the disposal of hazardous wastes. Research in these areas should assist in resource recognition and evaluation activities, as well as provide information on the structure and processes in the crust. Relevant activities of FY 1989 within the DOE Office of Basic Energy Sciences (OBES) include the following:

As part of the Continental Scientific Drilling Program, DOE/OBES is supporting, along with DOE's Geothermal Technology Division (GTD), USGS and the National Science Foundation, the drilling of a scientific corehole at the bottom of the 2,568 ft. deep magma exploratory well. The well is being drilled by GTD in the

resurgent dome area of the Long Valley caldera, California. The corehole has provided not only core, but has given an open hole for downhole geophysical measurements. This will become especially important as the borehole approaches its planned target depth of 20,000 feet. The program also supported the drilling and associated research of the VC-2B corehole in the Valles Caldera, New Mexico, which penetrated completely through the active hydrothermal system.

Other activities included laboratory and theoretical studies on the thermodynamics, chemical migration, isotopic exchanges and water-rock interactions of high-temperature aqueous solutions under natural conditions; field geophysical studies of caldera and other regions of high temperature gradient; and theoretical studies on multi-phase fluid flow in fractured rocks.

#### **Other Federal Agencies**

Other federal agencies, including the United States Geological Survey, Bureau of Mines, and Bureau of Reclamation within the Department of the Interior, have undertaken R&D activities in the geosciences area. However, neither the Bureau of Mines' program to extract minerals from geothermal fluids nor the Bureau of Reclamation's program to produce fresh water from saline geothermal fluids is active.

### **V. ENVIRONMENT**

The federal geothermal environmental activities focus on characterization of the environmental impacts from the development of geothermal energy sources and the development and evaluation of control methods for the mitigation or elimination of environmental concerns, including health issues. The coordination among the private sector, the research community, and federal and state government agencies on environmental matters has historically been provided by the IGCC's Environmental Controls Panel. The Environmental Controls Panel successfully completed its effort in FY 1981 to refocus and integrate federal environmental research programs, with EPA, DOE, and DOI the principal participants in the environmental program. Along with other IGCC specialized panels, the Environmental Controls Panel is now inactive. It can be reactivated as appropriate to respond to specific concerns. The environmental program has included acquisition of baseline data; monitoring, and research related to air quality, surface and ground water quality, hydrological alternations, ecology, solid residuals, subsidence and seismicity, health effects, socioeconomic problems; and development and evaluation of environmental control technologies. The work since FY 1981 has concentrated on developing improved control methods and measuring actual impacts in the field.

The description of geothermal resources in and around Yellowstone National Park continued to be based on information gained from studies at Lassen Volcanic National Park. Studying the hydrologic connection between geothermal targets outside of the Lassen Park and the major geothermal system centered under the fumarolic areas within the park support the park protection goals of the NPS.

Multiyear studies designed to locate and characterize the thermal springs in Crater Lake continue. From these studies NPS will be able to understand the role these springs play in the ecology of the lake. The geologic record preserved in the sediments will determine the spatial and temporal range of thermal activity in the lake. In November 1989, the NPS submitted an "Interim Report" to the Congress. The objectives of this report were to: (1) provide a detailed update of the multiyear hydrothermal studies at Crater Lake; (2) transmit the 1988 field study findings to the Congress; (3) transmit the findings of peer review of the data collected in the park to date; and, (4) estimate the delivery date of the final report on the thermal features in Crater Lake (late summer 1991). This interim report to the Congress does not make conclusionary statements regarding the presence or absence of thermal features in the lake. Such conclusions are premature and cannot be asserted until after all the data has been collected, interpreted, and reviewed. Environmental activities conducted in FY 1989 were focused on the assessments of geothermal systems and potential impacts of development at Yellowstone National Park and Crater Lake.

The USGS collected new measurements of heat flow from steaming areas in the Lassen geothermal area in northern California to supplement baseline measurements against which the effects of any future geothermal development may be assessed.

## VI. TECHNOLOGY TRANSFER

Technology transfer is an integral part of all geothermal R&D activities. Technology transfer of the products of federal R&D is directed toward both technology producers (manufacturers and service firms) and technology consumers (geothermal field developers, drillers, electric utilities, etc.). The DOE Geothermal Energy R&D Program emphasizes technology transfer approaches that encourage and allow market forces to obtain and utilize the technical information provided by the government. Earlier activities that employed direct financial incentives to promote the adoption of specific technologies have been discontinued. The annual DOE Geothermal Program Reviews and other meetings enhance the dissemination of information and coordination of R&D efforts that are important components of technology transfer. In addition, the Geothermal Drilling Organization with more than 20 industry members, and the Geothermal Technology Organization provide efficient forums for both planning and disseminating relevant technology development.

The *Geothermal Energy Research, Development and Demonstration Act of 1974* provided for the establishment of the Geothermal Loan Guaranty Program (GLGP) and the Geothermal Resource Development Fund. In March 1982, a Federal Register notice announced no further applications for new projects would be accepted, but all pending applications would be processed (10 CFR 790, March 1, 1982, Vol. 47, No. 40, p. 8555).

The objectives of the GLGP are to encourage the public and private sectors to accelerate the utilization of geothermal resources by minimizing lenders' financial risk; develop a financial service infrastructure to ultimately provide financing of geothermal



projects without Federal assistance; and promote competition and encourage new entrance of firms into the geothermal marketplace. The GLGP has largely fulfilled its purpose, with eight guaranties and/or commitments issued since its inception, and FY 1990 activities will concentrate on program direction to monitor one project still active.

The 1974 Act authorized a total guaranty authority of \$500 million. The eight loan guaranties have a total face amount of \$285.4 million. Of these, four loans have been repaid and their guaranties released (\$106.7 million face amount, but only \$99.4 million actually disbursed). The remaining four loans (with a total face amount of \$184.6 million, but actual disbursements of only \$38.7 million) have defaulted and been paid off by DOE under its guaranty obligations. One of the defaulted projects remains in a work-out mode.

Financial and economic incentives for private sector development are also provided by other federal agencies. The Departments of Commerce and Housing and Urban Development offer financing opportunities for geothermal development in their grant programs. Communities may choose to utilize their HUD Community Development Block Grant (CDBG) funds for this purpose, and may request Urban Development Action Grants (UDAG's) provided that private sector leveraging and other requirements are met.

## **VII. FEDERAL USE OF GEOTHERMAL ENERGY**

Where economically appropriate, the federal government has been involved in the utilization of geothermal resources. In particular, the Department of Defense has been active in the development and use of geothermal energy at several military installations.

The Navy is using a public/private venture contract to develop the geothermal resources at its Coso geothermal site, Naval Weapons Center, China Lake, California. On July 15, 1987 the Navy's Geothermal Plant Number One, unit one, began delivering power to the public utility grid. Plant one, units two and three were placed in production in November 1988 bringing the Navy's generation capacity to 80 megawatts. Construction on Plant Two, units four, five, and six, started in March 1988 with completion scheduled for early 1990. This will complete the 160 megawatt development allowed under the Navy's contract with the California Energy Company and bring the Coso site's total generation capacity (Navy and Bureau of Land Management) to 230 megawatts.

The Navy is preparing contract documents needed for a public/private venture contract to develop its geothermal resources at the Naval Air Station, Fallon, Nevada. Planned geoscientific studies for FY 1989 at the Indian Wells Valley, Main side China Lake, and Indian Wells were curtailed due to budget restrictions. The Navy's Geothermal Development Office at the Naval Weapons Center, China Lake released one technical document during 1989 titled "A Water Geochemistry Study of Indian Wells Valley and Kern Counties, California. Volume 1: Geochemistry Study and Appendix A. Volume 2: Appendixes B through G."

**TABLE 3**  
**GEOHERMAL RESOURCES DEVELOPMENT**  
**FUND AND GUARANTY AUTHORITY <sup>1</sup>**

|    |   | <u>FY 1989</u>     |                       |
|----|---|--------------------|-----------------------|
|    |   | <u>FUNDING(\$)</u> | <u>AUTHORITY (\$)</u> |
| a) | Program direction                         | \$ 75,000          |                       |
| b) | Carried over from FY 1988                 | 5,000,000          |                       |
| c) | Guaranty fees collected <sup>2</sup>      | <u>481,027</u>     |                       |
| d) | Total available                           | 5,481,027          |                       |
| e) | Paid on defaults                          | 0                  |                       |
| f) | Administrative expenses <sup>3</sup>      | <u>376,520</u>     |                       |
| g) | Total outlays                             | <u>376,520</u>     |                       |
| h) | Balance at end of FY 1989 (b through g)   | 5,104,507          |                       |
| i) | Guaranty authority                        |                    | \$500,000,000         |
| j) | Authority committed to date (8 projects)  |                    | 285,398,000           |
| k) | Authority available                       |                    | 214,602,000           |
| l) | Total paid off on defaults                |                    | 39,915,269            |
| m) | Guaranteed loans fully repaid by borrower |                    | 100,700,000           |

(1) This financial information is included in this Annual Report for FY 1989 to satisfy the requirements of Public Law 93-410, Section 204.

(2) Comprised of \$162,859 received as rental payments on Oregon Trail Mushroom (OTM) leases that were taken as collateral upon OTM default, plus \$318,168 additional allotment of prior authorized funds.

(3) Contractor, consultant, and personnel costs necessary to assist in evaluating technological, geophysical, financial, marketing, management, and legal data submitted with guaranty applications and to assist in monitoring guaranteed projects.

## VIII. PRIVATE SECTOR USE OF GEOTHERMAL ENERGY

The geothermal industry currently has more than 2,915 MWe of baseload electric energy production either on line or under construction (equivalent to nearly three nuclear power plants) at prices competitive with coal and nuclear power. Additionally, the industry produced nearly 17,000 billion BTU's of heat energy for direct use last year. Based on a 1987 Electric Power Research Institute (EPRI) survey of industry plans, the U.S. hydrothermal electric power capacity may reach 5,316 MWe by the year 2000 (*1987 EPRI-Survey of Geothermal Electric Utilities*). Thus, geothermal will play an increasingly important role in the U.S. energy future.

Geothermal energy has been used for space and district heating in the United States since the late 1800's. Current uses include agriculture and aquacultural applications, space/district heating, and industrial applications. Although direct use projects exist in most states, most of the direct-utilization of geothermal energy is concentrated in California, Idaho, Nevada, New Mexico, Oregon, and South Dakota. Direct-utilization is expected to grow significantly over the next few years, with expansion projected in industrial applications and district heating systems.

The commercial production of electricity from geothermal energy first occurred in the United States in 1960 at The Geysers in California. Since that time, numerous facilities have been constructed. Since March 1980, when qualification of small power and cogeneration facilities under 18 CFR 292 began, through the end of FY 1989, the Federal Energy Regulatory Commission has certified or received notices of qualifying status - those plants less than 80 MWe - for 2,238 MWe of non-utility geothermal electric generating capacity. During FY 1989, several prospective geothermal electric generating facilities were certified by the Commission to be qualifying facilities, or filed notices of qualifying status, as shown in Table 4.

**TABLE 4**  
**APPLICATIONS AND NOTICES FILED DURING FY 1989**  
**FOR GEOTHERMAL FACILITIES**

| <u>Applicant Name</u><br><u>(Docket No.)</u>     | <u>Location</u> | <u>Capacity (MWe)</u> |
|--|-----------------|-----------------------|
| * COSO FINANCE PARTNERS<br>(QF84-327-001)        | CA              | +5.0                  |
| EARTH ENERGY, INC.<br>(QF89-297-000)             | CA              | 20.0                  |
| * GEO EAST MESA LIMITED PARTN.<br>(QF82-18-001)  | CA              | -0.600                |
| * GEO EAST MESA LIMITED PARTN.<br>(QF88-202-002) | CA              | +1.500                |
| * GEO EAST MESA LIMITED PARTN.<br>(QF88-203-002) | CA              | +1.500                |
| * GEOTHERMAL ENERGY PARTN. LTD.<br>(QF89-47-000) | CA              | 20.0                  |
| * ORMESA GEOTHERMAL<br>(QF85-269-001)            | CA              | +4.0                  |
| * ORMESA IH<br>(QF88-532-001)                    | CA              | -6.4                  |
| * STAR GP IE GEOTHERMAL PARTN.<br>(QF88-381-002) | CA              | -2.0                  |
| * STILLWATER GEOTHERMAL I<br>(QF86-563-002)      | NV              | +3.1                  |
|  |                 | <hr/> 46.1            |

Note: An asterisk proceeding the Applicant's name indicates an amended filing.  
Therefore, the capacity shown represents either an increase (+), or decrease (-)  
in capacity.