THE EIGHTH ANNUAL INTERAGENCY GEOTHERMAL COORDINATING COUNCIL REPORT FISCAL YEAR 1983

April 3, 1984

DISCLAIMER

1.0 INTRODUCTION

Geothermal energy is the natural heat of the earth, and can be tapped as a clean, safe, and economical alternative source of energy. Three types of geothermal resources (hydrothermal, geopressured and hot dry rock) are expected to be commercially exploited by the year 2000. Of these, only hydrothermal resources, which are underground accumulations of hot water or steam, are technically and economically feasible for exploitation at this time. Figure 1 is a map of the United States indicating known and potential hydrothermal resources. Some of these resources are being tapped now, but much more of this energy resource is recoverable with current or near current technology. Therefore, those resources could make a significant contribution both to increasing domestic energy supplies and to reducing the United States' dependence on imported oil. Moreover, they can be used for various purposes: electric power production, residential and commercial space heating and cooling, industrial process heat, and agricultural process applications.

Although not intended as a statement of goals or targets, energy projections were prepared in conjunction with the National Energy Policy Plan. With a midrange total U.S. energy consumption in 1990 and 2000 of 86.2 and 93.4 quads, respectively, geothermal electric production of 0.25 and 0.35 quads and direct-heat use of 0.06 and 0.2 quads are projected. Although these contributions would be less than one percent of national energy consumption, regional contributions are expected to exceed several percent in certain areas of California, Nevada, Hawaii, Utah, and parts of the Cascade Range. Thus, geothermal energy represents one of several alternate energy sources which will play an increasingly important role in the U.S. energy future.

The Federal government has been actively involved in the development of geothermal energy since 1970, when the Geothermal Steam Act was passed. Since then it has been engaged in the leasing of Federal lands as well as numerous research, development, and demonstration programs to investigate the use of geothermal energy. This report summarizes the accomplishments of the Federal government during fiscal year 1983, and describes Federal geothermal energy programs. Table 1 presents a chronological history of significant geothermal energy developments.

The overall objective of the Federal geothermal program is to respond to the needs of private industry by undertaking long-term, high-risk, potentially high-payoff R&D, thus enabling private industry to undertake commercial development of geothermal resources; the Federal Government provides an appropriate level of assistance while removing technical barriers to exploration and development. Private industry's leading role in the direct planning and construction of geothermal energy systems other than DOE sponsored test or pilot plants, reflects the Administration's policy of relying on the marketplace for energy industrialization activities, including geothermal.

FIGURE 1

Known and Potential Hydrothermal Resources

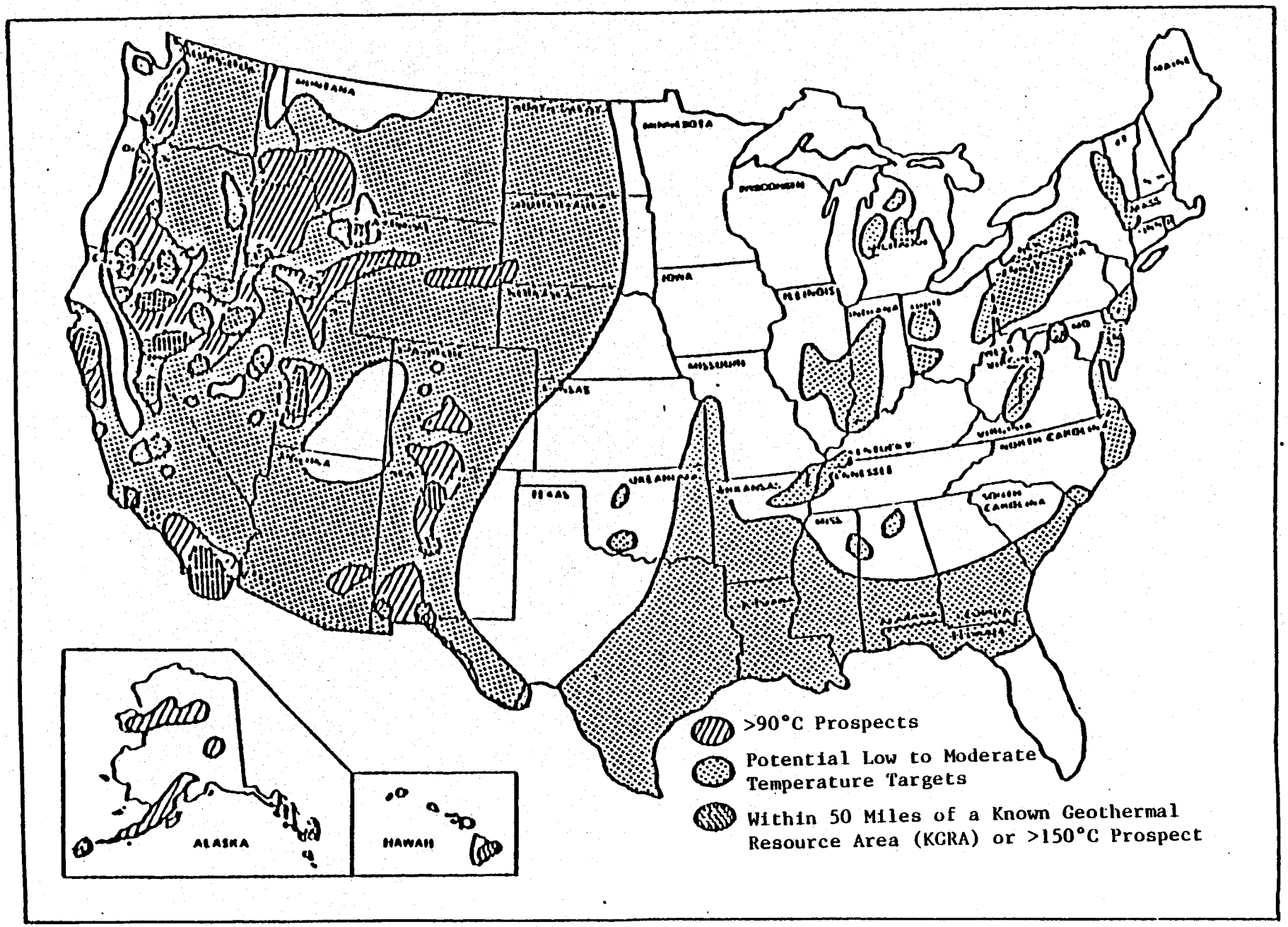

TABLE 1

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

1894	District heating implemented in Boise, Idaho
1900	Hot water provided to homes in Klamath Falls, Oregon
1916	Power generation at The Geysers resort
1927	First exploratory geothermal wells were 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 (PL 91-581)
1972	NSF became lead agency for Federal Geothermal Programs
1973	USGS, AEC, NSF prepared the first Federal Geothermal Program Plan
1974	Geothermal RD&D Act passed (PL 93-410) which included the establishment of the Geothermal Loan Guaranty Program (GLGP)
1975	ERDA formed; Division of Geothermal Energy formed primarily from NSF, AEC staff
	USGS released first national geothermal resource estimates and inventory
1977	DOE formed; DGE continued to manage the program
	Bureau of Reclamation successfully completed desalting tests to produce fresh water from geothermal brines
1978	Energy Tax Act passed (PL 95-618)
	Public Utility Regulatory Policies Act (PL 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

TABLE 1

SIGNIFICANT EVENTS IN THE DEVELOPMENT
OF GEOTHERMAL ENERGY IN THE UNITED STATES (Continued)

1979	USGS released updated national geothermal resource estimates and inventory
	FERC issued regulations (18CFR292) establishing hydrothermal geothermal resources as a renewable resource and geothermal facilities as qualifying facilities
	Streamlining task force recommended measures to speed Federal leasing to IGCC
	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
	Issued the first Geothermal Loan Guarantee to Geothermal Food Processors, Inc., for an onion drying plant at Brady Hot Springs, Nevada
1980	World's largest single geothermal power unit (129 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 5 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 passed, providing tax credit increase for geothermal equipment (PL 96-223)
	Energy Security Act, containing Title VI, "The Geothermal Energy Act of 1979", passed (PL 96-294)

TABLE 1

SIGNIFICANT EVENTS IN THE DEVELOPMENT
OF GEOTHERMAL ENERGY IN THE UNITED STATES (Continued)

1981	First U.S. geothermal electric generation plant outside the 48 contiguous states brought on-line in the Puna resource areas in Hawaii
	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
	A 76 MW geothermal electric powerplant was certified by the Federal Energy Regulatory Commission as a Qualifying Small Power Production plant using a renewable energy source. The plant is to be constructed in the Imperial Valley, California by Republic Geothermal, Inc. Qualifying power production facilities are entitled to the benefits specified under Section 210 of PURPA
1982	A 10 MWe flash plant utilizing hypersaline brine began operation at the Salton Sea, KGRA, California
	An 80 MW geothermal electric powerplant to be constructed by Occidential Geothermal, Inc. in Lake County, California and a 49 MW geothermal electric powerplant 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 MW geothermal powerplant 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

TABLE 1

SIGNIFICANT EVENTS IN THE DEVELOPMENT
OF GEOTHERMAL ENERGY IN THE UNITED STATES (Concluded)

	USGS completed the first quantitative national assessment of low-temperature (< 90°C) geothermal resources of the United States
1983	Federal leasing regulations rewritten resulting in the deletion of burdensome, counterproductive requirements
	As a result of continued development by the electric utility industry and through purchases from private developers the total generating capacity from geothermal resources currently stands at 1312 MWe

The efficient and timely development of geothermal resources depends on the coordinated efforts of Federal, state, and local governments; industry, consumer and environmental groups; and private citizens. Federal responsibilities and programs are divided among a number of agencies whose activities are coordinated through the Interagency Geothermal Coordinating Council (IGCC), which was established in 1974 by PL 93-410. The IGCC brings together all of the Federal agencies with responsibilities related to geothermal energy development, and serves as a forum for interagency program coordination and information exchange.

The IGCC consists of the Federal agencies which participate in the geothermal program and is responsible for supervising and coordinating the activities of the Federal government community. This responsibility is spelled out in the Geothermal Research, Development, and Demonstration Act of 1974 (PL 93-410); specifically it is "...to coordinate those Federal plans, activities, and policies which are related to or impact on geothermal energy, including auxiliary activities of agencies not represented in the council membership". The Council, through the Chairman, may make recommendations to the appropriate agencies and the President with regard to alternative policies or action considered necessary or desirable to expedite the development and utilization of geothermal energy resources. Member agencies include the Departments of Energy, Commerce, Defense, Interior, Housing and Urban Development, Treasury and Agriculture, and the Environmental Protection Agency. The Federal Geothermal Program budget of the member agencies is presented in Table 2.

2.0 LEASING

The goal of Federal geothermal leasing activities is to make lands available to industry for exploration and development. Leasing is accomplished by the Bureau of Land Management, with the consent of the Forest Service where National Forest System Lands are involved.

During FY 1983, the Federal government issued leases for 476,711 acres. Federal leases are issued either through the competitive or non-competitive leasing program.

Competitive Leasing

The Bureau of Land Management (BLM) conducts competitive geothermal lease sales several times each year. At the lease sales, parcels of land located in Known Geothermal Resource Areas (KGRAs) are offered to the public. Typically, a lease sale involves several tracts of land; each tract is bid on separately. The highest qualified bidder receives rights to explore and develop the geothermal resources, conditioned on compliance with applicable laws, regulations, and lease terms of the sale, and geothermal operational orders.

TABLE 2

FEDERAL FUNDING FOR GEOTHERMAL ENERGY ($000)*

ORGANIZATION UNIT	Actual 1979	Actual 1980	Actual 1981	Actual 1982	Actual 1983	Estimated 1984	Requested 1985
Department of Agriculture							
U.S. Forest Service	780	750	700	600	500	525	525
Department of Defense							
Navy	300	230	930	848	863	1,100	1,000
Air Force	0	200	1,010	182	0	0	0
DOD Total	300	430	1,940	1,030	863	1,100	1,000
Department of Energy							
Conservation & Renewable Energy	152,990	149,870	142,521	43,713	79,939	34,965	27,087
Office of Energy Research**	2,100	3,102	3,305	2,650	2,500	2,400	2,550
Environment	2,820	1,950	723	0	0	0	0
GLCP (Administrative Expenses)	0	181	193	134	120	300	121
DOE Total	157,910	155,103	146,742	46,497	82,559	37,665	29,758
Department of Interior							
National Park Service	***	***	***	100	50	250	250
Fish & Wildlife Service	200	200	70	100	50	0	0
Bureau of Land Management	3,340	3,410	3,548	4,055	3,861	3,197	3,207
Bureau of Reclamation	550	910	60	60	30	0	0
Bureau of Mines	1,050	800	400	384	300	0	0
USGS, Geothermal Research Program	12,043	10,047	7,889	7,953	7,090	7,215	5,417
DOI Total	17,183	15,367	11,069	12,652	11,381	10,662	8,874
Environmental Protection Agency	920	850	1,550	0****	0****	0****	0
TOTAL FEDERAL GEOTHERMAL PROGRAM BUDGET	177,093	172,500	162,001	60,779	95,303	49,952	40,157

* Budget authority rounded to nearest thousand.

** Best estimate based on the portion of BES research related to geothermal activities. The estimate represents the applicable portions of a number of research tasks.

*** Not known.

**** While the FY 82, 83, and 84 EPA budget does not target 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.

During FY 1983, the Federal government received $7,179,969 in high bids for 58,182 acres leased through the competitive process. Table 3 is a breakdown of acreage leased competitvely in FY 1983 on a state-by-state basis and includes acceptable bonus bids generated from these sales. Table 4 presents acceptable bonus bids from competitve lease sales in FY 1983 and the total for all years (1974-1983). Table 5 presents the total acreage leased competitively by state and year.

Non-competitive Leasing

Non-competitive leases are issued by the Federal government on land not located within a KGRA. During FY 1983, 418,529 acres were leased through this process bringing the cumulative total for lands leased non-competitively to over 4.5 million acres.

Post-lease Operations

The Deputy Director, Energy and Mineral Resources, BLM, is responsible for the regulation of all phases of post-lease geothermal development on Federal leases. The level of geothermal development on Federal leases during fiscal year 1983 was considerably less than the previous year.

There were eleven power plants in various stages of certification or construction at the end of fiscal year 1983. Three of these, PG&E (Pacific Gas and Electric) #16 and #20, and NCPA (Northern California Power Authority) #3 are located in The Geysers field. Others are the SMUD (Sacramento Municipal Utilities District) GEO-1, the CDWR (California Department of Water Resources) Bottle Creek Area, Occidental #1 in South Geysers field, Magma Power Co. #1, and two more plants certified for construction in the Imperial Valley. In Utah, at Roosevelt Hot Springs, Utah Power and Light and Phillips Petroleum Company have nearly completed construction of a 20 MW plant.

3.0 HYDROTHERMAL RESOURCE IDENTIFICATION, ASSESSMENT AND EXPLORATION

The United States Department of Energy and the United States Geological Survey have several programs designed to evaluate the geothermal energy potential in the U.S. These programs are complementary in nature but focus on different aspects of this goal. USGS activities emphasize geothermal resource inventory and assessment work; DOE activities focus on more detailed study of specific resource areas. The main objectives of the 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 longevity of geothermal systems.

TABLE 3

TOTAL ACREAGE LEASED COMPETITIVELY IN FY 1983

State	Acres	Acceptable Bonus Bids
New Mexico	7,007	$ 23,076
Oregon	4,706	9,611
California	40,568	7,141,381
Idaho	5,901	5,901
	58,182	$ 7,179,969

TABLE 4

ACCEPTABLE BONUS BIDS - COMPETITIVE LEASE SALES

State	FY 1983	Total for all years
California	$ 7,141,381	$64,971,027
Utah	0	4,457,192
Nevada	0	3,950,048
New Mexico	23,076	1,956,664
Oregon	9,611	2,219,834
Idaho	5,901	12,212
Colorado	0	13,577
Washington	0	231
Arizona	0	858
	$ 7,179,969	$77,581,643

TABLE 5

COMPETITIVE LEASING BY STATE, TOTAL ACREAGE LEASED, BY YEAR

STATE	1974 - 1976	1977	1978	1979	1980	1981	1982	1983	Total for all Years
Nevada	120,996	36,663	9,322	24,298	20,419	15,304	0	0	227,002
Utah	76,539	12,788	1,658	0	0	0	9,230	0	100,215
New Mexico	32,564	48,065	8,767	7,063	0	13,835	4,391	7,007	121,692
Oregon	68,872	0	5,818	0	32,630	0	16,411	4,706	128,438
California	36,937	2,856	4,395	6,959	10	84,914	168,411	40,568	347,350
Idaho	24,903	6,985	0	0	0	0	1,833	5,901	39,612
Colorado	5,036	0	0	0	0	0	0	0	5,036
Washington	0	0	0	0	0	0	2,307	0	2,307
Arizona	0	0	0	0	0	0	780	0	780
Total Acres Leased	365,847	107,357	29,960	38,320	53,059	114,053	203,413	58,182	972,492

Major accomplishments in FY 1983 included:

- Published the first quantitative national assessment of low-temperature (less than 90°C) geothermal resources of the United States, thus providing a basis for estimating the potential for non-electrical uses of geothermal energy in the United States (USGS Circular 892).

- Continued detailed geologic mapping and geochronologic studies at several major volcanic centers of the Cascade Range in the Pacific Northwest. Based on this work, a new geologic map of the Cascades is being compiled as part of the regional assessment of the large geothermal potential that is inferred in the Cascade Range.

- Investigated the deep crustal structure of the Oregon Cascades using seismic data, thus defining deep regions of magma generation and contributing to a characterization of the overlying geothermal features probably related to Cascades volcanism.

- Interpreted chemical analyses of geothermal fluids from Lassen Volcanic National Park, California, indicating that a single high-temperature vapor-dominated geothermal system is centered beneath the Park and that a deeper hot-water part of this system feeds hot springs just outside the Park.

- Completed a numerical modeling study of the hydrothermal system at Lassen Volcanic National Park, describing the evolution of the present-day system and the effects on surficial thermal features of potential geothermal development outside the Park.

- Drilled a research borehole in lake sediments of the southern Cascade Range for core recovery and detailed study of the volcanic history of this region to better understand the heat source for characterization of resources in this area of high geothermal potential.

- Completed a hydrologic study at Newberry Volcano, Oregon, in which a conceptual model of the shallow hydrothermal system was produced that estimates fluid recharge to the system; completed a related numerical model of conductive heat flow at Newberry which constrains estimates of the age and size of a possible shallow magma chamber beneath the volcano (the heat source for the Newberry geothermal system).

- Interpreted seismic refraction data from the Imperial Valley of southern California, providing a detailed contour map of the depth to basement rock underlying the many geothermal systems throughout the area and helping to define the geologic structure of these systems; interpreted heat-flow data which characterizes the Imperial Valley as an area of very high regional heat flow locally, modified by the effects

of crustal intrusions and fault-controlled hydrothermal circulation to depths of a few kilometers.

- Developed the theoretical basis necessary for production of a map of Nevada showing depth of the Curie isotherm (about 600°C). This map will allow estimation of crustal temperature profiles in the northern Basin and Range Province, a region of large geothermal potential.

4.0 HYDROTHERMAL TECHNOLOGY DEVELOPMENT

The process of locating, producing, and utilizing large volumes of fluids from high temperature, fractured, hard rock formations imposes a number of technological and economic constraints on geothermal development which forestall full-scale resource exploitation by the private sector. Conventional oil and gas technology, presently employed for exploration, drilling, reservoir assessment, and production of geothermal fields has proven expensive, unreliable and frequently non-functional in the hot, chemically hostile, downhole geothermal environment. Surface equipment, including power plant components, lack the efficiency and reliability for electric power generation for all except the high temperature, high flow rate, most benign hydrothermal reservoirs. As a result, only a small percent of the available hydrothermal reservoirs can be economically exploited with current technology.

The current R&D activities are in areas of high-risk and are directed toward substantially reducing hard rock drilling costs, increasing moderate temperature energy conversion efficiency through binary cycle technology, increasing reservoir production rates through well stimulation techniques and improved downhole brine pumps, developing reliable exploration techniques, greatly improving reservoir engineering methods for assessing site-specific capacity and longevity, and developing environmental control technology required to meet state and Federal standards for geothermal air emissions, and solid and liquid waste disposal.

Major accomplishments in FY 1983 included:

Drilling and Well Completion Technology

- Developed and field tested an inertial navigation wireline tool for spatial mapping of wellbores.

- Developed high-temperature prototype logging tools for measurement of temperature, pressure, and flow.

- Completed modeling (to predict optimum operating conditions) of polycrystalline diamond compact (PDC) bit frictional heating and hydraulic cooling.

- Completed testing of aqueous foam convective heat transfer properties, which will be used to predict foam temperatures in geothermal wellbores.

- Fabricated and began testing of the Lost Circulation Test Facility which will be used to develop materials and techniques for lost circulation control.

- Completed prototype development of high-temperature cement bond log tool.

Energy Conversion Technology

- Initiated supercritical/countercurrent condensing test program using isobutane/hexane working fluid mixtures.

- Completed the final report on the field testing of 1MWe helical screw expander (total flow power system) under IEA agreement.

- Published the final report on the field testing of a 500 kWe direct contact heat exchanger in the binary cycle pilot plant at East Mesa, CA.

- Moved the Heat Cycle Research Facility to the DOE Geothermal Test Facility at East Mesa, CA.

Reservoir Stimulation Technology

- Completed two acid-wash well treatments in the Rossi 21-19 well at Beowawe, Nevada. Two zones were stimulated; and the flow of the hotter, lower zone (which is the most important) increased significantly, however it was cooled by an upper, cooler zone, upon merging. Plans are to cement off the upper zone with predictions that the flow rate of the lower zone will bring the well within commercial requirements.

Geochemical Engineering and Materials Research

- Successfully field tested and commercialized a polymer lined pipe.

- Developed a high nitrogen-containing steel which appears to be less expensive and more chemically resistant to corrosion.

- Union Oil Company has planned to use a BNL/DOE developed polymer cement in a well completion.

- Completed testing of the isobutane probes which will be utilized in the Heber Plant.

- Built and field-tested, at the Magma Geothermal plant, the first models of the CO_2 probe and pH probes for monitoring hydrothermal power plants.

Brine Injection Technology

- Completed analysis of particle control technology for injectability of spent brines.

- Completed first phase of tests in which tracer-bearing fluids are injected into reservoirs and recovered, to assess fluid migration behavior.

Reservoir Definition

- Developed and field-tested new instruments for seismic and electromagnetic data to characterize geothermal reservoirs.

5.0 HOT DRY ROCK RESOURCES

The goal of the Hot Dry Rock (HDR) Program is to establish the long-term technical and economic feasibility of extracting energy from the earth's hot, water-deficient rocks. Intermediate objectives to attain the realization of this goal include: (1) developing a technology base for HDR energy extraction; (2) confirming that the resource potential is large and accessible; and (3) verifying that resource development can be undertaken with acceptable environmental effects. Successful demonstration of the technical feasibility of extracting HDR energy has been proven with a 5 megawatt (MW) thermal loop at Fenton Hill, New Mexico.

Major accomplishments in FY 1983 included:

- At the Fenton Hill site, three preliminary hydraulic fracturing tests were conducted in the upper portion (i.e., 11,000 to 13,000 foot zone) of the designated reservoir region. The first, a massive hydraulic fracturing (MHF) experiment, involved the pumping of some 840,000 gallons of fluid into the nominal injection well, EE-2, under a surface injection pressure of about 7,000 psi. The second and third involved the pumping of 40,000 and 150,000 gallons, respectively, of water into the nominal production well, EE-3.

- Preparations were nearly completed for a subsequent MHF in EE-2 which would be the most extensive operation of its type ever conducted.

- Custom-tailored, 5 1/2-in. diameter work pipe was designed and fabricated. The pipe was obtained to prevent future downhole pipe failures due to stress-corrosion cracking.

- Improvements in downhole, high temperature instruments included: incorporation of heat pipes in triaxial geophone tools for increased downhole residence-time capability; fabrication and successful test of "slimline" (3-in max OD) logging tools for fluid-velocity and temperature/collar-locator, measurements; initial design of a family of explosive workover tools; and inception of a temperature upgrading program for the acoustic televiewer tool.

- Significant progress was made in acoustic fracture mapping. A combination of holographic and triangulation techniques is now employed, to map the locations of microseismic events generated by the fracturing process. A sizeable statistical sample can be processed in near real-time with on-line ADP equipment at Fenton Hill.

- Preliminary laboratory and theoretical studies of chemically reactive tracers were begun to select candidates for use in assessing the "size" (i.e., effective heat transfer surface) of a HDR reservoir.

6.0 GEOPRESSURED RESOURCES

During the past several years, the Geothermal Geopressured Program has established that there is a very large quantity of hot brine contained at high pressure in sandstone aquifers beneath the Texas-Louisiana Gulf Coast. Essentially all of this brine is saturated with dissolved natural gas (methane), for a total of about 5,700 quadrillion (quads) BTU's of gas in place (U.S. gas consumption is about 18 quads/year). The thermal energy content of the brines is about equal to the chemical (methane) energy content, although the recoverable thermal energy is less than that of the gas. It is technically feasible to produce the brine at high rates through wells, separate the gas, and inject the spent brine into suitable underground formations. The principal program activity is the production testing of four specially-designed wells. Brine flow rates of up to 40,000 barrels per day will provide data on geopressured reservoir performance. Analysis of these data ultimately will allow industry to predict how much methane and thermal energy can be recovered from a geopressured reservoir.

Major accomplishments in FY 1983 included:

- Completed the well test at the Parcperdue site in Louisiana after acquiring 8 months of production test data.

- Completed repairs in the Gladys McCall well in Louisiana and began flow tests.

- Determined the causes of corrosion and scaling in the Pleasant Bayou and Sweetlake wells, and initiated corrective action.

7.0 GEOSCIENCES RESEARCH

Numerous entities, including the Office of Energy Research of the Department of Energy and the United States Geological Survey, Bureau of Mines, and the Bureau of Reclamation within the Department of Interior, have undertaken R&D activities in the geosciences area. A significant portion of these activities is centered on the conduct of basic R&D. Research and development activities have been structured to resolve uncertainties in determining the location, size, chemical and temperature characteristics, and longevity of geothermal reservoirs. In addition to research and development activities that have been conducted in the area of resource recognition and evaluation, other geothermal-related activities, such as mineral recovery from geobrines and the production of fresh water supplies through the desalting of geothermal brines, have been undertaken.

Major accomplishments in FY 1983 included:

- Completed research to evaluate technology to recover lithium from geobrines. In this work, a flowsheet was devised for preparing 99.9 percent pure LiCl with an attendant lithium recovery from the original brine of almost 90 percent.

- Completed research to provide data for the recovery of tungsten as a byproduct from Searles Lake, California brines using ion exchange methods.

- A convective heat flow probe for geological media is being developed to measure heat flow in regions where convective transport of heat is important. The probe has been fully assembled and tested in a shallow drill hole at Kirtland AFB. The test verified the mechanical and electrical design and produced baseline data for a purely conductive environment.

- Data from logs and other geophysical information at the Valles Caldera, N.M. site was obtained from Union Oil and assembled and collated to set up a complete data base of geological, geophysical, geochemical, and reservoir engineering information. The information will be of significant interest to the Continental Scientific Drilling Project and of long range interest to the geothermal energy program.

- The preliminary research program for deep scientific drilling in the Salton Sea geothermal area was developed and will help define the experimental scientific program to be conducted in the 12,000 to 18,000 foot hole of the Salton Sea Scientific Drilling Project.

8.0 HYDROTHERMAL TECHNOLOGY TRANSFER

The goal of the Hydrothermal Technology Transfer effort is to provide an appropriate level of Federal support to industry so that development of geothermal resources can proceed. The effort focuses

on low- to moderate-temperature resources for direct applications and high-temperature geothermal resources for electric power generation. Hydrothermal resource development is impeded by the private sector's perception of economic and technical risk, reservoir performance uncertainties, and a variety of legal and institutional barriers.

DOE's Hydrothermal Technology Transfer effort in FY 1983 consisted of information dissemination; sponsorship of a Technology Transfer Session at the Annual Meeting of the Geothermal Resources Council; site-specific direct heat feasibility studies and field demonstrations; and administration of the Geothermal Resources Development Fund. The Geothermal Energy Research Development and Demonstration Act of 1974 provided for the establishment of the Geothermal Loan Guaranty Program (GLGP) and of the Geothermal Resource Development Fund (Table 6 presents the FY 1983 status of the Fund) to support the program. The objectives of the GLGP are to encourage the private and public 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; promote competition and encourage new entrance of firms into the geothermal marketplace.

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. During FY 1983, 4 preliminary feasibility studies of geothermal district heating systems were completed: Bellows Falls, Vermont; Berlin, Maryland; Thermopolis, Wyoming; and Union County, Oregon. Total funding for the four projects was approximately $200,000.

9.0 ENVIRONMENT

The Federal Geothermal Environment Program focuses on characterization of the environmental impacts from the development of geothermal energy sources and the development and evaluation of control methods to mitigate or eliminate environmental concerns, including health. The coordination between the private sector, the research community, and Federal and state government agencies on environmental matters is 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 being the principal participants in the environmental program. The environmental program has included acquisition of baseline data, monitoring, and research related to air quality, surface and ground water quality, hydrological alterations, ecology, solid residuals, subsidence and seismicity, health effects, and socioeconomic problems; and development and evaluation of environmental control technologies.

TABLE 6

GEOTHERMAL RESOURCES DEVELOPMENT FUND(1)
AND GUARANTY AUTHORITY

	FY 83	
	FUND	AUTHORITY
Program Direction	$ 107,088	
Unobligated Appropriations, Carried Forward from FY 83	6,858,793	
Guaranty Authorization		$500,000,000
Value of Loans Guaranteed (6 projects)		138,300,000
Value of Conditionally Approved Applications FY 83 (3 projects)		151,100,000
Uncommitted Guaranty Authorization(2) Carried to FY 84		210,600,000
Interest Differential Paid	2,181,553	
Administrative Expenses Incurred(3) (FY 83)	282,151	
Guaranty Fees Collected in FY 83 and Deposited in GRDF	749,645	

(1) This financial information is included in the Eighth Annual Report to satisfy the requirements of PL 93-410, Section 204.

(2) The value of applications currently under review is $101,000,000. In addition, of the 6 projects that currently have loan guarantees, certain of these may require follow-on loans for powerplant construction.

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

Major accomplishments in FY 1983 included:

- Continued a low level program of assessment and monitoring of the geothermal resources in Lassen Volcanic and Yellowstone National Parks in order to evaluate the implications of proposed geothermal development. The program employs geochemical and geophysical techniques to better understand the relationship between geothermal resource areas of developmental interest and protected park resources.

10.0 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 throughout the U.S. and the world.

Major accomplishments in FY 1983 included:

- The Navy renegotiated the contract for the development of the geothermal resource at the Naval Weapons Center (NWC) China Lake, California and added four square miles of land to the area which the contractor may develop. The Navy also awarded a contract for the development of up to 75 MWe at the Naval Air Weapons Training Complex Fallon (NAWTC), Nevada in April 1983.

- Completed a Cooperative Agreement with DOE's San Francisco office for the Navy and DOE to cooperate in funding and sharing of data for the geologic exploration of potential geothermal sites.

- Work continued to gather additional site geothermal resource data. At Pickle Meadows, California a preliminary geological survey was completed for a space heating application. A preliminary survey for space heating was also completed at Twenty-nine Palms, California and a contract has been awarded for the drilling of thermal gradient wells at Twenty-nine Palms. DOE will perform the data logging on these wells. Additional geophysical survey work was also completed at Adak, Alaska.

- Identified Charleston, South Carolina; Norfolk, Virginia; and Jacksonville, Florida as sites which potentially have a low grade geothermal resource which could be used for space heating.

11.0 PRIVATE SECTOR USE OF GEOTHERMAL ENERGY

Geothermal energy has been used for space heating in the United States since the early 1900's and for district heating systems since the 1930's. Current uses include agricultural and aquacultural applications, space/ district heating, and industrial applications. Currently, direct utilization of geothermal energy is approximately .012 quads/yr. 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 dramatically over the next few years with significant expansion projected in industrial applications and district heating systems.

The 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 and currently account for 1312 MWe power-on-line. Numerous other plants are under construction, and by the end of 1985 total power-on-line could be approximately 2,100 MWe.