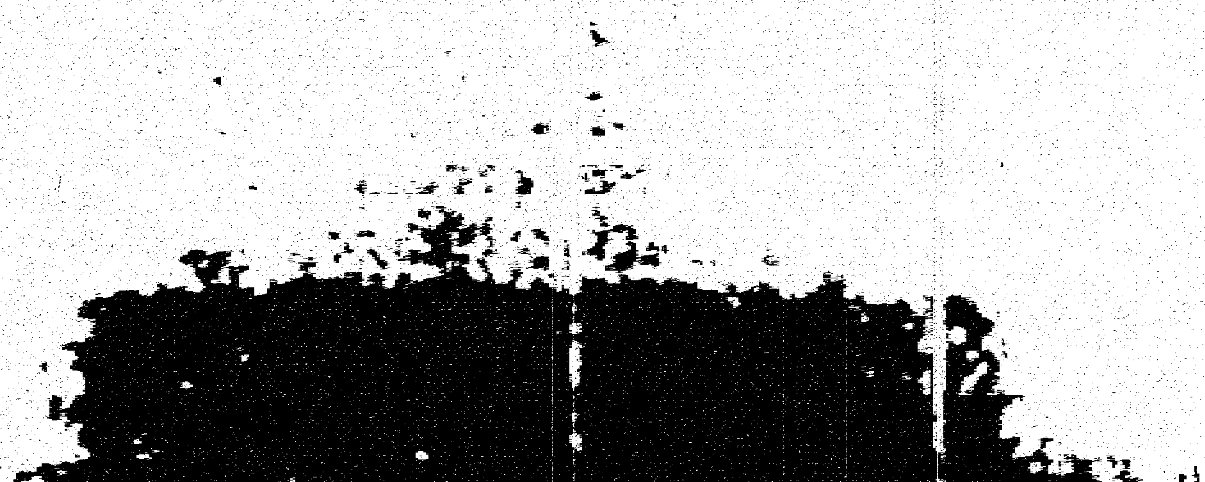
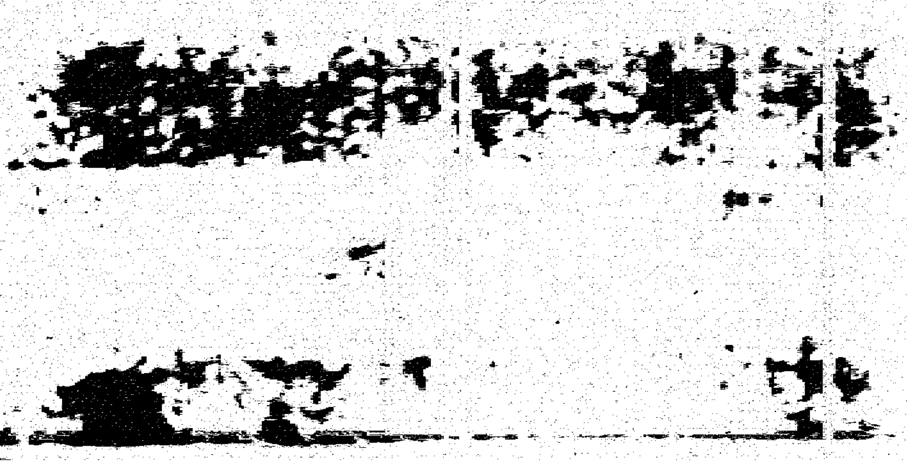
IGCC 81/2

FIFTH ANNUAL REPORT
INTERAGENCY GEOTHERMAL COORDINATING COUNCIL



FINAL DRAFT

JULY 1981



Department of Energy
Washington, D.C. 20461

July 7, 1981

MEMORANDUM TO: Members, Budget and Planning Working Group
Interagency Geothermal Coordinating Council

FROM: Fred H. Abel, Chairman
Budget and Planning Working Group
Interagency Geothermal Coordinating Council

SUBJECT: IGCC Annual Report to Congress

Enclosed is a copy of the final draft of the IGCC's Fifth Annual Report to Congress. Please review it carefully. Call any correction (no rewrites please) to Don Clements, 633-8820 or Fred Abel, 633-8814 by July 23, 1981.

Letters have been prepared for Mr. Tribble (Chairman of Council) to send to IGCC agencies requesting the designation of Staff Committee members. As soon as this is accomplished, a Staff Committee meeting will be called to get approval of the report. You should be prepared to brief your Staff Committee person on this report before the Staff Committee meeting.

The Staff Committee will then determine the appropriate way to get Council approval of the report.

Fred H. Abel

Fred H. Abel

Enclosure

FIFTH ANNUAL REPORT
INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

FINAL DRAFT
JULY 1981

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PREFACE

This is the Fifth Annual Report to Congress of the Interagency Geothermal Coordinating Council (IGCC), a body established by Congress to facilitate residential, industrial, commercial and utility sector use of geothermal energy. This report describes progress during fiscal year 1980 (FY 80) for the Federal Geothermal Program. In addition, it describes achievements in geothermal development by state and local governments and, where available, by the private sector.

The report also summarizes the goals, strategy, and plans that are the basis for the FY 81 and FY 82 program activities and reflects the recent change in the national policy affecting Federal research, development and demonstration programs.

Although its legal mandate and primary purpose is to provide information to the U.S. Congress, the report is also designed for use by the public.

It is the firm belief of the IGCC that geothermal energy is a clean, safe, and economical source of power, and is one of the most promising alternatives to conventional energy. Electric power production from the higher quality hydrothermal resources and direct heat applications from the lower quality resources are technologically feasible today. Widespread geothermal power will become increasingly available as research and development yield technologies appropriate for electric power production from moderate temperature fluids, discovery of new hydrothermal reservoirs, and economic extraction of energy from geopressured and hot dry rock resources.

Geothermal energy has the potential to expand quickly to meet near-term domestic needs. By the year 2000, geothermal energy could contribute significantly to the domestic and international energy supply.

Chairman
Interagency Geothermal Coordinating Council

EXECUTIVE SUMMARY

Geothermal energy is the natural heat of the earth, and can be tapped as a clean, safe, economical alternative source of energy. Much of the geothermal energy resource is recoverable with current or near-current technology and could make a significant contribution both to increasing domestic energy supplies and to reducing the United States' dependence on imported oil. Geothermal energy can be used for electric power production, residential and commercial space heating and cooling, industrial process heat, and agricultural process applications.

This report describes the progress for fiscal year 1980 (FY 80) of the Federal Geothermal Program. It also summarizes the goals, strategy, and plans which form the basis for the FY 81 and FY 82 program activities and reflects the recent change in national policy affecting Federal research, development and demonstration programs.

GOALS

The Interagency Geothermal Coordinating Council (IGCC) believes that substantial progress can and will be made in the development of geothermal energy. There are no quantitative goals for the amount of power to have on-line for future years, as this will be determined not by direct Federal actions to get power-on-line, but by the private sector as it responds to market forces. The IGCC goals focus on the removal of institutional (including Federal regulations) barriers that inhibit the private sector and on research and development that will reduce cost and risk to the private sector.

The IGCC goals are: (1) reduce the institutional barriers so that geothermal projects can be on-line in one-half the current time; (2) make moderate temperature resources an economically competitive source of electricity; (3) remove the backlog of noncompetitive lease applications; (4) competitive lease all KGRA lands; and (5) cut the cost of hydrothermal technology by 25%.

The IGCC has developed estimates of production potential that provide a basis for framing the Federal program. The estimated production potential is well within the private sector's capability, taking into consideration the amount of capital, material, skilled labor and geothermal resources required. However, the amount of geothermal energy actually obtained will depend on comparative economics and the degree of risk acceptance by industry.

The IGCC estimates of production potential for hydrothermal energy utilization in the year 2000 are electric power generation equivalent to 2 quads of fossil fuel energy (approximately 1 million barrels of oil per day) and direct heat use equivalent to 1 quad of fossil fuel energy (approximately 500,000 barrels of oil per day). It is known that the hydrothermal resource potential greatly exceeds the production estimates. In addition, it is estimated that geopressured resources could contribute 2,000 MWe for electric power production and 3 quads of methane by the year 2000. The energy potential for hot dry rock resources is estimated at 700 MWe for electric power production and 0.007 quads for direct heat applications. These production estimates are shown in Table ES.1. These production estimates provide a basis for framing Federal, state, and local policies and for determining measures necessary to increase the use of geothermal energy.

Geothermal energy production at the above levels could make a significant contribution to the national energy needs. The second National Energy Plan (NEP-II, May 1979, moderate oil price case) estimates that domestic energy production will reach about 103 quads per year by 2000; an increase of 28 quads/year over the 1980 production rate. Of this domestic energy production, 10 quads are expected to come from "renewables," or resources other than coal, oil, natural gas, and conventional nuclear. NEP-II identifies geothermal energy as one of the major long-term energy options to be pursued for national development. The hydrothermal energy resources of the U.S., if vigorously developed, could supply as much as 10% (3 quads) of the needed increase in annual domestic energy production. Geopressured (primarily methane production) and hot dry rock resources could supply an additional 10% (3.2 quads) of the required increase in domestic production.

Table ES.1

ESTIMATES OF GEOTHERMAL PRODUCTION POTENTIAL

	1980	1985	1990	1995	2000	2010	2020
Hydrothermal							
Electric Applications							
MWe	663*	3000	7000	14000	25000	38000	50000
QUADS/YR**	0.05	0.24	0.6	1.1	2.0	3.0	4.0
Direct Thermal Applications							
QUADS/YR	0.01***	0.1	0.2	0.4	1.0	3.0	6.0
TOTAL HYDROTHERMAL QUADS/YR	0.06	0.34	0.8	1.5	3.0	6.0	10.0
Geopressured							
Electric Applications**	0.0	0.001	0.006	0.04	0.16	0.3	0.4
Methane	0.0	0.02	0.1	0.7	3.0	5.0	7.0
TOTAL GEOPRESSURED QUADS/YR	0.0	0.021	0.106	0.74	3.16	5.3	7.4
Hot Dry Rock							
Electric Applications**	0.0	0.001	0.003	0.01	0.06	0.15	0.5
Direct Thermal Applications	0.0	0.001	0.001	0.004	0.007	0.015	0.6
TOTAL HYDROTHERMAL QUADS/YR	0.0	0.023	0.11	0.754	3.227	5.465	8.5
TOTAL GEOTHERMAL	0.06	0.363	0.910	2.254	6.227	11.465	18.5

*Actual hydrothermal electric capacity on line is 908 MWe.

**Based on MWe capacity estimates. Equivalent fossil fuel input needed to produce estimated MWe. Assumed capacity factory 0.80; fossil fuel plant efficiency 0.33.

***Actual hydrothermal direct thermal usage is .01 quads.

FEDERAL BUDGET

The overall objective of the Federal geothermal program is to enable private industry to undertake commercial development of geothermal resources by providing an appropriate level of Federal assistance while removing disincentives to exploration and development. All of the activities of the program are directed toward achieving this objective.

The Federal geothermal program comprises the efforts of the various Federal agencies that support the development of geothermal resources. These agencies include the Departments of Energy, the Interior, Agriculture, Treasury, Commerce, Defense, Housing and Urban Development, and the Environmental Protection Agency. The total Federal budget for geothermal development has remained fairly constant over the last several years, although there has been a significant reduction in funds requested for FY 82. This reflects a policy decision to rely on the marketplace for geothermal energy industrialization activities. Most notably, budget cuts have occurred in the DOE resource definition and hydrothermal industrialization activities. Table ES.2 presents the Federal funding levels for the geothermal program, ES.3 the geothermal resources development fund and guaranty authority and ES.4 the Federal leasing status.

ACCOMPLISHMENTS

During the past year, a number of significant accomplishments have been achieved through the Federal program. Highlights of planning activities and advances in the areas of leasing; environment; resource identification, assessment, and exploration; hydrothermal industrialization; GLGP; Federal use of geothermal energy; hydrothermal technology development; geopressured resources; hot dry rock resources; and international activities are given below.

Planning Activities

The most recent coordination efforts of the IGCC have resulted in the Federal Geothermal Program Plan, which is designed to provide an integrated

Table ES.2

FEDERAL FUNDING FOR GEOTHERMAL ENERGY ($000)*

ORGANIZATION UNIT Fiscal Year	Actual 1978	Actual 1979	Actual 1980	Estimated 1981	Requested 1982
Department of Agriculture					
U.S. Forest Service	678	780	750	700	650
Department of Defense					
Navy	542	300	230	930	1110
Air Force	0	0	200	1010	430
DOD Total	542	300	430	1940	1540
Department of Energy					
Conservation & Renewable Energy (Formerly Resource Applications)	105962	152990	149870	142521	48375
Office of Energy Research	2800	2100	3102	3305	3520
Environment	3896	2820	1950	723	1325
GLGP (Administrative Expenses)	410	0	181	193	200
DOE Total	113068	157910	155103	146742	53420
Department of the Interior					
Fish & Wildlife Service	200	200	200	70	**
Bureau of Land Management	2300	2590	2550	2650	2865
Bureau of Mines	550	1050	800	400	400
Bureau of Reclamation	1800	550	910	60	60
USGS, Geothermal Research Program	10184	12043	10047	7889	7889
USGS, Geothermal Evaluation & Lease Regulation	1854	750	860	898	898
DOI Total	16888	17183	15367	12024	12169
Environmental Protection Agency	670	920	850	1550	1550
TOTAL FEDERAL GEOTHERMAL PROGRAM BUDGET	131846	177093	172500	162956	69379

*Operating expenses rounded to nearest thousand.

**Dependent on transfer funds from other agencies.

Table ES.3

GEOTHERMAL RESOURCES DEVELOPMENT FUND AND GUARANTY AUTHORITY*

	FY 80 FUND	FY 80 AUTHORITY
Unexpended Appropriations, Carried Forward from FY 79	$ 43,832,277	
New Guaranty Authorization, FY 81		$150,000,000
FY 80 Guaranty Authorization		350,000,000
Value of Loans Guaranteed		91,048,000
Uncommitted Guaranty Authorization Carried to FY 81		258,952,000
Uncommitted Guaranty Authorization for FY 81		408,952,000
Administrative Expenses Incurred**(FY 80)	1,043,000	
Guaranty Fees Collected in FY 80	334,490	
Unexpended Appropriation Carried to FY 81	43,123,767	
Guaranty Fees Collected in FY 80 and Deposited in GRDF	118,715	

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

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

Table ES.4

FEDERAL LEASING STATUS,
CUMULATIVE AS OF SEPTEMBER 30, 1980

YPE	LEASES Number	Acres	APPLICATIONS Filed	Rejected	Withdrawn
oncompetitive					
Bureau of Land Management	1,611	2,827,767	5,814		
U.S. Forest Service	64	106,134	2,429		
Total Noncompetitive	1,675	2,933,901	8,243	1,615	2,678
ompetitive	306	514,148			
OTAL	1,981	3,448,049	8,243	1,615	2,678

overview of the geothermal program and activities of the IGCC member agencies. The Plan presents goals, objectives, proposed strategy, and planned activities for geothermal development in the FY 80-82 time frame. It also identifies major problems, inconsistencies, and shortfalls in the overall program and makes recommendations for improving program effectiveness.

In September 1980, DOE published the fourth issue of the Geothermal Progress Monitor, the first issue to receive wide distribution. The report was produced by the Geothermal Progress Monitor System which is designed to collect and compile information about geothermal activities. The report serves both program management and information dissemination functions for the member agencies of the IGCC.

Also in 1980, the report of the IGCC Environmental Controls Panel, entitled "Status of Environmental Controls for Geothermal Energy Development," was published. This report assesses the adequacy of existing environmental controls for geothermal energy systems, reviews ongoing programs to develop environmental controls and identifies controls-related research areas where Federal efforts are appropriate and necessary.

Leasing

In response to an identified need for guidelines on leasing Federal lands for geothermal development, the DOE/Leasing Policy Development Office has begun a project to establish production goals for energy from leased Federal lands. The goals are intended to help land management agencies in determining leasing programs and schedules and thereby prevent unnecessary delays in leasing that impede progress toward geothermal utilization. A preliminary analysis of the production estimates suggests that a minimum of 1.7 million acres of the highest potential Federal land would have to have been leased by 1980, 3.3 million acres by 1985, and 6.0 million acres by 1990 in order to reach the geothermal energy production estimates for the period 1985-2000 for both electric and direct heat uses. The analysis suggests further that (1) leasing of lands with potential merit for electric power production must be increased markedly; and (2) the BLM and USFS will have to lease about 500,000 acres per year of these high potential lands during

1981-1990 to ensure that enough land is explored to reach the geothermal utilization estimates for the year 2000. To ensure that this amount of high potential land is leased, BLM and USFS will have to lease all available known geothermal resource areas (approximately 1.5 million acres) and at least 18 million acres applied for noncompetitively by geothermal developers by 1990.

The number of noncompetitive leases issued by DOI in FY 80 increased by almost 50% from FY 79. The general status of geothermal leases indicates that Federal geothermal leasing is proceeding at a rate of 600,000 acres per year. Although this exceeds the rate of leasing (500,000 acres per year) indicated by the DOE/Leasing Policy Development Office's analysis as necessary to meet the IGCC potential production estimates, it is generally recognized that the areas being leased are not necessarily the areas having the highest geothermal potential. DOE/DGE has initiated a process to aid BLM and USFS in selecting specific areas on which to concentrate their efforts.

Only 25,000 acres were added to lands with Known Geothermal Resource Area (KGRA) status in 1980, resulting in a cumulative total of 3,410,000 acres being so designated. About 2.2 million acres of this land are Federally administered. Only 4 competitive lease sales were held in FY 80, compared to at least 12 sales held per year during the period FY 75 through FY 77. Most of the BLM administered KGRA parcels have already been offered for sale with the exception of those in California. Future competitive lease sales will involve primarily parcels administered by the USFS. The greatest amount of bonus bid money received has come from California and by far the greatest share of these monies has come from leases at The Geysers.

Environment

A technology assessment integrating environmental, health, and socioeconomic impacts of full-scale development of geothermal resources in the Imperial Valley of California was completed by DOE. This study will serve as a basis for understanding impacts from liquid-dominated resources in other regions of the country.

The Pacific Gas and Electric Company (PG&E), under a Cooperative Agreement with DOE and EPA, completed pilot scale tests during FY 80 of an H_2S removal process for geothermal steam developed by the EIC Corporation. A pilot scale field test documented H_2S emissions abatement efficiencies to 99.996 and led PG&E to announce that they planned to build a full-scale emissions control plant at their Geysers' power Unit 7 site.

The clarifier developed at the DOE-sponsored Geothermal Loop Experimental Facility in California was turned over to Magma Power, Inc. for their use in controlling solid wastes on a 28 MW geothermal power plant.

EPA issued revised Prevention of Significant Deterioration regulations and new Underground Injection Controls and Hazardous Waste Disposal regulations. These regulations clarify Federal environmental requirements for geothermal operators.

A major National Environmental Policy Act (NEPA) compliance activity involved the 50 MWe Geothermal Demonstration Power Plant on the Valles Caldera, New Mexico. The final environmental impact statement (EIS) for this project was prepared, approved and issued and a Record of Decision (ROD), documenting the decision by DOE to proceed with the project, was issued.

Resource Identification, Assessment, and Exploration

The geologic and geophysical study of the Snake River Plain of Idaho was completed by the USGS. The region shows considerable promise for the development of low- and moderate-temperature hydrothermal resources.

Several geophysical surveys undertaken in the Cascades region by the USGS have produced encouraging results; i.e., magnetotelluric data have revealed potential geothermal sources in the western high Cascades. Data were provided by five magnetotelluric profiles completed in California, Oregon, and Washington Cascades; 55 reconnaissance soundings completed in Oregon and Northern California; and a geomagnetic-telluric array traverse of the Cascade Mountains of Oregon.

Experiments with an airborne electromagnetic (AEM) system have shown that geothermal systems with a near-surface electrical signature can be detected by AEM. In surveys of five KGRA's, AEM techniques were successful in defining conductivity zones that had been previously mapped by AMT.

Increasingly encouraging evidence of the utility of the self-potential technique for delineating hydrothermal convective systems was gathered during the year. It appears more likely now that this technique has a great deal of promise as a new exploration tool.

The DOE-sponsored State-Coupled Program has resulted in cooperative agreements with 22 states' agencies to perform resource assessment activities in their states, as well as contracts with several institutions that provide geothermal investigations extending over a number of states. In all, assessment activities are under way in almost all states that have manifestations of a geothermal resource. To date, resource maps have been published for Arizona, Oregon, Nevada, Colorado, Idaho, New Mexico, and Utah. A more detailed definition of low- and moderate-temperature resources is accomplished under this program than is performed by the USGS in their regional surveys.

The User-Coupled Confirmation Drilling Program was established by DOE in FY 80 to stimulate the development of low- and moderate-temperature hydrothermal resources for direct heat applications. Projects selected for funding under this program will begin in early 1981. As a precursor to this program, five reservoir confirmation drilling projects were initiated in FY 80; three in Oregon, one in New York, and one in Delaware.

Analysis of the hydrothermal resource estimates of the USGS was recently conducted in support of a study by DOE designed to obtain improved estimates of the market potential of geothermal energy. Fifty-three development sites associated with known hydrothermal reservoirs having fluid temperature higher than 150°C are estimated to have a total electric power generation potential of 23,385 MWe.

Hydrothermal Industrialization

During FY 80 DOE continued to support geothermal commercialization teams in seventeen states, including Alaska, Hawaii, Idaho, Washington, Oregon, California, Arizona, Nevada, Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming, New York, and Delaware. The New York and Delaware state teams projects were initiated in FY 80. The level of consciousness of the benefits and values gained through the use of geothermal energy has been significantly advanced during the past year through individual state commercialization team activities such as resource area identification, site-specific development analysis, formulation of development plans, and information dissemination.

A series of outreach materials based on drilling, financing, resource definition, market, and R&D data, gathered from a national network of sources, has been prepared and disseminated, as appropriate, to the general public, to target audiences of potential end users, and to decisionmakers in government and industry. In addition, technical consultation has been made available on a limited scale to potential industry, community and utility end users through four regional technical assistance centers.

Recent market penetration studies based on extensive inputs from geothermal developers, utilities, and financial institutions have confirmed that in addition to a favorable busbar cost of geothermal electricity, factors such as rate of return on investment, size of project, and capital-at-risk determine whether a field developer-utility combination will undertake the development of a geothermal site.

DOE is supporting the design, construction, and operation of pilot and commercial-scale electric power plants. Current facilities include:

- Cost-Shared 50 MWe Flash-Steam Demonstration Power Plant at Baca Ranch, New Mexico - The final EIS was released in January 1980; plant design is under way and orders for a turbine and other long-lead time procurements have been placed; well drilling and flow testing have been initiated. The plant is scheduled to be operational by 1982.

- 5 MWe Binary Cycle Pilot Plant in Raft River area of Idaho - Work on construction is complete and the system is being checked out. Additional well tests are underway. The plant is expected to be operational in FY81.

- 3 MWe Wellhead Generator System near Puna, Hawaii - Plant construction is well under way. The plant is scheduled to be operational in FY81.

To date, 42 technical and economic feasbility studies of direct heat applications have been supported by DOE; 34 of these studies have been completed; 11 in FY80. A competitive solicitation covering cost-shared industrial applications was issued near the end of FY80. This led to the support of eight new studies, four involving direct heat use for ethanol plants.

Twenty-four cost-shared direct heat demonstration projects are now under way. The majority of these projects are for space and district heating, while four are directed toward agribusiness, and three involve industrial processing. Ten of these projects are in the reservoir confirmation phase, and five field experiments currently involve construction and installation. The following five projects are in operation:

- Haakon, South Dakota - space conditioning for five school buildings
- Klamath Falls, Oregon - space conditioning and hot water for YMCA
- Midland, South Dakota - agricultural uses on ranch
- Truth or Consequences, New Mexico - space conditioning for a hospital
- Pierre, South Dakota - space conditioning for a hospital

The Geothermal Loan Guaranty Program presently has guaranteed parts of six loans, including one refinancing. The guaranties from this program now total $136.0 million for projects totalling $202.7 million in cost (two projects were approved for loan guaranties of $94.4 million in FY80). Four of these projects will provide an added 258 MWe (gross) to current electric power production. Another project will provide 117 billion BTU/year for food processing.

Federal Use of Geothermal Energy

The following DOD-sponsored projects are in the planning or initiation stage:

- Adak Naval Station, Adak, Alaska - space heating and electric power generation
- China Lake Naval Weapon Center, Coso, CA - electric power generation
- Fallon Naval Air Station, Fallon, NV - electric power generation
- Hill Air Force Base, Utah - space heating
- Keflavik Naval Station, Iceland - space heating; construction is under way
- Norfolk Naval Station, Norfolk, VA - space heating
- Williams Air Force Base, Arizona - space cooling and electric power generation
- Kings Bay, GA - space heating; DOE/DOD-sponsored exploratory well drilled
- MX Weapon System - electric power generation in Nevada and Utah for MX system and its support facilities.

Hydrothermal Technology Development

A strategy of exploration for high-temperature hydrothermal systems in the Rocky Mountain Basin and Range Province has been developed, based on exploration data that were generated by DOE's Industry-Coupled Program.

An automatic seismic processor has been successfully field tested at The Geysers geothermal field in California. The processor obtains microearthquake data that can be used in identifying and delineating hydrothermal reservoirs.

Further field tests were conducted on a continuous chain drill, leading to a design incorporating all Stratapax (polycrystalline diamond) cutters. A new high-temperature drilling mud was also developed, and is now used commercially for geothermal drilling in the Imperial Valley, California.

Two wells at the Raft River site in Idaho were treated by hydraulic fracturing techniques. The analysis of the results of this well stimulation showed improved fluid flow for one of these moderate-temperature wells.

A 500 kWe binary power system employing a direct contact preheat/boiler was installed and operated at the DOE Geothermal Test Facility at Holtville, California. The boiler and associated working fluid recovery and noncondensible gas recovery subsystems have exceeded design performance goals.

A 1 MWe total flow wellhead power plant utilizing a helical screw expander was installed and tested at Cerro Prieto, Mexico, under a cooperative program of the International Energy Agency. DOE provided the power plant and technical specialists who advised the Mexican scientists on the operation and evaluation of the power plant. Preliminary data suggest that the power system could be a reliable and efficient small-scale prime mover, well suited for geothermal applications.

Geopressured Resources

Final preparations were made for long-term testing of the geopressured well in Brazoria County, Texas.

Recompletion of an existing gas well in Louisiana was initated prior to geopressured aquifer testing, and negotiations were completed for four additional Wells-of-Opportunity in the Gulf Coast.

Two new geopressured drilling projects for designed production wells in Louisiana were started, and a solicitation for proposals was issued for the drilling of four additional geopressured wells in Louisiana and Texas.

Hot Dry Rock Resources

Sixty kilowatts of electricity were generated on a continuous basis at the Fenton Hill, New Mexico, research installation, demonstrating the technical feasibility of electric power production from hot dry rock resources.

The first well of a large (20-50 megawatt thermal) hot dry rock thermal loop was completed at the Fenton Hill site.

A cost-shared agreement with the Federal Republic of Germany for participation in the Fenton Hill hot dry rock project was executed under the auspices of the International Energy Agency.

International Activities

At present, worldwide installed geothermal electric capacity is 2,475 MWe among 14 countries. There are also twelve countries with significant direct use of geothermal energy totalling 8,300 MWt for space conditioning, water heating, agricultural and industrial applications.

DOE currently is involved with three multilateral cooperative efforts through the International Energy Agency; has bilateral agreements with Italy, Japan, and Mexico; and is negotiating an agreement with New Zealand.

The 1.2 MWe geothermal power system (helical screw expander) developed by DOE is undergoing a program of research and development and demonstration of geothermal equipment involving test sites in Mexico, Italy and New Zealand.

PROGRAM PLANS

The Federal geothermal program activities are designed to transform several types of geothermal resources into an array of technically, economically, and environmentally sound commercial ventures. The major barriers to commercial development of geothermal energy are: (1) the initial risk associated with the expensive drilling needed to confirm geothermal reservoirs of all types prevents many potential users from starting projects; (2) the vast majority of higher-temperature hydrothermal reservoirs suitable for electric power production are only marginally economic with present technology; (3) the overall rate of leasing of Federal lands appears to be too slow to sustain rapid development of hydrothermal resources in the 1990-2000 time period; (4) the present state laws need further development to promote a clear legal climate for industrial geothermal activities; (5) there is a lack of an industrial infrastructure to suppport direct heat applications; (6) there is a general lack of knowledge about geothermal energy on the part of potential users and developers; and (7) the technology and economics have not been proven for geopressured and hot dry rock resources.

The overall strategy for accomplishing the Federal geothermal program is to support industrial development of U.S. geothermal resources through a time-phased set of government actions designed to allow more rapid action by the existing geothermal industry and to facilitate entry into the geothermal marketplace by additional resource developers, utilities, financial institutions, service firms, and consumers. The strategy is based on the concept that U.S. industry will develop all types of geothermal resources rapidly if the government provides initial assistance to resolve technical problems, economic questions, and institutional issues that are unique to geothermal energy systems and novel to the U.S. industry. The strategy emphasizes: (1) actions needed to resolve barriers to immediate industrial development of hydrothermal resources that are now economical; and (2) actions required to enable midterm development of geothermal resources for which technology and economics have not been fully proven.

Major Federal actions that are expected to support rapid growth of geothermal energy production include development of new leasing policies and environmental regulations, construction and operation of a major demonstration plant, refined resource estimates, and construction of geothermal facilities to supply energy to military installations throughout the U.S. These actions are discussed briefly below:

- The Bureau of Land Management (BLM) and the Forest Service (FS) have begun to formulate new regulations for leasing Federal lands for geothermal exploration. Under the new rules, lands could be explored prior to the exhaustive environmental assessments required to permit construction of facilities to produce energy. Comprehensive production-related environmental reviews are conducted if and when the developer determines potential for geothermal energy production. This new approach to leasing should help to reduce the backlog of lease applications and ensure that sufficient acreage is available for exploration. The Forest Service issued guidelines on leasing Federal lands for geothermal exploration during the year.

- The Environmental Protection Agency (EPA) revised the Prevention of Significant Deterioration (PSD) regulations under the Clean Air Act. Hazardous Waste Disposal and Underground Injection Control regulations have been issued under the Resource Conservation and Recovery Act and the Safe Drinking Water Act respectively.

- Because of the lack of sufficient data, the current inventory and assessment of national geothermal resources are based on a large number of assumptions about the location and size of identified hydrothermal systems and geopressured geothermal formations. In addition, relatively little is known about the undiscovered portion of the nation's geothermal resources. As new data become available from resource characterization studies and reservoir exploration, the national inventory and assessment of the various types of resources will be periodically updated to provide refined estimates of these resources.

- The 50 MWe hydrothermal flash-steam demonstration plant at Baca, New Mexico, will begin operation in 1982.

- DOD will construct geothermal facilities to provide energy to Navy and Air Force bases throughout the U.S. Projects being planned or under consideration include both space heating and electric power generation.

PROBLEM AREAS

In spite of the Federal initiative just described, achievement of the IGCC's objective to encourage rapid commercial development of geothermal resources may be inhibited by several short-falls in the program. These inadequacies relate to regulatory delays, low priority treatment of geothermal in some agency budgets, and a need for increased participation by agencies with capabilities to support the program further.

Problems and issues are summarized below:

- The rate of leasing lands for geothermal development between 1980 and 1990 may have to be double that of the previous decade if the production potential is to be reached. Moreover, the bulk of the leased acreage will have to be on lands identified as Known Geothermal Resource Areas (KGRA's). Federal land management agencies have resolved to expedite leasing procedures, particularly with respect to environmental reviews. BLM and the Forest Service are likely to require additional manpower to be able to process enough leases to help meet energy utilization objectives.

- While Federal environmental regulations for clean air areas, underground aquifers, and hazardous wastes were issued by EPA in 1980, emission and discharge technology-based standards to guide industry remain a critical need. Uncertainty over the regulatory framework surrounding future geothermal projects can delay action by companies otherwise ready to develop geothermal energy. In addition, other environmental problems (e.g., hydrological alterations, subsidence and seismicity) may prove severely constraining.

- Agencies that do not have budgets that show geothermal energy as a "line" item often have difficulty obtaining sufficient resources for their programs. For example, the Forest Service has adequate manpower in the field to conduct geothermal leasing activities; these resources, however, are being demanded to meet the needs of competing programs (i.e., coal leasing, oil and gas leasing, forest management, and recreational services).

OUTLOOK

Private industry has the leading role in the direct planning and construction of geothermal energy systems. The activities of the Federal geothermal program are designed to enable the existing geothermal industry to act more rapidly, and to encourage additional resource developers, utilities, financial institutions, and consumers to enter the geothermal marketplace. A close liaison will be maintained with the industry to ensure that the current and planned Federal actions are those most vital to geothermal development.

Hydrothermal energy has great potential in the near term. Indications are that the pace of development is rapidly accelerating and that even more plants will be built and more resources developed by the middle of this decade than previously estimated. For example, utility companies have publicly announced their intention to build hydrothermal electric generating plants totalling more than 1,000 MWe from hot water resources. This, along with the announced expansion of dry steam generating capacity at The Geysers, California, to 1,900 MWe, would produce installed capacity of about 3,000 MWe by 1985. Federal activities that support the hydrothermal industry in the near term include resolution of Federal lands leasing issues; continuation of technical assistance programs; and establishment and implementation of interagency agreements between DOE, HUD, the Farmers Home Administration and Rural Electric Administration with respect to geothermal electric power and direct heat projects. Other planned activities in support of hydrothermal resource development include a demonstration of a full-scale flash-steam electric plant in operation by late FY 83 and a pilot-scale binary-system plant by early FY 81; improvement of technology for reservoir assessment, well drilling and stimulation, energy conversion, and geochemical engineering through 1985; and the completion of direct heat demonstration projects and dissemination of information to industry. These activities are designed to enhance the commercial use of hydrothermal resources which has been inhibited by the industry's perception of economic and technical risk, reservoir uncertainties, and a variety of legal and institutional barriers.

The geopressured resource base is unquestionably large, but little is known about the economics of recovering its methane, thermal, and hydraulic energy. Hence, geopressured energy use is viewed as a midterm probability. Tests of the first design production well in Barzoria, Texas, will be completed in FY 82 and tests of additional design wells will continue through FY 86. If the assessment of the feasibility of energy extraction (particularly methane) is favorable, commercial development of the geopressured resources could begin in FY 87. Systems for using the heat from geopressured fluids for electric power production and direct heat applications will be adapted from hydrothermal technology.

Extensive use of energy from hot dry rock is a long-term possibility. The successful operation of a 5 MWt loop at the Fenton Hill site in New Mexico has established the technical feasibility of energy extraction. In FY 81, Phase II drilling at Fenton Hill will be completed in preparation for a 20-50 MWt loop scheduled for operation in FY 82. Experiments at Fenton Hill will continue to be conducted under the international agreement with the Federal Republic of Germany. Energy extraction experiments at a second site in a different geologic setting will be completed in FY 87. Commercial deployment of hot dry rock technology could begin around the year 1990. The industrial infrastructure associated with hydrothermal resource development is expected to participate in the development of hot dry rock, once the technology and economics are shown to be favorable.

Technology development efforts have successfully overcome many impediments to commercial geothermal activity. The efforts are now focused on those areas where technical advances will cut costs, improve reliability, and allow economic use of marginal resources. Geothermal component development efforts are expected to: (1) develop the technology for reducing the cost of deep geothermal wells by 50% by the end of FY 87 through the development of advanced drilling systems; (2) increase the productivity of selected geothermal wells by 50% by the end of FY 86 through development of well stimulation techniques; and (3) complete the development of advanced downhole pumps in FY 84. The component development work focuses on hydrothermal systems and maintains a schedule relationship with the hydrothermal industrialization activities; however, many products of this effort will contribute to the industrialization of geopressured and hot dry rock resources as well.

1.0 INTRODUCTION

1.1 OVERVIEW

The Federal government has been actively involved in the development of geothermal energy since 1970, when the Geothermal Steam Act was passed. Since then it has undertaken numerous research, development, and demonstration programs to promote the use of geothermal energy. This report summarizes the activities of the Federal government during fiscal year 1980 (FY80), and describes the near-term plans and programs for geothermal energy development.

In 1979, the United States produced about 63.5 quadrillion BTU (quads) of energy. Of these about 18 quads were from petroleum; 22 were from natural gas; 17.5 were from coal; 3 were from hydroelectric; 3 were from nuclear; and about 0.1 was "other," which included geothermal, biomass, and solar energy.

In order to keep energy imports at a manageable level, the U.S. must increase domestic energy production and reduce energy demands. The second National Energy Plan (NEP-II, May 1979, moderate oil price case) estimates that domestic energy production will reach about 103 quads per year by the year 2000, an increase of 28 quads/year over the 1980 production rate. Of this domestic energy production, 10 quads are expected to come from "renewables," or resources other than coal, oil, natural gas, and conventional nuclear. NEP-II identifies geothermal energy as one of the major long-term energy options to be pursued for national development. Current commercial geothermal energy comes from very highgrade resources; the national research and development plans are aimed toward developing the entire range of potentially suitable geothermal resources. The hydrothermal energy resources of the U.S., if vigorously developed, could contribute as much as 10% (3 quads) of the needed annual increase of domestic energy production. Geopressured (primarily methane production) and hot dry rock resources could supply an additional 10% (3.2 quads) of the required increase in domestic production.

1.2 SCOPE OF GEOTHERMAL ENERGY

Geothermal energy sources are concentrations of the earth's internal heat stored in subsurface rocks and fluids. Some of these resources can be tapped by drilling, and the hot fluids brought to the surface for generation of electric power or for direct uses of heat from the thermal fluids.

- Hydrothermal sources include water and steam trapped in fractured or porous rocks. A hydrothermal system is classified as either hot-water or vapor-dominated (steam), according to the principal physical state of the fluid. Hydrothermal resources are used both for electric power production and for direct thermal applications.

- Geopressured resources consist of water at moderately high temperatures at pressures higher than normal hydrostatic pressure. This water, in many cases, contains dissolved methane. Geopressured sources in sedimentary formations along the Texas and Louisiana Gulf Coast are believed to be quite large. Geopressured formations also exist in sedimentary basins elsewhere in the U.S. Commercial-scale recovery of these methane and thermal energy resources may begin in the late 1980's.

- Hot dry rock resources consist of relatively unfractured and unusually hot rocks at accessible depths that contain little or no water. To extract usable power from hot dry rock, the rock must be fractured and a confined fluid circulation system created. A heat transfer fluid is then introduced, circulated, and withdrawn. Commercial-scale utilization of hot dry rock resources may begin in the 1990's.

Geothermal energy has been used in this country since the end of the 19th century. In 1894, fluids from a geothermal system were used to heat homes in Boise, Idaho. In 1960, the geothermal resources at The Geysers field in California were tapped for the generation of electric power. Today, in more than a dozen states, geothermal energy is used for space heating and industrial and agricultural processes.

1.3 THE INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

The efficient and timely development of geothermal resources depends on the coordinated efforts of Federal, state, and local governments, industry, consumer and environmental groups, and private citizens. Figure 1.1 depicts the geothermal community in the United States, those entities with a direct stake in developing geothermal energy sources. Federal responsibilities and programs are divided among a number of agencies, whose activities are coordinated through the Interagency Geothermal Coordinating Council, which was established in 1977. The IGCC brings together all of the Federal agencies with responsibilities related to geothermal energy development, and serves as a forum for interagency program coordination and information exchange. It develops detailed Federal program plans and goals, and defines actions and policies to be followed by Federal agencies to accomplish these goals. The IGCC's organization, membership and activities are described in Appendix A. A history of the Federal geothermal program, including legislative and program activities, is presented in Appendix B.

1.4 ORGANIZATION OF THE FIFTH ANNUAL REPORT

This report discusses geothermal energy development in FY 80, with particular emphasis on Federal activities and their relationship to commercial geothermal energy development. The report encompasses the following topics:

- The national geothermal potential production estimates, as established by the IGCC, are described. The estimates for hydrothermal, geopressured, and hot dry rock energy reflect the current state of knowledge of the resource base and the likelihood of its development. The estimates have been set by the IGCC to illustrate the potential contribution of geothermal energy, and to encourage further exploration and development efforts.

Federal Agencies

Energy

Interior

Agriculture

Environmental Protection Agency

Treasury

Commerce

Defense

Housing & Urban Development

For-Profit Entities

Utilities

Developers

Service Industries

Component Manufacturers

Other Contractors

Non-Federal Governments

State

Local

City/Township

Regional Commissions

Non-Profit Entities

Scientific Labs

Universities

Other

Figure 1.1 The Geothermal Energy Community in the U.S.

- The geothermal development strategy is designed to surmount the economic, technical, and environmental barriers to development. The strategy considers the resource potential and production potential, and determines the appropriate distribution of the Federal activities among the various programs.

- The national plan outlines the responsibilities of the participating Federal agencies in land leasing, environment, resource assessment, reservoir evaluation, technology transfer, and research and development. Planning activities examine program plans and goals, and contribute to policy recommendations.

- The Federal program, designed to aid private industry's commercial development of geothermal energy, provides assistance and removes disincentives to exploration and development. The current activities of the participating Federal agencies are presented in detail, and future programs are described.

- Many states and local governments have active geothermal development programs. Their efforts and accomplishments also are described.

- Private sector geothermal activities that are required to accomplish the goals of the Federal program are enumerated and reported. These data enable program personnel and the IGCC to measure progress.

2.0 NATIONAL GEOTHERMAL PRODUCTION POTENTIAL ESTIMATES

2.1 OVERVIEW

The Interagency Geothermal Coordinating Council has established production potential estimates for geothermal energy resources over the next 40 years. The production estimates are based in part on the estimated quantity of the exploitable geothermal resources in the United States and in part on estimates of how rapidly the resources could be developed in a technically feasible manner, and reflect knowledge of existing and planned geothermal development.

2.2 NATIONAL GEOTHERMAL PRODUCTION ESTIMATES

The IGCC's estimates of the achievable commercial utilization of geothermal resources are presented in Table 2.1. These potential production estimates provide a basis for framing Federal, state, and local policies and for determining measures necessary to increase the use of geothermal energy.

The potential production estimates for hydrothermal electric power are 3,000 MWe capacity (about 0.24 quads) in 1985; 25,000 MWe in 2000; and 50,000 MWe in 2020. Reaching the electric power estimates will require aggressive exploration through 2010, identification of new prospects, technology to produce electric power from reservoir fluids with temperatures as low as 150°C, and a financial climate that ensures successive installation of plants at each appropriate geothermal site, until the currently estimated production capacity of each site is developed.

Hydrothermal resources could supply 0.1 quad/year of energy for direct heat applications in 1985, 1 quad/year in 2000, and 6 quads/year in 2020. Achievement of the 1985 direct heat production estimate will require a greatly accelerated pace of development. Attaining this estimate will require a tripling of current drilling rates in identified low- to moderate-temperature reservoirs and

Table 2.1

ESTIMATES OF GEOTHERMAL PRODUCTION POTENTIAL

1980	1985	1990	1995	2000	2010	2020	
Hydrothermal							
Electric Applications							
MWe	663*	3000	7000	14000	25000	38000	50000
QUADS/YR**	0.05	0.24	0.6	1.1	2.0	3.0	4.0
Direct Thermal Applications							
QUADS/YR	0.01***	0.1	0.2	0.4	1.0	3.0	6.0
TOTAL HYDROTHERMAL QUADS/YR	0.06	0.34	0.8	1.5	3.0	6.0	10.0
Geopressured							
Electric Applications**	0.0	0.001	0.006	0.04	0.16	0.3	0.4
Methane	0.0	0.02	0.1	0.7	3.0	5.0	7.0
TOTAL GEOPRESSURED QUADS/YR	0.0	0.021	0.106	0.74	3.16	5.3	7.4
Hot Dry Rock							
Electric Applications**	0.0	0.001	0.003	0.01	0.06	0.15	0.5
Direct Thermal Applications	0.0	0.001	0.001	0.004	0.007	0.015	0.6
TOTAL HYDROTHERMAL QUADS/YR	0.0	0.023	0.11	0.754	3.227	5.465	8.5
TOTAL GEOTHERMAL	0.06	0.363	0.910	2.254	6.227	11.465	18.5

*Actual hydrothermal electric capacity on line is 908 MWe.

**Based on MWe capacity estimates. Equivalent fossil fuel input needed to produce estimated MWe. Assumed capacity factory 0.80; fossil fuel plant efficiency 0.33.

***Actual hydrothermal direct thermal usage is .01 quads.

increasing direct heat project starts by a factor of 20 within the next two to three years. Reaching the direct heat estimate also will depend on continued exploration and assessment of the lower-temperature resources, reservoir confirmation, substantial user education and technical assistance, and removal of numerous institutional and legal barriers to development.

The production estimates for geopressured resources are 2,000 MWe for electric power production and 3 quads/year methane production in the year 2000, and 5,000 MWe and 7 quads/year methane production by 2020. Reaching this level of utilization would require proof of the economic feasibility of producing methane by about 1983, no significant adverse findings from ongoing environmental studies, no significant degree of ground surface subsidence in production areas, and use of offshore resources.

A level of output of about 700 MWe of electricity and 0.007 quads/year of direct heat use are possible from hot dry rock resources by the year 2000, and a corresponding 6,800 MWe and 0.6 quads/year by 2020. This level of output would require extensive characterization of geological environments conducive to the use of hot dry rock technology, development of effective and economical technology for extracting thermal energy, and significant improvements in technology for drilling deep holes in hot hard rock.

2.3 ESTIMATES OF GEOTHERMAL UTILIZATION

Estimates of hydrothermal electric power production can be made with a reasonable degree of confidence. The resource assessment work of the U.S. Geological Survey and announced plans of field developers and electric utility companies provide a useful basis for estimating rates of development.

In contrast, estimates of hydrothermal nonelectric use, geopressured methane production, and extraction of other energy from geopressured and hot dry rock resources are clouded by uncertainties related to the size of the producible resource, colocation of resources and markets, and the economics of production. Table 2.2 presents estimates of the current use of geothermal energy for nonelectric applications in the United States.

Table 2.2

SUMMARY OF KNOWN NON-ELECTRIC USE ON-LINE, 1980*

Area of Use	Number of Users	Btu/Year (10^9)
Current Uses On-Line	187	1,487.1
Enhanced Oil Recovery	1	10,000.0
Baths and Pools	90	51.8
TOTAL	278	11,538.9

*Because no detailed, systematic survey of non-electric uses has been made, many projects may not be included.

SOURCE: Geothermal Progress Monitor, Issue Number 4, September 1980.

Several recent estimates of geothermal hydrothermal electric power generation in the United States are shown in Table 2.3. The IGCC hydrothermal electric power goals from the Fourth Annual IGCC Report (FY 79) are included for comparison.

For the near term (through 1985) the results of the 1980 Electric Power Research Institute (EPRI) survey of electric utilities provide the most interesting results. Announced plans of utilities indicate a minimum of 1,600 MWe on-line by the end of 1985, with 1,900 MWe viewed as probable, and 2,000 MWe seen as possible. This represents about a 25% decline in announced planned electric power capacity for the same five-year period covered by the 1978 EPRI survey of industry.

There appears to be broad consensus from these estimates that by 1990, about 3,500-4,500 MWe could be installed given a moderate acceleration in the pace of commercial activity, while an intense effort might result in somewhere between 7,000-10,000 MWe.

Development of hydrothermal resources after 1990 is difficult to predict due to lack of knowledge about the general economic climate and uncertainty about the number and size of hydrothermal resources in unexplored areas.

Forecasts for installation of hydrothermal electric power plants by the end of 2000 fall in the range of 11,000-25,000 MWe. Cost estimates and scheduling exercises suggest that about 13,000-15,000 MWe could be developed from presently known resources. Almost all of the capacity installed through 1985 will be in California; installed capacity at The Geysers field will still predominate. Significant development of resources in the Imperial Valley, California, and in other western states is expected in the 1985-1990 period.

The Division of Geothermal Energy is estimating market share and market penetration of hydrothermal resources for direct heat utilization. These estimates require careful analyses involving the colocation of resource and potential markets, and the match between resource characteristics and end-use temperature and heat rate needs. The study is scheduled for completion in FY 81.

The National Resource Council's (NRC) Geothermal Resource Panel (reference g in Table 2.3) estimated that direct heat use by 2000, from all forms of geothermal resources, will be less than 1 quad, even if crash development occurs. That panel identified a low degree of colocation between resource and cities, and lack of mobility of industrial users as major limits to growth of direct heat use. More recent studies, however, suggest that this goal can be met with aggressive development.

Projections of hydrothermal electric power generation for the years 1985, 1990, and 1995 were included in the Energy Information Administration's Annual Report to Congress 1978. These projections are sensitive to a wide variety of parameters, including GNP projections, supplies of conventional fuels, and world oil prices, and are based upon the assumption that the governmental policies in force at the end of 1978 will continue unchanged. They should be regarded only as representative projections, but do provide some insight into the potential extent of application of electric power generation using hydrothermal energy. The input parameters relating to specific resources that were used for projecting hydrothermal electric power generation were derived from a study done by the Mitre Corporation for the DOE geothermal program, and were provided to EIA by DOE's Office of Policy and Analysis.

In all of the projections, the vast majority of hydrothermal electric power generation takes place in California, Nevada, Utah, New Mexico, and Arizona, with a small amount in the Gulf Coast. In a few projections, a small amount of geothermal electric power comes from the Rocky Mountain states.

For the near term (1985), total U.S. hydrothermal electric power generation is relatively insensitive to the projection parameters. This is to be expected, since commitments have already been made for most facilities likely to be operating by 1985.

Projected hydrothermal electric power generation for 1990 and beyond is relatively sensitive to the availability of domestic supplies of alternative fuels. Low domestic supplies of conventional fuels (principally oil and natural gas), coupled with high world oil prices, could raise projections of hydrothermal electric power by more than 25%.

Table 2.3

COMPARISON OF HYDROTHERMAL ELECTRIC FORECASTS
(MWe On-Line by End of Stated Year)

			1980	1985	1990	1995	2000
Commerce Department[a]	1977	"Most likely" Supply/Demand Balance	1,000	2,000	----	----	20,000
EIA Annual Report to Congress 1978[b]	1978	Mid-Range Economic Growth and Oil Price Case	----	2,600	4,500	6,200	----
EPRI Survey[c]	1978	Survey of Industry Estimates:					
		- Announced	----	2,019	3,019	3,619	3,919
		- Probable	----	2,664	5,414	7,473	9,023
		- Possible	----	3,374	7,664	11,323	14,723
IGCC Goals[d]	1979	Resource Potential and Economics	663	3,000	7,000	14,000	25,000
DGRM[e]	1979	General Knowledge of Developer/ Utility Plans	941	2,478	3,330	----	----
EPRI Forecast[f]	1979	EPRI R&D Plans	----	6,000	9,650	----	----
NRC CONAES Geothermal Resource Panel[g]	1979	Panel of Experts:					
		- Business as Usual	860	1,480	2,520	----	5,500
		- Moderately Accelerated Development	970	2,160	3,500	----	8,400
		- Strongly Accelerated Development	1,180	2,620	6,600	----	16,100
		- Crash Development	1,380	3,130	9,900	----	26,600
EPRI Survey[h]	1980	Survey of Industry Estimates					
		- Announced	----	1,574	2,294	2,599	3,299
		- Probable	----	1,912	4,216	5,631	7,416
		- Possible	----	2,117	5,203	8,106	10,761

[a]Forecast of likely U.S. Energy Supply/Demand Balances for 1985 and 2000, and Implications for U.S. Energy Policy, U.S. Department of Commerce, 20 January 1977.

[b]U.S. D.O.E. Energy Information Administration, Annual Report to Congress 1978, Vol. 3, Supplement 1.

[c]V. Roberts and P. Kruger, Geothermal Resource Council Transactions, September 1980.

[d]Geothermal Energy, Research, Development and Demonstration Program Fourth Annual Report, Table II.1, June 1980.

[e]Geothermal Progress Monitor Report #1, December 1979.

[f]EPRI New Energy Resource Department Strategy Paper, January 1979.

[g]Geothermal Resources and Technology in the United States, National Academy of Sciences, 1979.

[h]V. Roberts and P. Kruger, Geothermal Resource Council Transactions, September 1980.

Most hydrothermal electric power generation capacity projections for 1995 are on the order of 6,200 MWe. Low supplies of domestic oil and gas or a nuclear moratorium could raise geothermal power demand by 50 to 60%.

A summary of estimates of the quantity of natural gas recoverable from geopressured geothermal resources in Louisiana and Texas is shown in Table 2.4. The estimates of producible methane range from 50 to 5,000 trillion cubic feet. The spread in these estimates is due to the variety of assumptions used for, as yet unknown, factors such as geopressured well productivity, geopressured reservoir characteristics, the economics of production and reinjection, and the degree to which environmental effects such as ground subsidence could restrict production along the Gulf Coast.

2.4 GEOTHERMAL RESOURCE POTENTIAL IN THE UNITED STATES

2.4.1 National Resource Assessment

The U.S. Geological Survey is responsible for conducting resource inventory and assessment through a program of multidisciplinary research. A major product of the resource assessment program, USGS Circular 790, was published in 1979, "Assessment of Geothermal Resources of the United States, 1978." This circular is based on data available in July 1978, and is an update and expansion of USGS Circular 726, published in 1975. Circular 726 assessed for the first time moderate- and high-temperature hydrothermal resources and geopressured resources in a systematic manner. Circular 790 refines the original estimates and also includes the first tabulation of data on low-temperature (less than 90°C) geothermal waters at depths of less than 1 kilometer. Such low-temperature waters appear to be widely available over much of the country, and could have substantial potential for space heating and agricultural applications. The low-temperature assessment is being expanded to provide the first quantitative inventory of these resources using data from many new sources, including DOE's state-coupled program. Similar updates for various resource types will follow as new data make further refinements in the resource estimates possible.

Table 2.4

ESTIMATES OF NATURAL GAS IN GEOPRESSURED AQUIFERS
(Trillions of Cubic Feet)

		(Resource Base) Total Methane In-Place			Recoverable Methane***			Recovery
Date	Source	Texas	La.	Total	Texas	La.	Total	(%)
1977	Jones	---	---	50,000	---	---	5,000	10
1977	Dorfman (UT)	---	---	5,700	82	175	257	5
1977	Hise (LSU)	---	---	3,000	---	---	150	5
1978	Lewin & Assoc.*	300	800	1,000	10	40	50	5
1978	Bernard	---	---	----	40	14	54	---
1979	USGS, #790**							
	• Onshore	1,800	1,300	3,100	72	25	97	3
	• Offshore	---	---	2,600	---	---	53	2
1980	National Petr. Council****	---	---	---	---	---	81	MMcf/day

*The Lewin estimate for Texas includes only the Frio formation.

**USGS estimate is for sandstone only. The estimate of recoverable resource assumes sufficiently high wellhead pressure to limit subsidence to one meter, based on 1975 information.

***Assumes no reinjection into the produced aquifer. Reinjection could theoretically increase the recoverable resource by five to six times, but may not be either technically or economically feasible.

****The production rate in the year 2000 under the most optimistic case for onshore Gulf Coast sandstones.

Table 2.5 presents the current estimated potential of geothermal resources in the United States, based on USGS Circular 790. The energy estimates in this table differentiate between estimates of the resource, that is, the energy that could be extracted economically within a reasonable time (figures in the bold box), and the accessible resource base, that is, the energy in the ground to a specified depth. From the total estimated geothermal resource potential, the USGS has attempted to estimate the amount of energy available for utilization. Table 2.6 summarizes the energy available for utilization from the three resource types, and indicates a range from 710 to 3,400 quads of geothermal energy for both electric and direct thermal applications. The range of values exists due to a variety of assumptions used for energy recoverability and utilization.*

Figure 2.1 shows those areas in the United States that have been identified as having known or potential hydrothermal resources. Data for this map were derived from the regional and national assessments performed by the USGS and from state and site-specific assessments performed under the DOE state-coupled program. The western United States has the greatest potential for hydrothermal development, particularly for use in electrical power generation and direct heat applications that require relatively high temperatures. The Atlantic Coastal areas and the southeastern United States contain a number of prospective targets for development as low- to moderate-temperature heat sources.

The results of this assessment provide a foundation for other critical portions of the Federal geothermal program by identifying target areas for site-specific studies by DOE and for exploration by industry, providing a basis for estimating potential productivity of individual geothermal systems, and establishing guidelines for the development of technology to exploit the resources.

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*It must be noted that not all of the calculations for these values are based on actual resource estimates. It is not possible, given present knowledge, to estimate "resources" of hot dry rock. The hot dry rock energy values in Table 2.6 were generated from an illustrative calculation using resource base data from Circulars 726 and 790 and a set of reasonable, but arbitrary, assumptions. These values do not represent the complete range of reasonable assumptions that could be made. Because of this, the hot dry rock energy values should be considered to be illustrative only.

Table 2.5

GEOTHERMAL ENERGY OF THE UNITED STATES*

	Accessible Resource Base to 10 km (10^{18} J)**	Accessible Resource Base to 7 km (10^{18} J)**	Accessible Fluid Resource Base to 6.86 km (10^{18} J)**			Accessible Resource Base to 3 km (10^{18} J)**			Resource (10^{18} J)**	Electricity (MWe for 30 yr)	Beneficial Heat (10^{18} J)**
			Sandstone	Shale	Total	>150°C	90°-150°C	Total			
Conduction-dominated:											
Land area	33,000,000[a]	17,000,000[b]						3,300,000[a]			
Offshore gulf coast	370,000[c]	180,000[c]						16,000[c]			
Igneous-related:											
Evaluated	101,000										
Unevaluated	900,000										
Reservoirs of hydrothermal convection systems (90°C):											
Identified						950[d]	700	1,650[d]	400	23,000	42
Undiscovered						2,800-4,900	3,100-5,200	3,000	2,000	72,000-127,000	184-310
Northern Gulf of Mexico Basin (onshore and offshore):											
Thermal energy	850,000[c]	410,000[c]	11,000	96,000	107,000				270[f]-2800[g]		
Methane energy			6,000	57,000	63,000				158[f]-1640[g]		
Other geopressured basins					46,000[h]						

a. "Best estimates" of Diment and others (1975, Table 14). These values are each approximately 18 percent greater than the values determined by the "basic Calculation" of Diment and others (1975, Table 13).

b. Equations on p. 85 and 91 of Diment and others (1975) (assuming an exponential decrease of heat production with depth) give 11,700,000 x 10^{18} J for the "basic calculation." This value is then increased by approximately 18 percent to give a figure comparable to the "best estimetes" of Diment and others (1975, Table 14).

c. Calculated for an area of 135,000 km^2 using the "basic calculation" of Diment and others (1975) and the thermal parameters listed for the coastal plain on their Table 13. The result is then increased by approximately 18 percent to give a figure comparable their "best estimates."

d. Does not include 1290 x 10^{18} J in National Parks (mainly in Yellowstone).

e. Calculated for an area of 310,000 km^2 using the "basic calculation" of Diment and others (1975) and the thermal parameters listed for the coastal plain on their Table 13. The result is then increased by approximately 18 percent to give a figure comparable to their "best estimates."

f. Plan 3 of Papadopulos, Wallace, Wesselman, and Taylor (1975).

g. Plan 2 of Papadopulos, Wallace, Wesselman, and Taylor (1975).

h. From White and Williams (1975, Table 28): thermal energy only.

*Table 20 of USGS Circular 790, Assessment of Geothermal Resources of the United States, 1978.

**10^{18} J ≈ 1 quad.

Table 2.6

ESTIMATED GEOTHERMAL ENERGY FOR UTILIZATION*

GEOTHERMAL RESOURCE		ENERGY FOR UTILIZATION** (10^{18} Joules 1 quad)		
Hydrothermal				
150°C		142	-	90***
90°-150°C		230	-	350
	Total	372	-	440
Geopressured				
Thermal		31	-	320
Methane		79	-	820
	Total	110	-	1140
Hot Dry Rock				
Hot Igneous Systems		75	-	590
Regional Conductive Environments		152	-	1190
	Total	227	-	1780
TOTAL (ROUNDED)		710	-	3400

*Totals for identified plus undiscovered and evaluated plus unevaluated resources.

**These figures present a range for each category because of a variety of assumptions used for energy recoverability and utilization.

***The lower figure of 90 should be used for systems 150°C if the higher figure of 350 is used for systems 90-150°C, and vice versa.

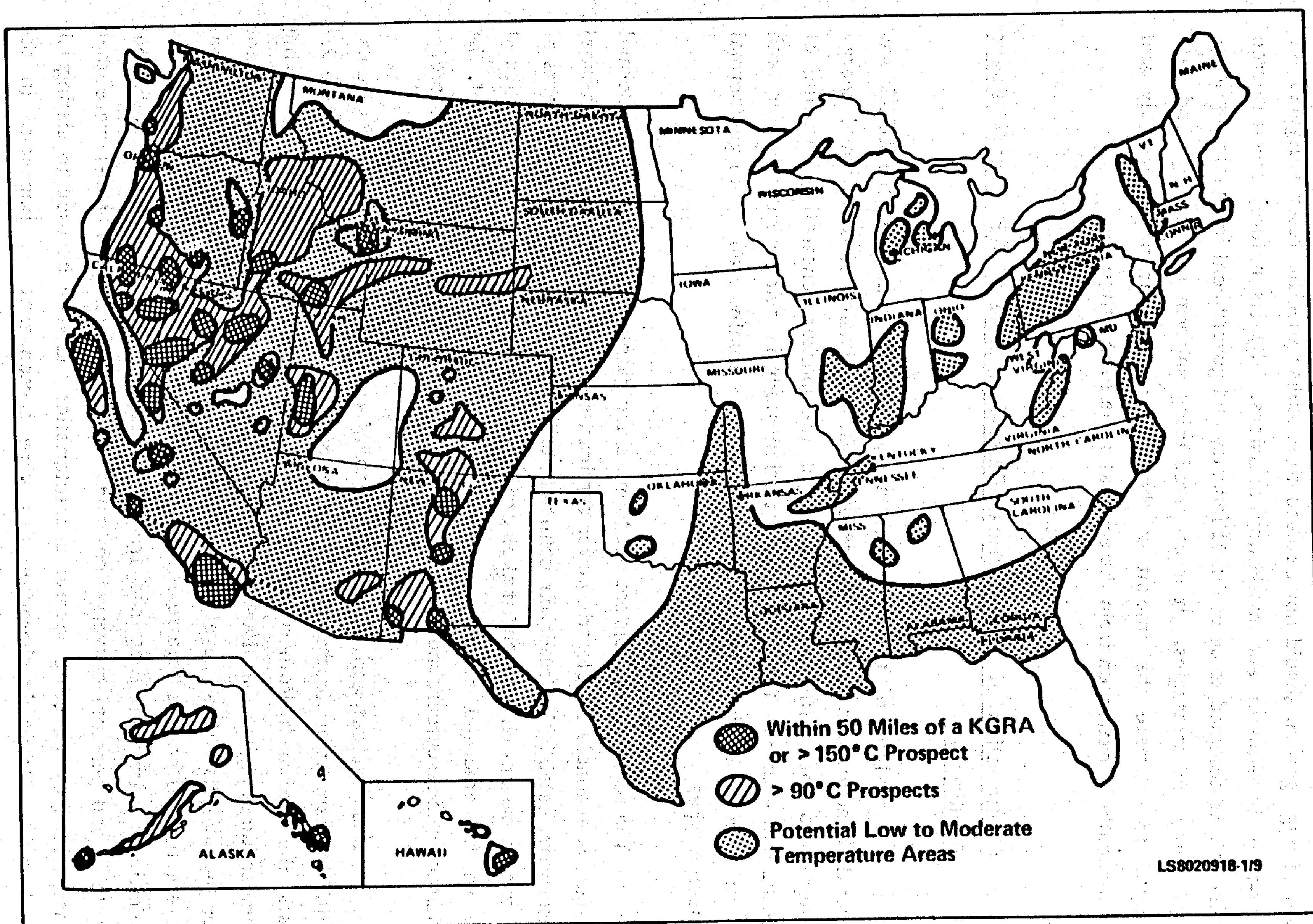


Figure 2.1 Known and Potential Hydrothermal Resources

It should be noted that the geothermal resource assessment, because of its high level of aggregation, should not be used to establish specific reserve figures for short-term investment and marketing decisions. By its nature, this resource assessment is designed to be useful to industry and government in developing long-term policy and strategies. It is prepared using uniform methodology and data analysis to estimate the amount of thermal energy that might feasibly and economically be extracted from the earth at some future time.

2.4.2 Confirmation of Hydrothermal Reservoirs Suitable for Electric Power Applications

An analysis of the hydrothermal resource estimates of the USGS was recently conducted in support of a study by DOE's Division of Geothermal Energy designed to obtain improved estimates of the market penetration potential of geothermal energy. The market penetration study is being conducted for both electric and direct heat applications, and will eventually examine all geothermal resource types.

The resource analysis set out to more accurately quantify the hydrothermal resources available for electric power applications by characterizing hydrothermal reservoirs, establishing reservoir confirmation rates, and evaluating the effects of Federal programs on hydrothermal electric power development. Characteristics of known hydrothermal reservoirs were used to predict characteristics of the undiscovered resources, and timing for confirmation of reservoirs was postulated.

Resource categorization began with information provided in USGS Circular 790, "Assessment of Geothermal Resources of the United States, 1978." Table 2.7 lists the known hydrothermal systems identified in Circular 790 as having temperatures higher than 150°C plus Raft River, which formed the starting point for the analysis. These development sites are associated with known hydrothermal reservoirs and have a total electric power generation potential of 23,385 MWe. Additional data were obtained from USGS open files on specific geothermal systems and personal conversations and expertise. Reservoir types were then categorized by selecting several characteristics that can be used to distinguish each type. Reservoir characteristics were chosen that are important in the

Table 2.7

HYDROTHERMAL RESERVOIRS SUITABLE FOR ELECTRIC POWER PRODUCTION

SITE	ESTIMATED RESERVOIR MEAN TEMPERATURE (°C)	ESTIMATED POTENTIAL ELECTRICAL ENERGY (MWe for 30 yrs)
ALASKA		
Hot Springs Cove	164	27
Geyser Bight	208	136
Bailey Hot Springs	162	26
ARIZONA		
Power Ranches Inc., Wells	165	23
CALIFORNIA		
Border	160	31
Brawley	253	640
Clear Lake	190	900
Coso Hot Springs	220	650
East Mesa	182	360
Geysers	237	1610
Heber	175	650
Long Valley	227	2100
Morgan Springs-Growler Springs	217	116
Randsburg	172	84
Salton Sea	323	3400
Surprise Valley	152	1490
Sulfur Bank Mine	194	75
Westmorland	217	1710
COLORADO		
Paradise Hot Springs	154	24
HAWAII		
Kamaili Homesteads	273	210
Kapoho Reservoir (Puna)	275	41
IDAHO		
Big Creek Hot Springs	162	26
Crane Creek-Cove Creek	171	340
Raft River	149	100

SOURCE: USGS Circular 790, Assessment of Geothermal Resources of the United States, 1978.

Table 2.7 (Cont.)

SITE	ESTIMATED RESERVOIR MEAN TEMPERATURE (°C)	ESTIMATED POTENTIAL ELECTRICAL ENERGY (MWe for 30 yrs)
NEVADA		
Baltazor Hot Spring	158	46
Beowawe	229	127
Brady Hot Springs	155	157
Desert Peak Area	221	750
Fernley Area	182	33
Great Boiling Springs	178	32
Hot Sulphur Springs	165	27
Humboldt House	217	47
Kyle Hot Springs	159	97
Leach	162	77
Lee Hot Springs	166	28
Pinto Hot Springs	173	90
San Emedio Desert Area	166	28
Soda Lake Area	157	146
Steamboat Springs	200	350
Stillwater Areas	159	450
Sulphur Hot Springs	178	74
NEW MEXICO		
Valles Caldera	273	2700
OREGON		
Alvord	181	49
Crump's Hot Springs	167	61
Hot (Borax) Lake Area	191	91
Mickey Hot Springs	205	160
Neal Hot Springs	188	36
Newberry Caldera	230	740
Trout Creek Area	154	24
Vale Hot Springs	157	870
UTAH		
Cove/Fort Sulphurdale	167	330
Roosevelt Hot Springs	265	970
WASHINGTON		
Gamma Hot Springs	165	27
TOTAL POTENTIAL ELECTRIC ENERGY		23,385

economic decisionmaking processes that lead to the development of hydrothermal resources for electric power generation. These characteristics include: wellhead temperature; unpumped well flow rate; and maximum producible acreage. Other reservoir characteristics were considered constant or dependent characteristics (such as exploration costs, reservoir life, injection well costs and fractions, etc.), and do not differ from one prospect to another. Other characteristics were dropped from further consideration because they lacked a significant economic impact in terms of this study.

Measurements of the above six characteristics were tabulated for the important, known hydrothermal reservoirs in the world. From this data base, typical ranges of values were determined for each reservoir characteristic and tested in the economic model for sensitivity. The ranges for each characteristic were used to establish generic hydrothermal reservoir types. The study eventually identified 20 generic reservoir types as reasonably representative of all known and undiscovered hydrothermal reservoirs suitable for electric power generation.

Characteristics of known hydrothermal reservoirs were compiled and were subsequently used to help postulate the rate of reservoir confirmation to the year 2000 and the nature of those confirmed reservoirs. Three general assumptions were made when postulating the reservoir confirmation rate: (1) the geothermal resource data base is adequate for this task; (2) the geothermal industry will be economically healthy between now and the year 2000; and (3) each of the Federal geothermal program elements will succeed in its objectives.

Resources were then considered on a region-by-region basis. The names of the presently confirmed reservoirs were listed and the total number and nature of unconfirmed reservoirs in each favorable geologic environment within a region were estimated. These estimated, unconfirmed reservoirs formed a candidate list of potential discoveries. The nature, problems, and extent of present and future exploration activities were considered for each favorable geologic environment, and the list of candidate confirmations was pared down to those with a high probability of confirmation before the year 2000.

The resource analysis projects that 101 to 134 reservoirs will be confirmed by 2000. A relatively small number will be confirmed in 1981-1985 because the current exploration pace is slow. The confirmation rate increases dramatically from 1986 to 1990, and reaches a maximum in 1991-1995. After this, a decline occurs because the more obvious discoveries will have been made. At this rate, a little less than half of the estimated total accessible hydrothermal resource base of the United States will be confirmed by the year 2000. There is a bias toward confirmation of proportionally more reservoirs in the higher temperature ranges; lower temperature reservoirs are not receiving much industry exploration effort.

Development of hydrothermal resources for electric power generation can be done either by private industry or the government. The Federal government recognizes that development by private industry is preferable; the Federal geothermal program, therefore, is designed to support discovery, confirmation, and utilization of hydrothermal resources by the private sector. The Federal program will not affect the ultimate number of reservoirs confirmed and used, but could affect the timing of confirmation. Several elements of the Federal program could be significant in terms of increasing the confirmation rate in the next 20 years, and include regulatory streamlining and technology development.

3.0 GEOTHERMAL DEVELOPMENT STRATEGY

3.1 OVERVIEW

The overall strategy for accomplishing the Federal geothermal utilization program is to support industrial development of U.S. geothermal resources through a time-phased set of government actions to support action by the existing geothermal industry and to support entry into the geothermal marketplace by additional resource developers, utilities, financial institutions, and consumers. The strategy is based on the concept that U.S. industry will develop all types of geothermal resources rapidly if the government provides initial assistance to resolve technical problems, economic questions, and institutional issues that are unique to geothermal energy systems and novel to the U.S. industry. The strategy emphasizes (1) actions needed to resolve barriers to immediate industrial development of resources that are now economical, and (2) actions required to ensure mid-term development of resources for which technology and economics have not been fully proven. In the near term, geothermal energy from hydrothermal resources can displace oil and natural gas as an economical and environmentally attractive source of energy. In the mid- and long term, geothermal resources can also supply natural gas from geopressured resources, and large quantities of useful heat from hot dry rock resources.

3.2 ALL GEOTHERMAL RESOURCES

The overall objective of Federal geothermal activities is to transform several types of resources into an array of technically, economically, and environmentally sound commercial ventures. The major barriers to commercial development of geothermal energy are: (1) the initial risk associated with the expensive drilling needed to confirm geothermal reservoirs of all types deters many potential users from starting projects; (2) the vast majority of higher temperature hydrothermal reservoirs suitable for electric power production are only marginally economic with present technology; (3) the overall rate of leasing of Federal lands appears to be too slow to sustain rapid development of hydrothermal resources in the 1990-2000 time period; (4) the present state laws need further development to promote a clear legal climate for industrial geothermal activities; (5) there is a lack of an industrial infrastructure to support direct heat applications; (6) there exists a general lack of knowledge about geothermal energy on the part of potential users and developers; and (7) the technology and economics have not been proven for geopressured and hot dry rock resources.

The commercial attractiveness of the three main resource types depends on the physical characteristics of the local resource and the costs of energy extraction and utilization technology. Various elements of the Federal strategy reflect the different conditions of technical and economic readiness of these resource types. The principal components of the Federal strategy that are applicable to all types of resources during the commercialization phase, and others that are tailored to the current needs of specific resource types, are described below.

3.2.1 Strategy Components Affecting All Resource Types

1. Accelerate the identification and quantification of the various types geothermal resources (approximately 80% of the estimated U.S. geothermal resource has not been located).

2. Continue an aggressive research and development effort to improve technology which is likely to reduce geothermal energy costs, expand the economically competitive resource base and lead to more rapid commercialization.

3. Propose ways in which Federal leasing and permitting processes can be simplified to speed the implementation of new development projects.

4. Support states in site-specific planning and outreach activities.

5. Establish appropriate environmental regulations, continue monitoring of environmental effects at each resource area, and develop control technology and procedures for mitigating potential problems.

3.3 HYDROTHERMAL RESOURCES

Hydrothermal energy has a great potential in the near term. The technology for producing electric power from steam and high-temperature hot water is commercially available, cost-competitive, and being used today on a limited scale. Electric power production from moderate-temperature resources is technically feasible; however, technological improvements (development and demonstration of binary cycle electric power generating systems) are necessary to realize economic competitiveness and establish market readiness. In general, the technology for direct heat applications of hydrothermal resources is proven, available, and economic. However, the required industrial infrastructure for using this technology is not in place, and confirmation of a larger number of reservoirs located near use sites is required. The elements of the Federal strategy affecting primarily the development of hydrothermal resources are listed below.

3.3.1 Strategy Components Affecting Hydrothermal Resources

1. Encourage widespread acceptance of the hydrothermal energy resource by developing a program to increase technology transfer.

2. Improve estimates of the nature and size of identified hydrothermal resources through improvement of geothermometers and geophysical techniques. Refine estimates of undiscovered resources through characterization studies.

3. Provide technical assistance to support use of conventional technologies for electric or direct heat applications.

4. Support research to develop adequate environmental controls.

The aggregate of these strategy elements leads to a carefully balanced mix of R&D projects directed at cost reduction. Knowledge gained in the near term from experience with hydrothermal resources can be applied later to the development of geopressured and hot dry rock resources.

3.4 GEOPRESSURED RESOURCES

Although the geopressured resource contains methane, thermal, and hydraulic energy, the methane has the greatest economic value. Technology exists for producing methane and other energy from these resources, but the economics are uncertain. The major impediment to commercialization is uncertainty about the methane concentration and productive capacity of geopressured reservoirs. If the economics are proven to be favorable, development could take place rapidly. Systems for utilizing the heat from geopressured fluids for electricity production (by binary cycle systems) and direct heat applications will be adapted from hydrothermal systems when industrialization of the geopressured resource begins. The elements of the Federal strategy affecting primarily the development of geopressured resources are outlined below.

3.4.1 Strategy Components Affecting Geopressured Resources

1. Focus on resource definition and assessment of reservoir performance relating to methane recovery, with thermal and hydraulic energy treated as potentially valuable by-products.

2. Collect the needed reservoir performance data through a series of high-rate, long-term flow tests of geopressured wells in the Gulf Coast area during the next three to four years. Test Wells-of-Opportunity (unsuccessful oil and gas exploration wells that have penetrated geopressured forma-

tions) for short periods of time for geopressured potential. Measure the performance of design wells that have been drilled and completed specifically for the purpose of long-term tests. These tests will also resolve uncertainties related to potential environmental impacts of geopressured energy production.

3. Assess data from sedimentary basins in areas other than the Gulf Coast where geopressures have been measured or indicated.

3.5 HOT DRY ROCK RESOURCES

The technology for exploiting the enormous heat content of dry geothermal resources is under development, and has been proven feasible on a pilot scale at one site. Of the three major resource types, the hot dry rock technology is at the earliest development stage. The basic concept must be proven to be technically and economically feasible for utilizing resources in different geologic settings. The main strategy elements applicable to the development of hot dry rock resources are those below.

3.5.1. Strategy Components Affecting Hot Dry Rock Resources

1. Continue evaluation of resource potential in order to define more fully the extent to which the energy extraction technology can be applied nationwide.

2. Conduct energy extraction experiments to refine the technology and improve the economics in the near to midterm.

3. Improve drilling and fracturing technology for high-temperature rocks in the near term.

4.0 THE NATIONAL GEOTHERMAL ENERGY PLAN

4.1 OVERVIEW

The National Geothermal Energy Plan comprises the efforts of several Federal agencies, as well as state and local governments, in support of national geothermal resource development. The Geothermal Research, Development, and Demonstration Act of 1974 (Public Law 93-410) assigned various responsibilities to Federal agencies, and gave ERDA (now the Department of Energy, DOE) lead responsibility for the Federal Geothermal Program. Other agencies active in geothermal development include: the Departments of the Interior (DOI), Agriculture (USDA), Defense (DOD), Commerce (DOC), Housing and Urban Development (HUD), the Treasury, and the Environmental Protection Agency (EPA). DOI is the lead agency for resource assessment; and EPA has lead responsiblity for environmental protection.

Key organizations within DOE are the Division of Geothermal Energy (DGE); within the Office of the Assistant Secretary for Conservation and Renewable Resources (ASCE); and the Office of the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness. Other key organizations in the program are the U.S. Geological Survey (USGS) and the Bureau of Land Management (BLM) in DOI; the U.S. Forest Service (USFS) in Agriculture; the Departments of the Navy and the Air Force in DOD; and the Office of Environmental Engineering and Technology and various regulatory offices in EPA.

Other participants in the program are DOE's Office of Leasing Policy Development (LPD) under ASFE; Office of Policy, Planning and Analysis; Office of Energy Research (ER); the Energy Information Administration (EIA); and the Federal Energy Regulatory Commission (FERC); DOI's Bureau of Mines (BOM), Fish and Wildlife Service (FWS), and Bureau of Reclamation (BUREC); the Economic Development Administration (EDA) within Commerce; the Office of Community Planning and Development in HUD; and the Office of Economic Policy in the Treasury Department.

Interagency cooperation was established through the Geothermal Energy Coordination and Management Project (now the Interagency Geothermal Coordinating Council), which retains substantial responsibility for coordination of the Federal program. The Interagency Geothermal Coordinating Council (IGCC) consists of the Federal agencies that participate in the geothermal program. The basic function of the IGCC is to promote and support the use of environmentally acceptable geothermal energy at the earliest possible date. The Council's functions are: (1) to provide a forum for information exchange among Federal agencies involved in the geothermal program; (2) to develop detailed Federal geothermal program plans and goals; and (3) to define actions and policies to be followed by Federal agencies to accomplish established goals.

The most recent coordination efforts of the IGCC have resulted in the Federal Geothermal Program Plan, which is designed to provide an integrated overview of the geothermal programs and activities of the IGCC member agencies for the FY 80-FY 82 time frame. The Plan was submitted to the Office of Management and Budget (OMB) in October 1980, as backup to the coordinated geothermal FY 82 budget. The Plan presented the goals and objectives of the Federal geothermal program, and proposed a strategy for achieving those goals. It described the missions of the participating agencies and their planned activities for geothermal development, and proposed budget and manpower levels for those agencies. The Plan also identified major problems, inconsistencies, and shortfalls in the overall program and made recommendations for improving program effectiveness.

The major inadequacies of the Federal program identified by the Federal Geothermal Program Plan for FY 80-FY 82 relate to regulatory delays, low-priority treatment of geothermal in some agency budgets, and a need for increased participation by agencies with capabilities to support the program further. Problem areas include: the slow rate of leasing lands for geothermal development and the uncertainty of environmental regulations. The Plan made several recommendations addressing these problems and designed to improve the effectiveness of the Federal program.

4.2 FEDERAL ACTIVITIES

In the Federal Geothermal Program Plan, the areas of leasing, environment, resource assessment, reservoir evaluation, industrialization, and research and development are thoroughly examined, with the contributions of each Federal agency detailed. (Much of the Plan material is incorporated in later sections of this report.) The major geothermal program activities for the near term (FY81-FY82), for each of the above areas, are described below.

4.2.1 Leasing

The regulatory requirements associated with leasing Federal lands for geothermal exploration and development, along with administrative delays in processing applications, have been identified as major impediments to more rapid development of geothermal resources. A major thrust of the leasing program will be to surmount some of these institutional barriers. The Federal land management agencies involved in the leasing program will implement recommendations of the IGCC Streamlining Task Force to reduce delays in processing applications and accelerate the rate of leasing Federal lands for geothermal exploration and development. Four Federal entities have leasing responsibilities: the Bureau of Land Management (DOI), the U.S. Geological Survey (DOI), the U.S. Forest Service (USDA), and the Leasing Policy Development Office (DOE).

BLM and USGS share major responsibilities within DOI. BLM sets terms and conditions for surface protection, reclamation, and adherence to various environmental laws; USGS assures compliance. BLM completes prelease environmental reviews, administers competitive lease sales, and issues leases. USGS evaluates all parcels for KGRA designation, evaluates competitive parcels to establish minimum acceptable bids before BLM offers them for sale, approves and monitors all postlease operations, and collects royalties.

The U.S. Forest Service's (USFS) primary role is to evaluate the possible impacts of leasing in National Forests on surface resources and uses, and to develop terms and conditions to assure that those impacts are eliminated or mitigated to the maximum reasonable extent. The Forest Service must also give its consent and specify terms and conditions for geothermal leasing on National Forest System lands.

DOE's Office of Leasing Policy Development (LPD) is responsible for promulgating regulations which relate to fostering competition for Federal leases, implementing alternative bidding systems, setting production rates, and setting terms for Federal royalties. LPD also approves the terms and conditions relevant to the above functions for leases issued by DOI.

4.2.2 Environment

The plan is to provide continuing environmental assessment of geothermal resource areas and development sites; develop technological and nontechnological controls to reduce negative environmental impacts; and develop standards, regulations, and other guidance to aid industry in developing geothermal resources. EPA and DOE study the environmental issues surrounding geothermal energy use, and develop environmental controls technologies. Studies range from baseline environmental monitoring of potential geothermal resource areas to control technology development and demonstration. Efforts are also under way to develop data bases upon which reasonable standards may be based. EPA has responsibility for developing environmental standards and regulations. DOE's role is to ensure that development and commercializatin of geothermal energy is environmentally and socially acceptable, with minimal risk to health and safety. Key activities planned for the next few years are summarized below.

1. Develop reliable and economical control technologies for H_2S emissions abatement: UOP's "sulfox" process and EIC's scrubber process (EPA and DOE); investigate electrochemical oxidation as a method of controlling H_2S emissions (EPA).

2. Assess non-H_2S air emissions for their environmental significance (EPA).

3. Characterize geothermal solid wastes and assess the environmental impacts of solid waste disposal (EPA and

DOE); determine the applicability of hazardous waste regulations to geothermal energy systems and review the effect of these regulations on such systems (EPA).

4. Address technical and regulatory problems related to geothermal fluids disposal: conduct research on fluid injection and ocean disposal of fluids and develop underground fluid injection monitoring methods (EPA and DOE).

5. Perform research on subsidence and induced seismicity resulting from geothermal operations (USGS and DOE/DGE); develop a system to monitor subsidence and compaction at depth; conduct seismic monitoring near geothermal fields under development (DOE).

6. Conduct a Geothermal Environmental Overview Project to identify and assess potential environmental problems in Known Geothermal Resource Areas where commercial development is likely (DOE).

7. Revise and update the Pollution Control Guidance document for hydrothermal energy systems and prepare a similar guidance document for geopressured resources and hot dry rock (EPA).

4.2.3 Resource Assessment

The resource assessment program focuses on efforts to understand better the nature and extent of geothermal resources in the United States, including undiscovered resources.

The USGS conducts a continuing broad assessment of U.S. geothermal resources of all types--hydrothermal systems of various temperature ranges, geopressured zones and hot dry rock regimes. This assessment identifies regions where such resources are known or are believed to exist; determines characteristic geologic, hydrologic, geochemical, and geophysical parameters of these resources;

develops scientific basis for geophysical and geochemical techniques to model these resources; and estimates geologic parameters, depths, areal extent, temperature ranges, and quantities of thermal energy. Emphasis is on the entire geothermal system encompassing one or more individual reservoirs that are the focus of DOE studies. Results provide fundamental knowledge for a better understanding of the nature, distribution, and energy potential of U.S. geothermal resources.

The USGS will continue major regional resource assessment and characterization studies in the Cascades. Similar studies are being completed for the Snake River Plain, and are being planned for the northern Basin and Range. In addition, USGS will conduct the first quantitative inventory of low-temperature thermal waters using data from several new sources including DOE's state-coupled program.

DOE will cooperate with DOI/USGS in determining energy recoverability estimates for geopressured resources and in national and regional hot dry rock (HDR) resource assessment activities. Detailed HDR investigations by DOE will be conducted at sites near Boise, Idaho; on the Delmarva Peninsula; and in the Clear Lake, California, area.

4.2.4 Reservoir Evaluation

Hydrothermal Resources

The risks inherent in exploratory drilling have been identified as the most significant barrier to development of low- and moderate-temperature resources. Therefore, DOE will complete current activities to confirm hydrothermal reservoirs suitable for commercial use within the broad resource areas identified by USGS. In the FY 80-FY 81 time frame, DOE will carry out a program to identify prospective low- and moderate-temperature hydrothermal reservoirs in cooperation with states that have identified resource potential. Existing data will be analyzed to establish probability and distribution of hydrothermal resource areas. Detailed assessments will be made of target areas.

DOE will also conduct a program to confirm low- and moderate-temperature resources colocated with prospective users in FY 81. Under the program, DOE selected teams comprised of a developer and a user to share costs of locating and confirming commercial reservoirs.

Geopressured Resources

DOE's geopressured program will concentrate on reservoir characterization and determination of commercial potential of energy from geopressured formations. Major efforts will be directed toward production testing of new and existing wells along the Texas and Louisiana Gulf Coast. DOE will design, drill, and test 8-12 new wells by 1985, and will continue short-term tests of existing wells through FY 83 at a rate of 2 or 3 tests a year.

4.2.5 Hydrothermal Industrialization

The approach for industrialization of hydrothermal resources is to provide appropriate Federal initiatives to support private sector participation in resource development. In FY 80 and FY 81, DOE conducted feasibility studies and provided technical assistance; DOD provided development opportunities and demonstration plants by actually utilizing geothermal energy at several of its facilities; and the Treasury provided economic assistance through the Crude Oil Windfall Profits Tax Act of 1979, as well as previous energy tax acts. Major activities planned for the next few years are described below.

1. Complete site-specific commercial development planning in 15 western states (DOE).

2. Complete state legislative reviews in 12 states to identify legal barriers to geothermal development and assist states in developing measures to reduce these barriers (DOE).

3. Continue technology-transfer efforts related to direct use of geothermal heat (DOE).

4. Complete reservoir confirmation drilling and construction activities for 22 hydrothermal direct heat demonstration projects initiated in FY 78 and FY 79.

5. Begin operation of a 5 MWe binary cycle pilot plant in the Raft River area of Idaho to collect technical and cost information (DOE).

6. Complete final design and initiate construction of an industry cost-shared 50 MWe flash-steam demonstration plant at the Valles Caldera, New Mexico (DOE).

7. Develop a site for construction of a geothermal power plant at the China Lake Naval Weapons Center in Coso, California (DOD).

8. Select a contractor, prepare an environmental assessment, and obtain permits to construct a central cooling plant or electrical plant at Williams Air Force Base in Arizona (DOD).

9. Conduct geophysical studies and exploration to determine feasibility of using geothermal direct heat or electricity at various Navy and Air Force bases (DOD).

10. Develop implementing regulations for the additional geothermal tax credits provided by the Crude Oil Windfall Profits Tax Act of 1979 (Treasury).

4.2.6 Research and Development

The plan is to continue cost-reducing research and development to increase the size of the economically recoverable portion of the geothermal resource base. DOE supports programs to improve the technology for energy extraction and use. DOE programs pioneer techniques, equipment, and materials for exploitation of geothermal resources; reduce the costs of the technology to make geothermal development competitive; and encourage the establishment of industrywide standards for geothermal materials and equipment. Major activities to be conducted by DOE are summarized below.

1. Improve conventional rotary drilling equipment and materials such as drill bits, downhole motors, drilling fluids, and completion equipment for use in geothermal environments.

2. Conduct field stimulation experiments in high-temperature reservoirs and support development of high-temperature hydraulic fracturing equipment and materials to back up the stimulation experiments.

3. Field-test high-temperature cements for well completions and reinforced polymer concrete pipe and concrete-lined pressure vessels for scale control in surface equipment.

4. Fabricate and test high-temperature elastomeric seals for downhole pumps, motors, and stimulation equipment and metallic seals for very high temperature applications.

5. Conduct geosciences activities to improve accuracy of reservoir performance predictions: field-test geophysical exploration techniques, develop and validate computer models for predicting reservoir performance, and develop high-temperature logging tools and cables to obtain reservoir data.

6. Complete drilling of well for a 20-50 megawatt (thermal) hot dry rock heat extraction loop at Fenton Hill, New Mexico, and begin construction of the downhole heat exchange area and surface facilities.

4.2.7 Federal Funding

Critical to the continuation of the above program activities is the provision of adequate Federal funding. Federal funding levels for FY 78 through FY 82 for the geothermal program are presented in Table 4.1. The status of the Geothermal Resource Development Fund and Guaranty Authority is shown in Table 4.2. The total geothermal budget has remained constant over the last several years, but the requested budget for FY 82 is sharply reduced. This reflects the policy of transferring the responsibility for the industrialization of hydrothermal resources to the private sector.

In some agencies geothermal energy is a "line" item in the budget process and the level of funding is determined by the regular Federal budget cycle. In these agencies geothermal activities must compete for funds only once a year. Other agencies do not have a specific line item for geothermal energy. In the middle of the fiscal year, an agency without a budget line item for geothermal might respond with greater flexibility if a redirection of funds is necessary.

Program development and modification are closely coupled with the Federal budget cycle. New policies may require new regulations, which can take up to three years to enact. Policies requiring funding are subject to the appropriations schedule of Congress. Thus the entire process can be very slow. Only those actions that do not require significant changes in funding or in regulations can be implemented in less than a year.

4.28 Federal, State, Local, and Private Cooperation

The Federal agencies, working in cooperation with states and local governments and the private sector, seek to support the use of geothermal energy as soon as possible. The basic responsibilities of the Federal agencies in the major geothermal program areas are presented in Table 4.3. In addition, the states, local governments, and private sector actively participate in the geothermal program. There interests are described below, and their activities, as well as those of the Federal agencies, are summarized in Table 4.4. The table gives an indication of the scope of activity surrounding geothermal development.

Table 4.1

FEDERAL FUNDING FOR GEOTHERMAL ENERGY ($000)*

ORGANIZATION UNIT Fiscal Year	Actual 1978	Actual 1979	Actual 1980	Estimated 1981	Requested 1982
Department of Agriculture					
U.S. Forest Service	678	780	750	700	650
Department of Defense					
Navy	542	300	230	930	1110
Air Force	0	0	200	1010	430
DOD Total	542	300	430	1940	1540
Department of Energy					
Conservation & Renewable Energy (Formerly Resource Applications)	105962	152990	149870	142521	48375
Office of Energy Research	2800	2100	3102	3305	3520
Environment	3896	2820	1950	723	1325
GLGP (Administrative Expenses)	410	0	181	193	200
DOE Total	113068	157910	155103	146742	53420
Department of the Interior					
Fish & Wildlife Service	200	200	200	70	**
Bureau of Land Management	2300	2590	2550	2650	2865
Bureau of Mines	550	1050	800	400	400
Bureau of Reclamation	1800	550	910	60	60
USGS, Geothermal Research Program	10184	12043	10047	7889	7889
USGS, Geothermal Evaluation & Lease Regulation	1854	750	860	898	898
DOI Total	16888	17183	15367	12024	12169
Environmental Protection Agency	670	920	850	1550	1550
TOTAL FEDERAL GEOTHERMAL PROGRAM BUDGET	131846	177093	172500	162956	69379

*Operating expenses rounded to nearest thousand.

**Dependent on transfer funds from other agencies.

Table 4.2

GEOTHERMAL RESOURCES DEVELOPMENT FUND AND GUARANTY AUTHORITY*

	FY 80 FUND	FY 80 AUTHORITY
Unexpended Appropriations, Carried Forward from FY 79	$ 43,832,277	
New Guaranty Authorization, FY 81		$150,000,000
FY 80 Guaranty Authorization		350,000,000
Value of Loans Guaranteed		91,048,000
Uncommitted Guaranty Authorization Carried to FY 81		258,952,000
Uncommitted Guaranty Authorization for FY 81		408,952,000
Administrative Expenses Incurred**(FY 80)	1,043,000	
Guaranty Fees Collected in FY 80	334,490	
Unexpended Appropriation Carried to FY 81	43,123,767	
Guaranty Fees Collected in FY 80 and Deposited in GRDF	118,715	

*This financial information in included in the Fifth Annual Report to satisfy the requirements of PL 93-410, Section 204(C).

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

Table 4.3

BASIC RESPONSIBILITIES OF FEDERAL AGENCIES

Responsibility	Agencies
Energy Production Incentives	Treasury HUD DOC/EDA
Reduce Institutional Barriers	DOE/CE DOE/EIA DOE/PE DOE/FERC
Make Federal Geothermal Resources Available	DOI/BLM DOI/USGS USDA/USFS DOE/CE DOD
Reduce Costs and Economic Risks (Research and Development)	DOE/CE DOE/ER DOI/BOM DOI/USGS DOI/BUREC
Improve Resource Estimates	DOI/USGS DOE/CERA
Reduce Environmental Risks	EPA DOE/CE DOI/USGS DOI/BLM DOI/FWS USDA/USFS
Support Energy Production	DOD DOC/EDA DOE/CE HUD

Table 4.4

SUMMARY OF ACTIVITIES OF FEDERAL, NON-FEDERAL, AND PRIVATE SECTORS

Federal Agencies	State & Local Governments	Private Sector
ACTIVITY: Energy Production Incentives		
Treasury	- Disseminate Information	- Broker Projects
- Administer Tax Incentives	- Plan	
	- Provide Appropriate State Geothermal Rights Laws	
	- Provide Tax Incentives	
HUD		
- Allocate Planning Funds		
DOC/EDA		
- Award Grants for Planning		
ACTIVITY: Reduce Institutional Barriers		
DOE/CE	- Formulate State Environment Regulations	- Provide Environmental Data Requested
- Make Recommendations on New Legislation		
- Facilitate International Technology Exchange	- Issue Required Permits and Approvals	- Apply for Permits and Approvals
DOE/EIA		
- Collect, Maintain and Analyze Data on Energy Production and Use	- Formulate Public Utility Commission Regulations and Decisions	
DOE/PE	- Cooperate with Federal Environmental Review Processes	
- Review DOE Policy on Geothermal Energy Development		

Table 4.4 (Cont.)

DOE/FERC		
- Issue Regulatory Decisions on Geothermal Power Projects - Determine Qualifying Status for Small Power Producers of Geothermal Energy	- Cooperate with Federal Permitting Procedures	
ACTIVITY: Make Federal Geothermal Resources Available		
DOI/BLM		
- Lease Competitive and Non-competitive BLM and FS Land - Approve Exploration on Unleased BLM-Administered Lands - Review Development Proposals on BLM-Administered Lands - Complete Environmental Analysis of BLM-Administered Lands	- Cooperate with Federal Leasing Procedures - Issue Permits and Approvals	- Apply for Lease Applications - Bid on Competitive Leases - Meet Requirements for Permits and Approvals
DOI/USGS		
- Review Development Plans - Provide Permits and Approvals - Evaluate Resource Areas To Determine Competitive Lease Sales		- Submit Plans of Operations - Apply for Permits
USDA/USFS		
- Consent to Leasing on FS Lands - Develop Terms and Conditions for Leasing FS Lands - Review and Approve Operating and Development Plans (shared responsibility with USGS)		
DOE		
- Establish Production Estimates - Set Production Rates for Federal Leases - Review Regulations		
DOD		
- Consent to Leasing on DOD Lands - Review Permits and Approvals		

Table 4.4 (Cont.)

ACTIVITY: Reduce Costs and Economic Risks (R&D)		
DOE/CE - Build Hydrothermal Demonstration Plants - Undertake Materials Research and Development - Undertake Drilling Research and Development - Develop Geopressured Technology - Develop Hot Dry Rock Technology - Undertake Geochemical Engineering Research and Development - Improve Reservoir Evaluation and Exploration Technology	- Conduct Research	- Conduct Research - Provide Insurance - Assume Risks
DOE/ER - Perform Research in Materials Sciences and Geosciences		
DOI/BOM - Perform Research on Minerals Recovery from Geothermal Brines - Develop Standard Test Methods for Geothermal Materials - Field-Test Site-Specific Materials		
DOI/USGS - Improve Resource Assessment and Exploration Concepts - Review Loan Guaranty and Grant Proposals Submitted to DOE		
DOI/BUREC - Investigate Desalting Brines for Fresh Water Supplies		
ACTIVITY: Improve Resource Estimates		
DOI/USGS - Characterize Various Types of Geothermal Systems - Assess Resources on a	- Conduct State Resource Assessments	- Conduct Reservoir Assessments

Table 4.4 (Cont.)

Regional Basis and Update and Refine National Inventory - Improve Exploration and Assessment Technology	- Cost-Share Federal Reservoir Assessments	- Cost-Share Federal Reservoir Confirmation - Provide Wells of Opportunity
DOE/CE		
- Explore Energy Potential of Geopressured Hot Dry Rock Resources		
ACTIVITY: Reduce Environmental Risks		
EPA		
- Develop Environmental Controls - Formulate Environmental Regulations - Perform Environmental Assessments	- Conduct Research	- Conduct Research - Provide Insurance - Assume Risks
DOE/RA		
- Provide Environmental Impact Assessments and Impact Statements on DOE Projects - Develop Environmental Controls - Review EAR's and EIS's - Write Environmental Development Plans - Write Area Environmental Assessments		
DOI/USGS		
- Determine Geology-Related Environmental Problems - Monitor Federally Leased Lands To Ensure Compliance with Environmental Regulations	- Provide Input to Environmental Assessments	- Collect Baseline Data and Monitor Environment

Table 4.4 (Cont.)

- Critique Data Collection and Environmental Monitoring Plans - Prepare Environmental Assessments		
DOI/BLM		
- Conduct Environmental Reviews To Determine Effects of Geothermal Development on BLM Lands		
DOI/FWS		
- Improve Ecological Knowledge Base - Provide Environmental Reviews as Requested by DOE, BLM, USGS, and USFS - Provide Environmental Reviews and Assessments for Forest Service Lands		
USDA/USFS		
- Conduct Environmental Reviews To Determine Effects of Geothermal Development on USFS Lands		
ACTIVITY: Support Energy Production		
DOD		
- Construct Facilities for Own Use	- Cost Share Projects	- Cost Share Projects
DOC/EDA	- Construct Facilities	- Construct Facilities
- Award Grants for Projects		- Provide Capital
DOE/CE		
- Cost-Share Field Demonstration Projects Technology Transfer		
HUD		
- Award Grants for Projects		

4.3 STATE ACTIVITIES

Each state with a significant potential for geothermal energy development conducts and coordinates a number of development and regulatory activities associated with developments. These include:

- Issuing state permits for exploration and development.
- Examining existing state legislation to determine applicability to geothermal development.
- Evaluating and authorizing state-level tax incentives for geothermal development.
- Resolving water and mineral rights and regulatory issues where laws designed for other resource uses do not include or actually impede geothermal development.
- Coordinating state and local activities to discover and develop the most beneficial uses and sites for geothermal development.
- Anticipating and monitoring environmental and use impacts of geothermal development to ensure that these comply with state regulations.
- Interacting with the Federal government to ensure that Federal policies and regulations will be beneficial to geothermal development in each state.
- Providing funds to meet cost-sharing requirements of Federal field demonstration projects.

4.4 LOCAL GOVERNMENT ACTIVITIES

County and city governments promote suitable development of geothermal energy use within their local domains while balancing requirements for geothermal development with other local needs. This can be accomplished in many cases by including geothermal elements in the community's master development plan.

One instance where local government leadership is especially valuable is in the promotion of centralized geothermal district heating systems. Based on experience in Iceland and Europe, these systems are very desirable when a sufficient amount of heat use is available from a common well or set of wells. To start such a system economically, usually one or two large buildings must be connected at the outset. Municipal office buildings, schools, and civic centers can provide the nucleus, with smaller users connecting to the system after its reliability and economics have been demonstrated.

Municipal utility staff are usually familiar with the simple technology used in geothermal direct heat systems, and municipal bonds can finance such projects advantageously. Local governments can find, and have been finding, start-up help with DOE funds for feasibility studies, and cost-shared development of feasible projects. Technical assistance is also available on a much more informal basis from DOE-supported regional centers.

4.5 PRIVATE SECTOR ACTIVITIES

The private sector is the primary focus of geothermal energy development. It is here that most specific projects are conceived, financed, and built. The many active roles of the private sector include: investment, exploration, field development through drilling, sale of steam, purchase of steam and hot water, operation of electric plants, improvement of drilling equipment, and provision of reservoir insurance. Federal and state sponsored geothermal activities are intended to foster an active private sector geothermal industry, rather than compete with it.

The most noticeable activities in the private sector center around continued development of The Geysers field and the beginnings of geothermal electric development at sites in the Imperial Valley, California. Near-term potential shortfalls in electricy supply in California will provide a strong impetus for continued geothermal resource development.

The private sector also contributes to the Federal program by providing members for the Geothermal Subcommittee of the Energy Research Advisory Board. The Committee reviews the plans for the Federal program and advises the Secretary of Energy on the program.

4.6 PLANNING ACTIVITIES

The Interagency Geothermal Coordinating Council is responsible for the coordination of the efforts of all Federal agencies involved with the development of geothermal energy. In order to develop Federal program plans and goals, the IGCC undertakes various planning activities designed to monitor and assess the status of geothermal development and to determine the actions to be followed by the Federal agencies to accomplish the geothermal goals.

The planning activities of the IGCC are coordinated by the Budget and Planning Working Group (BPWG) and carried out by the appropriate IGCC subgroup. The principal activities this year were: the preparation and submission to the Office of Management and Budget (OMB) of the Federal Geothermal Program Plan (described earlier); the establishment of a Geothermal Progress Monitor System and publication of four issues of the Geothermal Progress Monitor Report; the preparation of the Fourth Annual Report of the IGCC to Congress; the design of the Geothermal Site Development Forecasting System; an analysis of the requirements for the leasing of Federal geothermal lands; an assessment of the adequacy of existing environmental controls, and needed research and development efforts; identification of the major Federal funding programs available for geothermal development; and the development of preliminary market penetration estimates for geothermal energy. Each of these activities is described below. All of them are important to the development of planning activities of the IGCC and its member agencies.

The Geothermal Progress Monitor (GPM) System is designed to collect and compile information about geothermal activities, and serves both program management and information dissemination functions for the member agencies of the IGCC (see Figure 4.1). The principal objectives of the System are to: provide a single point of reference for the status of geothermal commercialization activities; identify significant trends in these activities; and report events that may have significant impact on the course of these activities. The primary source of information for the GPM System is the Division of Geothermal Energy's field organization, comprised of DOE Regional and Operations Offices and their designated contractors and state teams. In addition, data are supplied by other member agencies of the IGCC, primarily USGS and BLM in the Department of Interior, and USFS in the Department of Agriculture. The System has been operating for about one year.

The Geothermal Progress Monitor Report is published on a quarterly schedule and presents the information gathered by the GPM System. The report focuses on two types of information: status, the baseline of how much energy is being produced; and trends, changes that occur with respect to the baseline information. In September 1980, DOE published the fourth issue of the Geothermal Progress Monitor, the first issue to receive wide distribution. The first three issues were used only for development purposes; the fourth issue contains all the updated information presented in the previous issues.

The design for the Geothermal Site Development Forecasting System (formerly the Project Managment System) was completed. The objective is to develop a computer-based system to track and forecast development events and requirements at specific geothermal prospect sites. The complete system will forecast: power-on-line dates on a site-by-site basis; aggregated power-on-line summaries on a year-by-year basis; manpower requirements on a year-to-year basis; and individual and aggregated capital investment, Federal incentive revenue, and other costs in current dollars. The key information will cover about 50 major electric prospects in the United States, and will include: the current status of development at each prospect; industry's development plans; time and manpower requirements; estimation of the economics of electricity production; and consideration of impediments to development. The system will eventually be expanded to include direct heat sites.

DOE's Office of Leasing Policy Development (LPD) is responsible for promulgating regulations designed to: foster competition for Federal leases;

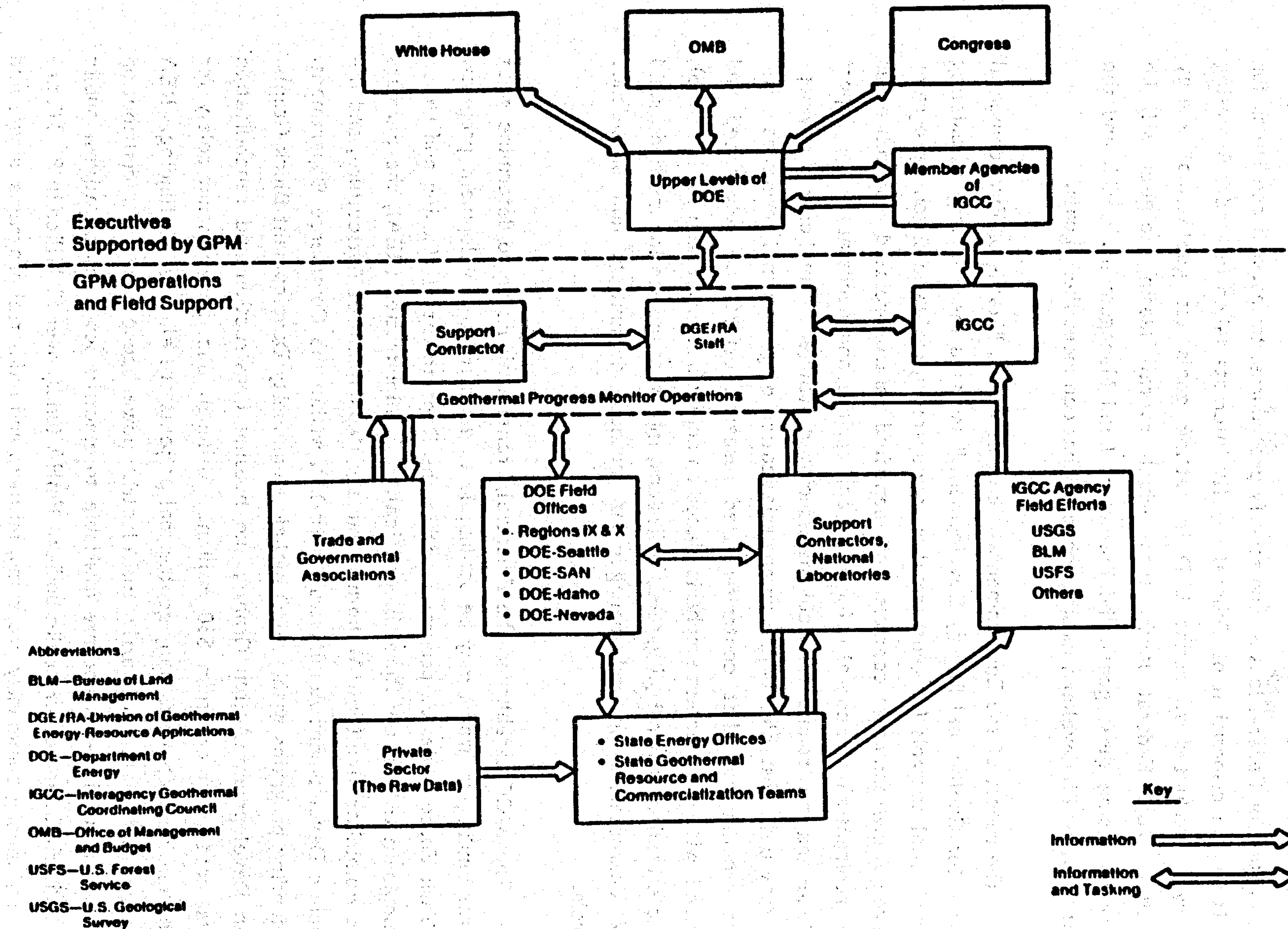


Figure 4.1 Geothermal Progress Monitor System

implement alternative bidding systems; establish diligence requirements; set production rates for Federal leases; and specify procedures, terms, and conditions for acquisition and disposition of Federal royalty interests taken in kind. A leasing study was conducted to assist LPD in setting goals for geothermal energy production from Federal lands, from which overall leasing targets will be developed. Using these goals, the Bureau of Land Management, USGS, and the Forest Service will develop a leasing schedule that can meet these goals.

The report of the Environmental Controls Panel, "Status of Environmental Controls for Geothermal Energy Development," assessed the adequacy of existing environmental controls for geothermal energy systems, reviewed ongoing programs to develop environmental controls, and identified controls-related research areas where redirection of Federal efforts are appropriate and necessary. The report concludes that environmental problems associated with geothermal energy development may pose obstacles to the commercialization of geothermal resources. The report recommends that controls-related research efforts be rebalanced and enhanced, with the greatest emphasis placed on controls for hydrogen sulfide (H_2S), characterization of non-H_2S gaseous emissions, injection monitoring methods, solid waste characterization and management methods evaluation, and subsidence controls.

The IGCC established the Financial/Grants Task Force to determine what Federal funding programs may be applicable to geothermal development projects. The Task Force reviewed programs within the Department of Housing and Urban Development (HUD), the Rural Electrification Administration (REA), the Farmers Home Administration (FmHA), both within the Department of Agriculture, and the Economic Development Administration (EDA), within the Commerce Department. The funding programs within HUD include Community Development Block Grants, Urban Development Action Grants, and housing construction and rehabilitation grants, totalling more than $30 million. Although this money is not solely for geothermal development, many geothermal projects are eligible for funding. REA funds are designated primarily for electric power generation and distribution facilities in rural areas, and are available to electric power cooperatives, public power districts, and other public bodies. FmHA funds, over $8 billion in FY80, are allocated among community programs, business and industrial programs, single and multiple family housing programs, and farmers' programs. EDA funds are available for public works projects, business development, planning, technical assistance, and economic adjustment in areas designated economically depressed.

DOE is conducting a study of the geothermal market penetration potential in order to establish a realistic basis for the establishment of R&D goals. Market penetration models were developed for electric power and direct heat applications (nonelectric), and generated projections for development schedules of geothermal systems. The model will be used to assess the Federal program and its impact on geothermal development.

4.7 POLICY DEVELOPMENT

The United States has been working to develop a comprehensive energy policy since the oil embargo of 1973. Through administrative and legislative actions, some directions are emerging. The IGCC continually contributes to policy development, making legislative recommendations to Congress and regulatory advice to administrative agencies.

The second National Energy Plan (NEP-II) is a major development toward establishment of a national energy policy. It outlines the administrative strategies to increase U.S. energy security by developing new domestic energy supplies and markets for those supplies. NEP-II's immediate objective is to reduce the nation's dependence on foreign oil and vulnerability to supply interruptions. The midterm objective is to maintain a low level of imports while developing the capability to use new, higher-priced technologies as world oil prices rise. An abundant supply of energy from renewable resources is the long-term objective of the National Energy Plan.

The near-term strategy to reduce the rate of growth in energy demand and to improve productivity of energy use is to encourage energy conservation and production through replacement cost pricing policies for domestic oil, to streamline regulations to prevent excessive delays in construction of energy facilities, to encourage investments in upgraded oil refinery capacity and enhanced oil recovery, to increase the use of coal as a substitute for oil by developing emission-control technologies and stable environmental regulations, and to enhance the security of

U.S. oil supplies by diversifying world oil supplies and filling the Strategic Petroleum Reserve. Despite their critical importance in the long term, renewable resources are not expected to make a significant contribution in the near term, except on a regional basis.

In the midterm, the nation will begin to reverse the trend toward increasing dependence on liquid fuels and gases. Natural gas will essentially maintain its existing share of the market, while direct coal use, electricity (from both new and conventional sources), and decentralized renewable resources will increase their share, thereby making scarce liquid and gaseous fossil fuels available for other uses. The strategy involves continued movement toward replacement cost pricing of oil and natural gas, regulatory policies and standards to increase energy efficiency of automobiles, new buildings, and appliances, increased emphasis on coal and nuclear as critical transition fuels, and commercial phase-in of new technologies.

The long-term strategy rests on two major transitions. The first transition will be to wide-scale use of nonrenewable sources such as conventional nuclear technologies, oil shale, coal-derived products, and others. The second major transition will occur after 2000 when renewable resources and advanced nuclear technologies will play major roles in U.S. energy production and use.

NEP-II identifies geothermal energy as one of the four major long-term energy options to be pursued. Current commercial geothermal energy comes from very highgrade resources; the national RD&D program is aimed toward developing other potentially suitable resources. NEP-II outlines the following development incentives for geothermal:

1. Tax incentives and loan guaranties are the primary tools to encourage the use of hydrothermal resources. RD&D will be used where the technology has not been demonstrated.

2. Geopressured energy resources will be developed primarily as sources of methane and secondarily as sources of heat from hot water.

3. Research and development will be used to develop the technology to use hot dry rock geothermal resources.

In addition to the administrative objectives outlined in NEP-II, geothermal policy has been established through legislative actions. Past actions include the Geothermal Steam Act of 1970 (PL 91-581), the Geothermal Energy Research, Development and Demonstration Act of 1974 (PL 93-410), and the Federal Non-nuclear Energy Research and Development Act of 1974 (PL 93-577). Legislative efforts continue to provide economic incentives for the development of geothermal resources, and include most recently the passage of the Windfall Profits Tax Act and the Energy Security Act.

In April 1980, the Crude Oil Windfall Profits Tax Act (PL 96-223) was signed by the President. The law provides tax credit increases over those provided by the National Energy Act. The investment tax credit for geothermal equipment is increased to 15% in excess of the normal 10% and extended through 1985. The residential credit is increased to 40% percent of the first $10,000 in expenditures for geothermal equipment, for a maximum of $4,000. Finally, a tax credit is provided equal to 10% of the cost of cogeneration equipment. Geothermal systems designed to tap waste heat or steam would qualify.

The Energy Security Act (PL 96-294) was enacted in June 1980. Title VI, the Geothermal Energy Act of 1979, contains the following major provisions:

(1) An $85 million five-year program under which the Federal government will share the risks of drilling for commercially viable geothermal resources. Loans will cover 50% of the cost of surface exploration and drilling and 90% of the cost of a project to use geothermal for space conditioning or process heat. The loans will be repayable out of project revenues and will be wholly or partially forgivable if a project is unsuccessful. Because the high economic risk perceived by drillers and developers is considered to be one of the major forces slowing development, the reservoir confirmation loan program could be expected to accelerate the rate of exploration for and confirmation of geothermal reservoirs. No funds have been authorized for the program in FY 81 and FY 82.

(2) A program authorizing DOE to grant low-interest, forgivable loans to cover up to 90% of the cost of feasibility studies and regulatory applications and up to 75% of the construction costs of nonelectric systems. No funds are authorized for feasibility studies in FY 81.

(3) A DOE study to examine the need for and feasibility of a Federal reservoir insurance and reinsurance program. On the basis of the report, Congress will determine whether to authorize a program of insurance or reinsurance against the risk of reservoir failure after investment of at least $1 million has been made in reservoir development and use. The direct insurance would be provided only where the developer could not obtain private insurance at reasonable premiums.

(4) Modification of Geothermal Loan Guaranty P-ogram (GLGP). The law extends the life of the GLGP from 1984 to 1990 and provides an increased level of assistance under the program. Loan guaranties for loans to municipalities and public cooperatives will increase from 75% to 90% of project costs. PL 96-294 also includes provisions to expedite processing of loan guaranties; such reforms include a four-month deadline for processing applications, requirements to give faster consideration to applicants for nonelectric projects, and a requirement to eliminate duplicative Environmental Impact Statements under NEPA for loan guaranty applications.

(5) A provision requiring consideration of the use of geothermal energy in Federal buildings or facilities in areas designated by DOE.

(6) New authorities under PURPA. The law explicitly includes geothermal facilities of 80 MWe or less in the small power producer category under the Public Utility Regulatory Policies Act (PURPA). Geothermal facilities qualifying as small power producers are eligible for interconnection, wheeling of power through grid transmission lines, exemption from the Federal Power Act and the Public Utility Holding Company Act, and other utility orders as determined by FERC. The law also allows qualifying utility-owned geothermal plants to qualify for these exemptions and for wheeling and interconnection.

The latest considerations by the Federal government include Federal leasing and permitting reforms; several Federal geothermal leasing bills are under consideration by the Congress. They would increase acreage limitations, redefine KGRA's, require expedited leasing procedures, and require geothermal production goals for Federal lands. Bills passed both the House (HR 6080) and the Senate (S 1388) during 1980.

5.0 THE FEDERAL PROGRAM

5.1 OVERVIEW

The overall objective of the Federal geothermal program is to enable private industry to undertake commercial development of geothermal resources by providing an appropriate level of Federal assistance while removing disincentives to exploration and development. All the activities of the program are directed toward achieving this objective.

Geothermal commercialization entails a number of successive phases of development in order to bring power on-line. The Federal geothermal program in FY 80 attempted to address each of these developments. This chapter discusses each of these issues in turn, and describes the FY 80 program activities designed to overcome the economic, technological, and environmental barriers to geothermal energy development. Preliminary development steps include leasing of suitable lands; environmental assessment of geothermal resource areas and development sites, and control technology development; reservoir identification, assessment, and exploration; field development and production drilling; and plant/facility construction and testing. Industrialization efforts include planning and technical assistance, demonstration of electric and direct heat applications, and financial incentives provided by recent legislation. Current programs are directed primarily at hydrothermal resources, because the hydrothermal technology is now available for potentially extensive development. Federal use of geothermal energy, primarily at Department of Defense facilities, provides development opportunities and demonstration plants for commercial-scale systems. Technology development is aimed at reducing the costs of geothermal exploration, assessment, and field development; reducing the capital costs of electricity-generating facilities; improving resource utilization efficiency; and reducing the technical risks in all aspects of geothermal fluid handling (production, utilization, disposal) in the near future. Geopressured resource development efforts are aimed at determining the technical, economic, and environmental feasibility of extracting methane, electricity, and end-use heat from the geopressured geothermal resources on the Gulf Coast of Louisiana and Texas. Hot dry rock resource development activities focus on evaluation of the nationwide potential for application of the hot dry rock (HDR) technology and support for the development of new technical approaches for extracting thermal energy from HDR deposits. Finally, international activities could have an important effect on the pace of commercialization of geothermal energy in the United States supplying both technologies and materials to U.S. developers, and creating markets for U.S. manufacturers.

Major Federal actions which are expected to support geothermal energy production include development of new leasing policies and environmental regulations, construction of a commercial-scale demonstration plant, refined resource estimates, construction of geothermal facilities to supply energy to military installations, and new incentives provided by recent legislation. These actions are discussed briefly below:

- The Bureau of Land Management (BLM) and the Forest Service (USFS) have begun to formulate new procedures for leasing Federal lands for geothermal exploration. Under the new rules, lands could be explored prior to the exhaustive environmental assessments required to permit construction of facilities to produce energy. Comprehensive production-related environmental reviews would be conducted if and when the developer determined there existed potential for geothermal energy production. This new approach to leasing should help to reduce the backlog of lease applications and ensure that sufficient acreage is available for exploration. Proposed legislation would require additional changes in leasing procedures.

- The Environmental Protection Agency (EPA) revised Prevention of Significant Deterioration (PSD) regulations under the Clean Air Act. Hazardous Waste Disposal and Underground Injection Control regulations have been issued respectively under the Resource Conservation and Recovery Act and the Safe Drinking Water Act. EPA will periodically review the adequacy of these regulations and revise them as necessary.

- Because of the lack of sufficient data, the current inventory and assessment of national geothermal resources is based on a large number of assumptions about the location and size of identified hydrothermal systems and geopressured geothermal formations. In addition, relatively little is known about the undiscovered portion of the nation's geothermal resources. As new data become available from resource characterization studies and reservoir exploration, the national inventory and assessment of the various types of resources will be periodically updated by the U.S. Geological Survey (USGS) to provide refined estimates of these resources.

- The hydrothermal 50 MWe flash-steam demonstration plant at Baca, New Mexico, will begin operation in 1982.

- DOD will construct geothermal facilities to provide energy to Navy and Air Force bases. Projects being planned or under consideration include both space heating and electric power generation, so the program may contribute to both direct heat and electric power production goals.

The Federal geothermal program activities are spread among the agencies participating in the program. DOE, as lead Federal agency for geothermal development, participates in all program areas and plays a lead role in many of them. Other agencies also have major responsibilities in the geothermal program, particularly in the areas of resource assessment, Federal lands leasing, and environmental regulation and controls development. The program activities of FY 80 are detailed below.

5.2 LEASING

The rate at which geothermal resources are developed in the United States will depend largely on the effectiveness of the Federal lands leasing program. Since the passage of the Geothermal Steam Act in 1970 and issuance of geothermal leasing regulations in 1974, Federal agencies have been confronted with the task of balancing the benefits of rapid resource development against environmental values and sound land management practices.

Federal lands are leased for exploration and development either through a competitive bidding procedure or through noncompetitive applications, according to the classification of the land. Lands designated as Known Geothermal Resource Areas (KGRA's), about 62 percent of which are Federally owned, are leased competitively; other Federal lands where there is potential for discovery of goethermal resources are leased noncompetitively.

Substantial increases in leased Federal acres are needed to reach the IGCC's production potential estimates. Even though approximately 4 million acres of Federal land were under application for geothermal lease, only 2.9 million acres had been leased noncompetitively by the end of FY 80. In addition, over 900,000 acres have already been relinquished. As of September 1980, less than 600,000 Federally leased acres were in KGRA's, which were those areas deemed most suitable for electric development.

The IGCC's Leasing and Permitting Panel was recently established to address problems in the Federal leasing program and attempt to resolve the issues raised by the IGCC Streamlining Task Force. The earlier group examined the sources of delays and shortfalls in the Federal leasing program and made recommendations to alleviate some of the problems now obstructing greater development of Federal lands for geothermal energy production. Among the problems identified were the lack of time constraints on actions in the pre- and post-lease approval process, the competitive overlap KGRA designation, the general low priority given to geothermal in relation to other resource management programs, and the exhaustive nature of pre-lease environmental reviews. Some of these problems were addressed by legislation which was before Congress in FY 80. The legislation would have mandated expedited leasing and declassification of unbid KGRA lands.

Leasing responsibilities are divided among the Bureau of Land Management, the Forest Service, and the Geological Survey. The activities of these organizations are described below.

5.2.1 Bureau of Land Management (BLM), Department of the Interior

The Bureau of Land Management (BLM) reviews applications and issues leases for geothermal development on BLM lands, maintains records, and supervises surface activities outside the area of operations. BLM also issues leases on Forest Service lands with the consent of and subject to the terms and conditions prescribed by the Forest Service. The Bureau's objective is to make geothermal resources available for development in response to national energy goals and industry interest while protecting the environment and assuring receipt of fair market value for use of the public's resources.

The Bureau's functions fall into the following two major categories: environmental assessment, which precedes lease issuance, and adjudication, which provides for an orderly, accurate system of issuing and maintaining records of leases. The Bureau also approves power plants or nonelectrical utilitization facilities following a joint environmental review with the USGS.

Specific objectives for FY 81 are: (1) to hold a minimum of 8 competitive lease sales and issue at least 400 competitive and noncompetitive leases; (2) to review 140 applications to explore or drill on geothermal lands; and (3) to process 2 nonelectrical use licenses, and possibly 1 power plant license. The schedule for leasing activities is shown in Table 5.1. The schedule indicates that BLM is projecting only a modest increase in the number of leases to be issued, in spite of the expection that the Forest Service was expected to allow leasing in many areas previously withheld, and the fact that BLM implemented a phased environmental review procedure. The procedure, which matches the level of review to the proposed or permitted activity, was intended to eliminate the necessity for conducting lengthy environmental reviews of phases of development which might not occur. BLM is now projecting complete elimination of all lease application backlogs by the end of FY 82 and offering of all unoffered KGRA parcels by the end of FY 82. To effect this, BLM is entering into a new, simplified coordination

Table 5.1

SCHEDULE OF BLM LEASING ACTIVITIES, 1979-1986

Fiscal Year	1979	1980	1981	1982	1983	1984	1985	1986
Competitive Lease Sales*	4	5	8	14	2	2	2	2
Noncompetitive Leases Issued**	202	343	350	1500	700	700	700	700
Applications to Drill Exploration or Temperature Gradient Holes	110	125	140	150	160	170	180	180
Powerplant or Large Scale Nonelectrical Use Licenses Issued	1	0	3	5	8	12	14	18

*Approximately 7 parcels result in leases from each sale.

**1983 figure includes reissuance of 100 relinquished leases.
1982-1986 figures include approximately 200 reissued leases per year.

agreement with USFS and USGS. In addition, phased environmental reviews and use of categorical exclusion from NEPA compliance for lease issuance will be emphasized.

5.2.2 U.S. Forest Service (USFS), Department of Agriculture

The Forest Service is responsible for evaluating possible impacts of geothermal leasing on surface resources and considers other uses in developing terms and conditions for leasing of National Forest System lands. USFS activities consist of prelease environmental analyses, issuance of prospecting (exploration) permits, and consulting with other agencies on various aspects of the leasing and permitting program. The Forest Service objective is to make National Forest System lands available for mineral development at levels commensurate with national needs.

The Forest Service is responsible for approving National Forest System lands for leasing and for providing terms and conditions for adequate protection of those lands. Upon receipt of applications for geothermal leasing from the Bureau of Land Management (BLM) or the notification by BLM of a proposed competitive lease sale, the Forest Service schedules a study to consider the leasing action and its impact upon National Forest System lands and upon established or planned uses on those lands. Consideration is given to the relative values of geothermal resources and those surface resources and uses that would be affected, as well as to available controls and mitigation measures to protect or restore affected areas. Upon completion of such an evaluation, the Forest Service then notifies the BLM of its decision on the availability of the lands for leasing and of any special terms and conditions required.

In accordance with the general aim of giving higher priority to mineral leasing activities by streamlining its leasing policy, the Forest Service in conjunction with BLM has resolved to eliminate the leasing backlog of several hundred geothermal applications and complete environmental reviews of all KGRA parcels by the end of FY 82.

The Forest Service is currently using a "staged" leasing procedure based on a conditional development stipulation. The use of the stipulation provides the rationale for not attempting unrealistic full-scale environmental review of possible development before leasing land. Instead, lease decisions will be based primarily on environmental review of exploration and generalities of development, with the understanding (as provided in the regulations) that if a lessee discovers a commercially viable resource and presents a development plan, the plan must be subjected to a comprehensive environmental review before development can begin.

5.2.3 U.S. Geological Survey (USGS), Department of the Interior

The role of the U.S. Geological Survey (USGS) is to provide geologic, economic, engineering and environmental expertise to the leasing program and to assure compliance with terms and conditions pursuant to the Geothermal Steam Act and those set by BLM for surface protection and reclamation and various environmental laws. Activities of the Geological Survey's Conservation Division include evaluating lands for KGRA designation; monitoring drilling operations on leased lands; conducting postlease environmental assessments; issuing postlease exploration, development, and production permits; collecting royalties and assuring receipt of fair market value for Federal geothermal resources; approving baseline data collection and environmental monitoring programs; and consulting with other agencies. Once Federal lands are leased for geothermal exploration and development, USGS becomes the lead Federal agency with respect to environmental protection within the area of operations.

At the present time, the Conservation Division's Geothermal Section supervises about 3.5 million acres contained in over 100 KGRA's. Development plans include increasing the number of economic evaluations in fiscal year 1980 to a minimum of 12 to keep pace with the proposed BLM sale schedule.

5.2.4 Fish and Wildlife Service (FWS), Department of the Interior

The Fish and Wildlife Service (FWS) provides biological expertise to the Federal surface management agencies (BLM, USFS, and USGS) in both pre- and post-leasing phases. These actions involve providing biological and ecological input to environmental studies, performing biological resource assessments, recommending lease stipulations and mitigation practices, developing baseline monitoring programs, recommending lease selections or alternatives, and evaluating compliance requirements. The objective of the Fish and Wildlife Service's participation in the geothermal program is to conserve, protect, and enhance fish and wildlife and their habitats and facilitate balanced development of geothermal resources by timely and effective provision of fish and wildlife information and recommendations.

The Fish and Wildlife Service conducts programs to (1) develop ecological information and techniques to be used to facilitate environmentally balanced geothermal development programs, (2) identify specific impacts on fish and wildlife resources and techniques to minimize adverse impacts, and (3) provide technical support to other Federal agencies to ensure adequate consideration of fish and wildlife resources in geothermal development considerations. This involves monitoring geothermal impacts on fish and wildlife and their habitats at specific sites, on a regional and national basis.

5.2.5 Leasing Policy Development Office (LPD), Department of Energy

DOE's Office of Leasing Policy Development (LPD) is responsible for promulgating regulations designed to (1) foster competition for Federal leases; (2) implement alternative bidding systems; (3) establish diligence requirements; (4) set production rates for Federal leases; and (5) specify procedures, terms, and conditions for acquisition and disposition of Federal royalty interest taken in kind. LPD is also responsible for approving or rejecting terms and conditions for leases issued by DOI subject to these DOE authorities.

In accordance with a DOE/DOI Memorandum of Understanding, LPD will establish production goals, subject to revision every two years, for energy mineral resources on Federal lands. The goals are to be used by DOI in determining leasing programs and lease planning schedules. Concurrent with the LPD's effort to set the production goals, DOE is identifying western geothermal resource areas with priority for Federal leasing. Other activities planned for the near term include developing a leasing schedule with USDA/USFS and DOI/BLM, identifying regulatory problems that would hinder achievement of leasing goals, analyzing and proposing changes in leasing policy and regulations to promote geothermal production, and identifying geothermal areas being affected by Federal Land withdrawals for wilderness preservation, wild and scenic rivers, national parks, and other land preserves.

In response to an identified need for guidelines on leasing Federal lands for geothermal development, the Leasing Policy Development Office has begun a project to establish production goals for energy from leased Federal lands. The goals are intended to help land management agencies in determining leasing programs and schedules and thereby prevent the unnecessary delays in leasing which impede progress toward geothermal utilization. The production goals will be established according to parameters of resource potential, market demand potential, and social and environmental impacts. A preliminary analysis of these production estimates suggests that a minimum of 1.7 million acres of the highest potential Federal land would have to have been leased by 1980, 3.3 million acres by 1985, and 6.0 million acres by 1990 in order to reach the geothermal energy production estimates for 1985 to 2000 for both electric and direct heat uses. To ensure that this amount of high potential land is leased, BLM and USFS will have to lease all available known geothermal resource areas (approximately 1.5 million acres) and at least 18 million acres applied for noncompetitively by geothermal developers by 1990.

The analysis suggests that:

- Leasing of lands with potential merit for electricity production must be increased markedly; and

- The BLM and USFS will have to lease about 500,000 acres per year of these high potential lands during 1981-1990 to ensure that enough land is explored to reach the production estimates for the year 2000.

Federal land management agencies (BLM and the Forest Service) have expressed a need for the production goals to be set on a location-specific basis so that lands can be leased according to energy production target areas. DOE has begun to address this issue by identifying specific prospects within each state which should receive priority by BLM or the Forest Service in reviewing applications for geothermal leases. Definitive goals for each of these areas, however, have not been set.

5.2.6 Status of Federal Geothermal Leases at End of FY80

The number of leases issued in FY 80 increased by 50% from FY 79. The general status of geothermal leases indicates that Federal geothermal leasing is proceeding at a rate of 650,000 acres per year. Although this exceeds the rate of leasing (500,000 acres per year) indicated by the Leasing Policy Development Office's analysis as necessary to meet the IGCC production goals, it is generally recognized that the acres being leased are not necessarily the areas having the highest geothermal potential. DGE has initiated a process to aid BLM and USFS in selecting specific areas on which to concentrate their efforts.

Tables 5.2 through 5.4 present general statistics that describe competitive leasing of KGRA lands in greater detail. Only 25,000 acres were added to lands with KGRA status in 1980, resulting in 3,410,000 acres being so designated, only about 2.2 million of which are Federally administered. FY 80 saw only 4 competitive lease sales held, compared to at least 12 sales held per year in FY 75 through FY 77 (Table 5.4). Most of the BLM administered KGRA parcels have already been offered for sale with the exception of those in California. Future competitive lease sales will involve primarily parcels administered by the Forest Service. The greatest amount of bonus bid money received has come from California (Table 5.3) and by far the greatest share of this has come from leases at The Geysers.

The progress for noncompetitive leasing is detailed in Tables 5.5 through 5.7.

5.3 ENVIRONMENT

The Federal geothermal environment program focuses on characterization of the environmental impacts of geothermal energy systems and delineating and mitigating or eliminating environmental or health concerns which are deterrents to development. Regulations and standards applying to geothermal energy development are established by EPA. The IGCC's Environmental Controls Panel and EPA's Alternate Fuels Group provide coordination between the research community, DOE, and regulation writers.

Table 5.2

COMPETITIVE LEASING BY STATE, TOTAL ACREAGE LEASED, BY YEAR

State	1974	1975	1976	1977	1978	1979	1980*	Total
Nevada	31,499	28,557	60,940	36,663	9,322	21,920	13,407	202,308
Utah	23,400	26,171	26,968	12,788	1,658	-0-	-0-	90,985
New Mexico	-0-	18,476	14,088	48,065	8,767	7,062	-0-	96,458
Oregon	1,347	47,689	19,836	-0-	5,818	-0-	19,523	94,213
California	26,354	10,583	-0-	2,856	4,395	6,958	-0-	51,146
Idaho	-0-	20,963	3,940	6,985	-0-	-0-	-0-	31,888
Colorado	-0-	5,036	-0-	-0-	-0-	-0-	-0-	5,036
Total Acres Leased	82,600	157,475	125,772	107,357	29,960	35,940	32,930	572,034

*September 30, 1980

Table 5.3

TOTAL HIGH BONUS BIDS BY STATE AND YEAR (IN DOLLARS)

STATE	1974	1975	1976	1977	1978	1979	1980*	TOTAL
California	8,614,912	134,532	0	780,451	16,016,169	798,595	0	26,344,659
Utah	877,188	2,705,661	96,688	668,825	33,862	0	0	4,382,181
Nevada	1,030,172	392,160	757,991	451,984	480,893	657,469	92,367	3,863,036
New Mexico	0	359,682	54,901	1,089,213	72,639	240,631	0	1,817,066
Oregon	13,831	296,798	140,251	0	86,581	0	1,311,119	1,848,580
Idaho	0	164,470	27,006	30,452	0	0	0	221,928
Colorado	0	13,577	0	0	0	0	0	13,577
TOTAL	10,536,103	4,066,837	1,076,837	3,020,925	16,690,144	1,696,695	1,403,486	38,491,027

*September 30, 1980

Table 5.4

DISTRIBUTION OF COMPETITIVE LEASE SALES BY STATE AND YEAR

STATE	1974	1975	1976	1977	1978	1979	1980*	TOTAL
Western Region								
Nevada	2	3	7	3	1	1	2	19
California	3	1	0	1	2	1	0	8
Oregon	1	5	3	1	2	0	2	14
Idaho	0	2	2	1	0	0	0	5
Arizona	0	1	0	0	0	0	0	1
Subtotal	6	12	12	6	5	2	4	47
Central Region								
New Mexico	0	1	2	3	1	1	0	8
Utah	1	2	1	1	1	0	0	6
Colorado	0	1	0	1	0	0	0	2
Montana	0	0	0	1	0	1	0	2
Subtotal	1	4	3	6	2	2	0	18
TOTAL	7	16	15	12	7	4	4	65

*September 30, 1980

Table 5.5

CUMULATIVE NONCOMPETITIVE LEASE TOTALS, 1976-1980

Year*	Filings	Withdrawn, Rejected, & Refused	Awaiting Action	Leases Issued	Acreage Leased
1976	5,432	2,734	2,012	656	1,141,980
1977	6,043	3,232	1,831	904	1,500,005
1978	6,655	3,673	1,806	1,117	1,930,163
1979	7,315	4,027	1,956	1,332	2,314,670
1980	8,243	4,457	2,111	1,675	2,933,901

*Year ends June 30 until 1979, thereafter September 30. Data for 1980 are for 15 months.

Table 5.6

NONCOMPETITIVE GEOTHERMAL LEASING, 1980

	APPLICATIONS							
	FILED			INACTIVE			AWAITING ACTION	
STATE	BLM	FS	SUBTOTAL	WITHDRAWN	REJECTED	REFUSED	BLM	FS
Alaska	0	0	0	0	0	0	0	0
Arizona	108	73	181	15	35	8	49	61
California	786	514	1,300	431	307	11	265	262
Colorado	113	83	196	100	17	2	4	23
Idaho	670	375	1,045	279	175	30	188	207
Montana	38	66	104	64	28	0	6	0
Nevada	2,077	77	2,094	676	417	78	151	19
New Mexico	676	42	718	354	87	12	118	19
Oregon	673	620	1,293	270	302	0	88	406
Utah	647	113	760	118	160	23	64	34
Washington	0	376	376	160	70	0	0	144
Wyoming	26	138	164	141	16	0	1	2
Eastern States	0	12	12	0	1	0	0	0
TOTALS	5,814	2,429	8,243	2,678	1,615	164	934	1,177

Table 5.6 (Cont.)

	LEASES					
	ISSUED			ACRES		
STATE	BLM	FS	SUBTOTAL	BLM	FS	SUBTOTAL
Alaska	0	0	0	0	0	0
Arizona	12	1	13	19,621	1,920	21,541
California	24	0	24	35,147	0	35,147
Colorado	45	5	50	52,394	10,099	62,493
Idaho	165	1	166	291,385	2,560	293,945
Montana	6	0	6	10,687	0	10,687
Nevada	750	3	753	1,378,225	4,434	1,382,659
New Mexico	128	0	128	231,179	0	231,179
Oregon	202	25	227	317,091	40,154	357,245
Utah	279	12	291	492,038	14,655	506,693
Washington	0	2	2	0	5,120	5,120
Wyoming	0	4	4	0	7,448	7,448
Eastern States	0	11	11	0	19,744	19,744
TOTALS	1,611	64	1,675	2,827,767	106,134	2,933,901

(1) Applications awaiting action for the following reasons:
- 27 Awaiting KGRA report from USGS
- 5 Prelease plan of development
- 701 Pending preparation of EAR (BLM only)
- 1,069 Awaiting comment of other agencies
- 31 Lease forwarded for signature
- 278 Processing (Adjudication)—BLM

Table 5.7

NONCOMPETITIVE GEOTHERMAL LEASING APPLICATIONS AWAITING ACTION

STATE	AWAITING KGRA REPORT FROM USGS	AWAITING PRE-LEASE PLAN OF DEV. FROM APPLICANT	PENDING PREP OF EAR (BLM ONLY)	AWAITING COMMENT OF OTHER AGENCIES		LEASE FORWARDED FOR SIGNATURE BY APPLICANT	PROCESSING (ADJUDICATION) BLM	TOTALS
				Other	FS			
Alaska								
Arizona			45		61		4	110
California			260		262		5	527
Colorado					23		4	27
Idaho	3		129		168		95	395
Montana					6			6
Nevada	1		50		18	26	75	170
New Mexico	2		60		19		56	137
Oregon	6		46		434		8	494
Utah	6	5	14	3	34	5	31	98
Washington	9		96		39			144
Wyoming			1		2			3
Eastern States								
SUBTOTAL	27	5	701	3	1066	31	278	2111

DOE, EPA, and DOI are the principal supporters of the environment program, with DOE sponsoring most of the research activities. The IGCC Environmental Controls Panel aids in coordination of environmental activities under DOE, EPA, DOI, USDA, and DOD.

The program includes acquisition of baseline data, monitoring, and research related to air quality, surface and ground water quality, hydrological alterations, ecology, noise, subsidence and seismicity, health effects and socioeconomic problems; regional and site-specific assessments of the environmental, health, and socioeconomic impacts of geothermal resource development; and development and evaluation of environmental control technologies.

5.3.1 Environmental Research and Assessment

The objective of environmental research and assessment activities is to help ensure environmentally sound development of geothermal resources by identifying key environmental issues through site-specific and regional assessments supported by baseline data gathering at development sites. Environmental assessment activities fall into two general functional categories according to the principal objective of the assessment.

Some site-specific and regional assessments conducted under the program are directly related to industrialization objectives. The purpose of DOE's Geothermal Environmental Overview Project (GEOP), for example, is to identify and assess current information on potential environmental concerns in those Known Geothermal Resource Areas (KGRA's) where commercial development is likely to occur.

Other site-specific assessments are not directly related to industrialization objectives. The purpose of these assessments is to identify research needs and to guide regulation and controls development. DOE performs environmental assessment in conjunction with its hydrothermal, geopressured, and hot dry rock resource programs. These assessments are related to specific projects. Current work includes research programs in subsidence and induced seismicity in conjunction with USGS; research on possible environmental effects of sustained highvolume geopressured brine production; geopressured test well monitoring of environmental problems related to fluids disposal; and environmental monitoring at the Fenton Hill, New Mexico, hot dry rock site.

Each of the major DOE resource programs, Hydrothermal and Geopressured, contains funding for an environmental subprogram, and Hot Dry Rock technology development activities include environmental monitoring. Some of DOE's programs focus on broad-scale assessments and environmental and health research, while others are oriented to specific assessments of DOE geothermal development projects at specific sites and to development of control technologies.

EPA's environmental research activities are carried out under the Office of Environmental Engineering and Technology (OEET) and include problem characterization, control technology development, and monitoring systems dèvelopment. Geoenvironmental assessment activities are carried out under the USGS Geothermal Research Program. EPA/DOE joint projects include solid waste characterization and impact assessment and studies in fluid injection and ocean disposal of fluids.

During FY 80, the following activities were completed:

- A technology assessment integrating environmental, health, and socioeconomic impacts of full-scale development of geothermal resources in the Imperial Valley, California, was completed by DOE. Although the study is site-specific, it will serve as a basis for understanding geothermal impacts from liquid-dominated resources in other regions of the country.

- DOE has completed its environmental overview project. Preliminary assessment reports for the following KGRA's will be available in FY 81: Hawaii; Oregon; New Mexico; northern Nevada; Raft River, Idaho; Mono-Long Valley, California; and Roosevelt Hot Springs, Utah.

- A socioeconomic study of The Geysers-Calistoga, California, KGRA was completed, and a final report will be available in FY81.

- DOE initiated planning for a new program to identify potential risks to human health associated with the installation, operation, and decommissioning of a reference geothermal system. The program will examine: source terms, environmental behavior, human exposures and metabolism, human health impacts, ecosystem impacts, and risk analysis.

- The planning was completed for environmental studies using the 50 MWe hydrothermal demonstration project at Baca Ranch, New Mexico. Data gathering and analysis for this program is scheduled to begin in FY81.

- EPA has completed the groundwater monitoring methodology development study, which prescribes a monitoring protocol for geothermal operators.

- EPA, with DOE, has completed a preliminary characterization of geothermal solid wastes, concluding that drilling wastes and sludge from air pollution control devices and from brine treatment may frequently not be hazardous.

- EPA completed a characterization of geothermal fluids, concluding that these fluids' potential for pollution is extremely site specific, ranging from virtually pure water to saturated brine.

- EPA completed a limited study of potential air emissions, concluding that H_2S controls will generally be required, and that the potential for pollution is very site specific.

5.3.2 Environmental Controls Development

The general objective is to eliminate or alleviate environmental problems related to geothermal development in consonance with other aspects of resource development.

Environmental controls are defined as technological or nontechnological methods to reduce, terminate, or prevent detrimental effects on the environment. DOE, EPA, USGS, and the Fish and Wildlife Service (FWS) are involved in developing and evaluating controls for various environmental impacts associated with geothermal development--hydrogen sulfide (H_2S) emissions, liquid and solid wastes, land subsidence, seismicity and hydrologic alteration.

The IGCC Environmental Controls Panel, which provides strategic oversight and coordination of the various agency efforts, has identified high-priority areas for controls-related research. These are H_2S and non-H_2S gaseous emissions; injection monitoring methods; solid waste characterization and management evaluation; and methods for subsidence prevention, prediction, and control. The Panel gave middle priority research to brine treatments, in-line monitoring, chemical and physical modeling/simulation techniques, characterization, monitoring, and prediction modeling of geothermal hydrologic systems, solid waste management technology development, induced seismicity identification and characterization, and induced subsidence characterization. Lower priority was given to induced seismicity controls and noise controls.

5.3.3 H_2S Emissions Control

H_2S emissions have been identified as a major environmental concern and an obstacle to geothermal development. EPA and DOE are working to develop reliable and economical control technologies for H_2S emissions abatement. The following program activities are under way:

- DOE is closely monitoring H_2S abatement technology development through frequent communication with key industry management and research personnel.

- Ongoing DOE funded research at UOP, Inc., indicates favorable results on a lab scale catalytic oxidation process to remove H_2S from both vapor and liquid dominated geothermal resources.

- Pacific Gas & Electric Co., under a Cooperative Agreement with DOE and EPA, completed pilot scale tests during FY 80 of an H_2S removal process developed by the EIC Corp. The process utilizes copper sulfate to effect upstream removal of H_2S and trade constituents from steam at turbine inlet temperatures and pressures. A pilot scale field test documented removal efficiencies to 99.9% and led PG&E to announce that they planned to build a full scale plant at their Geysers Unit 7 site. This process has also been selected as one of three to be incorporated into the California Department of Water Resources controversial Bottle Rock plant in order to meet stringent air quality standards.

- DOE and EPA are planning to continue to fund research to improve the state-of-the-art for H_2S abatement and reduce abatement costs. New projects proposed include initiation of an advanced system lab research, air oxidation and partitioning theoretical research, field test of a promising lab system, and a Cooperative Agreement with industry to rapidly develop technology to comply with local air pollution requirements.

5.3.4 Subsidence and Seismicity

Geoenvironmental effects of geothermal energy production--subsidence, seismicity, and hydrologic alteration--are most frequently associated with fluid withdrawal and injection and are closely related. USGS is studying these effects to understand the natural processes involved. This work is closely coordinated with and partly supported by DOE. A plan for a National Geothermal Induced Seismicity

Program has been prepared in consultation with a panel of experts from industry, academia, and government. The program calls for baseline seismic monitoring in regions of known future geothermal development, continued seismic monitoring and characterization of earthquakes in zones of geothermal fluid production and injection, modeling of the earthquake-inducing mechanism, in-situ measurement of stresses in the geothermal reservoir, and development of prediction and mitigation techniques for potentially damaging earthquakes induced by geothermal development. A similar plan is being implemented under the Geothermal Subsidence Program.

Seismic, geodetic, and gravity monitoring at The Geysers, California, by USGS has documented the occurrence of (1) daily microearthquake activity; (2) vertical and horizontal surface displacements of several centimeters per year; and (3) development of a mass deficit which implies little, if any, recharge of the field. These phenomena are closely correlated with the regions of maximum reservoir depletion as indicated by pressure decline data. In addition, large earthquakes (magnitudes up to 3.8) have occurred in the field, several in close proximity to injection wells. Earthquakes large enough to be felt occur on a weekly basis; some have caused temporary shutdowns of power plants. The continuing Geysers monitoring provides the data base needed for modeling, prediction, and mitigation of seismicity and subsidence under future cooperative programs with industry.

5.3.5 Liquid Discharge Control

DOE and EPA plan to develop injection monitoring instrumentation to allow remote sensing of fluid migration. This instrumentation would provide the geothermal industry with a method to comply with EPA underground injection control regulations to protect drinking water sources. The need for drilling witness wells would be eliminated if a reliable instrument is developed, and the cost of complying with the underground injection control regulations would be reduced.

5.3.6 Solid Waste Characterization and Control

DOE and EPA jointly funded a study to sample and analyze geothermal solid waste in California (at The Geysers and the Imperial Valley) and in Nevada.

The results were compared to EPA hazardous waste limitations (not presently applicable to geothermal). A small number of waste sample constituents exceeded the EPA limits. The handling and disposal of these wastes are, however, in compliance with state regulations, which are as stringent as the EPA requirements.

The Geothermal Loop Experimental Facility (GLEF) was established to evaluate the feasibility of flash-steam and flash-binary systems in the production of electric power. It was decommissioned in FY 80, but the techniques and data from this successful project are being used by developers at the numerous high-temperature, high-salinity resources in the Imperial Valley, California. The clarifier was turned over to Magma Power Company for their use in controlling solid wastes on a 28 MW power plant. Plans are being made to use the clarifier at other higher salinity resources such as Brawley and Westmoreland, California.

5.3.7 Noise Control

Noise from geothermal operations may be excessive, particularly from well drilling and steam venting. Other noise sources include well cleanout and flow testing, and generating unit operations. Noise emissions will generally be regulated at the state and local level. The Federal Noise Control Act does not specifically control geothermal sources, but does foster control of noise from Federal facilities. The USGS limits noise from geothermal operations on leased Federal lands.

Controls (shields and mufflers) are considered available at reasonable cost for meeting standards that may be applied. Federally funded research and development in geothermal noise control technology does not appear warranted.

5.3.8 Environmental Regulation

In the last 15 years, numerous laws have been enacted to protect and maintain the quality of the environment. These laws (listed in Table 5.8) could have significant implications for the development of geothermal energy. The Federal geothermal program objective is to provide environmental standards and regulations to allow development of geothermal resources as a safe, clean, environmentally acceptable alternative energy source.

Table 5.8

ENVIRONMENTAL AND CONSERVATION LAWS AFFECTING GEOTHERMAL DEVELOPMENT

The Wilderness Act of 1964 (PL 88-577)

The National Historic Preservation Act of 1966 (PL 89-665)

The National Environmental Policy Act of 1969 (PL 91-190), amended 1975 (PL 94-52 and PL 94-83)

The Geothermal Steam Act of 1970 (PL 91-581)

The Federal Water Pollution Control Act of 1972 (PL 92-500)

The Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532)

The Noise Control Act of 1972 (PL 92-574)

The Coastal Zone Management Act of 1972 (PL 92-583), amended 1976 (PL 94-37)

The Endangered Species Act of 1973 (PL 93-205)

The Safe Drinking Water Act of 1974 (PL 93-523)

The National Wild and Scenic Rivers Act of 1976 (PL 94-486)

The Federal Land Policy and Management Act of 1976 (PL 94-579)

The Resource Conservation and Recovery Act of 1976 (PL 94-580)

The National Forest Management Act of 1976 (PL 94-588)

The Clean Air Act Amendments of 1977 (PL 95-95)

EPA is responsible for providing guidance, standards, and regulations for geothermal development. Although EPA currently does not have regulations in force written specifically for the geothermal industry, existing standards and regulations limit allowable levels of pollutants in the atmosphere, receiving waters, and land from significant sources. Current and near-term EPA regulatory activities include the following:

1. Revision and update of the Pollution Control Guidance Document for hydrothermal energy development (6/82). Guidance documents will be developed for each of the three major resource types.

2. Revised Prevention of Significant Deterioration (PSD) regulations under the amended Clean Air Act (8/80). Geothermal power plants in attainment areas for criteria pollutants and with potential to emit 250 tons or more per year of H_2S will have to meet PSD permit requirements. Determinations regarding application of best available control technology (BACT) will be made on a site-by-site basis.

3. Final regulations protecting underground drinking water aquifers (6/80). Under the rules, groundwater must be protected from injected fluids by careful containment practices.

4. Hazardous waste regulations (5/80). These regulations specifically exclude geothermal wastes from classification as hazardous. This classification is pending, per Congressional direction, a two-year EPA study characterizing these wastes. This study also evaluates management options including resource recovery potential, management costs, and health and environmental effects, and recommends appropriate management options and regulations.

Few regulations are industry-specific, and EPA regulatory activities are carried out under various offices responsible for specific areas of environmental concern. Regulations promulgated by these offices are applicable or potentially applicable to geothermal development. An internal EPA working group supplies research data to the regulatory development process and prepares "early warning" Pollution Control Guidance Documents for industry.

5.3.9 National Environmental Policy Act (NEPA) Compliance

The National Environmental Policy Act (NEPA) of 1969 (PL 91-190) established for the first time a national policy for the protection of environmental quality. One of the most significant requirements of NEPA is the preparation of environmental impact statements (EIA) for virtually every development project. To meet the NEPA requirements, the responsible Federal agencies have examined a number of their ongoing geothermal development sites, and have prepared the necessary documents.

One of the major NEPA compliance activities involved the 50 MWe Geothermal Demonstration Power Plant in the Valles Caldera, Sandoval County, New Mexico. The final environmental impact statement (EIS) for this project was prepared, approved by ASEV, issued and widely distributed to interested parties and government agencies. A Record of Decision (ROD), documenting the decision by DOE to proceed with the project, was issued. Major environmental concerns addressed in the EIS, and mentioned in the ROD included the possibility of contamination and depletion of local surface water and ground water supplies, disturbance of archaeological and historic sites, hydrogen sulfide emission, and interface with local native American religious practices.

Another major NEPA compliance activity involved the preparation and issuance of an environmental assessment (EA) for the 50 MWe Binary Cycle Geothermal Demonstration Power Plant Project at Heber, Imperial County, California. Based on this EA, ASEV concluded that no significant environmental impact would result from the project, and that an environmental impact statement is not required. A formal finding of no significant impact (FONSI) was issued, allowing DOE to proceed with participation in the project.

Other NEPA compliance activities included the completion and issuance of EA's for a geopressured well test project, a direct heating project for a hospital and for two geothermal loan guaranty actions. Preparation of a supplement to the EIS for geothermal development at Coso Hot Springs in California was also initiated. This supplement addresses a geothermal loan guaranty application by the California Energy Corporation for field exploration leading ultimately to construction of a 20 MWe power plant at the Coso KGRA.

5.4 RESOURCE IDENTIFICATION, ASSESSMENT, AND EXPLORATION

The Department of Energy (DOE) and the U.S. Geological Survey (USGS) are collaborating on a Federal program to establish the extent and identify the location of geothermal resources in the United States. The objectives of the assessment program are: (1) to characterize the geological nature of each type of geothermal resource; (2) to estimate location, distribution, and energy content of geothermal resources in the United States; and (3) to evaluate geothermal energy potential in the United States through inventory of the identified portion and prediction of the undiscovered portion of the nation's resources. Objectives for each major resource type are:

- To identify and characterize high-temperature (150°C) hydrothermal resources suitable for electric power generation and low- to moderate-temperature (20°C-150°C) prospects with potential for direct heat applications,

- To determine location and estimate energy content (both thermal energy and methane content) of geopressured aquifers in the northern Gulf of Mexico and elsewhere in the United States.

- To assess the long-term potential of hot dry rock as an alternative energy source and select promising hot dry rock sites for detailed resource investigations.

To achieve these objectives, DOE and USGS undertake national, regional, and in cooperation with individual states, site-specific assessments of the geothermal resource. Exploratory drilling programs have begun in several regions where a strong interest in direct heat has been exhibited but where appropriate resources have not yet been confirmed. In addition, DOE has initiated several projects that foster and support detailed investigations to locate target areas with high potential, and the drilling of exploratory wells to confirm the existence of a suitable resource for either electrical power generation or direct heat utilization.

5.4.1 Resource Assessment

The U.S. Geological Survey, which is the lead Federal agency for geothermal resource assessment, is responsible for conducting resource inventory and assessment through a program of multidisciplinary research. The Geothermal Research Program (GRP) is aimed at understanding the nature, distribution, and energy potential of the various types of geothermal resources and estimating the location and magnitude of the nation's geothermal resources. In addition, the program advances the methodology of exploration for geothermal energy sources, develops a systematic knowledge of the characteristics of geothermal systems that may affect their development, and investigates certain geoenvironmental problems that may be associated with the extraction of geothermal energy. The principal parts of the program are directed toward resource assessment under these broad categories:

- National and regional resource inventory
- Resource characterization
- Exploration and assessment technology
- Geologic controls of subsurface porosity and permeability

The results of this assessment provide a foundation for other critical portions of the Federal geothermal program by identifying target areas for site-specific studies by DOE and for exploration by industry, providing a basis for estimating potential productivity of individual geothermal systems, and establishing guidelines for development of technology to exploit the resources.

The Survey's Geothermal Research Program includes several major projects in FY81. A wide variety of studies aimed at assessing the geothermal potential of the Cascade Range of northern California, Oregon, and Washington is under way and will continue in FY 82. The current state of knowledge of geothermal resources of the Snake River Plain in Idaho and the geothermal potential of the Great Basin in northern Nevada and adjacent areas is being summarized for major publication in FY 81 and FY 82. In addition, a nationwide assessment of low-temperature (<90°C) hydrothermal resources is being conducted, with completion scheduled for early FY82. For geopressured resources, the USGS is developing estimates of potentially recoverable energy, based on their estimates of the resource base in Circular 790. For hot dry rock resources, the USGS is cooperating with DOE in evaluating potential locations for hot dry rock energy sources. The USGS is also cooperating with DOE in studies aimed at the detection of induced seismicity and subsidence at The Geysers and the Imperial Valley. The GRP provides information to the USGS Conservation Division in support of its activities in the classification and evaluation of Federal lands for geothermal leasing. The major accomplishments of the GRP during FY80 are summarized below.

1. The well/spring file from GEOTHERM was entered into the General Electric Information Services Network. The file is now available to subscribers of the GE system. This will make the data file more easily accessible to the geothermal community and to other potential users.

2. A preliminary temperature gradient map of the U.S. was compiled using data from over 190 holes deeper than 600 m. The map displays temperature gradients in °C/km that can be expected to exist regionally in a conductive thermal regime to a depth of 2 km. The map will be used in the low-temperature geothermal resource assessment to distinguish between thermal anomalies of local and regional extent.

3. An up-to-date version of the heat-flow map of the United States was prepared. Although the gross features of the map have not changed significantly, several new regions of higher-than-normal heat flow have emerged in the eastern U.S. and many new significant details are apparent in the western U.S. There is a newly defined high associated with the southern Cascades, and the Battle Mountain high has

been extended to link up with the Brothers fault zone anomaly in southeastern Oregon. A hydrologic heat sink has been delineated in the eastern Snake River Plain, and there are some newly defined heat-flow highs associated with the margins of the Colorado Plateau.

4. The Snake River Plain study, under way for the past eight years, is coming to a conclusion. The study has resulted in a greatly increased knowledge of the geology and geothermal potential of the region. Information obtained from this study will contribute to site-specific investigations for low- and moderate-temperature reservoirs located in the Snake River Plain. The Snake River Plain shows considerable promise for the development of low- and moderate-temperature geothermal energy.

5. A 3-day conference on geothermal studies being conducted in the Cascade Range, attended by about 150 participants from universities, industry, and government agencies, was convened at Menlo Park in February 1980. The conference underscored the need for geologic mapping, detailed volcanologic and petrologic studies, geophysical studies, drill-hole information, and hydrologic studies in developing a better understanding of the geothermal potential of the Cascades.

6. Geologic mapping of Medicine Lake volcano in northeastern California was completed. It reveals a much more complex stratigraphy than previously recognized from earlier studies, and shows that the volcano is not a basaltic shield as previously thought by some investigators. The presence of significant amounts of rhyolite and dacite, the complex chemical evolution indicated by the eruptive products, and several rhyolite flows erupted within the last 1,200 years suggest that the volcano may have significant geothermal potential.

7. Several geophysical surveys undertaken in the Cascades during FY 80 have produced encouraging results in defining the geothermal potential of this major region. Five magnetotelluric profiles were completed in the California, Oregon, and Washington Cascades. In addition, 55 reconnaissance soundings were completed in Oregon and northern California. Computer modeling of the data has revealed a major electrical contact in the crust at the western high Cascades boundary. Interpretation of data from a geomagnetictelluric array traverse of the Cascade Mountains of Oregon indicates a shallow conductor associated with the high Cascades. There is some evidence that this conductor is not only associated with the high Cascades but also may be an extension of the conductive structure along the Brothers fault zone.

8. Experiments with an airborne electromagnetic (AEM) system have shown that many geothermal systems have a near-surface electrical signature which is detectable by AEM. AEM surveys in five KGRA's defined the same conductive zones mapped by surface AMT surveys, thus showing that AEM methods can be useful in exploring for and in defining geothermal systems with shallow electrical manifestation.

9. Increasingly encouraging evidence of the utility of the self-potential technique for delineating hydrothermal convective systems has been gathered during FY 80. The cause of self-potential anomalies and their correlation with parameters of a geothermal system is not yet well known, but it appears more likely now that this technique has a great deal of promise as a new exploration tool.

5.4.2 Reservoir Definition

DOE State-Coupled Program

As a supplement to the resource assessment performed by the USGS in FY 80, DOE has initiated the State-Coupled Program, under which a more detailed definition of low- and moderate-temperature resources is accomplished than is performed by the USGS in their regional surveys. The State-Coupled Program has resulted in cooperative agreements with 22 states' agencies to perform assessment activities in their respective states, as well as contracts with several institutions that provide for geothermal investigations extending over a number of states. An example would be the effort that is being undertaken by the Virginia Polytechnical Institute and State University, whereby an evaluation is being made of the geothermal potential along the Atlantic Coastal Plain from New Jersey to Georgia. These assessment activities will be phased out in FY 82.

A product of the State-Coupled Program is a resource map of the state showing the location of hot springs, wells with elevated temperatures, and in general, areas with good potential for geothermal development. To date, resource maps have been published for Arizona, Oregon, Nevada, Colorado, Idaho, New Mexico and Utah.

5.4.3 Exploratory Drilling for High-Temperature Reservoirs

Industry-Coupled Case Studies

The Industry-Coupled Case Study Program was initiated in FY 78 to accelerate the development of high-temperature reservoirs with commercial potential for electrical power generation. The decision was made in FY 79 to terminate this program in light of passage of the National Energy Act with its incentives for continued hydrothermal development. The only continuing activity under this program is a completion of the drilling operations in northern Nevada that was provided for in the FY 79 funding for the program. To date, 9 of the 14 exploratory wells have been drilled, with the remaining wells to be drilled during 1981.

5.4.4 Exploratory Drilling for Low- and Moderate-Temperature Reservoirs

User-Coupled Confirmation Drilling Program

To stimulate the development of low- and moderate-temperature hydrothermal resources for direct heat applications, the User-Coupled Confirmation Drilling Program (UCCDP) was established during FY 80. This program will share the cost of the exploration, well siting, drilling, flow testing, reservoir engineering, and, if necessary, injection well drilling to confirm the temperature and flow rate of a hydrothermal reservoir.

To implement the program, a solicitation was issued, requesting proposals that would detail a plan for siting and drilling a confirmation well that would be completed to provide hot water for a direct heat application. Response to the solicitation was very encouraging, demonstrating the widespread interest in the utilization of geothermal energy in a number of different applications. Projects selected for funding under this program will begin in early 1981.

As a precursor to the User-Coupled Confirmation Drilling Program, several reservoir confirmation drilling projects were initiated in FY 80. Two wells were drilled on Mt. Hood, Oregon, one at Old Maid Flat and one at Timberline Lodge. The 6,000-foot well at Old Maid Flat was drilled to test for a reservoir that could be used in providing hot water for district heating in Portland; while the 4,000 foot well at Timberline was exploring for a resource for use in heating the lodge. Both wells encountered zones with sufficient temperatures to meet the user's needs, but neither provided sufficient fluid flow.

Two of the projects initiated in FY 80 will not begin drilling until early 1981. An exploratory well will be drilled in collaboration with the New York State Energy Research and Development Authority at a site near Auburn, New York. Higher than normal thermal gradients have been measured in the area and there are prospects for tapping a resource that could be used by Clinton Corn Products as part of their industrial process. The second project will be undertaken at Lewes, Delaware, where a cost-shared well will explore for a resource that can be used by both the Barcroft Corporation for industrial processing, and the town of Lewes for space heating.

5.5 HYDROTHERMAL INDUSTRIALIZATION

The general objective of the goethermal industrialization program is to provide an appropriate level of Federal support to enable private industry to use high-temperature geothermal resources for electric power generation and low- to moderate-temperature resources for direct heat applications at the earliest possible date. Commercial use of hydrothermal resources is inhibited by the perception of economic and technical risk, reservoir performance uncertainties, and a variety of legal and institutional barriers. Figure 5.1 shows the different phases of hydrothermal electric development along with the entities involved and the barriers encountered in each phase. The role of the DOE geothermal industrialization program was to provide financial and other risk-reducing incentives to geothermal development, to demonstrate economical and environmentally acceptable hydrothermal resource applications, and to aid in streamlining regulatory procedures and alleviating legal constraints. The lower portion of the diagram in Figure 5.1 shows some of the important DOE/Federal industrialization activities that were conducted to remove these barriers.

Hydrothermal industrialization activities were designed to encourage exploitation of high-temperature reservoirs for electric power generation and low- to moderate-temperature reservoirs for direct heat applications. The electric power generation experience at The Geysers dry steam field in California has indicated that commercial use of dry steam reservoirs can proceed with minimal Federal support, but electric power production using the still unproven liquid-dominated hydrothermal reservoirs requires Federal support. Though electric power activities will continue in the near term, increasing program emphasis will be on exploiting the large essentially unutilized low- to moderate-temperature reservoirs for direct heat applications such as space conditioning, agricultural use, and industrial process heat. Present U.S. direct heat use is only about 0.001 quad, compared to the 1985 production potential of 0.1 quad.

DOE's hydrothermal industrialization program consisted of commercial development planning; outreach activities; construction and operation of pilot and commercial-scale electric power demonstration facilities; site-specific direct heat

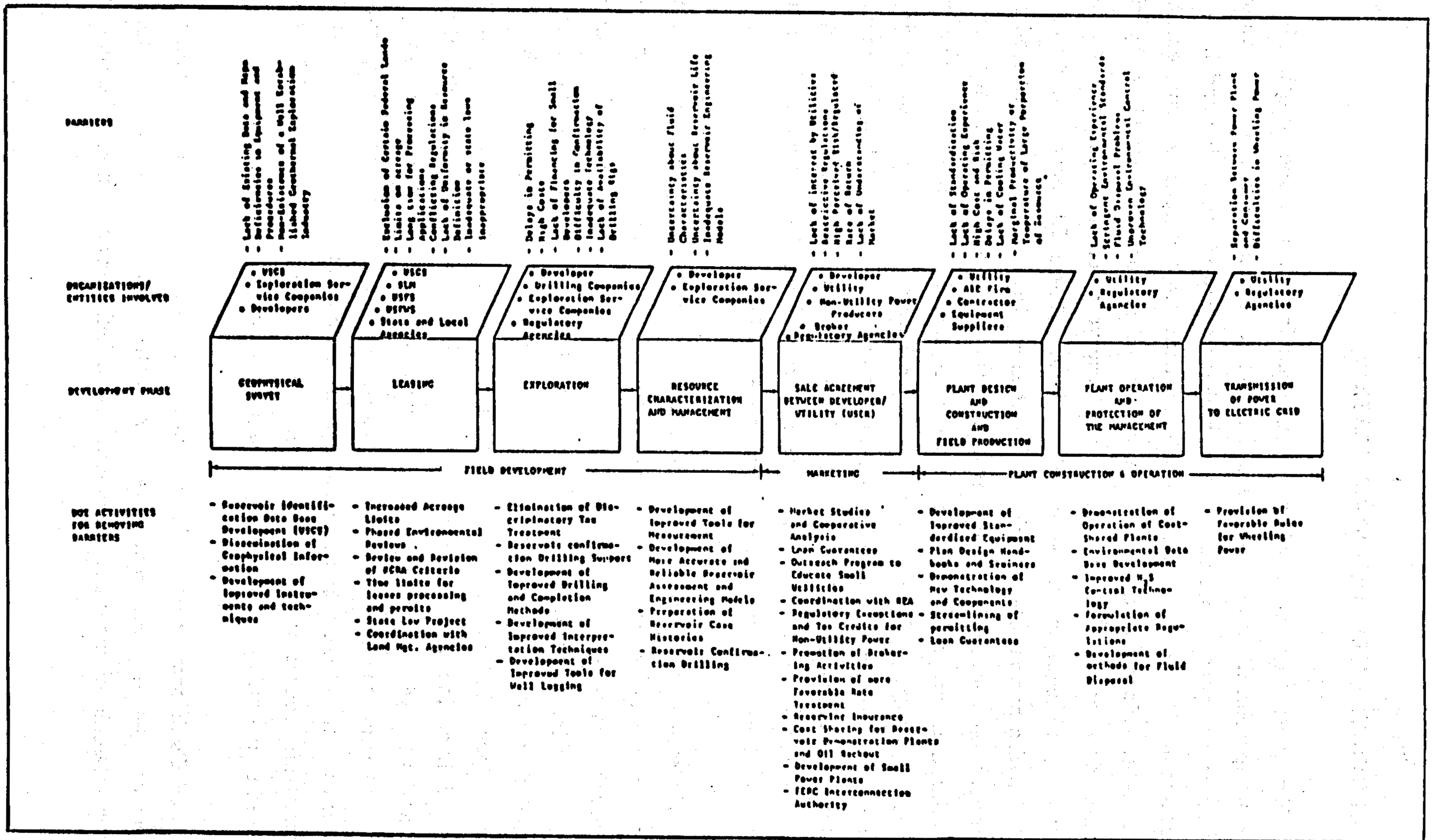


Figure 5.1. Barriers Associated with Phases of Hydrothermal Electric Development

feasibility studies and field demonstrations; geothermal loan guaranties; and legal and regulatory reform and streamlining. Financial and economic incentives for private sector development are also provided by other Federal agencies. The Departments of Commerce and Housing and Urban Development (HUD) include financing opportunities for geothermal development in their grant programs.

5.5.1 Commercial Development Planning

Energy market studies are being conducted to establish the market penetration potential of hydrothermal resources and to support development of market strategies. DOE supported state commercialization planning teams in an effort to identify specific cities and industrial plants near economically usuable reservoirs and to formulate potential schedules for development of such reservoirs. State planning activities are enhanced by the state laws governing geothermal resource classification and reservoir ownership and development.

State commercialization teams, with DOE support, were centers for geothermal action at the state level. Each team first prepares one or more reports detailing the location and potential of the geothermal resources; the types of energy demand they might meet; and the laws, regulations, and procedures for developing geothermal resources. These teams also respond to inquiries about geothermal development, trigger the assignment of geologic and engineering specialists who perform free (but limited) preliminary project analyses for would-be geothermal developers and users, refer users to sources of financial assistance and, in general, provide other invaluable information, consulting, and referral services that guide geothermal entrepreneurs through the complicated legal and institutional maze that confronts them. The commercialization teams also serve as a vital link between DOE program officials (in Washington and the field offices) and the community of developers, users, financiers, technical specialists, and regulators whose professional and business decisions, in the final analysis, must be relied on to achieve the hydrothermal resource utilization goals.

DOE is currently supporting geothermal commercialization teams in sixteen states, including Alaska, Hawaii, Idaho, Washington, Oregon, California, Arizona, Nevada, Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming, and Delaware. The Delaware state team project was initiated in FY 80.

In general, the level of consciousness of the benefits and values gained through the use of geothermal energy has been significantly advanced during the past year through the individual state commercialization team activities. The major accomplishments by several of the state teams are as follows:

Alaska

Site-specific development plans were completed for Unalaska, Tenakee Springs, Pilgrim Springs, Kotzebue and Adak. Identified electric power potential ranges from 25 to 85 MW; district heating systems could displace more than 1.5 million gallons of fuel oil each year. A state geothermal prospectus, estimating the possible pace of resource development, has been completed.

Arizona

The state commercialization team has stimulated geothermal interest among several major community developers, ten suburban and rural communities and up to a dozen agricultural groups. Most of the planned activity is nonelectric, but would conserve considerable fuel oil and natural gas. The first six geothermal applications in Arizona should be on-line within the next three years with Federal encouragement and some incentives. These applications include space heating and cooling for 5,000 housing units located outside Phoenix and Tucson; alcohol production facilities; agricultural cooperatives; and livestock processing.

California

During FY 80, the California Energy Commission (CEC), was instrumental in expediting the geothermal power plant siting process through the provisions of Assembly Bill 2644. This Bill places a one-year time limit on State Energy Commission site approval. The State also provided technical and financial support for the Heber binary demonstration plant. The CEC, in conjunction with DOE and BLM, cofunded a transmission corridor planning study for Imperial County and environmental impact studies for the Niland anomaly. They have provided funds to the GRIPS Commission and to EIA's being prepared for The Geysers area. The Energy Commission is also providing assessment of geothermal electrical and direct heat potential and estimates of resources that can be reasonably expected to be deployed. The CEC supports specific studies to evaluate economic and technical feasibility of different direct heat projects such as Rohr Industries plan to space heat their Chula Visto facility, and an alfalfa-drying plant near El Centro planned by Handlers.

Colorado

In Colorado, 58 geothermal resource areas have been inventoried. Three of these appear to have electrical power generation potential. Four site-specific development analyses have been completed, and one district heating project is in the final design phase. The projected use of geothermal energy in Colorado by the year 2000 has been estimated at 157.7×10^{12} BTU's (equivalent to 28 million barrels of oil per year).

Hawaii

During FY 80, the Hawaiian geothermal commercialization planning team engaged a consultant team to conduct research on probable geothermal development in the state. The team provided assistance to two major developers in obtaining exploratory drilling permits and assisted in the compilation of the State Geothermal Fact Book soon to be published as a public information document.

Idaho

The state commercialization team examined potential industrial development in six areas, including a potential electric power facility and five district heating systems; if constructed, these would displace an equivalent of 3 million gallons of fuel oil each year. Waste geothermal fluid disposal systems for two industrial projects (Capital Mall and Raystone Alcohol) were engineered and designed under contract. Four local assistance grants were given to counties and local governments to draft local geothermal land-use plans, preliminary designs of two district heating systems, and to identify ten exploratory drill sites.

Montana

In Montana, 73 geothermal resource areas have been identified, in which 4 sites are proven, 7 are potential sites, and 62 are inferred. Development estimates for four areas have been published and work is under way for three more areas. The projected use of geothermal energy that may be economically feasible in Montana by the year 2000 is 43.4×10^{12} BTU's (equivalent to 7.7 million barrels of oil per year).

Nevada

The Nevada state commercialization team provided administrative and planning assistance to the following private developments which went on-line during the period: 50 new residences heated with geothermal fluid; greenhouses; a trailer park; a hospital; a church; a hotel casino; and an ethanol production facility. Additional BTU's generated in 1980 totalled 241.15×10^9 to increase the total now generated in Nevada to 502.90×10^9 BTU's (equivalent to 90,000 barrels of oil per year).

New Mexico

In New Mexico, 47 geothermal resource areas have been identified, 15 of which are considered to have electrical power generation potential. New Mexico has a fortunate geologic coincidence of major geothermal resources and the state's major population centers. Two area development plans have been completed and work is under way in five other areas. Two geothermal direct heat projects have been completed and put into operation during the past year. The projected use of geothermal energy in New Mexico by the year 2000 is 66.5×10^{12} BTU's (equivalent to 11.8 million barrels of oil per year).

North Dakota

The Madison Formation underlying the largest part of the state of North Dakota has considerable potential for industrial, commercial and residential space heating. Subsurface temperatures of 155°F to 205°F are not considered high enough for electrical power generation. One Area Development plan has been published, and two additional reports are being prepared, one Site-Specific Development Analyses for a housing project for the elderly in Bismarck has been completed, and two additional promising areas identified. The projected use of geothermal energy in North Dakota by the year 2000 has been identified as 40.7×10^{12} BTU's (equivalent to 7.2 million barrels of oil per year).

Oregon

The efforts of the Oregon Geothermal Commercialization and the Oregon Institute of Technology Operations Research Planning Programs have significantly increased public awareness of geothermal energy and its applicability. In addition to numerous presentations and a state geothermal conference, technical data have been made available in development guidebooks, information kits, Forest Service geothermal leasing status maps, resource maps to be published by NOAA, and state geologic maps. The most important work in the institutional area has been the development of the Geothermal Task Force Report as a basis for the Governor's Alternate Energy Development Commission and Special Energy Package for the 1981 Oregon legislative session. The recommendations include a variety of institutional reforms and financial incentives to encourage development in all sectors, strong policy support for geothermal development, and a $1.5 million exploration fund. A geothermal model ordinance for Klamath Falls was developed with funding from this program. District heating feasibility studies were completed for Oakridge and Lakeview; exploration drilling followed in both cases.

Utah

In Utah, 50 geothermal resource sites have been identified, one of which has proven electrical power generation capability and at which a 20 MW demonstration plant is planned by industry. A total of nine area development plans have been initiated. Three demonstration projects are currently under active construction, and six additional candidate sites for Specific Development Analyses have been identified. The potential MX missile system could drastically affect current population and industrial projections within the states. The projected use of geothermal energy in Utah by the year 2000 is 111.2 x 10^{12} BTU's (equivalent to 19.8 million barrels of oil per year).

Washington

The geothermal commercialization program in Washington State was extremely successful during its first year. Major accomplishments include: (1) the development of projects in Ephrata North Bonneville, Yakima and Olympic National Park, which could ultimately result in an energy savings of 21.9 x 10^{12} BTU's/year; (2) the development of the State Geothermal Plan, which was completed with assistance from the State Interagency Geothermal Development Council and the industry-based Technical Advisory Committee; (3) the organization of two symposia; and (4) a successful challenge to the U.S. Forest Service leasing policy in the Gifford Pinchot National Forest, which has resulted in the reinstatement of all lease applications for reevaluation.

Wyoming

In Wyoming, 29 geothermal resource areas have been identified as potential low-temperature, direct-use prospects for agriculture, industrial processing or district heating projects. Three Area Development Plans are being completed, and 9 additional sites have been identified as candidates for Site-Specific Development Analyses. The State Commercialization Team has initiated a toll-free "Energy Hotline" on which citizens may call for geothermal information, and a monthly newsletter is being published. The projected use of geothermal energy in Wyoming by the year 2000 is 34.2×10^{12} BTU's (equivalent to 6.1 million barrels of oil per year).

National Conference of State Legislatures

Lack of state laws that clearly define geothermal energy, establish its ownership, and provide for access to it, constitutes a major barrier to industrial development. Under contract to DOE, the National Conference of State Legislatures (NCSL) offers research and legal assistance of state legislatures so that they can modify their geothermal laws to better accommodate and control the production and use of geothermal energy in their states. There are currently 14 state legislatures with which NCSL is actively involved. During FY 80, NCSL held or participated in 41 state legislative workshops/committee meetings, and prepared 30 policy letter reports which have led to the consideration of a total of 58 geothermal bills by 12 of the 14 states. Major legislation was passed in Alaska, Washington, and Delaware. The majority of the pending geothermal bills will be reintroduced in the FY 81 state legislature sessions.

5.5.2 Outreach Activities

Outreach activities in FY 80 and FY 81 were designed (1) to increase the general level of public and private understanding, interest, and enthusiasm for using geothermal energy as an alternative to imported or depletable domestic sources; (2) to stimulate interest in geothermal resource development by informing potential users and their support groups of the costs, benefits, reliability, and enrivonmental effects of geothermal systems; and (3) to encourage commitment to hydrothermal energy use within the private sector by providing technical assistance to developers and users. When appropriate, Federal, state and local government entities will facilitate agreements and users commitments for commercial developments.

A series of outreach materials based on drilling, financing, resource definition, market, R&D data, gathered from a national network of sources, has been prepared and disseminated, as appropriate, to the general public, to targeted audiences of potential end-users and to decision-makers in government and industry. These materials included information sheets, articles, brochures, maps, direct mailings, conference reports, and audio-visual materials. In addition, technical consultation has been made available on a limited scale to potential industry, community, and utility end-users through regional technical assistance centers. Potential users (private, public, or corporate entities) may obtain up to 100 hours of technical consultation without cost at three research institutes under contract to DOE. The technical assistance may involve an assessment of geothermal reservoirs, a brief study of the technical or economic feasibility of a proposed project, or a review of a proposed system design. A fourth research institute, the University of Utah Research Institute, provides assistance in defining and characterizing geothermal reservoirs. The institutions offering assistance during this report period, and the geographic areas served by them are as follows:

Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, OR
States: AZ, NV, CA, OR, WA, AL, HI

Applied Physics Laboratory
Johns Hopkins University
Laurel, MD
States: All states not listed previously

Idaho National Engineering Lab.
Idaho Falls, ID
States: MT, SD, ND, WY, UT, CO, NM, ID

Earth Sciences Laboratory
University of Utah Research Institute
Salt Lake City, UT

Demand for limited geothermal resource evaluation, planning assistance, utilization consultation has increased dramatically during the year reflecting the effects of increased public and corporate interest in geothermal energy as a realistic and economical energy alternative.

The ultimate goal of the outreach effort was to encourage serious consideration of the geothermal alternative by prospective users and business and community leaders. This involves working with trade associations and professional societies, and helping communities to take advantage of various Federal programs applicable to geothermal development. Such brokering activity is increasing, and public and private entities other than DOE are becoming interested in funding geothermal experiments. In particular, two geothermal projects will be funded under the HUD Innovative Grant Program in FY 81; one will be a joint effort with FmHA. In addition, a number of Community Assistance Teams will be funded by DOE in FY 81 to assist municipalities in evaluating the geothermal option for district heating and cooling systems.

5.5.3 Electric Power Applications

The purpose of DOE-sponsored demonstration and pilot facilities is to facilitate non-Federal development of liquid-dominated hydrothermal resources for generating electric power by (1) demonstrating the technical and economic feasibility and environmental acceptability of geothermal systems, (2) providing "hands-on" operating experience for industry, and (3) fostering growth of an industrial infrastructure necessary for wide-scale use of geothermal systems.

DOE supports design, construction, and operation of pilot and commercial scale electric power plants. These facilities generate technical and economic operating data and provide information on environmental impacts of geothermal electric power generation. As part of the electric power applications planning effort, DOE gathered data to identify the 5 highest-priority sites among the 53 known sites in order to provide immediate assistance to those areas with the greatest potential for near-term resource development.

Some projects were cost-shared with industry, while others were wholly DOE-supported. Facilities under development include a 50 MWe commercial-scale flash demonstration power plant at the Valles Caldera, New Mexico; a 5 megawatt binary cycle pilot plant in the Raft River area of Idaho; and a 3 MWe wellhead generator near the rift zone of an active volcano in Puna, Hawaii.

Demonstration Projects

DOE builds and tests facilities to demonstrate that the use of hydrothermal resources is technically feasible, economically sound, and environmentally acceptable. Demonstration will show that the use of geothermal fluids is feasible, provides vital engineering and economic data, and fosters the business infrastructure necessary for the private sector to continue Federal initiatives.

The specific objectives of the demonstration project are:

- To operate by the end of FY 82 a commercial-scale flash-steam electric plant capable of generating electricity from a superheated water hydrothermal resource.

- To demonstrate by 1985 that the environmental effects of the construction and operation of electric plants are acceptable.

- To demonstrate by 1985 the production of electric power from hot water resources at a commercially competitive cost.

- To demonstrate at Federal facilities the technical feasibility of selected electric and nonelectric applications.

The following hydrothermal experimental facilities are under construction or are being planned:

Raft River Facility

A pilot plant now being built has a 5 MWe turbine generator with a binary Rankine power cycle, and will use energy from a moderate-temperature hydrothermal resource (150°C) to generate electricity for a utility power grid. The objectives of the project are to compare costs and methods of geothermal power generation to those of conventional systems; to verify cost assumptions; and to supply valuable information on the geothermal reservoir, plant equipment, and plant operations for use in planning future generation systems. Work on the current construction contract is complete. The system is being checked out and additional wells tests are to be undertaken. This plant is expected to be operational in FY 81.

50 MWe Flash-Steam Demonstration Plant (Baca)

In FY 77, Congress authorized DOE to carry out a geothermal demonstration project using a hot water hydrothermal resource. The project entails construction and operation of a commercial-scale (50 MWe gross output) electric power plant. The plant will also serve as a "pathfinder" for the regulatory process and other legal and institutional aspects of geothermal development. A cooperative agreement between DOE, Union Geothermal of New Mexico, and Public Service Company of New Mexico was signed in August 1979. The final EIS was released in January 1980. Plant design is under way for the single-stage, flash-steam plant at Baca Ranch, New Mexico, and orders for a turbine and other long-lead procurements have been placed. Well drilling and flow testing have been initiated. Plant construction has been delayed pending successful completion of hearings being conducted by the New Mexico Public Service Commission. The plant is scheduled to be operational by 1982.

HGP-A Geothermal Wellhead Generator

This project will evaluate the feasibility of using a wellhead generator to produce baseload electrical power. The generator will use the geothermal fluid from geothermal well HGP-A in the rift zone of an active volcano in the Puna District of Hawaii. The major power plant components will be mounted in such a way that they can be moved to other sites at some future date. The project is expected to lead to commercial applications of wellhead generators in remote areas of the western continental United States and Hawaii.

Construction of this facility is progressing and major equipment including the turbine generator will arrive at the site in the first quarter of FY 81. The geothermal well, which required recementing, was flow tested during FY 80. Plant construction is well under way, and the plant is scheduled to be operational in the third quarter of FY 81.

Geothermal Loop Experimental Facility (GLEF)

Located near Niland, California, the GLEF has established the feasibility of using flash-steam binary systems for electric power production from high-temperature, high-salinity resources. The project was cost-shared with the San Diego Gas and Electric Company. The facility was decommissioned in FY 80.

Recently developed preinjection treatments had effectively eliminated injection clogging problems. Additionally, problems of scaling and corrosion had been addressed and solved. Facility testing was completed in FY 79. The data derived from the facility have prompted Magma Power Company to agree to construct and operate a 28 MWe gross plant on the site by late 1984, followed by future 50 MWe plants.

Geothermal Component Test Facility (GCTF)

The facility constructed in 1975 provides moderate-temperature, moderate-to-low-salinity geothermal fluid and supporting services to experimenters for testing of equipment and components used in advanced geothermal systems. Located at East Mesa, California, the GCTF is currently being used by several DOE-sponsored and independent experimenters; it will be operational until demand for its use diminishes. Both Federally and commercially developed components are being tested.

5.5.4 Direct Heat Applications

Use of geothermal energy for nonelectric proposes by the private sector within the United States has been quite small, yet, there is a large potential market for thermal energy in the temperature range 50° to 150°C utilized in such industry sectors as industrial processing (papermills, sugar refineries and other chemical and food processing plants), agribusiness (space, soil, and water heating in applications such as greenhouses, fish farming, and animal husbandry), and space/water heating of commercial (downtown business districts, shopping centers, schools, and hospitals) and residential buildings.

Detailed studies of the economics of direct heat applications have been sponsored by DOE to match the energy needs of prospective users with specific low-to-moderate-temperature hydrothermal reservoirs. To date, 42 technical and economic feasibility studies have been supported by DOE. Thirty-four of these studies have been completed; eleven in FY 80 (See Table 5.9). A competitive solicitation covering cost-shared industrial applications feasibility assessments, issued near the end of FY 80, led to the support of the following eight new studies for which work will begin in FY 81:

Project	Location
Alcohol Plant	Vale, OR
Ethanol Plant	San Luis Valley, CO
Ethanol Plant	East Mesa, CA
Ethanol Plant, Mushroom Growing Facility & Cannery	Fernly, NV
Zinc Processing Facility	Salida, CO
Barley Malting Facility	Pocatello, ID
Cottage Cheese Processing	Friendship, NY
Waste Water Treatment	San Bernardino, CA

The lack of experienced personnel and working relationships between nonelectric users and energy suppliers as well as absence of service industry infrastructure are inhibiting the commercial adoption of geothermal energy. Technical uncertainties and associated economic risks can influence users' perception of profitability to the point of limiting private investment in geothermal direct heat applications. Demonstration-type projects (field experiments) have been sponsored by DOE to (1) provide visible evidence to the profitability of various direct heat applications in a number of geographical regions and (2) obtain reliable, objective, definitive technical/economic data under field operating conditions that will facilitate decisions on the utilization of low-to-moderate-temperature hydrothermal energy.

Twenty-four cost-shared direct-heat demonstration projects (see Table 5.10) are now under way. The majority of these field experiments are for space and district heating applications, while four are directed toward agribusiness, and three

Table 5.9

COMPLETED TECHNICAL AND ECONOMIC FEASIBILITY STUDIES

PROJECT	LOCATION	COMPLETED IN FY 80
District and Institutional Heating		
Mini Core District System Municipal Waste Treatment	Glenwood Springs, CO	*
Community District System	Lakeview, OR	*
District System for 1,000 Planned Homes, Fort Peck Indian Reservation	Poplar, MT	*
University of New Mexico Campus System	Albuquerque, NM	*
District Heating	Mammoth Lakes, CA	
District Heating with Possible Augmentation	Susanville, CA	
Six Rural Alaskan Towns	AK	
District Heating for Baca Grand Community Development Project	Alamosa, CO	
Space Heating for Edgemont School Complex	Edgemont, SD	
District Heating and Cooling System Including Industrial Park	El Centro, CA	
Space Heating	Midland and Philip, SD	
Space Heating and Agribusiness	City of Desert Hot Springs, CA	
District Heating	Boise City, ID	
Agribusiness		
Salmon Aquaculture	Alaska	

Table 5.9 (Cont.)

Livestock Controlled Environment	Susanville, CA	
Agribusiness	Lake, Napa, and Sonoma Counties, CA	
Greenhouse Corps, Mushroom Culture, Fish Farming, and Biigos Generation	Lake County, CA	
Vertically Integrated Livestock, Meat and Feed Processing Facility	Mountain Home, ID	
Integrated Feed Lot and Farming Operation Producing Methane from Animal Waste	Vale, OR	*
Control Livestock Production System	CA and NV	
<u>Industrial Process Heat</u>		
Sugar Cane Processing	Puna, HI	
Industrial Park	Pahoa, HI	*
Wetcorn Milling Plant	East Mesa, CA	*
Hosiery Factory	Las Cruces, NM	*
Frozen Food Plant	Salisbury, MD	*
Sugar Beet and Barley Processing	San Luis Valley, CO	
Food Processing Using Geopressured/Geothermal Resource	Louisiana Geopressured Resources	
Holly Beet Sugar Refinery	Imperial Valley, CA	
Fertilizer Production, Valley Nitrogen	Heber KGRA Near El Centro, CA	
Potato Processing, Onion Dehydration, Alfalfa Drying, Greenhouses, and Sugar Refinery Feasibility	Klamath and Snake River Basin, OR	

Table 5.9 (Cont.)

Refrigeration for Food Processing Including Freeze Drying and Meat Packing	Raft River, ID; Weiser-Crane Creek, ID; Vale, OR; Coso Hot Springs, CA; and Imperial Valley, CA
Industrial Complexes, Including Forest Products, Caustic/Chlorine, and Corn Products	Calistoga, CA; Brawley, CA; Surprise Valley, CA; Lakeview, OR; Vale, OR; Brumeau Granview, ID; Steamboat Springs, NV; Core/Ft. Sulphurdale, UT
Ethanol Production for Automotive Fuel Use	Raft River, ID *
Alfalfa Dehydration Plant	El Centro, CA
Evaluation/Crystallization Industry, Including Tomato Paste Processing, Sugar Beet Refining, and Sodium Chloride Production	Not Site-Specific
Tungstan Ore Mining & Processing	Mona Lake, CA

Table 5.10

DIRECT HEAT APPLICATION DEMONSTRATION PROJECTS

State	Operator & Location	Type of Use	Operation First Year	BTU/Yr (Billions)	Project Dev. Phase in FY 80
CA	City of Susanville Susanville, CA	SP	1982	41.0	Reservoir Confirmation
CA	City of El Centro El Centro, CA	SP	1982	7.0	Reservoir Confirmation & Design
CA	Geothermal Power Corp. Kelley Hot Springs, CA	AG	1982	81.9	Environmental Assessment
CA	Aquafarms International Mecca, CA	AG	1981	171.0	Construction
CA	Holy Sugar, Inc. Brawley, CA	IND	1982	144.0	Reservoir Confirmation & Design
CO	Town of Pagosa Springs Pagosa Springs, CO	DH	1982	14.0	Construction
ID	City of Boise Boise, ID	DH	1981	95.0	Environmental Assessment & Design
ID	Ore-Ida Foods Boise, ID	IND	-	-	Project Terminated
ID	Rogers Food, Inc. & Madison County Madison County, ID	SP&IND	-	-	Under Review
MT	Warm Spring State Hosp. Butler, MT	SP	-	6.4	Under Review
NV	Hydro Energy Corp. Reno, NV	SP	1981	0.1	Reservoir Confirmation & Design
NV	Elko Heating Co. Elko, NV	SP	1982	42.0	Reservoir Confirmation & Design
OR	City of Klamath Falls, OR Klamath Falls, OR	DH	1981	35.4	Construction

Table 5.10 (Cont.)

OR	Klamath City YMCA Klamath Falls, OR	SP	1980	5.0	Operational
SD	Kaakon & Philips Schools Kaakon, SD	SP	1980	5.2	Operational
SD	St Mary's Hospital Pierre, SD	SP	1980	8.4	Operational
SD	Diamond Ring Ranch Midland, SD	AG	1980	5.5	Operational
TX	Torbett-Hutchings-Smith Hospital Marlin, TX	SP	1981	0.1	Construction
TX	Navarro College Corsicana, TX	SP	1981	0.1	Reservoir Confirmation
UT	City of Monroe Monroe, UT	DH	-	-	Under Review
UT	Utah State Prison Salt Lake City, UT	SP	1981	21.0	Reservoir Confirmation
UT	Utah Roses, Inc. Salt Lake City, UT	AG	1981	97.0	Reservoir Confirmation

SP - Space Heating and/or Cooling

DH - District Heating

AG - Agribusiness

IND - Process Heat

involve industrial processing. Each project will go through five phases: environmental assessment; reservoir confirmation; system design; construction and installation or retrofit; and operation. Ten of these projects are in the reservoir confirmation phase, and five field experiments currently involve construction and installation. The following five projects are in operation:

Haakon, SD - space conditioning for five school buildings
Pierre, SD - space conditioning for a hospital
Klamath Falls, OR - space conditioning and hot water for YMCA
Midland, SD - agricultural uses on ranch
Truth or Consequences, NM - space conditioning for a hospital

Of the remaining three projects, one encountered a nonproducing well and the other two are being reevaluated for possible redirection because the fluids of the geothermal reservoir were found to be of lower temperature than that required for the intended use. It is anticipated that a total of seven projects will be operational by the end of FY 81, and 12 additional projects will begin operating during FY 82. A brief description of each direct heat field demonstration project and the development phase for each project at the end of FY 80 are presented in Appendix D. The DOE direct heat field experiments initiative is expected to lead to the spread of industrial involvement and the building of geothermal direct use industry infrastructure in the western states. Greater emphasis will be placed on locating future demonstration sites in the East as suitable resources are defined.

5.5.5 Geothermal Loan Guaranty Program

The Geothermal Loan Guaranty Program (GLGP) was established in 1974 under the provisions of PL 93-410. The objective of the program is to assist the private sector in accelerating commercial development and use of geothermal energy by minimizing the financial risks associated with new technology and reservoir uncertainties. Geothermal loan guaranties are provided through the Geothermal Resources Development Fund. The guaranteed loans help reduce a lender's financial risk in making credit available for construction and operation of geothermal facilities, R&D projects, and field exploration. Total value of loan guaranties to an individual borrower is limited so that other borrowers and lenders have access to the guaranty. Guaranties are provided for both electric and nonelectric projects.

The program presently has guaranteed parts of six loans, including one refinancing now totalling $136.0 million for projects totalling $202.7 million in cost. Four projects will provide an added 258 MWe (gross) to current electricity production, and the other project will provide 117 billion BTU/year for food processing (dehydration of onions, celery). Applications are now pending for loan guaranties totalling $248.5 million for projects totalling $330.5 million in cost. However, no additional guarantees will be issued after the latter part of FY 81 as the GLGP is being phased out.

In FY 80, two projects were approved for loan guaranties of $94.4 million bringing the total portfolio of guaranteed loans to date to $136.0 million:

- CU-I Venture received a geothermal guaranty on a loan of $49.4 million from the Bank of Montreal (California) for further exploration and field development at South Brawley, California. Preliminary field testing results are optimistic for meeting or exceeding a 4 MWe (net) productivity goal per well to support the 45 MWe power plant.

- Northern California Power Corporation #2 (NCPC #2) received approval for a geothermal guaranty of a $45 million loan from the Bank of Montreal (California) for the purpose of constructing a 110 MWe power plant in The Geysers, California. Shell Oil Company has developed the field and has dedicated sufficient acreage to operate the plant by means of a steam sales agreement between it and NCPC #2. NCPC #2 is owned and operated by Northern California Power Agency, a joint power municipal agency consortium of 11 northern California municipalities and one rural electric cooperative, which will have 8 of its members purchase the power resulting from the project.

During the year the Program made extensive use of the MITRE cash flow model for analysis of electric power proposals and applications. The model, which has undergone intensive study and refinement, is capable of taking technical, cost, resource, and financial data and estimating project cash flows and revenue forecasts. Conversely, expected marketing conditions can be programmed into the model to determine the technical criteria for success. Several utilities have availed themselves of this model in assessing potential geothermal projects and have been very enthusiastic about the quality of the analysis.

The Energy Security Act of 1980 (PL 96-294) contains a number of major provisions for geothermal energy, including modification of the Geothermal Loan Guaranty Program. The Act extends the life of the GLGP from 1984 to 1990 and provides an increased level of assistance under the program. Loans to municipalities and public cooperatives will be increased from 75% to 90% of project costs. The Act also includes provisions to expedite processing of loan guaranties; such reforms include a four-month deadline for processing applications, requirements to give faster consideration to applicants for nonelectric projects, and elimination of requirements for duplicative Environmental Impact Statements under NEPA for loan guaranty applications.

Tables 5.11 through 5.13 summarize the status of all loan guaranty applications.

5.5.6 Financial Assistance Programs

The purpose of grants and loans provided by Commerce's Economic Development Administration (DOC/EDA) is to stimulate economic development in depressed areas. EDA encourages use of geothermal energy by giving special consideration to applications for projects using geothermal.

Under the Public Works and Development Facilities Program, DOC awards project grants of up to 80% of project costs to assist in construction of facilities needed for long-term economic growth. The Business Development Assistance Program provides direct or guaranteed/insured loans for businesses to expand or establish plants in geographically depressed areas.

HUD awards grants for the purpose of alleviating urban blight and expanding economic opportunities in blighted communities. HUD ecnourages

Table 5.11

SUMMARY: GEOTHERMAL LOAN GUARANTY APPLICATIONS*

Category	Number	Amount ($M)
I. Applications Received		
A. Approved	5	$136
B. Under Evaluation	3	$58
II. Applications Currently Being Prepared or Pending Acceptance	15	$556 (Estimated)
TOTAL	23	$750 (Estimated)

*Figures are current as of September 1980.

Table 5.12

SUMMARY OF GEOTHERMAL LOAN GUARANTIES MADE TO DATE

Borrower	Lender	Guaranty	Project	Location	Results
Republic Geothermal, Inc.	Bank of America	$9,017,000	Resource exploration and testing	East Mesa, California	Drilled 4 reinjection and 7 production wells
Westmorland Geothermal Associates	Bank of America	$29,100,000	Resource exploration, testing, and full field development	Westmorland Imperial County, California	Guaranty awarded: exploration beginning. Additional funding may be required
Geothermal Food Processors, Inc.	Georgia State State Teachers Retirement Systems	$3,500,000	Process heat to dry agriculture products	Brady Hot Springs, Nevada	Plant operational and running at 88-100% of capacity. Additional drying contracts received
CU-I	Bank of Montreal (California)	$49,400,000	Resource exploration testing and full field development	Brawley, Imperial County, California	One production well drilled to 14,000 feet, high temperature and salinity. Full flow testing commenced. Preliminary results indicate 4+MWe (net) per well
Northern California Power Corporation #2	Bank of Montreal California	$45,000,000	Construction of 110 MWe Power Plant	Geyers, California	Guaranty to close on 10/6/80

Table 5.13

LOAN GUARANTY PROJECTS UNDER EVALUATION

Project	Type	Cost ($M)	Guaranty
1. California Energy Corporation, Coso Hot Springs, CA	Field Development	$ 32	$ 24
2. Rorabough--The Geysers	Field Development	$ 39	$ 29
3. Oregon Trail Mushrooms Vale, OR	Mushroom Plant	$ 6.2	$ 4.7
	TOTALS	$ 77.2	$ 57.7

projects using geothermal energy; such projects may qualify for assistance if other conditions are met.

The Urban Development Action Grant (UDAG) Program provides grants to distressed cities and urban countries to attract private investment which will create employment and strengthen the tax base. Private investment in housing, commercial or industrial real estate projects must be at least 2.5 times the Federal grant. Community development block grants (CDBG) are awarded to local governments for a wide variety of community development activities. Innovative Grant Competition funds will be awarded to energy conservation or alternative fuels/resources projects which help low- and moderate-income areas or small businesses. Areawide and community planning may be funded under the Section 701 Comprehensive Planning Program and may include planning for geothermal use.

The Internal Revenue Service (IRS) is responsible for promulgating regulations under the Crude Oil Windfall Profits Tax Act of 1979 and the Energy Tax Act of 1978. Economic incentives to geothermal development provided by Federal law are (1) an option to deduct intangible drilling costs of geothermal wells, (2) a depletion allowance for income from geothermal reservoirs, (3) a 15 percent business investment tax credit (in addition to the normal 10 percent investment credit) for expenditures on geothermal property, and (4) a residential tax credit for expenditures on geothermal property (maximum $4,000 on expenditures of $10,000). Regulations for administering the residential tax credit were proposed in 1979, but final ruling was postponed pending action on tax provisions of the recently enacted Windfall Profits Tax Act. Business tax credit regulations are being written. Because the intent of legislation for intangible drilling cost deductions and the depletion allowance was to give equal treatment to geothermal energy sources and oil and gas under tax law the IRS intends to deal with geothermal development under existing oil and gas regulations.

The Financial/Grants Task Force of the IGCC was established to determine what Federal funding programs may be applicable to geothermal development projects. The Task Force reviewed programs within the Department of Housing and Urban Development (HUD), the Economic Development Administration (EDA) within the Commerce Department, the Rural Electrification Administration (REA), and the Farmers Home Administration (FmHA), both within the Department of Agriculture. These funding programs are detailed below.

Department of Housing and Urban Development

(1) Community Development Block Grants

- $3.9 billion in FY 80.
- Grants to local governments.
- For public works, community development, economic development.
- 75% is distributed by formula to large urban areas.
- 25% is available for specific projects in small cities (fewer than 50,000 population) on a competitive basis.
- Geothermal projects are definitely eligible under the latter category, and probably so under the former.

(2) Urban Development Action Grants

- Grants to cities and urban counties (severely distressed).
- $675 million estimated for FY 80.
- Competitive awards for a wide variety of projects and activities.
- Private capital of at least 2.5 times the award amount is required.

(3) Housing Construction and Rehabilitation

- A broad variety of programs.
- $26 billion planned for FY 81.

- Grants for district heating feasibility studies are under consideration.

- Projects involving alternative fuels and energy conservation in housing construction are encouraged.

- Projects that involve geothermal energy are eligible.

Economic Development Administration

- Budget of $228.5 million in FY 80.

- Grants, loans, loan guaranties for public works projects, business development, planning, technical assistance, and economic adjustment.

- States, communities, and businesses are eligible for different categories of assistance.

- Projects involving geothermal energy apparently would be eligible for assistance under many of these categories, but would have to be in areas designated by EDA as eligible. About 85% of the land area of the United States and its territories is so designated.

Rural Electrification Administration

- Loans and loan guaranties for electric power generation and distribution facilities in rural areas.

- In FY 80, REA will provide about $800 million in loans and will guaranty loans of about $5 billion.

- Electric power cooperatives, public power districts, and other public bodies are the beneficiaries of these loans and guaranties.

- Geothermal projects to provide electric power in rural areas presumably would be eligible for assistance, provided REA is able to make a finding that the project is using proven technology.

Farmers Home Administration

- Grants, loan guaranties, and loans are allocated for Community Programs, Business and Industrial Programs, Single Family Housing Programs, Multiple Family Housing Programs, and Farmers Programs.

- The FY 80 budget for these programs is about $8 billion.

- Funds are allocated by program category, by state, and by formula (population and income). Financial need is a criterion for distribution within states.

- States, counties, municipalities, public organizations, housing developers and individuals are eligible for assistance under different parts of these programs.

- Projects that involve development and utilization of geothermal resources could be eligible under many of these FmHA programs, depending on whether FmHA is able to make a determination that the projects are technically feasible.

5.6 FEDERAL USE OF GEOTHERMAL ENERGY

The Department of Defense is under the same mandates as the rest of the Federal sector to conserve energy and switch to alternate fuels. The direct use of geothermal energy as well as the use of geothermally generated electricity are significant factors in achieving the mandated goals.

Several direct use projects are either in the planning or initiation stage and one at the Naval Station, Keflavik, Iceland, is being constructed. There the entire Navy base is being converted to geothermal heating.

At the China Lake Naval Weapons Center, Coso, California, the Navy is using a private entrepreneur to explore the resource, develop the field, construct an electric power plant, and operate it at no cost to the Navy. The Navy has agreed to buy all power produced from the plant. Through this effort a previously untapped resource will be used and, if successful, should attract more developers to the remainder of the Coso resource when it is offered for development.

DOE is attempting to help other agencies identify buildings and facilities that could use geothermal energy for heating and cooling. Primary emphasis has been on DOD, but contacts have also been established with the U.S. Postal Service and other Federal agencies.

5.6.1 Adak Naval Station, Adak, Alaska

The Adak Geothermal Project is considering three different types of geothermal energy systems, each based on an assumed reservoir temperature range:

- Space heating, using either above-ground insulated fiber-glass pipelines or in-ground insulated steel pipelines.
- Flash steam electrical power generation, using geothermal fluids either at a central power plant or via individual wellhead generating units, either system producing a 25 MWe gross output.
- A binary geothermal electrical power plant, where the geothermal fluids would heat a secondary (binary) fluid to operate the electrical generating equipment, producing a 25 MWe gross output.

Of the systems analyzed, the most attractive are the wellhead generating units, which have been tested at temperature ranges as low as 160°C. Equipment can be fabricated in the lower 48 states, thus eliminating much of the cost of installation and construction at Adak. A wellhead unit system has the best payback period of all the systems and could be operational within 5 years from the date the reservoir is defined.

The primary question remaining is, which system can the geothermal resource of Adak support? This question can only be answered by drilling the initial production-size wells to test the reservoir characteristics. The estimated cost for drilling the first production hole at Adak is $8.5 million, due to the high cost of drilling rig mobilization. This high cost makes the whole project unattractive until fuel costs increase significantly. If that increase occurs, the project will be reevaluated.

5.6.2 China Lake Naval Weapons Center (NWC), Coso, California

Based on geological surveys by the USGS, China Lake personnel, and others, the Coso area of China Lake NWC was designated a Known Geothermal Resource Area (KGRA) with an estimated resource potential ranging up to 650 MWe. About 90% of the high-grade resource lies within NWC boundaries; however, some of the area are fee-owned lands. The Navy has two objectives--to protect its military mission capability, and to develop the resource. Accordingly, the decision has been made that the Navy will develop fee-owned lands for its own use while allowing the Bureau of Land Management to lease the remainder of the resource, subject to appropriate constraints. The Navy has hired a private contractor to further explore, develop the field, build a power plant, and own and operate it at the contractor's expense. Under this plan, the Navy will retain ownership of the resource and the electricity generated by the resource. The contractor will be paid for the electricity produced. The Navy filed a draft environmental impact statement for this undertaking in November 1978 and has completed the contractual package.

Initially, the minimum amount of power the Navy will accept will be the entire requirement of the Weapons Center. After this requirement has been satisfied, the contractor may pick up additional loads, up to a maximum of 75 MW. Development beyond 75 MW will be at the option of the Navy.

A contract was awarded for this effort in December 1979. The contractor has completed initial geologic investigations and is now preparing site-specific environmental documentation for the initial field development wells. A minimum of three wells should be completed during FY 81. If successful, power should be on-line by 1984.

5.6.3 Fallon Naval Air Station, Fallon, Nevada

For Fallon, USGS studies give a reasonable assurance of a good geothermal resource potential; indeed, some geothermal applications have already been implemented in the immediate area of this base.

The Navy is now conducting heat flow studies to determine the extent of the resource on U.S. lands. During FY 80 the resource analysis was completed. Current indications are that a geothermal project is definitely feasible and that geothermal electric power production is likely. During FY 81 the Navy will be preparing environmental documentation and contracting for resource development.

5.6.4 Hill Air Force Base, Utah

In a joint project between the Department of Energy and the Department of Defense, the availability of geothermal resources at Hill AFB was investigated. The project was divided into two phases. Phase I was to identify and initiate use of the geothermal resource. Phase II, predicated on the success of Phase I, would have expanded the application to other areas of the Base. In Phase I, DOE took responsibility for surface exploration and geological interpretations.

Two holes were drilled to test geologic structures, one to a depth of about 2,000 feet and the other about 3,000 feet. The scientific team from the University of Utah that performed the initial geological, geochemical, and geophysical studies at the Base also managed the test hole drilling. Interpretation of the results from these test hole wells indicated that the resource temperature was not sufficient for other than heat pump applications. The undertaking was terminated.

5.6.5 Keflavik Naval Station, Iceland

Geothermal resources have been used to heat Iceland's capital city, Reykjavik, for 50 years. The United States is committed by a 1974 Memorandum of Understanding to join with the Icelanders in developing geothermal heat sources.

Sudurnes Regional Heating Corporation (SRHC), a local entity, is developing geothermal wells and distribution lines to towns near Keflavik. Distribution lines now connect the Svartsengi plant area with towns on the Reykjanes peninsula; connection of Icelandic buildings is well advanced. However, the hookup of U.S. facilities of geothermal heat has been minor to date.

In FY 80, a military construction project started conversion to geothermal energy by providing connection charges to SRHC. Most of the conversions of Navy boiler rooms and heating systems are programmed in FY 81. However, installation of heating mains proceeded at a pace that permitted usable connections to some Navy buildings in FY 80. The total budget for connection and conversion is $35 million.

5.6.6 Norfolk Naval Station, Norfolk, Virginia

The demand potential for geothermal space heating at Norfolk appears to be excellent. However, before wells to define the resource are drilled, resource criteria must be established. The Navy is currently developing a program to identify the potential heating load at the Norfolk Naval Station--its location, resource temperature requirements, and flow requirements. In addition, site-specific legal, institutional, and environmental problems must be resolved. The Navy will then proceed with development if the project is still feasible. However, on the basis of a DOE-sponsored design study, the Navy has agreed to proceed with a project to convert one large building to geothermal space heat.

5.6.7 Williams Air Force Base, Arizona

In 1973, a private firm drilled two geothermal wells to a depth of 10,000 feet, approximately 1 mile from Williams. These wells demonstrated a hydrothermal resource of around 150°C. In June 1979, the Department of Energy completed a feasibility study for the Air Force, exploring the potential applications of geothermal energy at Williams.

The study concluded that both a central cooling plant and an electrical power plant are promising candidates for geothermal use; the choice will depend on the quantity and quality of the resource. The economic analysis projected a potential payback period of 11-15 years.

The Air Force has prepared a conceptual plan that divides the project into two development phases. Phase I encompasses exploratory production well drilling, and Phase II, follow-up drilling and design and construction of the central plant. Management and financial arrangements to accomplish these phases are being developed.

5.6.8 Kings Bay, Georgia

In a join project between the Department of Energy and the Department of Defense, the resource at Kings Bay is being evaluated relative to the feasibility of using the predicted resource for space heating. During FY 80, DOE as part of its Atlantic Coast geothermal program drilled a 1000-foot exploratory well at Kings Bay to determine the thermal gradient. Based on the results of this well, a deep production sized well may be jointly funded by DOE and DOD to explore the resource as "basement." If the resource proves viable, work on installing a space heating system using geothermal fluids would commence in FY 82.

5.6.9 MX Weapon System

To overcome the vulnerability threat to its present land-base missile system, DOD has authorized the beginning of engineering development for the MX

Weapon System. In a parallel activity, DOE and DOD are jointly sponsoring a program to determine the feasibility of using renewable energy sources to supply the electrical power requirements for the MX system. Under consideration are geothermal, solar, and wind.

It is estimated that geothermal energy could provide between 20% and 100% of the total energy required by MX and its support facilities. However, an aggressive resource definition program is needed in order to locate and prove enough resources to accomplish this. Therefore, extensive assessment activities are planned for the states of Nevada and Utah, proposed siting areas for MX, during 1981. At the same time, studies will be conducted to determine the feasibility of developing several confirmed resources in northern Nevada and central Utah to generate electrical power that can be wheeled into the MX deployment area.

5.7 HYDROTHERMAL TECHNOLOGY DEVELOPMENT

The recovery of geothermal energy is accomplished through the use of an evolving technology. The techniques used by the oil and gas industry for exploration and reservoir evaluation have been adapted for their purposes by the geothermal industry, but due to the marked difference in the geologic target being sought and the problems associated with making measurements for assessment purposes in high-temperature, briny environments, the oil and gas techniques are not always appropriate and new technology must be developed.

The areas of technology development described below apply primarily to hydrothermal resources, because hydrothermal appears to be the most likely resource candidate for immediate development, and has the greatest resource potential in the near term. Areas of study include exploration technology; reservoir engineering; and well drilling and completion, well stimulation, energy conversion, and fluid handling technology development. These development efforts are aimed at reducing the costs of geothermal exploration, assessment and field development; reducing capital costs of geothermal facilities; and improving resource utilization efficiency. Technology development for geopressured and hot dry rock resources is still in the preliminary stages, and will eventually build on the developments established for hydrothermal resources.

5.7.1 Reservoir Evaluation Technology

The purpose of reservoir evaluation technology is to more accurately locate hydrothermal reservoirs, measure their properties, and predict their behavoir. Relying on industry to flag key issues and technical problems, the government carries out research in exploration technology, reservoir engineering, log instrumentation, and log interpretation.

Exploration Technology

Exploration technology is seeking to develop more reliable and cost-effective techniques for locating and identifying geothermal resources. The success of this activity must be measured by the improvement in the success ratio of geothermal exploratory wells that are drilled. Success ratio in this instance is defined as the number of wells that intercept potentially commercial quantities of hydrothermal fluid, divided by the total number of exploratory holes. The present success ratio for wild-cat geothermal wells is lower than that for oil and gas wells. This fact is understandable when it is considered that oil and gas exploration technology has been developed over a much longer period of time than has geothermal, but it serves to point up the necessity for a vigorous technology development for geothermal.

In FY 80:

- A strategy of exploration for high-temperature hydrothermal systems in the Rocky Mountain Basin and Range Province has been developed, based on exploration data that were generated by DOE's Industry-Coupled Program. The strategy of exploration features a balance of geological, geochemical, geophysical, hydrological, and drilling activities to be employed in locating and confirming high-temperature resources. The strategy can be appropriately adapted to the search for lower-temperature resources that would be used in direct heat applications. With continuing research on methods of exploration for and modeling of convective hydrothermal systems, the strategy is expected to be refined and become more cost-effective with time. (USGS, DOE)

- The use of trace elements as an exploration tool has been demonstrated. Analysis of trace elements in drilling chips and bore samples provides valuable information on the location of production zones in drill holes, and trace elements in soil samples collected in a region with hydrothermal potential can lead to the identification of fault zones and other geological features that are keys in geothermal development. (USGS)

- Three-dimensional forward and inverse solutions have been developed for interpreting exploration data obtained using resistivity and magnetotelluric techniques. This permits toxographic variations, layering, and other structural features to be introduced into the algorithms, providing for a more meaningful interpretation of the data. (USGS)

- An automated seismic processor has been successfully field tested at The Geysers geothermal field in California. The processor is used to obtain microearthquake data that can be used in identifying and delineating hydrothermal reservoirs. The processor automatically processes and records the arrival times of the various wave forms, determines probability of the initial onset of the P wave, computes spectra for the P and S waves, and determines the corner frequency for the P and S. (USGS)

- Studies have been initiated, as a result of a solicitation, to: 1) improve or refine geothermometry techniques that are used to estimate the temperature of fluids at depth on geothermal systems, 2) investigate the use of microearthquakes as a geothermal exploration tool, and 3) evaluate the effects of water-rock interaction in the evaluation of geothermal reservoir systems. (USGS)

Reservoir Engineering

Reservoir engineering attempts to develop a basic understanding of the nature of hydrothermal reservoirs, including the distribution of temperature, pressure, porosity, salinity of fluid, and permeability. These factors are then used in developing numerical models that can be used in simulating the production of the reservoir. The ultimate goal of the simulation is to be able to predict reservoir production capacity and longevity.

In FY 80:

- A numerical code has been developed that simulates transient fluid flow in a fracture propagating through a porous medium. It is applicable to the study and design of hydrologic fracturing experiments. The code has been validated against field data. One use of the code is to investigate problems associated with reinjection of spent fluids into the reservoir formation. (DOE)

- A workshop was held to introduce industry to the various numerical simulation codes that have been developed by the Lawrence Berkeley Laboratory, and to teach them how to use the codes. (DOE)

- A transient, two-phase well-bore simulator was completed for use in calculating transient flow in the bore during pressure buildup tests. (USGS)

- A two-phased, multidimensional geothermal reservoir simulator has been developed by the Lawrence Berkeley Laboratory. The algorithm is based on mass and energy balance equations for two-phase flow in a porous medium. It can be used in solving a variety of problems related to real reservoir behavior, as well as to provide a better understanding of the physics of two-phase systems. Types of applications for the code are one- and two-phase reservoir depletion, two-phase reservoir behavior with distributed liquid, simulation of real reservoirs, matching production data, and estimating material parameters from well test data. (DOE)

- The various reservoir simulation codes that have been developed by reservoir engineering groups have been tested and compared to provide greater confidence in these simulators on the part of financial institutions, utilities, and investors who must rely on their use for estimates of reservoir production and longevity. A set of six problems was run using each of the codes and the results of the comparison were presented at the Stanford University Reservoir Engineering Workshop. (DOE)

Logging Instrumentation

Logging instrumentation activities are aimed at upgrading tool capabilities from the present rating of 180°C to 275°C, typical of geothermal temperatures. DOE log interpretation activities seek to analyze problems in data interpretation caused by significant differences between hydrocarbon and geothermal wells. The well logging services presently available are often unsuitable for the hostile environment of geothermal wells, and data essential for reservoir engineering are difficult to acquire. Calibration facilities for industrial plants will continue to be provided as part of this effort. Both activities work closely with industry in an effort to test and evaluate new concepts. A major achievement was realized in FY 80 with the production of 50 commercial hybrid circuits by Teledyne Philbrick, Inc.

5.7.2 Well Drilling and Completion Technology

The purpose of this program is to provide the technology to reduce the cost or geothermal drilling 25% by 1983 and an additional 25% by 1987. To do this, advances and improvements in drill bits, downhole motors, and drilling fluids are sought during the current program. Conducted primarily through contracts with private industry and universities, the program is directed by DOE.

In FY 80:

- Further field tests were conducted on a continuous chain drill, leading to a design incorporating all Stratapax (polycrystalline diamond) cutters.
- A new, high-temperature drilling mud was developed, and is now used commercially for geothermal drilling in the Imperial Valley of California.
- Further field tests were run to evaluate drill bits with polycrystalline diamond cutters.

The program is being conducted in six major categories: drilling hardware, drilling fluids, completion technology, lost circulation control methods, and supporting technology. Development of the technology to effect the 25% cost reduction is progressing on schedule. Next year, it is expected that the technology on the continuous chain drill can be transferred to industry for commercial application. Field tests will be conducted on inert gas drilling and completions in high-temperature geothermal wells to reduce corrosion. A complete well bore descaling system, using controlled cavitating water jets, will be field tested. A 200 hour-life bearing and seal section for downhole drilling motors will be tested.

5.7.3 Well Stimulation Technology

The DOE geothermal well stimulation program builds upon the technology available for oil and gas wells to make it useful for high-temperature applications in geothermal wells. It consists of two parts: first, the development of specialized geothermal hardware, stimulation treatments, and data analysis from existing well stimulation treatments; second, conducting field demonstration experiments at specific sites using specific techniques.

In FY 80:

- Two wells at the Raft River site in Idaho were treated by hydraulic fracture. The analysis of results showed improved flows for one of these moderate temperature wells.

- In East Mesa, California, two treatments on two different zones in a well were performed.

- A seminar was conducted to acquaint industry with the well stimulation program and to present results of activities to date.

At the present time, plans are being formulated for the next two tests in the series, while stimulation technology studies, particularly on advanced fluids and proppants, continue.

During the next year, the well at East Mesa will be flow tested and the results of the stimulation treatment will be analyzed. A high-temperature well at Baca, New Mexico, will be treated, as well as a well in The Geysers field in California. A second phase of the program will be initiated, whereby an additional ten tests will be conducted over a two-year period. As in the previous year, an industrywide symposium will again be held.

5.7.4 Conversion Technology

The purpose of the DOE conversion technology program is to reduce the cost of generating electricity from geothermal resources. Emphasis is placed on developing technologies for exploitation of moderate-temperature (150-200°C) hydrothermal reservoirs which are more prevalent than the higher-temperature ones but less economically attractive due to the lower thermal efficiencies dictated by the laws of thermodynamics.

Binary Rankine cycle conversion systems are believed to offer the greatest potential for economical utilization of moderate-temperature resources. Current development efforts include the design and fabricating of heat exchangers for both the extraction of energy from the geofluid and for waste heat reinjection, and field test of these subsystems in pilot binary cycle power plants. These efforts seek to improve performance and reduce cost of heat exchangers, which now account for 50-75% of binary plant costs.

Major Program Accomplishments of FY 80

- A 500 kWe binary power system employing a direct contact preheat/boiler was installed and operated at the DOE Geothermal Test Facility (GTF) at Holtville, California. The boiler and associated working fluid recovery and noncondensible gas removal systems have exceeded design performance goals. Details of the system design and data on the first part of the performance test have been published in Lawrence Berkeley Laboratory Report No. LBL-1153.

- An electric downhole pump designed and built for DOE ran nearly six months at the GTF before failing. During this period the only shutdowns of the pump were forced by local power outages. The pump was modified several times over the past year as design improvements were identified by analysis of failure modes. This test extended previous pump operational life sixfold.

- A large diameter well was drilled and cased in conjunction with the development and field test of a 4.2 MW "gravity head" binary power plant that could achieve 35% better brine utilization than conventional binary systems. Components were fabricated for field testing of a major subsystem of the plant.

- Comprehensive reference volumes entitled "Geothermal Energy as a Source of Electricity" and "Sourcebook on the Production Electricity from Geothermal Energy" were prepared for DOE by Brown University.

- Several months of unattended continuous operation of a 60 kWe binary power plant provided new data on the reliability of binary systems.

- A 1 MWe total flow wellhead power plant utilizing a helical screw-expander was installed and tested at Cerro Prieto, Mexico, under a cooperative program of the International Energy Agency. DOE provided the power plant and technical specialists who advised the Mexican scientists on the operation and evaluation of the power plant. Preliminary data suggests that the power system could be a reliable and efficient small-scale prime mover, well suited for geothermal applications.

5.7.5 Geochemical Engineering and Materials Technology

The geochemical engineering and materials program focuses on fluids handling problems. Fluid disposal and injection well maintenance procedures are being developed to control wastes and to optimize the potential for beneficial use of geothermal waste by-products. Materials activities address the interaction of geothermal fluids with other materials. DOE's program seeks to advance economical construction materials and to develop elastomers, metals, and nonmetallics for use in geothermal environments. Materials under development include polymer concrete for pipes and pressure vessels and corrosion-resistant steels for well casings, drill pipes, and energy conversion equipment. Over the next five years the geochemical engineering and materials effort will complete laboratory development of new corrosion- and temperature-resistant materials and will apply this knowledge to equipment construction and field testing of the new components and systems.

For successful fluid control and chemical treatment processes, the composition and properties of the geothermal fluid must be known. To meet this need, sampling and analysis efforts are in progress to develop reliable sampling techniques. In FY 80 a manual of field-tested geothermal fluid sampling techniques was published. A monitoring case study was undertaken, and will continue next year to field test the first 200°C high-temperature pH probes developed in laboratory programs. Laboratory activities in FY 81 will aim at the development of smaller probes with 275°C temperature capabilities. Recommendations for improved monitoring and new instrumentation are being incorporated in design specifications for demonstration plants.

Scale buildup and injection well problems are also being examined. Work is proceeding to characterize injected particulate materials, develop and field test injection well maintenance procedures, and evaluate chemicals and scale resistent materials for scale removal and control. Applied research and development activities in the field and laboratory are evaluating hydrodynamic effects as a possible means for mechanically controlling scale formation and removal.

New materials are being developed in an effort to reduce the cost of geothermal systems. Improved drill pipe, casings, and cements designed for higher temperature service are under development in programs that are cost-shared by industry, the Federal Republic of Mexico, and Italy. Laboratory screening tests of ten new cements will be completed and two years of field tests initiated in FY 81. Projects are also underway to screen, develop, and commercialize bearing, seal, and corrosion-resistant construction materials for down-hole pumps.

Technology transfer is an essential part of all materials research. In FY 80 technology transfer activities included the formation of a major ASTM committee on geothermal resources and energy. A major Geothermal Engineering and Materials Technology Transfer Conference is being planned for the fall of FY 81. Geothermal engineering and materials strategy documents and a National Research Council report on industry materials needs through the year 2000 will be completed in FY 81.

Geobrine research is another major area of study, and is being conducted by the Bureau of Mines. The objective of their program is to study methods of recovering minerals from geobrines and to examine the effects of geobrines on construction materials. Minerals recovery processes under study include a bulk precipitation technique, currently being demonstrated at Niland, California, and a selective sulfide process to recover lead and zinc and other metal values from highly saline geobrines.

5.7.6 Geobrine Desalination

The continued population growth in the Pacific Southwest area requires substantial amounts of water. Current water demands are being met by overdrafts of groundwater reservoirs. To augment these water supplies, the Water and Power Resources Services (DOI) began a program to desalt geothermal brines using heat energy inherent in the geothermal fluid. Field investigations, including a number of shallow test holes and geophysical tests, have now been completed at several promising sites and the data are being analyzed for potential geothermal and to determine whether to continue investigations through more detailed resource assessments. Two reports are now being prepared, incorporating the results of geophysical investigations and studies at several western sites.

5.8 GEOPRESSURED RESOURCES

The program to develop the geopressured resource is divided into two activities: reservoir definition and environmental research.

Tens of thousands of wells have penetrated geopressured aquifers in search of oil and gas in other horizons in the Gulf Coast sediments; the magnitude of the geopressure-geothermal resource is being defined and delineated by logs from these wells. These studies, along with seismic surveys and core analyses, have located 70 areas with high potential for geopressured production. These studies are being supported by programs to test Wells of Opportunity (unsuccessful oil and gas wells penetrating geopressured formations which will not be tested by the operator) and design wells drilled by DOE specifically to test geopressured aquifers.

A major accomplishment in FY 79 was DOE's successful drilling of a well in Brazoria County, Texas. The well is completed and under long-term testing.

Major accomplishments in FY 80 were the testing of three highly successful Wells of Opportunity, and the award of a contract to drill four design wells and test the associated geopressured aquifers.

Mapping, including the assembly of a computerized data base, will continue in FY 81. Emphasis will again be placed on resolution of the large identified reservoirs, mapping deeper formations, and extending the work to previously unmapped areas. The sites proposed for tests of existing wells and for drilling of new wells will also be evaluated within this program.

5.9 HOT DRY ROCK RESOURCES

DOE established its Hot Dry Rock (HDR) Program after the successful demonstration of the technical feasibility of extracting HDR energy with a 5 MW thermal (MWt) loop at Fenton Hill, New Mexico. The goal of the program is to demonstrate the commercial feasibility of geothermal energy derived from hot dry rock.

In FY 80:

- The first well of a commercial-scale, 20-50 MWt loop was completed at Fenton Hill. The original thermal loop was expanded from an effective surface area of 8,000 square meters to about 50,000 square meters; the enlarged loop was operated continuously for over 7 months.

- Evaluation of resource work, as part of an effort to select a second HDR demonstration site, continued.

- Geological evaluations near Mountain Home, Idaho, and Crisfield, Maryland, were completed.

- A national thermal gradient map was published.

During FY 81 the second well of the commercial-scale loop at Fenton Hill will be completed; initial hydraulic fracturing tests will be conducted. Data collection and analysis to determine the location of the second demonstration will continue, culminating with selection of a site in early FY 82.

5.10 GEOSCIENCES RESEARCH

The Geosciences Research Program of DOE's Office of Energy Research is divided into five broad categories:

(1) Geology, geophysics and earth dynamics
(2) Geochemistry
(3) Energy resource recognition, evaluation and utilization
(4) Hydrologic and marine sciences
(5) Solar-terrestrial-atmospheric interactions.

Research supported by this program may be directed toward a specific energy technology, national security, conservation of the environment, or the safety objectives of the Department of Energy. The purpose of this program is to develop geoscience and geoscience-related information of relevance to one or more of these DOE objectives or the development of a broad, basic understanding of geoscience materials and processes necessary for attainment of long-term DOE goals.

Geoscience research related to geothermal resources is supported primarily under the Energy Resource Recognition, Evaluation and Utilization research category. The research elements of this category may be summarized as follows:

1. <u>Resource Definition and Utilization</u>

   This research area has as its principal goal the development of new and advanced physically, chemically, and mathematically based techniques for energy and energy-related resource exploration and use. Efforts supported under this research element include:

(a) Feasibility of Shear Wave Vibrators for Deep Crustal Studies in Geothermal Environments (Lawrence Berkeley Laboratory). The use of horizontally polarized shear wave sources to detect the low shear rigidity zones characteristic of a geothermal resource has been studied with a time domain, finite element program; a frequency domain, integral equation program; and an analytical solution for the radiation pattern and radiation impedence of a torsional shear wave vibrator.

(b) Seismic Research in Northern New Mexico (Los Alamos Scientific Laboratory). The objective of this research is to analyze seismic data, collected from a network of seismic stations operated by LASL and the USGS, to investigate geodynamics of the rift where several major tectonic regions (Colorado Plateau, Basin and Range; Rio Grande Rift; and Southern Rockies and Great Plains stable area) intersect. Lateral variations in crustal structure, seismic wave propagation and attenuation and their relationships to the major geothermal regimes of Northern New Mexico are being investigated.

(c) Seismology of Crack Formations and Natural Geothermal Systems (Massachusetts Institute of Technology). A theory for interpreting data on seismic wave generation, transmission, scattering and attenuation in a medium containing a fluid-filled crack has been developed. The "fluid-filled crack" model of geothermal systems has been used to study various geothermal areas including Kilauea, Hawaii; Fenton Hill, New Mexico; Newberry Peak, Oregon; and Cerro Prieto, Baja California.

(d) Seismic Velocity Variations and Attenuation of Deliniated Geothermal Reservoirs (Stanford University). A sound velocity log was run in a 1 kilometer-deep borehole in fractured granite to measure seismic waveform distortion due to changing character of the borehole wall (degree of fracturing). Results of these measurements may provide the basis for improved, high-resolution sonic well logging techniques, with particular application to geothermal reservoir evaluation.

2. <u>Reservoir Dynamics and Modeling</u>:

This research is related to dynamic modeling of geothermal and hydrocarbon reservoirs in their natural and perturbed (production, injection or reinjection) states. Efforts supported under this research element include:

(a) Reservoir Dynamics Related to Geothermal Energy Development (Lawrence Berkeley Laboratory). A study is being made to understand the behavior of reservoir pressure and temperature when a doublet of one production and one injection well is present, with the injection well being used for injecting cold water. Another study is investigating single-well, cold-water injection pressure transient effects.

(b) Thermodynamics of High-Temperature Brines (Lawrence Berkeley Laboratory). Theoretical and experimental studies of solution thermodynamics of strong aqueous electrolytes over a wide temperature range are being conducted to provide essential information for technical utilization of several geothermal resources.

3. <u>Magma Energy Resources</u>:

This area consists of field, laboratory, experimental and theoretical research bearing on the origin, migration, implacement and crystallization of natural silicate liquids or their synthetic analogues. The emphasis is on studies related to energy extraction from such liquids. Efforts supported under this research element include:

(a) Geology/Geophysics (Los Alamos Scientific Laboratory). Geothermal research focuses on understanding structures, tectonics, and evaluation of potential geothermal resources and properties of reservoirs with special emphasis on thermal regimes of the Jemez Lineament and the Northern Rio Grande Rift. Geothermal support includes seismic profiling, radioactive heat transfer measurements, numerical modeling, field geology, trace elements and isotopic analyses of geothermal waters as well as electron microprobe, X-ray diffraction, and petrographic examinations of deep-hole rock samples. Special attention is given to three active hydrothermal systems within the Rio Grande Rift at Valles Caldera, Ojo Caliente and Lucero Uplift.

(b) Magma Energy Research (Sandia Laboratories). This project is divided into five major research tasks designed to assess the scientific feasibility of extracting energy directly from buried magma sources: (1) magma source location and definition, (2) magma source tapping (3) magma characterization, (4) magma/material compatibility, and (5) energy extraction. Geophysical, geochemical, and petrographic measurements are confined to the Kilauea Iki lava lake in Hawaii.

(c) Continental Scientific Drilling Program: Thermal Regimes (Sandia Laboratories). The objective of this effort is to develop an understanding of the heat and mass transfer within and between magma and hydrothermal systems and the evaluation of hydrothermal-magma systems in space and time, through the utilization of drilling to obtain samples and data and to conduct downhole experiments. Initial geosciences research will identify drilling and 'in situ' field measurements that are required to develop, test and confirm physical and chemical models of coupled hydrothermal and magmatic systems.

4. Information Compilation, Evaluation and Dissemination:

These are research activities that are principally oriented toward the evaluation of existing geoscience data to identify significant gaps. This area includes the necessary compilation and dissemination activities. Efforts supported under this research cateogry include:

(a) Information and Data Management Component of the Continental Scientific Drilling Program (CSDP) (Lawrence Livermore National Laboratory). This project provides data bank and information services for the CSDP program. It includes: (1) subsurface data from programmatic drilling by Federal agencies and new wells drilled by industry that offer opportunity for cooperative efforts and (2) a computerized data bank for drill-hole data acquired in CSDP projects. Information on plans and drilling activities can be distributed to the scientific community.

(b) Comparative Site Assessment Component of the Continental Scientific Drilling Program

(CSDP) (Sandia Laboratory). Available geologic, geophysical and geochemical data on five sites (The Geysers, Long Valley, and Salton Trough, California; the Rio Grande Rift, New Mexico; and Roosevelt Hot Springs, Utah) are being reviewed and compared to identify the specific scientific questions on the evaluation of hydrothermal-magma systems that can be optimally resolved at each site. A preliminary report, prepared jointly by the four participating laboratories and submitted to the Office of Energy Research, identifies specific opportunities for obtaining fundamental scientific information through exploitation of drilling planned for technological purposes.

5.11 INTERNATIONAL ACTIVITIES

The development of geothermal energy internationally is important to the pace of commercialization in the United States. Foreign developments can supply both technologies and materials to U.S. developers, and provide markets for the products of U.S. manufacturers. Based on information from international activities, Federal program plans can be designed to reflect the needs of U.S. manufacturers trading abroad. To aid in these efforts, and to assist other countries in developing their own energy resources, the United States maintains both bilateral and multilateral agreements with a number of countries.

At present, worldwide installed geothermal electric capacity is 2,475 MWe (see Figure 5.2). This reflects an increase of about 500 MWe in installed capacity during the past year. There are also 12 countries with significant direct use of geothermal energy totalling 8,300 MWt for space conditioning, water heating, agricultural and industrial applications. Total planned expansion in geothermal electric capacity of about 2,450 MWe among 14 countries through 1985 has been reported.

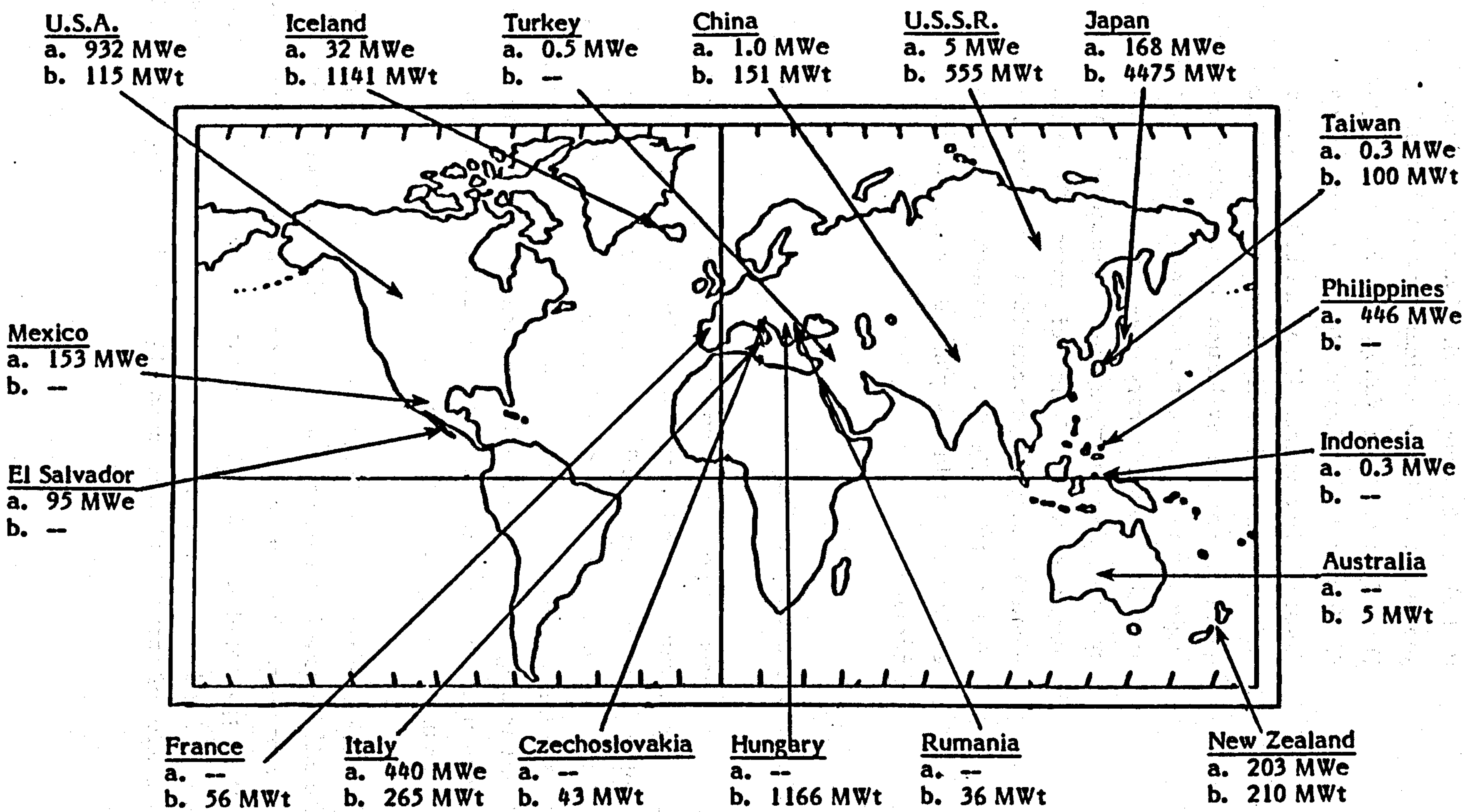


Figure 5.2. Worldwide Distribution of (a) Geothermal Electric Power (2475 MWe) and (b) Direct Heat Use (8300 MWt) September 1980

Many developed and less developed nations are assigning increasingly greater priority to the development of geothermal resources. The growth of this potential market is generating some export competition among countries with developed geothermal technology.

With few exceptions, the prospect for commercialization of geothermal technology is greatest among less developed countries (LDC's) because they are most sensitive to increased petroleum prices and are actively looking to the development of indigenous energy resources. Since most LDC's lack either experience with geothermal development or the expertise to closely manage a power plant project from exploration through construction, they have relied primarily on turnkey projects and the services of international consulting firms.

There are essentially three kinds of markets in geothermal turnkey projects: exploration/feasibility study; field development/production; and power plant construction. In the exploration and economic feasibility study phase, geothermal projects are generally subject to international bidding, and large U.S. energy corporations and architectural and engineering (A/E) firms are in a good competitive position relative to other international companies.

In the field development and production phase, established firms with local contacts have significant economic advantage over firms which must bring in their operating equipment and personnel. American A/E firms and equipment manufacturers are at a disadvantage because they cannot finance equipment quickly enough to be competitive with other countries that export geothermal technology, particularly Japan, Italy, New Zealand, or France; firms in these countries benefit from a tradition of close government-business cooperation in the development of a business opportunity and ready availability of vendor financing packages which are not available to U.S. companies.

The U.S. geothermal industry has, historically, concentrated on domestic markets but many companies are now awakening to the potential for export of geothermal expertise, especially to LDC's. From DOE's point of view a significant rationale for marketing geothermal technology overseas is that export markets provide an opportunity for expansion of U.S. manufacturing capacity in preparation for the emerging domestic geothermal market. At present it is unclear which

Federal geothermal technology export policy options and/or international program activities would assure U.S. firms a role in the growing international market.

In FY 80 two efforts were undertaken in an attempt to establish an effective international marketing strategy. The first effort involves the definition of the potential commercial market for U.S. industry in foreign countries. The preliminary studies are delineating the structure of the energy sector in less developed countries. Because energy distribution networks and capital are limited, the appropriate scale of geothermal applications is smaller in LDC's than in developed countries. The 50-100 MWe commercial-scale power plants of developed countries may be too large for many sites in LDC's, where wellhead generators in the 1-5 MWe range are more appropriate. The characteristics of this potential market parallel, to some degree, the market for smaller-scale development of power plant facilities for rural areas and small municipalities in the western United States.

A second effort was initiated which is designed to investigate policy options and implications for the United States in foreign markets, particularly the costs and benefits that export expansion would have for domestic commercialization. This study will be completed in the second quarter of FY 81. The findings of these studies and a review of existing cooperative International Agreements will provide the basis for the formulation of a DOE/DGE long-range program plan for international geothermal activities.

At least 20 countries have active geothermal energy programs, and through multilateral and bilateral agreements the United States participates in international programs. Generally, the agreements call for the exchange of information, exchange of visits of scientists, and selection of areas for cooperative activities. In some cases, agreements have led to more active research and development programs.

DOE currently is involved with three multilateral cooperative efforts through the International Energy Agency (IEA); has bilateral agreements with Italy and Mexico; and is negotiating agreements with Japan and New Zealand. DOE benefits from these agreements chiefly through access to unevaluated data and operating experience which are or were otherwise unavailable to it in the United

States, and which are needed to validate and improve reservoir models. Such efforts help in estimating the U.S. and the world's geothermal resources. For foreign participant, cooperation with DOE in general improves their understanding of their resources and how best to exploit them, and provides additional insight into new techniques and technologies being developed in the United States, and a chance to evaluate their worth. Cooperative activities are also part of the U.S. Government's conduct of foreign policy and serve such objectives as improving ties with allies and reducing world dependence on oil.

5.11.1 Multilateral Agreements

In the wake of the 1973-1974 oil crisis, various member countries of the Organization of Economic Cooperation and Development (OECD) signed in 1974 an Agreement of an International Energy Program to strengthen cooperation on energy policy. The International Energy Agency (IEA) was then established in Paris to administer the Agreement as an autonomous body with OECD. The IEA has set up a Committee on Energy Research and Development which consists of representatives of the member countries and is supported by a small secretariat staff. The Committee has various working parties under it, one of which is the Working Party for Geothermal Energy composed of specialists from Austria, Belgium, Federal Republic of Germany, Italy, Japan, Sweden, Switzerland, Turkey, the United Kingdom, the United States and the European Community. Currently there are three Implementing Agreements in effect under the Geothermal Working Party.

In May 1979 Italy, New Zealand and the United States signed an Implementing Agreement for a program of research and development and demonstration on geothermal equipment. The one and only annex to the Agreement lays out the specifics of the testing of a 1.2 MWe helical screw expander, developed for DOE by Hydrothermal Power Company, Limited, of California, at test sites in Mexico, Italy and New Zealand. The performance, reliability and economics of this advanced piece of equipment over a broad range of geothermal resource conditions are to be assessed by the host country. The helical screw expander is undergoing testing at Cerro Prieto, Mexico, in 1980 and is to be shipped to Italy in early 1981. An Executive Committee oversees the test program and has met twice, once in August 1979 in Washington, D.C., and again in June 1980 at Cerro Prieto.

In September 1979 the Federal Republic of Germany and the United States signed an Implementing Agreement for an R&D program in hot dry rock technology to last for four years. Under the Agreement's conditions, the Federal Republic of Germany will make annual cash contributions equivalent to 25 percent of DOE annual funding of the Fenton Hill project, up to $2.5 million. German scientists and technicians are to participate in the management and conduct of experiments and obtain raw data. Japan is currently considering participating in the Fenton Hill project under the same conditions as the Federal Republic of Germany.

In October 1977 the Federal Republic of Germany, Sweden, the United Kingdom and the United States signed an Implementing Agreement for a program of R&D on man-made geothermal energy systems (MAGES), primarily hot dry rock. Japan signed the Agreement in April 1979. Each participant has shared in the cost of a study to evaluate the technical and economic merits of MAGES and provide recommendations for future laboratory and modeling activities, and field tests at the pilot plant level. The study was completed June 30, 1979, and a final report was issued to participants in late 1979. The Geothermal Working Party is now considering extending the MAGES Agreement to a "hardware" phase, possibly a MAGES experiment in Western Europe. If so, it and the Fenton Hill project will provide a valuable basis from which the applicability of the Hot Dry Rock/MAGES concept to various geologic settings could be evaluated.

5.11.2 Bilateral Agreements

Italy - U.S.

An Agreement between Italy and the United States for cooperation in the field of geothermal energy research and development was signed in June 1975 and subsequently renewed five years later by an exchange of letters. The purpose of the cooperation is to develop technology for electric power applications and to improve equipment and techniques for assessing geothermal resources. The Agreement covers five project areas.

Project 1: Stimulation of Hot Dry Rock and Hydrothermal Resources. This project concerns itself with the identification and use of sites for hydrothermal stimulation techniques. The Los Alamos Scientific Laboratory, as a result of observing tests at Larderello, is now testing Italian high-temperature cementing techniques at Fenton Hill, New Mexico. Future effort will focus on exchange of information on explosive stimulation techniques. In 1980 Italy observed explosive fracturing tests at The Geysers using newly developed, high-temperature explosives.

Project 2: Utilization of Hot Brines. Only limited amounts of information on highly saline fields have been exchanged to date under this project.

Project 3: Reservoir Definition. This project is concerned with procedures for optimizing techniques for resource assessment and reservoir engineering. A joint report has been prepared which utilizes operating data and case histories supplied by Italy and analytical techniques supplied by the U.S. Joint activities are currently under way to refine techniques for estimating reservoir capacity, extent and behavior and to validate mathematical models of reservoirs with actual performance data.

Project 4: Deep Drilling. The content and scope of this cooperative effort has not been established to date.

Project 5: Environment. This project involves the study of the environmental effects of hydrogen sulfide and radon emissions associated with the production of electricity from geothermal energy. An air quality and meterological monitoring network has been established for the Larderello field. The U.S. has provided equipment for follow-on monitoring tests of radon, H_2S, and seismic noise levels.

A U.S.-Italy symposium was held in November 1980 in California to review all progress made under this bilateral agreement over the past five years.

Mexico - U.S.

The Agreement between Mexico and the U.S., signed July 1977, has allowed scientists of both countries to study the geologic setting and hydrothermal circulation of the world's only liquid-dominated field with seven years of production history. Much of the information exchanged is applicable to the development of the geothermal resources in the Imperial Valley, California, and to Mexico's plans to expand the use of the Cerro Prieto field. Of the seven task areas under the Agreement, the first three tasks (geology and hydrogeology, geophysics, and geochemistry) supply facts and insights from which an accurate, dynamic model of the Cerro Prieto field can be developed (under Task 4, reservoir engineering) and used to determine safe production rates, optimum well spacing, and life of the reservoir. Under Task 5 the extent of subsidence caused by extraction of geothermal fluids will be determined. Under Task 6 plans are being developed for large-scale, spent-brine reinjection operation. Under Task 7, information dissemination, two conferences have been held, one in San Diego, California, in September 1978 and another in Mexicali, B.C., in October 1979. Future conferences are to be held at 18-month intervals and workshops for experts in the various task areas are to be scheduled as needed.

Currently, the U.S. and Mexico are considering an annex to the Agreement to include cooperation at the Los Azufres field, 150 km west-northwest of Mexico City. To date, Mexico has performed resistivity, magnetotelluric, self-potential, and surface-geologic surveys, and drilled at least 15 deep wells. Measurements of this field will provide both countries the opportunity to study a high-temperature, fractured volcanic geothermal field using the most modern geological and geophysical equipment; the data will be used to enhance reservoir engineering techniques.

Japan - U.S.

On May 2, 1979, the U.S. and Japan signed an Agreement on Cooperation in Energy and Related R&D. Later in May 1979 the first U.S.-Japan Geothermal Coordinating Committee met in Washington, D.C., to review each other's domestic geothermal programs and to determine topics of mutual interest (chiefly binary cycle systems and hot dry technology) and plan future cooperation. In August 1979, the U.S. and Japan held a review session of each other's work in the areas of binary conversion systems, total-flow concepts, and the economics of the hot dry rock concept, as part of a Japanese delegation's tour of U.S. geothermal facilities. Since that time, the U.S. and Japan have been negotiating for Japan to join the IEA Hot Dry Rock Implementing Agreement, whereby Japan will contribute to the DOE Hot Dry Rock project at Fenton Hill, New Mexico, on the same basis as the Federal Republic of Germany under an IEA Agreement.

New Zealand - U.S.

As an outgrowth of the long and successful informal interactions between U.S. and New Zealand specialists in geothermal energy, DOE and the Department of Scientific and Industrial Research of New Zealand are currently drafting a Memorandum of Understanding that will allow exchanges of information, short-term visits and assignments of personnel, joint planning of tests and methodologies, and cooperative programs and projects in the areas of well drilling and completion; high-temperature well logging, brine chemistry and materials; well production stimulation techniques; reservoir engineering; study of two-phase flow; and brine and waste disposal.

6.0 STATE AND LOCAL GOVERNMENTS (BY REGION), AND INDIAN TRIBES

Although the primary governmental funding source for geothermal projects is at the Federal level, state energy offices are providing increased financial and technical assistance support to geothermal energy applications. Many states are helping localities to develop and implement district heating systems, food processing plants and numerous other projects. And there has been a proliferation of state assistance for resource assessment and other exploratory activities. State legislative and regulatory bodies are demonstrating a concern about the ramifications of developing hot-water reservoirs, as reflected in the many proposed bills and enacted laws defining the nature of geothermal fluids. Issues of mineral rights, water rights, ownership, permitting, and leasing are paramount. Regulations to ensure adequate environmental protection measures are being formulated.

This section describes geothermal activities sponsored, funded, initiated, or otherwise supported by state or local governments. Resource definition efforts are included as well as assistance supplied directly to geothermal application projects. The discussion of state and locally sponsored activities is presented by Federal region (see Figure 6.1).

Geothermal applications on Indian lands are discussed separately due to their importance in displacing conventional fuels, providing employment, and helping to fortify the economic base of Indian communities.

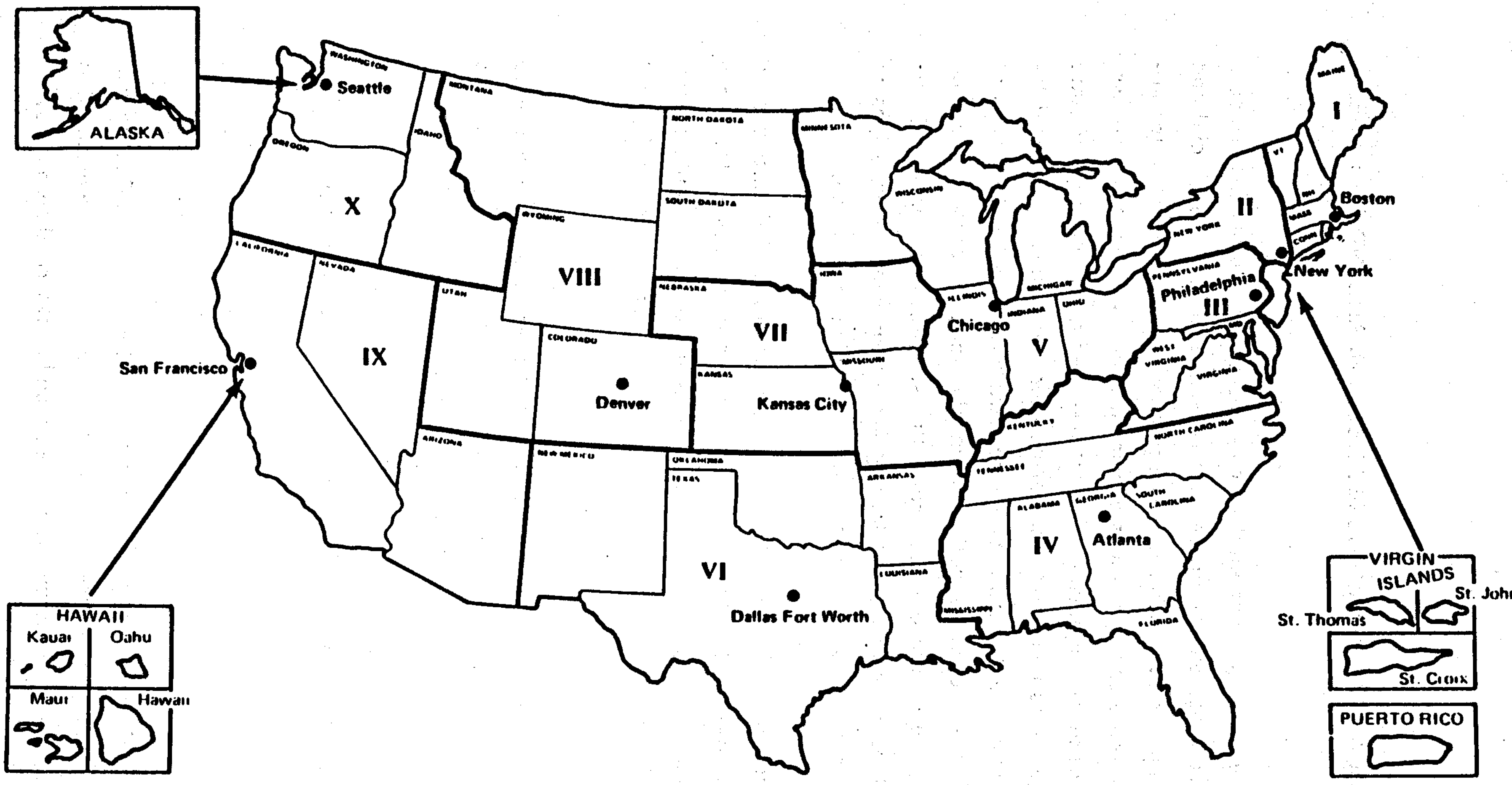
6.1 EASTERN STATES (FEDERAL REGIONS I, II, III, IV, V, AND VII)

6.1.1 Maryland

A State Energy Special Subcommittee reviewed the Maryland Geothermal Resources Act, passed in 1978. A consensus was reached on proposed revisions that would resolve ambiguity about the ownership of Maryland geothermal resources.

Figure 6.1

Ten Standard Federal Regions



Region	States
1	Conn, Maine, Mass, NH, RI, Vt
2	NJ, NY, Puerto Rico, Virgin Islands
3	Del, DC, Md, Pa, Va, W Va
4	Ala, Fla, Ga, Ky, Miss, NC, SC, Tenn
5	Ill, Ind, Mich, Minn, Ohio, Wis
6	Ark, La, NM, Okla, Tex
7	Iowa, Kan, Mo, Neb
8	Colo, Mont, ND, SD, Utah, Wyo
9	Ariz, Calif, Guam, Hawaii, Nev, Trust Territory of the Pacific Islands
10	Alaska, Idaho, Ore, Wash

The Columbia Natural Gas Company intends to convert their imported liquefied natural gas (LNG) terminal at Cove Point, Maryland from natural gas to geothermal energy use for LNG vaporization.

The Superintendent of Schools in Somerset is considering space heating Crisfield High School with geothermal energy. A recently completed study confirmed the technical and economic feasibility of this project. At the request of the Wicomico County School Board, the feasibility of space heating the Pittsville Middle School was examined. The project remains under consideration.

6.1.2 Delaware

Although the state of Delaware passed a geothermal law establishing public ownership and defining geothermal resources as unique and separate from water and mineral resources, it was subsequently vetoed by the Governor. Some groups within the state objected that the public ownership portions of the bill would interfere with personal property rights. No plans have been made to submit a modified bill during the 1981 legislative session.

Delaware has been granted funding by DOE to undertake a geothermal drilling project. The utilization of geothermal energy for space conditioning of a school and hospital near Lewes has been proposed and is under consideration.

6.1.3 Virginia

A State Geothermal Site Prospectus has been developed by the State Energy Office. Virginia continued to meet with the National Conference of State Legislatures to consider potential state geothermal legislation. A bill has been introduced to the legislature that legally defines the resource with respect to ownership and regulatory responsibility. The state is compiling a geothermal resources map, which should be complete next year.

6.1.4 Alabama

The Alabama Geologic Survey has completed an assessment of geothermal resources in South Alabama. The state has proposed a plan for similar investigations for the northern part of the state and hopes to receive Federal funding.

Waters from the Tuscaloosa formation, about 3,000 feet in depth with temperatures of 51°C, currently supplies heat to Sealy Springs. Hot baths, a health spa, and a recreational facility derive energy from this resource.

6.1.5 New York

The geothermal resource potential near Auburn is being explored by the Federal and state governments under a cost-shared program. Hydrothermal reservoirs at 4,000 feet may have temperatures as high as 125°F. Clinton Corn Products plans to test the well to determine the suitability of the resources to heat water for factory operations.

The Dunn Geoscience Corporation, under contract to the state, has assessed and characterized warm springs in the Lebanon Springs area. The study has been intensified to include well temperature measurements, magnetic surveys, heat flow measurements, and gravi-metric survey.

6.2 GREAT PLAINS STATES (REGIONS VI AND VIII)

6.2.1 Colorado

Colorado is pursuing extensive outreach programs and has proposed several sites for community and industrial project applications of hydrothermal resources. The Colorado Highway Department plans to drill several gradient holes in Garfield County. The proposed application is snow and ice melting on an interstate highway.

The Task Force for the Four Corners Regional Commission has funded a geothermal agripark site demonstration project. The application is being developed by Coury and Associates in Southern Colorado. A site northwest of Alamosa has been selected for a 2,000 foot test well.

The Colorado Commercialization Team has submitted an Area Development Plan for Chaffee County. The presence of several hot thermal springs, a KGRA, the main line of the Denver-Rio Grande Railroad, highways, and airports make this area attractive for geothermal development.

A shopping mall in Alamosa is being remodeled to use geothermal heat. Alamosa is located in the San Luis Valley, an area considered a prime geothermal prospect for agricultural processing as well as for space and water heating. A 3,080 foot artesian well there has a temperature of 116°F and flows at about 700-1,000 gallons per minute. After heating the building, the water would be used by a mobile home park for domestic water and irrigation.

Western Energy Planners, Ltd. have studied the utilization of geothermal energy to provide heat to selected state buildings. The report has been submitted to the state legislature for consideration.

6.2.2 Texas

A state-wide survey of well temperatures is being performed by the Bureau of Economic Geology, University of Texas at Austin. Survey work has been conducted by the Department of Geologic Sciences, University of Texas at El Paso on the Fort Bliss military base. Requests for proposals have been sent out by the University to drill test wells in the McGregor Range on the base.

The Bureau of Economic Geology is evaluating the potential use of geothermal energy for space and water heating at Air Force bases in Texas.

6.2.3 Oklahoma

The Oklahoma Geological Survey is preparing a state-wide thermal gradient map. Due to the relatively high thermal gradient of the Arkoma Basin, this area is being investigated in more detail.

6.2.4 Montana

The Montana Department of Natural Resources and Conservation has mapped potential geothermal use showing population distribution, recource location, and agricultural areas where processing facilities might be built.

At Broadwater Hot Springs, the geothermal resource is being used for forced-air space heating and for the heating of indoor hydrotubs at the Broadwater Health Spa. Geothermal greenhouse and aquacultural applications are under consideration at Barkell's Hot Springs and Hunter Hot Springs.

A geothermal ethanol plant has been proposed for Hot Springs. A completed feasibility study, funded by the state, proposes the use of locally grown grain as feedstock.

6.2.5 New Mexico

The New Mexico Energy and Minerals Department sponsored a project with DOE for the Carrie Tingley Hospital at Truth or Consequences. The hospital is equipped with a geothermal hot water preheating system.

Other geothermal projects being sponsored by the New Mexico Energy and Minerals Department include: an assessment of the geothermal potential of southwestern New Mexico, exploration and gradient studies near Columbus, geothermal energy development planning for Las Cruces and Dona Ana, and a geothermal heating demonstration project for Jemez Springs.

A geothermal heating and cooling feasibility study is being conducted for the University of New Mexico at Albuquerque. Efforts encompass reservoir assessment, a campus-wide energy audit, scaling and corrosion concerns, and evaluating geothermal effluent disposal methods.

Potential geothermal projects within the state are a fuel alcohol production plant in southwestern New Mexico, district heating for the Candle Light Homes subdivision in Las Cruces, and a geothermal ethanol plant in Dona Ana Country.

6.2.6 North Dakota

The North Dakota Geological Survey is evaluating state geothermal resources to identify prospective geothermal resource locations. The data will be used in a market penetration analysis for North Dakota. The state commercialization team has completed an area development plan. Comments received are being used to aid in the development of an institutional handbook. The State of North Dakota, the University of Utah Research Institute, and the National Oceanic and Atmospheric Administration are preparing a state geothermal resource map.

The Patterson Hotel, located in Bismarck, is being remodeled to utilize geothermal energy. Other potential applications are space heating systems at the Maryvale Convent and the Twilight Hills Ski Bowl.

6.2.7 South Dakota

A geothermal space heating system is being installed at the Vivian highway rest area under a cooperative agreement between the South Dakota Office of Energy and DOE. In Haakon, geothermal energy will heat the school and downtown business districts. At the Diamond Ring Ranch, geothermal energy is used to space heat farm buildings, dry grain, and warm stock water. Projects at the Capitol Mall complex, Edgemont school and city hall for space heating, and at Lemmon for grain drying, ethanol production, greenhousing, aquaculture, and space heating are under consideration.

The state commercialization team has completed a project to identify and rank prospective geothermal development on BLM/USFS lands.

The state legislature recently defined geothermal energy as the natural heat of the earth located beneath the surface that can be used for commercial or industrial heating or electric power generation. It provides for a rental fee of not less than one dollar per acre, and a royalty of not less than ten percent of gross revenue.

6.2.8 Utah

Within the state, many direct heat projects are under development. A few of these projects are highlighted here.

The Utah State Prison at Crystal Hot Springs may soon be equipped with a geothermal space heating and cooling system. The hydrothermal fluids may also be used to heat 20 acres of Utah Roses greenhouses situated on property adjacent to the prison.

Geothermal energy and sugar beets will be used to produce alcohol at a plant in the Cove Fort area. Plans include cascading the water for greenhousing or fish farming. The geothermal potential of the Wasatch front near Hill AFB is presently being assessed by the University of Utah, DOE, and DOD.

A map illustrating Utah's geothermal resources has been published under a state-coupled mapping program sponsored by DOE and the National Oceanic and Atmospheric Administration.

6.2.9 Wyoming

Area development plans have been prepared by the Wyoming Geothermal Commercialization Team for Big Horn Basin and Fremont County. Plans are also being drawn from the Natrona/Converse county area and Thermopolis.

The state commercialization team has been working with AMOCO Oil Company and ARCO to evaluate the potential use of hot water wells for district heating in Midwest and Edgerton. Other applications may include an agricultural/greenhouse complex, a small industrial park, and an aquaculture facility.

In Laramie and in Albany, along two interstate highways, two bridges demonstrate geothermal snow and ice melting. Potential developments include an aquaculture application in Midwest and a greenhouse near Cody.

6.3 PACIFIC STATES (REGION IX)

6.3.1 Arizona

In the state government, primary emphasis is currently on testing the resource. The Arizona Bureau of Geology and Mineral Technology is continuing evaluation of heat flow data and running conductivity studies in the state. Six temperature gradient holes in Yavapai County are being evaluated. Low and moderate temperature geothermal commercial applications in the Phoenix, Tucson, Safford, and Northern Hassayampa Plain areas will also be studied.

State land leasing regulations have been modified to require public notice of lease bidding to be published twice during a four-week period to speed up geothermal development. The state legislature has enacted geothermal development incentives including tax relief and a depletion allowance of 27.5 percent. Further, new geothermal legislation has been approved by the Arizona Senate Natural Resources Committee; amendments will follow.

At present, the Hooker Hot Springs health spa and hot baths at Safford and Buckhorn Hot Springs demonstrate geothermal energy use. The possible utilization of geothermal energy for copper solution mining at Morenci is under investigation.

6.3.2 California

To date, geothermal energy development in California has been primarily at The Geysers for private electric applications. (Electric development in California is discussed in Chapter 7.0, Private Industry.) An increasing number of direct heat applications, however, are being proposed for the state. The California Energy Commission plays a significant role in accelerating the development of these projects and providing assistance, where needed.

The Geothermal Office of the California Energy Commission reports that state and Federal funds amounting to $130,000 are available for technical and financial assistance to counties with potential geothermal resources. Los Angeles County has requested funding for an extensive study of resource potential. The country intends to evaluate ten candidate sites.

In Alameda, the Public Utilities Board is participating in a drilling project to tap geothermal power from underground steam sources in Lake County. Costs will be shared by the eleven member cities comprising the Northern California Power Agency. A Federal loan guaranty has been approved for this project.

An aerospace component manufacturer, Rohr Industries, has received a state grant to investigate the feasibility of using geothermal energy for space and water heating and drying freshly painted parts.

Geoproducts Corporation has proposed a 50 MW geothermal power plant in Wendel. The geothermal energy will heat and dehydrate wood residues burned for electrical generation, and heat boiler feed and combustion air. The Department of Agriculture, U. S. Forest Service, and the California Department of Water Resources are providing partial funding for this $60 million project.

The Geothermal Resource Information and Planning Service (GRIPS) Commission has been established to stimulate geothermal development in Lake, Mendocino, Napa, and Sonoma counties. A large timber milling complex in Cloverdale is being investigated at present. The resource there may be used for kiln drying or to produce steam for a small generating facility. District heating and fruit dehydration applications are also under consideration.

The Governor has signed a bill that creates a Renewable Resources Fund. The provisions of the bill stipulate that 30 percent of revenues derived from BLM leases in California be placed in a Renewable Resources Fund and that an additional 30 percent of these revenues be allocated to the California Energy Commission for disbursal to local governments as grants for geothermal projects. The remaining 40 percent of this money goes to the county of lease for:

1) Geothermal resource assessment and exploration technology development,

2) Local regulatory planning and policy development,

3) Implementation of environmental mitigation measures,

4) Collection of base data for environmental monitoring,

5) Preparation of geothermal resource elements,

6) Monitoring of geothermal facilities in compliance with applicable regulations,

7) Providing public services necessitated by geothermal development or production, and

8) Demonstration of technical and economic feasibility of geothermal direct heat and electric generation.

Another bill provides for the return of 60% of all lease money from leases on Federal lands to the county to cover the costs of development impacts.

The California Division of Mines and Geology is performing a micro-earthquake survey and analysis of geothermal resources near Long Valley. The San Bernardino Board of Water Commissioners has authorized a study to assess the feasibility of using geothermal fluid to provide industrial process heat for a waste-water treatment plant. The California Energy Commission is funding a space heating and snow melting application at Mammoth Lakes.

The California Energy Commission has conducted a market survey of direct heat potential and is assisting the City of Susanville with its district heating system. Several public building complexes and a low-income housing development will be heated with geothermal energy.

The California State Lands Commission held three competitive lease sales during 1980.

6.3.3 Hawaii

The state is studying potential high-temperature sites near Puna and Kailua-Kona on Hawaii. The University of Hawaii is assessing geothermal resources on Hawaii, and will extend its program to Maui and Oahu.

A $6 million generating plant for the island of Hawaii is under construction. The project is a joint venture among the Department of Energy, state, county, University of Hawaii and the Hawaii Electric Company (HELCO). HELCO will distribute the electricity and operate and maintain the facility.

6.3.4 Nevada

Nevada already has several commercial direct heat applications. Forty wells have been developed in Reno for space conditioning and recreational use. The Bureau of Mines and Geology is studying state thermal waters.

An ethanol plant using geothermal energy has been proposed for Mineral Hot Springs and Wabuska Hot Springs. A demonstration alcohol plant is proposed for the Winnemucca area. The Four Corners Regional Commission and DOE may jointly sponsor the project.

A cooperative study between the Bureau of Mines and Geology, the Nevada Department of Energy, and the Oregon Institute of Technology is being conducted to assess the potential development of a geothermal district heating system at Caliente. The City of Hawthorne, which has a hot water well immediately outside the town limits with a moderately high flow rate, is considering a geothermal district heating system. The Double Diamond Development Company of Reno is planning to heat their new south Reno housing tract with geothermal and solar energy. Preliminary exploration began in 1980 and the 8000 family unit project will be completed in 1982 or later. Several potential direct heat applications at Steamboat Hot Springs are being evaluated including district heating of 6000 unit subdivision, heating of the post office, and heating of an amusement park.

Resource assessments are being performed by the Nevada Bureau of Mines and Geology and University of Utah Research Institute for Hawthorne, Gabbs, and Wells. Exploratory drilling is continuing in Eureka, Churchill, and Pershing counties.

6.4 NORTHWEST STATES (REGION X)

6.4.1 Idaho

Numerous geothermal applications, mostly nonelectric, are under development in Idaho. Boise Geothermal is continuing to develop a comprehensive plan for the Boise district heating project. The Economic Development Administration, the City of Boise, and the Boise Warm Springs Water District will share the costs of expanding the existing geothermal space heating system.

The Idaho Water and Energy Resources Research Institute is assessing geothermal resources in the Blackfoot River Basin of southeastern Idaho.

At Malad, the school district is investigating the potential of geothermal energy for space heating. The possibility of a geothermal district heating system is being examined at Preston through a state grant. If constructed, the project will cost an estimated $3.5 million. Further, the state has granted $15,000 for a proposed alcohol plant at Roystone.

The Idaho Legislature has passed a law which defines space heating as a domestic use of water. Cities can issue revenue bonds to finance construction of geothermal systems and operate such systems.

The state has appropriated funds to the Division of Public Works for the geothermal retrofit of the Capitol Mall state office complex. A production well has been drilled and construction is underway. Morrison Knudson has been contracted by the state to study waste water disposal.

6.4.2 Oregon

The State of Oregon first derived benefit from geothermal energy in the early 1900s. The application, located in Klamath Falls, supplied geothermal heat to over 100 homes.

Since 1971, the Oregon Department of Geology and Mineral Resources has performed geothermal resource assessments at numerous sites. The program, which receives extensive state support, is also funded in part by DOE. Temperature gradient holes have been drilled near Mount Hood, Klamath Falls, Lakeview, Vale, Malheur County, Powell Butte, Willamette Pass, Lake County, Harney County, and La Grande. Harney County was among those recommended for intensive geothermal research.

A study initiated in 1976 by the Eastern Oregon Community Development Council and funded by the Pacific Northwest Commission is continuing. The investigation will determine the extent of geothermal resources in Union and Baker Counties and propose appropriate applications.

A district heating system has been proposed for Lakeview. The plan includes heating of 51 public and commercial buildings and the construction of an ethanol plant. The town has received funding from the Economic Development Administration, the State of Oregon, Lake County, and DOE under the User-Coupled Drilling Program.

Oakridge is seeking funding to district heat the elementary and high school, post office, city hall, and some residences. A feasibility study is underway.

The state is partially funding a project proposed for Burns. The Hines Lumber Mill, which had been shut down, is being renovated for cogeneration. A combination of biomass and geothermal energy will be used for preheating the boilers.

The Oregon Department of Energy administers a small grants program for community energy projects and contracts for district heating feasibility studies.

During the year Oregon voters approved the creation of a Renewable Resource Program Fund. It empowers the state to sell bonds for up to half of one percent of the value of taxable property. Bonding capacity is set a $300 million, a loan fund will be created, and principal and interest payments will be used to pay off bonds. Further, the Oregon legislature has established the Alternative Energy Development Commission to prepare a comprehensive alternative energy resource development state program.

6.4.3 Washington

The State Department of Natural Resources conducts a geothermal assessment and reservoir definition program, which is funded in part by DOE. Test holes are being drilled throughout the state.

Ephrata has been selected, along with 17 other cities, to receive a HUD grant for developing geothermal energy to heat commercial and residential buildings. Energy derived will be supplied to the Grant County Courthouse and low income housing in the area. The city of North Bonneville is examining the potential of district heat for a new town site.

The state has been studying the potential of area geothermal resources since 1972. The Washington Division of Geology and Earth Resources has drilled thermal gradient holes and conducted heat flow tests. Geologic, aero-magnetic, and gravity maps have been compiled and reports on the location of earthquake hypocenters have been published.

A bill has been proposed by the state legislature to establish a specific agency to accelerate energy facility licensing for hydroelectric and geothermal plants.

6.4.4 Alaska

The state of Alaska has expressed interest in geothermal energy development. The Department of Natural Resources, Division of Geologic and Geophysical Surveys is assessing the potential of geothermal resources on the Alaskan Peninsula and the Aleutian Islands. Site-specific investigations are planned for Unalaska Island. The Geophysical Institute, University of Alaska and the Department of Natural Resources are exploring the geothermal resource at Pilgrim Hot Springs as part of a six-year program of site-specific geothermal exploration studies. The program will include investigating the bedrock structure and evaluating surface deposits. The information will be published in an atlas of Alaskan thermal springs.

6.5 INDIAN TRIBES

Many tribes are pursuing the utilization of geothermal resources to supply costly energy demands. The development of resources on Indian reservations can provide jobs and strengthen the tribal economies.

6.5.1 Fort Bidwell Indian Community

The California Energy Commission has contracted with the Fort Bidwell Indian Community to assess local geothermal resources. The contract includes geochemical and geophysical studies and some drilling. Geothermal wells will be developed on the reservation for space heating of buildings, fish farming, and commercial greenhouses.

6.5.2 Cheyenne River Sioux

The Cheyenne River Sioux in Ziebach County, South Dakota, have been awarded a DOE grant to renovate geothermal artesian wells on the reservation.

6.5.3 Moapa Reservation

The Moapa Reservation in southern Nevada is considering the utilization of geothermal resources to heat four acres of greenhouses. A geothermal reservoir was discovered outside the reservation; the tribe is negotiating for use of the resource.

7.0 PRIVATE INDUSTRY

Since the geothermal industry got its start at The Geysers in the mid-1950s, the private sector has played the major role in developing geothermal resources for electricity generation. The Federal geothermal energy program is designed to accelerate the pace of private development by providing access to resources on public lands and removing technical, economic, and institutional barriers to the growth of the industry, while recognizing that the key role in developing a strong geothermal industry and producing and using significant amounts of geothermal energy must remain in the private sector.

7.1 INDUSTRY STRUCTURE

The geothermal industry in its present form is dominated by a core group of traditional companies with well-defined programs oriented toward electric power generation. Another distinct group, consisting of companies and joint ventures attracted by geothermal direct heat opportunities, has started to emerge.

The core group of traditional companies has evolved as a result of the pioneering efforts to develop the steam-dominated hydrothermal resource at The Geysers. This group is comprised primarily of four distinct types of industrial entities that are oriented to particular phases of development. Most of the companies in the categories described below have assumed more than one role and thus have been engaged in more than one phase of resource development.

- Energy companies include both small and large firms, including large oil companies, whose mission is to supply energy. Their geothermal efforts are focused on producing steam for electrical power generation. These firms have been very active in exploring for and developing the resource rather than in building power plants or using the geothermal energy.

- Geothermal companies have usually been formed for the express purpose of developing geothermal energy. Though generally small, some have affiliations with large energy companies. Their current role ranges from exploration support to steam production, including promotion of joint action between energy companies as operators and utilities as users.

- Engineering companies include both small, special-purpose engineering companies that are pioneering certain plant design concepts or components and large A&E firms that design and build geothermal plants in the same manner as other energy-generating plants. They are often the technical link between the developer/operator and the final user of the resource. In some cases, they market geothermal energy to users (generally utilities) and even underwrite project risks.

- Electric energy suppliers, the most significant users in the current industry structure, are comprised of regulated and nonregulated utilities, municipalities, and some large industries with a substantial need for electrical power. These users are currently located almost exclusively in the western U.S.--generally near major geothermal resources.

The traditional core of the industry has established industrial components with well-defined roles, accepted technological objectives, and limited geographical orientation. The evolving part of the industry--that portion involved in developing direct applications of geothermal heat--is currently somewhat unfocused, loosely structured, and characterized by differentiated and distributed markets. It is in the use of the resource that the electric and nonelectric segments of the industry basically differ. The principal nonelectric users are firms seeking access to geothermal energy, small resource owners wishing to develop or sell the resource, and engineering companies or companies formed as general promoters/developers to put together complete development packages.

Unlike the established industry, which has electric power production as the common objective and focuses on specific centralized markets (i.e., utilities), the direct heat industry is interested in a wide variety of applications at dispersed locations. Many of the activities of the evolving direct heat segment of the industry remain oriented around government-sponsored and funded programs.

7.2 RECENT INDUSTRY ACTIVITIES

Significant advances have been made in the last year in the use of both vapor- and liquid-dominated hydrothermal resources for electricity generation.

7.2.1 Power Plant Construction

Total capacity at The Geysers dry steam field in California, which has been developed solely by private industry, has been brought to 910 MWe with the addition in 1980 of PG&E Units 13 and 14, with respective capacities of 129 MWe and 110 MWe. Unit 13 is the world's largest single facility generating electricity from geothermal resources. Construction of Units 17 and 18, with planned capacities of 110 MWe each, is underway and Unit 16 is scheduled to begin construction in the spring of 1981. Approval has been granted to McCulloch Geothermal for a 55 MWe power plant in Lake County to provide electricity for industry, agriculture, and municipal uses and to the Northern California Power Agency for a 110 MWe power plant and a 66 MWe plant.

Outside The Geysers, historic milestones were achieved in 1980 in bringing liquid-dominated reservoirs on-line for electrical generation with the completion of demonstration and pilot plants at East Mesa and Brawley geothermal fields. Under industry/DOE cooperative agreements, Magma Energy and San Diego Gas and Electric (SDG&E) completed construction of a 10 MWe binary cycle plant at East Mesa, the first geothermal electric power plant in the United States to generate electricity from a hot-water resource. Union Oil and Southern California Edison (SCE) completed a 10 MWe flash-steam pilot plant at Brawley. SDG&E and Magma began negotiations to build two plants of 24 MWe and 49 MWe at Niland in the northern Imperial Valley and Union Oil and SCE announced plans to develop an additional 10 megawatts at Niland. A 48 MWe power plant at East Mesa is being planned by Republic Geothermal and Jacobs Engineering. A 55 MWe hybrid power plant at Wendel-Amedee, using geothermal resources and wood chips, is planned by the Geoproducts Corporation. DOE and SDG&E concluded contract negotiations for construction of a 50 MWe binary-cycle facility at Heber, just west of the East Mesa geothermal field. South of Brawley field, MCR Geothermal completed three wells in a joint venture with Geothermal Kinetics (CU-I Venture) under a DOE loan guarantee. The ultimate objective of the project is a 45 MWe dual-flash electrical generating plant planned in conjunction with the California Department of Water Resources.

Other electrical-generation projects have been pursued outside California. Phillips Petroleum has agreed with Utah Power and Light to provide geothermal energy for a 20 MWe flash-steam power plant at Roosevelt Hot Springs in southwestern Utah. Ten wells have been completed at the hot-water resource there. Construction of the 50 MWe geothermal demonstration plant at the Valles Caldera in New Mexico, where seven commercial-quality production wells have been completed, has been delayed by environmental, cultural, legal, and procedural problems. This project is being carried out under a DOE/Public Service of New Mexico/Union Oil agreement. DOE is cost sharing this demonstration project.

7.2.2 Exploration

Exploratory activity in 1980 included joint venture agreements in Hawaii and northern California and drilling of remote wildcats in Nevada, New Mexico, and Idaho by independent operators and geothermal divisions of large oil companies, sometimes in conjunction with state agencies and DOE resource assessment programs. The Petroleum Information Corporation has reported completion of eighteen wildcat "discoveries" in thirty-eight exploratory attempts in 1980. Eight of these were drilled in California as step-out wells from The Geysers or tapped liquid-dominated reservoirs in the Imperial Valley. Several discoveries made in South Dakota, Idaho, and elsewhere in California may result in direct use projects. Drilling statistics for the last year indicate an upsurge of interest in drilling outside The Geysers and the Imperial Valley.

Drilling agreements have been made between several companies. Geothermal Exploration and Development Company (GEDCO) and Water Resources International are drilling a well in the Puna Rift Zone in Hawaii. Aminoil USA and Geothermal Resources International have agreed on a three-year program of exploration on some 190,000 acres in The Geysers, CA., Nevada, New Mexico, Oregon and Utah. Union Oil of California and Mountain States Resources have agreed to conduct exploratory drilling in south-central Utah's Monroe-Joseph KGRA.

Table 7.1 provides a summary of industry activity in geothermal drilling ventures in 1980. Table 7.2 is a summary of drilling activities for the period 1975-1980. Leasing of lands by industry in 1980 is presented in Table 7.3.

7.2.3 Direct Heat Projects

With the help of federal funds, a number of direct heat applications projects were initiated or completed in 1980. Geothermal direct heat systems were put into service for ranch operations and space heating of a school and a hospital in South Dakota and space and water heating for YMCA in Klamath Falls, Oregon. Other 1980 geothermal direct heat activities include completion of drilling, testing, and system design for the Torbett-Hutchings-Smith hospital in Texas; construction of a heating system for a commercial-scale prawn farm in Riverside, California; confirmation drilling for space and water heating of a townhouse complex in Reno, Nevada; completion of a well by Utah Roses for greenhouse heating in Sandy, Utah; resource confirmation for space heating of a greenhouse and a prison in Salt Lake County, Utah; drilling of a well to supply water to heat the Patterson Hotel in North Dakota; leasing of land by Indian Rock Greenhouse for 10 geothermal greenhouses in Klamath County; and drilling of a production well for pulp-drying operations at the Holly Sugar Refinery in Brawley.

A quickly developing subindustry that has begun to emerge from the geothermal direct-heat industry focuses on the use of geothermal process heat to manufacture ethanol from a biomass feedstock. This industrial application of geothermal energy, besides displacing use of conventional fossil fuels for process heat, has the potential to respond to the U.S.' critical need for liquid fuels. Sites of currently planned and operating ethanol projects, several of which have received no federal funding, are located in nine states.

Two ethanol plants have begun operations this year and two more are under construction. A plant built by Tad's Enterprises in Yerington, Nevada uses 220°F flashed steam from Wabuska Hot Springs to distill ethanol from corn at a rate of 400,000 gallons a year. The 199 proof ethanol will be used in producing gasohol to be sold in service stations. At Hot Lake, Oregon, Grande Ronde Commodities is operating two ethanol stills, one primarily for experimental purposes which produces 48,000 to 65,000 gallons per year, and another commercial still with 1.5 to 2 million gallon per year capacity. Owyhee Energy Producers of Adrian, Oregon have started work on an ethanol plant that will use geothermal process heat in converting farm crop surpluses to produce 800,000 gallons per year of ethanol. At Cove Fort, Utah, R&R Energies is planning is use geothermal energy and sugar beets to produce 12 million gallons of alcohol annually. Currently plans are to cascade the water to a greenhouse or fish farm before reinjection. In addition to the projects just described, two projects in East Mesa, California and Brady Hot Springs, Nevada have been proposed and seventeen others in seven western states and Texas and Hawaii are being evaluated or considered. These projects could produce a total of about 223 million gallons of ethanol per year by 1985.

Several of the direct-heat projects described above, as well as other projects which are joint efforts between private industry, the Federal government and/or state and local governments, are described in greater detail in Chapter VI, State and Local Governments and Appendix D, Geothermal Direct Heat Applications Demonstration Projects.

PRIVATE INDUSTRY DRILLING ACTIVITIES, 1980

WELL TYPE	GEOTHERMAL						INJECTION			OBSERVATION			GEOPRESSURED			TEST		
STATUS / COMPANY NAME	PRODUCIBLE	SHUT IN	TESTING	DRILLING	SUSPENDED	ABANDONED	ACTIVE	SHUT IN	ABANDONED	ACTIVE	SUSPENDED	ABANDONED	TESTING	ABANDONED	DRILLING	DRILLING	ACTIVE	STATE(S)
Amax Exploration	1	1																NV
Aminoil USA	4		1				1											CA
Aquafarms International										1								CA
Chevron										4	1							NV, OR
Eaton Industries													1					LA
Eaton Operator														2				TX, LA
Elko Heat			1															NV
Geothermal Exploration & Development			1															HI
GRI Operator				1														CA
Gruy Federal														1				LA
Lamar Hunt Geothermal Operations				1														NM
Magma Gulf/Technadril															1			LA
MAPCO Geothermal	1																	CA
MCR Geothermal	1							1	1									CA
Northwest Geothermal										1		1						OR
Occidental Geothermal	2				1											2		CA
Phillips Petroleum	1	1		1			1										2	CA, ID, UT
Republic Geothermal	1																	CA, NV
Shell Oil	5					1												CA
Sunoco		1	1	1	2	2												ID, NV, CA
Thermogenics	2																	CA
TRW				1														CA
Union Oil	24		3	3			1											CA, NM
Utah Roses							1											UT
TOTAL	42	3	7	8	3	3	4	1	1	6	1	1	1	3	1	2	2	

Source: Geothermal Progress Monitor Drilling File

Table 7.2

GEOTHERMAL DRILLING ACTIVITIES SUMMARY, 1975-1980

CLASSIFICATION*	1975	1976	1977	1978	1979	1980
Producible	30	37	22	19	48	57
Injection	1	0	3	2	3	5
Observation	13	8	1	15	13	7
Geopressured	0	0	0	1	0	1
Hot Dry Rock	0	0	0	0	0	0
Test	0	0	0	0	0	3
Suspended	10	4	10	7	11	5
Abandoned	9	7	10	22	9	10
Unknown	4	3	0	4	2	0
TOTAL	67	59	46	70	86	88

*Does not include temperature gradient wells.

Source: Geothermal Progress Monitor Drilling File

Table 7.3

INDUSTRY LEASING ACTIVITY IN 1980

Leaseholding Company	Location: State	Location: Area	Location: County	Competitive Number	Competitive Acreage	Non-Competitive Number	Non-Competitive Acreage	Total Number	Total Acreage
AGD	NV		Pershing			9	20,857	9	20,857
Anadarko	NV		Churchill			1	1919		
	OR	Alvord Hot Springs	Harney	2	4743			3	6662
Atlantic Richfield	NV		Humboldt			1	758	1	758
Champlin Petroleum	NV	Dixie Hot Springs	Churchill	3	7007			3	7007
Chevron USA	NV		Eureka			1	1919	1	1919
Earth Power	NV		Humboldt			1	2018	1	2018
Francana Resources	OR		Lake			2	1039	2	1039
Geothermal Power	UT		Beaver			1	2553	1	2553
Geothermal Resources	NV		Washoe	1	248			7	11,100
	NV	Darroush Hot Springs	Nye	1	2379				
	NV	Dixie Hot Springs	Churchill	1	2559				
	OR		Malheur			4	5914		
Hassie Hunt Exploration	NV		Churchill			1	639	1	639
Hunt Oil	NV		Lander			5	7797	7	12,511
	OR	Crump Geyser	Lake	2	4714				
Getty Oil	OR	Alvord Hot Springs	Harney	4	7704			4	7704
Intercontinental Energy	OR	Klamath Falls	Klamath	1	118			1	118
Livingston International	NM	Lightning Rock	Hidalgo			1	1718	1	1718
O'Brien Resources	NV		Churchill			2	3376	2	3376
Philips Petroleum	NV		Pershing			1	1257	2	3816
	WA	Indian Heaven	Skamania			1	2559		
Sunoco Energy	OR		Linn			1	519	1	519
Thermal Power	NM	Socorro Peak	Sorroco	3	6426			4	7568
	UT	Cove Fort-Sulphurdale	Beaver			1	1142		
Thermal Resources	NM	Lightning Rock	Hidalgo			1	463	5	2964
	OR	Vale Hot-Springs	Malheur			4	2501		
Union Oil	OR	Breitenbush Hot Springs	Marion	1	1039			1	1039
Private Individuals *	CA		San Bernardino			1	639	111	210,222
	NM		Dona Ana			6	11,043		
	NM		Socorro			4	6063		
	NV		Pershing			27	55,265		
	NV		Churchill			9	14,688		
	NV		White Pine			15	33,712		
	NV		Eureka			1	1919		
	NV		Lander			10	15,493		
	NV		Humboldt			17	27,909		
	NV		Nye			1	1639		
	OR		Malheur			17	34,173		
	UT		Beaver			3	7679		

*Company affiliation, if any, is not known.

Source: Lawrence Berkeley Laboratory

Appendix A

INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

INTERAGENCY GEOTHERMAL COORDINATING COUNCIL

A.1 ORGANIZATION

The Interagency Geothermal Coordinating Council (IGCC) consists of the Federal agencies which participate in the geothermal program. The IGCC is responsible for oversight and coordination of the activities of the Federal geothermal community. That responsibility is spelled out in the Geothermal Research, Development, and Demonstration Act of 1974 (PL 93-410), specifically:

> ... to coordinate those Federal plans, activities, and policies which are related to or impact on geothermal energy, including ancillary activities of agenices not represented in the Council membership ... The Council, through the Chairman, may make recommendations to the appropriate agencies and the President with regard to alternative policies or actions considered necessary or desirable to expedite the development and utilization of geothermal energy resources.

The overall objective of the IGCC is to encourage development and use of geothermal resources as a clean, safe, and economical alternative energy source to meet the nation's energy needs. The IGCC's specific objectives to that end are to:

1. Promote commercial development of known hydrothermal resources for electricity generation and direct heat use where such development appears to be economically feasible and environmentally acceptable.

2. Continue to discover and assess additional geothermal resources.

3. Determine whether methane can be produced economically from geopressured resources, with an acceptable level of environmental effects.

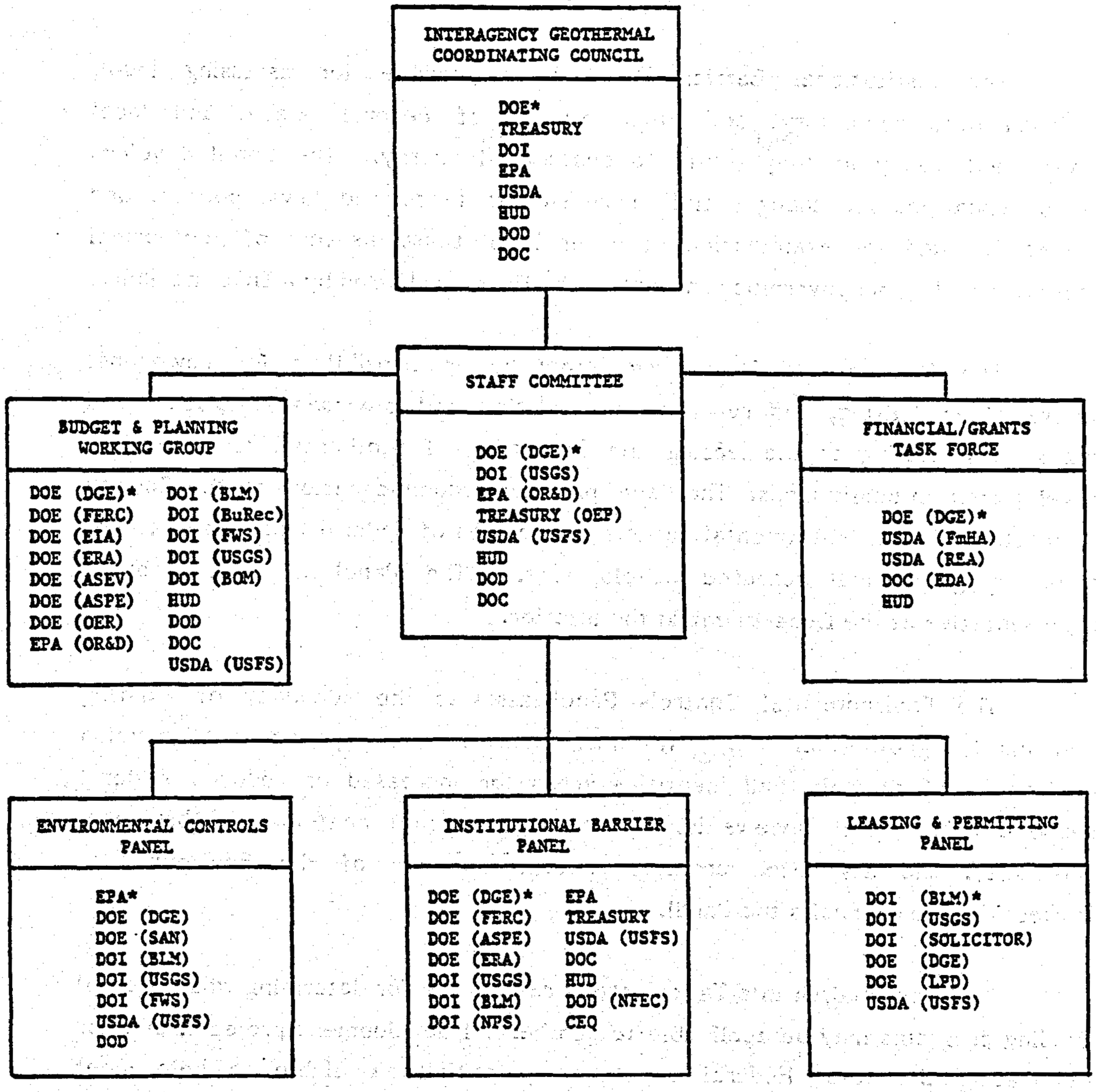
4. Reduce costs of technology associated with geothermal exploration, site development, energy production and environmental compliance.

5. Simplify the regulatory and institutional maze faced by commercial geothermal developers while ensuring that the societal values reflected in current regulations are protected.

6. Explore the technological and economic feasibility of extracting heat from hot dry rock as a potential new source of energy in the long term.

The structure and membership of the IGCC is presented in Figure A.1. The Council, chaired by an assistant Secretary of the Department of Energy, has responsibility for coordinating the entire Federal program for geothermal energy. Six major subgroups comprise the IGCC. The Staff Committee, chaired by a representative of DOE, supports the Council and manages the other groups. The agency members of the Staff Committee are appointed by the Council and represent suborganizations of those Federal agencies on the Council.

The Budget and Planning Working Group coordinates budgets and agency plans for geothermal energy activities. The Group is responsible for formulating long-range geothermal energy utilization goals, coordinating the annual program plans and budgets of the Council agencies and other agencies participating in the Federal Geothermal Program, identifying programmatic and policy issues for Council consideration, monitoring and reporting on the progress of the Federal program, and preparing the Annual Reports of the IGCC. The Group is chaired by a representative of DOE, and its membership includes representatives of each of the Council agencies.



LEGEND

CEQ-Council on Environmental Quality
DOC-Department of Commerce
DOD-Department of Defense
- NFEC Naval Facilities Engineering Command

DOE-Department of Energy
- ASEV Office of Assistant Secretary, Environment
- ASPE Office of Assistant Secretary, Policy Planning and Evaluation
- ASRA Office of Assistant Secretary, Conservation and Renewable Energy
- DGE Division of Geothermal Energy
- EIA Energy Information Administration
- ERA Economic Regulatory Administration
- FERC Federal Energy Regulatory Commission
- LPD Leasing Permitting Division
- OER Office of Energy Research
- SAN San Francisco Operations Office

DOI-Department of the Interior
- BLM Bureau of Land Management
- BOM Bureau of Mines
- FWS Fish and Wildlife Service
- NPS National Parks Service
- SOLICITOR Office of the Field Solicitor
- USGS United States Geological Survey
- BuRec Bureau of Reclamation

HUD-Department of Housing and Urban Development
EPA-Environmental Protection Agency
- OR&D Office of Research and Development

TREASURY-Department of the Treasury
USDA-United States Department of Agriculture
- FmHA Farmers Home Administration
- REA Rural Electrification Administration
- USFS United States Forest Service

*Denotes chairing function.

Figure A.1 Organization of the IGCC

The Institutional Barrier Panel is responsible for assessing legal, environmental, regulatory, and other aspects of Federal, state, and local government policy as they relate to geothermal energy. The Panel develops recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including nongovernment aspects. The Panel is chaired by a DOE member.

The Leasing and Permitting Panel has responsibility for reviewing, analyzing, evaluating, and reporting on existing and proposed legislation and regulations relating to the leasing and permitting of geothermal resources and development on public lands. The Panel provides recommendations to the Council on matters of interdepartmental concern in the area of Federal lands management affecting geothermal resource development. The Panel is chaired by a representative of the Department of the Interior.

The Environmental Controls Panel assesses the adequacy of existing controls for geothermal energy systems, reviews ongoing programs to develop environmental controls, and identifies areas for increased or reduced Federal support. The Panel reviews issues covering pollutant abatement, subsidence, seismicity, and associated areas. A representative of the Environmental Protection Agency chairs the Panel.

The Financial/Grants Task Force is responsible for determing what Federal funding programs may be applicable to geothermal development projects, and for delineating the total Federal assistance potentially available to help meet geothermal objectives. The Task Force is chaired by a member of DOE.

The membership of the Council and its subgroups is listed on the following pages. In addition, a summary of activities is provided for the Council and each subgroup.

A.2 MEMBERSHIP

A.2.1 Interagency Geothermal Coordinating Council

Member	Alternate
Chairperson Honorable Ruth M. Davis Assistant Secretary for Resource Applications Department of Energy	
Honorable M. Rupert Cutler Assistant Secretary for Natural Resources and Environment Department of Agriculture	Dr. Ned D. Bayley Deputy Assistant Secretary for Natural Resources and Environment
Honorable Joan M. Davenport Assistant Secretary for Energy and Minerals Department of the Interior	Mr. Richard Wilson Special Assistant for Energy and Minerals
Honorable Robert C. Embry Assistant Secretary for Commercial Planning and Development Department of Housing and Urban Development	Mr. Anthony M. Carey Energy Advisor
Honorable Stephen J. Gage Assistant Administrator for Research and Development Environmental Protection Agency	Mr. Steven Reznek Deputy Assistant Administrator for Environmental Engineering and Research
Honorable Curtis A. Hessler Assistant Secretary for Economic Policy Department of the Treasury	Mr. Dell V. Perry Office of the Assistant Secretary for Economic Policy

Member	Alternate
Honorable Jerry J. Jasinowski Assistant Secretary for Policy Department of Commerce	Mr. Frederick T. Knickerbocker Deputy Assistant Secretary for Industry Policy
Honorable Robert B. Pirie, Jr. Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) Department of Defense	Mr. George Marienthal Deputy Assistant Secretary of Defense (Energy, Environment and Safety)

Staff:
Ms. Helen Krupovich
Division of Geothermal Energy
Resource Applications
Department of Energy

A.2.2 Staff Committee

Member	Alternate
Chairman Mr. Bennie G. DiBona Director, Division of Geothermal Energy Resource Applications Department of Energy	
Mr. David R. Berg Energy Process Division Office of Research and Development Environmental Protection Agency	
Mr. Anthony M. Carey Energy Advisor Assistant Secretary for Community Planning and Development Department of Housing and Urban Development	Mr. Eric Stevenson Special Assistant Assistant Secretary for Community Planning and Development
Mr. George H. Davis Director, Minerals and Water Resources U.S. Geological Survey Department of the Interior	Mr. Donald W. Klick Deputy Chief Office of Geochemistry and Geophysics
Mr. Sidney F. Gray Minerals and Geology U.S. Forest Service Department of Agriculture	
Mr. Frederick T. Knickerbocker Deputy Assistant Secretary for Industry Policy Department of Commerce	Mr. Joseph F. Gustaferro Office of Policy (Industry Programs)

Member	Alternate
Captain T. F. Stallman, USN Director, Energy and Natural Resources Division Naval Material Command Department of Defense	Mr. Thomas A. Ladd Energy and Utilities Division Naval Facilities Engineering Command
Mr. William E. Steger Office of Energy Policy Department of the Treasury	Ms. Eleanor Bryan Office of Energy Policy Department of the Treasury

A.2.3 Budget Planning and Working Group

Member	Alternate
Chairman Dr. Fred Abel Division of Geothermal Energy Resource Applications Department of Energy	
Mr. David R. Berg Energy Process Division Office of Research and Development Environmental Protection Agency	
Mr. Anthony M. Carey Energy Advisor Assistant Secretary for Community Planning and Development Department of Housing and Urban Development	
Mr. George H. Davis Director, Minerals and Water Resources U.S. Geological Survey Department of the Interior	Mr. Donald W. Klick Office of Geochemistry and Geophysics Mr. Alan Kover Office of Geochemistry and Geophysics
Mr. Karl Duscher Divison of Onshore Energy Resources Bureau of Land Management Department of the Interior	
Mr. Wayne Fernelius Planning Policy Staff Water Power and Resources Service Department of the Interior	

Member	Alternate
Mr. Malcolm Furbush Conservation Division Office of Resource Evaluation U.S. Geological Survey Department of the Interior	
Mr. Sidney F. Gray Minerals and Geology U.S. Forest Service Department of Agriculture	Mr. Walter E. Schlumpf Minerals and Geology
Mr. Joseph F. Gustaferro Office of Policy (Industry Programs) Department of Commerce	
Dr. Thomas Henrie Chief Scientist Bureau of Mines Department of the Interior	
Mr. Walter H. Howe Conservation Division Office of Resource Evaluation U.S. Geological Survey Department of the Interior	
Mr. William Spaulding, Jr. Office of Ecological Services U.S. Fish and Wildlife Service Department of the Interior	Mr. Richard Forrester Offfice of Ecological Services
Captain T. F. Stallman, USN Director, Energy and Natural Resources Divison Naval Material Command Department of Defense	Mr. Thomas A. Ladd Energy and Utilities Division Naval Facilities Engineering Command

Department of Energy Members

Member	Alternate
Dr. Robert Blaunstein Solar, Geothermal, Conservation Assessment Program Technology Assessments Division Office of Assistant Secretary Environment	
Mr. Daniel Dick Leasing Policy Development Division Office of Assistant Secretary for Resource Applications	Mr. John Broderick Leasing Policy Development Division
Mr. Franklin C. Emerson Office of Integrative Analysis Energy Information Administration	
Mr. Bruce Engelbert Conservation and Renewable Resources Office of Assistant Secretary Policy and Evaluation	
Mr. Charles R. Mandelbaum Program Analysis Office of Energy Research	
Mr. William I. Wheelock Interconnection Systems Analysis Federal Energy Regulatory Commission	

A.2.4 Institutional Barrier Panel

Member	Alternate
Chairman Mr. Randall C. Stephens Division of Geothermal Energy Resource Applications Department of Energy	
Mr. David R. Berg Energy Process Division Office of Research and Development Environmental Protection Agency	
Mr. James Bussee Division of Power Supply and Reliability Office of Utility Systems Economic Regulatory Administration Department of Energy	
Mr. Anthony M. Carey Energy Advisor Assistant Secretary for Community Planning and Development Department of Housing and Urban Development	
Mr. Bernard B. Chew Director, Division of Interconnection and Systems Analysis Office of Electric Power Regulation Federal Energy Regulatory Commission Department of Energy	William I. Wheelock

Member	Alternate
Mr. Bruce Engelbert Conservation and Renewable Resources Office of Assistant Secretary Policy Evaluation	
Mr. Seymour Fiekowsky Office of Tax Analysis Department of the Treasury	
Mr. Sidney F. Gray Minerals and Geology U.S. Forest Service Department of Agriculture	
Mr. Raymond Herrman National Park Service Department of the Interior	
Mr. Thomas A. Ladd Energy and Utilities Division Naval Facilities Engineering Command Department of Defense	
Mr. R. W. Lawton Leasing Policy Development Office Resource Applications Department of Energy	Mr. Daniel B. Dick
Mr. James Mackenzie Office of Energy Programs Council on Environmental Quality	
Mr. Billy Shoger U.S. Geological Survey Department of the Interior	

Member	Alternate
Mr. Dale Zimmerman Bureau of Land Management Department of the Interior	Ms. Doris Koivula Mr. Karl Duscher Mr. Kenneth Lee Division of Energy and Resources Office of the Solicitor

A.2.5 Leasing and Permitting Panel

Member	Alternate
Chairman Mr. Winston B. Short Division of Energy Minerals Resources Bureau of Land Management Department of the Interior	
Mr. Burton B. Barnes Division of Geothermal Energy Resource Applications Department of Energy	
Mr. Robert Conover Office of the Field Solicitor Department of the Interior	
Mr. Gerald R. Daniels U.S. Geological Survey Department of the Interior	
Mr. Daniel B. Dick Leasing and Policy Development Office Resource Applications Department of Energy	
Mr. Karl Duscher Division of Energy Minerals Resources Department of the Interior	
Mr. Sidney Gray Minerals and Geology U.S. Forest Service Department of Agriculture	

Member	Alternate
Mr. Bruce Hellier Office of the Area Geothermal Supervisor U.S. Geological Survey Department of the Interior	
Mr. Theodore Holland Division of Technical Services Bureau of Land Management Department of the Interior	
Mr. Kenneth Lee Division of Energy and Resources Office of the Solicitor Department of the Interior	
Mr. Billy Shoger Conservation Division U.S. Geological Survey Department of the Interior	
Mr. Norman Stark Minerals Assessment Branch U.S. Forest Service Department of Agriculture	

A.2.6 Environmental Control Panel

Member	Alternate
Chairman Mr. David R. Berg Energy Processes Division Office of Research and Development Environmental Protection Agency	
Vice Chairman Mr. Clifton McFarland Division of Geothermal Energy Resource Applications Department of Energy	
Mr. A. David Allen Division of Geothermal Energy Resource Applications Department of Energy	
Mr. Douglas Boehm Office of Environmental Compliance and Overview Environment Department of Energy	Dr. Robert Blaunstein Solar, Geothermal, Conservation Assessment Program Technology Assessments Division
Sie Ling Chiang U.S. Geological Survey Department of the Interior	Mr. Alan Kover Office of Geochemistry and Geophysics
Mr. Karl Duscher Division of Onshore Energy Resources Bureau of Land Management Department of the Interior	

Member	Alternate
Mr. Robert P. Hartley Industrial Environmental Research Laboratory Cincinnati, Ohio	
Mr. Gerald Katz San Francisco Operations Office Department of Energy	
Mr. Thomas A. Ladd Energy and Utilities Division Naval Facilities Engineering Command Department of Defense	
Mr. Walter Schlumpf Minerals and Geology U.S. Forest Service Department of Agriculture	
Mr. William Spaulding, Jr. Office of Ecological Services U.S. Fish and Wildlife Service Department of the Interior	Mr. Richard Forrester

A.2.7 Financial/Grants Task Force

Members	Alternates
Chairman Mr. Lachlan Seward Division of Geothermal Energy Resource Applications Department of Energy	
Mr. Anthony M. Carey Energy Advisor Assistant Secretary for Community Planning and Development Department of Housing and Urban Development	
Mr. M. David Feld Farmers Home Administration Department of Agriculture	
Mr. Thomas B. Heath Director, Energy Management and Utilization Division Department of Agriculture	
Mr. John C. Thalmayer Economic Development Administration Department of Commerce	

A.3 MEETINGS AND ACTION ITEMS

A.3.1 Interagency Geothermal Coordinating Council

The IGCC held two meetings during the year, on February 6, 1980, and September 26, 1980. The Council reviewed the status of the various panels, offered directions to the panels and member agencies, and approved several reports of the panels. Each panel presented summary reports of their activities.

At the February 6, 1980 meeting, the following actions were reviewed:

1. The Budget and Planning Working Group reported on four activities. (1) The Fourth Annual Report to Congress was delayed. (2) An integrated program plan is being prepared. (3) The Geothermal Progress Monitor System is operating and the first report issued. (4) A Leasing Coordination Meeting is scheduled for April.

2. The Institutional Barrier Panel reported on the status of its legislative recommendations, a number of which are included in pending legislation. The Council agreed to forward to the Congress the positions of member agencies regarding geothermal leasing on or near National Parks. The Council also approved the withdrawal of the National Science Foundation from the Council, owing to a lack of funds.

3. The newly created Leasing and Permitting Panel reported on its first meeting, and had its charter accepted by the Council.

4. The Environmental Controls Panel reviewed their activities to assess the adequacy of environmental controls and research activities.

5. The Research and Technology Panel, which has been dissolved, presented a final report of its lifetime activities. It suggested that there is no need for an Interagency Coordinating Panel, since almost 95% of research is sponsored by DOE.

6. The Resource Panel, also dissolved, summarized its activities, including a 1976 plan for geothermal resource assessment, and a report on proprietary technical data in the Federal Geothermal Energy Program.

7. The Council considered the formation of a Financial/Grants Task Force to identify funding sources. Members from HUD, DOE, USDA, and DOC indicated interest in participating.

8. The Council adopted a revised charter, which includes the addition of DOC, HUD, and DOD as members and provides for quarterly meetings.

At the September 26, 1980 meeting, the following actions were taken:

1. The Budget and Planning Working Group reported that the 4th Annual Report had received concurrence from all Council members and was submitted to Congress on June 2, 1980. The Federal Geothermal Program Plan was completed, and the Council agreed to submit it to OMB. The 4th Geothermal Progress Monitor was published and circulated.

2. The Institutional Barrier Panel reported on several bills that have passed Congress and provide incentives to geothermal energy (the Windfall Profits Tax Act and Energy Security Act). Several leasing bills are currently under consideration. Leasing of Federal lands was noted to be very slow,

and it was recommended that DOA and DOI be requested to investigate the matter and provide leasing schedules.

3. The Environmental Controls Panel presented their report, "Status of Environmental Controls for Geothermal Energy," which was approved for publication by the Council. The Panel's second report, "Environmental Controls Research Strategy For Geothermal Energy Development," includes R&D recommendations, and the Council agreed to send letters to DOE, EPA, and DOI designating high priority areas for R&D. The Panel was directed to examine questions of hydrological alterations and whether pending legislation poses impediments to geothermal development.

4. The Leasing and Permitting Panel has held no formal meetings, and is open to suggestions from the Council.

5. The Financial/Grants Task Force presented its fact-finding report, which gives a breakout of the Federal funding available for geothermal development projects. The Council accepted the report and approved the follow-on implementation plan.

6. A status report on the Geothermal Market Presentation study, being conducted by DOE, was given. The Council will consider the results of the study in revising the goals for geothermal energy.

7. The Council instructed the panels and agencies to review the list of incompleted action items (see Table A.2), and be prepared to report on them at the next meeting. The Council reversed an earlier decision to hold meetings quarterly, and agreed to revert to semi-annual meetings, with extra meetings as required.

A.3.2 Staff Committee

The Staff Committee meets to review the work of the Panels, to provide guidance, and to prepare materials for the IGCC meetings. Three meetings are held during FY 80: January 18, 1980, April 21, 1980, and July 16, 1980.

The following issues were discussed at the April 21, 1980 meeting:

1. The Budget and Planning Working Group reported that the 4th Annual Report was awaiting approval. The geothermal goals were discussed, and it was felt that they should be reviewed. In addition, priorities should be set for leasing and development. The draft Federal Geothermal Program Plan is awaiting comments from Council members.

2. The Institutional Barrier Panel gave a legislative update on the Windfall Profits Tax Act and the pending Energy Security bill.

3. The Leasing and Permitting Panel has not met, and is hampered by a shortage of operating funds.

4. The Environmental Controls Panel presented a draft of their report, and noted that only 3 of 7 major issues are receiving significant research efforts.

5. The Financial/Grants Task Force gave a status report on their efforts to identify Federal funding for geothermal projects.

6. The Staff Committee recommended that the IGCC meeting be delayed for lack of action items. Committee members suggested the following issues for Council attention: (1) the impact of delayed response to lease applications; (2) ocean dumping of brine; (3) goals for geopressured gas; and (4) the release of the Federal Geothermal Program Plan.

At the meeting of July 16, 1980 the Committee reviewed the status of the panels' work in preparation for the September meeting of the IGCC.

1. An interim report was presented of the Geothermal Market Penetration Study, describing methodology and major assumptions.

2. The Budget and Planning Working Group distributed a revised Executive Summary to the Federal Geothermal Program Plan. The Plan will be presented to the Council for approval.

3. The Institutional Barrier Panel reported on the passage of the Energy Security Act. The Panel asked that DOI be requested to resolve the question of royalty payments for the non-electric use of geothermal energy. Noting the slowness with which geothermal lease applications are being processed, particularly in California, the Panel suggested that the Council consider sending letters to DOA and DOI requesting clarification of the issue and establishment of a leasing schedule. This will be brought to the attention of the Council.

4. The Environmental Controls Panel submitted its first report to the Committee for approval. It should then be forwarded to the Council for final approval.

5. The Financial/Grants Task Force outlined the results of their investigations, and will present a report to the Council. A proposed follow-on project will be recommended to the council for their approval.

A.3.3 Budget and Planning Working Group

The Budget and Planning Working Group (BP&WG) met several times during the year. The principal activities were the preparation of the Fourth Annual IGCC Report to Congress, the establishment of the Geothermal Progress Monitor System, and the preparation of the first Federal Geothermal Program Plan. The Fourth Annual Report presented the status and progress of the Federal Program in FY 79 as well as selected accomplishments in the private sector. It included, for the first time, a National Energy Plan and a review of goals and production forecasts obtained from several sources.

The BP&WG established a Geothermal Progress Monitor System and published four issues of the Geothermal Progress Monitor Report. The report contains statistics on electric power plants, on-line and planned; direct-heat applications, on-line and planned; drilling and exploration activity; status of Federal leasing; DOE-funded feasibility studies and application demonstration; the loan guaranty program; and legal, institutional and regulatory activities. Quarterly publication of the Progress Monitor is planned.

The Federal Geothermal Program had been directed by established goals and very general program plans. In order to better direct and coordinate the Federal program, it was decided to prepare a much more detailed program plan. The program plan included specific objectives for each of six major areas: leasing, resource assessment, reservoir evaluation, industrialization, research and development, and environment. Budgets and manpower requirements were obtained for the next six years. Agency activities were then evaluated for consistency with the IGCC goals. The Federal Geothermal Plan was submitted to OMB to provide the interagency perspective of the Federal Geothermal Program as backup to the FY 82 budget exercise.

A.3.4 Institutional Barrier Panel

The Institutional Barrier Panel met twice during the year, on January 10, 1980 and July 15, 1980, to discuss the status of legislation and regulations affecting geothermal.

The following legislative issues were reviewed:

1. The IRS has changed its tax laws allowing for a 40% tax credit for the first $10,000 a homeowner spends on geothermal, and business claims to 15% for similar investments. Utility companies were excluded.

2. Title VI of the Energy Security Act (PL 96-294) carries specific provisions for geothermal energy (see Appendix C). While almost all programs recommended by the Panel were adopted, the funding levels were greatly reduced. In addition, the reservoir insurance program may require Federal support. The ceiling for qualifying as small energy producers was raised from 30 MWe to 80 MWe.

3. Several Federal geothermal leasing bills are under consideration by the Congress. They would increase acreage limitations, redesignate KGRA's, require expedited leasing procedures, and require geothermal production goals for Federal lands.

Status reports were given from the various agencies on regulatory actions affecting geothermal.

1. The IRS is reviewing residential tax credits, and is considering lowering water temperature requirements to qualify for tax credits.

2. USGS reported that no applications have been received which relate to nonelectric royalties, and thus the issue is considered relatively unimportant. Responsibility for the matter should be settled soon.

3. EPA has issued regulations on underground injections which require monitoring wells only if drinking water aquifers would be affected. Geothermal waters are currently exempted from any controls by Resource Conservation and

Recovery Act (RCRA) regulations, but this exemption may be reconsidered.

4. The National Parks Service (DOI) is attempting to identify significant geothermal resources on lands under its jurisdiction, and to determine where conflicts between geothermal energy development and other park uses might exist. Currently Yellowstone, Mount Rainier, and Lasan Volcanic Rocks National Parks are sites of conflict.

5. FERC is reviewing the new ceiling for small energy producers for any exemptions which might be allowed.

6. The Bureau of Land Management's (DOI) Wilderness Inventory Study has identified a number of areas where conflicts occur between geothermal resources and roadless areas, primarily in northwestern Nevada, southwestern Oregon, and east-central California. BLM estimates that there are between 800 and 1,000 Wilderness Study Areas whose energy resources will have to be evaluated to determine what level of energy development, if any, will be allowed. A tremendous backlog of geothermal site evaluations remain to be done, and the IGCC should request BLM and the Forest Service to clear this backlog.

7. Geothermal resources are being used by oil producers to assist in enhanced oil recovery operations, even though oil producers do not own the geothermal rights. A task force composed of BLM, USGS, and DOD was appointed to examine this question.

A.3.5 Leasing and Permitting Panel

The Leasing and Permitting Panel did not meet during the year, and would accept any guidance from the Council.

A.3.6 Environmental Controls Panel

The Environmental Controls Panel was established in August, 1979 to perform the following tasks: (1) assess the adequacy of existing environmental controls; (2) review the ongoing Federal R&D program for controls; and (3) identify areas for increased or reduced Federal R&D efforts to assure that adequate controls are available by 1985. The Panel was asked in February, 1980 to provide: (1) specific recommendations for additional required R&D; (2) funding requirements and timing for this work; and (3) suggestions for agency responsibilities. The Panel met six times during the year to discuss these issues: November 2, 1979, January 7, March 5, May 28, June 20, and August 28, 1980. Two meetings were held on July 8 and July 9, 1980 with industry (cosponsored by the Geothermal Resources Council): The purpose of the meetings was to compare views on environmental priorities and research needs. The work of the Panel has resulted in two major studies: "Status of Environmental Controls for Geothermal Energy Development," and "Environmental Controls Research Strategy for Geothermal Energy Development."

The first report of the Panel, "Status of Environmental Controls for Geothermal Energy Development," investigated the availability of existing environmental controls for geothermal energy systems. The report finds that environmental controls are neither fully adequate, nor are likely to be by 1985, if current R&D programs are continued. Funding allocations were found to be both misdirected, in certain areas, and inadequate, in the aggregate.

Subsequent to these findings, the Panel worked closely with member agencies to revamp current R&D programs within the available resource allocations. Resources have been redirected to high priority areas, key projects have been coordinated between agencies, and most original programs have been restored with the addition of approximately 1.6 million in the FY81 budget of EPA and DOE.

The Panel then went on to develop more extensive recommendations for R&D, funding requirements, timing, and agency responsibility. These results were incorporated in the second report of the Panel, "Environmental Controls Research Strategy for Geothermal Energy Development." The report concludes that current Federal efforts are insufficient to ensure timely development of adequate environmental controls. After considering potential environmental impacts of geothermal development and their relationship to industrialization, availability of controls, regulatory considerations, and the extent and adequacy of ongoing research, the Panel achieved a priority ranking of environmental problems requiring Federal controls research.

Top priorities for environmental controls research identified by the Panel are as follows:

1. Hydrogen sulfide (H_2S) emission - H_2S controls for power plants and H_2S steam stacking/well emission controls;

2. Non-H_2S gaseous emissions characterization and controls development;

3. Solid waste characterization and management evaluation;

4. Injection monitoring; and

5. Methods for subsidence prevention, prediction, and control.

The middle priority group includes brine treatment, in-line monitoring, chemical and physical modeling/simulation techniques, solid waste management technology development, induced seismicity identification and characterization, and induced subsidence characterization, characterization, monitoring, and predictive modeling of geothermal hydrologic systems, and treatment and use of nongeothermal waters. Research areas which received low priority for Federal funding are induced seismicity controls and noise controls.

Many of the research priorities identified by the Panel are particularly critical for geothermal industrialization in the eyes of both government and industry. The lack of adequate controls for geothermal-related environmental problems poses a significant impediment to faster growth of a geothermal industry. Therefore, Federal support for environmental controls research should be increased and adjusted to a level commensurate with the identified priority areas. The Panel is currently developing recommended funding levels through FY85 for six major environmental controls related research areas.

The Panel has also recommended that Federal research for environmental controls development be closely coordinated among the Federal agencies which conduct geothermal research--EPA, DOE, DOI, USDA and DOD. A continuing exchange of data on emissions, environmental impacts, and controls performance is essential to an effective controls development research program. Specific recommendations are to (1) use the Panel as a means of interagency coordination in developing a Federal research strategy and as a means of coordinating with industry and environmental groups on controls-related issues, and (2) develop a better understanding of environmental concerns and controls through joint monitoring of production sites.

A.3.7 Financial/Grants Task Force

The Financial/Grants Task Force was established as an ad hoc group by the IGCC at its February 1980 meeting, with the mission of determining what Federal funding programs may be applicable to geothermal development projects. The Task Force includes members of the Department of Housing and Urban Development (HUD), the Rural Electrification Administration (REA), the Economic Development Administration (EDA), and the Farmers Home Administration (FmHA).

At the Task Force meeting of April 17, 1980, members provide information about their funding programs, which was compiled into their report. The data is summarized below. (A more complete description appears in Section 5.5 of this report.)

1. HUD programs include (1) Community Development Block Grants ($3.9 billion in FY 80); (2) Urban Development Action Grants ($675 million in FY 80); and (3) Housing Construction and Rehabilitation ($26 billion planned for FY 81).

2. REA provides loans ($800 million) and loan guarantees ($5 billion in FY 80) for electric power generation and distribution facilities in rural areas.

3. EDA's budget of $228.5 million in FY 80 provides for grants, loans, and loan guarantees for public works projects,

business development, planning, technical assistance, and economic adjustments.

4. FmHA allocates grants, loan guarantees, and loans for community programs, business and industrial programs, single family housing programs, multiple family housing programs and farmers' programs (FY 80 budget about $8 billion).

The Task Force has recommended a follow-on implementation plan to increase and expand the efforts of the Council. The plan, approved by the Council at its September 1980 meeting, includes: (1) development of a realistic upper bound of Federal assistance to geothermal development; (2) expansion of the Task Force membership; (3) closer coordination of Federal assistance projects; and (4) development of a geothermal Federal assistance fact book.

Table A.1

COMPLETED ACTION ITEMS OF THE IGCC, FY 79 & FY 80

Date Recommended	Assignment	Description of Recommended Action	Status
January 18, 1979	Streamlining Task Force	The Streamlining Task Force was directed to discuss recommendations 13, 14, & 17 with CEQ staff and report any problems to the Council.	Completed No problems reported
January 18, 1979	Streamlining Task Force	DOE Environment Office (Ruth Clusen) should be given the opportunity to comment on these recommendations.	Completed
January 18, 1979	Streamlining Task Force	The recommendations should be costed out in terms of personnel and funds, and each agency should be apprised of its required contribution.	Council moved on the recommendations without this report
January 18, 1979	Streamlining Task Force	The Institutional Barrier Panel was directed to prepare letters from the Chair to the responsible agencies citing the relevant Streamlining Task Force recommendations and urging prompt implementation.	Completed March 1977
January 18, 1979	Streamlining Task Force	Recommendation to issue a noncompetitive lease unless area is in a KGRA at the time of applications was remanded to the Streamlining Task Force for further study, and is to be presented at the next Council meeting.	Incorporated in Bill pending in Congress
January 18, 1979	Streamlining Task Force	Mr. Short was directed to provide suggestions for the composition of the permanent group to be designated to implement the recommendations in the report of the Task Force.	Completed

Table A.1 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
January 18, 1979	Staff Committee	Letters are to be prepared issuing invitations to the Department of Commerce, Department of Defense, and the Department of Housing and Urban Development to membership on the IGCC.	Completed
January 18, 1979	Staff Committee	The report of the Streamlining Task Force will be publicly available and copies sent to the White House and Congress.	Completed March 1979
January 18, 1979	Institutional Barrier Panel	Members were directed to review the proposed omnibus legislation in detail and submit any problems, comments, or changes to the Institutional Barrier Panel by February 1.	Completed
January 18, 1979	Institutional Barrier Panel	Mr. Stephens will coordinate the IGCC's legislative proposals with the Policy Office of DOE as well as with the Economic Regulatory Administration of DOE.	Completed
January 18, 1979	Institutional Barrier Panel	Each agency was directed to submit initial reactions on the proposed legislative actions to the Chair by February 1.	Completed
January 18, 1979	Budget and Planning Working Group	Council members are to review the summary in Section 2 of the Third Annual Report which reports the Council's responsibilities, and submit comments to Dr. Abel.	Completed February 1979
January 18, 1979	Staff Committee	Establish a permanent task group to review and make recommendations to review DOI/DOA/DOE geothermal regulations and special lease stipulation policy.	Establish Leasing and Permitting Panel, August 28, 1979

Table A.1 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
March 26, 1979	DOI & DOA	Establish coordinators, modify agreements, and improve coordination among and within Federal, state, and local government agencies.	DOA has established coordinators; DOI has established coordinator positions in each State BLM Office
March 26, 1979	DOI & DOA	Increase program priority for and management commitment to geothermal development.	DOA and DOI have sent memoranda to field
March 26, 1979	DOI & DOA	Modify proposed power plant siting regulations to clarify readjustment rentals.	Completed
March 26, 1979	DOI & DOA	Provide, as an alternative, leases based upon separate environmental assessment of exploration and development phases.	Implemented
March 26, 2979	DOI & DOA	Use generalized, areawide environmental assessments through the land management planning process in prelease review and detailed site specific studies for post-lease actions.	Implemented
March 26, 1979	DOI & DOA	Expedite the wilderness/roadless review process and prioritize study areas where geothermal potential is high.	Study is completed
March 26, 1979	DOE	Encourage DOE to tier environmental assessments concerned with the loan guaranty program.	Implemented
March 26, 1979	DOE	Urge prompt implementation of the foregoing recommendations and provision for the needed capability to do so.	Completed

Table A.1 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
August 28, 1979	DOC	Deputy Assistant Secretary Curlin (Commerce) will suggest that appropriate action in Commerce be given to geothermal energy and to the IGCC.	Jerry Jasinowski appointed to Council
August 28, 1979	HUD	Mr. Kluckhuhm (HUD) will find out if Urban Development Assistance Grants could be used to develop geothermal heat in cities that qualify for the grants.	Completed Cities can use UDAG
August 28, 1979	Council Chairman	Gus Speth will be asked if CEQ has the time, personnel, and interest to join the IGCC.	CEQ declined
August 28, 1979	Institutional Barrier Panel	DOE was to report at the next meeting on appropriate roles for IGCC agencies in geothermal training activities.	Completed Specific geothermal training not required
August 28, 1979	Institutional Barrier Panel	The Institutional Barrier Panel will look into the need for continued NSF membership in the IGCC.	Completed NSF not needed
August 28, 1979	EPA	Mr. Reznak (EPA) was directed to provide Council members with EPA's plans for dealing with PSD and BACT.	Information sent
August 28, 1979	Staff Committee	A Council meeting was to be scheduled for December. The agenda should include progress reports on H_2S, on Island Park, on information of the Environmental Controls Technology Panel, and on the Resource Panel.	Held February 6, 1980
August 28, 1979	Budget and Planning Working Group	The Budget and Planning Working Group was directed to prepare an integrated budget for FY 81, based on September 15 agency submissions.	Completed memo to OMB October 22, 1979

Table A.1 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
February 6, 1980	Budget and Planning Working Group	The BPWG was tasked with developing a joint interagency plan. Concurrence with such an effort will be sought by phone following the first meeting of the BPWG, probably in March. A draft will be due mid-June, with the final report to be provided by mid- to late July.	Draft delivered to Staff Committee June 2, 1980. Final was submitted to Council September 26, 1980, and approved
February 6, 1980	Staff Committee	The proper Congressional committees will be notified that the IGCC is reviewing and preparing a position on legislation relating to the protection of national park geothermal resources. The Council position (or agency positions) will be made within 3 weeks.	Action presented by OMB
February 6, 1980	DOI	The charter of the Leasing and Permitting Panel was approved. Appointment of a Chairmanship was remanded to the Department of the Interior.	Completed
February 6, 1980	Environmental Controls Panel	The Environmental Controls Panel was directed to provide specific recommendations for areas of research concerning environmental controls, the kind of research, the level of funding, and which agencies would be appropriate for doing such research.	Final report to be submitted to Council September 26, 1980
February 6, 1980	Staff Committee	An ad hoc group was established to delineate the funding, the economic incentives, and the loans and other financial incentives available from various government agencies that could be used for geothermal development.	Financial/Grants Task Force established
February 6, 1980	Staff Committee	The Council agreed to hold meetings quarterly, with the next meeting to be scheduled in May.	Moved to September 26, 1980

Table A.1 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
September 26, 1980	Budget and Planning Working Group	The Federal Geothermal Program Plan, as produced by the BPWG, was accepted. Agencies were given until the first week in October to comment on the report, at which time it was to be sent to the Office of Management and Budget, as backup to the FY 82 exercise.	Submitted October 1980
September 26, 1980	Budget and Planning Working Group	The BPWG was directed to send a copy of the 4th Geothermal Progress Monitor to the Edison Electric Institute.	Completed
September 26, 1980	Financial/Grants Task Force	The Report of the Task Force was accepted by the Council.	Completed
September 26, 1980	Financial/Grants Task Force	The Council authorized the follow-on implementation plan of the Task Force.	Completed

Table A.2

INCOMPLETE ACTION ITEMS OF THE IGCC, FY 79 & FY 80

Date Recommended	Assignment	Description of Recommended Action	Status
January 18, 1979	Streamlining Task Force	Recommendation to require a 30-day limit on prelease permit applications was remanded to the Streamlining Task Force for further study.	Task transferred to LPP No action
January 18, 1979	Institutional Barrier Panel	The Institutional Barrier Panel was directed to study further the proposals for investment tax credits for geothermal projects.	Delayed--awaiting completion of new financial analytical models
January 18, 1979	Institutional Barrier Panel	Questions concerning the eligibility of injection wells for the intangible drilling cost deduction need further study.	Deferred--awaiting treatment under existing law
March 26, 1979	DOI, DOA & DOE	Compile a comprehensive handbook of regulations with flow diagrams.	DOI requested inputs--now inactive Low priority
March 26, 1979	DOI & DOA	Initiate a training and education program for Federal field managers with management responsibilities in the geothermal program.	Program proposed in DOI--not acted upon Low priority
March 26, 1979	DOI & DOA	Require a response within 30 days for noncompetitive lease applications and indicate anticipated actions and time requirements.	DOA--drafted revision for FS manual DOI--not acted upon
March 26, 1979	DOI & DOA	Require a 30-day time limitation on postlease response to permit applications.	DOA--included in draft revision to FS manual DOI--not acted upon
March 26, 1979	DOI	Revise geothermal lease form.	DOI meeting proposed in FY 81 on general stipulations, pending approval by BLM

Table A.2 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
March 26, 1979	DOI	Review and revise KGRA designation criteria.	Drafted--November 1979 Held up for law
August 28, 1979	Council Chairman	It was recommended that Mr. Cutler, Mr. McIssac, and Ms. Davenport get together to discuss the choices between energy and environment issues associated with geothermal development.	Not completed
August 28, 1979	Institutional Barrier Panel	The Institutional Barrier Panel will review which agency, DOE or DOI, has the authority to issue regulations relating to establishing royalties for nonelectric geothermal production.	DOI has a proposed policy statement on this issue
February 6, 1980	Staff Committee	Comments on the Progress Monitor should be submitted to Mr. Black by February 20.	Comments received only from Department of Agriculture
February 6, 1980	Institutional Barrier Panel Leasing and Permitting Panel	The Institutional Barrier Panel, in conjunction with the Leasing and Permitting Panel, will determine the agency positions on protection of national park geothermal resources. The positions will be reviewed by the IGCC and then transmitted to Congress.	No action
September 26, 1980	DOA & DOI	The Council agreed to send a letter to DOA and DOI requesting an investigation of the slow pace of leasing of Federal lands for geothermal development, a schedule for future leasing, and the allocation of resources to meet the schedule. DOA and DOI Council members have one week to review the draft letter and return comments to Mr. DiBona (by October 3).	Unknown

Table A.2 (Cont.)

Date Recommended	Assignment	Description of Recommended Action	Status
September 26, 1980	Environmental Controls Panel	The Council approved for publication the first report of the Environmental Controls Panel, "Status of Environmental Controls for Geothermal Energy," with the directive that the report be brought up to date with current regulations.	Not completed
September 26, 1980	Staff Committee	The Council agreed to send letters to DOE, EPA, and DOI, recommending the Environmental Controls Panel's findings on priority research areas and funding levels necessary to develop adequate controls by 1985.	Unknown
September 26, 1980	Environmental Controls Panel	The Panel was directed to examine questions concerning hydrological alterations, and whether pending legislation poses impediments to geothermal development.	Unknown
September 26, 1980	Budget and Planning Working Group	The BPWG was instructed to consider the results of the DOE Geothermal Market Penetration Study in revising the IGCC's goals, and should factor those results into the 5th Annual Report.	Not completed
September 26, 1980	Staff Committee	The Council agreed to hold semiannual meetings (changing an earlier decision to have quarterly meetings), with extra meetings called as required. The Staff Committee is to review the Charter and prepare the necessary change. The next meeting is scheduled for January 1981.	Not completed

Appendix B

HISTORY OF THE FEDERAL GEOTHERMAL PROGRAM

HISTORY OF THE FEDERAL GEOTHERMAL PROGRAM

Geothermal energy has been used in the United States in isolated cases since the late 1800's. However, serious commercial interest did not arise until the late 1960's, when growing concerns over diminishing energy resources led to demands for the development of new, cleaner sources of energy such as solar and geothermal. Since then, both legislative and program actions have been directed at stimulating the development of geothermal energy.

The first Federal program activity was undertaken by the USGS in 1969, when they compiled a limited assessment of geothermal resources. This assessment was drawn from basic research that the USGS has been conducting since 1945 to assess national resources.

Legislative action followed shortly thereafter with the passage of the Geothermal Steam Act of 1970 (PL 91-581). The Act establishes guidelines for leasing and production, and for the judicious use and conservation of geothermal resources. The Act states:

- ...the Secretary of the Interior may issue leases for the development and utilization of geothermal steam and associated geothermal resources (1) in lands administered by him, including public, withdrawn, and acquired lands, (2) in any national forest or other lands administered by the Department of Agriculture through the Forest Service, including public, withdrawn, and acquired lands, and (3) in lands which have been conveyed by the United States subject to a reservation to the United States of the geothermal steam and associated geothermal resources therein.

- If the production, use, or conversion of geothermal steam is susceptible of producing a valuable by-product...the Secretary shall require substantial beneficial production or use thereof...(except) in the interest of conservation of natural resources.

- ...the lessee will...use all reasonable precautions to prevent waste of geothermal steam and associated geothermal resources...

The Geothermal Steam Act also provides broad authority for the Secretary to issue regulations governing geothermal operations on leased Federal lands, including conservation of resources, protection of the environment and protection of the public interest.

By 1971 there was momentum enough to start a geothermal program in the Atomic Energy Commission. The AEC Act had been amended to mandate research into energy sources other than nuclear power. The Division of Applied Technology included Coal, Electrical Storage, Solar, and Geothermal offices. Even though the main emphasis was placed on geothermal technology, there was an attempt to relate the program to industrial applications. At approximately the same time, the National Science Foundation considered geothermal energy in its Research Applied to National Needs project. NSF thereafter became the lead agency for geothermal activities. In 1973 the USGS, AEC, and NSF prepared the first coordinated Federal geothermal program plan.

As the need for even more rapid development of geothermal energy technologies as well as resources became evident, the Congress enacted the Geothermal Energy Research, Development, and Demonstration Act of 1974 (PL 93-410), which affirmed the potential benefits to the Nation of geothermal energy development and defined the major components of a coordinated Federal program to realize these benefits. The Act states that:

- ...geothermal resources...which have extremely large energy content...are known to exist; (but)...technologies are not presently available for the development of most of these geothermal resources, but technologies for the generation of electric energy from geothermal resources are potentially economical and environmentally desirable, and the development of geothermal resources offers possibilities of process energy and other nonelectric applications...

- Federal financial assistance is necessary to encourage the extensive exploration, research, and development in geothermal resources which will bring these technologies to the point of commercial application...

- The Federal Government should encourage and assist private industry through Federal assistance for the development and demonstration of practicable means to produce useful energy from geothermal resources with environmentally acceptable processes.

To achieve this goal, the Congress established through the Act the Geothermal Energy Coordination and Management Project (now identified as the Interagency Geothermal Coordinating Council) and directed the Project to develop and report to the Congress a coordinated Federal program. The Program Definition Report (ERDA-86) was submitted and published in October 1977. The Program directed by Congress included demonstration plants, loan guaranties, and extensive lists of other necessary activities to be undertaken, including regional and national resource surveys, drilling research, information clearinghouses in the states, development and recommendation of policy, and environmental impact assessments. It also authorized the National Science Foundation to encourage international participation in educational programs to train the personnel necessary for these expanding activities.

The wide range of the functions and activities named in PL 93-410 and other energy legislation, and the importance of their success to the Nation, led the Congress to promulgate the Energy Reorganization Act of 1974, which established the Energy Research and Development Administration (ERDA). The responsibilities of the new agency included:

- exercising central responsibility for policy planning, coordination, support, and management of research and development programs respecting all energy sources

- encouraging and conducting research and development, including demonstration of commercial feasibility

- engaging in and supporting environmental, biomedical, physical and safety research related to the development of energy sources and utilization technologies

- taking into account...other public and private research and development activities

- participating in and supporting cooperative research and development projects

- making available for distribution, scientific and technical information concerning the manufacture or development of energy

- creating and encouraging the development of general information to the public on all energy conservation technologies and new energy sources

- encouraging and conducting research and development in energy conservation...toward the goals of reducing total energy consumption...and toward maximum possible improvement in the efficiency of energy use

- encouraging and participating in international cooperation in energy and related environmental research and development

- helping to ensure an adequate supply of manpower for the accomplishment of (energy R&D programs)

- encouraging and conducting research and development in clean and renewable energy sources.

Responding to the urgency of the Nation's energy challenge, the Congress further classified and enlarged the scope of ERDA's responsibilities in the Federal

Non-nuclear Energy Research and Development Act of 1974 (PL 93-577), which emphasized that "proper priority" must be given "to developing new non-nuclear energy options to serve national needs, conserve vital resources, and protect the environment." Besides reiterating the high priority to be given to energy conservation and the importance of taking the environmental and social consequences of proposed programs into account, the Act required that ERDA submit a comprehensive program plan each year to the Congress. It repeated the directive of PL 93-410 that commercial demonstrations of geothermal energy technologies and environmental control systems be accelerated; called for joint Federal/industry experiments, demonstration plants, and corporations, along with other forms of Federal assistance; and required the promulgation of "regulations establishing procedures for submission of proposals to (ERDA) for the purposes of this Act."

Seeing the rapid growth of energy programs in the past decade, Congress acted to consolidate the energy-related functions and responsibilities of several different agencies, primarily ERDA, FEA, and the FPC, under the aegis of the Department of Energy, creating a cabinet post for this important area of Government activity. The DOE Organization Act of 1977 (PL 95-91) consolidated and updated earlier Acts, giving ongoing and new programs continued guidance and support. The objectives of the Act are:

- to achieve...effective management of energy functions...and to promote maximum possible energy conservation measures

- to provide for a mechanism through which a coordinated national energy policy can be formulated and implemented

- to place major emphasis on the development and commercial use of solar, geothermal, recycling and other technologies utilizing renewable energy resources.

The Act also emphasized the importance of coordinated efforts with the states, local entities, the public, private industry, and other nations, and it reiterated the Congress' concern with protection of the environment.

Originally ERDA's orientation to geothermal energy was primarily technological. Although demonstration projects were envisioned, no funds were appropriated for them. The ERDA activities were aimed at electric power production, almost entirely to the exclusion of nonelectric uses. A formal commercialization program was established only with the organization of the Department of Energy (DOE) in 1977; however, the concept of involving industry in geothermal development had been implicit from the beginning of Federal involvement in geothermal activities. In 1975, ERDA's Division of Geothermal Energy (DGE) had started to phase in commercialization activities, but kept these activities closely tied to basic research. In 1979, the Division of Geothermal Resource Management was created under the Assistant Secretary for Resource Applications of DOE; research and development continued in DGE under the Assistant Secretary for Energy Technology. Subsequently, DGE was placed within Resource Applications as well.

Legislative efforts continue to provide economic incentives for the development of geothermal resources. In April 1980, the Crude Oil Windfall Profits Tax Act (PL 96-223) was signed by the President. The law provides tax credit increases over those provided by the National Energy Act. The investment tax credit for geothermal equipment is increased to 15% in excess of the normal 10% and extended through 1985. The residential credit is increased to 40% of the first $10,000 in expenditures for geothermal equipment, for a maximum of $4,000. Finally, a tax credit is provided equal to 10% of the cost of cogeneration equipment. Geothermal systems designed to tap waste heat or steam would qualify.

The Energy Security Act (PL 96-294) was enacted in June 1980. Title VI, the Geothermal Energy Act of 1979, contains the following major provisions:

(1) An $85 million five-year program under which the Federal government will share the risks of drilling for commercially viable geothermal resources. Loans will cover 50% of the cost of surface exploration and drilling and 90% of the cost of a project to use geothermal for space conditioning or process heat. The loans will be repayable out of project revenues and will be wholly or partially forgivable if a project is unsuccessful. Because the high economic risk perceived by drillers and developers is considered to be one of the major forces slowing development, the reservoir confirmation loan program is expected to accelerate the rate of exploration for and confirmation of geothermal reservoirs. Authorization is $5 million for FY 81 and $20 million for each of fiscal years 1982 through 1985.

(2) A program authorizing DOE to grant low-interest forgivable loans to cover up to 90% of the cost of feasibility studies and regulatory applications and up to 75% of the construction costs of nonelectric systems. Five million dollars is authorized for feasibility studies in FY 81.

(3) A DOE study to examine the need for and feasibility of a Federal reservoir insurance and reinsurance program. On the basis of the report, Congress will determine whether to authorize a program of insurance or reinsurance against the risk of reservoir failure after investment of at least $1 million has been made in reservoir development and use. The direct insurance would be provided only where the developer could not obtain private insurance at reasonable premiums.

(4) Modification of Geothermal Loan Guaranty Program (GLGP). The law extends the life of the GLGP from 1984 to 1990 and provides an increased level of assistance under the program. Loan guarantees for loans to municipalities and public cooperatives will be increased from 75% to 90% of project costs. PL 96-294 also includes provisions to expedite processing of loan guarantees; such reforms include a four-month deadline for processing applications, requirements to give faster consideration to applicants for nonelectric projects, and a requirement to eliminate duplicative Environmental Impact Statements under NEPA for loan guaranty applications.

(5) A provision requiring consideration of the use of geothermal energy in new Federal buildings or facilities in areas designated by DOE.

(6) New authorities under PURPA. The law explicitly includes geothermal facilities of 80 MWe or less in the small power producer category under the Public Utility Regulatory Policies Act (PURPA). Geothermal facilities qualifying as small power producers are eligible for interconnection, wheeling of power through grid transmission lines, exemption from the Federal Power Act and the Public Utility Holding Company Act, and other utility orders as determined by FERC. Multiple geothermal units at a site are also eligible for exemption from public utility regulation, provided their combined capacity does not exceed 140 MWe. The law also allows utility-owned plants to qualify for these exemptions and for wheeling and interconnection.

The latest considerations by the Federal government include Federal leasing and permitting reforms; several Federal geothermal leasing bills are under consideration by the Congress. They would increase acreage limitations, redefine KGRA's, require expedited leasing procedures, and require geothermal production goals for Federal lands. Bills passed both the House (HR 6080) and the Senate (S 1388) during 1980. A summary of the significant events in the development of geothermal energy is presented in Table B.1.

Table B.1

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

- 1894 District Heating in Boise, Idaho
- 1900 Hot Water to Homes in Klamath Falls, Oregon
- 1916 Power Generation at Geysers Resort
- 1927 First Exploratory Geothermal Wells Drilled in Imperial Valley, California, by Pioneer Development Company
- 1959 Small Pilot Plant Operated Near Niland, California, on Sinclair No. 1 Well
- 1960 Commercial Electricity Generated from Dry Steam at The Geysers (California)
- 1970 Geothermal Steam Act Passed
- 1972 NSF Becomes Lead Agency for Federal Geothermal Programs
- 1973 USGS, AEC, NSF Prepare First Federal Geothermal Program
- 1974 Geothermal RD&D Act Passed

  First Federal Lands Leased
- 1975 ERDA Formed; Division of Geothermal Energy Formed Primarily from NSF, AEC

  USGS Releases First National Geothermal Resource Estimates and Inventory
- 1977 DOE Formed; DGE Kept Intact
- 1978 NEA Tax Act Passed

  EPA Issues Pollution Control Guidelines for Geothermal Energy Development

  Successful Hot Dry Rock Experiment Conducted (New Mexico)

  First Geothermal Crop-Drying Plant (Nevada)
- 1979 USGS Releases Updated National Geothermal Resource Estimates and Inventory

Table B.1 (Cont.)

•	1979	10 MWe Plant Built by Industry at East Mesa (California)
		Streamlining Task Force Recommends to IGCC Measures To Speed Federal Leasing
		First Production from Federal Lands, at The Geysers (California)
		World's First Commercial Binary Cycle Plant (10 MWe) Built by Industry at East Mesa, California
•	1980	World's Largest Single Geothermal Power Facility (129 MWe) Generator Electricity at The Geysers, California
		10 MWe Flash-Steam Plant Built by Industry at Brawley, California
		First Production of Electric Power from a Hot Dry Rock Resource at Fenton Hill, New Mexico
		First Geothermal Ethanol Plant in Production at La Grande, Oregon, under Private Funding
		First 5 DOE-Sponsored Field Demonstrations of Direct Heat Applications Became Operational
		First Deep Geothermal Reservoir Confirmation Well Drilled in Atlantic Coastal Plain near Cristfield, Maryland
		Crude Oil Windfall Profits Tax Act Passed--Provides Tax Credit Increase for Geothermal Equipment
		Energy Security Act, Containing Title VI, "The Geothermal Energy Act of 1979," passed

Appendix C

METHODOLOGY FOR SETTING MARKET PENETRATION ESTIMATES

C.2

METHODOLOGY FOR SETTING MARKET PENETRATION ESTIMATES

INTRODUCTION

The 20-year market penetration forecast for hydrothermal electric power was estimated by Technecon Analytic Research, Inc. Starting with the resource discoveries forecasted by UURI/ESL, Technecon applied quantitative investment decision analysis techniques to estimate time-wise power development profiles at each discovery. The results of this computerized and statistically sound approach are estimates of the likelihood of various levels of megawatts on-line at the several resource sites over the 20-year time frame.

Hydrothermal power development at each resource discovery is dependent upon a joint investment decision to (a) develop the well field and (b) construct power plant and transmission facilities. Technecon's methodology considers multiple investment objectives of both (a) well field developers and (b) electric utilities as they relate to the respective investment decisions. This methodology is capable of estimating the likely investment behavior of major resource corporations, independent operators, third-party financiers, investor-owned utilities and tax-exempt municipal utilities.

In early 1978, under contract to the U.S. Department of Energy,* Technecon conduted interviews with no fewer than 70 executives from geothermally active firms in the above categories. Many of these interviews have been repeated periodically since 1978 to update pertinent data. The interviews provided both qualitative and quantitative insights into the investment objectives and decision criteria of these firms. The decision models applied by Technecon in the model are based upon statistical regressions of data obtained directly from these firms over the past three years.

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*Contract No. DE-AC-02-79ET27242; Dr. Fred Abel, U.S. DOE Division of Geothermal Energy Program Manager.

MODEL DESIGN

Figure C.1 illustrates the structure of the hydrothermal electric power model. Following is a summary of the model which discusses the sequence of computerized operations progressing from left to right through the schematic diagram.

The hydrothermal power market estimates are prepared on a site-by-site basis. Resource discovery characteristics provided by UURI/ESL are provided to two detailed cash flow programs. One program simulates the life of a hydrothermal power plant. The economically optimum combination of pumped versus unpumped wells and binary versus flash plant design is selected at each site. Well field and power plant performance data from EG&G Idaho, Inc. is used in these computerized cash flow programs. Tables C.1 through C.4 list the several input data parameters that are provided to the cash flow analyses.

The two cash flow programs are executed probabilistically to account for uncertainties and risk perceptions that are inherent to many geothermal ventures. Eight stochastic variables within the cash flow (i.e., resource temperature, well flow, well cost, well life, dry well fraction, reservoir size, reservoir life and plant availability) vary over time as a function of on-site production experience, number of wells drilled and acreage in production.* Figure C.2 presents the several stochastic parameters, the probability profile associated with each, and the independent variables that influence time-wise changes in the probability profiles.

Results from the well field and power plant cash flow simulations are then provided to the respective decision models of the resource developer and of the electric utility. The decision models analytically compare the geothermal investments to alternative investment opportunities available to each type of firm. From the resource developers' point of view, comparisons are made in terms of return, duration of investment exposure, project size, amount of capital at risk, and the probability of project failure. From the electric utilities' point of view,

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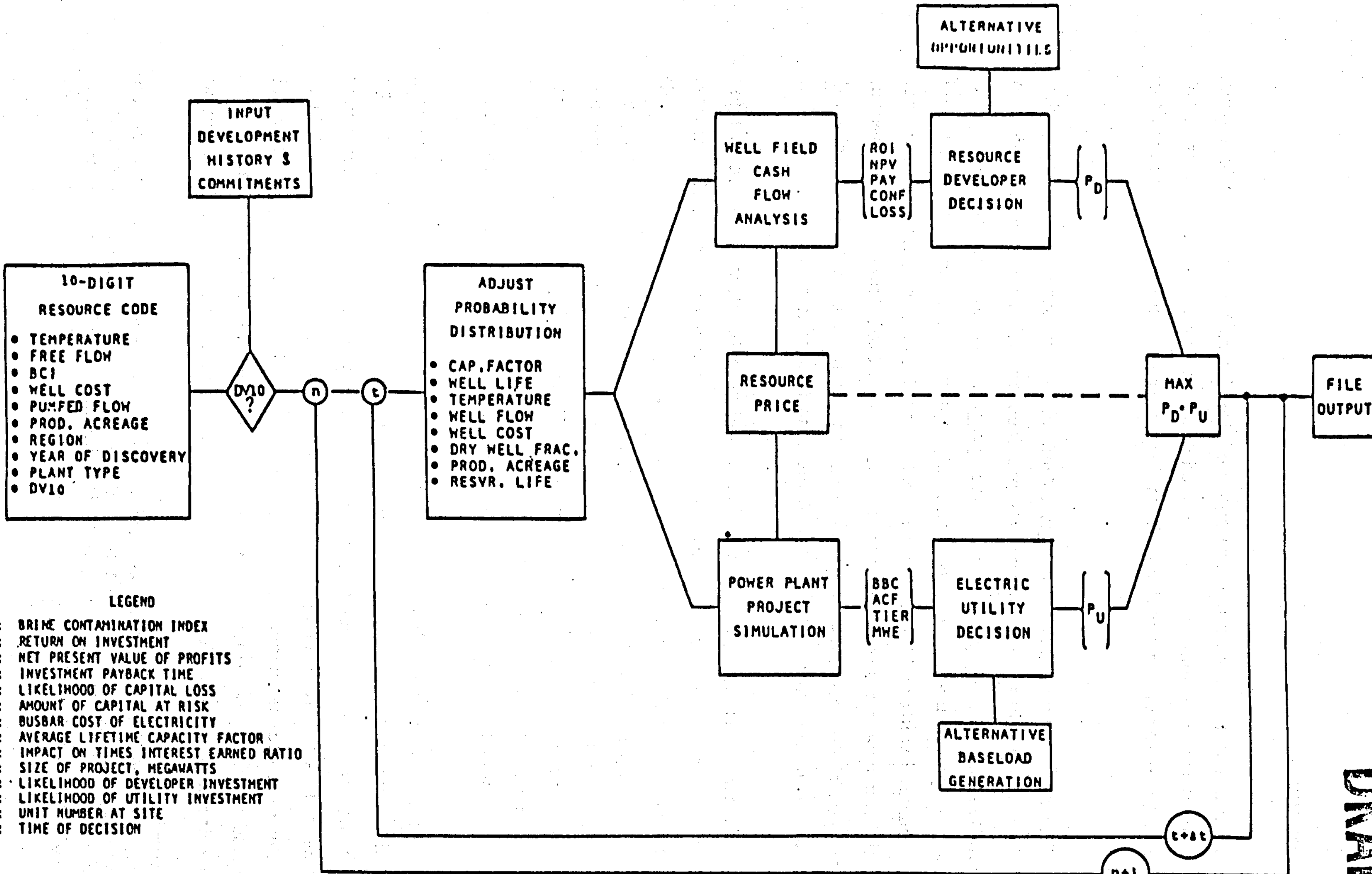
*Reservoir risk perceptions and time-wise variances are based upon the recommendations of three consultants: Dr. S. Sanyal of Stanford University; D. Goldman of EG&G Idaho, Inc.; and E. Ciancanelli of Cascadia Exploration Corporation, San Diego.



LEGEND

BCI : BRINE CONTAMINATION INDEX
ROI : RETURN ON INVESTMENT
NPV : NET PRESENT VALUE OF PROFITS
PAY : INVESTMENT PAYBACK TIME
CONF: LIKELIHOOD OF CAPITAL LOSS
LOSS: AMOUNT OF CAPITAL AT RISK
BBC : BUSBAR COST OF ELECTRICITY
ACF : AVERAGE LIFETIME CAPACITY FACTOR
TIER: IMPACT ON TIMES INTEREST EARNED RATIO
MWE : SIZE OF PROJECT, MEGAWATTS
P_D : LIKELIHOOD OF DEVELOPER INVESTMENT
P_U : LIKELIHOOD OF UTILITY INVESTMENT
n : UNIT NUMBER AT SITE
t : TIME OF DECISION

FIGURE C.1

INTEGRATED HYDROTHERMAL ELECTRIC POWER SYSTEM SIMULATOR AND INDUSTRIAL DECISION MODEL (Illustrative Example)

SOURCE: TECHNECON

Table C.1

RESOURCE PARAMETERS

BRINE CONTAMINATION INDEX
CONFIRMATION WELLS REQUIRED
DEVELOPMENT COMMITMENTS TO DATE
DRY WELL COST
DRY WELL FRACTION
FINDING COST CAPITALIZED
FINDING COST EXPENSED
FIRMS IN JOINT VENTURE
FLOW TEST AND MODELING COST
LAND RENT
LEASE BONUS
OPERATION AND MAINTENANCE EXPENSE
PERMITTING EXPENSE
PRODUCER/INJECTOR RATIO
PRODUCIBLE ACREAGE AT 50% CONFIDENCE
PRODUCIBLE ACREAGE AT 99% CONFIDENCE
REDRILL COST
REDRILL FRACTION
REWORK COST
REWORK FRACTION
ROYALTY RATE
SPARE WELL FRACTION
SURFACE FACILITY COST
SURFACE PIPING COST
TEMPERATURE OF RESOURCE
TYPE OF RESOURCE DEVELOPER
WELL COST
WELL FLOW, FREE
WELL FLOW, PUMPED
WELL LIFE
WELL PUMP THRESHOLD
WELL SPACING
YEAR OF DISCOVERY

SOURCE: TECHNECON

Table C.2

POWER PLANT PARAMETERS

BOOK LIFE OF ALTERNATIVE PLANT
BOOK LIFE OF HYDROTHERMAL PLANT
CAPACITY FACTOR OF ALTERNATIVE PLANT
CAPACITY FACTOR OF HYDROTHERMAL PLANT
CAPITAL COST OF ALTERNATIVE PLANT
CAPITAL COST OF HYDROTHERMAL PLANT
CAPITAL COST OF TRANSMISSION
EFFICIENCY OF HYDROTHERMAL PLANT
FUEL PRICE OF ALTERNATIVE PLANT
INSURANCE PREMIUMS
LAST YEAR OF PROJECT OPERATION
RECURRING ANNUAL COST OF ALTERNATIVE PLANT
RECURRING ANNUAL COST OF HYDROTHERMAL PLANT
REPLACEMENT POWER COST
REPLACEMENT POWER COST ALLOWABLE
SIZE OF HYDROTHERMAL PLANT
TIME FROM DECISION TO PLANT ON-LINE
TIME INTERVAL BETWEEN PLANTS
TYPE OF PLANT (FLASH/BINARY)
TYPE OF UTILITY
WRITE-OFF PERIOD ALLOWABLE

SOURCE: TECHNECON

Table C.3

ECONOMIC & FINANCIAL PARAMETERS

ALTERNATIVE PLANT COMMON STOCK COST
ALTERNATIVE PLANT COMMON STOCK FRACTION
ALTERNATIVE PLANT LONG-TERM DEBT COST
ALTERNATIVE PLANT LONG-TERM DEBT FRACTION
ALTERNATIVE PLANT PREFERRED STOCK COST
ALTERNATIVE PLANT PREFERRED STOCK FRACTION
ELECTRIC UTILITY DEBT OBLIGATIONS
ELECTRIC UTILITY GROWTH RATE
ELECTRIC UTILITY NET INCOME
HYDROTHERMAL PLANT COMMON STOCK COST
HYDROTHERMAL PLANT COMMON STOCK FRACTION
HYDROTHERMAL PLANT LONG-TERM DEBT COST
HYDROTHERMAL PLANT LONG-TERM DEBT FRACTION
HYDROTHERMAL PLANT PREFERRED STOCK COST
HYDROTHERMAL PLANT PREFFERED STOCK FRACTION
INFLATION RATE FOR GOODS AND SERVICES
INFLATION RATE POWER PLANT CONSTRUCTION
INFLATION RATE FOR POWER PLANT FUEL (REGIONAL)
RESOURCE DEVELOPER'S DISCOUNT RATE
THIRD PARTY'S DEBT INTEREST RATE
THIRD PARTY'S DISCOUNT RATE
THIRD PARTY'S EQUITY FRACTION
THIRD PARTY'S RETURN ON EQUITY

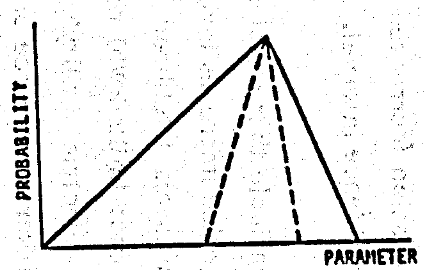
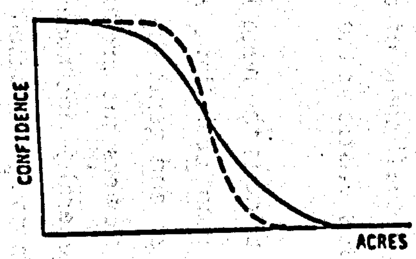
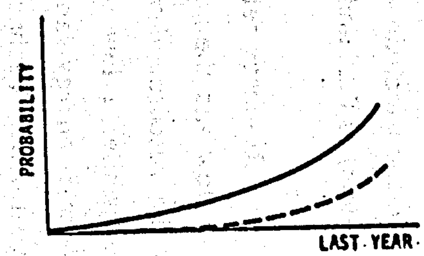
SOURCE: TECHNECON

Table C.4

TAX PARAMETERS

FEDERAL TAX RATE FOR RESOURCE DEVELOPER
FEDERAL TAX RATE FOR ELECTRIC UTILITY ALTERNATIVE
FEDERAL TAX RATE FOR ELECTRIC UTILITY HYDROTHERMAL
FEDERAL TAX RATE FOR THIRD PARTY
INTANGIBLE FRACTION OF WELL COST
INVESTMENT TAX CREDIT FOR NON-UTILITY HYDROTHERMAL
INVESTMENT TAX CREDIT FOR ELECTRIC UTILITY ALTERNATIVE
INVESTMENT TAX CREDIT FOR ELECTRIC UTILITY HYDROTHERMAL
LOCAL TAX RATES
MINIMUM TAX RATE ON PREFERENCE ITEMS
PERCENTAGE DEPLETION ALLOWANCE SCHEDULE
STATE TAX RATE FOR ELECTRIC UTILITY ALTERNATIVE
STATE TAX RATE FOR ELECTRIC UTILITY HYDROTHERMAL
STATE TAX RATE FOR RESOURCE DEVELOPER
STATE TAX RATE FOR THIRD PARTY
TAX RATE FOR ALTERNATIVE PLANT
TAX LIFE FOR HYDROTHERMAL PLANT
TAX LIFE FOR WELL FIELD CAPITAL

SOURCE: TECHNECON

UNCERTAIN PARAMETER	DISTRIBUTION	FACTORS AFFECTING VARIANCE
• POWER PLANT CAPACITY FACTOR • WELL LIFE, INJECTORS • WELL LIFE, PRODUCERS • RESERVOIR TEMPERATURE • WELL FLOW RATE • WELL COST • DRY WELL FRACTION		• ON-SITE PRODUCTION TIME; ABSOLUTE TIME • ON-SITE PRODUCTION TIME; ABSOLUTE TIME • ON-SITE PRODUCTION TIME; ABSOLUTE TIME • ON-SITE PRODUCTION TIME; ABSOLUTE TIME; WELLS DRILLED • ON-SITE PRODUCTION TIME; ABSOLUTE TIME; WELLS DRILLED • ABSOLUTE TIME; WELLS DRILLED • ABSOLUTE TIME; WELLS DRILLED
• PRODUCIBLE ACREAGE		• ACREAGE IN PRODUCTION
• ECONOMIC RESERVOIR LIFE		• ON-SITE PRODUCTION TIME; ABSOLUTE TIME

SOURCE: TECHNECON

FIGURE C.2

HYDROTHERMAL POWER PROJECT UNCERTAINTIES comparisons are made in terms of: electric energy production cost (mills/kWh) delivered to a main transmission corridor, plant availability, net plant output, and risk to corporate or municipal bond rating.

The resource developers' decision model is described in considerable detail in Technecon's publication entitled "Geothermal Investment and Policy Analysis with Evaluation of California and Utah Resource Areas".* This publication describes the decision modeling technique of integrated multiattribute utility analysis and logic choice estimation which is also applied to the electric utilities' decision model. Documentation of the latter model will be forthcoming in the winter of 1980.

The two decision models provide estimates of the numerical likelihood of investment in a specified hydrothermal opportunity by resource developers and by electric utilities, respectively. These models are statistically strong in their ability to reproduce investment preferences as expressed by the respective firms in executive interviews and in demonstrated field practice. Statistical indicators of confidence include a high coefficient of determination (corrected for degrees of freedom) of 0.86 and an F-statistic at the 99% confidence interval.

Resource selling price is the negotiable variable that couples the well field cash flow and the power plant cash flow. A high price improves investment returns to the resource developer and generally increases his likelihood of investment. Meanwhile, a low price lowers the production cost (mills/kWh) of hydrothermal electric energy and generally increases the electric utility's likelihood of investment. Technecon's computer-based simulation of resource price negotiation uses an iterative technique to converge on a price that maximizes the joint likelihood of investment ($P_D P_U$ in Figure C.1) by both parties.

When estimating the time-wise development of a specified resource discovery, each plant addition is evaluated separately. This evaluation is repeated in successive time periods until either the 20-year time horizon is exceeded or the

*Document DOE/RA/4713-1 dated October 1979 available from NTIS, Springfield, VA.

likelihood of the joint well field/plant investment approaches 100%. Subsequent plant additions at the specified resource are evaluated in the same manner and continue until the resource is fully utilized or until the 20-year time horizon is reached.

MODELING ASSUMPTIONS

Significant modeling assumptions that underlie the market estimates provided in this project include the following:

- Regionality. Figure C.3 and Table C.5 illustrate the regional boundaries that were established by the Task Force for the purposes of this project. State tax rates, local ad valorem tax rates, and regional electric utility characteristics and economics were researched and assigned to each region respectively. Regions 1 through 9, inclusive, are found to have appreciable hydrothermal electric power generation within the next twenty years. In each of the nine regions except Arizona, utilities reported that the economic competitiveness of hydrothermal generation will be evaluated in comparison with coal-fired generation. In Arizona, nuclear generation was the reported basis for comparison.

- Capital Structure. Both investor-owned and municipal electric utilities were examined in this project. The long-term debt/common equity/preferred proportion which is assumed for the investor-owned utilities' capital is 0.50/0.35/0.15 at average annual costs of 8%, 13½%, and 8½% respectively. Municipal financing is assumed to be with tax exempt bonds.

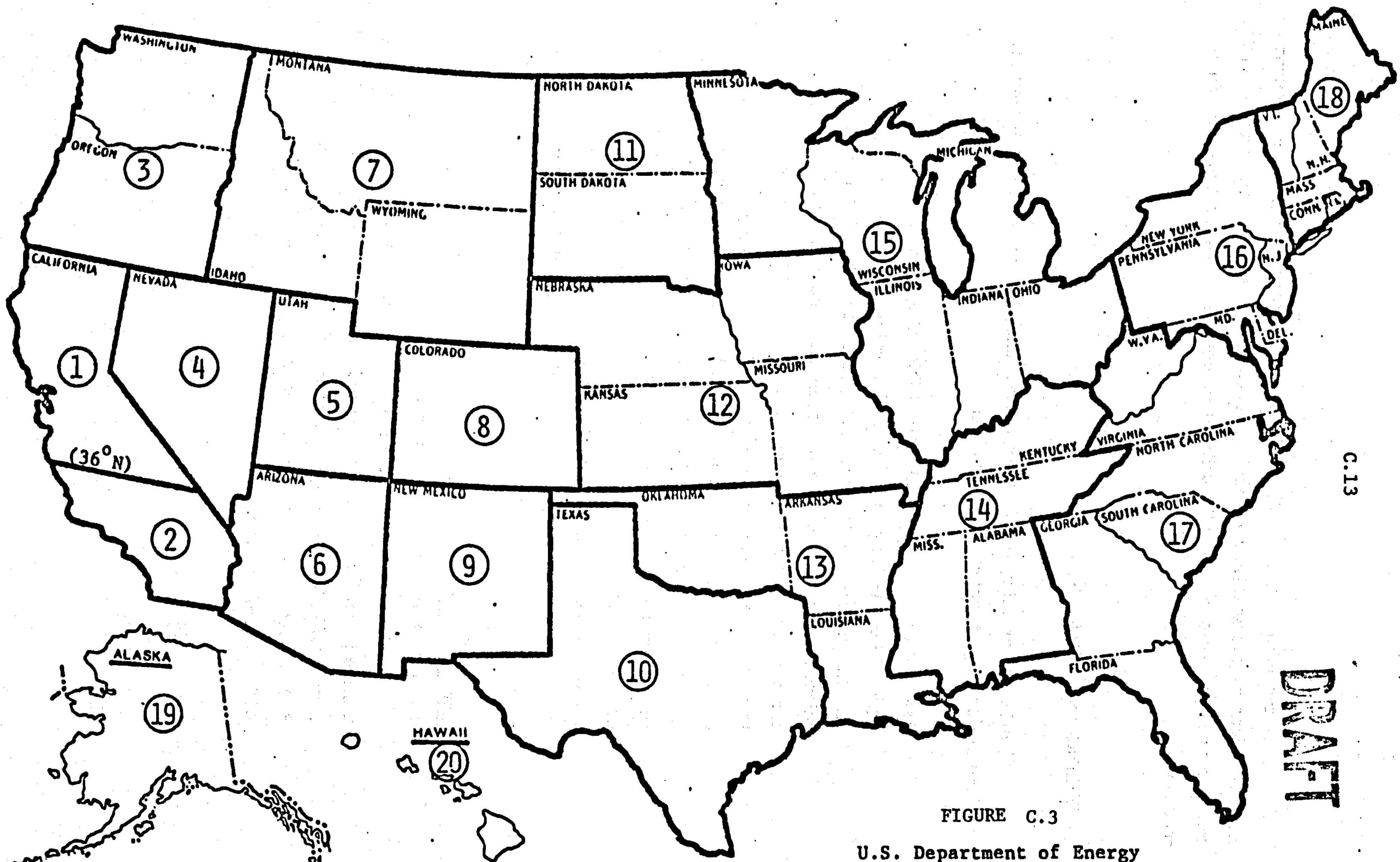


FIGURE C.3

U.S. Department of Energy
HYDROTHERMAL MARKET ESTIMATES PROGRAM

Map of Regional Boundaries

SOURCE: *TECHNECON*

Table C.5

U.S. DEPARTMENT OF ENERGY
HYDROTHERMAL MARKET ESTIMATES PROGRAM

REGIONAL BOUNDARIES

No.	REGION	BOUNDARIES
1.	NORTHERN CALIFORNIA	California north of 36° latitude
2.	SOUTHERN CALIFORNIA	California south of 36° latitude
3.	PACIFIC NORTHWEST	Oregon and Washington
4.	NEVADA	Nevada
5.	UTAH	Utah
6.	ARIZONA	Arizona
7.	MOUNTAIN NORTHWEST	Idaho, Montana, and Wyoming
8.	COLORADO	Colorado
9.	NEW MEXICO	New Mexico
10.	TEXAS	Texas
11.	DAKOTAS	North Dakota and South Dakota
12.	CENTRAL	Iowa, Kansas, Nebraska, and Missouri
13.	SOUTH CENTRAL	Arkansas, Louisiana, and Oklahoma
14.	EAST SOUTH CENTRAL	Alabama, Kentucky, Mississippi, and Tennessee
15.	GREAT LAKES	Illinois, Indiana, Ohio, Michigan, Minnesota, and Wisconsin
16.	MID-ATLANTIC	Delaware, Maryland, New Jersey, New York and Pennsylvania
17.	SOUTH ATLANTIC	Florida, Georgia, North Carolina, South Carolina, Virginia, and West Virginia
18.	NEW ENGLAND	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
19.	ALASKA	Alaska
20.	HAWAII	Hawaii

- Inflation Rates. Table C.6 provides the average annual inflation rates used in this project. These rate assumptions are based upon data from the Wharton econometric model.

- Tax Incentives. An investment tax credit for nonutility geothermal capital of 25% is assumed through 1985 after which it drops to the standard 10% credit. A percentage depletion allowance of 22% is used through 1980, 20% in 1981, 18% in 1982, 16% in 1983 and 15% is used thereafter. 75% of successful well costs are assumed to be "intangible" and, therefore, are expensed for tax purposes.

- Well Field Development. The success fraction for post-confirmation production wells is defined by a triangular probability distribution with a maximum of 0.9, mode of 0.85 and minimum of 0.65. Abandoned dry wells are assumed to cost 90% of successful well costs. 30% of all new wells are assumed to require redrilling for successful production. Redrilling is assumed for every two production wells and a standby, spare production well fraction of 20% is assumed. The assumed spacing of production wells is forty acres.

- Power Plant Development. At resource sites where power plants are either on-line or committed, the plants' size (in megawatts) and on-line years are input to the model. In the absence of existing plants or commitments, assumptions are made regarding sequential plant sizes and the minimum number of years between plants. The first plant is assumed to be a 20 MWe unit which is placed in service not sooner than five years after resource discovery. This five-year minimum lag estimate is based upon the mean lag observed at seven known resource areas. Following the initial 20 MWe unit, two 50 MWe units are assumed to be 100 MWe at one-year minimum intervals. The decision model estimates the numerical likelihood that plants are placed in service

Table C.6

EXPECTED INFLATION RATES FOR 1980-2000

Sector	Twenty Year Estimate of Average Annual Rate of Inflation	Comment
All Goods and Services (CPI)	7-8%	
Fuel Oil and Related	8-11%	Approximately 2-3% real growth
Natural Gas		7-8% real growth over next 5 years
		Because of deregulation, thereafter similar to oil products
Labor costs:		
a) Construction	8-10%	Assuming no major change in productivity, real wages will continue the historical real growth
b) Maintenance - Repair	9-11%	
Capital:		
a) Inputs for plant/equipment (nondrilling)	6-8%	May not beat inflation
b) Pipes and drilling related	7-10%	Likely to do a little better than general rates of inflation
Long Term Interest Rates	10-11%	Reflects 1-3% real rate of return
Coal	7-8%	Probably at CPI, interregional shift to western coal

SOURCE: TECHNECON

with these minimum lag intervals as well as with longer intervals. Federal program elements which are intended to reduce these minimum lags are also evaluated.

FEDERAL PROGRAM EVALUATION

Impacts of the Federal program that is intended to accelerate hydrothermal power development were assessed as a major objective of this current project. Engineering and Economics Research, Inc. provided estimates of the quantifiable effect that this program is expected to have on cash flow parameters. To assess the program's effectiveness, the likelihood of hydrothermal power development was estimated both with and without a Federal program at each resource discovery.

In summary, Technecon's role on the Hydrothermal Market Estimates Task Force has been to apply accepted decision analysis techniques to realistically forecast the development of hydrothermal electric power in the United States. These techniques are based upon investment decision criteria as directly expressed by firms in the geothermal industry. The approach used in this work is uniquely realistic in that it is capable of evaluating multiple investment criteria of both well field developers and power plant investors. Tests of statistical confidence indicate that the computerized methods used in the current project provide a statistically strong representation of industry investment practices.

Appendix D

GEOTHERMAL DIRECT HEAT APPLICATIONS DEMONSTRATION PROJECTS

GEOTHERMAL DIRECT HEAT APPLICATIONS DEMONSTRATION PROJECTS FUNDED IN PART BY THE U.S. DEPARTMENT OF ENERGY

DISTRICT HEATING/SPACE HEATING

- Space Heating, Torbett-Hutchings-Smith Hospital, Texas

  This project will augment space and water heating for the Torbett-Hutchings-Smith Memorial Hospital in Marlin, Texas. Geothermal fluids will be pumped from a known hot water reservoir using a new well to be drilled as part of this project. At peak efficiency, this system will provide 215 million BTU/hour to the hospital. Well has been drilled and tested, and system design completed. Construction is expected to begin during FY 81.

- Heating Phillips School, Haakon, South Dakota

  In this project, several Haakon, South Dakota, school buildings and eight business buildings are heated with geothermal water from a well drilled into the Madison Aquifer. The government has shared the cost of design, construction, and start of operations for the completed system which will be dedicated in October 1980.

- Heating St. Mary's Hospital, Pierre, South Dakota

  The hospital has augmented its heating system with hot water (106°F) from the Madison Aquifer. Retrofit of the 148,000 square foot hospital has been completed. The water will be used for space heating and preheating domestic hot water. The geothermal system will be dedicated in October 1980.

- District Heating, Klamath Falls, Oregon

  Klamath Falls has designed and planned construction of an extensive geothermal heating system in its central business district. The system will be owned and operated by the city itself, and has initial plans to serve 14 government office buildings in the central district. Plans also include subsequent expansion to 115 private commercial buildings and to several hundred private homes. The system currently includes one production well, one reinjection well and retrofitting equipment for all 14 buildings. The project will begin construction in early 1981. Klamath Falls also received Community Development Block Grant from HUD to extend the district heating system to an economically depressed area adjacent to the business district.

- Multiple Uses at Moana, Nevada

  This project involves utilizing the geothermal resource in the Moana District to provide space and water heating to a condominium in Reno, Nevada. The environmental assessment has been approved and preliminary system design completed. Reservoir confirmation drilling has begun and the construction phase is expected to be completed during FY 82.

- District Heating, Pagosa Springs, Colorado

  An extensive geothermal heating system has been planned for the town of Pagosa Springs, Colorado. The scope of this project has grown without significant increase in cost. The number of users, public, private and industrial, has been expanded from 57 to 127. The wells have been drilled and system design completed. Construction is scheduled to begin in the spring of 1981.

- Direct Uses, Elko, Nevada

The Elko Heating Company will tap the geothermal resource in the area to provide space, service water, and process heating to several buildings within the city. Gradient wells are currently being drilled. The environmental assessment for the project has been approved and preliminary system design completed. Reservoir confirmation drilling will begin in early FY 81 and construction is to be started in mid-FY 81.

- District Heating, Boise, Idaho

The city of Boise, Idaho, and the Boise Warm Springs Water District are developing a large-scale district heating system. The environmental assessment has been approved for the project and preliminary design completed. The reservoir confirmation phase will be completed in FY 81 followed by the start of construction.

- District Heating, Monroe, Utah

A geothermal district heating system has been planned for the city of Monroe, Utah. Preliminary drilling has shown that the system is not economically feasible at this point. The city of Monroe is now considering alternate direct heat uses in consultation with DOE.

- Warm Springs State Hospital, Butte, Montana

The utilities at a hospital near Butte, Montana, will be partially convered from natural gas to geothermal energy. Managed by the Montana Energy and MHD Research and Development Institute, this project is an outgrowth of State studies funded to determine the feasibility of converting existing plants to geothermal energy. One geothermal well has been drilled to a depth of 1500 feet. Current well flow rate does not appear adequate for district heating. Consideration is being given to well stimulation. If flow rates are not increased, the project will be rescoped to supply hot water needs only. Construction could begin in FY 81.

- Geothermal Heating, Navarro College, Corsicana, Texas

  The proposed system will augment hot water heating demands of Navarro College student union building and the Navarro County Memorial Hospital. The production and injection wells near Corsicana, Texas, are undergoing tests. Construction is expected to begin in the spring of 1981.

- District Heating, Susanville, California

  The city will utilize Susanville's geothermal resource to provide space heating to 17 public buildings. A parallel effort funded by HUD will involve providing heat to 130 homes in low-income areas. Other applications include space conditioning for industrial park and state prison. The project is in the reservoir confirmation phase. Construction will begin in FY 81, with operation expected in FY 82.

- YMCA Geothermal Space and Water Heating, Klamath Falls, Oregon

  A system has been designed, constructed, and implemented using geothermal fluids to provide space heating and hot water to the YMCA in Klamath Falls, Oregon. The existing fossil fuel system will be retained as a backup or booster system. The system became operational in the summer of 1980.

- Heating - Utah State Prison, Salt Lake City, Utah

  Using the Crystal Hot Springs, one building of the prison will be heated with geothermal fluids. This demonstration will be for the nucleus of a system that can be expanded to service the heating requirements of other existing and planned facilities. The project has obtained approval of environmental assessment and completed preliminary system design. Resource confirmation has begun and the system is expected to be in operation in FY 82.

- Geothermal Core Field Experiment, El Centro, California

  Geothermal fluids from the Heber known geothermal resource will be used to provide space heating, domestic hot water, and space cooling to the community center at El Centro, California. The project will use 10% of the fluids; additional users are being sought. The project has obtained environmental assessment approval and completed preliminary design. Reservoir confirmation drilling is expected to begin in mid-1981.

PROCESS HEAT/AGRICULTURE/AQUACULTURE

- Direct Utilization, Diamond Ring Ranch, Rapid City, South Dakota

  The space and water heating system is now completed at Diamond Ring Ranch outside of Rapid City, South Dakota. Using a low-temperature geothermal resource, this system provides heat and hot water to ranch buildings, and powers a grain dryer. The crop drying system will be used for the Fall 1980 harvest. The system is to be dedicated in October 1980.

- Food Processing, Ore-Ida, Boise, Idaho

  A geothermal well was drilled to supply fluids for the food processing and space heating needs at the Ore-Ida food plant in Ontario, Idaho. However, insufficient water was found and the project has been abandoned.

- Multiple and Industrial Uses, Madison County, Idaho

  A joint effort between Madison County, Idaho, and Rogers Food, Inc., this project would provide for the development of geothermal energy retrofit for municipal space heating and industrial food processing. Two exploratory wells were drilled. Findings indicate that the project does not seem to be feasible as originally proposed.

- Direct Use, Utah Roses Greenhouse, Salt Lake City, Utah

  This project plans to convert six acres of greenhouses from fossil fuels to a geothermal system. The well has been drilled and preliminary design of heating system completed. Approval is currently being sought from the Utah state environmental agency for surface discharge of spent geothermal brines to the Jordan River. Final design and construction could begin in spring of 1981 with system operation following in the 1981-1982 heating season.

- Direct Applications at Kelley Hot Springs, California

  Utilizing two wells at Kelley Hot Springs, California, the Geothermal Power Corporation will demonstrate a geothermal direct energy application to a livestock feed production system and hog feed lot operation. The project has encountered delay in approval of environmental assessment because the site may have historical significance. An archaeological field survey was required.

- Aquafarms International, Mecca, California

  A commercial fish farmer will expand an existing geothermally supplied system to raise giant Malaysian prawns. Substantial project delays in approval of environmental assessment have been encountered. Project is being redirected to avoid cost overruns. The work is 75% complete with operation expected in spring of 1981.

- Holly Sugar Geothermal Project, Brawley, California

  This project involves the design, installation, and operation of a geothermal energy system to be used directly for process heat at the Holly Sugar Refinery. The geothermal system could save over 225,000 barrels of fuel oil each season. The project has encountered delays in approval of reservoir confirmation drilling program. Drilling is now scheduled for late fall of 1980. If successful, construction of the pilot system will begin in spring of 1981.

- Carrie Tingley Children's Hospital, Truth or Consequences, N.M.

  This project involves the use of an existing geothermal well for space heating and pre-hot water heating for the hospital.

- New Mexico State University, Las Cruces, N.M.

  This project involves the utilization of a geothermal reservoir to supply the thermal energy needs of the university campus.