INTERAGENCY GEOTHERMAL

COORDINATING COUNCIL ANNUAL REPORT

FOR

FISCAL YEAR 1989

DRAFT

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of the
Interagency Geothermal Coordinating Council

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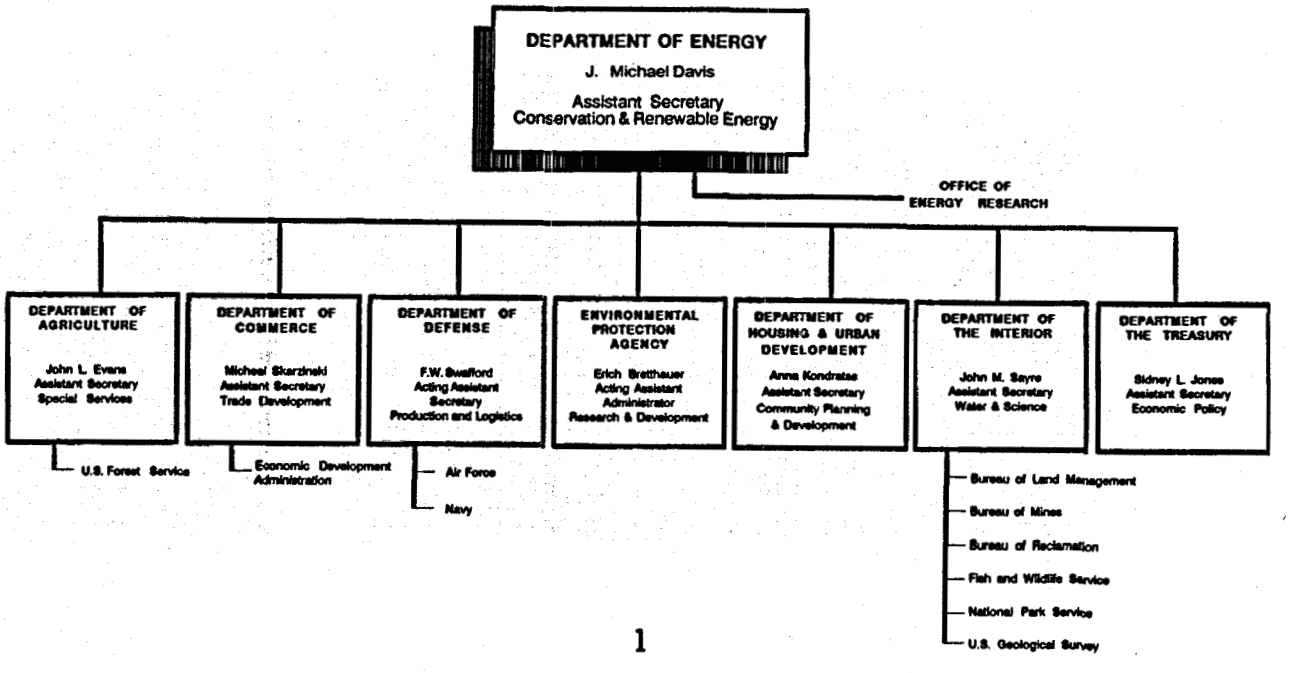
I. INTRODUCTION

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 (DOE), Interior (DOI), Treasury, Agriculture, Defense (DOD), Commerce, and Housing and Urban Development, and the assistant administrator from the Environmental Protection Agency (EPA). The 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 budget of the member agencies is 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 Bureau of Land Management (BLM), with the consent of the 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.

In December 1987, the BLM, FS, USGS, and NPS signed an Interagency Agreement (IA) to implement the leasing procedures required under Section 115 of the *Department of the Interior and Related Agencies Appropriations Act for FY 1987* (Public Law 99-591). The specific requirements of this Act were reported extensively in the *Twelfth Annual Interagency Coordinating Council Report for FY 1987.* This IA remains in effect because the leasing procedures outlined in the IA remain appropriate and applicable to leasing decisions necessitated under the Geothermal Steam Act Amendments.

The *Geothermal Steam Act Amendments of 1988* provide new opportunities for extension of qualified leases for up to 10 years beyond their primary terms. It further provides protection for significant thermal features in the 16 listed units of the National Park System from the effects of geothermal development.

Section 6 requires the Secretary of the Interior to maintain a list of significant thermal features and adds Crater Lake National Park, Big Bend National Park, and Lake Mead National Recreation Area to the list of features previously listed by the Department in June 1987. This section allows the Secretary to add to the list of units. The NPS, in cooperation with USGS, is required to establish a research program on the geothermal resources in listed units and assess data for these features near current or proposed geothermal development areas. Paragraph (c) further requires the Secretary to attach specific stipulations to all permits issued, extended, renewed, or modified

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 ($1000)

ORGANIZATION UNIT	Actual 1979	Actual 1980	Actual 1981	Actual 1982	Actual 1983	Actual 1984	Actual 1985	Actual 1986	Actual 1987	Actual 1988	Actual 1989	Estimated 1990	Requested 1991
Department of Agriculture													
U.S. Forest Service	780	750	700	600	500	525	946	1,081	966	900	900	900	900
Department of Defense													
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
Department of Energy													
Conservation & Renewable Energy (b)	152,990	149,870	142,521	43,713	79,939	32,615	33,511	25,200	20,630	20,725	19,556	18,509	18,000
Office of Energy 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	
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	22,331	20,584	18,080
Department of Interior													
National Park Service	(c)	(c)	(c)	100	50	250	250	250	225	250	250	250	1,000,000
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	2,500	1,613	
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 Research Program	12,043	10,047	7,889	7,953	7,090	7,215	7,314	5,601	5,841	5,943	5,909	4,928	
DOI Total	17,183	15,367	11,967	12,652	11,381	10,662	10,791	8,490	8,541	8,393	8,659	6,791	1,000,000
Environmental Protection Agency	920	850	1,550	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)
TOTAL FEDERAL GEOTHERMAL PROGRAM BUDGET	177,093	172,500	162,899	60,779	95,303	47,403	49,229	39,023	33,760	32,658	31,745	29,132	

(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.

where it is determined that development could result in an adverse effect to a listed feature. Section 6 also requires the Secretary of Agriculture to consider the effects on significant thermal features in units of the National Park System when determining whether to consent to leasing on lands in the National Forest System.

Section 7 requires the Secretary of the Interior to submit to Congress a report on the presence or absence of significant thermal features in Crater Lake National Park. The Department of the Interior projects that this final report will be submitted to Congress by late summer 1991. Because of the concern over existing geothermal development outside of Yellowstone National Park, section 8 of the Act provides for a study of the impact of the present and potential geothermal development in the Corwin Springs KGRA on the thermal features in the park. Production from existing wells and any development of new wells is prohibited until six months after the report is received by Congress. The statute requires this report to be submitted to the Congress by December 1990.

Competitive Leasing

At the end of FY 1988, there were 233 competitive leases in effect on a total of 406,355 acres (California, 140 leases on 232,662 acres; Nevada, 66 leases on 122,393 acres; Oregon/Washington, 8 leases on 16,825 acres, and Utah with 19 leases on 34,475 acres).

Non-Competitive Leasing

At the end of FY 1988, there were 531 non-competitive leases in effect on a total of 939,575 acres (California, 128 leases on 181,569 acres; Nevada, 160 leases on 262,672 acres; Oregon/Washington, 225 leases on 463,060 acres; and Utah, 18 leases on 32,274 acres).

The revenues generated by leasing on Federal land has amounted to over $18 million.

Utilization

At the end of FY 1988, 725 MWe of capacity were on-line from federal leases at The Geysers (California); 70 MWe from East Mesa (California); 62.5 MWe from Dixie Valley (Nevada); 20 MWe from Roosevelt Hot Springs (Utah); 16 MWe from Beowawe (Nevada); 15 MWe from Steamboat Springs (Nevada); 10 MWe from Desert Peak (Nevada); 9.8 MWe from San Emidio (Nevada); 3.6 MWe from Soda Lake (Nevada); and 2.2 MWe from Cove Fort (Utah) for a total of 934.1 MWe.

III. HYDROTHERMAL RESOURCE IDENTIFICATION, ASSESSMENT, AND EXPLORATION

The 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.

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

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; 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** 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 geopressured 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 development to study the geology, geophysics, geochemistry, and dynamics of thermal regions in the earth of long-term relevance to geothermal resources. Research and development in these areas should assist in resource recognition and evaluation activities. Relevant activities of FY89 within the DOE Office of Basic Energy Sciences (OBES) include the following:

As part of the **Continental Scientific Drilling Program**, DOE/OBES supported the drilling of a scientific corehole at the bottom of the 2,568 ft. deep magma exploratory well being drilled in the resurgent dome area of the Long Valley caldera. The corehole provided not only core, but provides an open hole for downhole geophysical measurements.

Other activities included laboratory and theoretical studies on the thermodynamics, chemical migration isotopic exchanges and water-rock interactions of high-temperature aqueous solutions under geothermal 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. 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.

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.

TABLE 3

GEOTHERMAL RESOURCES DEVELOPMENT FUND AND GUARANTY AUTHORITY [1]

		FY 1989 FUNDING($)	AUTHORITY ($)
a) Program direction		$ 75,000	
b) Carried over from FY 1988	5,000,000		
c) Guaranty fees collected[2]	481,027		
d) Total available		5,481,027	
e) Paid on defaults	0		
f) Administrative expenses[3]	376,520		
g) Total outlays		376,520	
h) Balance at end of FY 1988 (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) Guarantied 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 guarantied projects.

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 FY89 at the Indian Wells Valley, Mainside 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."

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 project 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 2,212 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
QUALIFICATION STATUS OF NON-UTILITY
GEOTHERMAL GENERATING CAPACITY

Applicant Name (Docket No.)	Location	Capacity (MWe)
COSO ENERGY DEVELOPERS (QF86-590-001)	CA	9.1
CALIFORNIA ENERGY COMPANY (QF86-591-001)	CA	0.1
GEO EAST MESA NO. 2 INC. QF88-202-000)	CA	37.0
GEO EAST MESA LIMITED PARTN. (QF88-202-001)	CA	18.5
GEO EAST MESA NO. 2 INC. (QF88-203-000)	CA	37.0
GEO EAST MESA LIMITED PARTN. (QF88-203-001)	CA	18.5
CEJA CORPORATION (QF88-316-000)	NV	5.0
ORMESA IE (QF88-381-000)	CA	10.0
STILLWATER GEOTHERMAL 2 (QF88-523-000)	NV	10.0
RYE PATCH GEOTHERMAL 2 (QF88-524-000)	NV	10.0
EMPIRE GEOTHERMAL 2 (QF88-525-000)	NV	10.0
STEAMBOAT GEOTHERMAL 4 (QF88-526-000)	NV	10.0
STEAMBOAT GEOTHERMAL 2 (QF88-527-000)	NV	10.0
STEAMBOAT GEOTHERMAL 3 (QF88-528-000)	NV	10.0
STILLWATER GEOTHERMAL 4 (QF88-529-000)	NV	25.0
RYE PATCH GEOTHERMAL 1 (QF88-530-000)	NV	10.0
STILLWATER GEOTHERMAL 3 (QF88-531-000)	NV	10.0
ORMESA IH (QF88-532-000)	CA	12.8
ANADARKO PETROLEUM CORPORATION (QF88-536-000)	OR	12.0
I-A ENTERPRISES (QF88-538-000)	NA	1.5
EATON OPERATING COMPANY, INC. (QF88-539-000)	TX	1.05
		175.35