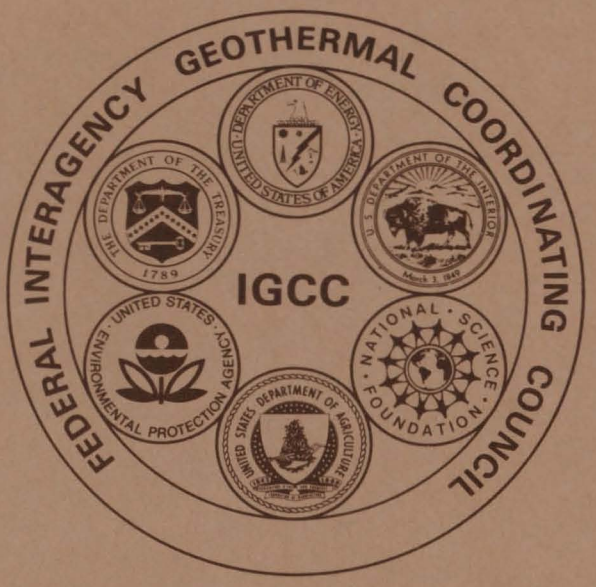
Second Annual Report

Geothermal Energy, Research, Development & Demonstration Program

April 1978

Interagency Geothermal Coordinating Council



DISCLAIMER

GEOTHERMAL RESOURCES

Geothermal resources are underground sources of heat stored in rock and fluids. These resources can be tapped by drilling, and the heated fluids brought to the surface for generation of electricity or for direct thermal utilization. The principal types of geothermal resources are hydrothermal, geopressured, and hot dry rock.

Hydrothermal resources consist of water and steam which are trapped in fractured rocks or sediments by confining surface layers. A specific hydrothermal system is classified as 'vapor' or 'liquid' dominated, according to the principal state of the subsurface fluid. Hydrothermal resources are currently being utilized for electric production and direct thermal applications.

Geopressured resources are comprised of water and dissolved methane at moderately high temperatures, but at pressures higher than the normal hydrostatic pressure. In the United States, geopressured resources have been confirmed in sedimentary formations along the Gulf Coast. On the basis of geological information obtained from petroleum operations, the Gulf Coast geopressured resources are believed to be quite large, and there are indications of similar geopressured formations in sedimentary basins elsewhere in the United States. Commercial-scale utilization of the heat, pressure, and methane contained in these resources is expected to begin in the late 1980s.

Hot dry rock resources consist of hot rocks at accessible depths that are relatively unfractured and contain little or no water. To extract usable power, these resources require fracturing for the introduction and circulation of a heat transfer fluid. Commercial-scale utilization of hot dry rock resources is expected to begin in the 1990s.

Recipients of DOE/ET-0039/1, Second Annual Report: Geothermal Energy Research, Development and Demonstration Program

ERRATA FOR SECOND ANNUAL REPORT

Attached are errata and replacement pages for DOE/ET-0039/1, Second Annual Report: Geothermal Energy Research, Development and Demonstration Program.

Robert D. Thorne, Chairman
Interagency Geothermal
Coordinating Council

Attachments

ERRATA SHEET

DOE/ET-0039/1 Second Annual Report
Geothermal Energy Research, Development and Demonstration Program

Page iii	Replace with attached page
Page vi, line 19	For "Paris" read "Parish"
Page viii, line 7	For "Springs" read "Springs, NV"
Page S-1, paragraph 4, line 2	For "local power" read "local public power"
Page S-5, paragraph 1, line 2	Delete "fluidized bed"
Page 3, line 2	For "local power" read "local public power"
Page 11, paragraph 2, line 1	For "affected" read "effected"
Page 38) Page 60) Page 68) Page 80)	For heading "Post 1990" read "1990-2020" In footnote *, insert after the first sentence "The generating capacity estimates in Table I (page 2) for the years after 1985 assume development of additional sites."
Page 64, paragraph 1, line 6	For "and drilling" read " and preparations for drilling"
Page 64, paragraph 1, line 7	For "is" read "are"
Page 65, paragraph 1, line 1	For "Delchambre" read "Delcambre"
Page 65, paragraph 1, line 8	For "fluid." read "fluid as determined by laboratory recombination."
Page 94, paragraph 6, line 2	For "77 lpm" read "775 lpm"
Page 111, paragraph 3, lines 1-2	For "DOGMI, and DGE" read "DGE and and Oregon Department of Geology and Mineral Industries"
Page 113, line 7	For "NM" read "NV"
Page A-3, paragraph 1, line 5	For "Committee)" read "Council)"
Pages A-8 through A-13	Replace with attached revised pages
Page B-2	Under heading FY 1977 STATUS, paragraph 2, for "subsidies" read "substudies"
Page B-5	Under heading FUTURE ACTIVITIES, line 2, for "1978." read "1977."

PREFACE

This is the second annual report on the Federal Geothermal Energy Program. The Department of Energy (DOE), which was established by P.L. 95-91 (of August 1977), is now the lead agency for coordinating the Federal Geothermal Energy Program.*

This report was prepared under the auspices of the Interagency Geothermal Coordinating Council (IGCC) under the Chairmanship of the Assistant Secretary for Energy Technology, DOE. It presents accomplishments of the Federal Program during FY 1977 (October 1, 1976 - September 30, 1977) and future plans.

The Federal Geothermal Energy Program is designed to enable industry to maximize utilization of the nation's geothermal resources in an environmentally and socially acceptable manner. This includes electric generation and direct thermal energy use of the nation's geothermal resources, and methane extraction from the Gulf Coast geopressured geothermal resources.

Robert D. Thorne, Chairman
Interagency Geothermal
Coordinating Council

*The DOE has replaced the Energy Research and Development Administration (ERDA) which was established as the lead agency of the Federal Program by P.L. 93-410, the Geothermal Energy Research, Development and Demonstration Act of 1974 and the subsequent P.L. 93-438, the Energy Reorganization Act of 1974, and P.L. 93-577, the Federal Nonnuclear Energy Research, Development, and Demonstration Act of 1974. Following the creation of ERDA, the Geothermal Advisory Council was established and later renamed as the Interagency Geothermal Coordinating Council (IGCC). The IGCC serves as the successor to the Geothermal Energy Coordination and Management Project, which was established by P.L. 93-410.

Revised

TABLE A-I

MEMBERSHIP OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

ORGANIZATION	REPRESENTATIVE
Department of Energy	Acting Assistant Secretary of Energy Technology *
Department of the Treasury	Assistant Secretary for Economic Policy
Department of the Interior	Assistant Secretary for Energy and Minerals
Environmental Protection Agency	Assistant Administrator for Research and Development
National Science Foundation	Assistant Director for Science Education
Department of Agriculture	Assistant Secretary for Conservation, Research, and Education

* Chairman

TABLE A-II

MEMBERSHIP OF STAFF COMMITTEE

ORGANIZATION	REPRESENTATIVE
Department of Energy	
Energy Technology	Director, Division of Geothermal Energy *
Environmental Protection Agency	
Office of Research and Development	Deputy Assistant Administrator for Energy, Minerals and Industry
Department of the Interior	
U.S. Geological Survey	Assistant Director, Energy and Mineral Resources
National Science Foundation	Director, Division of Advanced Energy and Resources Research and Technology
Department of the Treasury	Petroleum Specialist, Office of Energy Policy
Department of Agriculture	
U.S. Forest Service	Watershed Management Staff

* Chairman

TABLE A-III

MEMBERSHIP OF STAFF COMMITTEE: BUDGET AND PLANNING WORKING GROUP

ORGANIZATION	REPRESENTATIVE
Department of Energy **	
Energy Technology	Chief, Planning Branch, Division of Geothermal Energy *
Department of the Interior	
Bureau of Land Management	Chief, Branch of Upland Minerals
Bureau of Mines	Associate Director, Mineral and Materials Research and Development
Bureau of Reclamation	Chief, Resources Planning Branch Division of Planning
Office of Water Resources Research and Technology	Water Research Scientist
U.S. Fish and Wildlife Service	Office of Biological Services
U.S. Geological Survey	Chief, Office of Geochemistry and Geophysics
Department of Agriculture	
U.S. Forest Service	Watershed Management
Environmental Protection Agency	Energy Processes Division, Office of Energy, Minerals and Industry; Office of Research and Development

* Chairman

** FY 1978 BPWG membership may include representatives assigned by the DOE:

- Assistant Secretary for Policy and Evaluation,
- Assistant Secretary for the Environment,
- Assistant Secretary for Conservation and Solar Applications,
- Assistant Secretary for Resource Applications,
- Administrator for the Economic Regulatory Administration,
- Federal Energy Information Administration, and
- Director of the Office of Energy Research.

TABLE A-IV

MEMBERSHIP OF THE RESOURCE PANEL OF
THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

ORGANIZATION	REPRESENTATIVE
Department of the Interior	
U.S. Geological Survey	Chief, Office of Geochemistry and Geophysics *
Office of Water Resources Research and Technology	Assistant Director Research
Bureau of Mines	General Engineer, Division of Interfuels Studies
Department of Energy	
Energy Technology	Chief, Resource Exploration and Assessment Branch, Division of Geothermal Energy
Department of Agriculture	
U.S. Forest Service	Watershed Management

* Chairman

TABLE A-V

MEMBERSHIP OF THE RESEARCH AND TECHNOLOGY PANEL OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

ORGANIZATION	REPRESENTATIVE
Department of Energy	
Energy Technology	Assistant Director for Research and Technology, Division of Geothermal Energy *
	Resource Exploration and Assessment Branch, Division of Geothermal Energy
Department of the Interior	
Bureau of Mines	Associate Director for Mineral Materials R&D
	Chief, Office of Energy & Minerals Technology Coordination
Bureau of Reclamation	Planning Division
U.S. Geological Survey	Chief, Office of Geochemistry and Geophysics
Department of Agriculture	
U.S. Forest Service	Watershed Management
Environmental Protection Agency	
Office of Research and Development	Monitoring and Air Transport Coordinator
Department of Defense	
Naval Facilities Engineering Command	Energy Program Manager
National Science Foundation	Division of Advanced Energy Resources Research and Technology
National Aeronautics and Space Administration	Power Systems

* Chairman

TABLE A-VI

MEMBERSHIP OF INSTITUTIONAL BARRIER PANEL OF
THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

ORGANIZATION	REPRESENTATIVE
Department of Energy	
Energy Technology	Chief, Policy Research Branch, Division of Geothermal Energy *
Federal Energy Regulatory Commission	Director, Division of Interconnection and Systems Analysis, Office of Electric Power Regulation
Department of the Treasury	Assistant Director, Business Taxation Staff, Office of Tax Analysis
Department of Commerce	Office of Ocean Resource and Scientific Policy Coordination
Department of the Interior	
Bureau of Land Management	Assistant Director, Minerals Management
U.S. Geological Survey	Associate Chief, Conservation Division
Council on Environmental Quality	Staff Member for Energy Programs
Environmental Protection Agency	Policy Planning Division
Department of Agriculture	
U.S. Forest Service	Watershed Management Staff

* Chairman

DOE/ET-0039/1
IGCC-3

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Member Agencies
Department of Energy — Chairman
Department of the Treasury
Department of the Interior
Environmental Protection Agency
National Science Foundation
Department of Agriculture

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EXECUTIVE SUMMARY

National Geothermal Utilization Potential

More than 500 MWe* (enough to supply greater than half of the electric requirements of San Francisco) is being produced from a geothermal resource in California, and geothermal space heating is occurring at numerous locations in the United States. In addition, geothermal development activity by industry has been accelerating.

The Interagency Geothermal Coordinating Council (IGCC) estimates that production of geothermally-derived power will be equivalent to about 0.3 to 0.5 Quad** per year by 1985, 4 to 9 Quads per year by the year 2000 and 16 to 28 Quads per year by 2020. Each of these estimates includes direct heat applications and the generation of electricity.

The achievement of these ambitious levels of geothermal utilization will require a national effort involving many elements of the private sector and the support of all levels of government. This report describes primarily those activities that are a part of the Federal Geothermal Energy Program.

Federal Geothermal Energy Program Objective

The objective of the Federal Geothermal Energy Program is to stimulate private and local power authorities to develop geothermal resources as reliable, operationally safe and environmentally acceptable energy sources for the production of electricity and/or direct heat applications. To achieve this objective, the Federal Government is implementing research, development and demonstration (RD&D) initiatives, and administrative and policy initiatives. These Federal initiatives are properly timed with initiatives of non-Federal entities.

Program Strategy

The Federal Geothermal Energy Program Strategy is to reduce uncertainties concerning geothermal resource characteristics, and to stimulate the commercial development of hydrothermal resources by the mid 1980s, the initial development of geopressured resources by the mid 1980s and hot dry rock resources by the year 2000.

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*In this report, "MWe" refers to the megawatts of installed capacity at an electric generating plant.

**1 Quad = 1.0×10^{15} BTU. 1 Quad per year = approximately 0.5 million barrels of crude oil per day.

The Federal Geothermal Energy Program Strategy encompasses various planning, implementation, progress monitoring, coordination and management activities.

Program Planning

The Federal Geothermal Energy Program has evolved over the last two years into a program of mission-oriented planning that addresses the development requirements of each major identifiable geothermal energy prospect in the U.S. Priorities that were established for Federal activities in FY 1977 will assist the private sector to achieve the commercial geothermal energy utilization potential as early as possible. The priorities were established through Federal program planning activities that incorporated input from all levels of Government and from the private sector.

Program Implementation

The Federal Geothermal Program is implementing RD&D, administrative, and to the extent possible, policy measures that are needed to achieve the estimated national geothermal utilization. In implementing Federal initiatives, proper timing with non-Federal activities is emphasized.

Progress Monitoring

Site-specific and regional geothermal development progress is being monitored to enable interpretation of early development indicators. Progress monitoring will thus allow enough time for corrective measures and Federal program redirection.

Coordination and Management

Geothermal activities of the Federal agencies are coordinated through the Interagency Geothermal Coordinating Council (IGCC). The Advisory Committee on Geothermal Energy, which is comprised of representatives of state and local governments and the private sector, provides recommendations from the non-Federal sector.

Coordination between Federal and non-Federal initiatives is achieved primarily by each of the Federal agencies involved, through their field organizations in cooperation with local, public and private entities.

FY 1977 Progress and Accomplishments with Multi-Regional Impact

In FY 1977, Federal Program initiatives focused on three types of interrelated activities that have national or multi-regional impact on commercial development. These activities are:

- resource exploration, assessment and confirmation,
- administrative and policy initiatives, and
- technology-related research and development.

Resource Exploration, Assessment, and Confirmation

Since early 1975, industry and government-sponsored drilling has confirmed many of the USGS geothermal resource estimates of Circular 726.* New estimates, which include additional sites, are being developed by the USGS.

In FY 1977, resource exploration, assessment and confirmation occurred at numerous sites, and new geothermal resource modeling and exploration techniques were developed. These activities will contribute to geothermal electric production of the mid- to late 1980s. However, additional resource exploration, assessment and confirmation activities are needed to achieve the national geothermal utilization estimates.

Administrative and Policy Initiatives

Leasing. The Federal government has jurisdiction over more than half of the nation's land that may have geothermal development potential. During FY 1977, the Bureau of Land Management issued competitive leases for 51 tracts totaling 80,809 acres and issued 230 noncompetitive leases for a total of 377,852 acres. These lease sales represent the coordinated activity of several Federal agencies including the Bureau of Land Management, the Geological Survey, the Forest Service and the Fish and Wildlife Service.

Permitting. To shorten the geothermal development process, significant steps have been taken at Federal, state and local levels to eliminate duplication of requirements among participating jurisdictions. At the Federal level, a policy of issuing leases with no-surface-occupancy stipulations was established. Congress proposed

*U.S. Department of the Interior, Geological Survey, Assessment of Geothermal Resources in the United States - 1975, USGS Circular 726, D.E. White, D.L. Williams, editors, 1975.

an amendment to the Geothermal Steam Act of 1970 that would more than double acreage holding limits for individual leaseholders, and would allow environmental assessments to proceed in phases on land leased from the Federal government.

The Federal government participated in a California initiative to coordinate Federal, state and county permitting procedures in that state. Federal agencies are cooperating in similar fashion with other states' agencies.

Loan Guaranties. Two loans for a total of $11.8 million were guarantied by the Federal government in FY 1977. Five other applications for loans totaling about $75 million are pending. Congress proposed amendments to the Geothermal Loan Guaranty Program (Title II of the Geothermal Research, Development and Demonstration Act of 1974, P.L. 93-410) that would make the Loan Guaranty program more flexible and responsive to the needs of borrowers and lenders.

Tax Policy. Economic analyses of geothermal prospects have shown that fiscal incentives (in combination with cost-reducing technology improvements) are needed at many prospects to make geothermal energy an economically competitive alternative. Several bills now before the Congress propose tax incentives including depletion allowances, the expensing of intangible drilling costs, and investment tax credits.

International Cooperation. To promote the international exchange of geothermal technology and development techniques, the U.S. has been participating in various cooperative efforts with other nations. Major cooperative activities in FY 1977 included the completion of a geothermal study by the NATO-Committee on the Challenges of Modern Society (CCMS), the exchange of information between the U.S. and Italy, and the signing of an agreement with Mexico.

Technology-Related Research and Development

Site-specific economic analyses have shown that the cost of geothermal energy production may be significantly reduced by improvements in technology for extracting geothermal fluids from the reservoir. (This includes drilling, well completion, and downhole pumping technology.) Drilling technology accomplishments in FY 1977 included the development of improved bearings and seals to extend the life of downhole drilling motors. Various drill bits, including a continuous chain diamond drill bit that could reduce hard rock drilling costs by more than 10 percent, were laboratory tested.

Improved resource utilization technology may further reduce geothermal energy production costs. A fluidized bed direct-contact heat exchanger that was laboratory tested in FY 1977 may reduce primary heat exchanger capital costs by as much as 60 percent. A fluted tube design that may provide similar capital cost savings for condensers, and polymer concrete materials were field-tested in FY 1977. Polymer materials replacing steel components may reduce the total costs of components in a geothermal electric plant by 20 percent.

A copper sulfate system that successfully controlled hydrogen sulfide air emissions from geothermal electric generation plants has been field-tested at The Geysers. Negotiations for a pilot scale facility are underway.

FY 1977 Regional Progress and Accomplishments

The Department of Energy has defined five tentative geothermal regions for program planning and implementation purposes. Regions 1 and 4 contain high-temperature hydrothermal resources that may support significant generation of electricity by 1985. Region 3 contains predominantly low- to moderate-temperature hydrothermal resources that may support extensive direct thermal utilization by 1985. Electric power may be generated in Region 3 if sufficient cost reduction occurs from technology improvements and policy initiatives. Region 2 contains geopressured resources that can produce energy in the form of dissolved methane, heat, and hydraulic pressure. Region 5 contains many lower-temperature geothermal resources which are believed to be best suited for direct thermal applications.

Table S-1 presents the regional geothermal electric development schedules postulated by the IGCC for planning purposes. A similar schedule for direct thermal utilization is being prepared.

FY 1977 accomplishments within each region are summarized below.

Region 1 - California and Hawaii

The only commercial-scale geothermal electric power in the United States is being produced at The Geysers steam field in California. Seven more sites are projected by the IGCC to produce power by 1985. Geothermal development is currently on or ahead of the anticipated schedule for the first plant at six of these sites.

TABLE S-1
SUMMARY OF GEOTHERMAL ELECTRIC SCENARIOS
POSTULATED BY THE IGCC FOR PLANNING PURPOSES*

Cummulative Commercial-Scale Generating Capacity (MW_e)**

	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990
Region 1 - California and Hawaii. (11 sites)	1680	1990	2210	2790	3765	4340	4990	5540	6340
Region 2 - Louisiana and Texas. (7 sites)	--	--	--	--	25	325	425	525	1025
Region 3 - Alaska, Idaho, Montana, Oregon, Washington, Wyoming. (8 sites)	--	--	--	--	--	100	250	250	750
Region 4 - Arizona, Colorado, Nevada New Mexico, Utah. (10 sites)	--	200	200	300	600	750	1150	1200	1900
United States Total***	1680	2190	2410	3090	4390	5515	6815	7515	10015

*The postulated generating capacities are based on current knowledge of the geothermal resources in the regions. The scenario is intended for planning purposes only and does not imply any commitment on the part of the Federal government to development at these sites.

**Pilot plants and test facilities have not been included in these totals.

***Region 5, the Eastern States, has not been included in this table because the Regions's geothermal resources are postulated to undergo only direct thermal utilization.

In FY 1977, initiatives to coordinate permitting and regulatory procedures were recommended by the California Geothermal Permitting Task Force. The California Energy Resource Conservation and Development Commission (CERCDC) drafted regulations (expected to be approved in FY 1978) that would promote geothermal development. Federal funds helped to support the four-county Geothermal Resources Impact Program Study (GRIPS), the Geothermal Element of the development plan for Imperial County, and the Imperial Valley Environmental Program for environmental monitoring.

In FY 1977, direct thermal development activities were occurring at Susanville and Desert Hot Springs, California. FY 1977 development activities at sites postulated to produce electric power by 1985 are summarized below:

- Brawley, California: Industry announced plans to construct a 10 MWe pilot plant.

- Coso, California: Federal participation has included test drilling by the DGE, geologic investigations by the USGS, and solicitation of industry interest in geothermal electric production by the Navy.

- East Mesa, California: Industry expressed interest for the construction of two 10 MWe pilot plants and a 36 MWe commercial power plant. The DGE constructed and began operation of a facility that is being used by industry, primarily for heat exchanger and corrosion research.

  The U.S. Bureau of Reclamation has been operating a pilot fluid desalination plant. Materials testing is being conducted by the U.S. Bureau of Mines.

- The Geysers, California: Industry announced plans to construct a 110 MWe plant to be completed by 1980. Other industry geothermal power plant construction was underway, and nine exploratory wells deeper than 2,000 feet were drilled.

- Heber, California: Financial negotiations for an electric plant are underway. A project jointly funded by DGE and industry analyzed the feasibility of direct thermal use for agricultural chemical processing.

- Mono/Long Valley, California: The CERCDC initiated a project to construct a geothermal space heating and snow melting system. The DGE sponsored hot dry rock research. USGS

assessment activities indicated that the hydrothermal system may be significantly hotter than previously estimated.

- Puna, Hawaii: DGE plans were underway to install a small wellhead generator of about 5 MWe capacity to be operational at an existing Puna well by 1979.

- Salton Sea, California: The Geothermal Loop Experimental Facility (GLEF), which is cosponsored by DGE and industry, tested a technique for separating and scrubbing steam from the highly saline fluid found in the Salton Sea reservoir.

Region 2 - Louisiana and Texas

Federal Program emphasis in Region 2 has been on defining the geopressured resource characteristics. In FY 1977, DGE sponsored the first geopressured well test. The test produced moderate-temperature fluids that were saturated with methane.

An environmental assessment of the Gulf Coast geopressured region established general zones of environmental suitability for geopressured development, and a USFWS study of the ecological implications of geopressured energy development was initiated.

In Texas, a geopressured reservoir which appears to have high commercial potential was delineated and a drilling contract was awarded.

Region 3 - Alaska, Idaho, Montana, Oregon, Washington, Wyoming

Because the identified geothermal resources in Region 3 are predominantly of low to moderate temperature, primarily space heating and industrial applications are expected by 1985.

Resource assessment activities in FY 1977 included the USGS identification of a potential geothermal resource on Adak Island, Alaska. In Idaho, the USGS has provided more accurate estimates of the temperature and extent of resources at Raft River and the Snake River Plain.

Most of the development accomplishments in Region 3 have been for direct geothermal applications. Shallow wells in Klamath Falls (Oregon) and in Boise (Idaho) are supporting numerous individual residential and business heating systems. In FY 1977, development activities occurred at:

- Boise, Idaho: A district geothermal heating system for the downtown area is being designed.

- Mount Hood, Oregon: A program was proposed for geothermal space heating at a ski lodge. Production drilling for a district heating system began.

- Raft River, Idaho: In FY 1977, a preliminary design for a DGE-sponsored experimental plant (that would generate electricity from the moderate-temperature resource) was completed; baseline environmental data were collected, and three production wells and one injection well were completed.

  Geothermal fluids were used successfully for irrigation. Industry started a study to determine the feasibility of processing food by using the waste heat from the Raft River geothermal electric plant.

Region 4 - Arizona, Colorado, Nevada, New Mexico, Utah

Extensive production of electricity from geothermal resources is expected in Region 4. The first commercial-scale electric production is postulated to begin at four sites in 1983.

In FY 1977, more Federal land was leased in Region 4 than in any other region. The USGS refined previous resource estimates of the Battle Mountain region, identified a potential high-temperature and hot dry rock resource in Arizona, and confirmed numerous low- to moderate-temperature reservoirs in Colorado. The USGS determined that subsurface temperatures of 155°C may exist in western Utah. A cooperative USGS/State program found indications of temperatures in excess of 200°C in New Mexico.

Development for the first electric plant at each of the sites postulated for geothermal electric power production by 1985 is proceeding as anticipated by the IGCC. The development status at each site is summarized below.

- Beowawe, Nevada: By the end of FY 1977, at least 13 wells had been drilled and temperatures greater than 200°C were encountered.

- Brady Hot Springs, Nevada: By the end of FY 1977, numerous wells, some with bottom-hole temperatures greater than 200°C, were drilled. A loan guaranty application to construct a vegetable dehydration plant was submitted to DOE. (It was approved in October 1977.)

- Cove Fort/Sulphurdale, Utah: In FY 1977, drilling was being conducted by industry.

- Roosevelt Hot Springs, Utah: In January 1977, industry announced that one of the existing wells could produce sufficient steam to generate 12.5 MWe.

- Steamboat Springs, Nevada: By the end of FY 1977, at least 15 wells had been drilled. Geothermal space heating was occurring.

- Thermo, Utah: Applications for Permits to Drill (APDs) were submitted to the USGS, and one plan of operation was approved. (Drilling is expected to begin in early FY 1978.)

- Valles Caldera, New Mexico: At least nine high-temperature, high-flow rate wells have been drilled at the site. In FY 1977, negotiations were underway to sell steam to the utilities.

  The Department of Energy has been conducting hot dry rock experiments at Fenton Hill (in the Valles Caldera KGRA). A thermal energy extraction loop was operated for approximately 100 hours in September 1977.

FY 1977 activities at Socorro Peak (New Mexico), Desert Peak and Soda Lake (Nevada), indicate that these three sites may be incorporated into future electric scenarios.

Region 5 - The Eastern United States

Geothermal development activity in Region 5 was far greater in FY 1977 than in any previous year. For the first time, the BLM has issued geothermal leases in the region. The vast number of low-temperature resources underlying populated areas have the potential for widespread direct thermal utilization.

In FY 1977, most of the geothermal development activity in the Region was for resource exploration, assessment and confirmation. It was determined that the fluids contained in sediments overlying eight large granitic bodies may be useable for direct thermal applications.

In FY 1977, a joint Federal/State of Georgia project was initiated to measure temperatures and recover cores in an existing oil and gas well near one of the granitic bodies in Georgia. A joint Federal/State of Mississippi project was initiated to survey existing oil and gas drilling data for indications of a geothermal resource. A joint Federal/State of South Dakota study was initiated to assess the Madison Aquifer, which is an identified thermal resource. A school district initiated planning activities to utilize the Madison

Aquifer geothermal resource for space heating. Geothermal space heating in the Hot Springs National Park, Arkansas, was planned.

Projected FY 1978 Accomplishments

Geothermal development by industry is expected to accelerate in FY 1978. In addition, the number of sites where geothermal development is feasible will increase as a result of various Federally-funded projects.

The DGE plans to award a contract for a cost-shared geothermal electric demonstration plant. Successful operation of the demonstration plant is expected to have a major impact in stimulating the public's confidence in geothermal development. Other efforts to increase public confidence will include the initiation of several Federally sponsored direct-use field experiments.

Federally-sponsored technology development will include the first field applications of the diamond chain bit drill and 1 MWe helical screw expander, and the design and testing of a 500 kW power conversion system which uses a direct-contact heat exchanger.

In Region 1, five competitive lease sales of Federal land are planned by BLM. Construction and operation of the Magma Power Company's 10 MWe binary plant at East Mesa is expected to occur in FY 1978.

In Region 2, the DGE will sponsor tests of four to six existing wells. The first well designed specifically for testing geopressured aquifers will be drilled and tested in Brazoria County, Texas. An additional well will be drilled in Louisiana late in FY 1978.

In Region 3, the USGS will assess geothermal resources in Oregon and Idaho. Construction of the first 40 MWth (5 MWe equivalent) thermal loop is expected to begin at Raft River, Idaho.

In Region 4, construction of a geothermal vegetable dehydration plant will be completed at Brady Hot Springs, Nevada. Cooperative Federal-industrial exploratory drilling is planned to begin at Cove Fort/Sulphurdale, Utah. Construction of a 52 MWe plant at Roosevelt Hot Springs (Utah) will be negotiated by industry. At Fenton Hill a thermal loop that will extract heat from hot dry rock will be operated for approximately 8 months.

The search for, and evaluation of geothermal resources in the Region 5 sedimentary basins will continue in FY 1978. A preliminary development scenario will be completed for direct thermal applications in western South Dakota.

Future Federal Activities in FY 1979 and Beyond

In FY 1979, geothermal electric pilot plants should be operating at Puna (Hawaii), Raft River (Idaho), East Mesa and Brawley (California); and direct thermal utilization may begin at a number of sites including Mono/Long Valley (California), Mount Hood (Oregon) and downtown Boise (Idaho). Technologies that are currently being tested in DGE-sponsored projects, including magnetotelluric exploration technology, Compax™ diamond and continuous chain drill bits, are expected to be commercially available in FY 1979. The Bureau of Mines project to evaluate the corrosion and scaling resistance of commercially available metals and alloys in geothermal brine environments will be completed, and results will be made available to industry. Results from current regulatory coordinating efforts should also be in effect by FY 1979.

Power from the first commercial-scale electric plants using liquid-dominated hydrothermal resources is expected in the early 1980s. Commercial-scale geothermal electric plants may be operating at Roosevelt Hot Springs (Utah) and East Mesa (California) in 1981 or 1982.

Federally sponsored deep exploratory drilling is planned to begin in FY 1979 at Mount Hood (Oregon) and in the Snake River Plain (Idaho) in Region 5. These activities, if successful, will confirm the existence of additional geothermal resources that industry may use to produce electric or direct thermal power in the second half of the 1980s.

Testing of the binary cycle heat exchanger will begin in FY 1979 at Raft River, Idaho. If the tests are successful, the generation of electricity from moderate-temperature hydrothermal resources may be economically feasible in the late 1980s.

Hot dry rock utilization may be economically feasible by the late 1980s as a result of technology that is currently being developed by the DGE at Fenton Hill, New Mexico.

Federally sponsored activities in the Gulf Coast region are expected to enable industry to produce methane and electric power from the geopressured resources around 1986.

NATIONAL GEOTHERMAL UTILIZATION ESTIMATES

The pace of geothermal development by industry has been increasing. This increase is reflected in the drilling of deep exploratory wells and in the leasing of Federal land: both activities were greater in FY 1977 than in any previous year. More than 500 MWe are being produced from a vapor-dominated geothermal resource in California, and geothermal space heating is occurring at a number of locations in the western United States. In FY 1977, industry announced numerous plans to use geothermal resources for additional generation of electricity, and for space heating and industrial process heat.

Table I presents the IGCC's estimate of the achievable commercial utilization of geothermal resources in the United States. These estimates incorporate knowledge of existing and planned geothermal development, and the vast quantity of developable geothermal resources in the United States. Achievement of these estimates will require a national effort, primarily by the private sector, but supported by local, state and Federal governments.

This report describes primarily those activities that are a part of the Federal Geothermal Energy Program. While the extent of these activities is only a small share of the total effort needed to achieve the national geothermal development goals, they have been planned to provide assistance at key points in the development process.

TABLE I
NATIONAL GEOTHERMAL UTILIZATION ESTIMATES

	1985	2000	2020
Electric Capacity (MW)	3,000-4,000*	20,000-40,000	70,000-140,000
Electrical Applications (Equiv. fossil-fuel energy in quads/year)***	.2-.3**	1.5-3.0*	5.0-10.0*
Direct-thermal Applications (quads/year)	.1-.2	.5-2.0	6.0-8.0
Geopressured Methane (quads/year)	0-.02	2.0-4.0	5.0-10.0
TOTAL (quads/year)	.3-.5	4.0-9.0	16.0-28.0

*Based on utilization of reservoirs with temperatures of approximately 180°C or greater.

**Calculations are based on an assumed capacity factor between 0.65 and 0.85, and an efficiency equivalent of fossil-fuel plants of 0.3 to 0.4.

***1 Quad = 1.0×10^{15} BTU. 1 Quad per year = approximately 0.5 million barrels of crude oil per day.

FEDERAL GEOTHERMAL ENERGY PROGRAM OBJECTIVE

The objective of the Federal Geothermal Program is to stimulate private and local power authorities to develop geothermal resources as reliable, operationally safe and environmentally acceptable energy sources for the production of electricity and direct heat applications. To achieve this objective, the Federal Government is implementing research, development and demonstrations (RD&D) initiatives, and administrative and policy initiatives. These Federal initiatives are properly timed with initiatives of non-Federal entities.

FEDERAL GEOTHERMAL ENERGY PROGRAM STRATEGY

The Federal geothermal program strategy consists of four major thrusts.

First, the program is targeted at reduction of uncertainty in assessments of the available resource base, on both regional and site-specific scales.

Second, the program is intended to stimulate the commercial development of hydrothermal resources by the mid-1980s with rapid growth through the year 2000. Strategic elements for accomplishing this end include: (a) an RD&D program to reduce technological and environmental risks, (b) a loan guaranty program to reduce lenders' risks and (c) deployment of policy measures to reduce institutional uncertainties.

Third, the program includes measures for stimulating the initial development of geopressured resources by the mid 1980s, and encouraging continued growth.

Fourth, the program includes the performance of advanced technological research and development, and the provision of other incentives required for initial development of the very large hot dry rock resource base in time for rapid development around the turn of the century by a then maturing geothermal industry.

FEDERAL PROGRAM PLANNING, IMPLEMENTATION AND PROGRESS MONITORING

Plans for accomplishing the program objectives have been concerned principally with developing economically viable and environmentally acceptable technology and reducing institutional barriers to help make geothermal energy competitive with available alternate energy resources.

Over the past two years, the Federal approach toward stimulating geothermal energy resource development has shifted from a program of many relatively independent research and development projects that provided the basic technology for resource extraction and utilization, to a mission-oriented program aimed at accelerating the commercial utilization of actual geothermal reservoirs. This mission-oriented approach includes planning, implementation, and monitoring of the time-phased, interrelated activities (both technical and nontechnical) that are needed to produce electricity and to utilize direct heat in commercial quantities from geothermal resources.

To form a basis for this approach, estimates of the achievable commercial utilization potential have been formulated. These estimates were derived from prospect-specific scenarios that were developed by assessing industry activity and the need for technological or institutional initiatives at the Federal, state, and local levels. The scenarios, together with an estimate of the potential contribution of new discoveries, provide a realistic estimate of achievable levels of geothermal energy utilization in the United States.

The Federal Government is working closely with state and local governments, industry, municipal authorities, and environmental and other public interest groups to identify alternative public and private initiatives that will most effectively encourage investment in geothermal energy and promote public acceptance of its development. Information will be gathered on a prospect-specific basis and then aggregated to provide the data base for regional and national mission-oriented planning. Annually-updated geothermal development scenarios will provide the data base for making decisions about required government resources, their allocation, and priorities among various program initiatives.

The mission-oriented approach to program planning, implementation, progress monitoring and overall coordination and management was adopted to place primary focus in achieving environmentally acceptable utilization of geothermal energy resources as early as possible. The following is a more detailed description of the mission-oriented approach adopted for planning, implementing and progress monitoring activities of the Federal geothermal program.

Program Planning

Major geothermal energy prospects within each region are identified from the results of regional resource assessment activities and site-specific reservoir confirmation studies. Development scenarios*

*An achievable pace of development delineated in the form of incremental addition of energy production capacity for both electric and direct thermal utilization.

for each of these prospects are then formulated through collective regional planning, with direct participation of Federal, state and local government entities, industry, and community interest groups. With the prospect development scenario as a framework, all public and private activities which are required to realize these scenarios, are identified by type of activity, magnitude, and schedule. Needed Federal RD&D, administrative actions (e.g., land leasing, management and loan guaranties), and regulatory and legislative policy measures are aggregated at the national level to provide a basis for formulating (and updating) the Interagency Geothermal Coordinating Council's comprehensive Federal program plan for geothermal energy development. This enables maximum coordination of activities not only with the the Federal program but also with activities of the non-Federal sector. In FY 1977, priorities for Federal Agency activities were established through these Federal Program Planning Activities.

These priorities for program implementation are established primarily by selecting Federal initiatives which will maximize power production at the earliest possible time. It is expected that hydrothermal resource development will affect the formation of an industry infrastructure capable of exploiting the more advanced geothermal resource types (geopressured and hot dry rock). Resource assessment and technology development required for exploiting these resource types are being pursued to ensure the sustained growth of

geothermal utilization beyond the time frame for peak hydrothermal resource utilization.

Program Implementation

Implementation of Federal initiatives so that they are properly time-phased with initiatives of non-Federal entities will continue to be an important aspect of the Federal Program. These initiatives include RD&D, administrative, and to the extent possible, policy measures that are needed to realize the development scenarios. Academic community, not-for-profit research laboratories and direct industry involvement in the Federal RD&D program implementation are emphasized. This is accomplished via contracts, grants and cost sharing on RD&D projects. The direct involvement of industry in the program will minimize the time required for technology transfer and commercialization. Cost sharing with industry is helping to leverage the Federal expenditures in RD&D and maximize the overall quality of program implementation.

Progress Monitoring

The mission-oriented program philosophy requires continuous progress monitoring and program updating. This is accomplished via regional monitoring activities which are implemented by the appropriate DOE Operations Offices.* Progress made within the Federal program and the response of non-Federal entities toward achieving the

*Both regional planning and progress monitoring are implemented by the appropriate DOE Operations Offices supported by Regional Operations Research Contractors.

regional (and hence the national) targets for geothermal energy utilization are also monitored. The progress monitoring is conducted in a manner so as to enable interpretations of early development indicators, thereby allowing enough time for corrective measures and Federal program redirection.

Coordination and Management

Coordination and management of the Federal program are affected both in the field, via DOE and other agencies' regional and field offices, and in Washington, D.C. via the Interagency Geothermal Coordinating Council (IGCC) and its suborganizations, and the Advisory Committee on Geothermal Energy.

Coordination between Federal and non-Federal initiatives is primarily achieved by each of the Federal agencies involved, through their field organizations in cooperation with local, public and private entities.

ORGANIZATION OF THE REPORT

Throughout this report, industry, academic, Federal, state and local government initiatives for geothermal electric generation and direct use have been presented as interwoven, interdependent elements. These elements are working together to maximize geothermal development in an environmentally and socially acceptable manner.

The remainder of this report is presented in three sections:

(1) current geothermal development status, with emphasis on FY 1977 activities;

(2) activities expected to occur in FY 1978; and

(3) activities that are to occur beyond FY 1978.

Discussions for each of the above are focused on national, regional and site specific initiatives. The discussion of FY 1977 site-specific accomplishments includes conclusions on whether development is occurring as postulated by the IGCC for the first electric plant at the site. (Development activities for the first electric plant at a site are not necessarily adequate for subsequent plants that may require additional leasing, permitting, and development activities.)

NATIONAL PROGRESS AND ACHIEVEMENTS

Three interrelated types of Federal Program initiatives that may have national or multi-regional impact on commercial geothermal development have been identified. These initiatives focus on:

- resource exploration, assessment and confirmation,
- institutional support, and
- technology-related research and development.

The following is a discussion of the FY 1977 activities in each of the three areas.

Resource Exploration, Assessment and Confirmation

Attainment of the estimated national geothermal electric and direct thermal (nonelectric) utilization will require the identification and characterization of an appropriate number of prospective resource locations.

A DGE estimate of the heat energy that may be extracted from the nation's geothermal resources is presented in Table II. These estimates are based on the total heat content of the U.S. geothermal resources as presented in USGS Circular 726*. The USGS is preparing new resource estimates that will reflect results of the numerous exploration, assessment and confirmation activities that have occurred recently.

*U.S. Department of the Interior, Geological Survey, Assessment of Geothermal Resources in the United States - 1975, USGS Circular 726, D.E. White, D.L. Williams, editors, 1975.

TABLE II

ESTIMATED RECOVERABLE HEAT FROM GEOTHERMAL RESOURCES USING PRESENT OR NEAR-TERM TECHNOLOGY, WITHOUT REGARD TO COST (IN QUADS)*

RESOURCE TYPE	KNOWN	INFERRED
Hydrothermal Convective**		
Vapor Dominated (>150° C)	2	2
Liquid Dominated		
High Temperature (>150° C)	20	110
Moderate Temperature (90° - 150° C)	80	250
Geopressured		
Electrical Utilization	100	230
Methane Production	500	1500
Hot Dry Rock		
Scenario I+	80	240
Scenario II++	600	1900
TOTAL		
Scenario I+	~782	~2,332
Scenario II++	~1302	~3,992
GRAND TOTAL (Known plus Inferred)		
Scenario I+	3114 Quads	
Scenario II++	5294 Quads	

*Normal Gradients are not included at this time as they are not presently considered recoverable. 1 Quad = 1.0×10^{15} Btu's.

**Does not include less than 90° C systems, although such systems may be economically exploitable especially for direct thermal applications.

+Scenario I: Assuming 2% Extraction Recovery, 8% Conversion Efficiency.

++Scenario II: Assuming 12.5% Extraction Recovery, 10% Conversion Efficiency.

Source: Definition Report - ERDA-86, October 1975, Energy Research and Development Administration, Division of Geothermal Energy, Washington, D.C. 20545.

The DGE has estimated that approximately 20 liquid-dominated hydrothermal reservoirs with temperatures of approximately 180°C or higher are needed to attain the estimated national utilization potential of 3,000 to 4,000 MWe by 1985. Approximately 2,000 MWe of this will be supplied by The Geysers, California, steam field. Exploration activities have occurred at all of the sites where electric power production is postulated to occur by 1985. However, at many of these sites, the geothermal fluid temperature at depth, flow rates, and predicted longevity must be confirmed.

Geothermal electric generation postulated by the IGCC to occur in the late 1980s will require a substantial increase in the number of prospective resource locations. Because of the 8 to 10 years' lapse between initial exploration and the production of geothermal electric power, exploration, assessment, and confirmation of a geothermal resource must be underway now or initiated very soon at each location to meet the geothermal electric generation estimates of the late 1980s.

Federal initiatives to encourage resource exploration, confirmation and assessment include leasing of land to industry and providing capital (through cost-sharing, loan guaranties and tax incentives). These Federal initiatives are summarized later, in the discussion of institutional support activities. The DGE and USGS have been sponsoring projects to identify geothermal resources with development potential. These projects are described under regional and site

specific accomplishments. Other projects are being sponsored to improve resource exploration, assessment and confirmation techniques. These improved techniques will reduce:

- uncertainties concerning geothermal resource characteristics,
- the number of wells required to define a resource,
- the geothermal development costs, and
- the demand for drilling rigs.*

FY 1977 accomplishments that will contribute to reductions in these four areas are summarized below. Additional reductions will result from drilling accomplishments that are discussed under "Technology-Related Research and Development."

1. Geothermal "mixing" models, which assume a mixture of waters from more than one source in a geothermal system, were developed by the USGS to estimate subsurface temperatures more accurately. This represents an advance beyond previously available geothermometers that were based on mineral constituents of water samples.

2. A helium survey exploration technique for identifying hidden geothermal systems was demonstrated by the USGS at several geothermal locations in California, Utah, Colorado, and Wyoming. USGS success prompted several private companies to test this relatively inexpensive technique at their own geothermal locations.

3. Tests were begun by USGS on a downhole heat flow probing system that allows data from the probe to be reduced at the site so that heat flow calculations can be completed immediately. In addition, DGE sponsored the development of downhole instrumentation that could withstand temperatures as high as 275°C.

4. Several investigations were initiated by the USGS and the DGE to evaluate seismic wave analyses as passive methods

*Due to the expanded activities of the oil and gas industry, there is a shortage of rigs for geothermal drilling.

for determining the structure of geothermal systems. P-wave delays are useful in defining potential magma chambers and partial melt zones, which are the heat source for geothermal reservoirs.

5. The USGS and the DGE sponsored projects and field tests to improve the accuracy of magnetotelluric and audiomagnetotelluric techniques. (These surface techniques are used to detect geophysical anomalies that would indicate probable geothermal resources.)

6. DGE-sponsored reservoir engineering models were established to allow calculation of reservoir capacity. (These models have been applied to reservoirs at Raft River, Idaho, East Mesa, California, and Larderello, Italy.)

7. The USGS developed methods to predict the thermodynamic properties of complex geothermal brines, when given the chemical analysis and the temperature of a brine. These methods will improve the accuracy of geothermal reservoir appraisals.

8. The DOE/Division of Engineering, Math and Geosciences studied the flow of geothermal fluids through crystalline rocks of low permeability. Results of this study may be used to characterize geothermal reservoirs in crystalline formations.

Institutional Support Activities

Institutional support activities of the Federal Geothermal Program focus on national leasing and permitting procedures, economic studies and incentives, information dissemination, and international cooperative programs.

Leasing and Permitting Activities

Leasing and permitting activities are critical elements in the Federal Geothermal Energy Program because 59 million acres that may have resources suitable for electric power generation and direct thermal applications are under Federal jurisdiction.

The Federal government has been leasing land for geothermal development. In FY 1977, 13 competitive geothermal lease sales for 142,107 acres were conducted, and competitive leases for 51 tracts totaling 80,809 acres were issued. Within the same period, 230 noncompetitive geothermal leases were issued for a total of 377,852 acres. These lease sales represent the coordinated involvement of several Federal agencies operating under a formal memorandum of understanding. Included in the tripartite agreement are the Department of the Interior's (DOI) Bureau of Land Management (BLM), which has lead responsibility for leasing Federal lands; the DOI's United States Geological Survey (USGS), which participates in the evaluation and selection of lands for leasing; and the DOI's United States Fish and Wildlife Service (USFWS), which provides biological data and technical review of environmental assessment reports (EARs) on all public land.

In the past year, the Department of Agriculture's United States Forest Service (USFS) entered into an agreement with the aforementioned agencies. For all of its lands, the USFS provides prelease environmental assessments and issues permits for geological and geophysical assessment.

Approximately 17 million acres of National Forest System lands have known or potential value for geothermal development. Of the 37 prospects in the IGCC geothermal electric development scenarios, seven include National Forest System lands. During FY 1977, the U.S.

Forest Service completed environmental statements for two prospects and worked on statements for the other five. (The five are expected to be complete by the end of FY 1979.)

Additional permitting accomplishments in FY 1977 include USGS approval of 10 Applications for Permits to Drill and 11 Plans of Operation for geothermal development on Federal lands. (Each permit or plan may include numerous wells.)

The need to reduce time required for geothermal licensing and permitting has been expressed in the following statement by the National Research Council's Committee on Nuclear and Alternative Energy Systems*:

> Geothermal energy systems are highly capital intensive and the period between initial investment and return is long and, under present circumstances, very uncertain. Considering only prudent engineering and construction, about 5 years should normally be required between the discovery of a reasonable high-grade reservoir and production of electricity from it. However, obtaining the approvals, licenses, and certifications required at various stages of development is likely to extend this period by an additional 2 to 5 years or more.

Some reduction in geothermal development time is expected to occur as people in industry and government gain experience with regulatory procedures. Additional reductions in geothermal development time may be achieved by coordinating the regulatory requirements of Federal, state and local governments.

The IGCC's Institutional Barrier Panel (IBP) has been active in identifying inadequate or overlapping Federal, state and local

*"Preliminary Report on Geothermal Energy", March 1977.

regulations. Many achievements of the Federal agencies and legislative proposals included in this report are the direct result of IBP recommendations.

Regulatory achievements in FY 1977 include the U.S. Forest Service and the U.S. Bureau of Land Management agreement on a policy of issuing no-surface-occupancy leases for Forest Service lands. Prelease environmental reviews will not be required for these Forest Service lands. (No-surface-occupancy leases will be used primarily where Federal lands are interspersed with state and private lands. They serve as an incentive to development of state or private land by assuring the developer that, if his activities are successful, adjacent Federal land prices will not be driven up and leased or developed by a competitor.) The no-surface-occupancy policy was implemented for the first time at Mount Hood, Oregon, in August 1977.

A substantial legal issue that was addressed in FY 1977 concerns the ownership of geothermal resources on lands patented under the Stock Raising Homestead Act of 1916. The Federal ownership of these resources was questioned by Union Oil in U.S. vs Union Oil Company et al. The U.S. district court ruled that "minerals," which are reserved by the Government, do not include geothermal resources. The U.S. appealed this decision. The 9th Circuit Court of Appeals reversed the ruling of the district court, holding that geothermal resources were equivalent to other leasable minerals. The Union Oil

Company petitioned the Supreme Court for review of this decision but the review was denied.*

Other legislative initiatives in FY 1977 included tax incentive and loan guaranty proposals (discussed later under "Economic Studies and Incentives"). The U.S. Congress proposed amendments (H.R. 6942) to the Geothermal Steam Act of 1970 that would:

1. Allow an individual leaseholder to lease up to 51,200 acres of Federal land in a single state. (Leaseholders are currently limited to 20,480 acres per state),

2. Allow environmental assessments for geothermal development to proceed in phases on land leased from the Federal government, and

3. Ensure that lessees will have access to transmission lines or transmission rights-of-way that are on public lands in the general area of the leasehold.

Various efforts were underway in FY 1977 to establish standards that would reduce industry uncertainties regarding environmental requirements for leasing and permitting. The DOE's Environmental Development Plan for Hydrothermal Energy Systems FY 1977 (EDP/G 01 (77), June 1977) identified environmental, health, safety, social and economic issues associated with hydrothermal development, and proposed actions to resolve the issues. The DOE also began a project to create uniform techniques for monitoring the environment at DOE-sponsored geothermal facilities.

The EPA drafted prototype guidelines for pollution control. This is a step in developing formal guidelines for permissible levels

*A petition to the Supreme Court was resubmitted on January 11, 1978 (Albert Ottoboni vs. U.S., Docket 76-1796).

of emissions from commercial geothermal facilities. The prototype guidelines were reviewed by the IGCC member agencies, and the EPA is preparing a revision for public comment.

The U.S. Fish and Wildlife Service has been developing techniques to predict probable effects of commercial-scale geothermal development on fish and wildlife.

Economic Studies and Incentives

The Federal Geothermal Program has been sponsoring various efforts to improve the economics of geothermal development by industry.

Federally-sponsored studies have been determining the economic feasibility of various geothermal applications. In FY 1977, geothermal cost models and projections were developed by national laboratories, and the regional and national contractors. In addition, DGE sponsored 18 general and site-specific feasibility studies on direct-thermal utilization. The findings of the general application studies are:

1. In absorption refrigeration in the food processing industry, a topping cycle can be used with geothermal resources. The geothermal fluid temperatures required for different absorption refrigeration cycles were identified.

2. In the evaporation and crystallization industry, the technical and economic feasibility of direct geothermal applications were evaluated for three selected industries: preserved fruits and vegetables (tomato paste processing), sugar and confectionery products (sugar beet refining), and the chemical industry (sodium chloride production). Geothermal resource characteristics (well flow, temperature, and distance of transportation), the duration of the evaporation/crystallization process, and the type of energy extraction process were concluded to have the greatest impact on cost.

3. In the near future, the direct use of geothermal energy in industrial complexes can be economical for processing wood in the Northwest, caustic/chlorine products in California, and corn products in Idaho. Other potential applications of geothermal heat may include soda ash production in California, alumina compounds and potassium sulfate in central Utah, and soda ash, shale oil and aluminum in central Utah.

The DOE-sponsored Loan Guaranty Program received its first loan application in October 1976 when funding appropriations were made available. In FY 1977, the DOE received seven applications for loan guaranties: two applications for a total of $11.8 million were approved for drilling at East Mesa, California, and for a geothermal food-drying plant at Brady Hot Springs, Nevada. The other applications are for loans totaling approximately $75 million. The money would be used for drilling exploration and production wells, primarily in New Mexico, Utah, and California.

In FY 1977, Senate bill 1340 proposed amendments to the Title II Geothermal Loan Guaranty Program of the Geothermal Research, Development and Demonstration Act of 1970 (P.L. 93-410). The amendments would make the Loan Guaranty Program more responsive to industry needs by:

1. Allowing a guaranty to cover 75 percent of the total costs of a direct thermal utilization project when its economic viability is dependent upon the performance of the geothermal reservoir,

2. Raising the guaranty limits from $25 million to $50 million per project for direct thermal applications, up to $100 million for electric applications, and from $50 million to $200 million per borrower,

3. Allowing interest differential payments for guaranties on taxable borrowing by states, municipal utilities or other political subdivisions of states, or Indian tribes,

4. Pledging the full faith and credit of the United States to the payment of guaranties,

5. Allowing interim payments of principal and interest to avoid defaults on worthwhile projects, and

6. Providing for borrowing authority by the Administrator to meet default payments rapidly.

Other fiscal incentives proposed by Congress in FY 1977 include H.R. 8444 and five separate Senate bills that would provide geothermal developers with:

- an investment tax credit,
- a depletion allowance, and
- expensing of intangible drilling costs.

Some form of subsidies are needed to encourage near-term industry activities and to attain the national geothermal utilization estimates.

Information Dissemination

The Federal government has promoted the exchange of information through various media including the IGCC, State Permitting Task Forces, Regional Contractors' symposia and seminars. The results of Federally-sponsored projects are announced in industry and government publications. In addition, the National Science Foundation (NSF) has been administering several scientific and technical education programs in geothermal and related energy areas: in FY 1977, the NSF funded 3 Postdoctoral Fellowships in geothermal research, and 25 Graduate Traineeships in related energy research.

In FY 1977, DGE issued a Request for Expressions of Interest in a commercial-scale demonstration plant. Several companies responded; and on September 30, 1977 the DGE released a Program Opportunity Notice.* Pilot plants and test facilities that are being sponsored by DGE (at Raft River, Idaho, and Salton Sea and East Mesa, California), and the planned demonstration plant should provide industry with significant technical and economic information.

International Cooperation

Cooperative geothermal activities of the United States and other nations enhance the DOE's ability to develop and demonstrate a wide range of energy options and will contribute to the development of markets for U.S. geothermal technology.

Cooperative activities have included both bilateral agreements with individual countries and multilateral programs under the aegis of international organizations such as the International Energy Agency (IEA) and the NATO Committee on the Challenges of Modern Society (CCMS). In FY 1977, the U.S. contributions to the NATO Committee on the Challenges of Modern Society (CCMS) included the training of foreign scientists at the hot dry rock experiments at Fenton Hill (New Mexico), the completion of a set of guidelines for a 5 MWe geothermal power plant, and the analysis of economic models for district heating. Other U.S. cooperative activities have been continuing under individual geothermal development agreements with Italy

*Prospective companies must submit demonstration proposals by February 2, 1978. DGE plans to select a contractor in March 1978.

and Iceland. In July 1977, a 5-year agreement with Mexico for reservoir analysis in the Salton Trough was signed. A U.S./Federal Republic of Germany bilateral agreement and the geothermal portion of a U.S./Japan Agreement on Energy R&D were approved in principle in FY 1977.

Appendix B provides additional information on these and other international projects.

Technology-Related Research and Development

In FY 1977, engineering R&D efforts to reduce technology-related geothermal production costs focused on:

- drilling technology,
- utilization technology, and
- environmental control technology.

Projects in each of these areas address problems that must be solved to achieve the estimated national geothermal utilization. Near-term projects should have an impact on commercial development costs in the next two to five years. Longer-term projects may contribute to near-term work, but are expected to have their major impact on development after 1982.

Drilling Technology

Existing geothermal drilling technology has been adopted from the oil and gas industry. In many respects, this technology is inadequate or uneconomical for the severe downhole environments found in geothermal reservoirs. These environments commonly include high pressures, high temperatures, corrosive brines, and hard crystalline rocks.

The Federal Geothermal Drilling Program is emphasizing the improvement of existing drill bits, downhole motors, and drilling fluids. The most important FY 1977 efforts to reduce near-term drilling costs included:

- Final laboratory testing of roller cone drill bits that are expected to last about three times longer than conventional bits in geothermal environments,
- Laboratory testing of the Compax™ diamond bit. These synthetic industrial pellets provide a more economical means for cutting into hard rock formations,
- Design and laboratory testing of a diamond chain drill bit capable of high penetration rates in hard igneous rocks (that are typical in many geothermal areas). This bit hydraulically advances an indexed chain to bring new cutting surfaces into place downhole without the costly removal of the entire drill string. The concept, if completely successful, can reduce total drilling costs by 10 percent or more.
- The development of improved bearings and seals for downhole motors. Improved bearings and seals should extend the operation time of downhole motors which may be used for drilling and for pumping geothermal fluids out of a well.

Utilization Technology

Improvements in the technology required to utilize geothermal resources can prolong reservoir life and can achieve significant reductions in the capital, and operation and maintenance (O&M) costs of geothermal installations. These benefits can be derived from the development of improved scaling and corrosion control, advanced heat exchanger and energy conversion systems, and methods to stimulate the production of fluids from a well.

In FY 1977, scaling and corrosion control projects focused on geothermal fluid chemistry and the development of materials.

Water utilization, fluid control, and fluid chemistry projects that were underway in FY 1977 are expected to improve geothermal fluid management and disposal in the near-term.

Research in new materials should provide near-term benefits through the development of new high-temperature elements for geothermal well completion, less expensive materials for construction for geothermal power plants, and improved elastomers for seals, packers, logging cables and blow-out preventers. Laboratory and field tests in FY 1977 confirmed that high-temperature epoxies and polymers have a lower permeability and a higher strength than standard well cementing materials. By using low-cost polymer concrete materials to replace steel components, the total cost of components in a geothermal electric plant may be reduced by 20 percent.

Advanced heat exchanger developments in FY 1977 included work on direct-contact heat exchangers, fluidized-bed heat exchangers, organic working fluids, and heat rejection techniques. The development of advanced energy conversion systems included work on conversion machinery such as the helical screw expander, the geothermal rotary separator, and wellhead generator systems. Downhole pumps and well stimulation techniques are being developed to increase production from geothermal wells.

The significant heat exchanger, energy conversion system, and downhole pump accomplishments that occurred in FY 1977 are summarized below:

Heat Exchangers:

- Field tests of a direct-contact heat exchanger at the East Mesa test facility were completed in August 1977. Follow-on tests were initiated to establish commercial design criteria by September 1978.

  The direct-contact system has the potential of reducing capital costs of heat exchangers by 60 percent. The system employs a heat exchanger in which droplets of immiscible secondary fluid absorb heat directly as they flow through the hot geothermal fluid. The system provides a reliable solution to scaling and heat exchanger fouling which are major technical problems in using some geothermal fluids.

- Successful laboratory tests of a fluidized-bed self-cleaning heat exchanger were completed in FY 1977. This heat exchanger will reduce costs associated with scaling and corrosion control. Plans were initiated to field test this heat exchanger as part of an experimental thermal loop at Raft River, Idaho.

- A fluted tube condenser component test began in late FY 1977 at the East Mesa test facility. This new configuration of heat exchanger tubing is expected to improve heat transfer efficiency.

Energy Conversion Systems:

- The helical screw expander was prepared for field testing. This conversion system is designed to improve thermal efficiency by accommodating steam and hot water mixtures from the geothermal resource.

- Computer codes and equations-of-state for working fluids were developed to identify optimum binary cycle parameters. As a result of this effort, plans were initiated late in FY 1977 to award a design contract for development of an improved binary turbine.

Downhole Pumps:

- Two projects were being conducted in advanced downhole pump technology. These efforts were directed at providing improved geothermal fluid transport pumps for industry and DOE use by December 1977. Pumping the fluid from the well enhances the flow rate and prevents flashing of the fluid. (Flashing can cause scaling of the well casing.)

Environmental Control Technology

Various efforts were underway to improve the efficiency and costs of existing environmental control technology.

The following projects, that were underway in FY 1977, are grouped according to the environmental issues that they address. Many of the issues deal with potential problems that have not yet occurred:

1. Hydrogen Sulfide (H_2S) Emissions. The emission of H_2S from geothermal plants has already been evidenced at The Geysers, California. H_2S emissions at The Geysers have been substantially below the levels that pose a threat to health or the environment. However, public concern over the odors delayed issuance of permits for new geothermal construction and threatened the renewal of a land use variance for an older plant at the resource.

   A number of H_2S control projects were underway in FY 1977. In December 1976, a limited field test at The Geysers cleaned 1,000 lbs/hr of steam for 30 hours, using a copper-sulfate steam process that was developed in a DOE-sponsored project. The installation of a pilot system to scrub 100,000 lbs/hr of steam for four months was being negotiated by industry.

   Plans were also underway to develop and demonstrate a brine oxidation method for removal of H_2S in the liquid phase of geothermal utilization. (Cooperative support for this project is planned by DOE and the EPA.)

2. Geothermal Fluid Disposal. A DOE-sponsored project was initiated in FY 1977 to assess the state-of-the art in fluid disposal systems, and to provide the geothermal industry with a choice of environmentally acceptable waste disposal systems.

3. Land Subsidence. The DOE was developing operational policies and technology requirements to minimize the potential for land subsidence.

4. Seismicity. A DOE project (completed in November 1977) assessed the state of knowledge on seismicity induced by man-made operations. Related projects were initiated to collect data on past seismic activity and to monitor seismicity at geothermal development sites. These data are currently being analyzed to determine whether there is a correlation between geothermal development and seismic acivity.

5. Noise. The DOE planned to develop a program to evaluate noise associated with the use of geothermal resources, the state-of-the-art of noise abatement technology, and Federal and state standards for noise.

6. Well Blowouts. The DOE sponsored a review of existing well blowout procedures and equipment to determine whether the existing techniques are adequate.

REGIONAL PROGRESS AND ACCOMPLISHMENTS

For planning purposes, the DGE has defined five geographical regions based on a relative similarity of geothermal resource and development characteristics (see Figure 1). Regions 1 and 4 contain high-temperature hydrothermal systems believed capable of producing significant amounts of electricty by 1985. Region 3 contains predominantly low- to moderate-temperature hydrothermal resources that can support extensive direct-thermal utilization by 1985, and generation of electricity once cost reduction due to technology improvements and policy measures are incurred. Region 2 contains geopressured systems that can produce energy derived from dissolved methane, heat and hydraulic pressure. Region 5 is believed to contain many lower temperature geothermal resources which are best suited for direct thermal applications.

The following is a summary of the principal FY 1977 progress and accomplishments in each region.

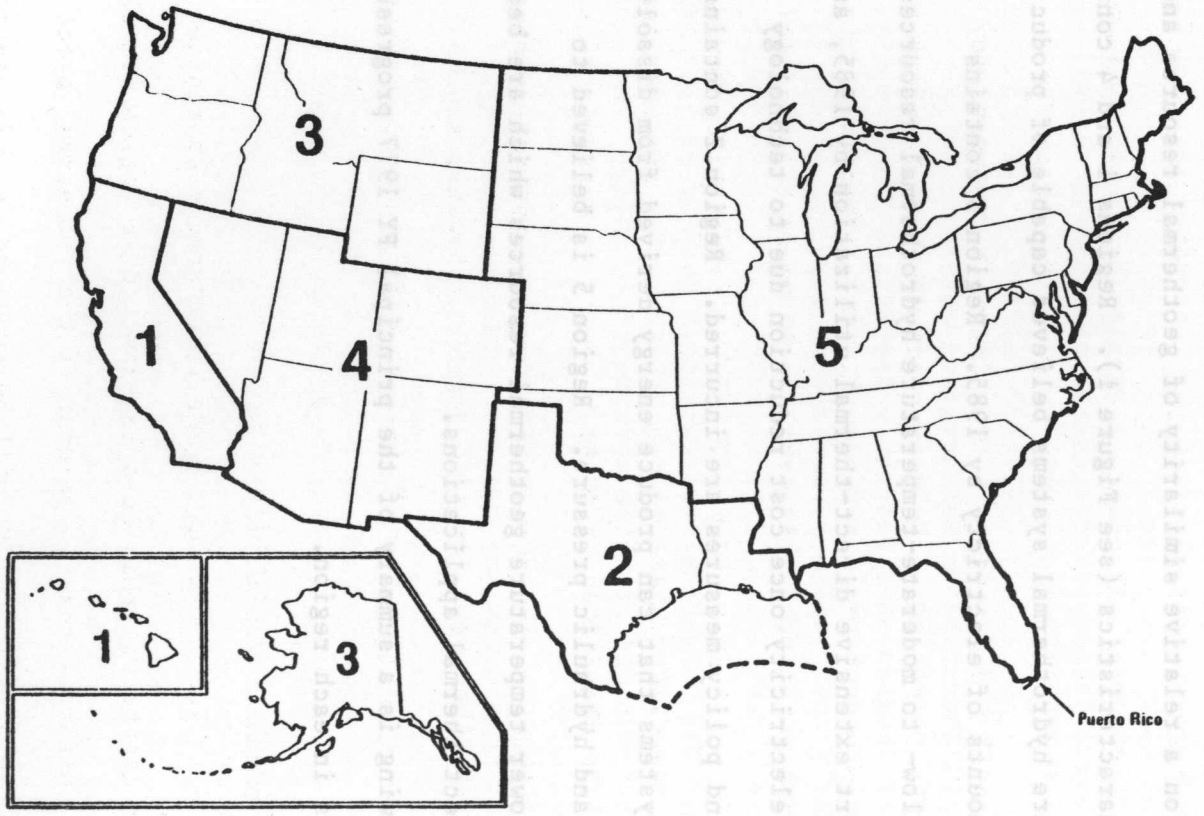

FIGURE 1

GEOTHERMAL ENERGY OPERATIONS RESEARCH REGIONAL BOUNDARIES*

*Regional boundaries based on rough estimates of near future development activities as deduced by ERDA from the USGS Circular 726, Assessment of Geothermal Resources of the United States - 1975. The regions were established such that roughly equivalent levels of activity are expected to occur in each region.

REGION 1 - CALIFORNIA AND HAWAII

Resource Characteristics

Region 1 geothermal resources are primarily of the hydrothermal convective type. Although liquid-dominated resources are predominant in the region, a large vapor-dominated resource exists at The Geysers, California (north of San Francisco). Hot dry rock resources may exist in the region, especially in Hawaii and northern California.

The Known Geothermal Resource Areas (KGRAs) within the state of California consist of 1,051,533 acres or 56 percent of the KGRA acreage in the United States today. The U.S. Geological Survey has not surveyed the state of Hawaii to determine whether any land has the potential to be classified as KGRA; however, as a result of a DGE-sponsored project, the existence of a large geothermal reservoir has recently been confirmed on the Big Island of Hawaii, and USGS seismic surveys were conducted in FY 1977 to define the boundaries of the resource.

Geothermal Development Scenarios

As indicated in Table III and Figure 2, extensive generation of electricity from geothermal resources is expected in Region 1. The IGCC postulates that more than 80 percent of the geothermal electric power in the United States by 1985 will be produced in this region.

Direct use of the geothermal resources in the Region 1 may also be substantial. The following is a partial list of sites where this development may occur:

TABLE III

GEOTHERMAL ELECTRIC SCENARIOS POSTULATED BY THE IGCC FOR PLANNING PURPOSES* -- REGION 1

	Generating Capacity Installed Each Year (MW_e)										
	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990	Post-1990	Total
Brawley, CA**	--	50	--	50	--	100	100	100	100	500	1000
Coso Hot Springs, CA	--	--	--	50	50	50	150	150	150	--	600
East Mesa, CA**	--	--	--	50	--	--	50	--	--	--	100
Geysers, CA (liquid-dominated)	--	--	--	100	100	100	100	100	100	400	1000
Geyers, CA (steam)	1680	160	220	110	--	--	--	--	--	--	2168
Glass Mt., CA	--	--	--	--	--	--	--	--	50	--	50
Heber, CA	--	50	--	50	--	100	100	--	--	700	1000
Lassen, CA	--	--	--	--	--	50	--	--	50	--	100
Mono-Long Valley, CA	--	--	--	50	--	100	--	--	100	--	250
Puna, HI	--	--	--	20	--	--	--	--	50	850	920
Salton Sea, CA	--	50	--	100	75	75	100	100	100	1400	2000
Surprise Valley, CA	--	--	--	--	50	--	50	100	100	1700	2000
Cumulative Totals	1680	1990	2210	2790	3765	4340	4990	5540	6340	11890	

*The selection of sites and the postulated generating capacities are based on current knowledge of the geothermal resources in the region. The scenario is intended for planning purposes only and does not imply any commitment on the part of the Federal government to development at these sites.

**The IGCC postulates that a 10 MW_e pilot plant will be completed at East Mesa in 1978 and at Brawley in 1979.

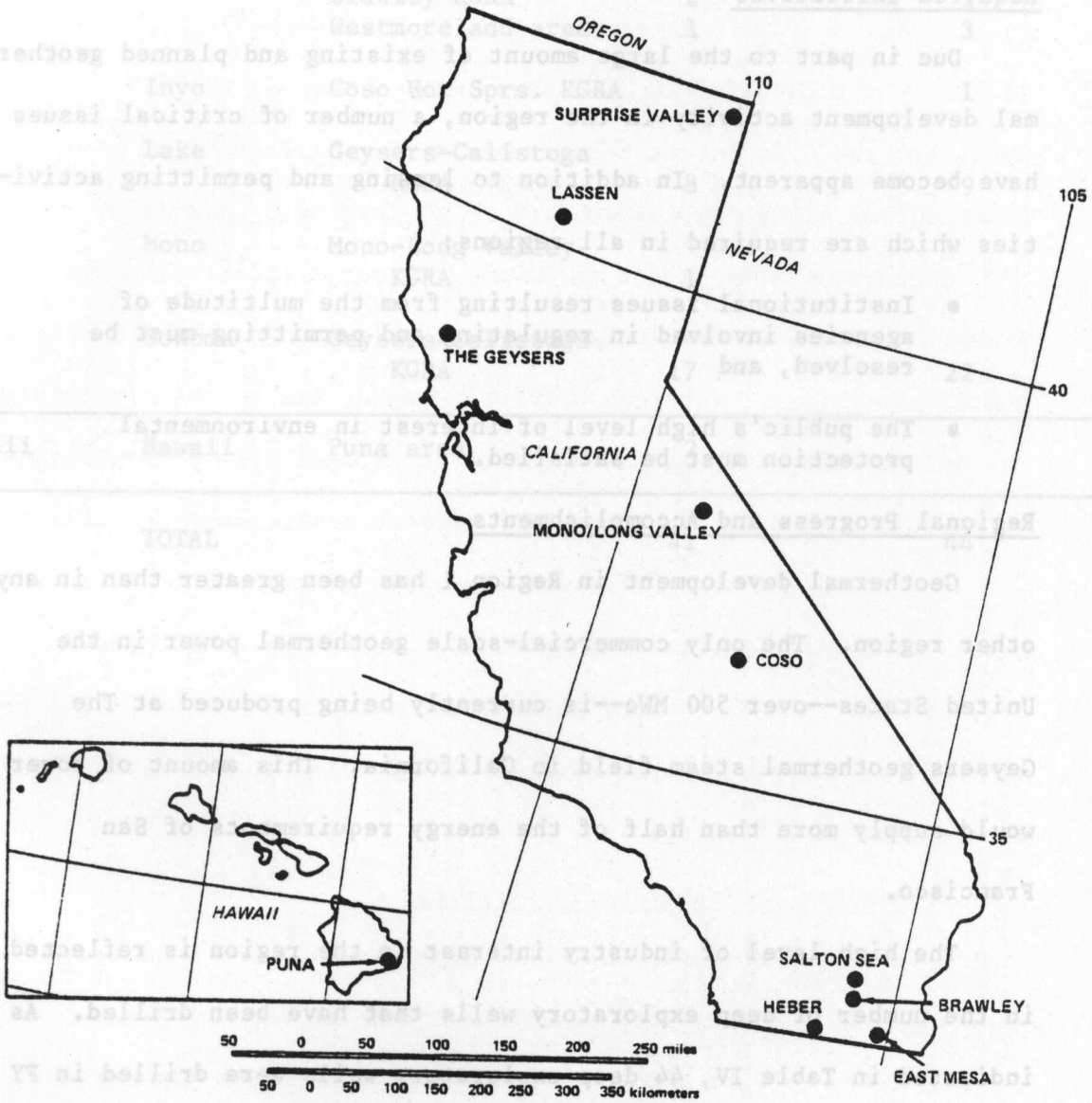

FIGURE 2
REGION 1 SITES IN THE IGCC GEOTHERMAL ELECTRIC SCENARIO

Brawley, CA
Calistoga, CA
Desert Hot Springs, CA
Hawaii
Heber, CA
Mono/Long Valley, CA
San Bernardino, CA
Surprise Valley, CA
Susanville, CA

Required Initiatives

Due in part to the large amount of existing and planned geothermal development activity in the region, a number of critical issues have become apparent. In addition to leasing and permitting activities which are required in all regions:

- Institutional issues resulting from the multitude of agencies involved in regulating and permitting must be resolved, and
- The public's high level of interest in environmental protection must be satisfied.

Regional Progress and Accomplishments

Geothermal development in Region 1 has been greater than in any other region. The only commercial-scale geothermal power in the United States--over 500 MWe--is currently being produced at The Geysers geothermal steam field in California. This amount of power would supply more than half of the energy requirements of San Francisco.

The high level of industry interest in the region is reflected in the number of deep exploratory wells that have been drilled. As indicated in Table IV, 44 deep exploratory wells were drilled in FY 1977. This represents approximately 75 percent of the total number

TABLE IV
GEOTHERMAL EXPLORATION WELLS GREATER THAN 2,000 FEED DEEP* - REGION 1

STATE	COUNTY	AREA	NUMBER OF WELLS DRILLED 10/1/75-9/30/76	10/1/76-9/30/77
California	Imperial	East Mesa KGRA	5	4
		Salton Sea KGRA	2	
		Heber KGRA	3	3
		Brawley KGRA	2	2
		Westmoreland area	1	3
	Inyo	Coso Hot Sprs. KGRA		1
	Lake	Geysers-Calistoga KGRA	8	9
	Mono	Mono-Long Valley KGRA	1	
	Sonoma	Geysers-Calistoga KGRA	17	22
Hawaii	Hawaii	Puna area	2	
	TOTAL		41	44

of FY 1977 deep exploratory wells drilled throughout the United States.

A substantial amount of Federal land has been leased in the Region. The BLM has issued a total of 28 competitive leases on 39,449 acres in California; one of these sales for 2,857 acres occurred at The Geysers-Calistoga KGRAs in FY 1977. Ten noncompetitive leases on 17,078 acres have also been issued--five of these leases, for a total of 10,784 acres, were issued in FY 1977. In addition, the U.S. Forest Service has been conducting land management planning and environmental studies in the region. (See Table V.)

Geothermal development in Hawaii has occurred on state and private land. This development therefore is not reflected in the BLM and FS statistics. Although a formal project has not been initiated, the DGE is currently negotiating with state and local organizations to stimulate commercial geothermal electric development in Hawaii.

The following discussion on regulatory coordination and environmental assurance initiatives emphasizes activities that occurred in California. This is because geothermal development in Hawaii is very limited and negotiations for further development in Hawaii have been progressing smoothly.

Regulatory Coordination Initiatives

Overlapping Federal, state and local regulations have been identified by industry as a source of confusion and development delay. In FY 1977, a number of actions were taken to accelerate geothermal development by eliminating regulatory overlap.

TABLE V

U.S. Forest Service Environmental Statements And Land Management Planning--Region 1

State	KGRA	National Forest	Halo of Non-Competitive Leases Around KGRA No. Pending	Geothermal Environmental Statements as of December 1, 1977 Estimated Starting Date	Estimated Finished Date	KGRA plus Non-Competitive Federal Acres	Land Mangement Planning Area--Geothermal Prospect Total or in Part within the LMPA, as of October 15, 1977 Estimated Date Draft Filed with CEQ	Estimated Date of Final
California	Beckwourth	Tahoe-Plumas				2,040	Oct. 78	July 79
	Geysers*	Mendocino				5,671	Nov. 77	Mar. 78
	Glass Mtn.*	Modoc				96,000 118,640	Nov. 77 Nov. 77	Feb. 78 Feb. 78
	Lassen*	Lassen		78		60,000	Sept. 77	June 78
	Little Horse Mtn.	Mendocino				1,196	Nov. 77	Feb. 78
	Lovelady Ridge	Mendocino				2,560	Nov. 77	Feb. 78
	Mono-Long Valley*	Inyo	(Grandfather)	78 75	Mar. 79 Mar. 79	380,000 260,000	Sept. 78 Mar. 78	Mar. 79 Nov. 78
	Sespe HS	Los Padres				6,680	June 78	Dec. 78
	Surprise Valley/ Lake City	Modoc				1,880	Nov. 77	July 78
Subtotal California			01			934,667		

*Included in the DOE geothermal electric scenarios.

[1]The USGS estimates that there are 125 noncompetitive leases on F.S. land, and that a total of 793,821 acres of KGRA and noncompetitive have been leased.

A California Geothermal Permitting Task Force composed of 17 state agencies and 3 public members was formed early in FY 1977. The Task Force has been striving to identify constraints to development of geothermal resources, to determine the State's role in resolving such constraints, and to make appropriate recommendations to the legislature. During April and May 1977, the Task Force conducted eight days of hearings. Extensive testimony on state agency permits and duplication of state/Federal regulatory requirements was presented. Following the hearings, the Task Force submitted a draft report which proposed regulatory changes to the state legislature.

The California Geothermal Permitting Task Force and representatives of local and Federal organizations constitute the membership of the California Geothermal Permitting Project. This project is studying the interjurisdictional aspects of geothermal-related permitting to better coordinate Federal, state and county permitting. The Project is currently in the first phase of activity--analyzing existing Federal and state permitting procedures and developing mechanisms to coordinate permitting requirements. (The second phase of the project, implementation and monitoring of recommended permitting procedures, is expected to begin in the latter half of FY 1978.)

Substantial input to the California Geothermal Permitting Project came from a workshop held in early FY 1977. This workshop brought together representatives of industry, state and Federal organizations.

They discussed geothermal regulatory problems, identified overlapping regulations and designed a program for geothermal regulatory training. A workshop report was published in mid-1977.

One major industry concern is over the permitting requirements of the California Energy Resources Conservation and Development Commission (CERCDC). The CERCDC officially has authority to issue permits for the construction of any power plant over 50 MWe that is constructed on state or private land. However, CERCDC regulations concerning geothermal development have not been well-defined.

A project began in November 1976 to establish CERCDC policies and regulations that are designed specifically for geothermal development. To encourage the utilities to include geothermal energy in their regional supply plans, the CERCDC regulations will facilitate geothermal development as an attractive alternative energy source.

Joint CERCDC/DGE efforts have focused on various technological and economic aspects of geothermal development. In January 1977, the proceedings of a jointly sponsored CERCDC/DGE geothermal power plant siting workshop (held in Asilomar, California) were published. Engineering and economic feasibility studies for direct use of geothermal energy in California determined that low-temperature resources must be identified, and regulations concerning direct use must be clarified.

Several county and multiple-county geothermal planning initiatives were conducted in California during the past year.

In northern California, the Geothermal Resources Impact Projection Study (GRIPS) was initiated by Lake, Sonoma, Mendocino, and Napa Counties (which include The Geysers resource area). GRIPS, which qualifies as a legal agency under California joint-powers laws, is funded by county, state and DGE sources. In FY 1977, GRIPS began to develop a management plan for environmental data from the four counties. The plan includes recommendations for implementing environmental studies, and for the construction of an environmental data base that would expedite geothermal development decisions. As part of this effort, GRIPS is assessing existing environmental baseline data to determine whether additional environmental data is needed.

The Imperial County Draft Geothermal Element was completed in FY 1977. The document, which is part of the county development plan, defines goals, objectives, and policies to assure maximum benefits and minimum impact from the development of geothermal resources. In the Draft Geothermal Element, it was projected that the geothermal resources in the Imperial Valley are capable of producing between 10,000 and 40,000 MWe for at least 30 years. Based on current technology, it was projected that the County could develop at least 4500 MWe by the year 2020, with much of the remaining geothermal resource being used for direct-thermal applications. These projections were based on development occurring at the Salton Sea, East Mesa, Brawley and Heber reservoirs.

In September 1977, a meeting was held to discuss potential direct thermal applications at Susanville, California. As a result of this meeting, the Lassen County Geothermal Coordinating Committee was formed. The Committee, comprised of industry, local, state and Federal representatives, will work to ameliorate the geothermal development problems at Susanville.

Environmental Assurance Initiatives

The Imperial County Draft Geothermal Element described the shortage of cooling water, and the potential for subsidence and seismicity caused by the withdrawal of fluids, as the most significant environmental concerns related to geothermal development in the County. These concerns, together with odors from H_2S emissions and possible threats to wildlife and scenic beauty, characterize the major environmental concerns of the state.

These environmental concerns must be addressed in numerous leasing and permitting requirements in California. The requirements have often created delays in geothermal development and additional costs to the developer. Various activities are underway to reduce these delays and costs. Some reduction should result from efforts to coordinate Federal, state and county regulations. Further reductions should result from the creation of data bases that eliminate the duplication of environmental data collection for individual leases or permits.

In FY 1977, a major environmental baseline study was sponsored by the Lawrence Livermore Laboratory (with DGE funding), the CERCDC, the USGS and industry to determine rates of natural subsidence and seismic earth movement in the Imperial Valley. Evidence of slow aseismic creep along various faults was found. This and additional information from the study will be used in comparison studies after large-scale geothermal production starts. The National Geodetic Survey (of the National Oceanographic and Atmospheric Administration) and the U.S. Geological Survey are currently interpreting data gathered in the Imperial Valley Study.

Site-Specific Progress and Accomplishments

The following is a summary of activities for each of the sites that have been postulated for geothermal electric development in Region 1. At many of these sites, such as Mono/Long Valley and Brawley, direct geothermal use is also discussed. Other geothermal sites that may be developed for direct thermal applications include Susanville and Desert Hot Springs.

In June 1976, the City of Susanville began a project to expedite direct utilization of geothermal heat in Susanville. A geological map and a report describing the resource have been prepared, an ordinance for utilization of geothermal resources in Susanville has been adopted, and a report on possible utilization for greenhouse, onion dehydration, and kiln drying of lumber has been completed.

At Desert Hot Springs, a study co-sponsored by the DGE and the CERCDC is underway to identify possible direct applications of the geothermal resources. Thus far, the study has identified aquaculture and greenhouse development.

Brawley, CA

Geothermal development is occurring as postulated for the production of 10 MWe in 1979 and the production of an additional 50 MWe in 1983. In FY 1977, Union Oil announced plans to construct a 10 MWe pilot plant at the resource. Other FY 1977 activities included unitization of the resource, continued resource exploration and assessment, and initiation of a test by private industry to determine the feasibility of direct geothermal utilization at a sugar refinery.

Coso, CA

At Coso, the postulated production of 50 MWe in 1985 may be achieved only if leasing of Federal land occurs in 1978. Most of the geothermal resource at Coso is on Federal land withdrawn for use by the Navy. The Navy drilled a shallow well in 1967 to 375 feet. A bottom-hole temperature of 145°C was measured and a relatively high downhole pressure of greater than 20 psig was indicated. To define the geothermal resource more accurately, the USGS operated a 69-seismometer network for 71 days.

In July, 1977, the DGE initiated test drilling on the land held by the Navy. In October 1977, the Navy issued a Request for Expressions of Interest (REI) from industry for development of the Coso

geothermal resource. A meeting was held in November 1977 to discuss the REI with interested developers and utilities.

Along with the Navy stipulations for development, two additional issues that may affect the commercial leasing of Coso land are (1) the effects of development on the Coso Hot Springs which have cultural significance to the Paiute-Shoshone Indians, and (2) the need to prepare an environmental assessment of the area.

In June 1977, negotiations between the BLM and the Navy for a master contract (Request for Proposals) were initiated for an environmental assessment. The contract (which may not be signed until January 1978) is to perform all the work that will be required by an Environmental Impact Study for leasing of Navy land.

East Mesa, CA

Development of the 10 MWe pilot plant at East Mesa is proceeding as postulated for completion in 1978. The IGCC-postulated production of 50 MWe by 1985 may require leasing of additional Federal land by 1981.

Extensive development of the geothermal resource has already occurred at East Mesa. In FY 1977, the Magma Power Company applied for permits to construct a 10 MWe geothermal binary power plant. Early in FY 1977, the DOE granted a loan guaranty for exploration drilling and assessment to the Republic Geothermal Corporation. Republic has indicated that it intends to construct a 10 MWe pilot plant to be followed by a 36 MWe power plant which could be operational in 1982.

Other geothermal development at the East Mesa site includes the U.S. Bureau of Reclamation operation of a multiple flashed-steam water desalination pilot plant (where materials testing sponsored by the U.S. Bureau of Mines has occurred), DGE-sponsored testing of preliminary reservoir engineering models, and operation of the DGE-sponsored Geothermal Component Test Facility (GCTF).

The GCTF was constructed and put into operation in 1977. It consists of four test pads with manifolds. The pads are available for industry use on a first-come first-served basis; and since they were made available, they have remained fully utilized, primarily for heat exchanger and corrosion research. In addition to the test pads, DGE has been providing the users with electrical power, potable water, instruments, a chemistry laboratory, a machine shop, a resident welder, and normal operation and maintenance of the facility.

The Geysers, CA

Over 500 MWe are currently being produced at The Geysers geothermal steam field, and the IGCC has postulated that by 1985, a total of more than 1500 MWe of steam power may be produced. It appears unlikely that a liquid-dominated resource will be developed until the extent of the steam resource is known, all the land is leased, and it is established that production from a liquid-dominated reservoir will not jeopardize production from the vapor-dominated reservoir. Therefore, the IGCC-postulated production of 50 MWe from a liquid-dominated resource by 1985 may be delayed.

Exploration and assessment of the resource continued at The Geysers throughout FY 1977. Nine exploratory wells were drilled deeper than 2000 feet. In the Clear Lake area, the USGS mapped the geology, and analyzed geophysical data and the geochemistry of the thermal waters. The USGS studies indicate that an additional high temperature system may lie at the northeastern boundary of The Geyser steam field. This would be a significant increase in the size of the geothermal resource in The Geysers area.

In July 1977, the Northern California Power Agency and the Shell Oil Company announced plans to construct a 110 MWe plant to be completed in late 1980. Construction by the Pacific Gas and Electric Company (PG&E) continued throughout FY 1977.

The major development obstacles at The Geysers have been related to the odor of H_2S emissions. The public's concern over the odors from existing geothermal plants was a prime element in delaying permitting for additional power plant construction between 1972 and 1976 and may threaten the renewal of variance permits for older plants that are now in operation at The Geysers.

In FY 1977, an H_2S abatement project sponsored by the DOE was completed. The project successfully demonstrated a greater than 90 percent pre-power plant abatement using a 6-inch copper sulfate test column. In addition, H_2S abatement using sodium hydroxide and hydrogen peroxide was successfully demonstrated by FMC and the Union Oil Company.

A CERCDC-sponsored study is underway to provide meteorological data and analysis at 18 locations in The Geysers KGRA. The project will define the meteorological and air quality monitoring needed to predict the local and regional impact of H_2S emissions from geothermal development at The Geysers. Data and project results will be incorporated in the interagency planning efforts of the Geothermal Resources Impact Planning Study (GRIPS).

Information on wildlife in The Geysers area has been collected for use in determining the environmental effects of geothermal development. In September 1977, three critical habitat zones (CHZs) for peregrine falcons in The Geysers area were established by the U.S. Fish and Wildlife Service. In FY 1977, The Geysers Wildlife Study was completed. This baseline study was sponsored cooperatively by the Pacific Gas and Electric Company, the Union Oil Company, the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and several universities. The entire study is computerized and available for government and public use through the Pacific Gas and Electric research laboratory in Oakland, California. (The GRIPS project has incorporated this data.)

Glass Mountain/Diablo, CA

Attainment of the IGCC-postulated production of 50 MWe by 1990 will require leasing of Federal land at the resource by 1982.

Geothermal development at Glass Mountain is in its earliest stage. Limited preliminary exploration activities have occurred--

more are needed. Considerable commercial interest in the resource, particularly for Klamath Forest land, has been expressed through noncompetitive lease applications. However, BLM leasing decisions will be contingent upon the completion of U.S. Forest Service environmental assessments.

Heber, CA

Development at Heber is progressing adequately to meet the IGCC-postulated production of 50 MWe in 1983.

In FY 1977, the San Diego Gas and Electric Company (SDG&E) proposed to start preparations for a demonstration plant. The power plant would be designed, constructed, and operated by a consortium of utilities and the Electric Power Research Institute (EPRI), with SDG&E as project manager and majority owner of the plant.

A conceptual design and preliminary test plan were started in FY 1977 for a project sponsored by the DGE and EPRI. The project will determine the design, materials, and operating and maintenance procedures to be used in brine-to-hydrocarbon, sheet-and-tube heat exchangers at Heber.

A project jointly funded by DGE and the Valley Nitrogen Producers, Inc. (of El Centro, California) was completed in FY 1977. The project focused upon the engineering and economic feasibility of using the Heber resource for potential agricultural chemical processing at the Valley Nitrogen Producers Plant.

Lassen, CA

The attainment of the IGCC-postulated 1987 production of 50 MWe may require the leasing of Federal lands by 1982. Because the Lassen geothermal resource is in a National Forest, public and Federal concern over the potential environmental effects of development may be substantial.

Prior to March 1977, two wells were drilled on private land at Lassen. No wells have been drilled on Federal land, which comprises 70 percent of the KGRA.

Mono/Long Valley, CA

The IGCC-postulated 1985 power production may be delayed one year due to environmental uncertainties in the resource area and the need to lease additional land.

A great deal of interest in the resource has been expressed by industry, including the Southern California Edison Company (SCE), and the City of Burbank.

The CERCDC initiated a one and a half-year project in July 1977 to design, construct, operate and test a geothermal space heating/ snow melting system at Mammoth Lakes Village. DGE support for implementing a full-scale district heating system is awaiting the successful implementation of the CERCDC demonstration. Meanwhile, DGE is sponsoring a space heating feasibility study conducted by SCE and the Ben Holt Company.

Resource exploration and assessment activities at Mono/Long Valley included Los Alamos Scientific Laboratory research on potential hot dry rock resources at Mammoth. Various government agencies, including the U.S. Fish and Wildlife Service, have been participating in this project.

In FY 1977, the USGS conducted seismic and geochemical surveys at a deep test well that was drilled in FY 1976 by the Republic Geothermal Corporation. This USGS analysis defined areas of greater geothermal development potential. In addition, the USGS reevaluation of chemical and isotopic data indicates that the resource may be hotter than previously estimated. The temperatures may be as high as 280°C.

Puna, HI

Geothermal development at Puna, Hawaii has progressed so well that the IGCC-postulated production of 20 MWe in 1985 may be achieved as early as 1983.

To date, one successful well has been drilled at Puna, and interest has been expressed by industry for a loan guaranty on additional drilling. The collection of environmental data for possible geothermal development along the Puna Rift was initiated in FY 1977. Plans are currently underway to install a small wellhead generator of approximately 5 MWe to be operational at the Puna well by 1979.

Extensive development of the Puna resource may depend on the potential for industrial heat or electric applications (e.g., metal refining), or the feasibility of transmitting electrical power across the 6,500-foot deep channel from Hawaii Island to Maui Island.

Salton Sea, CA

Attainment of the IGCC-postulated production of 50 MWe in 1983 will depend on the results of the Geothermal Loop Experimental Facility (GLEF) which is now operating at the site.

The GLEF, which is being co-sponsored by DGE and the San Diego Gas and Electric Company (SDG&E), began operation in June 1976. The experimental loop has been testing the ability to extract heat from separated steam in a highly saline brine. Salinity of the geothermal fluid at the Salton Sea has been measured as high as 300,000 ppm, or approximately 10 times the salinity level of sea water. The average salinity of the fluid is 220,000 ppm. The U.S. Bureau of Mines has been conducting research on problems associated with the use of materials in high salinity water. In addition, the Bureau has nearly completed a detailed design of a pilot plant for recovering selected minerals from post-flash brines at the site.

Other accomplishments at Salton Sea in FY 1977 include the reduction of dissolved solids to less than 0.2 percent through steam scrubbers. This indicates that a two-stage flash steam system may be viable for Salton Sea. Water jet techniques have been employed to

clean scale in the pipes, and pigging of the reinjection pipes (forcing a reamer through) has been tested.

Surprise Valley, CA

Attainment of the IGCC-postulated production of 50 MWe in 1986 will depend on the success of exploratory drilling and reservoir evaluation activities in the area.

Although at least eight wells have been drilled at Surprise Valley, the existence of a hydrothermal resource capable of supporting the generation of electricity has not been confirmed.

REGION 2 - LOUISIANA AND TEXAS

Resource Characteristics

Region 2 contains geopressured-geothermal resources that consist of three forms of energy: thermal, dissolved methane, and energy derived from hydraulic pressure. The geopressured resources extend both landward and seaward from the Gulf Coast in Texas and Louisiana. Estimates in USGS Circular 726 indicate the potentially recoverable thermal energy of these reservoirs could exceed 38,000 megawatt-centuries, and that the energy of the dissolved methane could be several times greater.

The region may contain hydrothermal resources in a deep, structurally-controlled abnormal gradient fault zone that extends from Hot Springs (Arkansas) to San Antonio (Texas). The existence of this zone has been suggested by data derived from oil and gas drilling.

Geothermal Development Scenario

As indicated on Table VI, commercial-scale utilization of the geopressured resources is not expected to occur until 1986. The sites that are included in IGCC electric scenario are shown in Figure 3.

Direct thermal use of the abnormal gradient fault zone, which is north of the geopressured zone, may begin in the mid-1980s. The zone underlies many major cities in Texas, including San Antonio and Dallas, that could use the geothermal resource for space heating.

TABLE VI
GEOTHERMAL ELECTRIC SCENARIOS POSTULATED BY THE IGCC
FOR PLANNING PURPOSES* -- REGION 2

	Generating Capacity Installed Each Year (MW_e)										
	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990	Post-1990	Total
Acadia Parish, LA	--	--	--	--	--	50	--	--	50	250	350
Brazoria, TX	--	--	--	--	25	--	100	100	200	1800	2225
Calcasieu Parish, LA	--	--	--	--	--	50	--	--	50	250	350
Cameron Parish, LA	--	--	--	--	--	50	--	--	50	400	500
Corpus Christi, TX	--	--	--	--	--	50	--	--	50	1550	1650
Kenedy County, TX	--	--	--	--	--	50	--	--	50	200	300
Matagorda County, TX	--	--	--	--	--	50	--	--	50	400	500
Cumulative Total					25	325	425	525	1025	5875	

*The selection of sites and the postulated generating capacities are based on current knowledge of the geothermal resources in the region. The scenario is intended for planning purposes only and does not imply any commitment on the part of the Federal government to development at these sites.

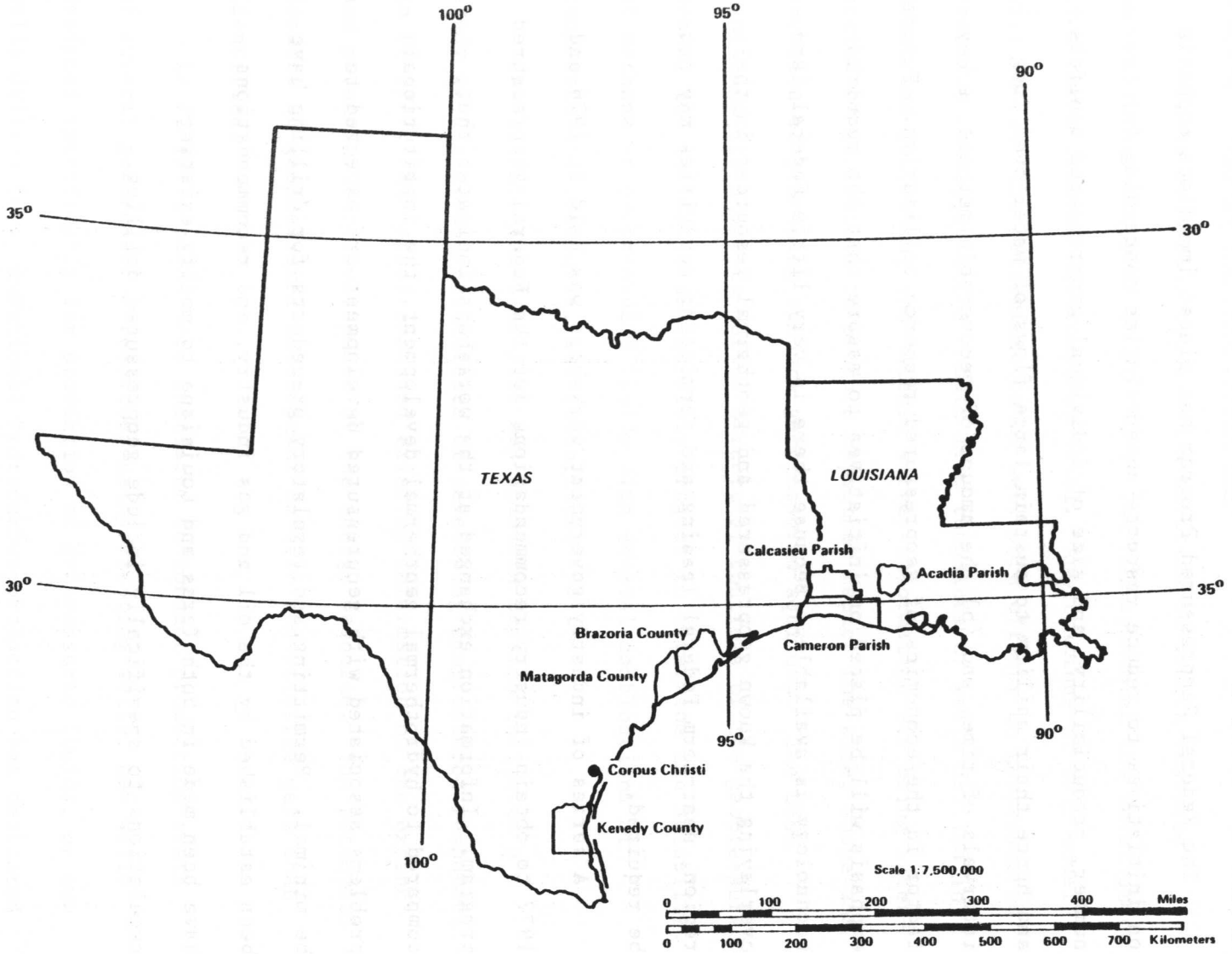

FIGURE 3
REGION 2 SITES IN THE IGCC GEOTHERMAL ELECTRIC SCENARIO

Required Initiatives

The Federal Geopressured Program has placed immediate emphasis on initiatives to reduce resource uncertainties concerning (a) the number, producibility, and size of individual geopressured aquifers, and hence their ability to sustain large flows of water over long intervals of time, and (b) the amount of recoverable methane, a key factor in the economics of geopressured resource utilization. Future emphasis will be placed on initiatives to assure that the required technology is available. Because there is very little Federal land overlaying the known geopressured and geothermal resources in the region, near-term Federal leasing and permitting activities may not be required.

A series of industry/government workshops was held in 1976 and 1977 to obtain industry recommendations for the Federal geopressured program. Information exchanged at the workshops indicates that, compared to hydrothermal geothermal development, the institutional problems associated with geopressured development are expected to be minimal. Permitting and regulatory precedents for drilling have been established by the oil and gas industry, and recommendations have been made in both Texas and Louisiana to modify existing regulations to specifically include geopressured drilling.

Regional Progress and Accomplishments

Various Federally-sponsored activities to reduce resource uncertainties occurred in FY 1977. The DGE sponsored the development of a three-dimensional computer model. Applications of this model will include the determination of well bore effects on geopressured resource characteristics. Data from thousands of wells drilled in Texas and Louisiana, and seismic survey information are being interpreted by geologists to produce maps that depict the size, shape and location of promising onshore geopressured aquifers. The USGS continued its study to define structural controls of the geopressured zones, and initiated a laboratory project to determine the solubility of methane in geopressured fluids with several combinations of temperatures, pressures, and salinities.

In FY 1976, the U.S. Fish and Wildlife Service initiated a study of the ecological effects of developing geopressured resources. In FY 1977, this study assessed existing information on the extent and potential for development of the energy resource. The potential impacts of geopressured development on fish and wildlife were then identified.

In FY 1977, plans were initiated to conduct production tests of several geopressured resources using existing wells, new wells designed specifically for production of geopressured fluids, or new wells drilled for conventional hydrocarbon production but dedicated temporarily to testing geopressured aquifers. Well tests at several

locations along the Gulf Coast will explore regional variations in resource characteristics. Each test will be in an area of significant potential for geopressured development as identified by the three-dimensional computer model. As part of this effort, testing of an existing oil and gas well in Vermillion Parish, Louisiana, was completed in FY 1977 and drilling of a test well in Brazoria County, Texas, is underway.

The technology required to develop geopressured resources must economically recover thermal and hydraulic energy, and separate methane gas from the fluid. Existing equipment used to extract hydrothermal, oil and gas resources may partially satisfy these needs. However, the development of geopressured resources will require

- improved well-completion methods so that wells can withstand the high pressures and temperatures of geopressured fluids;
- methods of reducing the amount of sand that is produced with the geopressured fluids to prevent erosion, corrosion and well plugging;
- methods of disposing of fluids to accommodate fluid production in quantities which are significantly greater than those associated with hydrothermal-geothermal utilization, and which may pose potential subsidence problems; and
- high volume, high pressure separators.

Future well tests sponsored by DGE will incorporate development of much of the needed technology.

Site-Specific Progress and Accomplishments

Vermillion Parish, Louisiana

In FY 1977, DOE sponsored geopressured tests in the Delchambre Well, which was originally drilled for oil and gas production. The tests were conducted at 12,600 and 12,900 feet to determine aquifer fluid properties, reservoir and fluid behavior, reservoir characteristics, and to evaluate well completion techniques and production strategies. The test encountered downhole temperatures of 120°C (248°F), high fluid salinities of 115,000 to 135,000 ppm, and methane concentrations of 20 cubic foot per barrel of fluid.

Brazoria County, Texas

The Brazoria Fairway was chosen as the first prospect for DGE-sponsored geopressured drilling as a result of detailed analysis which occurred in FY 1977. It was the only prospect that satisfied all of the following minimum requirements: reservoir volume of 3 cubic miles, minimum core permeability of 20 millidarcys, and fluid temperatures of 150°C.

Drilling is expected to begin in March 1978 on land leased for oil and gas production by the General Crude Oil Company. In exchange for the free use of their land, General Crude Oil has been given the option to market any gas extracted from the well. If drilling is successful at the Brazoria well, and subsequent wells are productive, the IGCC postulated production of 50 MWe by 1986 may be achieved.

In support of the Brazoria drilling project, preliminary environmental data were collected and analyzed for approximately 150 square kilometers of land near Chocolate Bayou in Brazoria County. These data were used to determine an environmentally suitable location for the test well.

REGION 3 - ALASKA, IDAHO, MONTANA, OREGON, WASHINGTON, WYOMING

Resource Characteristics

The geothermal resources in Region 3 are predominantly low- to moderate-temperature hydrothermal convective.

Geothermal Development Scenarios

Because the region's known geothermal resources are predominantly of low- to moderate-temperature, power from the first commercial-scale geothermal electric plant is not expected until 1987. (See Table VII and Figure 4.) Significant geothermal power generation in the region may depend on the development of technology that will reduce the cost of utilizing fluids with temperatures less than approximately 180°C. Near-term geothermal development activity is expected for space heating and industrial applications. The following is a partial list of sites where direct thermal utilization is likely to occur:

Alaska
Boise, ID
Bruneau-Grandview, ID
Klamath Falls, OR
Lakeview, OR
Madison Aquifer, WY
Mountain Home, ID
Mount Baker, WA
Mount Hood, OR
Pocatello, ID
Preston, ID
Raft River, ID
Southeast Idaho
Vale Hot Springs, OR
White Sulfur Springs, MT

Required Initiatives

To stimulate electric and direct thermal use of the geothermal resources in Region 3, initiatives are required:

TABLE VII
GEOTHERMAL ELECTRIC SCENARIOS POSTULATED BY THE IGCC
FOR PLANNING PURPOSES* -- REGION 3

	Generating Capacity Installed Each Year (MW_e)										
	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990	Post-1990	Total
Alvord, OR	--	--	--	--	--	50	--	--	50	200	300
Baker Hot Springs, WA	--	--	--	--	--	--	--	--	50	--	--
Bruneau-Grandview, ID	--	--	--	--	--	50	--	--	100	3000	3150
Mt. Hood, OR	--	--	--	--	--	--	--	--	50	--	--
Raft River, ID**	--	--	--	--	--	--	50	--	50	--	100
Vale Hot Springs, OR	--	--	--	--	--	--	50	--	50	700	800
Weiser-Crane Creek, ID	--	--	--	--	--	--	50	--	100	850	1000
West Yellowstone, MT	--	--	--	--	--	--	--	--	50	--	--
Cumulative Total						100	250	250	750	5500	

*The selection of sites and the postulated generating capacities are based on current knowledge of the geothermal resources in the region. The scenario is intended for planning purposes only and does not imply any commitment on the part of the Federal government to development at these sites.

**The IGCC postulates that a 10 MW_e pilot plant will be completed at Raft River in 1979.

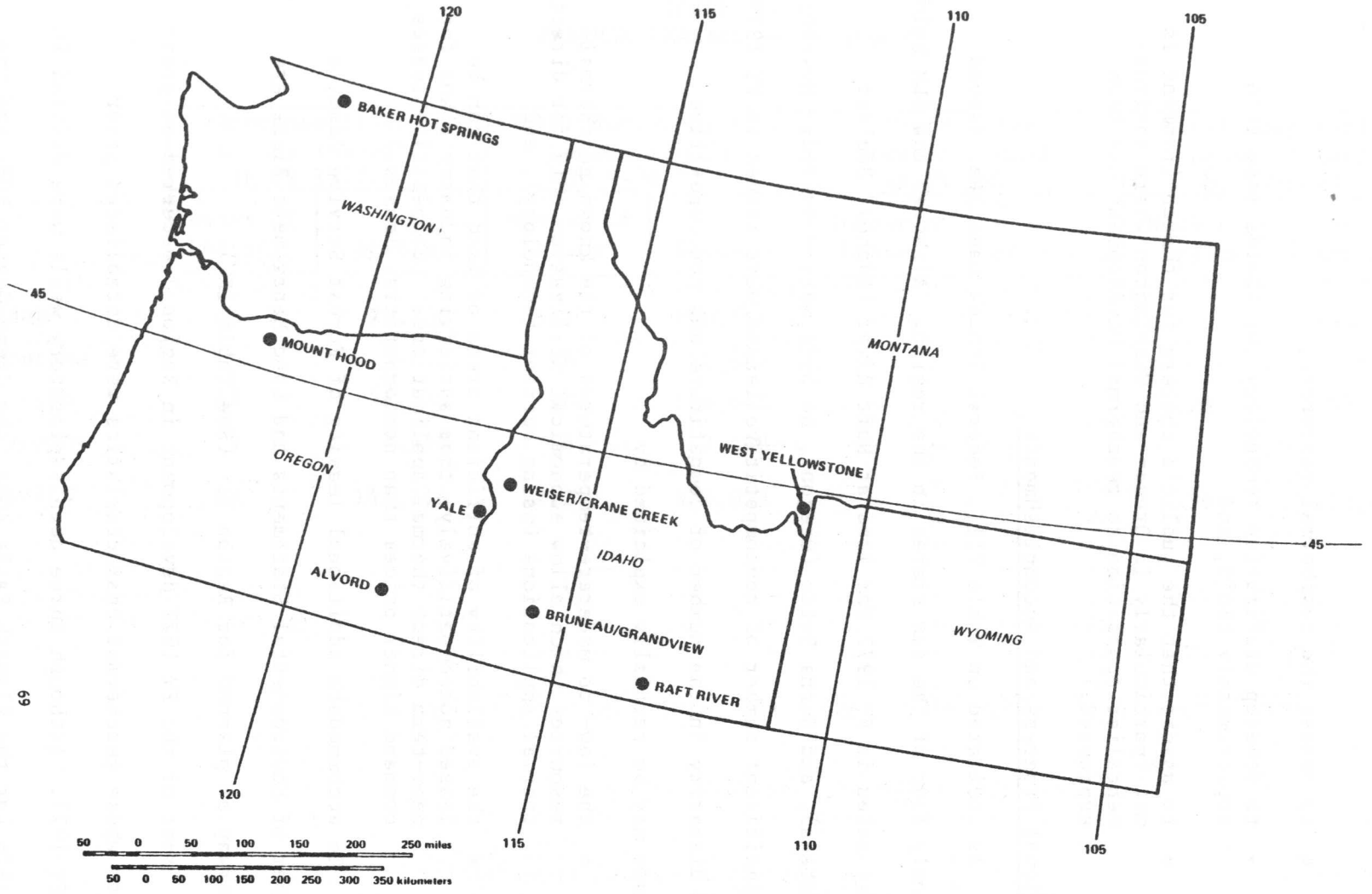

FIGURE 4
REGION 3 SITES IN THE IGCC GEOTHERMAL ELECTRIC SCENARIO

- to assess the geothermal resources,
- to develop utilization technology for fluids less than approximately 180°C, and
- to assure that the public's concern for the environment is met (particularly in Oregon and Washington where environmentalist opposition to geothermal development has been expressed.)

Regional Progress and Accomplishments

As indicated on Table VIII, Federal leases have been issued in only four of the six states in the region. Although the BLM held lease sales in FY 1977 for land at Raft River (Idaho), Boulder (Montana), and Burns Butte (Oregon), no bids were received. However, a significant number of noncompetitive leases were issued in FY 1977. The disparity in the number of competitive and noncompetitive leases may be partially explained by

- the low- to moderate-temperatures of the known geothermal resources which allow economical utilization only for direct thermal applications (using current technology), and
- the availability of sufficient areas of land that can be leased noncompetitively, thus satisfying industry plans for near-term direct thermal applications. (Competitive leases command higher prices than noncompetitive leases.)

To accommodate additional leasing of Forest Service land, a number of Environmental Statements and Land Management Plans are underway or planned for Region 3. (See Table IX.)

Most of the FY 1977 development in Region 3 occurred at prospects whose geothermal characteristics were established prior to FY 1977. Although three deep exploratory wells were drilled in FY 1976 (at the Klamath Falls KGRA, the Crump Geyser KGRA and the

TABLE VIII
FEDERAL LEASING -- REGION 3

	Noncompetitive Leases Issued in FY 1977		Total Noncompetitive Leases Issued by 9-30-77		Competitive Leases Issued in FY 1977		Total Competitive Leases Issued by 9-30-77	
	Number of Leases	Acreage	Number of Leases	Acreage	Number of Leases	Acreage	Number of Leases	Acreage
Idaho	43	79,738	112	190,240	-	-	12	190,240
Montana	-	-	6	10,687	-	-	-	-
Oregon	42	56,358	90	119,648	-	-	24	53,711
Wyoming	4	7,448	4	7,448	-	-	-	-
TOTALS	89	143,544	212	328,023	-	-	36	243,951

TABLE IX

U.S. Forest Service Environmental Statements And Land Management Planning--Region 3

			Halo of Non-Competitive Leases Around KGRA	Geothermal Environmental Statements as of December 1, 1977			Land Management Planning Area--Geothermal Prospect Total or in Part within the LMPA, as of October 15, 1977	
State	KGRA	National Forest	No. Pending	Estimated Starting Date	Estimated Finished Date	KGRA plus Non-Competitive Federal Acres	Estimated Date Draft Filed with CEQ	Estimated Date of Final
Idaho	Island Park	Targhee		Sept. 76	Jan. 79	28,539	July 78	Jan. 79
	Vulcan	Boise			Completed[1]	3,836	Mar. 75	Jan. 79
Subtotal Idaho			198[2]			32,375		
Montana	Boulder	Deerlodge			Completed[1]		Oct. 78	Mar. 79
	Chico HS	Gallatin					Jan. 78	May 78
	Corwin Springs	Gallatin				40,000	Jan. 78	May 78
	Marysville	Helena			Completed[1]	19,200	July 76	April 78
	West Yellowstone*	Gallatin		Nov. 76			Jan. 78	May 78
Subtotal Montana			8			59,200		

*Included in the DOE geothermal electric scenarios.

[1]Completed prior to FY77.

[2]15 noncompetitive applications may not be covered by active planning and environmental statements.

TABLE IX (Concluded)

U.S. Forest Service Environmental Statements And Land Management Planning--Region 3 (Continued)

State	KGRA	National Forest	Halo of Non-Competitive Leases Around KGRA: No. Pending	Geothermal Environmental Statements as of December 1, 1977: Estimated Starting Date	Estimated Finished Date	KGRA plus Non-Competitive Federal Acres	Land Management Planning Area--Geothermal Prospect Total or in Part within the LMPA, as of October 15, 1977: Estimated Date Draft Filed with CEQ	Estimated Date of Final
Oregon	Austin HS	Mt. Hood				106,000	June 78	Nov. 78
	Clackamas	Mt. Hood	62				June 78	Nov. 78
	Mt. Hood*	Mt. Hood					Dec. 76	Jan. 78
	Belknap-Foley HS	Willamette	37	Dec. 77	June 78	100,000	-	-
	Breitenbush	Willamette	11	Jan. 74	Dec. 77	44,283	-	-
	McCredie HS	Willamette		Nov. 77	July 78	19,600	-	-
	Newberry Caldera	Deschutes	137	Jan. 75	Dec. 77	321,500	Aug. 77	Dec. 78
	(None Defined)	Freemont	29	June 75	July 78	140,000	Mar. 78	Oct. 78
Subtotal Oregon			276			731,383	-	-
Washington	Indian Heaven	Gifford Pinchott	127	Jan. 78	July 78	2,547	July 77	July 78
	Mt. St Helens	Gifford Pinchott		Sept. 77	Oct. 79	20,000	Feb. 78	Oct. 78
	(None Defined)	Mt. Baker	8	July 78	Jan. 78	61,000	Jan. 78	Sept. 78
	(None Defined)	Okanogan	8	Mar. 78	July 79	8,000	Nov. 77	July 78
Subtotal Washington			143			91,547		

*Included in the DOE electric scenarios.

Spring Lake area in Oregon), none was drilled in FY 1977. However, the USGS conducted surface reconnaissance and resource assessment activities. In FY 1977, USGS-sponsored projects included:

1. Mineralogical and age-dating studies (conducted by the USGS and the Navy) which identified a potential geothermal resource on the Adak Island in Alaska.

2. The analysis of data obtained from deep wells at Raft River, Idaho. It was concluded that the geothermal system is self-sealing and that 145°C water may be found at reasonable depths near any young fault within the Raft River Basin.

3. Geologic mapping and related volcanic studies of the Snake River Plain, Idaho. These studies refined previous assessments of the extent, temperature, and depth of the system.

Site-Specific Progress and Accomplishments

Most of the site-specific progress in Region 3 has been for direct thermal utilization of geothermal resources. Approximately 400 shallow wells have been drilled in Klamath Falls (Oregon) and 50 wells in Boise (Idaho). The wells supply fluids to support numerous individual residential and business heating systems.

The principal direct thermal use occurring at Boise is in an 80-year-old district residential-heating system. This residential district has been cooperating with the state and with the City of Boise to determine the best method of providing geothermal heat for downtown retail and office space and 14 city, county, and Federal government buildings.

The project to heat the downtown area of Boise began in the summer of 1976 when the City Council created an Energy Task Force to

focus on downtown urban renewal. In FY 1977, a state-sponsored demonstration project that modified the 33,000 square foot state Agricultural and Health Laboratory for geothermal heating was completed. Following the successful completion of the demonstration project, the Energy Task Force (using a planning grant from DGE) completed designs, cost projections, and environmental assessments for the downtown space-heating system. The plans addressed various issues, including the appropriate developmental and marketing structure, methods of fluid disposal, Federal leasing requirements, and regulatory problems.

Developments at the Region 3 sites included in the IGCC electric scenario are discussed below:

Alvord, Oregon

Attainment of the IGCC-postulated 50 MWe by 1987 may require favorable resolution by 1980 of the pending lawsuit concerning the sufficiency of existing environmental assessments. In addition, an appeal to issue leases for bids that were previously rejected has been submitted to the DOI Board of Land Appeals.

Baker Hot Springs, Washington

The IGCC has postulated that, if geothermal electric generation is to occur at Baker Hot Springs, the first commercial-scale plant could be operational by 1990. Although the U.S. Geological Survey has monitored thermal activity at the site, the resource characteristics are still unknown.

Bruneau/Grandview, Idaho

At Bruneau/Grandview commercial-scale geothermal power could be produced up to two years earlier than the IGCC-postulated date of 1987. Numerous low-temperature irrigation wells have been drilled in the Bruneau/Grandview area (which includes the Mountain Home, Bruneau and Castle Creek KGRAs). At Castle Creek, one nonproducing well that was drilled for oil and gas exploration had temperatures greater than 200°C. In FY 1977, industry interest in geothermal process heat was expressed, and plans were underway to begin drilling for direct thermal applications.

Mount Hood, Oregon

The postulated production of 50 MWe in 1990 may require favorable resolution of existing legal and regulatory issues by 1983. Disagreements concerning watershed regulations, the Wilderness Act and the Hatfield Amendment are currently halting Federal leasing and development.

Geothermal development in FY 1977 has been for direct thermal applications. A program was proposed to utilize the Mount Hood resource for ski lodge space heating. Drilling was initiated at the Old Maid Flats to provide geothermal fluid for a district heating system. Industry interest in direct geothermal applications for food processing was expressed.

An Environmental Impact Statement was completed in August 1977. The BLM has issued leases with no-surface occupancy stipulations.

Raft River, Idaho

To determine the feasibility of exploiting moderate-temperature geothermal resources for electric development, DGE currently is sponsoring the construction of a 5 MWe experimental binary cycle electric plant to be operational by 1979. In FY 1977, a preliminary design for the entire test facility (including the geothermal loop, buildings and roads) was completed. The final design is expected by January 1978. Baseline environmental data for the pilot plant were collected; by the end of FY 1977, three production wells were drilled to 6,000 feet, and one 3,000 foot injection well was completed. In addition, FY 1977 funds were authorized to install a turbine, and DGE-sponsored testing of preliminary reservoir engineering models was underway.

Development for direct thermal applications has been occurring at Raft River. In FY 1977 the Idaho National Engineering Laboratory experimented with the use of geothermal water for irrigation. Preliminary test results indicated that the mineral content of the geothermal water had no adverse effects on crops. In addition, a private company studied the feasibility of using waste energy from Raft River geothermal electric generation for food processing (primarily of sugar beets and potatoes).

Vale, Oregon

The IGCC-postulated 50 MWe by 1988 will require successful resource exploration and assessment by the early 1980s.

As part of a long-term program to prepare a comprehensive heat flow map of Oregon, the Oregon State Department of Geology and Mineral Industries completed a heat flow drilling program in the Vale area in 1976. However, no deep geothermal wells have been drilled.

In FY 1977, interest was expressed in direct geothermal applications at Vale, particularly for processing sugar beets and for residential heating.

Weiser/Crane Creek, Idaho

If the current reservoir confirmation activities are successfully completed by 1980, the IGCC-postulated production of 50 MWe by 1988 could be attained up to two years earlier. In 1977, a 2,000-foot stratigraphic test hole was being drilled on private land.

The BLM rejected noncompetitive lease applications because of environmental uncertainties.

West Yellowstone, Montana (Including Island Park, Idaho)

Attainment of the IGCC-postulated 50 MWe by 1990 may require leasing of Federal land by 1982. Private land at West Yellowstone has been leased, but no drilling has occurred.

In FY 1977, U.S. Forest Service work on an Environmental Impact Statement (EIS) was underway. Noncompetitive lease applications are currently awaiting the outcome of the EIS, which will be completed in 1979. In addition, the first draft of an Island Park Land Use Plan was being reviewed by the Regional Forest Service in June 1977.

REGION 4 - ARIZONA, COLORADO, NEVADA, NEW MEXICO, UTAH

Resource Characteristics

Region 4 contains a relatively large number of high temperature hydrothermal convective resources. A hot dry rock resource has also been confirmed in the region (at Valles Caldera, New Mexico).

Geothermal Development Scenarios

As indicated in Table X and Figure 5, geothermal electric production in Region 4 is expected to be extensive, with the first commercial-scale electric production postulated to begin at four sites in 1983.

Direct thermal use of the resources in Region 4 is also expected to be substantial. The following is a partial list of sites where this development is postulated to occur:

Albuquerque, NM
Alamosa, CO
Chandler, AZ
Las Cruces, NM
Monroe, UT
N. Wasatch Front, UT
Safford, AZ
Springerville, AZ
Steamboat Hot Springs, NV
Steamboat Springs, CO
Wasatch Front, UT

Required Initiatives

The Federal Program has placed emphasis on initiatives to assure that resources are available to keep pace with the region's rapidly expanding commercial interest in geothermal development. These initiatives include leasing of Federal land to industry, and Federally-sponsored resource exploration and assessment.

TABLE X
GEOTHERMAL ELECTRIC SCENARIOS POSTULATED BY THE IGCC
FOR PLANNING PURPOSES* -- REGION 4

	Generating Capacity Installed Each Year (MW_e)										
	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990	Post-1990	Total
Brady Hot Springs, NV	--	50	--	--	50	--	100	--	100	700	1000
Beowawe, NV	--	50	--	--	50	--	50	--	100	750	1000
Chandler, AZ	--	--	--	--	50	--	--	--	100	80	230
Cove Fort-Sulfurdale, UT	--	--	--	50	--	50	--	50	50	1300	1500
Leach, NV	--	--	--	--	--	50	--	--	50	1400	1500
Roosevelt Hot Springs, UT	--	50	--	--	50	--	50	--	100	750	1000
Safford, AZ	--	--	--	--	--	50	--	--	--	50	100
Steamboat Springs, NV	--	--	--	50	--	--	50	--	100	--	200
Thermo, UT	--	--	--	--	--	--	50	--	--	450	500
Valles Caldera, NM	--	50	--	--	100	--	100	--	100	1150	1500
Cumulative Total		200	200	300	600	750	1150	1200	1900	8530	

*The selection of sites and the postulated generating capacities are based on current knowledge of the geothermal resources in the region. The scenario is intended for planning purposes only and does not imply any commitment on the part of the Federal government to development at these sites.

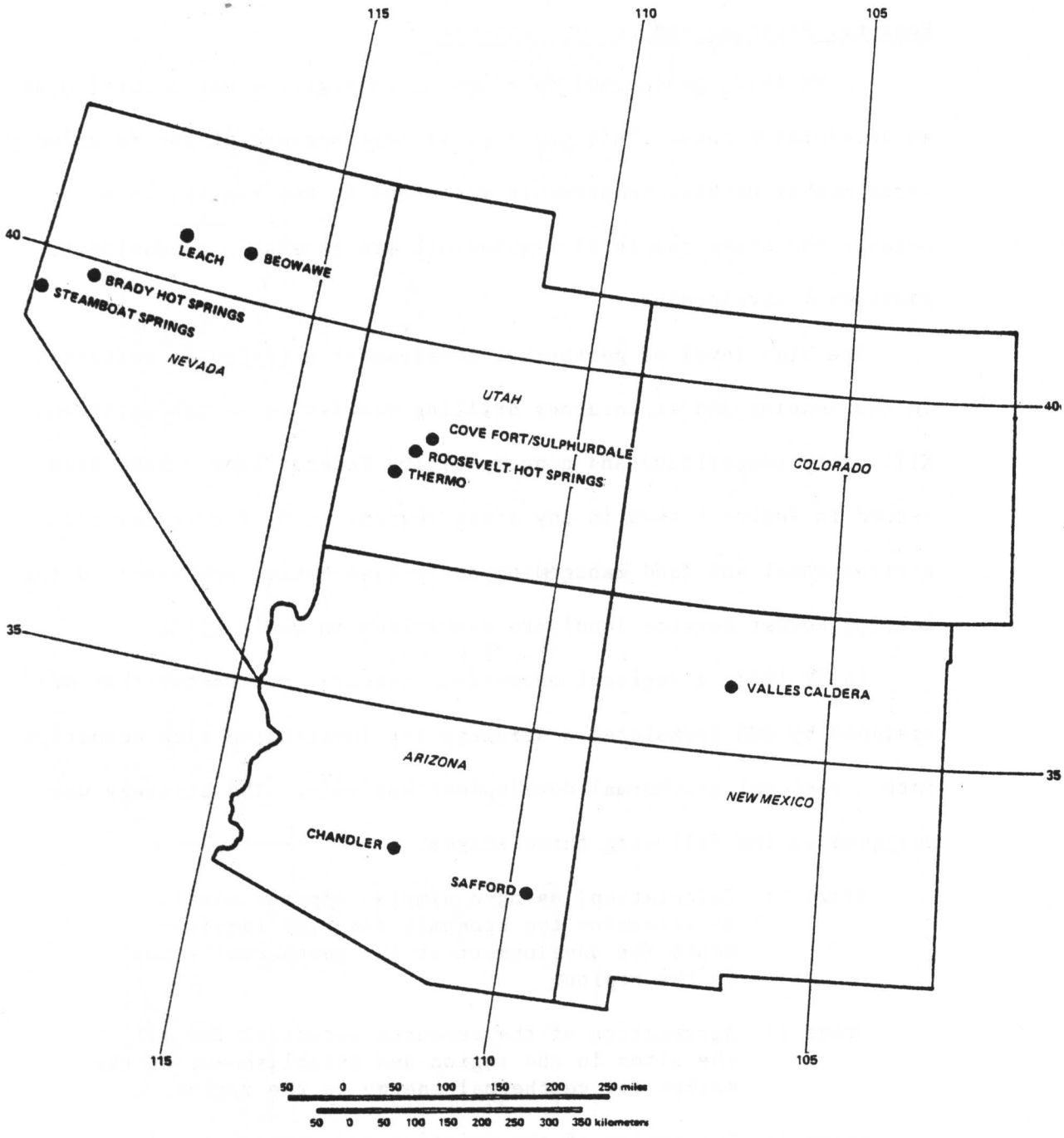

FIGURE 5
REGION 4 SITES IN THE IGCC GEOTHERMAL ELECTRIC SCENARIO

Regional Progress and Accomplishments

In FY 1977, geothermal development in Region 4 was occurring at an accelerated rate. This occurred in part because of the relatively large number of high-temperature resources in the region, in part because the state and local regulations are generally conducive to geothermal development.

The high level of geothermal development activity is reflected in the leasing and exploratory drilling statistics in Tables XI and XII. More competitive and noncompetitive Federal leases have been issued in Region 4 than in any other region. U.S. Forest Service environmental and land management activities (which are required for leasing Forest Service land) are summarized in Table XIII.

In FY 1977, a regional operations research contractor that was assigned by DGE formulated a strategy for integrating site scenarios into a regional geothermal development analysis. The strategy was designed in the following three stages:

Stage 1: Calculation, using a simple computer model, to determine the economic and time requirements for development at the geothermal sites in the region.

Stage 2: Aggregation of the resource potential for all the sites in the region and establishment of the market for geothermal energy in the region.

Stage 3: Evaluation of the existing and potential policy variables which may facilitate geothermal development.

TABLE XI
FEDERAL LEASING -- REGION 4

	Noncompetitive Leases Issued in FY 1977		Total Noncompetitive Leases Issued by 9-30-77		Competitive Leases Issued in FY 1977		Total Competitive Leases Issued by 9-30-77	
	Number of Leases	Acreage	Number of Leases	Acreage	Number of Leases	Acreage	Number of Leases	Acreage
Arizona	1	640	5	7,148	-	-	-	-
Colorado	8	12,464	43	50,245	-	-	3	5,036
Nevada	39	73,654	386		4	30,582	66	131,565
New Mexico	35	44,674	85	153,742	3	34,314	37	61,812
Utah	42	72,349	218	380,559	1	12,788	46	92,320
TOTALS	125	203,781	737	1,280,549	7	77,954	152	290,733

TABLE XII

GEOTHERMAL EXPLORATION WELLS GREATER THAN 2,000 FEET DEEP* - REGION 4

STATE	COUNTY	AREA	NUMBER OF WELLS DRILLED	
			10/1/75-9/30/76	10/1/76-9/30/77
Nevada	Churchill	Stillwater-Soda Lake KGRA		3
		Brady-Hazen KGRA		2
	Eureka	Hot Springs Point KGRA	2	
	Lander	Beowawe KGRA		2
	Washoe	San Emidio Desert KGRA	1	
New Mexico	Sandoval	Valles Caldera area	1	
Utah	Beaver	Roosevelt Hot Springs Unit (KGRA)	3	6
	Iron	Avon area Lund KGRA	2	1
TOTAL			9	14

* USGS statistics for exploratory wells drilled on Federal, state and private lands.

TABLE XIII

U.S. Forest Service Environmental Statements And Land Management Planning--Region 4

State	KGRA	National Forest	Halo of Non-Competitive Leases Around KGRA: No. Pending	Geothermal Environmental Statements as of December 1, 1977: Estimated Starting Date	Estimated Finished Date	KGRA plus Non-Competitive Federal Acres	Land Management Planning Area--Geothermal Prospect Total or in Part within the LMPA, as of October 15, 1977: Estimated Date Draft Filed with CEQ	Estimated Date of Final
Arizona	Clifton	Apache		None	-	320	Oct. 77	April 78
Colorado		Pike-San Isabel	None			75,500	Sept. 76	April 78
New Mexico	Fricso	Gila				5,760	Oct. 78	June 79
	Gila HS	Gila			Completed[2]	-	-	-
	Valles Caldera*	Santa Fe			Completed[2]	496,500	Sept. 77	Feb. 78
Subtotal New Mexico						502,260		
Utah	Cove Fort/ Sulphurdale*	Fishlake			Completed[1]	24,074	May 78	Nov. 78
	Monroe-Joseph	Fishlake			Completed[1]	16,364	Dec. 77	April 78
	Navajo Lake	Dixie			Completed[1]	2,522	Dec. 77	June 78
Subtotal Utah						42,960		

*Included in the DOE electric scenarios.

[1]Completed prior to FY77.

[2]Completed in FY77.

Stage 1 development is currently underway in Region 4. The Applied Physics Laboratory at New Mexico State University is hosting a data base system whose installation began in FY 1977.

In FY 1977, a state operations research study team and supporting advisory groups comprised of representatives of various government, industry, educational institutions and special interest groups, were formed for each state in the region. These state teams and advisory groups provide input to the regional operations research contractor. In August or September 1977, each state submitted a quarterly report that summarized geothermal-related state regulations and legislation, state participating agencies and organizations, geothermal leasing and developing status, and needed or planned State Geothermal Team activities.

The following is a summary of the geothermal status for each state in the region, which is intended to supplement the state drilling and leasing statistics (that have already been discussed).

Arizona

Geothermal resource assessment occurred in Arizona in FY 1977. Geologic studies that were conducted by the USGS in the San Francisco (Arizona) volcanic field implied the existence of a young volcanic system that probably contains high-temperature hydrothermal and hot dry rock resources. A cooperative study involving the DGE, the USGS and the Arizona Bureau of Mines and Geology was initiated to assess the state's geothermal resources. (A preliminary state map of geothermal resources will be published in mid FY 1978.)

Approximately four shallow-gradient wells have been drilled for geothermal purposes in the state. Geothermal development in Arizona has been hampered by a lack of state geothermal leasing regulations and procedures.

In Arizona (and New Mexico), the possibility of cleaning and purifying geothermal brines to make them suitable for secondary water uses is being considered along with the possibility of marketing the waste products. Because water is scarce in Arizona and the geothermal fluids may contain low total dissolved solids (TDS), treatment of the geothermal fluid for secondary water uses may be economical.

Colorado

Geothermal activities in Colorado are still in the exploration, resource confirmation and assessment stage. Only one geothermal well has been drilled in the state. Drilled in 1974 by Mapco, the well encountered high bottom hole temperatures and water which flowed to the surface in 21 minutes from a depth of 5,304 to 5,491 feet.

In a FY 1977, a cooperative study by the USGS, the Colorado Geological Survey and the Colorado Department of Water Resources analyzed samples of water that were taken from springs throughout the state. The study confirmed the existence of numerous low-to-moderate temperature resources. Data on these resources and the conclusion that the sampled resources would probably produce only hot water and little or no steam were published in a report.

Subsequent to the report, the DGE initiated the State Cooperative Program to further evaluate the low temperature potential of the

Colorado resources. Five thermal areas (Pagosa Springs, Glenwood Springs, Mineral Hot Springs, Mount Princeton and Cebolla Hot Springs) were designated to undergo further resource assessment through geothermal drilling. Consultation with industry representatives is underway to learn of specific plans which will provide the basis for site-specific geothermal development scenarios in these areas.

Nevada

Geothermal development in Nevada has been extremely active.

Approximately 86 percent of the land in Nevada is administered by the Federal government, while state lands are negligible in area. In FY 1977, Federal competitive leases were issued for Kyle, Pinto Hot Springs, Baltazor and Leach, Nevada. A large area of private land was also leased.

Several thousands of temperature gradient holes have been drilled in the state. Exploration surveys and field studies encompass a large portion of northern and western Nevada--perhaps over 75 different valleys in all. By the end of FY 1977, the U.S. Bureau of Land Management had received a total of 166 Notices of Intent for geothermal exploration in the Elko, Winnemucca, Carson City, Ely, Las Vegas, and Battle Mountain Districts.

The USGS has been sponsoring a project to define the Battle Mountain heat flow high (in northern Nevada). Most of the 30 new heat flow holes required for the study had been drilled by the end of FY 1977.

New Mexico

Exploration and assessment activities in FY 1977 identified high temperature resources in the state. The University of New Mexico and the New Mexico State University, with support from the USGS and the State of New Mexico, conducted a geological, geophysical, and geochemical study of New Mexico and the Rio Grande Rift. The study determined that reservoir temperatures near 170°C exist in the southwestern part of the state, and that reservoir temperatures may exceed 200°C in several areas in the southern part of the Rio Grande Rift.

Numerous geothermal development activities have occurred in New Mexico. In FY 1977, the Federal government issued competitive leases for Baca and Radium Springs/San Ysidro. By late September 1977, over 40 wells had been drilled in the state. This includes 14 exploratory wells that were greater than 2,000 feet deep. The most significant work in the state has occurred at the Baca Location No. 1 KGRA (at Valles Caldera) where dry steam and hot rock dry wells have been drilled.

The State of New Mexico is interested in promoting geothermal development. In 1977, the State Legislature enacted a resolution directing the Energy Resources Board and other state agencies to study the feasibility of heating state office buildings with geothermal energy. The New Mexico statutes relating to the geothermal leasing process and regulation of geothermal development are well established and seem to be adequate. There have been no court cases

concerning geothermal development in the state. However, industry has expressed some concern regarding the requirement that all state leases be issued competitively.

Utah

The existence of high-temperature resources in south-central Utah has been confirmed by commercial exploratory drilling at Roosevelt Hot Springs, Cove Fort/Sulphurdale, and in the vicinity of Thermo Hot Springs. In FY 1977, the USGS estimated that reservoir temperatures of 155°C in west-central Utah.

Industry has expressed a great deal of interest in geothermal exploration and development in Utah; but the lack of well-defined state policies and regulations concerning geothermal resources is currently impeding development.

The Utah Division of Water Rights has the legal authority to regulate geothermal development on state and private lands. However, specific geothermal regulations or procedures have not yet been issued. By the end of FY 1977, the Division's draft regulations, which had been in existence for two years, were revised with imminent adaptation of the revised regulations intended.

Under current state procedures, a developer may drill a geothermal well, but cannot extract the geothermal fluids until a water appropriations permit is issued. By the end of FY 1977, no water appropriations for geothermal development had been approved. The primary dilemma has been to determine how to allocate water rights for a single geothermal resource among various applicants.

In August 1977, cooperative case studies were conducted by DGE and industry to acquire reservoir data in Southern Utah.

Site-Specific Status Progress and Accomplishments

The following is a summary of activities for each of the sites which has been postulated by the IGCC for geothermal electric development in Region 4.

Activities that occurred in FY 1977 suggest that at least three additional sites may be incorporated into future electric scenarios. These sites are:

1. Desert Peak, Nevada, where the Phillips Oil Company has drilled three deep wells, one of which appears very promising;

2. Soda Lake, Nevada, where the Chevron, Union, and Phillips Oil Companies have planned a multiple drilling program under a unit agreement; and

3. Socorro Peak, New Mexico, where the Bureau of Land Management has received at least eight requests for permission to conduct exploration activities.

Beowawe, Nevada

Geothermal development at Beowawe is proceeding as postulated by the IGCC for the production of 50 MWe in 1983. At least 13 wells have been drilled at the resource. Many of the wells had high temperatures (greater than 200°C). Negotiations for unitization were in progress.

Brady Hot Springs, Nevada

Development at Brady Hot Springs is progressing adequately to meet the IGCC-postulated production of 50 MWe in 1983. Numerous wells, some with bottom hole temperatures greater than 200°C, have been drilled at the prospect.

In October 1977, the DOE issued a geothermal loan guaranty to construct a vegetable dehydration plant at Brady Hot Springs. Geothermal fluids extracted from one or more existing wells will be used (in place of natural gas) to heat the vegetable dryer and desiccator. When completed in September 1978, the plant will process 15 to 18 million pounds of raw onions per year.

Chandler, Arizona

Attainment of the IGCC-postulated 50 MWe by 1986 may be threatened by the delay in leasing state lands in Arizona.

Two deep wells were drilled at Chandler in 1975. Due to the low brine flow rates and well completion problems, the wells failed to be good producers. No drilling has occurred since then.

Cove Fort/Sulphurdale, Utah

Geothermal development at Cove Fort/Sulphurdale is progressing well. The IGCC-postulated production of 50 MWe in 1985 could be attained one year earlier, if the current drilling program by the Union Oil and Phillips Petroleum Companies succeeds in identifying a high-temperature resource.

More than 19,000 Federal acres have been leased at the site, and other Federal leases are currently pending the outcome of the U.S. Forest Service Land Management Plan which was expected to be complete by 1978.

Leach, Nevada

A significant level of surface exploration has been occurring at Leach. If exploration activities are successful, the IGCC-postulated production of 50 MWe in 1987 could be achieved as early as 1985.

Intensive geological, geochemical, geophysical, and drilling exploration research was conducted in FY 1977 by the Lawrence Berkeley Laboratory (under a DGE contract). Results of two years' investigation and study indicated that there are approximately 7,000 prospective geothermal acres at Leach. There has been no deep exploratory drilling at this prospect.

Roosevelt Hot Springs, Utah

Geothermal development at Roosevelt Hot Springs is occurring on schedule for the IGCC-postulated 50 MWe in 1983.

Numerous high-temperature, high-pressure wells have been drilled at the site. In January 1977, the Phillips Petroleum Company announced that tests of one of their existing wells indicated that it could produce sufficient steam to generate 12.5 MWe. Of the six deep wells drilled in the KGRA by June 1977, the best well was producing approximately 1,500,000 pounds per hour of water and steam at 250°C.

In October 1977, the DGE awarded a contract to the Thermal Power Company to gather data from two producing geothermal wells in the Roosevelt Hot Springs KGRA. In addition, DGE awarded a contract to the Geothermal Power Company to drill 15 temperature gradient holes 300 to 500 feet deep and to log the results, drill two 2,000-foot

observations holes, and to drill three exploratory production wells to 7,000 feet. In a separate contract action, the Denver Research Institute will conduct research and development on two-phase continuous flow technology to utilize the water and steam from the Thermal Power Company well.

Safford, Arizona

Attainment of the IGCC-postulated production of 50 MWe by 1987 may require leasing of U.S. Federal land by 1979.

To date, no geothermal wells have been drilled at the prospect. However, several mineral exploration wells drilled to 1,000 feet have encountered temperatures of approximately 100°C.

In FY 1977, the direct use of geothermal heat was being considered for copper refining in the Safford-Morenci copper district.

Steamboat Springs, Nevada

Geothermal development is occurring as scheduled for the IGCC-postulated 50 MWe plant in 1985.

At least 15 shallow wells have been drilled at the resource. One 725-foot well recorded 185°C and flowed 77 lpm (200 gpm) for over two weeks, but then the flow declined. The decline may have resulted from pressure reduction or calcite deposition.

Some geothermal energy is used for space heating at Steamboat Springs, a suburban area of Reno, Nevada; and additional space heating is being considered.

Thermo, Utah

The IGCC-postulated production of 50 MWe in 1985 could be attained up to three years early if drilling begins as planned and is successful.

Extensive surface exploration activity has occurred at Thermo, but no drilling has occurred. In FY 1977, drilling applications were received by DGE, and one plan of operations was approved. Republic Geothermal Incorporated, is expected to begin drilling in early FY 1978.

Valles Caldera, New Mexico

Geothermal development at Valles Caldera is occurring as postulated for the first 50 MWe plant to be operational in 1983. At least nine high-temperature, high-flow rate wells have been drilled at the site. At three wells drilled at Redondo Peak, separated steam flowed at rates greater than 50,000 pounds per hour. The maximum downhole temperature is approximately 300°C. In FY 1977, negotiations were underway to sell geothermal steam to the utilities, and to construct a 50 MWe power plant.

The Los Alamos Scientific Laboratory (LASL) has been conducting hot dry rock (HDR) experiments at Fenton Hill on the periphery of the Valles Caldera. A low impedance connection between two boreholes was successfully accomplished, and a 5 to 20 megawatt thermal energy extraction loop operated in September 1977 for approximately 100 hours. Significant advances were made in the equipment and

procedures for operating in the HDR environment. These advances included improved fracture mapping, borehole surveying and ranging equipment, open hole packers, directional drilling, and logging procedures.

REGION 5 - EASTERN UNITED STATES

Resource Characteristics

The Virginia Polytechnic Institute and State University (VPI & SU) of Blacksburg, Virginia, described the region in their resource assessment and confirmation progress report* as follows:

> Region Five...encompasses a diversity of geologic environments and a corresponding diversity of geothermal resource potential. Although the relatively stable tectonic setting of the eastern United States seems to rule out the possible occurrence of conventional, high-temperature hydrothermal resources, the region does contain geothermal resources which are being developed now, or which may be exploited in the future. The geothermal resources anticipated will be low- to moderate-temperature fluids that are best suited for direct heat applications.
>
> The geothermal resources in Region Five may be grouped for discussion into six types:
>
> I) radiogenic granitic rocks beneath the Atlantic Plain,
>
> II) hot oil field brines produced with oil and gas from sedimentary basins,
>
> III) hot, relatively fresh groundwater produced from aquifers of regional extent,
>
> IV) hot water emanating from fault zones as a result of apparent leakage from greater depths,
>
> V) hot dry rock in regions of abnormal gradient resulting from radiogenic heat, and
>
> VI) normal geothermal gradient resources.

*Evaluation and Targeting of Geothermal Energy Resources in the Southeastern United States, Progress Report by J. K. Costain, et al., July 1, 1977 - September 30, 1977, prepared for ERDA, Contract No. EY-76-5-05-5103.

Knowledge of those individual resource types varies considerably. Region Five contains a number of sedimentary basins which have been thoroughly explored for oil and gas; a number of areas which produce hot fluids with the oil and gas have been identified. Increasingly deeper drilling for groundwater has also identified intermediate depth aquifiers which produce hot water, such as the Madison Formation of South Dakota. In much of Region Five, therefore, the resource assessment is different from the high risk geothermal exploration in the western United States. In the eastern United States, geothermal resource assessment is often more a question of whether or not a known hot or warm water occurrence can be developed economically.

Geothermal Development Scenarios

Because there have been no high-temperature geothermal resources discovered in Region 5, the region has not been included in the IGCC geothermal electric scenario. However, the discovery of a vast number of low-temperature resources that underlie populated areas suggest that widespread use of the geothermal resources for direct thermal applications can occur.

Required Initiatives

The principal initiatives required in the region are to continue resource exploration, confirmation and assessment activities, and to demonstrate the feasibility of using low-temperature resources for direct thermal applications.

Regional Progress and Accomplishments

Geothermal development activity in Region 5 was far greater in FY 1977 than in any other year. For the first time, industry interest in geothermal leasing was expressed--and 11 noncompetitive leases were issued for 19,744 acres of U.S. Forest Service land.

A three-year geologic and geophysical study of the Atlantic Coastal Plan by VPI has been supported by DGE and its predecessor agencies. Recently this study culminated with the identification of eight granitic plutons buried beneath 4000 to 7000 feet of water-saturated sediments. The plutons may be quite warm: they are believed to contain greater than average amounts of long-lived radioactive elements, and the escape of heat has been reduced by the insulating properties of the sediments. Extensive aquifers immediately overlying the plutons are also believed to be hot and may represent a large source of geothermal energy at temperatures quite attractive for use in industrial processes and space heating.

Site-Specific Progress and Accomplishments

Late in FY 1977, DGE initiated a project to measure temperatures and recover cores in an existing oil and gas well near one of the buried plutons in Georgia. The USGS and the State of Georgia are participating in this project.

Region 5 contains a number of deep sedimentary basins that have been subjected to extensive drilling for gas and oil. This drilling has often encountered hot water at depth. In FY 1977, DGE contracted with the Mississippi State Geologist to survey existing oil and gas data for indications of a geothermal resource in the Mississippi Salt Dome Basin.

A large portion of the state of South Dakota is underlain by the Madison Formation. This formation is an aquifer containing

moderately hot water that can be pumped from wells less than 1000 feet deep. DGE is currently supporting a cooperative study between the state and the USGS to model the system and map its heat flow characteristics. In addition, the Edgemont, S.D., School District initiated planning activities to utilize the resource for space heating under a DGE contract.

There appear to be few technical, environmental, economic or institutional obstacles to the early commercial development of the Madison Aquifer in South Dakota, and DGE is working to encourage such development. However, because of the low density of population and industry, it is not likely that major energy markets will develop for the application of geothermal heat from the aquifer.

Other warm shallow aquifers occur in Region 5, notably in southern Arkansas. Although less is known about these aquifers than the Madison, they share with it an apparent limited market potential. However, the use of naturally flowing hot springs is being considered to heat buildings in the Hot Springs National Park, Arkansas.

FY 1978 ACTIVITIES

The following is a discussion of the major activities that are planned to begin or produce significant results in FY 1978. Descriptions of many FY 1978 activities have not been repeated if they were underway in FY 1977 (and were therefore discussed previously), and are expected to continue beyond FY 1978.

Because of the proprietary nature of most industry and private-sector planning, this discussion of future plans places heavy emphasis on government activities. However, the initiation of these government activities has been based upon needs expressed, formally and informally, by the private sector to achieve the national geothermal utilization estimates.

Resource Exploration, Assessment and Confirmation

Through increased industry and government efforts, many new hydrothermal convective geothermal resources are expected to be confirmed in FY 1978. Significant expansion of other resource types may result from increased emphasis by DGE on hot dry rock initiatives in the Western United States, and radiogenic resource assessment initiatives in the Eastern United States. In addition, a major project will be initiated by DGE in cooperation with industry to confirm the existence of high temperature reservoirs in the Northern Basin and Range Province (in southeastern Oregon, southern Idaho and northern Nevada). As part of this project, drilling is expected to begin in at least three new high-temperature prospects.

Geothermal exploration activity by industry is expected to be much greater in FY 1978 than in FY 1977.*

Surface exploration technology initiatives conducted by industry and supported by the DGE and USGS will continue throughout FY 1978. These activities will include magnetotelluric (MT) testing and related studies to define the optimum mix of exploration tools and associated data interpretation methods. DGE-sponsored MT field tests will be completed in mid FY 1978, with improved MT technology expected to be transferred to industry by early FY 1979.

Based on the economics and reliability of existing technology and techniques, a decision will be made by DGE to issue Requests For Proposals (RFPs) for resource exploration and confirmation initiatives. These initiatives may include improvements in well-log interpretation methods, and the development of new borehole systems, new electromagnetic systems or new high-temperature circuits and components. A DGE decision to acquire sites for testing and calibration is expected to occur by mid FY 1978.

The USGS and DGE will continue to conduct seismic and heat flow studies to define new areas with geothermal resource potential. In addition, the USGS will initiate activities associated with new applications of existing exploration technology and the development of new technology. Examples of these FY 1978 initiatives include

*This expected increase is reflected in the number of Applications for Permits to Drill (APDs) received by the USGS. In the first 3 months of FY 1978, 8 APDs were received. A total of 11 APDs were received in all of FY 1977. (Each APD may include numerous wells.)

improved dating methods for young igneous rocks, an expanded program to measure the physical properties of geothermal rocks and fluids and correlate these with geophysical data from exploration surveys, improved geothermometry based on mixing models, and the development of numerical techniques for modeling resistivity data.

Institutional Support Activities

Joint industry, academic, and government activities will continue throughout FY 1978 to identify institutional problems and to coordinate leasing and permitting procedures. Federal policy studies, carried out in part through the members of the Institutional Barriers Panel of the Interagency Geothermal Coordinating Council and in part through university contracts, will concentrate on land leasing policies, utility regulations and policies, and state legal and regulatory systems.

DGE planning emphasis will be placed on developing site-specific scenarios for direct thermal utilization, and on refining the existing electric scenarios. This emphasis will assure that the Federal Program will continue to provide industry with assistance at key points in the development process.

Economic and legal studies will continue to serve as essential components of the overall planning and policy development effort. Options for sharing the risk of premature reservoir failures will be formulated in FY 1978.

Federally-sponsored technology transfer and information dissemination efforts will continue throughout FY 1978. The National Science Foundation will award three to five postdoctoral fellowships to individuals engaged in geothermal research. Major Federal publications are expected to include:

- a revision of the DOE's existing Environmental Data Plan on Hydrothermal Energy Systems. The revision will include the environmental, health, and safety issues associated with geopressured and hot dry rock development;
- a U.S. Fish and Wildlife Service report on techniques for predicting the probable effects of geothermal commercial-scale development on fish and wildlife;
- a DGE-sponsored geothermal materials design and selection handbook; and
- the first maps (of Idaho and Arizona) in a series of state geothermal resource maps.

The USGS has initiated activities to update information on resource characteristics that was published in USGS Circular 726, "Assessment of Geothermal Resources in the United States - 1975."

In FY 1978, three major Federal initiatives will be undertaken to provide technical and economic information based on actual geothermal utilization experience. This information will come from:

- The Federally cost-shared geothermal electric generation demonstration plant. Proposals for the authorized demonstration plant will be received and evaluated, and a contract for its construction and operation will be negotiated. Design of the plant will be started and long lead time orders will be placed.

- Direct use field experiments. Several new engineering and economic studies for direct users will be performed; and in response to a Program Opportunity Notice (PON), a number of direct use field experiments will be underway by the end of the fiscal year.

- The Federal Buildings Project. To serve as a catalyst for further industry development, Federal buildings will be selected for installation of geothermal space heating systems.

Technology-Related Activities

Technology-related activities in FY 1978 will include a number of drilling, utilization and environmental control field tests. If successful, these tests could bring about a significant near-term reduction of geothermal development costs.

In FY 1978, DGE-sponsored projects will include the first field applications of the diamond chain bit drill, man-made diamond drill bits and the unsealed roller cone drill bit. Utilization activities will include the design and testing of a 500 kW direct-contact power conversion system, which is expected to provide the basic engineering design data and operating experience necessary to design and build commercial-scale modules up to 50 MWe in size.

Technical feasibility and economic impact analysis will be performed for a major new DGE-sponsored program that is being initiated to develop a binary heat-exchanger system. For this system, modified heat-exchanger tubes will be installed downhole to save the cost of conventional pressure vessels and to gain a greater efficiency in heat transfer.

The DGE will sponsor field tests of a 1 MWe helical screw expander wellhead generator on a geothermal well in Utah. This will be the first demonstration of a commercial-size wellhead-generator system which is rugged, easily transportable, and offers the prospect of providing an early return on drilling investment from wells during field development.

In the DGE Hot Dry Rock Program, FY 1978 emphasis will be on developing a controllable and effective rock fracturing and fluid circulation technique to produce the highest possible heat extraction capability and efficiency. This effort will include instrumentation and equipment development, drilling and hydraulic fracturing, borehole and fracture mapping methods, and extraction experiments. Testing of hot dry rock equipment and techniques will occur at Valles Caldera, New Mexico.

In FY 1978, standards will be established by the American Petroleum Institute and the American Society for Testing Materials, for the testing of cements used in geothermal well completions and the elastomeric seals used in blowout preventers and packers.

Along with the above materials standards development (which may relate to environmental control technology), other projects that focus on the potential for geothermally induced subsidence, seismicity, noise and well blowouts will continue in FY 1978. Emphasis will be placed on the reduction of hydrogen sulfide and other atmospheric pollutants, and on the disposal of geothermal fluids.

REGIONAL FY 1978 ACTIVITIES

The following is a summary of major activities that will be initiated or completed in FY 1978 and that will have regional or site-specific impact.

REGION 1 - CALIFORNIA AND HAWAII

Major FY 1978 milestones that relate to the resolution of institutional problems in California include:

- A final report on permitting and regulatory requirements to be issued by the California State Task Force by January 1, 1978;
- The implementation and monitoring of regulatory coordination procedures by the California Geothermal Permitting Project; and
- The implementation of a program to develop conceptual designs and cost estimates of power plants at those California prospects that are expected to produce geothermal electric power by 1985.

In Hawaii, the first element of a program to develop a family of wellhead generators will be initiated in a jointly funded program with the Hawaii Geothermal Project Development Group, which includes the State of Hawaii, the University of Hawaii, and the Hawaiian Electric Company. Conceptual and preliminary wellhead generator designs will be completed in FY 1978.

FY 1978 Site-Specific Activities in Region 1

The following is a summary of the major site-specific activities that will be initiated or completed in FY 1978. In addition to the activities summarized below, BLM competitive lease sales in California are planned for:

- Randsburg (7/78),
- Wendel-Amedee (5/78), and
- The Geysers (10/78).

Coso, CA

The BLM and the Navy will initiate the collection of environmental baseline data for the Coso Hot Springs area. Leasing of Navy land is planned for FY 1978; and the DGE will sponsor the first deep geothermal well test at the resource.

East Mesa, CA

Operation of the DGE-sponsored Geothermal Component Test Facility, is expected to continue in FY 1978 and beyond.

The Magma Power Company expects to start construction of a 10 MWe binary pilot plant in FY 1978.

Puna, HI

Additional drilling, resource assessment and reservoir engineering activities will be pursued at DGE's test site, and the installation of a small wellhead generator (of approximately 5 MWe) will be initiated.

Salton Sea, CA

In FY 1978, a study funded by the San Diego Gas and Electric Company (SDG&E) and the DGE, will be initiated. The study has been designed to identify the most technically and economically feasible conversion cycle, to identify any associated technical barriers, and

to plan test activities which could be undertaken at the existing Geothermal Loop Experimental Facility (GLEF).

The U.S. Bureau of Mines' minerals extraction and materials studies will continue at Salton Sea; and the USGS will refine a model of the geothermal water/rock interreaction and the geohydrologic framework relationship to geothermal systems in the area.

REGION 2 - LOUISIANA AND TEXAS

FY 1978 initiatives in Region 2 will continue to place emphasis on resource assessment and confirmation. DGE-sponsored resource assessment studies will map the Wilcox and Vicksburg formations in Texas and complete the delineation of five optimum wellsites in reservoirs of Miocene sands in Louisiana: About 75 percent of the onshore mapping is expected to be completed in FY 1978. In addition, the USGS will conduct geological and hydrologic studies to assess the deeper on-shore and the off-shore geopressured resources.

A final report on a U.S. Fish and Wildlife Service study to identify the ecological implications of geopressured development will be issued in January 1978. The report will identify potential impacts and describe possible alternatives and options for geopressured development procedures.

A DGE-sponsored project to conduct an inventory and case studies of direct-thermal use of geopressured resources by industry in Louisiana will be completed in FY 1978. The project is directed

towards an inventory and classification of industries within the U.S. Census Bureau's Standard Industrial Code 20, "Food and Kindred Products." The study will consider the industries' energy requirements and locations relative to the geopressured resource.

FY 1978 Site-Specific Activities in Region 2

In FY 1978, the DGE will sponsor four to six tests of existing wells in the Region. The first well designed specifically for testing geopressured aquifers will be drilled and tested in Brazoria County, Texas. By the end of FY 1978, tests at the Brazoria well are expected to attain 40,000 barrels of geopressured fluid per day. An additional well will be drilled in Louisiana late in FY 1978.

Reservoir computer simulators will use the Brazoria well and other well test parameters to estimate long-term producibility. Concurrent field and laboratory measurements of formation compaction will develop methods for mapping optimum reservoir locations and to determine possible subsidence effects. The National Geodetic Survey will do first-order leveling along grids in the Brazoria test area to provide reference levels for the determination of possible geopressured development-induced subsidence. Microearthquake surveying will also be done to determine if fault activation will result from fluid production. Air and water quality monitoring will occur prior to, during, and after production.

REGION 3 - IDAHO, MONTANA, OREGON, WASHINGTON, WYOMING

In addition to the DGE/Industry cooperative effort to assess the high-temperature resources of the Northern Basin and Range Province (discussed previously), resource exploration, confirmation and assessment activities will be sponsored in Region 3 by the USGS.

The USGS will conduct hydrologic, geologic and geophysical evaluations of geothermal prospects in the Snake River Plain in Idaho and geologic reconnaissance and hydrological studies in the Cascade Mountains.

FY 1978 Site-Specific Activities in Region 3

FY 1978 activities in Region 3 will include a joint USGS, DOGMI, and DGE resource assessment project near Mount Hood (Oregon), where thermal gradient measurements will be made.

At Raft River, Idaho, DGE-sponsored detailed engineering designs will be completed and, by mid FY 1978, construction will be underway on the first 40 MWth (5 MWe equivalent) thermal loop.

The Boise City (Idaho) Task Force anticipates that the major development and regulatory issues concerning the proposed extension of the existing residential district heating system will be resolved by the summer of 1978. Drilling and construction of the Boise City downtown geothermal heating system may then begin.

The U.S. Forest Service plans to complete the environmental statements and land management plans for

Indian Heaven, WA;
Marysville, MT;
Mount Baker, WA; and
Newberry Caldera, OR.

(see Table IX). The completions may enable additional leasing of U.S. Forest Service Land. In addition, BLM plans to hold competitive lease sales for

Breitenbush, OR (9/78);
Burns Butte, Crump Geyser, and Klamath, OR (6/15/78),
Mount Hood, OR (7/6/78); and
Vulcan, ID (10/17/78).

REGION 4 - ARIZONA, COLORADO, UTAH, NEVADA, NEW MEXICO

In FY 1978, geothermal development in Region 4 is expected to continue at an accelerated rate. To complement the extensive industry interest in developing the region's geothermal resources, a number of Federal activities are planned.

The USGS is planning to conduct water analyses for geothermal studies of the Arkansas and San Luis Valleys in Colorado, and to conduct regional heat flow and geochemical studies in southwestern Utah. As part of the Battle Mountain High project that was underway in FY 1977, the USGS plans to formulate a conceptual model of the hydrology and geology, and characterize the seismic subprovinces of central and northern Nevada.

Numerous institutional and technological initiatives are expected to begin as a direct result of the Regional Operations Research Study Team's recommendations.

In New Mexico, it is anticipated that a bill authorizing the state to underwrite part of the cost of driling for low- to moderate-temperature resources and to demonstrate direct geothermal applications will be introduced to the state legislature in January 1978.

FY 1978 Site-Specific Activities in Region 4

The BLM has planned competitive lease sales for the Stillwater, Soda Lake, Gerlach, and Fly Ranch (Nevada) KGRAs to occur on March 22, 1978, and for the Double Hot Springs (Nevada) KGRA on August 10, 1978. The following summarizes additional site-specific activities expected in FY 1978.

Brady Hot Springs, NM

Construction of a vegetable dehydration plant will be completed in September 1978. The plant is expected to process 15 to 18 million pounds of raw onions per year.

Cove Fort/Sulphurdale, UT

A U.S. Forest Service land management plan for the Cove Fort/Sulphurdale area is expected to be complete in November 1978. This completion (coupled with the Forest Service environmental statement that was completed prior to FY 1977) may enable future leasing of Forest Service lands at the geothermal resource.

Exploratory drilling, cofunded by industry and the DGE, is expected to result in further identification of reservoir characteristics and development potential at this site.

Roosevelt Hot Springs, UT

Negotiations are expected to begin by the Utah Power and Light Company and Phillips Petroleum in order to construct a 52 MWe power plant at Roosevelt.

The Thermal Power Company (under a DGE contract) is planning to gather data from two existing wells at Roosevelt Hot Springs. DGE-sponsored testing of the helical screw expander will be conducted at Roosevelt in mid FY 1978.

Thermo, UT

Exploratory drilling by Republic Geothermal Inc., is expected to confirm the existence of a high-temperature reservoir at Thermo in FY 1978.

Valles Caldera, NM

The LASL thermal loop will be operated for approximately 8 months to assess the long-term stability of the heat extraction rate, to determine the geothermal effects and to evaluate fluid loss and energy input requirements. First steps will also be taken toward a Phase 2 (50 - 100 MWt) energy extraction loop at Fenton Hill.

The U.S. Forest Service plans to complete the environmental statement and land management plan for the Valles Caldera in FY 1978.

REGION 5 - EASTERN UNITED STATES

The USGS will place increased emphasis on updating temperature and water sampling data to the GEOTHERM computerized file. This updated data will be used to assess the low-temperature geothermal resources in Region 5.

The Los Alamos Scientific Laboratory will continue to gather and analyze existing data from Region 5 sedimentary basins. This

information will be reviewed in FY 1978 to determine what further steps are needed to investigate possible geothermal resources in the basins.

The Applied Physics Laboratory of Johns Hopkins University plans to complete, under a DGE contract, a preliminary scenario for geothermal development in the Madison Limestone Aquifer in western South Dakota. The scenarios are expected to include a schedule for the engineering, construction and operation of geothermal community heating systems and agribusiness applications.

In FY 1978, DGE will support the drilling of 60 wells, each 1000 feet deep, to measure temperature gradients near buried plutons that were identified in FY 1977. The resulting data will better define the boundaries of the plutons and permit refined estimates of temperatures at depth.

Preliminary surveys suggest that some of these insulated plutons are located close to significant energy markets. Early in FY 1978, DGE will sponsor local energy market surveys and geothermal penetration analyses for the areas that appear to have the most promise for early commercial development. The results of this work, together with the temperature gradient and other geologic and geophysical data, will be used to prioritize the sites for deep hole drilling.

FEDERAL PROGRAM ACTIVITIES IN FY 1979 AND BEYOND

Many significant accomplishments that will have direct impact on commercial geothermal development are expected to occur in FY 1979. A 5 MWe wellhead generation system will begin operation at Puna, Hawaii, in FY 1979. (This project is being funded by the Hawaii Geothermal Project Development Group which includes the State of Hawaii, the County of Hawaii, the University of Hawaii, and the Hawaiian Electric Company.) The electric power produced during field testing will be distributed by the Hawaiian Electric Company.

Construction of the thermal loop facility at Raft River (Idaho) will be completed in FY 1979. Operation of this facility as a 5 MWe electric pilot plant will begin in FY 1980 following the installation of a turbine generator.

Based on the results of a joint DGE-industry funded feasibility study (to be conducted in FY 1978), an order for a turbine generator may be placed in FY 1979 and structural system design modifications for the Geothermal Loop Experimental Facility (GLEF) at Salton Sea, California, may begin. This action would convert the GLEF to a 10 MWe electric pilot plant which could be operational in FY 1981.

Based on plans announced in FY 1977, industry-sponsored 10 MWe geothermal electric pilot plants should be operational at East Mesa and Brawley, California by FY 1980.

Power from the first commercial-scale electric plants utilizing liquid-dominated hydrothermal resources is expected in the early

1980s from the DGE-sponsored demonstration plant and from commercially sponsored plants. Industry-sponsored commercial-scale geothermal electric plants may be in operation at Roosevelt Hot Springs (Utah) and East Mesa (California) as early as 1981 or 1982. The Northern California Power Agency and the Shell Oil Company have already announced plans to construct a 110 MWe plant to be completed in late 1980 at The Geysers' vapor-dominated hydrothermal resource.

Direct thermal utilization may begin in FY 1979 at a number of sites including Mono/Long Valley (California), Mount Hood (Oregon), and downtown Boise (Idaho). A series of direct thermal utilization experiments will be supported by the DGE in FY 1978, 1979, and 1980. The results of these experiments are expected to stimulate commercial utilization of low- to moderate-temperature hydrothermal resources.

Technologies that are currently being tested in DGE-sponsored projects, including the man-made diamond and the continuous chain bits, the direct-contact binary cycle heat exchanger and improved well logging equipment, are expected to be commercially available in FY 1979. Electric power production from moderate-temperature hydrothermal resources may be economically competitive in the late 1980s as a result of the binary cycle heat exchanger development. In addition, the Bureau of Mines project to evaluate metals and alloys in geothermal brine environments will be completed in FY 1979, and results will be made available to industry for incorporation into geothermal plant designs. By the early 1980s, an ongoing Bureau

of Mines project is expected to define candidate processes for recovering valuable minerals from high salinity geothermal brines.

The DGE-sponsored "thermal siphon" binary wellhead generator will be carried through the hardware development phase in FY 1979, leading to precommercial demonstration testing in mid-FY 1980. Commercial design criteria will also be established for the 1 MWe helical-screw expander wellhead generator system. Successful demonstration of these 1 to 5 MWe wellhead generator systems will enable early return on drilling investment from wells drilled during geothermal field development for commercial-scale electric plants.

Several other Federal program activities that are underway or planned are expected to have a major impact on geothermal electric and direct thermal utilization in the second half of the 1980s. U.S. Forest Service environmental statements will be completed in FY 1979 for the seven sites with Forest Service land that are in the IGCC electric scenarios, and all National Forest Management Plans (which include land at numerous geothermal prospects) will be complete in FY 1983. The completed environmental statements and management plans will make more land available to the public for geothermal leasing. In addition, the BLM has already announced tentative plans to lease land competitively at:

Knoxville, CA	(2/79),
Yuha, CA	(2/79),
East Mesa, CA	(7/80),
Indian Heaven, OR	(3/79),
Belknap-Foley, OR	(early 1979),

Mount Saint Helena, OR	(2/80), and
Newberry Caldera, OR	(3/80).

Formal IGCC regulatory recommendations that are now under consideration by the Department of Interior and other cognizant agencies, and legislative proposals for alternative tax incentives that are now before Congress should be in effect or enacted by FY 1979 and/or FY 1980.

Numerous drilling projects are expected to begin in FY 1979. Deep exploratory wells will be drilled for the first time in the Mt. Hood (Oregon) area and in previously unexplored portions of the Snake River Plain (Idaho). This drilling will be sponsored by the DGE and the USGS. In addition, six new high-temperature prospects will be drilled for reservoir confirmation as part of the ongoing DGE/industry cost-sharing program. DGE also plans to drill the first deep exploratory well in the Atlantic Coastal Plain in FY 1979. Site selection for this drilling project will be determined by the results of the thermal gradient drilling effort conducted in FY 1978. A deep continental drilling program sponsored by the DOE/Division of Engineering, Math and Geosciences, the USGS, the National Science Foundation (NSF), and the Department of Defense (DOD) will begin in FY 1979. These drilling activities may confirm the existence of additional geothermal resources that industry could use to produce electric or direct thermal power in the second half of the 1980s.

Results from well tests planned for FY 1978 and FY 1979 will support a FY 1979 decision to proceed with the development of advanced technology for utilizing energy from geopressured reservoirs. The first commercial-scale geopressured energy production may be achieved in FY 1986.

In FY 1979, the DGE-sponsored Hot Dry Rock Program will include continued operation of the heat extraction loop at Valles Caldera, New Mexico, additional drilling at a site to be selected, and supporting technology development. Successful completion of the elements of the hot dry rock development plan will prove the technical and economic feasibility of a number of hot dry rock energy extraction concepts and sites. This work can be accomplished before 1985. The first commercial-scale (50 MWe) electric power plant could be in operation by about 1990.

Dissemination of information acquired from the numerous activities of the Federal Geothermal Energy Program will continue. As part of the effort to disseminate geothermal information, the NSF plans to award additional fellowships for geothermal education under the National Needs Postdoctoral Fellowship Program. A major documentation of geothermal resource characteristics throughout the United States may be published by the USGS in January 1979. Federally-sponsored projects will continue to provide information on the potential environmental effects of geothermal development.

In FY 1979, the DOE-Sponsored Environmental Development Plan for the Federal Geothermal Energy Program will undergo the annual update. Environmental monitoring and health effect studies are scheduled to continue in the Imperial Valley as a follow-on to the regional environmental assessment (to be completed in FY 1978). The environmental baseline measurement project at Raft River, Idaho, will be completed in FY 1979; however, environmental monitoring will continue through the test period for the pilot plant in FY 1980 and beyond. Environmental assessments for the Geysers, California; Roosevelt Hot Springs, Utah; Valles Caldera, New Mexico; and Northern Nevada will continue through the end of FY 1980.

Annual updating of geothermal development scenarios based on known prospects, the achievable pace of development, and assessments of industry activity will continue in FY 1979 and beyond. This effort will continue to provide coordinated, mission-oriented planning support for both the Department of Energy Programs and the overall multiagency Federal Geothermal Energy Program.

APPENDIX A

INTERAGENCY COORDINATION AND PROGRAM MANAGEMENT
INTERAGENCY GEOTHERMAL COORDINATING COUNCIL (IGCC)

APPENDIX A

INTERAGENCY COORDINATION AND PROGRAM MANAGEMENT
INTERAGENCY GEOTHERMAL COORDINATING COUNCIL (IGCC)

Inasmuch as the development and commercial application of geothermal energy technology depends on the execution of program responsibilities that are vested in several Federal agencies, the formation of the Interagency Geothermal Coordinating Council (previously named the Geothermal Advisory Committee) constituted a significant step toward realizing the national goals for geothermal energy. This group was organized at ERDA's initiative to carry on the interagency program coordination function of the Geothermal Energy Coordination and Management Project mandated by Public Law 93-410 prior to the formation of ERDA.

The structure, purpose, and responsibilities of the IGCC are formally established by the IGCC Charter that was adopted in November, 1977. This Appendix presents the IGCC Charter, followed by a Figure and Tables that display the Council's organizational structure and membership, and by budget information for the Federal agencies that were active IGCC members.

INTERAGENCY GEOTHERMAL COORDINATING COUNCIL CHARTER

I. COUNCIL MEMBERS

The Council shall be composed of six members as follows:

A. An Assistant Secretary of the Department of Energy

B. An Assistant Secretary of the Department of Interior

C. An Assistant Administrator of the Environmental Protection Agency

D. An Assistant Director of the National Science Foundation

E. An Assistant Secretary of the Treasury Department

F. An Assistant Secretary of the Department of Agriculture

II. COUNCIL CHAIRMAN

The member representing the Department of Energy shall serve as Chairman.

III. In accordance with the provisions and intent of Public Law 93-410, the Geothermal Energy Research, Development and Demonstration Act of 1974, the Council shall coordinate those Federal plans, activities and policies which are related to or impact on geothermal energy, including ancillary activities of agencies not represented in the Council membership. Such other agencies shall 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 Chairman, may make recommendations to the appropriate agencies and the President with regard to alternative policies or actions considered necessary or desirable to expedite the development and utilization of geothermal energy resources. The Council shall meet not less than twice a year, such meetings to be at the call of the Chairman.

IV. STAFF COMMITTEE

There shall be a Staff Committee composed of six members, one of whom shall be appointed by each member of the Council. The Staff Committee shall be responsible for the formulation of Coordinated Federal Geothermal Program Plans and for directing and coordinating the activities of the Budget and Planning Working Group and the panels provided for in Paragraph VI and for reporting periodically to the Council on those activities. The Chairman shall be the DOE representative and will serve as Executive Secretary to the Council.

V. BUDGET AND PLANNING WORKING GROUP

There shall be a Budget and Planning Working Group responsible for:

A. Formulating long-range geothermal energy utilization goals and a comprehensive program of Federal activities and initiatives and associated budget requirements to meet these goals;

B. Coordinating annual program plan updates and budgets of the Council agencies and other agencies participating in the Federal Geothermal Program;

C. Preparing the Annual Report on the Geothermal Energy Program progress and future plans identified in Paragraph VIII;

D. Identifying programmatic and policy issues and other relevant information resulting from interagency planning coordination activities requiring Council resolution; and

E. Monitoring and reporting to the Council on the progress of the Federal program and the response of the non-Federal sector toward achieving the goals.

A Department of Energy representative shall serve as Chairman of the Budget and Planning Working Group.

VI. PANELS

There shall be three panels as follows:

A. A Resource Panel, responsible for continuing assessment of the geothermal and related resources of the Nation, including those required in connection with the development

and utilization of geothermal energy, and for facilitating the availability of those resources for development through the Federal leasing program and other means, as appropriate. The Department of the Interior representative shall serve as Chairman.

B. A Research and Technology Panel, responsible for coordinating and providing for exchange of information regarding the Federal research, development, and demonstration programs for geothermal exploration, resource assessment, energy and other product utilization, environmental effects and control technology, and basic and applied research related to geothermal energy. The Department of Energy representative shall serve as Chairman of the Panel.

C. An Institutional Barrier Panel, responsible for assessing legal, environmental, regulatory, and other aspects of Federal, state, and local government policy as they relate to geothermal energy and for developing recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including nongovernmental aspects. The Department of Energy representative shall serve as Chairman of the Panel.

Each Panel shall be composed of representatives of such Federal agencies and bureaus as are appropriate, including those that are not on the Council membership. Each Panel shall provide Ad Hoc Working Groups as needed, to be responsible for specific topics, problems, and to develop recommendations. Each Panel shall report periodically to the Staff Committee on its activities and plans.

VII. AMENDMENT OF CHARTER

The provisions of this Charter, including Paragraph IX, may be amended at any time by majority vote of the Council members.

VIII. ANNUAL REPORTS

In accordance with the provisions of Section 302 of Public Law 93-410, the Council shall prepare and submit to the President and Congress by January 31 of each year a report on Federal activities and programs in geothermal energy.

IX. DURATION OF THE PROJECT

The Council shall terminate on December 31, 1985.

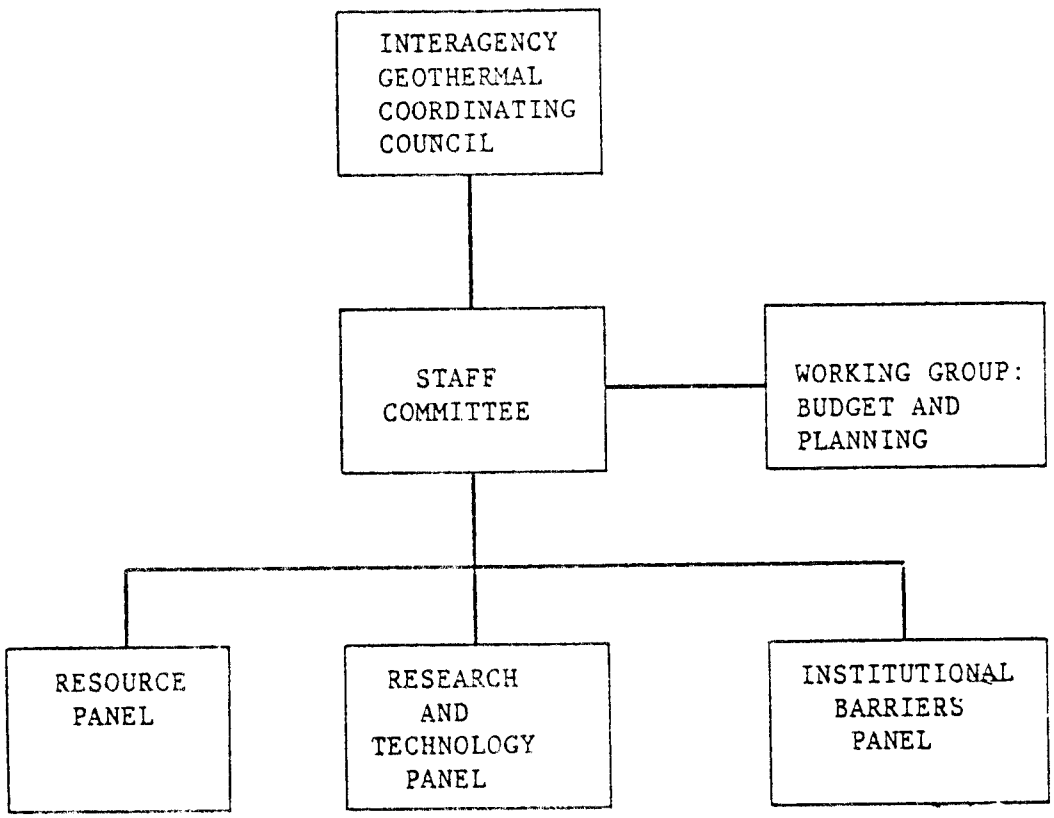

FIGURE A-1

ORGANIZATION OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

TABLE A-I

MEMBERSHIP OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

ORGANIZATION	REPRESENTATIVE
Department of Energy	Acting Assistant Secretary for Energy Technology
Department of the Treasury	Assistant Secretary for Economic Policy
Department of the Interior	Assistant Secretary for Energy and Minerals
Environmental Protection Agency	Assistant Administrator for Research and Development
National Science Foundation	Assistant Director for Science Education
Department of Agriculture	Assistant Secretary for Conservation, Research, and Education

TABLE A-II

MEMBERSHIP OF STAFF COMMITTEE

ORGANIZATION	REPRESENTATIVE
Department of Energy	Director, Division of Geothermal Energy (Chairman)
Office of Research and Development - Environmental Protection Agency	Deputy Assistant Administrator for Energy, Minerals and Industry
U.S. Geological Survey (Department of Interior)	Assistant Director, Energy and Mineral Resources
National Science Foundation	Director, Division of Advanced Energy and Resources Research and Technology
Department of the Treasury	Petroleum Specialist, Office of Energy Policy
Department of Agriculture, U.S. Forest Service	Watershed Management Staff

TABLE A-III

MEMBERSHIP OF STAFF COMMITTEE: BUDGET AND PLANNING WORKING GROUP

ORGANIZATION	REPRESENTATIVE
Department of Energy	Chief, Planning Branch, Division of Geothermal Energy; Chairman *
Department of the Interior	
Bureau of Land Management	Chief, Branch of Upland Minerals
Bureau of Mines	Associate Director, Mineral and Materials Research and Development
Bureau of Reclamation	Chief, Resources Planning Branch Division of Planning
Office of Water Research and Technology	Water Research Scientist
U.S. Fish and Wildlife Service	Office of Biological Services
U.S. Geological Survey	Chief, Office of Geochemistry and Geophysics
Department of Agriculture	
U.S. Forest Service	Watershed Management
Environmental Protection Agency	Energy Processes Division, Office of Energy, Minerals and Industry; Office of Research and Development

* FY 1978 BPWG membership may include representatives assigned by the DOE

- Assistant Secretary for Policy and Evaluation,
- Assistant Secretary for the Environment,
- Assistant Secretary for Conservation and Solar Applications,
- Assistant Secretary for Resource Applications,
- Administrator for the Economic Regulatory Administration,
- Federal Energy Information Administration, and
- Director of the Office of Energy Research.

TABLE A-IV

MEMBERSHIP OF THE RESOURCE PANEL OF
THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

Bureau of Mines

Department of Agriculture

Department of the Interior

DOE/Division of Geothermal Energy

NASA/Goddard Space Flight Center

NASA/Office of Energy Programs

U.S. Geological Survey

TABLE A-V

MEMBERSHIP OF THE RESEARCH AND TECHNOLOGY PANEL OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

Bureau of Mines

Bureau of Reclamation

Environmental Protection Agency

U.S. Department of Energy

DOE/Division of Geothermal Energy

National Aeronautics and Space Administration

National Science Foundation

Naval Facilities Engineering Command

U.S. Fish and Wildlife Service

U.S. Geological Survey

TABLE A-VI

MEMBERSHIP OF INSTITUTIONAL BARRIERS PANEL OF THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

Bureau of Land Management

Council of Environmental Quality

Department of Commerce

Department of Treasury

Department of Energy

Environmental Protection Agency

USDA/U.S. Forest Service

U.S. Geological Survey

TABLE A-VII

FEDERAL FUNDS ASSOCIATED WITH THE DEVELOPMENT OF GEOTHERMAL RESOURCES--IN $ THOUSANDS

	Actual FY 1977	FY 1978	Est. FY 1979
Department of Agriculture			
U.S. Forest Service	40	341	475
Department of the Interior (DOI)			
Fish and Wildlife Service	200	200	200
Bureau of Land Management	2,500	2,500	2,500
Bureau of Mines	528	542	650
Geological Survey	11,831	11,724	15,737
DOI TOTAL	15,059	14,966	19,087
Environmental Protection Agency			
Office of Research & Development	600	720	650
National Science Foundation*	220	70	70
Department of Energy (DOE)			
Division of Geothermal Energy	51,554	104,582	126,700
Division of Engineering, Math and Geosciences	1,235	1,400	2,570
Office of the Assistant Secretary for Environment	3,840	3,910	4,025
Geothermal Resources Development Fund and Guaranty Authority (Administrative Expenses)**	380	?	?
DOE TOTAL	57,009	109,892	133,295
TOTAL FEDERAL GEOTHERMAL PROGRAM BUDGET	72,928	125,989	153,577

*Includes 25 Energy-Related Traineeships in FY 1977 that may include geothermal education, and 3 National Needs Postdoctoral Fellows per year for geothermal research.

**Table A-VIII contains detailed information on funding and authority.

TABLE A-VIII

GEOTHERMAL RESOURCES DEVELOPMENT FUND AND GUARANTY AUTHORITY*

	FY 1977	
	Fund	Authority
Appropriation	$30,000,000	
Total Value of Loans Authorized for Guaranty		$200,000,000
Value of Loans Guaranteed		9,030,000
Guaranty Authorization Carried to FY 1978		$190,970,000
Administrative Expenses Incurred	379,756	
Unexpended Appropriation Carried to FY 1978	$29,620,244	
User Charge Collections Deposited in Miscellaneous Receipts	$27,000	

Geothermal Loans Guaranteed	Status as of September 30, 1977
Borrower:	Republic Geothermal, Inc.
Lender:	Bank of America
Project Cost:	$12,407,000
Borrower's Equity:	3,377,000
Guaranteed Loan:	$ 9,030,000
Term:	10 years
Loan Proceeds Disbursed:	$ 2,250,000
User Charges Paid by Borrower:	$ 27,000
Agreement Executed	May 6, 1977

*This financial information is included in the Second Annual Report to satisfy the requirements of P.L. 93-410, Section 204(c).

APPENDIX B

INTERNATIONAL ACTIVITIES

TABLE B-I

MULTILATERAL INTERNATIONAL AGREEMENTS WITH THE UNITED STATES

AGREEMENT	PARTICIPATING COUNTRIES	FY 1977 STATUS	FUTURE ACTIVITIES
International Energy Agency (IEA) Agreement	Geothermal Energy Working Party: Austria, Canada, the Federal Republic of Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, Turkey, the United Kingdom, the United States.	Four Expert Panels were established under the auspices of the IEA Geothermal Energy Working Party. The Panels continued discussions on the possibility of international cooperation in the areas of low enthalpy geothermal energy sources for direct thermal applications, high enthalpy geothermal energy sources for small electric power plants, man-made geothermal energy systems (hot dry rock), and geophysical exploration techniques. The U.S. delegation presented proposals for cooperative testing of a low velocity fluidized-bed heat exchanger and a helical screw expander unit.	The Man-Made Geothermal Sources (MAGES) project has reached the stage of an implementation agreement which is expected to be signed in October 1977. The Agreement will involve a 15-month study of methods to extract heat from hot dry rock, to be conducted at the Los Alamos Scientific Laboratory in New Mexico. Participating countries will include the Federal Republic of Germany, Sweden, Switzerland, the United Kingdom, and the United States.
NATO-CCMS* Geothermal Pilot Study	Canada, the Federal Republic of Germany, France, Greece, Iceland, Italy, Luxembourg, Mexico, New Zealand, Nicaragua, the Philippines, Portugal, Turkey, the United Kingdom	All five subsidies of the Geothermal Pilot Study, (1) Computer-Based Information Systems, (2) Direct Application of Geothermal Energy, (3) Reservoir Assessment, (4) Small Power Plants, and (5) Hot Dry Rock Concepts, were completed by the end of FY 1977. Pilot study activities in FY 1977 included an economic analysis of district heating models, a conference on the direct use of geothermal heat (held in Washington, DC), the completion of a set of design guidelines for a 5 MW_e geothermal power plant, and a Second Information Meeting on Hot Dry Rock held at Los Alamos, New Mexico.	A new bilateral agreement between the United States and Mexico for a cooperative investigation of the Cerro Prieto System will continue reservoir assessment activities initiated under the Reservoir Assessment Substudy. The CCMS Geothermal Pilot Study helped to lay the groundwork for a study on "Man-Made Geothermal Energy Systems" that will be conducted by the International Energy Agency.

* Committee on the Challenges of Modern Society

TABLE B-II

BILATERAL INTERNATIONAL AGREEMENTS WITH THE UNITED STATES

AGREEMENT	FY 1977 STATUS	FUTURE ACTIVITIES
U.S.-Iceland Bilateral Agreement	Technical information was exchanged under the joint auspices of the Bilateral Agreement and the CCMS Geothermal Pilot Study. Information was exchanged on site-specific operating experiences, exploration techniques, binary heat exchangers, hot dry rock energy recovery, water desalination and systems of cost-benefit analysis of various geothermal utilization techniques. Site visits by U.S. and Icelandic geothermal experts occurred.	In FY 1978, correspondents will be appointed for the exchange of information on liquid fluidized bed heat exchangers.
U.S.-Federal Republic of Germany Bilateral Cooperation	The Federal Republic of Germany proposed to contribute funds and scientists for hot dry rock research that is being conducted at the Los Alamos Scientific Laboratory (New Mexico).	Implementation is expected to occur in FY 1978.
U.S.-Italy (ENEL*) Bilateral Agreement	In FY 1977, a number of resource and regional reservoir assessment tasks in Central and Southern Tuscany and Travale, Italy, were completed; and several environmental control technology projects were initiated.	Activities planned for FY 1978 will include modeling of vapor dominated geothermal reservoirs, a workshop on resource assessment and reservoir engineering, analysis of the distribution of H_2S and radon gases associated with geothermal development, and field testing of a direct oxidation process for the removal of H_2S from geothermal fluids.
U.S.-Italy (ENEL/CNR**) Bilateral Agreement	In FY 1977, status of data collection at participating data centers in the United States (GRID, TIC, GEOTHERM) and Italy was reviewed at a meeting on Information Exchange in Washington, D.C. The DOE provided CNR with computer tapes containing bibliographic data, hydrogen sulfide data, geothermal fluid data and documentation format. Italy reported that negotiations with France, Hungary, Greece, and the USSR may lead to future information exchange. The United States reported that permanent contacts have been established with Bolivia, Canada, Costa Rica, Guatemala, Mexico, and the United Nations.	Information exchange will continue.

*Ente Nationale per l'Energia Elettrica

**Centro di Ricercha Geotermica

TABLE B-II (Continued)

AGREEMENT	FY 1977 STATUS	FUTURE ACTIVITIES
U.S.-Japan Agreement on Energy Research and Development	A geothermal implementation agreement with the Japanese Agency of Industrial Science and Technology was approved in principle in FY 1977.	This program will assist the development of technology for both electric power and direct applications of geothermal energy, and will contribute to improved equipment and techniques for resource assessment. Cooperative activities will also include studies on the environmental impact of siting and operating geothermal power plants.
U.S.-Mexican Bilateral Agreement	A five-year agreement was signed in July 1977 to conduct an extensive survey of the Cerro Prieto geothermal field in Mexico. The initial planning and coordination for all tasks were accomplished in FY 1977.	Under the terms of the five-year agreement, the Mexican Commision Federal de Electricidad, U.S. scientists from Lawrence Berkeley Laboratory, the U.S. Geological Survey, and the University of California at Riverside will survey the Cerro Prieto field to determine economic and productive methods to develop the reservoir. Information on subsidence, brine disposal, and reservoir characteristics will be directly applicable to geothermal development in the Imperial Valley which is the same geological province as the Cerro Prieto field. A major portion of the work at Cerro Prieto will be conducted in FY 1978 and 1979.
U.S.-New Zealand Science and Technology Agreement	Technical information on the development and utilization of geothermal energy has been exchanged. The U.S. has been given access to historical information on geothermal energy production at Broadlands and Wairelki, New Zealand.	The exchange of geothermal development information is expected to continue.
U.S.-USSR Agreement for Cooperation in the Field of Energy	In FY 1977, discussions were underway to identify potential areas of cooperation in geothermal energy.	

TABLE B-III

INTERNATIONAL ACTIVITIES SPONSORED BY THE UNITED STATES

ACTIVITY	PARTICIPANTS	FY 1977 STATUS	FUTURE ACTIVITIES
Central American Trade Mission/ Seminar	The U.S. Department of Commerce (DOC), DOE/DGE and U.S. industry representatives.	Planning activities were underway for a DOC-sponsored seminar to present U.S. geothermal technology to interested government representatives of Costa Rica, Guatemala, Nicaragua, and Mexico.	The seminar will be held in Central America in November 1978.
International Energy Development Program (IEDP) for Less Developed Countries	The U.S. Department of Energy (DOE), Department of State (DOS), and Agency for International Development (AID)	The Program was created to support President Carter's initiative of providing non-nuclear technical assistance for the utilization of indigenous energy sources in less-developed countries.	
		In FY 1977, DOE recommended criteria for selecting countries to receive geothermal development aid.	Small-scale demonstration plants for geothermal electric production and direct thermal applications may be implemented on a cost-shared basis with selected countries.