Geothermal Progress Monitor

8

✓ Progress Report November 1983

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U.S. Department of Energy

Assistant Secretary for Conservation
and Renewable Energy

Division of Geothermal and Hydropower Technologies

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GEOHERMAL PROGRESS MONITOR

REPORT NO. 8

November 1983

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U.S. Department of Energy
Assistant Secretary for Conservation and Renewable Energy
Division of Geothermal and Hydropower Technologies
Washington, D.C. 20585

Prepared in Cooperation with the
Interagency Geothermal Coordinating Council
with the Assistance of
The Mitre Corporation, McLean, Virginia

FOREWORD

Geothermal Progress Monitor (GPM) Report Number 8 presents information concerning ongoing technology transfer activities and the mechanisms used to support these activities within geothermal R&D programs. Another section of this report provides a state-by-state review of major geothermal development activities for the reporting period 1 February 1983 through 31 July 1983. Additional sections summarize recent drilling and exploration efforts and the current status of geothermal electric power plant development in the United States.

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1.0 INTRODUCTION

This is the eighth Geothermal Progress Monitor (GPM) Report summarizing the significant events and trends in the U.S. geothermal industry and the federal geothermal program. It covers the period from February 1983 through July 31, 1983.

1.1 Summary and Guide to GPM Report Number 8

Section 2.0 is a new feature of the GPM Reports. It highlights technology transfer activities within geothermal research and development programs. The legislative background and policy directives supporting the technology transfer function are described. Technology transfer mechanisms employed by the national laboratories are explained and examples of successful actions are described.

Section 3.0 provides a state-by-state summary of geothermal development activities during the current reporting period. Many of the reported activities deal with direct use projects such as the San Bernadino, California low temperature geothermal heating system at a wastewater treatment plant. Resource assessments have been scheduled or are underway in northern California, Colorado, Oregon and in several other states. Also various legal and institutional issues have been addressed by the legislative or judicial branches of the state governments.

Drilling and exploration activities are reported in Section 4.0. The trends in drilling activity from 1973 through 1982 are analyzed and the status of current drilling activity is summarized on a state-by-state basis.

Section 5.0 gives a recent update of electric power plant development in the United States. The existing on-line capacity is now about 1270 MW with almost 730 MW of additional capacity under construction and scheduled to be operating by 1986. Plants which are in the planning stages through 1992 are also identified.

The final section of this report (Section 6.0) provides a directory of the members of the Interagency Geothermal Coordinating Council (IGCC) and the participants in the GPM system.

1.2 Background

In 1978 the DOE geothermal energy program was recognized as a priority area for rapid energy technology development. The Division of Geothermal Resource Management (DGRM) was established in October

of 1978 to promote geothermal energy technology and development throughout the nation. In February 1980, DGRM was merged back into the Division of Geothermal Energy which in turn became the Division of Geothermal and Hydropower Technologies.

The design of the GPM began in 1975, when a study to develop a systems concept for monitoring the development and use of geothermal energy in the United States was initiated. In 1979, a panel of the DGRM Commercialization Workshop developed the rationale for a progress monitoring system and described a preferred approach for its development. This panel evaluated a number of concepts and in July 1979, it recommended the development and implementation of the GPM.

In August 1979 DGRM convened a meeting of geothermal data base managers. The results of this meeting served as a basis for developing an initial GPM design and a proposed first report of the GPM. These were reviewed at a meeting of DGRM field elements in November 1979, and a consensus was reached to produce the GPM report on a trial basis for three issues. GPM Report Number 1 was issued in January 1980. The trial edition of these reports was successful enough to warrant publication of a fourth report in September 1980.

Production of GPM Report Number 5 began in February 1981; it was issued in June 1981. Geothermal activities during the second half of 1981 were reported in GPM Report Number 6 (June, 1982). Material compiled throughout 1982 and the beginning of 1983 was reported in GPM Report Number 7 (April, 1983). This issue covers the period from February through July 1983.

1.3 Purpose and Objectives

The Geothermal Progress Monitor is an information system designed for the Division of Geothermal and Hydropower Technologies (DGHT, formerly Division of Geothermal Energy) of the U.S. Department of Energy. The overall purpose of the GPM is to identify and quantify trends in the development and use of geothermal energy resources. To achieve this purpose, information from several sources is collected, analyzed for status indicators and trends, and reported to users. The information sources of the GPM system are paper and computerized files maintained by a number of organizations throughout the United States. Trade and technical publications are also used to supplement the information-gathering network. A schematic representation of the information network is given in Figure 1-1.

FIGURE 1-1
SCHEMATIC OF INFORMATION FLOW IN
THE GEOTHERMAL PROGRESS MONITOR

The general objective of the GPM is to provide a quick-response, centralized, geothermal information collection, storage, analysis, and reporting system that tracks the development of geothermal energy in the United States and the world. It assists the Director of DGHT in effective management of the federal geothermal program and in reporting geothermal energy activities, status, and trends to officials in the government, the IGCC, and other interested parties in the geothermal industry.

The principal policy-oriented aim of the GPM relative to the federal geothermal program is to detect the degree to which the United States' geothermal energy program has affected the growth of geothermal energy use and to assure that federal programs and policies meet the needs of actual geothermal development. With regard to the private sector, the aim is to provide industry with information for its own geothermal development decision-making processes.

In summary, the GPM reports provide the geothermal community with a technology transfer vehicle that maintains or accelerates the rate of geothermal development.

2.0 TECHNOLOGY TRANSFER

In recent years there has been an increasing awareness in the legislative and executive branches of the federal government, as well as in industry, of the benefits which may be gained from the use of unclassified technology developed at taxpayer expense for American industrial innovation. This awareness resulted in the passage of the Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480): which "promotes technological innovation for the achievement of national economic, environmental, and social goals and for other purposes." Some of the findings and declarations incorporated into this act are summarized in the following list:

- Technology and industrial innovation offer an improved standard of living, increased public and private sector productivity, creation of new industries and employment opportunities, improved public services, and enhanced competitiveness of United States products in world markets.
- Many new discoveries and advances in science occur in universities and federal laboratories, while the application of this new knowledge depends largely upon actions by business and labor. Cooperation ... in such forms of technology transfer, personnel exchange, joint research projects and others should be renewed, expanded, and strengthened.
- The federal laboratories and other performers of federally funded research and development frequently provide scientific and technological developments of potential use to state and local governments and private industry. These developments should be made accessible to those governments and industry. There is a need to provide means of access and to give adequate personnel and funding support to these means.

This chapter of GPM Report Number 8 reviews those legislative and policy directives which have particular relevance to technology transfer from the geothermal research and development programs in the national laboratories. It also includes a summary of the technology transfer mechanisms used by the laboratories and examples of successful technology transfer actions. The final section of this chapter is a directory of the people involved in the technology transfer process at each of the laboratories as well as the individuals involved in or acquainted with the geothermal research and development programs in these laboratories.

2.1 Legislative and Policy Directives Supporting the Technology Transfer Function

2.1.1 The Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480)

This legislation was enacted on October 21, 1980 "to promote.... technological innovation for the achievement of national economic, environmental, and social goals and for other purposes." As outlined in Section 3 of the Act these purposes are to be achieved by:

- establishing organizations in the executive branch to study and stimulate technology
- promoting technology development through the establishment of centers for industrial technology
- stimulating improved utilization of federally funded technology developments by state and local governments and the private sector
- providing encouragement for the development of technology through the recognition of individuals and companies which have made outstanding contributions in technology, and
- encouraging the exchange of scientific and technical personnel among academia, industry and federal laboratories

Section 11 of this Act addresses the central issue of stimulating the utilization of federal technology. This section includes a policy statement concerning the responsibility of the federal government for ensuring the full use of the results of federal investment in research and development. The Act further states that the federal government shall strive, where appropriate, to transfer federally owned or originated technology to state and local governments and to the private sector.

In order to carry out these policies, Section 11 of the Act required each federal laboratory to establish an Office of Research and Technology Applications (ORTA) or to combine this office with an existing structure which performs the functions outlined below. The laboratory and its operating agency were directed to establish the funding and staffing levels except that a minimum of one full time professional staff was mandated for laboratories having a total annual budget in excess of \$20 million. Beginning in FY 1982 each federal agency which operated or directed a federal laboratory was

to set aside one half of one percent of the agency's research and development budget to support the technology transfer function at the agency and at its laboratories, including support of the ORTAs. These requirements may be waived by the agency head upon submission to Congress of an explanation for the waiver and alternate plans for conducting the technology transfer function.

The ORTAs are to perform the following functions:

- prepare an application assessment of each research and development project....which has potential for successful application in state, or local government or in private industry;
- provide and disseminate information on federally owned or originated products, processes, and services.....;
- cooperate with and assist the Center for the Utilization of Federal Technology and other organizations which link the research and development resources of that laboratory and the federal government as a whole to potential users in state and local governments and private industry; and
- provide technical assistance in response to requests from state and local government officials.

This Act also establishes a Center for Utilization of Federal Technology within the Department of Commerce. This organization is to serve as a central clearinghouse for information collection and dissemination concerning technology transfer. It is also chartered to receive requests for technical assistance from state and local governments and to refer those requests to the appropriate federal laboratories. The Center, at the discretion of the Secretary of Commerce, can provide funding to the federal laboratories so that they may respond to the requests for technical assistance from the state and local governments.

2.1.2 Department of Energy Order Number 5800.1

In March of 1982 the Assistant Secretary for Management and Administration of the Department of Energy (DOE) issued DOE Order Number 5800.1. This order established the policies and responsibilities for the management of the technology transfer programs at DOE's research and development laboratories.

This order states that "it is DOE policy that technology transfer activities as required by Public Law 96-480 are legitimate functions of the R&D laboratories and will be conducted, as appropriate, at those laboratories specified in this Order." In addition to this policy statement the following other objectives are established:

- To assure the application of consistent assumptions and procedures in the planning and conduct of technology transfer activities.
- To assure appropriate and effective administration and management of the technology transfer program.
- To assure the timely and accurate collection of data and information about technology transfer for the purpose of describing the overall DOE effort in the technology transfer program.

Technology transfer is defined in order 5800 as the transformation of R&D into processes, products and services that can be applied to state and local government and private sector needs. The emphasis of the technology transfer program is on personal interaction between the technical staff at the laboratories and representatives of the public and private sectors. The program includes the following activities:

- Assessment of R&D projects for applicability and their adaptation to the needs of the private and public sectors.
- Technical assistance to the private and public sectors.
- Cooperation with organizations or institutions which provide a link between the organization performing R&D and the potential users of the technology.
- Licensing of DOE-owned patented technology for commercial use.

Because of the broad range of activities encompassed by DOE's R&D programs the responsibilities and authorities for carrying out this order are dispersed throughout several offices within the Department. These are summarized in Table 2-1.

TABLE 2-1

**RESPONSIBILITIES AND AUTHORITIES OF DEPARTMENT OF ENERGY
PERSONNEL FOR IMPLEMENTING DOE ORDER NUMBER 5800.1**

DEPARTMENTAL ELEMENT	RESPONSIBILITIES AND AUTHORITIES
UNDER SECRETARY	<ul style="list-style-type: none"> Establishes policy and provides overall guidance for the technology transfer program
DIRECTOR OF ENERGY RESEARCH	<ul style="list-style-type: none"> Reports to the Under Secretary regarding recommended policies for conducting the technology transfer program Interacts with the cognizant Secretarial Officers to provide schedules and guidance for the development of the annual five year technology transfer program plan and the annual technology transfer program report Provides guidance for incorporating the technology transfer functions into the existing institutional plans for multiprogram laboratories Provides, through the Laboratory Management Division, a focal point for the technology transfer program and for interagency coordination
COGNIZANT SECRETARIAL OFFICERS	<ul style="list-style-type: none"> Incorporate and administer the technology transfer program in the laboratories for which they are responsible Coordinate with the Director of Energy Research regarding policies, assumptions, definitions and procedures affecting the technology transfer program Provide guidance to the R&D laboratories through the operations offices for developing and implementing the technology transfer program consistent with the schedule and guidance issued by the Director of Energy Research Incorporate the technology transfer program into the institutional planning process and approve the annual 5 year technology transfer program plan

TABLE 2-1 (Concluded)

RESPONSIBILITIES AND AUTHORITIES OF DEPARTMENT OF ENERGY
PERSONNEL FOR IMPLEMENTING DOE ORDER NUMBER 5800.1

DEPARTMENTAL ELEMENT	RESPONSIBILITIES AND AUTHORITIES
ASSISTANT SECRETARY, MANAGEMENT AND ADMINISTRATION	<ul style="list-style-type: none"> • Provides appropriate support
ASSISTANT SECRETARY FOR DEFENSE PROGRAMS	<ul style="list-style-type: none"> • Provides guidance pertaining to security classification of new areas of information
ASSISTANT SECRETARY FOR CONGRESSIONAL, INTERGOVERNMENTAL, AND PUBLIC AFFAIRS	<ul style="list-style-type: none"> • Provides recommendations to the Under Secretary regarding the interactions between the laboratories and state and local governments
ASSISTANT GENERAL COUNSEL FOR PATENTS	<ul style="list-style-type: none"> • Administers patent licensing program • Negotiates patent licensing including charging of royalties where appropriate • Coordinates with operations offices and laboratories to provide technical assistance to patent licensees when appropriate
DEPUTY ASSISTANT SECRETARY FOR NAVAL REACTORS	<ul style="list-style-type: none"> • Establishes procedures and approves all technology transfer concerning information in the Naval reactors program
MANAGERS OF OPERATIONS OFFICES	<ul style="list-style-type: none"> • Overview of laboratories' compliance with the guidance provided by the Director of Energy Research and the cognizant Secretarial officers • Advise and concur on the annual 5 year plans and reports

2.2 Technology Transfer of Geothermal Energy Research and Development Programs

In response to the legislative intent of the Stevenson-Wydler Act, DOE Order Number 5800.1 established the policies and responsibilities for conducting technology transfer programs at the DOE R&D laboratories. This section describes the technology transfer process as it relates to the Geothermal Energy R&D programs at several of these laboratories. Specific examples of successful technology transfer actions are also cited.

2.2.1 Technology Transfer Mechanisms

In order to describe the technology transfer process as it relates to the Geothermal Energy Research and Development Programs, members of the technical staff of The MITRE Corporation met with past and current program participants in several of the national laboratories. These meetings had three principal objectives:

- To identify and discuss examples of successful transfers of geothermal R&D results to the private sector.
- To determine those institutional arrangements and program management methods/techniques which most effectively stimulate the involvement of industry and its desire to implement the technology advances of geothermal energy R&D programs.
- To gather views on the definition of technology transfer as it applies to geothermal energy.

Although specific details of the technology transfer process may differ from laboratory to laboratory, in general there is considerable agreement regarding the mechanisms used to effectively conduct technology transfer activities. Personal contacts, initiated at workshops, conferences, or meetings are considered to be one of the most effective mechanisms. In one instance it has led to a cooperative working arrangement between Battelle Pacific Northwest Laboratory (PNL) and Magma Power Company (see Section 2.2.2.1). At Sandia National Laboratories, Technology Review Panels comprised of industrial, governmental, and academic experts are another manifestation of the role of personal interactions in technology transfer activities (see Section 2.2.2.4).

Workshops are also a useful medium for technology transfer due to the multiplier effect of having several individuals with specialized training and interests involved in directed discussions, usually at the facility where these interests are being pursued.

Some of the laboratories use direct mailings of their technical project reports to supplement the traditional Technical Information Center distribution. The project personnel are responsible for maintaining lists of interested parties in the private and public sectors to whom early transmission of project status or results may be of value.

Another mechanism for facilitating technology transfer is to involve the private sector as subcontractors and, if possible, as co-sponsors for hardware development. This has worked effectively in instrument development programs such as those at PNL, Los Alamos, and Sandia.

Other opportunities include making laboratory test facilities available to the private sector and having laboratory personnel serve on committees of trade associations, professional societies and various consortia.

Throughout the various conversations between the MITRE staff and the laboratory personnel the comment most frequently made was that technology transfer worked best when there was a high level of personal interaction between the research and user communities.

As a result of the meetings held with laboratory personnel, a fairly comprehensive listing of technology transfer mechanisms was developed. This list is given as Table 2-2. These mechanisms represent a variety of approaches to technology transfer, some of which are similar to others. The extent to which each is being used and the degree of success of each mechanism is dependent on a variety of factors including: the types of technology being transferred (e.g., hardware, test results, software), the nature of the laboratory work program in terms of applicability to industrial needs, and the laboratory's history of interacting with industry.

2.2.2 Examples of Successful Technology Transfer Actions

This section highlights specific examples of technology transfer actions from the geothermal R&D programs at several of the national laboratories. Brief descriptions of a representative sample of these actions from each laboratory are included. More detailed information may be obtained by contacting the laboratory personnel.

2.2.2.1 Battelle Pacific Northwest Laboratories. The geothermal R&D program at Battelle Pacific Northwest Laboratories (PNL) has evolved from geochemical studies of geothermal brines to geochemical

TABLE 2-2

TECHNOLOGY TRANSFER MECHANISMS

Employee Exchanges

Presentations at Technical Meetings

Publication in Scientific and Trade Journals

Direct Mailing of Technical Reports to Industry

Unreimbursed Consulting Services for Industry

Limited Reimbursable Work for Industry

Use of Industrial Facilities to Test Laboratory-Developed
Hardware and Equipment

Technology Inventories Made Available to Industry
(e.g., Applications Assessments)

Inventory of Laboratory Facilities Made Available to
Industry and Use of These Facilities by Industry

Informal Interactions with Private Sector Personnel

Formal Visits to Discuss Research in Progress

Special Conferences and Workshops Held at Labs and
Focused on Technology of Mutual Interest

Liaison with Industry Associations

Use of Industrial Advisory Committees/Technology Review
Panels

Federal Laboratory Consortium for Technology Transfer

Lab Personnel Transferring to Industry or Forming New
Companies

Licensing of DOE Patents to Corporations

Use of Technology Champions in Laboratories or Brokers
Outside of Laboratories

engineering in support of heat cycle research, brine injection technology, and the Heber Binary Power Plant project. The principal focus is on inline instrumentation to improve power plant reliability. Instrument sensors which are beyond the current industrial state-of-the-art are being developed to measure inline chemistry and corrosion. These instruments will set off alarms if unacceptable conditions occur.

Magma Power Company's East Mesa demonstration plant is being used for field tests of these instruments. The cooperative arrangement between PNL and Magma Power, which makes access to their plant available at no cost, is an example of a successful technology transfer mechanism. PNL has been able to develop instrumentation which will be used on the Heber plant. Magma power has received information about the operating characteristics of its plant. It has also received guidance in setting up its own analytical chemistry laboratory.

Examples of technology products under development or in the testing phase are given below:

1. Technology Product: Leak Detector

Product Type: Hardware

Description: In binary cycle power plants, a hydrocarbon working fluid circulates in a closed loop through the heat exchangers and turbine. The leak detectors have been designed to monitor leaks of both the brine into the hydrocarbon loop or hydrocarbon into the brine. A non-dispersive infra-red analyzer or a gas chromatograph is used to detect the presence of the hydrocarbon.

2. Technology Product: Corrosion Monitor

Product Type: Hardware

Description: Early in its operational life, Magma Power Company's East Mesa plant experienced corrosion problems which emphasized the need for reliable corrosion monitoring equipment. Eight sacrificial probes are now installed throughout the plant. Each electrode is selectively used as the fourth leg of a Wheatstone Bridge circuit. As the electrodes corrode, their electrical resistances change, affecting the current measured across the Wheatstone Bridge. The changes in the measured current can be equated to the rate of corrosion.

3. Technology Product: Conductivity Cell

Product Type: Hardware

Description: PNL has also developed an electrode-less conductivity cell which will aid in controlling the formation of calcium carbonate scale. The PNL engineers found that conductivity in a fluid is strongly affected by its bubble content. The bubbles indicate two phase (steam-liquid) flow. The steam phase aids in the evolution of CO₂ which in turn contributes to scale formation.

Significance: These three instruments will contribute to the reliable and efficient operation of the 45 MW Heber Binary Project. An estimated \$100,000 in lost revenue is projected for each day of downtime. Successful development and deployment of these instruments will help to minimize power outages.

Other Applications: In line high temperature, high pressure probes have potential applications in the pharmaceutical industry (in autoclaves) and in the petroleum industry.

Additional Information:

Donald W. Shannon
Cecil H. Kindle
Battelle Pacific Northwest Laboratories
Battelle Boulevard
Richland, Washington 99352

2.2.2.2 Lawrence Berkeley Laboratory. At Lawrence Berkeley Laboratory the geothermal R&D effort is focused on two general areas. The Geothermal Exploration Technology Development Program develops new and refined geophysical techniques and methodologies to be used in exploration for geothermal reservoirs. Associated case histories are used to document and validate the new systems.

The Geothermal Reservoir Engineering Research Program studies the fundamental physical and chemical processes of geothermal reservoirs and develops new methods for reservoir engineering analysis. Demonstrations and validation of the analytical methods used are an integral part of the program.

Examples of successful technology transfer actions are given in the following list:

1. Technology Product: Q-LOG

Product Type: Integrated hardware/software package

Description: This is the commercial version of LBL's automated seismic processor (ASP). This processor is a real time distributed processing system that continuously monitors a seismic array, automatically detects events and provides complete calculation of seismological source parameters within one minute of each event.

Significance: In geothermal field monitoring the usefulness of event location and analysis diminishes greatly as time delays increase. This instrument and software package can replace conventional data reduction techniques, which may require months of labor and expensive computer time, with complete high speed data analysis for each event.

Other Applications: Conventional microearthquake surveys, induced seismicity studies and monitoring of large reservoirs, nuclear waste repository studies, and volcano monitoring.

Additional Information:

- Technical and Prototype Development
T.V. McEvilly
University of California
Lawrence Berkeley Laboratory
Berkeley, California 94720
- Commercial Product
Q-LOG
Sprengnether Instruments, Inc.
4150 Laclede Avenue
St. Louis, Missouri 63108

2. Technology Product: Downhole Flow Meter

Product Type: Hardware

Description: A downhole flow meter, constructed of stainless steel and titanium was successfully tested at a site in the Imperial Valley. It is capable of withstanding temperatures of over 520°F and depths of approximately 13,000 feet. It also resists the highly corrosive brines of the Imperial Valley. The flow meter, which can be lowered into a wellbore as small as 3 inches in diameter, is connected

mechanically and electrically to a high temperature armored logging cable. Fluid passing through the flow meter in the well rotates an impeller, measuring the rate and amount of flow and producing a signal which can be monitored at the surface.

Significance: A reliable, high temperature, downhole flow meter is an important new tool for geothermal reservoir engineering research. It can be used to delineate productive rock strata and to determine the flash depth in the wellbore. It can also detect variations in the wellbore diameter caused by scale buildup, casing changes or caving.

Other Applications: This instrument has potential to be used in basic energy research and may be of value to geologists and geophysicists studying a variety of natural geologic systems. One such application may be a study of the global circulation of water deep within the earth's crust.

Additional Information:

Sally Benson
Ray Solbau
University of California
Lawrence Berkeley Laboratory
Berkeley, California 94720

3. Technology Product: SHAFT 79

Product Type: Computer Code

Description: The acronym for this computer program stands for Simultaneous Heat And Fluid Transport. The program is an integrated finite difference program for computing two-phase non-isothermal flow in porous media.

This software has been designed to aid in geothermal reservoir simulation studies. It was used to conduct a two dimensional study of the Krafla (Iceland) geothermal reservoir where different space and time patterns of production and injection were modeled. Other modeling efforts have included one dimensional rectangular modeling of various production and injection schemes for reservoirs with uniform initial conditions and a one dimensional cylindrical model of two phase flow near wells. This latter effort simulated geothermal production from two-phase zones

and cold water injection into two phase and superheated steam zones.

Other Applications: The program can be used for studies of nuclear waste repositories and, as a pressure and phase transition program, it can be used for studies of enhanced oil recovery methods.

Additional Information:

Karsten Pruess
University of California
Lawrence Berkeley Laboratory
Berkeley, California 94720

2.2.2.3 Los Alamos National Laboratory. There are three general areas of interest in the geothermal R&D programs at Los Alamos National Laboratory (LANL). A major effort to investigate the possibilities, promise, and potential usefulness of hot dry rock energy systems was formally initiated in 1973 and is continuing. Other program areas at LANL include reservoir stimulation and a geothermal pump program. The following list identifies some examples of technology transfer activities from these programs.

1. Technology Product: Hot Dry Rock Resource Evaluation and Site Characterization

Product Type: Data Collection and Dissemination

Description: The Hot Dry Rock program met with early skepticism concerning the existence of useful hot rock with low enough permeability and located close enough to the surface to be reached with conventional drilling equipment. In cooperation with the U.S. Geological Survey, a study of the Hot Dry Rock thermal energy resource base was undertaken. Other organizations, individuals and university groups are also involved in the resource evaluation and site characterization studies. Heat flow investigations have been performed by scientists from universities throughout the country. Seismic, geophysical, hydrologic, and geochronological studies have been conducted in more limited areas. In contrast to the regional studies, detailed geological and geophysical evaluations have been made for a number of sites within the continental United States. Some of the sites that have been studied are Cayuga Lake, New York; Coso Hot Springs, California; Desert Peak and Dixie Valley, Nevada; Mt. Hood and Vale, Oregon; and the Rio Grande Rift and Zuni Uplift in New Mexico.

Significance: The regional studies have documented the fact that useful heat in hot dry rock, at accessible depths represent a large supply of directly usable energy. This conclusion is supported by the large number of hot dry holes that have been drilled by energy companies in and around known hydrothermal areas and in unsuccessful prospecting for new hot-water and steam fields. The site characterizations and evaluations have demonstrated both the broad distribution of the hot dry rock thermal energy resource base and its presence in many locations where its commercial development may be attractive when the technology for exploiting it has matured.

Additional Information:

John Rowley
Mort Smith
Los Alamos National Laboratory
University of California
P.O. Box 1663
Los Alamos, New Mexico 87545

2. Technology Product: Geothermal Pump Test Facility

Product Type: Hardware

Description: As part of the Geothermal Pump Program at Los Alamos, the Geothermal Pump Test Facility was developed by Barber-Nichols. It is a useful diagnostic tool which has been responsible for detecting numerous required changes in the engineering design, material specifications, and installation procedures of downhole electric submersible pumping systems. This transportable facility can test pumping systems up to 150 horsepower. Instrumentation and data recording systems are self contained and may operate in an unmanned mode except for periodic maintenance and surveillance. The facility has successfully operated for extended testing periods at temperatures of 350-375°F.

Significance: Several important benefits can be realized from downhole pumping of geothermal wells. These include enhanced flow rates which reduce the number of wells required for a given production capacity, elimination or reduction of wellbore chemical precipitation and scaling through downhole pressurization, higher wellhead brine temperatures for increased energy conversion efficiency,

and single-phase fluid distribution lines on the surface as opposed to separate steam and brine piping to the power plant.

Additional Information:

R.J. Hanold
Los Alamos National Laboratory
University of California
P.O. Box 1663
Los Alamos, New Mexico 87545

2.2.2.4 Sandia National Laboratories. As an engineering laboratory, the geothermal R&D programs at Sandia National Laboratories (SNL) are directed at technological issues affecting geothermal well drilling and completion. Sandia uses Technology Review Panels (TRP) to help guide their R&D efforts. The TRPs are composed of industrial, government, and academic experts from the geothermal community. They meet semi-annually to critique programs in progress, to identify capabilities for joint endeavors, and to become personally involved in technologies of interest to their firms. The technology transfer mechanism has resulted in several successful technology transfer actions. A few of these are cited below:

1. Technology Product: Stratapax Drill Bits

Product Type: Hardware

Description: Sandia National Laboratories has contributed to the development of these drill bits in three areas. Computer code has been developed to model the interaction between a polycrystalline diamond compact (PDC) cutter and the country rock. The numerical modeling effort predicts the effects of weight, cutting speed and cutting depth on the stress patterns in the cutter and the rock. The geometry of the placement of the PDC cutters on the bit face was also computer generated. This has helped to optimize bit life. Sandia has also developed a diffusion bonding process for securing the PDC to bit studs.

Significance: Geothermal drilling is different from oil and gas drilling because of the hot, hard rock and corrosive fluids encountered. The design of the Stratapax Drill Bits and the associated diagnostic tools might not have occurred in the private sector because the market was perceived to be quite limited. There are now more than 15 companies marketing PDC bits.

Other Applications: These bits are being used for oil and gas operations.

Additional Information:

James Kelsey
Richard Traeger
Sandia National Laboratory
Albuquerque, New Mexico 87185

2. Technology Product: Lost Circulation Test Facility

Product Type: Hardware

Description: A large facility which simulates geothermal well conditions has recently been built at Sandia. It will be used to develop new materials and methods for solving lost circulation problems. With some additional equipment the Lost Circulation Test Facility can also perform experiments on mud/cement displacement problems which in the field may lead to casing buckling.

Significance: Lost circulation of drilling fluid and efforts to restore circulation can represent from 30 to 50 percent of the cost of a geothermal well. Problems associated with lost circulation range from lost drilling fluid to loss of the well. Many types of materials, ranging from pecan shells to metal chips, have been tried as bridging materials to solve the lost circulation problem but these rarely work in geothermal reservoirs which are characterized by high temperatures and large fractures. This facility is modeled after an oil industry test center which is currently booked for testing for the next five years, 7 days per week, 24 hours per day.

Additional Information:

Bill C. Caskey
Geothermal Technology Development
Sandia National Laboratory
Albuquerque, New Mexico 87185

3. Technology Product: Borehole Televiewer

Product Type: Hardware

Description: This high temperature acoustic televiewer has been developed for borehole inspection. An acoustic pulse is generated in the wellbore by a rotating piezoelectric

transducer which is pulled slowly up the well at a rate of about 5 feet per minute. The televiewer output is an acoustic picture of the wellbore. The circumference of the well is laid out flat to show fractures that intersect the wellbore. Pressure and flow transducers have recently been added to the instrumentation package to facilitate the location and definition of lost circulation zones. A unique heat sink design, using eutectic mineral salts, provides a 4 hour period of operation at temperatures above 500°F.

Significance: This borehole logging system enables drilling service contractors to map producing zones and non-producing zones. It also helps to identify and characterize lost circulation zones in the wellbore. The high temperature electronics and heat protection system is a unique new development.

Other Applications: It is anticipated that this logging tool will have broad applications in deep oil and gas well development.

Additional Information:

John T. Finger
Geothermal Technology Development
Sandia National Laboratory
Albuquerque, New Mexico 87185

2.3 Sources of Additional Information

2.3.1 Office of Research and Technology Applications

As described in Section 2.1 the Stevenson-Wydler Act established an Office of Research and Technology Applications in each federal laboratory. The following list is a directory of these offices at the laboratories which have been involved in geothermal energy research and development.

Argonne National Laboratory
Richard O. Ivins, Director
Office of Industry Marketing
Sciences
9700 South Cass Avenue
Argonne, Illinois 60439
(312) 972-7694 or FTS 972-7694

Lawrence Livermore National
Laboratory
Gerald T. Richards, Head
Office of Research and
Technology Applications
University of California
P.O. Box 808
Livermore, California 94550
(415) 422-6416 or FTS 532-6416

Brookhaven National Laboratory
William Marcuse
Upton, L.I., New York 11973
(516) 282-2103 or FTS 666-2103

Lawrence Berkeley Laboratory
Robert J. Morris
Office of Technology Applications
University of California
Berkeley, California 94720
(415) 486-6502 or FTS 451-6502

Oak Ridge National Laboratory
Donald W. Jared
Research Applications Officer
P.O. Box X
Oak Ridge, Tennessee 37830
(615) 574-4193 or FTS 624-4193

Pacific Northwest Laboratory
Loren C. Schmid
P.O. Box 999
Richland, Washington 99352
(509) 375-2559 or FTS 375-2559

Los Alamos National Laboratory
Eugene E. Stark, Jr.
Industry Liaison Officer
P.O. Box 1663
Los Alamos, New Mexico 87545
(505) 667-1230 or FTS 843-1230

Sandia National Laboratories
Robert P. Stromberg
Technology Transfer Officer
Org. 400
Albuquerque, New Mexico 87185
(505) 844-5535 or FTS 844-5535

Idaho National Engineering
Laboratory
Clyde B. Toole, Director
Office of Research and Technical
Application, INEL
P.O. Box 1625
Idaho Falls, Idaho 83415
(208) 583-6316 or FTS 583-6316

2.3.2 U.S. Department of Energy-Technical Information Center

The Technical Information Center (TIC) distributes the results of DOE's research and development programs to the Department's program managers and contractors. A subject category scheme insures distribution of the reports in the contractor's area of interest. The category code for Geothermal Energy is UC-66. Several subsections may be specified as shown in the following list:

UC-66 GEOTHERMAL ENERGY

Reports in this category include information on all aspects of the Geothermal Energy program. All geothermal reports are distributed to the addresses in the basic list with additional distribution as appropriate to supplemental list(s).

UC-66a
GE-RESOURCE DEVELOPMENT

Reports in this category include information on:

1. Present status of resource development
2. Resources and Reservoir Assessment
3. Geology, Hydrology, and Geothermal systems.

UC-66b
GE-EXPLORATION TECHNOLOGY

Reports in this category include information on:

1. Geophysical exploration techniques and surveys
2. Geochemical exploration techniques and surveys
3. Exploratory drilling technology and well logging
4. Downhole and surface instrumentation

UC-66c
GE-DRILLING TECHNOLOGY

Reports in this category include information on:

1. Advanced drilling systems and methods of drilling.
2. Drilling fluids and cementation.
3. Downhole drill motors.
4. Other well hardware.

UC-66d
GE-UTILIZATION TECHNOLOGY

Reports in this category include information on:

1. Materials development, corrosion studies, scaling control
2. Heat exchangers, pumps, advanced conversion systems
3. Extraction technology, reservoir stimulation
4. Fluid transmission pipeline design

UC-66e
GE-ENVIRONMENTAL RESEARCH

Reports in this category include information on:

1. Ground subsidence, seismic effects
2. Noise, blow-outs, gaseous emissions
3. Emission control and abatement
4. Surface and groundwater effects

UC-66f
GE-EXPERIMENTAL AND COMMERCIAL ELECTRICITY
PRODUCTION FROM GEOTHERMAL RESOURCES

Reports in this category include information on:

1. Closed thermal loops
2. Pilot and demonstration plants
3. Commercial power plant design and operation

UC-66g
GE-DIRECT APPLICATIONS OF HEAT
FROM GEOTHERMAL RESOURCES

Reports in this category include information on:

1. Agricultural applications
2. Medical treatment
3. Aquaculture
4. Industrial applications
5. Residential and commercial applications

UC-66h
GE-LEGAL AND OTHER INSTITUTIONAL ASPECTS
OF GEOTHERMAL ENERGY EXPLOITATION

Reports in this category include information on:

1. Effects of Federal, State and local laws and regulations on geothermal development
2. Social implications
3. Taxation policies
4. Land use criteria

UC-66i
GE-ECONOMIC AND FINANCIAL ASPECTS OF
GEOTHERMAL ENERGY EXPLOITATION

Reports in this category include information on:

1. Cost projections
2. Market analyses and projections
3. Federal Loan Guaranty Programs
4. Economic incentives to lease, explore and exploit geothermal energy

UC-66j
GE-FEDERAL ENERGY PLANS

Reports in this category include information on:

1. Annual update of National Energy Plans
2. Geothermal Definition Report

For more information call:

Ramona Nelson
615-576-1267
Department of Energy
Technical Information Center
Oak Ridge, Tennessee

Department of Energy contractors should be prepared to give their contract number.

3.0 STATE SUMMARIES

This section of GPM Report Number 8 is a state-by-state summary of geothermal development activities for the period February through July 1983. Specific information about drilling and exploration activities, however, is given in Section 4.0 and advances in electric power plant development are reported in Section 5.0.

The information has been gathered from the traditional sources of the GPM system. These include the Petroleum Information Corporation's National Geothermal Service (PIC NGS) newsletter, the monthly regional activities reports prepared by E.G.&G. Idaho, the Bulletin of the Geothermal Resources Council (GRC), and other technical and trade publications. Additional information is usually obtained through personal communications with members of the geothermal community.

ALASKA

Leasing Activity

- Results of Competitive Lease Sale in Kenai Peninsula Borough

Sixteen tracts in Kenai Peninsula Borough were offered at a competitive lease sale held in May by the Alaska Department of Natural Resources. The tracts, located on the flanks of Mt. Spurr, an active volcanic feature 75 miles west of Anchorage, totaled more than 10,000 acres.

The only bidder was Suzan Tierney who offered \$10.94 per acre on a 640 acre parcel in T. 13N., R. 17W. Should a lease be issued, she is proposing the development of a hydroponic truck farm. The produce would be air freighted to Anchorage for marketing. She estimates that it will take approximately five years for the project to reach production.

Sources: GRC Bulletin Vol. 12, No. 03, 03/00/83.
PIC NGS Vol. 05, No. 13, 03/31/83.
Vol. 05, No. 21, 05/27/83.

CALIFORNIA

Direct Use Projects

- Indian Community Receives Grants for Geothermal Projects

The Fort Bidwell Indian Community has received two federal grants for geothermal projects. Under a Department of Labor grant, the Hydrothermal Energy Corporation of Los Angeles will provide training to install a geothermal space and greenhouse heating system. The Indian community will be able to change from general agriculture to geothermally heated greenhousing and agriculture.

The second grant is from the Housing and Urban Development Agency. It will provide funds for engineering work and hardware to retrofit the community center, gym, medicare clinic, cafeteria and a senior citizen's complex.

The reservation is in the northern portion of Surprise Valley near Alturas in northeast California.

Source: GRC Bulletin Vol. 12, No. 2, 02/00/83.

- Plumas County Project Proceeding

The Indian Valley Hospital District has successfully completed a direct use geothermal well near the town of Greenville. The well was flow tested for eight hours at a rate of 300 gallons per minute. Water temperature was 117°F. The well will be used to heat the hospital facilities where retrofitting of the heating system is expected to be completed by the fall of this year. A second well is planned for the area.

Source: PIC NGS Vol 5, No. 6, 02/11/83.

- Low-Temperature Geothermal System Goes On-Line

In San Bernadino, the Water Department has placed a low temperature geothermal heating system on line. The geothermal fluid is used to heat an anaerobic digester at the city's wastewater treatment plant. The well supplying the fluid flows at a rate of 2500 gallons per minute, artesian. The water temperature is 134°F and the flow pressure is 20 pounds per square inch. Another digester is being built

and the San Bernadino Water Department is seeking a grant-loan from the California Energy Commission to establish a geothermal heating district.

Source: PIC NGS, Vol. 5, No. 20, 05/20/83.

- California Energy Commission Releases Bridgeport Project Report

The California Energy Commission has released an analysis of a proposed district heating system for Bridgeport, the county seat of Mono County. The supply well for the project will be located one and a half miles southeast of Travertine Hot Springs. It is expected to yield 1000 gallons per minute at temperatures ranging from 205 to 240°F. The hot brine will drive a 500 kilowatt binary cycle generator. The geothermal effluent will then be used for the district heating system which is to serve 15 public and private buildings. The analysis concluded that the project is feasible based on three critical assumptions: a successful supply well, a commercially viable wellhead generator, and success in obtaining financing from private investors, a commercial lender, and a granting agency.

Source: PIC NGS, Vol. 5, No. 19, 05/13/83.

Resource Assessments

- Siskiyou County To Be Evaluated for Geothermal Potential

Using a California Energy Commission grant, the Siskiyou County board has hired Eliot Allen and Associates to study the county's geothermal resource potential. Several objectives have been identified for this project:

- An assessment and volume determination of the county's low temperature water resources
- An engineering and economic study for agricultural uses such as greenhouses and heat pump systems for public buildings
- A study to help advise the county on policies and regulations involving the Medicine Lake and Glass Mountain geothermal areas.

Source: PIC NGS, Vol. 5, No. 17, 04/29/83.

- Proposed Evaluation of Eight Riverside County Sites

The Southern California Association of Governments (SCAG) is seeking a \$60,000 grant from the California Energy Commission to determine and possibly develop the geothermal potential of southern California. The Riverside, California Board of Supervisors has endorsed SCAG's proposal which includes eight sites in Riverside County. The areas in the county which are under consideration for development are Lake Elsinore-Temescal Valley, Winchester, Hemet-San Jacinto, Desert Hot Springs, Salton Sea, Desert Center, Ford Dry Lake, and Palo Verde Valley.

Source: PIC NGS Vol. 5, No. 25, 06/24/83.

- Kern County Receives Grant

The Kern County Council of Governments has received a grant for almost \$46,000 from the California Energy Commission. A technical advisory board will be established to identify possible resources and probable markets for alternative energy sources. The study is intended to accelerate the county's development of geothermal resources and further development in other energy related areas.

Source: PIC NGS, Vol. 5, No. 22, 06/03/83.

COLORADO

Resource Assessment

- Colorado Geological Survey Reports on Western San Luis Valley

The last report in a series of resource assessments of the San Luis Valley has been released by the Colorado Geological Survey (CGS). The report, "Geothermal Resource Assessment of Western San Luis Valley," notes that the only thermal waters above 68 °F are found at Shaws Warm Spring. The spring is relatively unused and flows at a rate of 40 gallon per minute. The resource is considered to be of limited capacity.

The C.G.S., in cooperation with the U.S. Department of Energy, has been studying the geothermal resource potential of the entire San Luis Valley to assess the possibility for

near term development. The agency estimates that between 50 and 75 percent of the Valley's energy needs could be met by the use of geothermal waters in direct use applications.

All of the reports produced by the Colorado Geological Survey during the five-year geothermal project are available from C.G.S., Room 715, 1313 Sherman Street, Denver, CO. 80203. The telephone number is (303) 866-2611.

Sources: PIC NGS, Vol. 5, No. 9, 03/04/83.
E.G.&G. Idaho, Regional
Geothermal Activities
Report 03/00/83.

HAWAII

Legal and Institutional Activities

- Environmental Study in the Puna District on the Island of Hawaii

A one year study of the air quality of the Kilauea East Rift Zone has been commissioned by the Energy Division of the Hawaii Department of Planning and Economic Development. The study will concentrate on those areas where geothermal development has been proposed. It will assess existing levels of natural and man-made air pollution. Monitoring will include hydrogen sulfide, mercury and other volcanic emissions as well as particulate matter from such sources as cane burning and road dust. Meteorological data and rain water samples will also be collected.

Source: GRC Bulletin, Vol. 12, No. 2, 02/00/83.

- Final Resolution of Campbell Estate Geothermal Plan Still Pending

Hawaii's Board of Land and Natural Resources announced its decision on the Campbell Estate's application to develop geothermal energy on the Puna Rift. This application has been the subject of controversy since May 1982. The land is within a conservation district although the surface is owned by the Estate. The original application included a proposal to develop five electric power plant sites involving 90 wells

at 35 surface locations. The Board handed down a decision to allow the Estate to proceed with exploration. However, the following six stipulations were attached to the decision.

1. Only eight geothermal wildcats may be drilled. None may be within 2000 feet of the Estate's boundaries.
2. The permit is for exploration only; it does not convey a right to develop.
3. All exploration needs to be completed within five years.
4. No more than two wells shall be drilled at any well site.
5. The exploration plan should include a comprehensive monitoring plan to oversee air quality, water quality, impact on habitat and other environmentally related matters.
6. A project employee must be available by telephone on a 24 hour-a-day basis.

Still pending is the decision of whether geothermal development is a proper use of conservation lands. This question may have to be decided by Hawaii's Supreme Court.

Source: GRC Bulletin, Vol. 12, No. 5, 05/00/83.

IDAHO

Direct Use Projects

• Boise City Distribution System Dedicated

Early in February, the Boise city distribution system was dedicated at a ceremony at the Number 2 well pumphouse. Senator James McClure started a pump which initiated geothermal flow through the distribution system to the river disposal point.

Source: E.G.&G. Idaho, Regional 02/00/83.
Geothermal Activities Report

- Projects Planned on Snake River Plain

Two geothermal projects have been planned on the Snake River Plain. The first, near the city of Boise, is intended for space heating. A successful geothermal well was drilled 2 miles east of Boise to a depth of 1115 feet. Eight inch casing was set to 640 feet and the well was pump tested for 6 hours at a rate of 800 gallons per minute. Water temperature was 160°F.

In Pocatello, Idaho Malting Company of Boise and Vancouver has scheduled a 2000 foot direct use well intended for grain processing. The well site is in the northern part of the city about three miles south of the Tyhee area.

At Tyhee, seven low temperature geothermal wells produce hot water for space heating, domestic stock and irrigation purposes.

Source: PIC NGS Vol. 5, No. 5, 02/04/83.

- Boise Geothermal Project Receives Loan Guarantee

The U.S. Department of Energy has guaranteed a \$2.3 million loan issued by the Bank of America to Boise Geothermal Ltd. The loan is for the initial production stage of a space heating project within the Boise city limits. It supplements the more than \$1 million already spent by Boise Geothermal on the \$8 million project. Four of the five wells needed for the first phase are already in place. Three are equipped for production and one is a temperature observation well.

The wells were drilled to total depths of approximately 1000 feet and yield water at 170°F. The total flow from the first production phase is expected to be 2000 gallons per minute.

The city of Boise will purchase the production and act as the distributor. The city will negotiate with residential, commercial and institutional customers for the supply of geothermal fluids to be used for space heating.

Source: PIC NGS, Vol. 5, No. 19, 05/13/83.

- Geothermal Heating System Installed at Madison High School in Rexburg

In February the heating system at Rexburg's Madison High School was converted to use geothermal energy. Groundwater at 54°F receives a temperature boost from an electrical heat pump to about 125°F. The new system is projected to save 70 percent of the annual heating cost.

Source: GRC Bulletin, Vol. 12, No. 5, 05/00/83.

Research and Development Activities

- Small Scale Power Plant Moved to California

A small scale binary cycle power plant has been moved from the Raft River site to the Geothermal Test Facility at East Mesa, California. The plant has been operated by personnel from the Energy Programs Division of EG&G Idaho; a prime operating contractor for DOE at the Idaho National Engineering Laboratory. Two EG&G Idaho employees will assist with the operation of the plant at the Imperial Valley site.

The 60 kilowatt Mobile Heat Cycle Research Facility was operated at the Raft River site from 1978-1982. It will be used at East Mesa to test advanced geothermal power cycle concepts with a hotter geothermal fluid which is more representative of the resources being considered for commercial development. The plant will also be used to test different working fluid mixtures.

Source: GRC Bulletin, Vol. 12, No. 06, 06/00/83.

MONTANA

Direct Use Project

- Warm Springs State Hospital Heating System Dedicated

The geothermal domestic hot water heating system at Warm Springs State Hospital was dedicated on February 18, 1983. The key-note speaker was Governor Ted Schwinder who three years ago participated in the ground breaking ceremony as the Lieutenant Governor.

Source: E.G. & G. Idaho, Regional Geothermal
Activities Report, 02/00/83

Resource Assessment

- Study of the Upper Centennial Valley Published

The results of a study of the Upper Centennial Valley have been published as Memoir 50 of the Montana Bureau of Mines and Geology. The report includes a section on the Madison Valley thermal springs.

Geologic, geophysical and hydrochemical investigations in the Upper Centennial Valley indicate that the temperature of the thermal resource reservoir is 104 to 113°F. The water is believed to be heated by deep circulation within the Madison Group limestones.

The most viable thermal resource is the Wolf Creek Hot Spring area in the Madison Valley. The calculated reservoir temperature is 171°F at a depth estimated to be 1500 to 2000 feet below land surface. This spring currently discharges about 50 gallons per minute of 154°F water.

Source: E.G. & G. Idaho Regional Geothermal
Activities Report, 05/00/83

NEVADA

Direct Heat Application

- Elko Project On-Line

The Elko Heat Company began supplying hot water to downtown buildings in December 1982. An 850 foot well, three quarters of a mile west of Elko produces 175°F water at a rate of 400 to 600 gallons per minute. After most of the heat has been extracted, the geothermal water is used by the city for irrigation and other municipal purposes.

Source: GRC Bulletin Vol. 12, No. 4, 04/00/83

NEW MEXICO

Legal and Institutional Issues

- Geothermal Energy Tax Credit

The state legislature has enacted a special tax credit for investments in geothermal energy equipment. Initially a 25 percent tax credit, up to a maximum of \$60,000, will be available to either individuals or corporations effective for taxable years beginning on or after January 1, 1983. The percentage declines stepwise to zero by 1990.

To qualify for the credit, the geothermal fluids must be naturally occurring steam or hot water at a temperature of at least 95°F. Groundwater heat pumps and other devices used to increase the temperature of geothermal resources are specifically excluded.

Source: GRC Bulletin Vol. 12, No. 6, 06/00/83

- Geothermal Rules Amended

Rule changes concerning definitions, bonding requirements, and a classification for thermal gradient wells have been considered by the New Mexico Energy and Minerals Department, Oil Conservation Division. Information about the rule changes can be obtained from the Oil Conservation Division, State Land Office Building, Santa Fe, and at the Division's district offices in Artesia, Hobbs, and Aztec.

Source: PIC NGS Vol. 5, No. 20, 05/20/83

OREGON

Legal and Institutional Issues

- Klamath Falls Ordinance Puts Projects on Hold

A geothermal ordinance which was passed in June 1980 requires users of geothermal fluids to install downhole heat exchangers or inject the produced water into the same well from which it was pumped. Because of these restrictions two firms have put "on hold" the construction of industrial processors which use geothermal energy.

A project at the Oregon Institute of Technology has involved the institute in a lawsuit concerning this ordinance. The question in the case is whether a library, which was under construction at the time the ordinance was passed, can be excluded from compliance.

Also in Klamath Falls, a district heating system which has been completed cannot be put into service since it involves pumping from one well and injecting in another.

Source: GRC Bulletin Vol. 12, No. 2, 02/00/83

- Sale of Park Lands for Energy Development

Oregon's state legislature has been asked to authorize the sale of trees, minerals, land, and power resources from the state's park system in an effort to generate new funds for park management and acquisition. The legislation would allow the parks superintendent to sell unneeded tracts of park land and to lease parks to utilities or private companies for geothermal power development, dams, windmills, oil and gas drilling, farming, and mining of coal, gravel and sand.

The Superintendent has stated that the legislation authorizing these activities will not be used as a vehicle for beginning to manage park-land forests on a sustained yield basis or to strip-mine large tracts of park land. Revenue from the sales/leases would be used to create a parks trust fund for the maintenance and acquisition of parks.

Source: GRC Bulletin Vol. 12, No. 4 04/00/83

- Zoning Laws for Small Energy Projects

The Oregon Department of Energy (ODOE), under contract to the Bonneville Power Administration (BPA), will draft a set of model zoning laws that will determine for county governments how, where, and when small scale solar, wind, geothermal and hydroelectric projects will be built. The model laws will suggest standards for siting energy projects that generate less than 25 MW using renewable resources and transmission lines that carry 230 kilowatts or less.

The model laws are being developed to save each county the time, effort, and expense of developing its own laws for

such projects. The counties are not required to use the model laws but each county using them may adapt them to local needs.

Development of the model laws was prompted after many counties contacted ODOE for help in sorting out federal, state, and county authority. BPA and ODOE agreed to produce model siting laws that conform to federal and state laws and clearly describe when and where energy projects will be allowed.

Source: GRC Bulletin Vol. 12, No. 5 05/00/83

- Guidelines for the Purchase of Electrical Energy

A bill introduced into the Oregon legislature provides for the purchase of electrical energy from geothermal sources at a rate which is based on the highest cost base load plant in the state. The new bill modifies the definition of "public utility" to exclude cogeneration facilities and small power production facilities. It requires a public utility to purchase or transmit energy produced by a cogeneration or small power production facility. Electric utilities are also required to offer to supply on-site power to these facilities.

Source: GRC Bulletin Vol. 12, No. 6, 06/00/83

Resource Studies

- Klamath Falls Plans Resource Study

The City of Klamath Falls is conducting a resource study as part of the planning process for a citywide geothermal heating district. A controversy has arisen over the use of wastewater rather than well water for the downtown heating system. Edward Sammel, a U.S. Geological Survey hydrologist, has outlined a three phased study which is expected to lead to recommendations for development of the resource by the end of the year. The first phase involves baseline data collection and well monitoring. During the second phase the geothermal system will be tested and analyzed. The second phase will include geochemical and geophysical studies. The final phase is the analysis of the baseline and field data and the formulation of recommendations.

Source: GRC Bulletin, Vol. 12, No. 4, 04/00/83

- Resource Assessment of Ashland, Oregon

In 1982 the Oregon Department of Geology and Mineral Industries conducted a temperature gradient study in the vicinity of Ashland. The Department published the results of this study in their May 1983 issue of Oregon Geology and reached the following conclusions:

- Most of the low-temperature geothermal potential is confined to the northwestern portion of Ashland.
- In the northwest, the potential is highest between the existing hot springs and the fault which controls distribution of the fluids. The water temperature, however, will probably not exceed the surface temperature of the nearest spring.
- In order to discover fluids at temperatures significantly greater than the temperatures of the springs, holes have to be situated in a fashion to intersect the faults controlling the distribution of geothermal fluids. With limited knowledge of the precise location and the dip of the controlling faults, the optimum location for such holes are not known.

Source: PIC NGS Vol. 5, No. 21, 05/27/83

Direct Use Project

- State Supports Study for the City of Vale

The Oregon Department of Energy is funding a district heating study for the city of Vale. Resource temperatures vary to above boiling and users are within one mile of the resource.

Source: E.G. & G. Idaho; Regional Geothermal
Activities Report, 04/00/83

TEXAS

- Multiple Use Project at Navarro College

This past spring Navarro College in Corsicana, Texas began a multiple use geothermal research project. Heat from

geothermal water is used to grow shrimp, tropical fish, and catfish. The water is also used to grow plants and to irrigate farmland.

The college's 3 year old well produces 125°F water at a rate of 350 gallons per minute. The geothermal water passes through a heat exchanger where it is cooled to 74°F. Fresh water in the heat exchanger is heated from 70°F to 115°F. Pumps distribute the warm freshwater to two 40 by 300 foot shrimp ponds where shrimp will grow near the bottom and tropical fish grow closer to the surface. The water is then directed into greenhouses and catfish ponds. Finally it is be used to irrigate a separate 25 acre experimental agricultural plot.

Source: GRC Bulletin Vol. 12, No. 4, 04/00/83

4.0 DRILLING AND EXPLORATION ACTIVITIES

This section has been compiled from data files maintained by The MITRE Corporation. These are updated from sources including the weekly reports of the Petroleum Information Corporation's National Geothermal Service, monthly reports and interested party letters of the U.S. Minerals Management Service, and publications such as the Bulletin of the Geothermal Resources Council and Geothermal Energy Magazine.

Section 4.1 includes a status report on Deep Geothermal Well Completions for 1982 and an analysis of the trends in deep drilling from 1973-1982. For the purposes of this report a deep well is defined as being greater than 2500 feet in depth.

The status report identifies the number of deep wells spudded in 1982 and reported completed as of July 31, 1983. Due to reporting delays, drilling in progress, or ongoing testing and evaluation some deep geothermal wells may not be included in the completion data for 1982. The well data are reported by state, well type and footage drilled.

Section 4.2 contains a summary of recent geothermal drilling activities reported on a state-by-state basis and Section 4.3 highlights recent or planned exploration activities.

4.1 Deep Well Completions - Status and Trends

During 1982, geothermal developers issued first reports for 73 deep geothermal wells. Fifty-six of these wells were spudded in 1982 and completed. The total footage drilled was almost 410,000 feet. Fifty of the wells (89 percent) were completed as potential geothermal producers. Table 4-1 shows the deep geothermal well completions for 1982 by state and type of well.

The number of deep wells completed and the total footage drilled during the analysis period of 1973-1982 is shown for each state in Table 4-2. California, with the largest number of deep well completions (415) accounted for 71.7 percent of the total. Nevada was the next most active state with 57 deep wells (9.8 percent) completed. Another 60 wells (10.4 percent) were completed in New Mexico, Utah, and Idaho. The remaining 47 deep wells (8.1 percent) are divided among the other states listed in the table. In terms of the total footage drilled the distribution varies only slightly from the percentages cited above.

TABLE 4-1

DEEP GEOTHERMAL WELL COMPLETIONS FOR WELLS SPUDDED IN 1982

WELL TYPE	CALIFORNIA		HAWAII		NEVADA		NEW MEXICO		UTAH		TOTAL	
	# OF WELLS	FOOTAGE	# OF WELLS	FOOTAGE	# OF WELLS	FOOTAGE	# OF WELLS	FOOTAGE	# OF WELLS	FOOTAGE	# OF WELLS	FOOTAGE
Producible	45	356773	1	8005	1	5500	1	2645	2	6026	50	378949
Injection	1	4439									1	4439
Observation					1	3703			1	2517	2	6220
Geopressured												
Thermal Gradient					1	6703					1	6703
Suspended												
Abandoned	2	13400									2	13400
TOTAL	48	374612	1	8005	3	15906	1	2645	3	8543	56	409711

TABLE 4-2A

NUMBER OF DEEP WELLS COMPLETED AND TOTAL FOOTAGE DRILLED
1973-1977

YEAR	1973		1974		1975		1976		1977	
STATE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE
ARIZONA	2	19661	1	8027	-	—	-	—	-	—
CALIFORNIA										
Geysers	22	156934	21	152552	24	163052	23	182005	28	227727
Imp. Valley	6	34616	7	39402	11	70777	16	108887	8	53349
Other	4	23437	2	11951	—	—	2	17148	1	4848
HAWAII	1	4123	-	—	1	6450	-	—	-	—
IDAHO	-	—	1	11125	2	11530	1	5850	2	17342
LOUISIANA	-	—	-	—	-	—	-	—	-	—
MARYLAND	-	—	-	—	-	—	-	—	-	—
MONTANA	-	—	1	6790	-	—	-	—	-	—
NEW MEXICO	2	12930	3	24464	3	22548	-	—	1	8909
NEVADA	-	—	5	31876	5	21593	5	19342	1	4975
OREGON	1	5440	1	2828	1	7510	1	5842	-	—
SOUTH DAKOTA	-	—	-	—	-	—	-	—	-	—
TEXAS	-	—	-	—	-	—	-	—	-	—
UTAH	-	—	1	11005	1	6886	4	30902	4	26987
TOTAL	38	257141	43	300020	48	310346	52	369976	45	344137

TABLE 4-2B

NUMBER OF DEEP WELLS COMPLETED AND TOTAL FOOTAGE DRILLED
1978-1982

YEAR	1978		1979		1980		1981		1982		TOTAL	
STATE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE	NO.	FOOTAGE
ARIZONA	-	—	5	21235	-	—	-	—	-	—	8	48923
CALIFORNIA												
Geysers	24	190183	30	208961	42	312418	44	347153	43	337745	301	2278730
Imp. Valley	12	92227	10	64844	9	81591	10	52437	4	27791	93	625921
Other	3	17035	3	13543	1	9104	4	25026	1	9076	21	131168
HAWAII	1	5595	1	6500	2	15000	2	15640	1	8005	9	61313
IDAHO	7	38385	2	14356	2	11936	1	3000	-	—	18	113524
LOUISIANA	1	16234	1	15231	3	48626	1	17000	-	—	6	97091
MARYLAND	-	—	1	5562	-	—	-	—	-	—	1	5562
MONTANA	-	—	-	—	-	—	-	—	-	—	1	6790
NEW MEXICO	1	6254	2	13010	5	37313	6	43995	1	2645	24	172068
NEVADA	4	21503	12	72523	10	74038	12	87605	3	15906	57	349361
OREGON	1	4003	2	12874	3	13004	3	16063	-	—	13	67564
SOUTH DAKOTA	1	4266	1	4112	-	—	-	—	-	—	2	8378
TEXAS	2	19128	3	24320	2	26942	-	—	-	—	7	70390
UTAH	3	20742	2	17654	-	—	-	—	3	8543	18	122719
TOTAL	60	435555	75	494725	79	629972	83	607919	56	409711	579	4159502

The majority of the deep well completions have occurred in California and particularly at The Geysers and in the Imperial Valley. The annual and cumulative number of deep wells completed in these two principal areas and in all the other areas combined is shown in Table 4-3. The total number of deep well completions as well as the completions by area are plotted in Figure 4-1.

4.2 Recent Drilling and Exploration Activities - Reports by States

CALIFORNIA

- Development Continues in The Geysers

The Geysers continues to be the most active area for geothermal drilling. Since the beginning of the year seven operators have drilled or staked locations for 36 deep wells. Union Oil Co. of California is responsible for almost two thirds of the well sites. Occidental Geothermal and MCR Geothermal Corporation have completed 4 wells each. Other active operators include Sunoco Energy Development Co. Aminoil, U.S.A., Shell Oil Co., and Natomas Co. Twenty of these deep wells have already been completed; nineteen as potential geothermal producers and one as an injection well.

Source: PIC NGS Vol. 5, Nos. 1-30, 01/07/83-07/28/83.

- Deep Drilling in the Imperial Valley

In March, Magma Power began testing the deepest geothermal well in the East Mesa KGRA. Originally drilled to 9785 feet, the well was plugged back to 7537 feet. Magma ran 7 inch liner and set a shoe at 7520 feet. The well is about one half mile east of Magma's dual binary demonstration plant.

About 20 miles west, MCR Geothermal has drilled four wells which are the deepest ever completed in the Imperial Valley's South Brawley area. One of these bottomed at 14,000 feet and the three others were completed below 13,381 feet. Two are considered to be potential geothermal producers.

TABLE 4-3

NUMBER OF DEEP WELLS COMPLETED

	A N N U A L				C U M U L A T I V E			
	Geysers	Imperial Valley	Other	Total	Geysers	Imperial Valley	Other	Total
1973	22	6	10	38	22	6	10	38
1974	21	7	15	43	43	13	25	81
1975	24	11	13	48	67	24	38	129
1976	23	16	13	52	90	40	51	181
1977	28	8	9	45	118	48	60	226
1978	24	12	24	60	142	60	84	286
1979	30	10	35	75	172	70	119	361
1980	42	9	28	79	214	79	147	440
1981	44	10	29	83	258	89	176	523
1982	43	4	9	56	301	93	188	579

FIGURE 4-1
NUMBER OF DEEP WELLS COMPLETED ANNUALLY

The Department of Energy's FY 84 appropriation includes 5.9 million dollars to fund a deep research well to increase scientific knowledge of deep geothermal resources. Other objectives are to determine the mode of formation of geothermal fluids and to better understand the role of the Continental Plate concerning geothermal reservoirs.

Sources: PIC NGS Vol. 5, No. 07, 02/18/83.
PIC NGS Vol. 5, No. 10, 03/11/83.
PIC NGS Vol. 5, No. 27, 07/08/83.
PIC NGS Vol. 5, No. 31, 08/05/83.

- Geothermal Wildcat in Lassen County

Litchfield Developers of Sacramento has staked location for a geothermal exploratory test well in southern Lassen County. The site is about eight miles east and slightly south of the town of Susanville. The location is two miles east of thermal wells where recorded surface temperatures were less than 120°F and eight miles east of the Susanville KGRA where hot water temperatures can reach about 165°F.

Source: PIC NGS Vol. 5, No. 23, 06/10/83.

- Direct-Use Well Completed in Napa County

A direct use potential geothermal producer has been completed by the Calistoga Unified School District. Calistoga 1 is located in Napa County about 12 miles north-northeast of Santa Rosa. The exploratory test well is cased with eight inch pipe to its total depth of 350 feet. The bottom hole temperature is 172°F and the well is expected to heat a school district building.

Source: PIC NGS Vol. 5, No. 31, 08/05/83.

- Direct Use Well Planned in Shasta County

A geothermal exploratory test well has been planned by the Indian Springs School District. The site, about 35 miles north-northeast of Redding, is offset to the east of two thermal springs where hot surface temperatures are greater

than 120°F. No objective has been disclosed for this well but it is expected to be used for direct use purposes.

Source: PIC NGS Vol. 5, No. 31, 08/05/83.

- Coso Drilling Blocked

A ruling by the leasing board of the Great Basin Unified Air Pollution Control District has blocked the drilling of three exploratory wells in the Coso KGRA in Inyo County. The wells were planned by the Los Angeles Department of Water and Power (LADWP) to determine if a viable geothermal resource exists to support a demonstration or commercial-size power plant that could be in operation by the latter half of the 1980s. The hearing board denied the well drilling permit until the LADWP applies for permits for water collection facilities that would be associated with geothermal development.

Although the water facilities do not emit pollutants, the air pollution officials say they indirectly cause an increase in airborne dust levels and should comply with standards for stationary air emission sources. The LADWP has not applied for the permits for the water facilities because it fears the process could be used to restrict the city's water supply. The LADWP is reviewing the district's written decision and its legal options.

Sources: GRC Bulletin Vol. 12, No. 02, 02/00/83.
Electric Utility Week 02/21/83.

LOUISIANA

- Tests at Geopressure Wells

In Cameron Parish, in southeastern Louisiana, Technadrill and Fenix & Scisson, in conjunction with DOE is flow testing the 1 DOE-Gladys McCall. The 16,510 foot wildcat has been plugged back to 15,200 feet. It is located in the Crab Lake oil field where oil and gas operations have encountered large volumes of salt water brine with entrained methane gas at shallower depths. Geopressured regime characteristics in the area indicate the presence of reservoir sands extending from 14,500 feet to 17,000 feet.

Also in Cameron Parish, Magma Gulf and Technadrill have temporarily suspended operations at the 1 DOE-Amoco-Fee well. This 15,740 foot geopressured wildcat was tested flowing 12,000 barrels per day of 245°F of water from perforations between 15,387 feet and 15,414 feet. Flowing tubing pressure was 933 pounds per square inch (psi). Associated gas flowed at a rate of 18 cubic feet per barrel.

Testing is also underway in Vermilion Parish at the 1 Leeroy Sweezy well in the Parcperdue field. This well which has been plugged back to 13,534 feet was drilled to a total depth of 13,612 feet.

Sources: PIC NGS Vol. 5, No. 10, 03/11/83.
PIC NGS Vol. 5, No. 31, 08/05/83.

NEVADA

● AMAX Exploration Active in Western Nevada

In the McCoy Unit in Churchill County, AMAX suspended operation on a projected 4000 foot well after reaching a depth of 1002 feet. AMAX ran logs and set 4 1/4 inch casing to 1002 feet. The company is waiting on a rotary rig equipped with diamond drilling bits to reach the projected depth. The collapse of casing at the original drill site, after reaching a total depth of 406 feet, caused AMAX to skid the rig 20 feet to the east.

AMAX has also been active in its Alum Unit in Esmeralda County. Three thermal gradient wells (total depths of 1906 feet, 1906 feet, and 2307 feet) have been completed. All the holes have been cased with surface casing at shallow depths and narrow diameter tubing to total depth.

Sources: PIC NGS Vol. 5, No. 11, 03/18/83.
PIC NGS Vol. 5, No. 12, 03/25/83.
PIC NGS Vol. 5, No. 13, 03/31/83.
PIC NGS Vol. 5, No. 14, 04/08/83.
PIC NGS Vol. 5, No. 17, 04/29/83.

- Temperature Gradient Wells Completed by GRI

Geothermal Resources International (GRI) has completed four temperature gradient wells in the northern portion of Dixie Valley in western Nevada. The wells are within an area that encompasses the Senator Fumaroles and Hyder (Cone) Hot Spring. Total depths range between 995 feet and 2000 feet. All four of the wells have seven-inch casing set to 200 feet and two-inch pipe is set to total depth.

Sources: PIC NGS Vol. 5, No. 05, 02/04/83.
PIC NGS Vol. 5, No. 06, 02/11/83.

- Magma Power Company Active in Fish Lake Valley

Magma Power Company has staked locations for 12 temperature gradient wells in the Fish Lake Valley area of Esmeralda County. Target depths range between 500 and 1000 feet.

Sources: PIC NGS Vol. 5, No. 11, 03/18/83.
GRC Bulletin Vol. 12, No. 06, 06/00/83.

- Temperature Observation Well in Humboldt County

Earth Power Production has completed a wildcat in northwestern Humboldt County as a temperature observation well. The wildcat is just west of Baltazor Hot Springs where water temperatures have been measured at approximately 200°F. Total depth of the well is 3703 feet.

Source: PIC NGS Vol. 5, No. 12, 03/25/83.

- U.S. Department of Energy Provides Funding for Study of the Moana Area

The University of Nevada will perform a detailed study of the Moana Area of southwest Reno with funds provided to the Nevada Department of Energy by the U.S. Department of Energy. Work to be done includes geologic mapping, geophysical surveys, geochemistry, and shallow well drilling. Another part of the study will examine the relationship of volcanic rocks to known geothermal areas and to volcanic

rocks in other parts of the state. The object is to identify techniques that could be used to discover "blind" geothermal targets.

Source: GRC Bulletin Vol. 12, No. 02, 02/00/83.

NEW MEXICO

- Deep Test Wells Planned to Lightning Dock KGRA

AMAX Exploration has staked location for four deep test wells on the east side of the Lightning Dock KGRA in central Hidalgo County. Projected depths for these holes are between 5000 and 7000 feet. Previously, most of the wells drilled in the area have been shallow irrigation wells drilled to about 300 feet.

Source: PIC NGS Vol. 5, No. 14, 04/08/83.

- Drilling Results from the East Mesa Field

Samuel Jennings of Las Cruces has completed a 250 foot geothermal assessment well in the East Mesa Field in Dona Ana County. A bottom hole temperature of 96°F has been reported. A 300 foot well was also completed with a bottom hole temperature of 118°F. One-and-a-half inch pipe was set to total depth in each.

Also in the East Mesa Field, the City of Las Cruces is planning to drill a 300 foot well within the city limits. The energy derived from the well will be used to heat the Las Cruces City Building.

Five miles southeast of Las Cruces Myron George has drilled a 300 foot well which is being evaluated. A temperature of 146° Fahrenheit has been reported and the heat is expected to be used in a greenhouse.

Sources: PIC NGS Vol. 5, No. 14, 04/08/83.
PIC NGS Vol. 5, No. 24, 06/17/83.
PIC NGS Vol. 5, No. 30, 07/29/83.

- Temperature Gradient Wells Planned for North-Central New Mexico

A 15 hole geothermal exploration program has been announced by the New Mexico Resources and Development Institute at New Mexico State University, Las Cruces. The 300 foot wells will be drilled in Sandoval, Socorro, Valencia, and Rio Arriba counties and will be funded exclusively by the State.

In addition the Institute has planned 30 new wells for the Las Cruces-East Mesa area.

Source: PIC NGS Vol. 5, No. 28, 07/15/83.

TEXAS

- Geopressured Well Completed

The first geopressured well in southeast Texas' Brazoria County has been completed by Gruy Federal. The 2 Pleasant Bayou well has undergone extensive testing since 1979. It flowed 20,000 barrels of 290°F water from perforations in the interval between 14,647 feet and 14,707 feet. Total depth is 16,500 feet. Flowing tubing pressure was 1710 psi. Associated gas flowed a rate of 21 cubic feet per barrel of water.

About 500 feet to the northwest, 1 Pleasant Bayou has been completed by the original operator (General Crude) as a water disposal well. After being junked and abandoned in 1978, the 15,675 foot well was recompleted in three zones between 6460 and 6530 feet. Injection pressure during tests were 540 psi at the surface and 3177 psi at casing perforations.

Source: PIC NGS Vol. 5, No. 10, 03/11/83.

4.3 Exploration

Since February Plans of Operation (POO's) and/or development have been filed for several areas in the western states. Table 4-4 lists the proposed plans in approximate chronological order. The location, the responsible party, and the type of activity, are also included in the table. This information was gathered from Interested Party letters disseminated by the Deputy Minerals Manager, Geothermal of the U.S. Minerals Management Service, Western Region, Menlo Park, California.

TABLE 4-4

LIST OF PROPOSED PLANS SUBMITTED TO THE DEPUTY MINERALS MANAGER, GEOTHERMAL

APPROXIMATE DATE OF INTERESTED PARTY LETTER	LOCATION	RESPONSIBLE PARTY	TYPE OF PLAN AND ACTIVITY
February 1, 1983	The Geysers Lake and Sonoma Counties California	Aminoil, U.S.A.	Plan of Operation - Construction of a well pad and access road to drill infill wells to supply SMUDGE #1 power plant
February 8, 1983	The Geysers Lake and Sonoma Counties California	Union Oil Company	Plans of Operation (2) - Construction of roads and well pads and the drilling of geothermal development wells
March 15, 1983	Core Fort-Sulphurdale KGRA, Beaver County Utah	Mother Earth Industries	Plan of Operation - Exploration Drill seven (7) 3000 foot geothermal test wells
March 21, 1983	The Geysers Lake and Mendocino Counties California	Union Oil Company	Plans of Operation (3) - Construction of roads and well pads, and the drilling of geothermal exploration wells
May 11, 1983	Glass Mountain Unit Siskiyou County California	Union Oil Company	Plan of Operation - Construction of roads and well pads and the drilling of geothermal exploration wells
June 6, 1983	The Geysers Lake and Mendocino Counties California	Union Oil Company	Plan of Operation (Revised) - Construction of roads and well pads, and for the drilling of geothermal exploration wells
June 13, 1983	East Mesa KGRA Imperial County California	Magma Power Company	Plan of Operation - Construction of roads and drilling of four (4) geothermal development wells

5.0 ELECTRIC POWER PLANT DEVELOPMENT

This chapter provides a general summary of the status of geothermal electric power plants in the United States. Section 5.1 describes recent development activities in several states. Section 5.2 presents tables of existing and planned power plants. The usual sources of information have been supplemented by the Monthly Geothermal Reports of the Bureau of Land Management and by the "Coordinated Bulk Power Supply Program, 1982-1992" of the Western Systems Coordinating Council (April 1, 1983). The latter report is a reply to the Department of Energy's Form EP-411 which requests information from the regional electric reliability councils on coordinated regional bulk power supply programs.

5.1 Recent Major Activities

CALIFORNIA

- Summary of Activities at The Geysers

In mid-February Pacific Gas and Electric began generating electricity from its newest geothermal steam powered facility, Unit Number 18. The 110 MW generating unit is the utility's seventeenth power plant at The Geysers where PG&E's total installed capacity is now 1128 MW. During the next six years the utility plans to bring four more geothermal steam powered generating units on line including Unit Number 16 which, at the beginning of May, was estimated to be about 9 percent complete. Another 110 MW unit (Number 20), the nineteenth PG&E facility at The Geysers, was approved by the California Energy Commission at the end of February. It is expected to come on line by March 1986.

In another development, the Northern California Power Agency (NCPA) announced in February that it has awarded a contract to Ansaldo S. p. A of Italy, a major supplier of power plant equipment. The contract calls for Ansaldo to supply turbines, generators, condensers, main pumps, cooling towers, and electrical systems for the two 55 MW generating units which will comprise the NCPA Number 3 project. Site preparation for this project began in early April. The units are expected to come on line during the last quarter of 1985.

Earlier this year NCPA brought its number 2 project on stream. The two 55 MW units are part of the first publicly financed geothermal project in the U.S. More than half of the \$100 million project was funded through a tax exempt

bond issue with remainder of the costs provided by a Department of Energy loan. The addition of these units raised the total installed capacity at The Geysers to almost 1240 MW.

Another major development, early this year, was the announcement by Geothermal Resources International (GRI) that they had entered into definitive agreements with Aminoil, U.S.A. and the Central California Power Agency (CCPA) concerning the exploration and development of approximately 60,000 acres of proven and potential geothermal resource properties located in and around The Geysers. The first agreement resulted in GRI's acquisition of Aminoil's 50 percent interest in these properties on which six geothermal wells capable of commercial production have already been drilled. GRI is now the sole owner of the resources and will be the operator on the properties during both exploration and development.

CCPA and GRI have established sufficient proven steam reserves on a 686 acre portion of the area to warrant the construction of a 55 MW electricity generation plant. GRI's second agreement is with the CCPA who has agreed to purchase the steam produced from this parcel at a price dependent upon the quantity of steam delivered and subject to adjustment in accordance with relevant economic indices.

GRI's goal over the next three years is to establish proven geothermal resources sufficient to support the generation of at least 165 MW of electricity.

Finally, under an agreement between the California Energy Commission (CEC), state and local agencies, steam suppliers, and utilities a comprehensive air quality monitoring program has been established for The Geysers. The California Air Resources Board, the Lake and Northern Sonoma County Air Pollution Control Districts and 13 steam suppliers and utilities will monitor hydrogen sulfide and trace element emissions from geothermal power plant activities at The Geysers. Centralized sites for data acquisition will be set up throughout the area. The program will satisfy air quality conditions of the CEC for certification of geothermal power plants. The data will also provide a baseline of present air quality against which to measure public health impacts of geothermal power plants at The Geysers.

Sources: PIC NGS Vol. 05, No. 07, 02/18/83
PIC NGS Vol. 05, No. 08, 02/25/83
PIC NGS Vol. 05, No. 09, 03/04/83
PIC NGS Vol. 05, No. 11, 03/18/83

- Other Recent Activities

Early this year, the Southern California Edison Company (SCE) cancelled its 49 MW project at Heber, in the Imperial Valley, because the proposed rates for power sales were not acceptable to the California Public Utilities Commission. In May, Chevron Resources, Inc. announced that they had signed a letter of agreement with the Dravo Corporation to construct and operate a 49 MW, dual flash plant at the Heber site. Power will be sold to SCE who will distribute it on its grid. Start up is scheduled for mid-1985.

Also in the Imperial Valley, DOE has approved \$99.6 million in loan guarantees for the nation's first commercial power plant using geothermal brine. Parsons Corporation will build the 25 MW plant in Niland. The total cost of the project is estimated to be about \$135 million. A second phase calls for the expansion of the power plant to 49 MW. The electricity will be sold to Southern California Edison.

Sources: PIC NGS Vol. 05, No. 05, 02/04/83
GRC Bulletin Vol. 12, No. 02, 02/00/83
Vol. 12, No. 08, 08/00/83
Energy Research Digest 02/07/83
The Wall Street Journal 01/25/83

HAWAII

- Developers Respond to Maui Electric Company, Limited

As reported in GPM Report Number 7, the Maui Electric Company has requested developers to submit proposals for developing geothermal energy on the Island of Maui. Twenty five applications for proposals have been sent out and about eight applicants have expressed serious interest in a geothermal project.

Source: GRC Bulletin Vol. 12, No. 02, 02/00/83

OREGÓN

- Electric Power from Wellhead Generator

In Lakeview, Oregon electric power produced from a geothermal wellhead power generator entered the power grid on April 14. The power was produced as part of testing activities at the Hammersly Canyon site where 213°F geothermal water is being used in modular organic Rankine cycle geothermal power plants. Pacific Power and Light will purchase the output from the project at a price of 7 cents per kilowatt hour. This rate has been approved by the Oregon Public Utilities Commission through the Spring of 1984.

Long range plans for this project include using the exhaust water from the power plants (at about 155 °F) to heat the city of Lakeview. A water disposal system will need to be developed to attain full scale operation of both the power plant and the district heating system.

Sources: GRC Bulletin Vol. 12, No. 04, 04/00/83
EG&G Idaho, Regional
Geothermal Activities Report 04/00/83

UTAH

- Activities at Roosevelt Hot Springs

In late 1982 and through the beginning of this year, Utah Power and Light has been testing the 1.6 MW Transamerica Delaval Biphase Rotary Separator Turbine and Generator. The system would supplement electrical power produced by steam at the wellhead. It is not intended as a primary power source, although during the tests the electricity produced has been fed into the grid.

Meanwhile, construction of the 20 MW single-flash power plant is continuing. The structural work is underway and the foundations for the General Electric turbine/generator are already in place. By the end of April, the plant was about 18 percent complete. The completion date is estimated to be November 1985.

Source: GRC Bulletin Vol. 12, No. 02, 02/00/83

5.2 Existing and Planned Geothermal Electric Power Plants

This section presents in tabular form, information concerning the existing geothermal electric power plants in the United States and the planned additions through 1992. Throughout the tables several abbreviations have been used to identify the location, the type of power plant, and the utility. The following guide provides an explanation of the abbreviations used in Tables 5-1 through 5-3.

GUIDE TO ABBREVIATIONS (For Tables 5-1 through 5-3)

<u>COLUMN HEADING</u>	<u>ABBREVIATION</u>	<u>EXPLANATION</u>
Location	CA-GE	California - The Geysers
	CA-IM	California - Imperial Valley
	CA-MA	California - Mammoth Hot Springs
	CA-CO	California - Coso Hot Springs
	HI-PU	Hawaii - Puna
	UT-RH	Utah - Roosevelt Hot Springs
PLANT TYPE	DS	Dry Steam
	DB	Dual Binary
	B	Binary
	SF	Single Flash
	DF	Double Flash
	F	Flash - Number of Stages not specified
	U	Unknown
UTILITY	PG&E	Pacific Gas and Electric
	SDG&E	San Diego Gas and Electric
	SCE	Southern California Edison
	HELCO	Hawaii Electric Company
	NCPA	Northern California Power Authority
	SMUD	Sacramento Municipal Utility District
	UP&L	Utah Power and Light
	CDWR	California Department of Water Resources
	IID	Imperial Irrigation District
	MID	Modesto Irrigation District
	SNCL	City of Santa Clara
	LDWP	Los Angeles Department of Water and Power

TABLE 5-1

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL IN THE UNITED STATES

LOCATION	PLANT NAME	UNIT NUMBER	PLANT TYPE	UTILITY	YEAR ON-LINE	CAPACITY MW	CUMULATIVE CAPACITY MW
CA-GE	Geysers	1	DS	PG & E	1960	11	11
CA-GE	Geysers	2	DS	PG & E	1963	13	24
CA-GE	Geysers	3	DS	PG & E	1967	27	51
CA-GE	Geysers	4	DS	PG & E	1968	27	78
CA-GE	Geysers	5	DS	PG & E	1971	53	131
CA-GE	Geysers	6	DS	PG & E	1971	53	184
CA-GE	Geysers	7	DS	PG & E	1972	53	237
CA-GE	Geysers	8	DS	PG & E	1972	53	290
CA-GE	Geysers	9	DS	PG & E	1973	53	343
CA-GE	Geysers	10	DS	PG & E	1973	53	396
CA-GE	Geysers	11	DS	PG & E	1975	106	502
CA-GE	Geysers	12	DS	PG & E	1976	106	608
CA-GE	Geysers	15	DS	PG & E	1979	55	663
CA-GE	Geysers	13	DS	PG & E	1980	135	798
CA-GE	Geysers	14	DS	PG & E	1980	110	908
CA-IM	East Mesa	1	DB	SDG & E	1980	10	918
CA-IM	Brawley Demonstration		SF	SCE	1980	10	928
HI-PU	Puna		SF	HELCO	1981	3	931
CA-IM	Salton Sea Demonstration		SF	SCE	1982	10	941
CA-GE	Geysers	15	DS	PG & E	1982	110	1051
CA-GE	Geysers	13	DS	PG & E	1983	110	1161
CA-GE	Geothermal Project	2	DS	NCPA	1983	110	1271

SOURCES: The MITRE Corporation.
 GRC Bulletin Vol. 12, No. 05, 05/00/83.
 Department of the Interior, Bureau of Land Management, Office of the Deputy
 Minerals Manager - Geothermal, Monthly Geothermal Report; April 1983.

TABLE 5-2

GEOTHERMAL ELECTRIC POWER PLANTS UNDER CONSTRUCTION IN THE UNITED STATES

LOCATION	PLANT NAME	UNIT NUMBER	PLANT TYPE	UTILITY	RATED CAPACITY MW	ESTIMATED YEAR ON-LINE	STATUS ¹
CA-MA	Mammoth Geothermal	1	B	SCE	7	1983	+
CA-GE	SMUDGE	1	DS	SMUD	72	1983	+
UT-RH	Milford	1	SF	UPL	20	1984	-
CA-IM	Geothermal	1	U	SCE	5	1984	+
CA-IM	Geothermal	1	U	SCE	9	1984	+
CA-GE	Oxy Geothermal		DS	PG & E	80	1984	-
CA-GE	Bottle Rock		DS	CDWR	55	1984	-
CA-IM	Niland	1	DF	SDG & E	24	1985	-
CA-IM	Heber Binary		B	SDG & E/ IID	45	1985	-
CA-IM	Niland Geothermal		DF	SCE	25	1985	-
CA-GE	Geysers	16	DS	PG & E	110	1985	-
CA-GE	Geothermal Project	3	DS	NCPA	110	1985	0
CA-GE	South Geysers		DS	CDWR	55	1985	-
CA-GE	Geysers	20	DS	PG & E	110	1986	-

TOTAL 727 MW

¹Key to symbols:

+ Construction more than 50 percent complete

- Construction less than 50 percent complete

0 Approval pending

SOURCES: The MITRE Corporation.

GRC Bulletin Vol. 12, No. 05, 05/00/83.

Department of the Interior, Bureau of Land Management, Office of the Deputy Minerals Manager - Geothermal, Monthly Geothermal Report; April 1983.

Western Systems Coordinating Council Coordinated Bulk Power Supply Program, 1982-1992; April 1983.

TABLE 5-3

U.S. GEOTHERMAL ELECTRIC POWER PLANTS PLANNED ADDITIONS THROUGH 1992

LOCATION	PLANT NAME	UNIT NUMBER	PLANT TYPE	UTILITY	PLANNED CAPACITY MW ¹	ESTIMATED YEAR ON-LINE
CA-GE	Wild Well		DS	PG & E	5	1984
CA-CO	Coso	1	SF	U.S. NAVY	20	1984
CA-GE	MSR	1	DS	MID, SNCL	10	1985
CA-IM	Heber		B	SCE ²	49	1985
CA-MA	Mammoth Geothermal	2	B	SCE	7	1986
CA-IM	Niland	2	DF	SDG & E	50	1987
CA-IM	Geothermal	1	U	SDG & E	37	1987
CA-GE	Geysers	22	DS	PG & E	110	1988
CA-GE	Geysers	19	DS	PG & E	55	1988
CA-IM	Geothermal		U	SCE	50	1988
CA-IM	Niland Geothermal		DF	SCE	24	1988
CA-IM	North Brawley	2	SF	LDWP	44	1988
CA-GE	Geysers	21	DS	PG & E	110	1988
CA-GE	Wildhorse State		DS	SMUD	70	1989
CA-GE	CCPA	1	DS	MID, SNCL	40	1989
CA-GE	Geysers	23	DS	PG & E	110	1989
CA-IM	Geothermal		U	SCE	50	1989
CA-GE	Hot Water Geothermal	1	F	PG & E	50	1990
CA-GE	Dunlavy		DS	SMUD	35	1990
CA-GE	CCPA	2	DS	MID, SNCL	20	1990
CA-GE	MID	1	DS	MID	25	1990
CA-IM	North Brawley	3	F	LDWP	44	1990
CA-IM	Geothermal		U	SCE	50	1990
CA-GE	Hot Water Geothermal	2	F	PG & E	50	1991
CA-GE	Geysers	24	DS	PG & E	110	1991
CA-GE	Hot Water Geothermal	3	F	PG & E	50	1992

¹Magma Power holds permits for two plants (28 MW and 50 MW) at the Salton Sea Area; no other details are available.

²To be developed by Chevron Resources, Inc.

SOURCES: The MITRE Corporation.

GRC Bulletin Vol. 12, No. 05, 05/00/83.

Department of the Interior, Bureau of Land Management, Office of the Deputy Minerals Manager - Geothermal, Monthly Geothermal Report; April 1983.

Western Systems Coordinating Council Coordinated Bulk Power Supply Program, 1982-1992; April 1983.

As of July 31, 1983 the installed capacity of the geothermal electric power plants in the U.S. was 1271 MW. This figure does not include the wellhead generators being tested at Roosevelt Hot Springs, Utah and Lakeview, Oregon. The Geysers accounts for 1238 MW; the Imperial Valley, 30 MW; and the remaining 3 MW are installed at Puna on the Island of Hawaii. Table 5-1 provides detailed information about the geothermal electric power plants which are operational in the United States.

Several power plants are also currently under construction. The total rated capacity of these is 727 MW. A detailed listing by location, estimated year on-line and construction status is given in Table 5-2.

The Western States coordinating Council of the National Electric Reliability Council lists another 1226 MW of planned additional geothermal capacity through 1992. Table 5-3 identifies these planned additions by location, utility, and estimated year on-line.

A summary of the total geothermal electric capacity that may be installed through 1992 is shown in Table 5-4. By 1986 the existing 1271 MW will be increased by 57 percent when the 727 MW which are currently under construction are placed in operation. If all of the additional capacity comes on-line as planned, then by 1992 approximately 3300 MW of electricity will be generated by geothermal resources.

TABLE 5-4

**SUMMARY OF U.S. GEOTHERMAL ELECTRIC POWER PLANT
CAPACITY BY YEAR, THROUGH 1992**

YEAR	U.S. GEOTHERMAL ELECTRIC POWER PLANT CAPACITY, MW				
	EXISTING	UNDER CONSTRUCTION (Estimated on-line date)	PLANNED ADDITIONS (Estimated on-line date)	ANNUAL TOTAL	CUMULATIVE TOTAL ¹
1983	1271	79	0	1350	1350
1984	--	169	25	194	1544
1985	--	369	59	428	1972
1986	--	110	7	117	2089
1987	--	-	87	87	2176
1988	--	-	393	393	2569
1989	--	-	270	270	2839
1990	--	-	224	224	3063
1991	--	-	160	160	3223
1992	--	-	50	50	3273

¹Does not include the 78 MW planned by Magma Power

SOURCE: The MITRE Corporation.

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