GEOTHERMAL PROGRESS MONITOR

JULY 1987

U.S. Department of Energy
ASSISTANT SECRETARY FOR CONSERVATION
AND RENEWABLE ENERGY
GEOTHERMAL TECHNOLOGY DIVISION

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REPORT NO. 10

JULY 1987

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

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**COVER PHOTO:** Steam gathering lines at The Geysers. Photo courtesy Pacific Gas and Electric Co.
This issue of the Geothermal Progress Monitor (GPM) is the 10th since the inception of this publication in 1980. It continues to synthesize information on all aspects of geothermal development in this country and abroad to permit identification and quantification of trends in the use of this source of energy.

In addition, the GPM is a mechanism for transferring current information on geothermal technology development to the private sector and, over time, provides a historical record for those who are interested in the development pathway of the resource. In sum, the Department makes it available to the many diverse interests that make up the geothermal community for the multiple uses it may serve.

Due to the courtesy of the Geothermal Resources Council (GRC), the international professional organization whose membership comprises a broad spectrum of industrial, scientific, and technical interests, the GPM is probably familiar to more people today than it has been on the strength of its own circulation alone. A section of GPM No. 9 recounting the early progress and setbacks in geothermal development was serialized in the June, July, and August 1986 issues of the GRC Bulletin as a feature entitled "A Decade of Geothermal Development in the United States, 1974-1984: A Federal Perspective." The Department of Energy hereby expresses its thanks to Mr. David N. Anderson, GRC's executive director, for making this story available to a worldwide audience.

This issue looks more to the future than to the past. For example, the results of an informal survey of the educational institutions in the U.S. that offer opportunities for students to prepare themselves for employment in the geothermal industry are presented in the INDUSTRY SCENE. This survey assumes that a work force of trained manpower will be needed through future years to explore for and develop the resource, design and operate geothermal power plants, and engineer direct use applications.

The INDUSTRY SCENE also contains statistics to confirm the greater reliability of geothermal power plants in comparison to fossil-fired and nuclear plants. While the performance data supplied are historic in nature, their purpose is to encourage greater future use of geothermal energy on the basis that, when the resource is properly characterized and managed, it is a reliable and economic source of energy.

The FEDERAL BEAT in this issue presents current information on several projects of the Department's Geothermal Technology Division that will greatly expand the body of knowledge on hydrothermal resources and bring the use of geopressed, hot dry rock, and magma closer to reality. The data developed in all of these projects will be made available to the public along with the analyses of the scientific and technical investigators carrying out the projects.

Throughout the GPM, sources are identified when a news item or report is excerpted directly from another publication. When no source is identified, the information derived from Department of Energy activities, from individuals involved in the event reported, or was developed by the GPM staff for inclusion in this issue.

GPM readers are invited to submit comments on this publication and news of developments that could be reported in issue No. 11. Your communications will be most welcome.
Hydrothermal Convection System
SALTON SEA WELL A
"RESOUNDING SUCCESS"

Based on preliminary analyses, the high-temperature well drilled in the geothermal anomaly of the Salton Sea in Imperial Valley was described by DOE managers as a "resounding success." This project, sponsored jointly by DOE's Geothermal Technology Division and Office of Basic Energy Sciences, the National Science Foundation, and the U.S. Geological Survey, is serving a number of scientific purposes.

First, it is expected to lead to a better understanding of the deep continental crust and its formation processes, and thus provide further insight into the Earth's history. It also provides an opportunity to study a unique, hostile environment which has never been subjected to comprehensive investigation and to attempt to reach technological breakthroughs to overcome instrumentation and materials barriers and limitations.

Specific geothermal goals of the Salton Sea Scientific Drilling Project are to:

- better define the volume of the Salton Sea hydrothermal system and test for extension of the system to greater depths
- improve hydrothermal energy resource estimates
Drilling Summary of the Salton Sea
Scientific Well

1985

OCT
Set 30" casing

NOV
Set 20" casing

DEC
Schlumberger* & USGS** logs

Set 13-3/8" casing

1986

JAN
Injectivity test

Schlumberger* logs

USGS BHT Survey

FEB
Injectivity test, 2 USGS** BHT Surveys

MAR
Set 9-5/8" casing

April drilling

USGS** BHT & logs

Flow test #1 Shut-in, DH sample, BHT

APR
Directional drilling

Flow test #2

USGS** temperature survey

FLOW TESTS*

<table>
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<tr>
<th>#</th>
<th>temp.</th>
<th>press.</th>
<th>flow rate</th>
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<tbody>
<tr>
<td>1</td>
<td>104°C</td>
<td>180 psi</td>
<td>475,000 lbs/hr</td>
</tr>
<tr>
<td>2</td>
<td>229°C</td>
<td>345 psi</td>
<td>560,000 lbs/hr</td>
</tr>
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*wellhead measurements

USGS**/Schlumberger* logs
Temperature Surveys

Hang 7" liner
Flow test #2

* Schlumberger Well Services, Houston, TX
** U.S. Geological Survey

Drilling Summary of the Salton Sea
Scientific Well
- develop a better understanding of the genesis of hydrothermal ore deposits
- investigate the possibility of "superconvection"
- study the origin, nature, and occurrence of earthquake swarms generated during hydrothermal convection.

The well was completed in March 1986 at over 10,564 feet, or about 2 miles, at an estimated temperature of 350°C (662°F). About six zones of lost circulation were penetrated, indicative of hydro-thermal reservoirs. More than 725 feet of core and extensive samples of drill cuttings were collected. The well was also flow tested at two depth intervals during which fluid and gas samples were retrieved. The core, samples, and well logs are being analyzed by an international team of 37 research groups, coordinated by the University of California, Riverside.

The Salton Sea geothermal field is the only active continental spreading zone on the U.S. continent and one of the world's largest liquid-dominated geothermal systems. The upper boundary of a deep hydrothermal convection system may have been penetrated at about 10,370 feet, and tests suggest that energy from the production zone (10,450 - 10,564 feet) is equivalent to 9-10 MWe of electricity, double the output of typical liquid-dominated wells.

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The well was open through August of 1986 for downhole testing. Proposals for conducting a long-term flow test and for deepening the well to 13,000-14,000 feet are under consideration. Scientists were given until September 15, 1986 to request access to drill cuttings and a comprehensive suite of wireline logs.

DOE will publish the technical data on the well later this year.

DOE/INDUSTRY COOPERATIVE DRILLING PROGRAM IN THE CASCADES EXTENDED; USGS TO CONTINUE REGIONAL ASSESSMENT

In the spring of 1986, DOE's Idaho Operations Office let a contract for cost-sharing with industry an additional deep thermal gradient hole in the Cascades region of the Pacific Northwest. It is being drilled by California Energy Co., east of Crater Lake, Oregon. USGS has also received funds to continue its regional resource assessment of the area through 1987.

The Cascades region has high geothermal potential -- perhaps the largest in the country -- but there are few surface manifestations and only limited subsurface data have been generated. DOE's current objective is to increase the knowledge of applicable exploration techniques and the depth required to penetrate the overlying cold ground water system that masks and suppresses evidence of the underlying hydrothermal system.

The first hole to be drilled under the DOE/industry cooperative program was finished in November 1985 on the south flank of Newberry Crater in Deschutes County, Oregon, by GEO-Newberry Crater, Inc., a wholly-owned subsidiary of GEO Operator Corp. The hole was rotary drilled to a depth of 487 feet and then cored to more than 4,000 feet, with about 95 percent core recovery. The preliminary temperature is 72°C (161°F). The second GEO-Newberry Hole in the area has been completed at 4,000 feet. Thermal Power Co. has also completed a 4,800-foot borehole in the Clackamas area.
Well logs and other well data will be open filed at the University of Utah Research Institute in Salt Lake City, and splits of the core can be inspected at the UURI Sample Library by appointment. The contact for this arrangement and for obtaining copies of data and photographs is Joan Pingree, UURI, 391 Chipeta Way, Suite C, Salt Lake City, Utah 84108. Copies of the Dresser Logs can be obtained from the Rocky Mountain Well Log Service, P.O. Box 3150, Denver, CO 80201. A workshop is planned for April 1987 for presentation of the information gathered by the several involved agencies.

Industry's increased interest in the Cascades region was spurred to a large extent by a borehole drilled by USGS at Newberry in 1981 where temperature in the upper 2,070 feet did not exceed 99°C (210°F), but increased rapidly in the lower part of the hole to a maximum of 265°C (509°F) at 3,060 feet. This well was drilled as part of the Survey's effort to understand the active volcanic, tectonic, and hydrothermal processes of the Cascades as a framework for characterizing and quantifying the geothermal resources of the region.

Cascade Geothermal Area

![Cascade Geothermal Area Map]
In addition to the well, the USGS Cascades studies have included geologic mapping, geochronology, petrology of fresh and hydrothermally altered rock, fluid geochemistry, hydrology, and both regional and local geophysical surveys. Starting later this year, the information from these multidisciplinary studies will be synthesized in a regional assessment of the geothermal potential of the Cascades.

**LONG VALLEY CALDERA MAY BE SITE OF FIRST MAGMA WELL**

Long Valley, California, has been selected as the prime site for further geophysical work which may lead to drilling of the world’s first magma well in the 1990’s. This project is being undertaken by DOE to determine the engineering and economic feasibility of extracting energy from a magma body.

This resource, with the availability of appropriate technology, could provide a considerable portion of the Nation’s energy needs. It is estimated that approximately 500,000 quads of heat energy are contained in the molten rock within the top 10 km of the Earth’s surface. The significance of this figure is best appreciated in the context of annual U.S. consumption of primary energy -- about 74 quads in 1985.

The scientific feasibility of utilizing the heat of magma was established by a 7-year DOE study completed in 1982. It was concluded that there are no known insurmountable theoretical or physical barriers which would preclude the heat extraction process.

The current research is designed to:

- develop drilling and completion technology for entry into a magma body
- characterize the magma environment and select compatible engineering materials
- develop heat extraction technology that will produce sufficient power to justify the expense of drilling into magma
- define a crustal magma body in sufficient detail to support energy extraction.

After screening over 20 potential sites as candidates for intensive surface and downhole investigation, the field was narrowed to the Long Valley Caldera and Coso Hot Springs area, also in California. After more intensive study, the former site was selected, and the drill site for a geophysical hole to confirm the existence of magma is expected to be identified this year. It is likely that technology for magma exploration will ultimately be tested by drilling and completing an experimental well and extracting energy for about 6 months in the early 1990’s. With magma temperatures of 900°C (1800°F) and above, this would have been considered a technological impossibility until very recently.

The U.S. Geological Survey is pursuing fundamental research on magma as part of its long-term basic investigation of igneous-related geothermal energy. These studies are necessary to determine the true magnitude of this form of the resource and to evaluate how its content is divided among magma, hot dry rock, and hydrothermal convection systems.
POWER GENERATION TEMPERATURE ACHIEVED WITH HOT DRY ROCK RESERVOIR

A 30-day flow test of the new Phase II reservoir at the hot dry rock experimental site at Fenton Hill, New Mexico, conducted in June 1986, produced fluid temperatures of over 190°C (374°F). More important, the reservoir performance improved as the test progressed, and by the end of the experiment, the project was providing enough usable heat to power a town of 2,000 people.

The creation and operation of a reservoir commercially viable for private sector power generation was the objective of Phase II of this project. The technical feasibility of the concept to provide sufficient heat for direct uses of the fluid for heating was proven during Phase I with a smaller, shallower reservoir. The Phase II objective has not been met. Longevity and other characteristics of the reservoir are yet to be determined -- with longer-term flow tests expected to be completed in 1992. Power generation experiments may also be conducted.

Locations of Microearthquakes Induced By Massive Hydraulic Fracturing at the Fenton Hill, New Mexico, Hot Dry Rock Experiment. Water is injected through Well EE-2 and brings heat to the surface through Well EE-3. These microearthquakes were monitored by a technique called microseismology to determine the outlines of the fractured reservoir and thus to guide the direction of drilling to connect it to the two wells.
The Phase II reservoir, hydraulically fractured in December 1983 with millions of gallons of water under pressure, is the deepest and hottest geothermal system yet created by man. In May 1985, the system was completed with the successful connection of the injection well and production well 2 1/2 miles down through solid rock. The connection created an underground loop through which water is circulated to absorb and bring the heat of the dry, hot rock to the surface. The connection was described by Dr. Robert San Martin, Deputy Assistant Secretary of DOE for Renewable Energy, as "a major milestone for the hot dry rock project which has been pushing the forefront of science and technology."

The two wells are approximately 13,000 feet deep, where the rock temperature is above 250°C (482°F). New technology has been necessary to operate in this harsh environment, and much of that developed has already been adopted by industry, including improved drilling and well completion equipment and techniques, high-temperature instruments, and acoustic fracture mapping methods.

Although the project was initiated in 1972 by the Atomic Energy Commission alone, more recently Japan and West Germany contributed both funds and manpower under an International Energy Agency agreement. However, both countries have now ended their participation in the program.

Operation of the experimental system is expected to be concluded in 1993. Several options will be considered for site disposition which take advantage of previous federal investments, including its possible use for power generation by the private sector.

MAJOR HURDLE IN GEOPRESSURED PRODUCTION APPEARS TO BE OVERCOME; ELECTRIC POWER EXPERIMENTS POSTPONED

Calcite scaling of geopressed wells has hampered continuous, long-term brine production from the inception of the DOE geopressed program over 10 years ago. In 1985, a complex new chemical mixture, with a phosphonate as the active ingredient, was injected into the Gladys McCall well in Louisiana, and effectively controlled scale formation.

When production dropped off after seven months of flow testing, another "pill" of the inhibitor was injected in February 1986. After 16 months, the well continued to perform very well despite no detectable phosphonate in the brine.

The cooperative DOE/Electric Power Research Institute electric power generation experiments at the Pleasant Bayou geopressed well near Houston, Texas, have been postponed until 1988. EPRI is providing the conversion system, and DOE will support its installation and operation.

HEBER 45 MWe BINARY PLANT DEDICATED

On December 6, 1985, the largest binary cycle geothermal power plant yet constructed was dedicated at Heber, California, in the Imperial Valley. At 45 MWe (net), the plant is the commercial scale prototype of large size binary systems. It was partially funded by the Department of Energy to prove the operational viability and to establish the
economics of this technology for geothermal application. Its commercial success will help open up the geothermal reservoirs in the 150-200°C (300-400°F) range to development, and thus potentially quadruple the hydrothermal reservoirs available for economic exploitation for power generation.

San Diego Gas and Electric Co. is operator of the plant, and provided substantial funding as well. Other contributors included the Electric Power Research Institute; Southern California Edison Co.; State of California; California Department of Water Resources; and the Imperial Irrigation District. Ownership is held only by SDG&E, the State, and IID; with SDG&E accounting for 82.5 percent.

Shell and tube heat exchangers at the Heber 45 MWe proof-of-concept binary plant dwarf workman. Eight of these 160-ton, 27-meter long by 2-meter diameter devices are used to transfer geothermal heat to an organic working fluid.
The importance of the plant to potential geothermal development as a major energy source for California and to the local economy brought a varied audience of about 425 to the dedication. Presentations were made by U.S. Senator Allen Cranston of California; Thomas Page, Chairman, President, and Chief Executive Officer of San Diego Gas and Electric Co.; Robert San Martin, Deputy Assistant Secretary for Renewable Energy, U.S. Department of Energy; Richard Balzhiser, Electric Power Research Institute; Charles Imbrecht, Chairman, California Energy Commission; William Condit, Imperial Irrigation District; Abe Seabolt, Imperial County Board of Supervisors; and Clair Burgener, former U.S. Congressman.

After the dedication the plant operated in excess of 90 percent availability for about 7 months. During this time Chevron conducted extensive reservoir tests and analysis to determine where to drill the remaining wells. Currently, Chevron is drilling the remaining 6 wells and it is expected that 100 percent brine flow will be available in 1988. Shortly thereafter a one-year demonstration program will begin and upon completion the plant is expected to operate commercially.

TWO-PRONGED U.S. NAVY GEOTHERMAL PROGRAM CONTRASTS WITH DEPARTMENT OF DEFENSE FINDINGS

The U.S. Navy has published a Geothermal Plan, dated December 1984, prepared by the Energy Program Management Office at the China Lake, California, Naval Weapons Center. The Plan sets forth two major objectives for the Navy Geothermal Program:

- to provide a technical, economic, and environmental data base to prevent encroachment pressure of private exploration efforts from degrading the ability of the individual bases in performing their assigned missions

- to use geothermal resources to supply electrical power and space heating and cooling at appropriate naval shore installations.

These objectives will be accomplished by:

- an R&D program that will include phased exploration to provide technical information on the existence of a resource and a utilization study to determine how to make use of the resource

- a resource development program.

In a more recent DOD Renewable Energy Report to the Senate and House Committees on Armed Services, it was concluded that: "At this time geothermal energy appears to have limited potential as a viable alternate energy resource for DOD." Although the report states that exploratory and development costs are prohibitively high at many of the sites identified by the military, it noted that the Navy will buy power at substantially reduced costs upon completion of the privately-capitalized geothermal power plant under construction to serve its China Lake facility.
EPA INVESTIGATING WASTES OF GEOTHERMAL INDUSTRY FOR POSSIBLE FEDERAL REGULATION AS HAZARDOUS WASTE

The Environmental Protection Agency has initiated a study of certain wastes generated by the geothermal industry as required by the Resource Conservation and Recovery Act (RCRA). This Act is the federal vehicle for regulating the disposal of hazardous wastes.

The 1980 amendments to RCRA exempted several types of "solid" wastes from its jurisdiction pending further EPA study. Drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil, natural gas or geothermal energy were among the exempt categories.

The amendments required EPA to conduct a study of these wastes and submit a report to Congress by October 1982. For whatever reason, EPA did not conduct the study. In August 1985, the Alaska Center for the Environment sued EPA for this failure, and EPA agreed to a consent order obligating it to submit the report by August 31, 1987.

The first phase of the study has been completed with issuance of a report entitled, Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy, An Interim Report on Methodology for Data Collection and Analysis. The report is dated October 1986, and the National Technical Information Service accession number is EPA/530-SW-86-051.

In interpreting the legislative history of the applicable portion of RCRA, EPA determined that the geothermal wastes involved are those "intrinsically derived from the primary field operation." This phrase, the report notes, is intended to differentiate exploration, development, and production operations from transportation and manufacturing operations. Thus, the study covers only the wastes of field operations and not power plants.

Application of the criteria developed for determining the exempt waste streams results in the following list for geothermal:

- drilling media and cuttings
- precipitated solids from brine effluent
- reinjection well fluid wastes
- piping scale and flash tank solids, except for those associated with electrical power generation
- settling pond wastes.

As defined by RCRA, "solid" waste includes solid, liquid, semi-solid, or contained gaseous material resulting from commercial operations. The Act confers upon EPA the right of entry to facilities generating such wastes and access to all records relating to them.

REPEAL OF FUEL USE ACT POSTPONED

Legislation that would repeal the Power Plant and Industrial Fuel Use Act of 1978 passed the House in September of 1986, and passage in the Senate was expected soon thereafter. However, the bill was caught up in a log-jam of tax, budget, and other major issues and died with adjournment of the 99th Congress. Enactment by the 100th Congress is predicted.
This Act was part of the National Energy Act of 1978 and prohibits the use of oil and gas as primary fuel in new electric power plants and in major fuel burning installations. It also requires that new facilities be capable of using coal or an alternate fuel. The provision that would require the conversion of existing power plants to coal or an alternate fuel by 1990 was repealed in 1981. Natural gas interests are the major proponents of full repeal.

[Editor's Note: Major portions of FUA were repealed in May 1987.]

FEDERAL ASSISTANCE AVAILABLE FOR DEVELOPING WORLDWIDE GEOTHERMAL MARKET

Seventeen countries already produce and utilize geothermal energy, and, according to 1984 statistics of the United Nations Revolving Fund for Natural Resources Exploration, 52 other countries have geothermal exploration programs or were on the point of initiating them when the information was compiled. Many of the countries involved are developing nations which are receiving, or are eligible to receive, financial assistance for geothermal projects from international agencies, e.g., the United Nations, Interamerican Development Bank, and the U.S. Agency for International Development (AID). Many opportunities exist in this market for the U.S. geothermal industry to expand its sales of products and services.

To become the U.S. partner in a geothermal project in a developing country funded by an international agency or AID, a U.S. firm must usually be under contract by the foreign government. For example, a proposal by a U.S. company to conduct geothermal exploration in Kenya would not be entertained under this policy. The impetus for this type of project funding must derive from the other country.

For reasons that are not fully understood, the products and services of the U.S. geothermal industry, with the exception of UNOCAL Corp., are not being utilized by the foreign market to the extent that might be expected. Two situations may influence this to some degree. One is subsidies provided by some countries to their geothermal industries to enhance the competitiveness of their products and services in the international market. The other is the competitive advantage that may accrue to the countries which host internationally-funded geothermal educational institutions such as Iceland, Italy, Japan, and New Zealand.

A federal working group, called the Committee on Renewable Energy Commerce and Trade (CORECT), was formed under the Renewable Energy Industry Development Act of 1983 to coordinate federal efforts to overcome these disadvantages. This legislation created no new federal programs, but gave the working group a mandate to make existing export assistance programs -- of which there are over 100 -- more efficient in promoting increased exports of geothermal and other renewable energy technology and services.

The federal overseas marketing assistance programs which CORECT is directed to coordinate and improve are open to U.S. firms directly, and no prior foreign involvement is required. They can be very helpful, especially to firms that can qualify as a "small" business. While "small" by some definitions varies in accordance with the definition used by the Small Business Administration (SBA), the Export Import Bank defines the term to mean $25 million in gross annual sales in the previous year by
all affiliates, subsidiaries, and parent companies.

The Exim program to which this definition applies is implemented by the Exporter Credits, Guaranties, and Insurance Division and enables U.S. commercial banks to extend fixed-rate medium-term loans to finance small business exports of manufactured products and services. An aggregate of up to $10 million per year is allowed per buyer, and up to $2.5 million per transaction. The fact that this program is under-utilized indicates that its availability is not well known. In 1983 and 1984, $100 million was budgeted, and although no application for assistance was turned down, less than one-third was expended per year.

Even AID has a program for direct assistance to U.S. firms under its Office of Small and Disadvantaged Business Utilization. The Agency will contract with small U.S. firms -- SBA definition -- to provide technical services for AID-financed infrastructure projects in developing countries. Interested and qualified firms should request to be listed on the Contractor’s Index.

One of the most important areas of assistance available to firms of all sizes is the fixed interest rate financing of the Export-Import Bank for export sales of products facing subsidized, government-supported export credit competition from abroad. It will lend up to 85 percent of the contract value. The Bank also assumes commercial and political risk for and guarantees repayment of export obligations acquired by U.S. financial institutions from U.S. exporters. It enables companies to obtain pre-export financing for working capital, finances feasibility studies, and offers a number of other financial services to exporters.

The Overseas Private Investment Corporation (OPIC) insures new investments and those used for the enlargement or modernization of existing plants and equipment in developing countries with coverage to protect investors against 1) the inability to convert local currency received into U.S. dollars; 2) confiscation or nationalization of an investment; and 3) war, revolution, or civil strife. In today’s world, this is highly significant coverage.

The SBA provides financing to borrowers who cannot otherwise obtain funds on reasonable terms, makes export loan guarantees to eligible small businesses wishing to establish or expand their export operations, and offers trade consultation to first-time exporters.

Other programs provide export support which does not involve direct financial assistance. The International Trade Administration in the Department of Commerce promotes awareness of and provides export marketing information to small, medium-sized, and new-to-export (no size limit) U.S. businesses. This agency also promotes U.S. trade by organizing overseas trade missions for U.S. companies of any size, developing overseas product catalogues, sponsoring video shows for U.S. products, and sponsoring U.S. firms in international trade fairs. It also facilitates visits by potential foreign buyers, and, in conjunction with the State Department, facilitates visits of foreign government officials to domestic trade fairs.

For further information on these and other programs or to provide useful information and experience CORECT can be contacted through:
BONNEVILLE POWER ADMINISTRATION STUDY IDENTIFIES PRIME GEOTHERMAL SITES IN PACIFIC NORTHWEST

A two-year study, sponsored by the Bonneville Power Administration, selected eight high-temperature sites and five lower temperature fields as having the best economic and production potential for geothermal power production and direct utilization respectively. Published in June 1985, the study report evaluates the resource in Idaho, Montana, Oregon, and Washington as part of the BPA 20-year power plant projection for the Pacific Northwest.

In the selection process, 78 high-temperature sites and 120 direct use locations were initially considered worth developing geothermally. On the basis of cost, 29 high-temperature sites were rated technically capable of supporting at least 1,000 MWe competitively with conventional power generating costs; 60 others have direct heat resources considered to be at or below conventional energy prices.

Combining resource potential with price projections, the final selections are:

**High-Temperature**

1. Newberry Caldera, OR  
2. Crane Creek, ID  
3. Klamath Falls, OR  
4. Glass Buttes, OR  
5. Big Creek, ID  
6. Raft River, ID  
7. Olene Gap, OR  
8. Klamath Hills, OR

**Direct Use**

1. Boise, ID  
2. Yakima, WA  
3. Pocatello, ID  
4. Pullman, WA  
5. Klamath Falls, OR

BPA's plans indicate that due to the surplus of power in the area expected to continue over the next two decades, near-term geothermal power development is unlikely. It is estimated that the power load growth for the region will be 30 percent less than the national average. Institutional and regulatory problems also impede power plant development in the area with considerable acreage in environmentally sensitive areas.

The report noted that given the results of the study and the developable geothermal energy, this resource should be expected to play a major role in providing direct heating as well as future power generation when the need arises. It urged that sufficient resource, environmental, and market data be developed "to ensure that a significant portion of the geothermal potential that has been identified will be made available when needed."

Source: Geothermal Report 8/1/85
KNOWN GEOTHERMAL RESOURCE AREAS (KGRA's)
UNDER DEVELOPMENT FOR HOT WATER PLANTS
(as of January 1987)

1 - Lakeview, OR
2 - Wendel-Amedee, CA
3 - Salton Sea, CA
4 - Brawley, CA (dismantled)
5 - Heber, CA
6 - East Mesa, CA
7 - Coso Hot Springs, CA
8 - Mono-Long Valley, CA
9 - Brady Hazen, NV
10 - Beowawe, NV
11 - Salt Wells Basin, NV
   (declassified)
12 - Steamboat Springs, NV
13 - Wabuska, NV
14 - Dixie Valley, NV
15 - Darrough Hot Spring, NV
16 - Stillwater, NV
17 - Silver Peak, NV
18 - Roosevelt Hot Springs, UT
19 - Cove Fort Sulphurdale, UT
20 - Gila Hot Springs, NM
21 - Lightning Dock, NM
22 - Puna, HI (not KGRA)
AVAILABILITY DATA CONFIRM GEOTHERMAL POWER PLANTS MUCH MORE RELIABLE THAN FOSSIL OR NUCLEAR PLANTS

According to papers presented to the 11th Inter-RAMP in 1984, the fossil steam power industry has been spending hundreds of millions of dollars per year in improving plant availability, and the nuclear power industry is also struggling with lower than expected availability. At the same time, geothermal power plants -- both dry steam and hot water -- are maintaining availability factors well above 95 percent.

According to the North American Reliability Council equipment availability data, the average availability percentage for U.S. fossil-fired plants from 1974 to 1983 was 78.72 percent, and the average for nuclear plants over the same period was 65.25 percent. By contrast, data gathered from the geothermal literature and summarized in the following table show that new plants at The Geysers reached nearly 100 percent availability during the first year of operation. Such high percentages are not uncommon among Japanese units, according to information supplied on plants in that country, and the small wellhead flash plant in Hawaii has been available for operation 98 percent of the time. Even the Southern California Edison/UNOCAL demonstration flash plant at Brawley, recently dismantled as uneconomic, had a record of 71 percent over nearly four years, which is comparable to or better than the performance of a number of conventional energy plants. It is to be remembered that this plant was the first to operate on brines of such extreme salinity.

A high availability -- the percentage of time a plant is operable and available for service -- is especially important to the economics of base load plants with their high capital costs and low operating costs. When they are out of service, power from plants in the system more costly to operate must be substituted. Put another way, in areas where geothermal power is an option, an economic use of it would be to displace some less reliable base load capacity, leaving the latter to meet peak loads.

FACILITIES FOR TRAINING MANPOWER FOR GEOTHERMAL EMPLOYMENT SURVEYED

Spurred by the call of Hector Alonso Espinosa, Mexico’s geothermal chief in the Commission Federal de Electricidad (CFE), for increased specialized training for the "human resources" needed for geothermal development in his country, GPM undertook an informal survey of the U.S. educational institutions offering such training. The survey found that a number of institutions offer opportunities for geothermally-related course work or research for potential geothermal professionals, but only one--Stanford University--provides a full-blown curriculum in "geothemetics," to use the term in favor abroad.

Mr. Alonso, speaking to the attendees of DOE’s Third Geothermal Program Review at Mexicali, Mexico, in October 1984 stated that it might be possible for Mexico to accomplish a total installed capacity of 2,440 MWe of geothermal power capacity by the year 2000. However, he said, not all resources necessary to meet this goal are merely economic, and "human resources acquire an important significance due to the specialization involved. It is therefore necessary," he added, "that the fields of geology, geophysics, geochemistry, and drilling include the specialization or training in
### Availability Factors of Specific Geothermal Power Plants Compared to Average Availability of Conventional Fossil-Fired and Nuclear Power Plants

Average for U.S. fossil-fired plants = 78.72% availability
Average U.S. nuclear plants = 65.25% availability

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</tr>
</thead>
<tbody>
<tr>
<td>SMUDGEO No. 1 (Geysers)</td>
<td>72</td>
<td>DS</td>
<td>98.9**</td>
<td>First year of operation from 12/83</td>
<td>Hibara, Y., et al., &quot;Advanced Technology for Geothermal Turbines,&quot; Ibid.</td>
</tr>
<tr>
<td>NCPA No. 1 (Geysers) ***</td>
<td>110</td>
<td>DS</td>
<td>97.0</td>
<td>4 months operation following full transmission of power 10/83-1/84</td>
<td>Fontes, R.A., &quot;NCPA Geysers Geothermal Development of Integrated Steam Field Management System,&quot; GRC Transactions, Vol. 8, Aug. 1984</td>
</tr>
<tr>
<td>15 PG&amp;E units operable in 1982 (Geysers)</td>
<td>11.0 - 135.0</td>
<td>DS</td>
<td>85-90</td>
<td>Lifetime Average</td>
<td>Geysers Unit 21 Application for Certification</td>
</tr>
</tbody>
</table>

* Source: North American Reliability Council Equipment Availability, 1974-1983
** As of Sept. 1, 1986, SMUDGEO No. 1 had been operating at 99 percent capacity for the whole year
*** Formerly referred to as NCPA No. 2
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<tr>
<td>B.C. McCabe (Magma Power-East Mesa)</td>
<td>12.5</td>
<td>B</td>
<td>93.6*</td>
<td>1984*</td>
<td>Geothermal Report, April 1, 1985</td>
</tr>
<tr>
<td>Brawley (UNOCAL/SCE)</td>
<td>10.0</td>
<td>F</td>
<td>71.0</td>
<td>6/80 start-up through 9/84</td>
<td>Whitescarver, O.D., &quot;Union Oil Geothermal Development in the Imperial Valley,&quot; The Hot Line, Dec. 1984</td>
</tr>
<tr>
<td>Salton Sea (UNOCAL/SCE)</td>
<td>10.0</td>
<td>F</td>
<td>91.0</td>
<td>Cumulative from 7/82 start-up through 9/84</td>
<td>Ibid.</td>
</tr>
</tbody>
</table>

* Actually on-line; prior to increase in capacity from 10-12.5 MWe

** Over the first 4 1/2 months of operation this plant averaged over 95%. This is accounted for by performance up to 98% combined with a brief period when freezing interfered with performance at night.
### AVAILABILITY FACTORS OF SPECIFIC GEOTHERMAL POWER PLANTS COMPARED TO AVERAGE AVAILABILITY OF CONVENTIONAL FOSSIL-FIRED AND NUCLEAR POWER PLANTS

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<tr>
<td>JAPAN</td>
<td></td>
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<tr>
<td>Matsukawa</td>
<td>22.0</td>
<td>DS</td>
<td>84.4*</td>
<td>1984</td>
<td>Private communication from Idemitsu Geothermal Co., Ltd., Tokyo 1/23/86</td>
</tr>
<tr>
<td>Otake</td>
<td>12.5</td>
<td>SF</td>
<td>100.0</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Onuma</td>
<td>8.6</td>
<td>SF</td>
<td>95.5</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Onikobe</td>
<td>12.5</td>
<td>SF</td>
<td>97.3</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Hatchobaru</td>
<td>55.0</td>
<td>DF</td>
<td>96.2**</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Kakkonda</td>
<td>50.0</td>
<td>SF</td>
<td>87.9***</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Suginoi</td>
<td>3.0</td>
<td>SF</td>
<td>100.0</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Mari</td>
<td>50.0</td>
<td>DF</td>
<td>94.0</td>
<td>1984</td>
<td>Ibid</td>
</tr>
<tr>
<td>Kirishima</td>
<td>0.1</td>
<td>SF</td>
<td>83.0</td>
<td>1984</td>
<td>Ibid</td>
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</table>

* 1984 was only the fifth year since 1966 that the available operating days of this plant fell below 90%. The average over 19 years is 92.2%; in 10 of the 19 years, the percentage was between 95.6 and 98.4.

** The average over eight years for this plant is 95.4; in 1983, the factor was 100 percent.

*** Average over seven years is 93.1%.
AVAILABILITY FACTORS OF SPECIFIC GEOTHERMAL POWER PLANTS COMPARED TO AVERAGE AVAILABILITY OF CONVENTIONAL FOSSIL-FIRED AND NUCLEAR POWER PLANTS

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<tr>
<td>Italian plants</td>
<td>-</td>
<td>-</td>
<td>Consistently above 90.0; often exceed 95</td>
<td>Prior to 1970</td>
<td>DiPippo, R., Geothermal Energy as a Source of Electricity, U.S. Dept. of Energy, Jan. 1980</td>
</tr>
<tr>
<td>Ahuachapan (El Salvador)</td>
<td>60.0</td>
<td>SF</td>
<td>95.0*</td>
<td>From start-up in 1975 to 1978</td>
<td>Ibid.</td>
</tr>
<tr>
<td>Wairakei (New Zealand)</td>
<td>157.2</td>
<td>DF</td>
<td>85.0**</td>
<td>1973-74</td>
<td>Ibid.</td>
</tr>
<tr>
<td>Cerro Prieto (Mexico)</td>
<td>700.00</td>
<td>SF</td>
<td>94.0***</td>
<td>Sept. 1975</td>
<td>Ibid.</td>
</tr>
</tbody>
</table>

* Based on outages caused by breakdowns alone; 84% with scheduled maintenance.
** Actually in service.
*** Stated as "capacity" factor. Capacity factor of 87% in 1976 is the highest of any Mexican power plant.
geothermics." The same should be applied to other areas such as "mechanics, civil engineering, thermodynamics, reservoir engineering, etc., which is the object of the technological development program being elaborated alongside the investment plan, contemplating a sustained annual increase of approximately 20 percent over personnel already on hand."

Certainly, this level of hiring is currently not needed in the U.S. geothermal industry, especially in view of the slower than expected pace of development due to bargain oil prices. In addition, the oil glut is making engineers and scientists trained in oil and gas exploration and production technology available for other employment, a fact which may increase the value of the short courses, workshops, and seminars available on geothermal technology. With the education and experience of this work force, it will need only to be reoriented to the uniqueness of geothermal resources.

Looking to the future, however, an increased pool of labor will be needed as the economic climate for development improves and technologies for exploiting lower grade resources become increasingly competitive. The major educational institutions currently equipped to prepare students for employment in the geothermal industry are typically those that participate in the Federal geothermal research and development program. Some of these institutions and their areas of research are identified in the table below. While many other schools offer related geoscience and engineering courses, it is considered doubtful that many of them are oriented toward producing or utilizing geothermal energy, particularly those geographically removed from the general location of the resource.

As noted above, Stanford University has taken the lead in geothermal studies. They are located in its Department of Petroleum Engineering in the School of Earth Sciences. The specialized curriculum available includes -- in addition to basic geology, geophysics, geochemistry, and mathematics -- courses in

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**UNIVERSITIES IMPLEMENT DEPARTMENT OF ENERGY GEOTHERMAL RESEARCH ACCORDING TO THEIR SPECIALTIES**

- **Hydrothermal Reservoir Technology**
  - Stanford University
  - University of California at Berkeley
  - University of Utah

- **Brine Chemistry**
  - University of California at San Diego

- **Salton Sea Scientific Drilling Project**
  - University of California at Riverside

- **Young Volcanic Reservoirs**
  - University of Utah

- **Two-Phase Flow**
  - Brown University

- **Hot Dry Rock**
  - Massachusetts Institute of Technology
  - Howard University

- **Geopressured Resources**
  - University of Texas at Austin
  - Louisiana State University
  - University of Southwestern Louisiana
  - Texas Southern University

- **Heat Cycle Research**
  - Pennsylvania State University
  - North Carolina Agricultural and Technical University
The U.S. institution considered preeminent worldwide in the direct uses of geothermal energy is the Geo-Heat Center at the Oregon Institute of Technology (OIT). The Center was established as the result of the 1974 International Conference on Geothermal Energy for Industrial, Agricultural, and Commercial-Residential Use, held at the geothermally-heated Institute, and increased interest in non-electric applications of geothermal energy. It serves as the focal point for research into direct use applications and dissemination of technical information, both in this country and abroad. OIT has considered implementing a post-graduate program in geothermal earth sciences and geothermal engineering.

New Mexico State University also provides another very active and attractive curriculum in geothermal direct use applications. It uses the resource to heat and cool campus buildings, and has sponsored the construction of research greenhouses, co-funded by the state and industry.

The U.S. does not, however, enjoy the advantages provided by geothermal education programs sponsored by international funding agencies in four other developed countries. These include the International School of Geothermics at Pisa, Italy; Iceland’s United Nations University post-graduate training program; the Post-Graduate Geothermal Diploma Course at the University of Auckland, New Zealand; and the United Nations Development Fund geothermal program at Kyushu University in Japan. These programs are primarily for the use of students from developing countries, but host country nationals are permitted to attend.

Those interested in short-term orientation courses should contact the Geothermal Resources Council,
which sponsors a number of sessions each year, and publishes lists of others in its monthly Bulletin. The Council can be reached at:

P.O. Box 1350
Davis, CA 95617-1350
916/758-2360

HOT WATER RESOURCE JOINS GEYSERS STEAM AS "BIG BUSINESS"

Before Magma Power Co.’s new 34 MWe hot water geothermal power plant near Niland, California, in the Imperial Valley was even completed, the company sold half interest in the plant for $46 million to Burlington Northern. Initial financing for the whole installation was reported at $73 million. In a November 1985 assessment of Magma’s stock by Woolcott Research Associates, Inc., the value of its holdings at East Mesa and Niland was estimated at $1.5 billion, based on U.S. government surveys of commercial power potential at these sites and the price paid in 1984 for geothermal holdings. In effect, this reasoning equates the value of properties in Imperial Valley with those at The Geysers since the 1984 sales referred to were at the latter location. It was further estimated that the 130 MWe of geothermal power for which Magma has contracted with Southern California Edison to have on-line by 1989 will bring its annual revenues to approximately $100 million by the end of that year.

Although Magma’s initial 10 MWe plant -- now enlarged to 12.5 MWe -- was built as a demonstration plant, "it has reached the status of a successful commercial plant justifying its largely expensed (versus capitalized) $20 million-plus development costs," the Woolcott brochure stated. "Based on the current annual rate paid, East Mesa should generate gross revenues of over $3.5 million in 1985 and about 5.5 million in 1986."

Property sales at The Geysers continue to bring the high prices that have become commonplace in that area. Ending its litigation against Grace Geothermal for an alleged short supply of steam to operate its plant, the Northern California Power Agency (NCPA) purchased Grace’s two leases on which the plant is located for $165 million. Shell Oil Co., the original lessee, obtained rights to the federal acreage in 1974 for $4.5 million, and sold the property after development work to Grace for $106 million in 1983.

Phillips Petroleum Co. also sold its 4,000-acre leasehold of productive lands at The Geysers, its wholly-owned subsidiary, Geysers Geothermal, and interests in nine other California properties to Freeport-McMoRan for $215 million. The Geysers operations include the steam supply for PG&E Unit No. 13, rated at 133 MWe; No. 16 at 113 MWe; and SMUD Geo #1 at 65 MWe. Geysers Geothermal also has an agreement with PG&E to supply Unit 19 when it is built.

More recently, Phillips also sold its geothermal properties outside California to Chevron Corporation for a reported price of over $30 million. These properties include the resource in Utah supplying the 20 MWe plant of Utah Power and Light, and the 10 MWe operation at Desert Peak in Nevada.

Source: In part, Geothermal Report 2/15/86, 12/2/85, 10/1/85; Geothermal Resources Council Bulletin 5/86
GEOTHERMAL BUSINESS ENERGY TAX CREDIT EXTENDED; GEOTHERMAL POWER PROJECTS WOULD REMAIN ECONOMICALLY VIABLE WITHOUT IT, ACCORDING TO LBL ANALYSIS

The Tax Reform Act of 1986 extended the energy investment tax credit for commercial geothermal operations through 1988, but the credit for residential tax credits for geothermal use was allowed to die. All credits had expired on December 31, 1985. The geothermal business credit is 15 percent for 1986 and 10 percent for 1987 and 1988.

Looking to the future beyond 1988, a 1985 study of the Impact of Tax Reform on Renewable Energy and Cogeneration Projects by the Applied Science Division of the Lawrence Berkeley Laboratory found that geothermal power generation projects will remain economically viable without the credit. However, high investor rates of return would be greatly reduced for plants that include transmission costs, such as the project in a remote area used as the geothermal example in the study. As geothermal resource areas are developed, the report observes, incremental projects will not have to bear transmission costs, and will therefore become more viable.

It was estimated that the rate of return on the equity for the 18 MWe geothermal project analyzed would be 39 percent before expiration of the tax credit, and 23 percent without it. For a similar plant without transmission costs, the projections are 54 and 33 percent, respectively. In terms of the ratio of tax credits to equity funds, the ratio declined for the geothermal project from 57 percent with the tax credit to 26 percent without it.

Although the findings of the LBL analysis are not considered forecasts due to the fact that underlying project data may mask technological and market trends, the study indicated that lack of the tax credit would have the most dramatic effect on wind turbines and small hydro. It was concluded that the returns on investments for these technologies will be reduced to such an extreme that they will be unlikely to attract much capital.

GE CREDIT CORP. COMMITTED TO FINANCING ALTERNATIVE ENERGY PROJECTS

General Electric Credit Corporation (GECC), financial backer of the $85 million Heber Geothermal dual flash plant, has financed seven other alternative energy projects for a total of $525 million. Speaking to the New York section of the Geothermal Resources Council, George P. Schaefer, manager of energy marketing for GECC’s Corporate Services Financing Department, said, "This recent experience has led us to believe that we know something about financing alternative energy projects. It has whetted our appetite to the extent that we are currently expanding our services and financial commitment in this area."

Pinpointing GE strategy, Schaefer said all of "these deals" are similar in that they utilize the same financing structure and provide short-term construction funding which is converted to permanent financing on commencement of plant operations. The latter is provided by either single investor lease or leveraged lease.
Such loans are made possible, he said, by containing and sharing the risks involved. In the case of the Heber plant, while "Dravo, Chevron, and Southern California Edison have creditworthiness to handle this deal on their own," he said, "none wanted to go directly on the line for all of the various risks involved. So risk containment and allocation among the parties allowed each to assume the risks it could handle best..." The ground rules adopted are as follows:

- As resource owner, Chevron agreed to guarantee the minimum amount of geothermal energy necessary to operate facility.

- Engineer-constructor-operator Dravo guaranteed that the plant would be built on schedule, within budget, to agreed on specifications, and that it would operate as designed for the life of project.

- Power user Southern California Edison will buy the approximately 52 MW of power expected to be generated.

This plant began operating in June 1985.

General Electric Financial Services, parent company of GECC, has recently joined forces with Kidder, Peabody & Co., a large Wall Street investment banking firm which has also been active in geothermal financing.

Source: In part, Geothermal Report 4/15/85
GEYSERS CELEBRATES 25TH ANNIVERSARY AS DEVELOPMENT CONTINUES

On October 23, 1985, Pacific Gas and Electric Co. hosted a 25th anniversary celebration of the first geothermal power generation in this country by its 11 MWe Unit No. 1, which began operation on September 25, 1960. The ceremonies were held at Unit No. 18, and included the announcement that two new units had been completed a week earlier, both ahead of schedule and under budget.

Units No. 16 and 20 bring the total of PG&E's plants to 19 with a combined capacity of 1,363 MWe. This accounts for about 15 percent of the utility's total generating capacity and enough to supply cities the size of San Francisco and Oakland. It was noted that the cost of power produced by these plants is second only to hydro as the cheapest source of energy in PG&E's service area. This is especially significant since both large 1,100 MWe nuclear units at Diablo Canyon are in operation. The 19 plants displace about 14 million barrels of oil per year which would cost about $380 million.

This development has taken place in spite of many costly technologies required to control environmental problems. Speaking to a Joint Geothermal Conference with Mexico held in San Diego in June 1985, Barton W. Shackelford, PG&E president, said, "Except for boron, (considered harmful to fish, resort areas, and irrigated crops) geothermal energy was first regarded as a clean, pollution-free energy resource. But not so, as consciousness of the environment in the 25 years brought drastic changes to the energy business, and considerable expense to ameliorate boron, arsenic, and mercury trace impurities in the steam, and, the most difficult environmental problem of all, hydrogen sulfide emissions." These emissions are fully controlled at the newest plants, and others are in compliance with local requirements and California's H2S emission standard.

The environmental expenditures are continuing with the construction of Unit 21, which will be the largest of all at 140 MWe. Because of the anxiety of nearby pear farmers, PG&E is being required to install 15 water quality monitoring stations and to maintain them for a minimum of 10 years. Construction of the plant, originally scheduled to be completed in April 1988, is now delayed by at least a year while the California Public Utilities Commission reconsiders the terms of its certification.

At another festive gathering at The Geysers, the California Department of Water Resources dedicated its Bottlerock plant of 55 MWe capacity on May 16, 1985. Located in Lake County, the plant was described as "a significant step forward, not only in the development of the County, but also in the development of sound standards for further geothermal expansion of The Geysers." Opposition to development was quieted, a spokesman for the County Board of Supervisors noted, with the institution of new drilling practices. Five or six wells were drilled for the first time from a single pad, reducing environmental damage. "Owing to precautions taken in design and construction of collection, steam feed and stripping, and sulfur removal," he said, "a near-zero H2S emission level has been achieved."

Subsequent to this optimistic beginning, the plant has suffered technical problems, including an as-yet unexplained casing rupture resulting in a worker fatality.
Currently, the plant is operating at 42 MWe rather than its full capacity of 55 MWe due to a short steam supply. This shortage developed because of declining steam prices for the steam supplier, MCR Geothermal Corp., and unfavorable economics for further capital investment in field development. One solution under active consideration is for DWR to buy out MCR and proceed with field development on its own. An economic assessment is underway.

The Department, however, has indefinitely postponed further construction of its South Geysers plant, citing unsuccessful efforts to negotiate an alternate steam supply to replace the inadequate flow of the leasehold expected to supply the plant. A Department spokesman indicated that negotiations are continuing in an effort to permit completion of the plant at a later date. UNOCAL's nearby Unit 15 was operated at only 44 percent capacity in 1984 due to the lack of availability of design quality steam.

In other recent activity at The Geysers, construction started on the 130 MWe (2 - 65 MWe units) plant of the Central California Power Agency (CCPA) plant, and the second North California Power Agency (NCPA) plant began commercial operation. In addition, the first step in licensing a transmission line to carry the output of the CCPA and NCPA plants and that of the Sacramento Municipal Utility District (SMUD) plant to the service areas of these utilities was approved. It is anticipated that the licensing process will be completed in time for construction to start in April 1987.

H2S treatment facility at SMUDGE #1 72 MWe geothermal power plant at The Geysers. The Sacramento Municipal Utility District plant began commercial operation in December 1983. Photo courtesy Stone and Webster Engineering Corp.
In still other news involving The Geysers, the City of Santa Rosa is investigating injection of treated wastewater to recharge the steam field as a wastewater treatment and disposal option.


MAGMA POWER CO. SCHEDULES THREE NEW POWER PLANTS IN THE IMPERIAL VALLEY

The Magma Power Co. has announced a program to construct three additional power plants at the Salton Sea Geothermal Field in Imperial Valley, California. The plants, rated at 34 MWe net each, will be copies of Magma’s Vulcan Plant that went on line at the Salton Sea Field in 1985. Magma has power sales contracts with Southern California Edison Co. to sell fixed rate power for 10 years followed by escalating rates during the final 20 years.

Construction on the first plant, Vulcan II, will begin in April of 1987 with completion scheduled for September 1988. The construction schedules for the second and third plants, Elmore I and Leathers I, are October 1987 to February 1989 and December 1987 to May 1989, respectively.

Source: Imperial Magma

GEOTHERMAL POWER GETS START IN NEVADA

In its August 18, 1985, edition, the Reno Gazette Journal reported that geothermal projects under construction or planned for Nevada over the next three years total 121 MWe, or enough electricity for a city the size of Reno. The article said that a conservative estimate of Nevada’s total geothermal resources is 4,000 MWe, double the entire generating capacity of conventional power plants in the state today, according to an Ormat spokesman. Thus, over the years, a $4 billion energy exporting industry could be created in Nevada.

The tables at the end of this section show that plants are operating at the Wabuska, Beowawe, Steamboat Springs, and Brady-Hazen Known Geothermal Resources Areas with a total capacity of about 30 MWe. The field at Dixie Valley is currently under development for installation of a 50 MWe plant, the developer of which, Oxbow Geothermal, is also financing a 220-mile transmission line to Bishop, California. These are "ice breaker" plants for these KGRA’s. Other Nevada areas under first development include the Stillwater, Darrough Hot Springs, and Silver Peak KGRA’s.

NAVY SEEKING NEW CONTRACTOR FOR FALLON POWER PLANT PROJECT

Although the Helioscience-General joint venture terminated its contract to develop up to 75 MWe of geothermal power generation capacity at the Navy’s Fallon, Nevada, facility, the Navy does not plan to abandon this project and is seeking a new contractor. The Navy hopes that the project will save money and encourage other geothermal projects in the area.

The joint venture participants, Helioscience and General Energy
Technology, cited a sharp decline in their contract selling price of electricity as the cause for ending the contract, without penalty, and said that $700,000 in expenditures would be written off by Helioscience. The project was to be financed by third party venture capital which sources in Nevada had felt would be difficult to obtain for such an ambitious undertaking in an unproven geothermal field.

Sources: In part, Geothermal Report 9/2/85, Geothermal Resources Council Bulletin 3/86

HEBER GEOTHERMAL DUAL FLASH POWER PLANT DEDICATED

On October 31, 1985, officials from Dravo Corporation, Chevron Resources Co., and the Heber Geothermal Company (a limited partnership between Dravo and Centennial Energy Co.) met at the site of the Heber Dual Flash Power Plant for dedication ceremonies. The plant is the culmination of many years of exploration and field development by Chevron Resources, plus almost an equal amount of time to resolve numerous funding and permitting problems.

This was the first dual flash plant built in the Imperial Valley. It has the capacity to produce 50 MW gross and 47 MW of net power. In full operation, it will use 26 million gallons of geothermal fluid per day.

The reservoir temperature is 182°C (360°F) and the salinity is 14,000 ppm. The nine production wells (4,500 - 10,500 feet deep) are located on an elongated 5-acre production site adjacent to the power plant. The eight injection wells are sited on a drilling island which is located 1-1/4 miles from the power plant and the production wells. Both the production and injection wells

Low pressure flash tanks at the Heber Geothermal Co. dual-flash power plant. High and low pressured steam is separated from geothermal brine and passed through a single two-stage turbine. Photo courtesy Gibbs and Hill, Inc.
are directionally drilled from the sites to minimize the amount of surface acreage taken out of agricultural production.

Source: Geothermal Resources Council Bulletin 1/86

DRY STEAM PLANT DEDICATED AT COVE FORT, UTAH

On September 19, 1985, Mother Earth Industries (MEI) officially dedicated its new geothermal power plant at Sulphurdale, near Cove Fort, Utah. It is being operated on only the fifth dry steam discovery in the world. The plant consists of four Ormat modular binary units with a capacity of 0.8 MWe each for a total of 3.2 MWe. Two production wells supply the plant which, combined, produce 100 tons or 200,000 pounds per hour. This production could sustain from 7 to 10 MWe, depending on the type of system used. The power purchase contract of the City of Provo, a partner in the venture, includes the right to take the first 200 MWe developed incrementally by MEI at the site. Power is being wheeled to Provo by Utah Power and Light.


INDEPENDENT POWER DEVELOPERS SEEN AS SOURCE OF ELECTRIC CAPACITY GROWTH FOR SEVERAL YEARS

The Chairman of the California Public Utilities Commission, Donald Vial, told the annual meeting of the Independent Energy Producers Association in Sacramento in May 1985 that all the large electric utilities in California would rely on them to meet load growth until "well into the 1990's." Big utilities do not plan new base load plant construction until then, he said, which is an indication of the growing importance of third-party power. Independent power development accounted for about 8 percent of California's power production in 1985.

Source: Geothermal Report 6/15/85

FIRST DIRECT FLASH PLANT CLOSED

UNOCAL Corp. closed an uneconomic geothermal power plant in California's Imperial Valley. "Due to the declining energy market, it is no longer economically feasible to continue operating this small developmental project," said Carol Otte, head of the company's geothermal division. UNOCAL is the world's largest geothermal energy producer.

The 10-megawatt plant was operated for five years by Southern California Edison under a partnership with UNOCAL, the Los Angeles Department of Water and Power, and the city-owned utilities of Burbank, Pasadena, and Riverside. The project started operations in mid-1980 and generated more than 134 million kilowatt-hours of power.

"The experience gained at the plant led to the development of new technology and materials which resist corrosion and reduce scale build-up in pipes and other equipment caused by this saline resource," Otte said. "Many of the advances were incorporated into the technology at the Salton Sea geothermal plant near Niland, where research continues."

Source: The Energy Daily 11/7/85
McCORMICK SPICE TO USE GEOTHERMAL ENERGY TO DEHYDRATE ONIONS

McCormick & Co., Inc., the spice company based in Hunt Valley, Maryland, plans to use geothermal energy to dehydrate onions in California.

Gilroy Foods, Inc., a McCormick subsidiary based in Gilroy, California, has acquired the assets of Geothermal Food Processors, Inc. of Brady’s Hot Springs, Nevada, for an undisclosed sum.

Geothermal, a subsidiary of McKesson Corporation, will become an operating unit of Gilroy, which is one of the world’s largest dehydrators of onion and garlic, McCormick said.

The acquisition will help the company expand its onion-drying facilities and develop new products, said Gilroy President George E. Clausen. "It is a natural complement to our business," he said.


GRI JOINS MAGMA POWER/JAPANESE AGREEMENT FOR DEVELOPMENT

Geothermal Resources Inc. has entered into the agreement signed in 1983 by Magma, Nippon Steel Corp., and Mitsui and Co., to explore and develop the geothermal resources on Hokkaido; Japan’s northernmost island. The Japanese government has contributed to the project by conducting the high-risk, early exploration, but will withdraw in mid-1987 and turn over its accumulated data to the partnership. Besides providing technical expertise to the effort, GEO will also contribute a share of the capital -- less than 25 percent -- once development gets underway.

"Historically," a GRI spokesman said, "the Japanese have been state-of-the-art in the area of electrical power, but they are behind in geothermal technology. But," he added, "the Japanese government is very interested in expanding their base of technology and energy sources to include geothermal."

Source: National Geothermal Service 8/29/86

DIRECT USE APPLICATIONS CONTINUE TO INCREASE

The installed or under construction thermal power from direct heat projects in 11 western states in 1986 (excluding resorts) was about 717.8 million Btu/hour. An additional 22 proposed projects could produce 700.8 million Btu/hour. The annual energy use from the 213 installed projects is 2081.7 billion Btu/year. The amount of oil saved by geothermal direct use was estimated to be 520,000 barrels per year or $15.5 million based on 71 cents per gallon (May 1986). Of the total capacity, space and water heating (236.9 x 10^6 Btu/hr) account for 33 percent; district heating (201.0 x 10^6 Btu/hr) 28 percent; greenhouses (150.7 x 10^6 Btu/hr) 21 percent; fish farming (86.1 x 10^6 Btu/hr) 12 percent; and industrial processing (43.1 x 10^6 Btu/hr) 6 percent.

Sixty-six resorts are estimated to account for 75 billion Btu/year of additional geothermal energy use.

(It is to be noted that the term "project" in this usage may range from one residence to a large multi-structure district heating system.)

Source: Geo-Heat Center, Oregon Institute of Technology
PLANS FOR NEW HOT WATER PLANTS CONTINUE DESPITE POOR MARKET CONDITIONS

According to information announced in other geothermal publications and obtained from other sources, 25 additional hot water plants are in planning stages for a total capacity of about 728 MWe. It is understood that power sales contracts are in place for most, if not all, of this capacity. Nineteen of the planned facilities will be in California, one in Hawaii, and five in Nevada. These statistics represent a very optimistic future for geothermal energy in the face of current power over-supply and cheap oil.

The following tables also indicate that 16 operational hot water plants have a total capacity of over 215 MWe. Over 60 MWe is reported to be under construction.

The only current construction reported at The Geysers is the Cold Water Creek plant of the Central California Power Agency in which the Sacramento Municipal Utility District, Modesto Irrigation District, and the City of Santa Clara are participants.

The key to the abbreviations used in the power plant tables are as follows:
## Plant Type

- **DS** - Dry Steam
- **DB** - Dual Binary
- **SF** - Single Flash
- **B** - Binary

## Utilities

- **CCPA** - Central California Power Agency
- **HELCO** - Hawaii Electric Light Co.
- **LADWP** - Los Angeles Department of Water and Power
- **NCPA** - Northern California Power Agency
- **PG&E** - Pacific Gas and Electric Co.
- **PP&L** - Pacific Power and Light Co.
- **SCE** - Southern California Edison
- **SDG&E** - San Diego Gas and Electric Co.
- **SPP** - Sierra Pacific Power Co.
- **UP&L** - Utah Power and Light Co.
### Geothermal Electric Power Plants Operational in the United States

#### Hot Water Plants

<table>
<thead>
<tr>
<th>Location (State and KGRA)</th>
<th>Plant Name</th>
<th>Field Developer</th>
<th>Owner</th>
<th>Utility</th>
<th>Rated Capacity (MW)</th>
<th>Year On Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>East Mesa B.C. McCabe</td>
<td>Magma Power Co.</td>
<td>Magma Power Co. SDGSE</td>
<td>12.5*</td>
<td>1980</td>
<td></td>
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<tr>
<td></td>
<td>Brawley**</td>
<td>UNOCAL Corp.</td>
<td>SCE, LADWP, Pasadena, Riverside, Burbank</td>
<td>**</td>
<td>**</td>
<td>1980</td>
</tr>
<tr>
<td></td>
<td>Salton Sea Demonstration*</td>
<td>UNOCAL Corp. (operator for itself and Southern Pacific Land Co. and Mono Power)</td>
<td>SCE</td>
<td>10</td>
<td>1982</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mono-Long Valley Mammoth Geothermal Project</td>
<td>Mammoth-Pacific***</td>
<td>Mammoth-Pacific***</td>
<td>SCE</td>
<td>7</td>
<td>1984</td>
</tr>
</tbody>
</table>

* Enlarged from 10 MWe.
** 10 MWe plant dismantled in 1985.
**** Partnership of Dravo Corporation and Centennial Energy
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>RATED Capacity (MW)</th>
<th>YEAR</th>
<th>ON LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>California, (Cont'd)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Heber</td>
<td>Heber Binary Project</td>
<td>B</td>
<td>Chevron Resources Co.</td>
<td>SDG&amp;E, Imperial Irrigation District, State of Calif.*</td>
<td>SDG&amp;E</td>
<td>45</td>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>Salton Sea</td>
<td>Vulcan Power Plant</td>
<td>DF</td>
<td>Magma Power Co.</td>
<td>Magma Power Co.</td>
<td>SCE</td>
<td>34</td>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>Wendel-Amedee</td>
<td>Wineagle Project</td>
<td>B</td>
<td>Wineagle Developer</td>
<td>Wineagle Developer</td>
<td></td>
<td>.7**</td>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>HAWAII</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puna***</td>
<td>HGP-A</td>
<td>SF</td>
<td>Barnwell Industries</td>
<td>HELCO</td>
<td>HELCO</td>
<td>3</td>
<td>1981</td>
<td></td>
</tr>
<tr>
<td>NEVADA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wabuska</td>
<td>Wabuska</td>
<td>B</td>
<td>Tad’s Enterprises</td>
<td>Tad’s Enterprises</td>
<td>SPP</td>
<td>0.8****</td>
<td>1984</td>
<td></td>
</tr>
</tbody>
</table>

* Demonstration plant supported by the U.S. Dept. of Energy.  
** To be increased by 2.8 MWe.  
*** Not a KGRA.  
**** May be expanded.
<table>
<thead>
<tr>
<th>LOCATION (State and KGRA)</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>RATED CAPACITY (MW)</th>
<th>YEAR ON LINE</th>
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</thead>
<tbody>
<tr>
<td>NEVADA, (Cont'd)</td>
<td>Beowawe</td>
<td>DF</td>
<td>Chevron Geothermal</td>
<td>Crescent Valley Geothermal (subsidiary of SCE)</td>
<td>SCE</td>
<td>10</td>
<td>1985</td>
</tr>
<tr>
<td></td>
<td>Brady Hazen</td>
<td>Desert Peak</td>
<td>BP and DF</td>
<td>Chevron (originally Phillips)</td>
<td>Chevron</td>
<td>SPP</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>Lightning Dock</td>
<td>Burgett Floral, Inc.</td>
<td>B</td>
<td>N/A</td>
<td>Burgett Floral</td>
<td>*</td>
<td>&lt;1</td>
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<tr>
<td></td>
<td>Lakeview</td>
<td>Hammersly Canyon</td>
<td>B</td>
<td>Northwest Geothermal Inc.</td>
<td>Wood and Associates</td>
<td>PPL</td>
<td>&gt;2</td>
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</tbody>
</table>

* Power used for greenhouse facility needs.
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>CAPACITY (MW)</th>
<th>YEAR ON LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTAH</td>
<td>Blundell I</td>
<td>SF</td>
<td>Chevron Resources (originally Phillips)</td>
<td>UP&amp;L</td>
<td>UP&amp;L</td>
<td>20</td>
<td>1984</td>
</tr>
<tr>
<td>Roosevelt Hot Springs</td>
<td>Mother Earth</td>
<td>B*</td>
<td>Mother Earth Industries</td>
<td>Mother Earth Industries/ City</td>
<td>Provo City</td>
<td>4.7*</td>
<td>1985</td>
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</table>

* The installed binary units operate on dry steam; a steam turbine is being added which will increase output to 6.5 MWe.
### Geothermal Electric Power Plants Under Construction in the United States (Hot Water Plants)

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant Name</th>
<th>Type</th>
<th>Field Developer</th>
<th>Plant Owner</th>
<th>Utility</th>
<th>Rated Capacity (MW)</th>
<th>Year On Line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>California</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Mesa</td>
<td>ORMESA</td>
<td>B</td>
<td>Ormat</td>
<td>Ormat</td>
<td>SCE</td>
<td>20</td>
<td>1987</td>
</tr>
<tr>
<td>Coso</td>
<td>China Lake</td>
<td>DF</td>
<td>California Energy Co.</td>
<td>California Energy Co.</td>
<td>SCE</td>
<td>25</td>
<td>1987</td>
</tr>
<tr>
<td><strong>Nevada</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stillwater</td>
<td>NA</td>
<td>B</td>
<td>Trans-Pacific Geothermal</td>
<td>Trans-Pacific Geothermal</td>
<td>SPP</td>
<td>1-2</td>
<td>end of 1987</td>
</tr>
<tr>
<td>Brady Hazen</td>
<td>Brady Hot Springs</td>
<td>B</td>
<td>Munson Geothermal</td>
<td>Munson Geothermal</td>
<td>SPP</td>
<td>3.9</td>
<td>1987</td>
</tr>
<tr>
<td>Brady Hazen</td>
<td>NA</td>
<td>B</td>
<td>Munson Geothermal</td>
<td>Munson/EG&amp;G Hydra Co.</td>
<td>SPP</td>
<td>5*</td>
<td>1987</td>
</tr>
<tr>
<td><strong>Utah</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roosevelt Hot Springs</td>
<td>Wellhead No. 1</td>
<td>BP/DF</td>
<td>Chevron Resources (originally Phillips)</td>
<td>UP&amp;L</td>
<td>UP&amp;L</td>
<td>14.5</td>
<td>NA</td>
</tr>
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</table>

*This is the Department of Energy experimental binary unit tested briefly at the Raft River, Idaho, Geothermal Facility.
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>RATED CAPACITY (MW)</th>
<th>YEAR ON LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within Imperial Irrigation</td>
<td>NA</td>
<td>DF</td>
<td>Chevron Resources Co.</td>
<td>Imperial Geothermal Co.</td>
<td>SCE</td>
<td>160 (4 plants at 40 MWe each)</td>
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<tr>
<td>District Jurisdiction</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mono-Long Valley</td>
<td>Chance Ranch</td>
<td>B</td>
<td>Wood and Associates</td>
<td>Bonneville Pacific</td>
<td>SCE</td>
<td>10</td>
<td>NA</td>
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<tr>
<td>Mono-Long Valley</td>
<td>Unit 2</td>
<td>B</td>
<td>Mammoth Pacific</td>
<td>Mammoth Pacific</td>
<td>SCE</td>
<td>9</td>
<td>NA</td>
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<tr>
<td>Mono-Long Valley</td>
<td>Unit 3</td>
<td>B</td>
<td>Mammoth Pacific</td>
<td>Mammoth Pacific</td>
<td>SCE</td>
<td>9</td>
<td>NA</td>
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<tr>
<td>Mono-Long Valley</td>
<td>Mammoth Lakes</td>
<td>B</td>
<td>Santa Fe Geothermal</td>
<td>Santa Fe Geothermal</td>
<td>SCE</td>
<td>10</td>
<td>NA</td>
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<tr>
<td>East Mesa</td>
<td>Magma Unit No. 2</td>
<td>B</td>
<td>Magma Power Co.</td>
<td>Magma Power Co.</td>
<td>SCE</td>
<td>25</td>
<td>By 1991</td>
</tr>
<tr>
<td>East Mesa</td>
<td>Magma Unit No. 3</td>
<td>B</td>
<td>Magma Power Co.</td>
<td>Magma Power Co.</td>
<td>SCE</td>
<td>25</td>
<td>By 1991</td>
</tr>
<tr>
<td>East Mesa</td>
<td>Ormesa Geothermal No. 1</td>
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<td>Ormesa</td>
<td>Ormesa</td>
<td>SCE</td>
<td>15</td>
<td>NA</td>
</tr>
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* Partnership between Dravo and Centennial Energy.
## Geothermal Electric Power Plants Planned in the United States

(Hot Water Plants) (Cont’d)

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>RATED CAPACITY (MW)</th>
<th>YEAR ON LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coso</td>
<td>China Lake</td>
<td>DF</td>
<td>California Energy Co.</td>
<td>California Energy Co.</td>
<td>SCE</td>
<td>67.5</td>
<td>1988</td>
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<tr>
<td>Coso</td>
<td>China Lake</td>
<td>DF</td>
<td>California Energy Co.</td>
<td>California Energy Co.</td>
<td>SCE</td>
<td>67.5</td>
<td>1988</td>
</tr>
<tr>
<td>Wendel-Amedee</td>
<td>Honey Lake</td>
<td>Hybrid (wood/geothermal)</td>
<td>GeoProducts</td>
<td>GeoProducts</td>
<td>PG&amp;E</td>
<td>20</td>
<td>1988</td>
</tr>
<tr>
<td>Salton Sea</td>
<td>Vulcan II</td>
<td>DF</td>
<td>Magma Power Co.</td>
<td>Magma Power Co.</td>
<td>SCE</td>
<td>34</td>
<td>1988</td>
</tr>
<tr>
<td>Salton Sea</td>
<td>NA</td>
<td>DF</td>
<td>UNOCAL Corp.</td>
<td>UNOCAL Corp.</td>
<td>SCE</td>
<td>&lt;50</td>
<td>1989</td>
</tr>
<tr>
<td>Salton Sea</td>
<td>Elmore I</td>
<td>DF</td>
<td>Magma Power Co.</td>
<td>Magma Power Co.</td>
<td>SCE</td>
<td>34</td>
<td>1989</td>
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<tr>
<td>Salton Sea</td>
<td>Leathers I</td>
<td>DF</td>
<td>Magma</td>
<td>Magma</td>
<td>SCE</td>
<td>34</td>
<td>1989</td>
</tr>
<tr>
<td>HAWAII</td>
<td>Puna*</td>
<td>F</td>
<td>Thermal Power Co. (PGV)**</td>
<td>PGV** Hawaii Electric</td>
<td>HELCO</td>
<td>25***</td>
<td>1993***</td>
</tr>
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</table>

* Not declared a KGRA
** Composed of Thermal and Amfac Energy Inc.
*** Two 12.5 MWe increments; second by 1993, first earlier.
<table>
<thead>
<tr>
<th>LOCATION (State and KGRA)</th>
<th>PLANT NAME</th>
<th>TYPE</th>
<th>FIELD DEVELOPER</th>
<th>PLANT OWNER</th>
<th>UTILITY</th>
<th>RATED CAPACITY (MW)</th>
<th>YEAR ON LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darrough Hot Springs</td>
<td>Big Smoky Valley</td>
<td>NA</td>
<td>Nevada Geothermal Associates</td>
<td>Nevada Geothermal Associates</td>
<td>SPP</td>
<td>10</td>
<td>Uncertain</td>
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<tr>
<td>Noncompetitive Acreage</td>
<td>Fish Lake Valley</td>
<td>B</td>
<td>Steam Reserve Corp.</td>
<td>Steam Reserve Corp.</td>
<td>NA</td>
<td>5*</td>
<td>1987</td>
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<tr>
<td>Dixie Valley</td>
<td>Oxbow</td>
<td>DF</td>
<td>Oxbow Geothermal</td>
<td>Oxbow Geothermal</td>
<td>SCE</td>
<td>50</td>
<td>1987</td>
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<tr>
<td>Stillwater</td>
<td>NA</td>
<td>B</td>
<td>Trans-Pacific Geothermal</td>
<td>Trans-Pacific Geothermal</td>
<td>SPP</td>
<td>8-9**</td>
<td>1987</td>
</tr>
<tr>
<td>Steamboat Springs</td>
<td>NA</td>
<td>SF</td>
<td>Chevron Resources</td>
<td>Chevron Resources</td>
<td>SPP</td>
<td>12.5</td>
<td>NA</td>
</tr>
</tbody>
</table>

* To be increased to 15 MWe 1988.
** Extension of smaller unit to be completed early in 1987.
### Geothermal Electric Power Plants Operational in the United States

(Dry Steam Plants at The Geysers)

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Field Developer</th>
<th>Plant Owner</th>
<th>Utility</th>
<th>Rated Capacity (MW)</th>
<th>Year On Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG&amp;E Unit No. 1</td>
<td>UNOCAL/Magma/Thermal</td>
<td>PG&amp;E</td>
<td>PG&amp;E</td>
<td>11</td>
<td>1960</td>
</tr>
<tr>
<td>No. 2</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>13</td>
<td>1963</td>
</tr>
<tr>
<td>No. 3</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>27</td>
<td>1967</td>
</tr>
<tr>
<td>No. 4</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>27</td>
<td>1968</td>
</tr>
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<td>No. 5</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>53</td>
<td>1971</td>
</tr>
<tr>
<td>No. 6</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>53</td>
<td>1971</td>
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<td>&quot;</td>
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* Originally NCPA Nov. 2 and 3.
GEOTHERMAL ELECTRIC POWER PLANTS UNDER CONSTRUCTION AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers) (Cont.)

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<tr>
<th>PLANT NAME</th>
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<th>PLANT OWNER</th>
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<th>RATED CAPACITY (MW)</th>
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<tr>
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<td>When capacity is needed</td>
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* Plant ownership divided among Sacramento Municipal Utility District (SMUD), Modesto Irrigation District (MID), and the City of Santa Clara.
Geophysical Exploration - Setting Up Seismic Monitoring Instruments in the field. Photo courtesy Lawrence Berkeley Laboratory.
ACREAGE LIMITATION OF GEOTHERMAL STEAM ACT INCREASED; LEASE EXTENSION SOUGHT

As of December 26, 1985, the amount of acreage that can be held under geothermal lease by any one lessee in any one state was increased from 20,480 acres to 51,200 acres. This action was taken administratively by the Secretary of the Interior as permitted by the Steam Act 15 years after the date of its enactment. No opposition was expressed during the rulemaking period. The final rule also increases the geothermal noncompetitive lease application fee from $50 to $75.

Meanwhile, a bill introduced by Senator Chic Hecht of Nevada (S. 1322) seeks to amend the Steam Act to provide a mechanism to extend the primary term of geothermal leases for up to 15 years where diligent exploration has proven the presence of commercial resources, but which cannot be developed within the 10-year primary term for economic reasons. Current law requires a bona fide contract for sale of the resource as a condition for lease extension.

Hecht said that "the combination of large front-end development costs, risky power plant technology, and uncertainty over future world energy prices has led to cancellation or delay of many geothermal power projects. These problems are being compounded by certain inflexible provisions of the Steam Act which prohibit the extension of leases where diligent field development has occurred, but active power plant construction has been delayed by market forces."

Stopgap legislation in 1984 gave the leaseholders of the earliest geothermal leases a temporary respite, but the mechanism in the pending bill would apply to all leases if applied for within 180 days after adoption of the amendment or 60 days before the lease primary term expires, depending on which is later. Up to three successive 5-year extensions could be approved by Interior upon proof that lessees had made substantial investments in exploration without being able to consummate a commercial sale. The legislation also requires the Department to consider terminating leases "not reasonably necessary to the economic viability of a unit or cooperative plan."

The Subcommittee on Natural Resources Development and Production of the Senate Committee on Energy and Natural Resources held a hearing on S.1322 on April 24, 1986. Robert H. Lawton of the Bureau of Land Management appeared as the principal administration witness in support of the bill, but advocating some perfecting amendments. Industry witnesses supporting enactment included Kenneth P. Nemzer, Chairman of the Geothermal Resources Assn. and General Counsel of California Energy Co.; Joseph L. Wilson, Vice President, UNOCAL; and Dominic J. Falcone, vice president, Geothermal Resources International, Inc. R. Gordon Bloomquist of the Washington State Energy Office noted that the need for legislation such as S.1322 was singled out during the course of the recent Bonneville Power Administration Geothermal Assessment Program (see Section 2) as the most important institutional issue facing geothermal development at this time.

Destry Jarvis, Vice President for Conservation Policy of the National Parks and Conservation Association, appeared to recommend that the legislation be amended to include specific language generic to protection of the 21 national park...
ONLY SIX OF 53 PARCELS RECEIVED BIDS AT BUREAU OF LAND MANAGEMENT CALIFORNIA LEASE SALE

In a June, 1985, geothermal lease sale for parcels in seven California KGRA’s, the Bureau of Land Management received bids on only 6 of 53 tracts. The high bids for the six parcels totaled just over $323,850. One bid, the Geysers Geothermal offer for Parcel No. 32 at The Geysers of $234,638 for 870 acres, was higher than all of the other bids put together. UNOCAL made the second highest offer of $50,648 for Parcel 26, also at The Geysers. These two companies were the only bidders for 2 of 20 parcels in that KGRA. The other bids were for 4 of 11 tracts offered in the Coso KGRA. The tracts offered in the Dunes, East Brawley, Glamis, and Salton Sea KGRA’s in Imperial Valley, received no bids nor did the Lake City-Surprise Valley KGRA in northern California.

The sales announcement attached many special stipulations and advisory notices to all of the lands offered. For example, the Dunes area has been used by the Army and Navy as a bombing area and for maneuvers, and the government does not guarantee that the area is free of unexploded bombs or other hazardous materials.

Source: Geothermal Report 8/1/85, 6/15/85

UNOCAL WINS LEASE NEAR MAMMOTH LAKES

In January 1985, the Bureau of Land Management (BLM) issued a geothermal lease to UNOCAL Corp. near Mammoth Lakes, Mono Co., California. The lease, which contains 12,000 acres, is located north of Mammoth Knolls. UNOCAL paid $6 million for the 10-year lease. The bidding process began in July 1983, when the BLM accepted lease proposals for approximately 25,000 acres of prospective land north of Mammoth Lakes and mostly west of Highway U.S. 395.

Because of protests by the Sierra Club and the Mono Lake Committee, the U.S. Forest Service and the BLM developed an environmental assessment which addressed some of their concerns. In July 1984, the BLM issued a supplemental environmental assessment which made stipulations for geothermal developers more stringent. These added stipulations were appealed and the BLM mediated an agreement between UNOCAL, the Sierra Club, and the Mono Lake Committee. The agreement culminated with the awarding of the geothermal lease to UNOCAL. The lease is only a few miles east of Mammoth Lakes at Casa Diablo Hot Springs where a 7-MWe binary plant is in operation.

Source: Geothermal Resources Council Bulletin 5/85

ANADARKO PETROLEUM MAKES DISCOVERY IN NEVADA

On October 30, 1985, the Anadarko Petroleum Corp. of Houston, Texas, announced a commercial scale discovery of geothermal energy in Churchill County, Nevada. The well is located in the Salt Wells area approximately 60 miles from Reno. The well was pumped at a maximum sustained rate of 1,300 gallons of hot water per minute during a
4-day test. Water temperature ranges from 127 to 141°C (260 to 285°F). Depth of the well is 700 feet.

Robert C. Edmiston, geothermal manager for Anadarko at Santa Rosa, California, stated that the volume of water and temperature at the wellhead are consistent with commercial generation of electricity using binary (heat exchanger) technology. Test results indicate that the shallow discovery zone has the potential for development into a resource capable of generating at least 30 MW.

Source: Geothermal Resources Council Bulletin 12/85

GDO LETS FIRST CONTRACT FOR DRILLING TECHNOLOGY COMMERCIALIZATION

The Geothermal Drilling Organization (GDO), the formation of which was described in GPM No. 9, has funded a contract for the construction of two acoustic borehole televiewers that will operate at temperatures of up to 270°C (527°F). Squire-Whitehouse Inc. of San Diego, a logging tool manufacturer, will build and conduct laboratory tests of the televiewers under a 20-month, $950,000 award. In accordance with the charter of the GDO, the Department of Energy is contributing 50 percent of the cost, and interested members -- in this case UNOCAL Corp. and Geothermal Resources International -- are funding the other half. The contractor is eligible to receive any patent involved on the equipment, and the financial contributors are entitled to royalty-free licenses for any patented equipment. Flo-Log Inc., of Long Beach, California, will use the tools in the field for a year to conduct geothermal well-logging operations requested by interested companies.


CHINA LAKE WELL FLOWS FROM DRY STEAM RESERVOIR

California Energy Co. Inc. (CECI) has completed a dry steam well in the U.S. Navy's Coso geothermal field at China Lake, California, featuring one of the highest temperatures ever for a moderate depth well in North America.

The 72-19 well, drilled to 6,553 feet, recorded a bottomhole temperature of 326°C (646°F). It is the hottest well drilled in the field. Data from the new well reinforce early estimates of Coso resource potential as supporting at least 1 million kW of electric power capacity, according to the Naval Weapons Center's Geothermal Program Office.

About 12-13 wells have been drilled in the area by CECI and the Los Angeles Department of Water and Power to serve planned power generation projects.

Source: Oil and Gas Journal 7/28/86

API WORK GROUP REPORTED FIELD TESTS OF GEOTHERMAL CEMENTS

The Oil and Gas Journal of February 11, 1985, described the work of the API Task Group on Cements for Geothermal Wells in the Cerro Prieto field in Mexico. Quoting the Group's
report, the Journal noted that the completed field tests showed that 9 of 16 cements exposed to flowing brine satisfied the durability criteria specified by the Group. These criteria were maintenance of a compressive strength of at least 1,000 psi, and a permeability to water less than 0.1 md throughout a downhole exposure of 12 months. Downhole temperature was 214°C (417°F), depth was 2,300 feet, and the flowing brine contained 18,292 ppm dissolved solids. For eight commercially available cements, high silica content (44.8 to 60.7 parts per 100 parts by weight of cement solids) appear to have been important factors leading to successful performance.

This work represents the first test of cement samples downhole in a flowing geothermal well. It completes the program initiated in 1978 as a joint effort of the API Committee on Standardization of Well Cements and an advisory panel consisting of Brookhaven National Laboratory, DOE, and representatives from the petroleum industry active in recovery of geothermal energy. The Mexican agencies, Federal de Electricidad (CFE) and Institute de Investigaciones Electricas (IIE) provided considerable assistance, and the National Bureau of Standards participated in laboratory measurements.

Air drilling a well at The Geysers. Air is used as the circulation medium when high temperatures and under-pressured conditions are encountered. Water-based drilling fluids can solidify and damage the producing formation. Photo courtesy Dresser Industries.
ACTIVE U.S. GEOTHERMAL LEASES IN EFFECT AS OF SEPTEMBER 30, 1985*

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* Information for Fiscal Year 1986 is in preparation by BLM.
## Geothermal Exploration, Development, and Injection Wells and Temperature Gradient Holes Deeper Than 1,000 Feet*

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** Pre-1981 data include only wells deeper than 2500 feet.

*** Coso well estimated.
ALASKA

GEOTHERMAL LEASING BEGINS IN ALASKA

Geothermal leasing began in Alaska with a high bid of $39,026--or $3 per acre--for a tract on the western shore of Cook Inlet, about 70 miles south of Anchorage. The lease sale, the second held by the state in the Mt. Spurr area, offered two tracts covering 2,640 acres. The second tract received no bids. A Geothermal Resources International Inc., bid for Tract No. 1 failed to qualify.

Legislation providing for geothermal resource development was enacted by the Alaska Legislature in 1980. Leasing regulations were promulgated in July 1982 and revised in May 1983.

Source: Idaho National Engineering Laboratory Regional Geothermal Progress Monitor 11/85, 8/86, 8/86

FEASIBILITY OF POWER PRODUCTION AT UNALASKA IS UNDER EVALUATION

An economic feasibility study that started in September 1986 could lead to Alaska's first commercial geothermal power plant--a 13 MW facility at Unalaska, an official said. Dave Denig-Chakroff, a project manager for the Alaska Power Authority (APA), said study costs are not to exceed $225,000. The study go-ahead came about a month after the APA and two native organizations agreed on access and royalties associated with the Unalaska geothermal reservoir. These organizations are the Aleut Corp., which owns the land; and Onalashka Corp., which holds the surface rights to property that may be needed for roads and power lines.

Source: Idaho National Engineering Laboratory Regional Geothermal Progress Month 9/86

CALIFORNIA

CALIFORNIA ENERGY COMMISSION SUPPORTING ACCELERATED MARKET ACCEPTANCE OF NEW TECHNOLOGIES

In November, 1985, the California Energy Commission advertised the availability of $6 million for loans and grants under its Energy Technologies Advancement Program for low- and medium-temperature geothermal direct heating and power generation systems. Loans must be repaid in 7 1/2 years, and proposals for grants are to provide at least 50 percent of project costs on a matching basis.

The Commission’s energy development program was set up under state law passed in 1984 to promote an active partnership between the private and public sectors. Other goals were to come up with lowest cost energy for the benefit of ratepayers plus increasing energy independence via California’s indigenous resources, providing environmental benefits and building the state’s economy. In particular, the Commission hopes to accelerate market acceptance of new technologies, such as geothermal, by providing financial assistance to a limited number of projects designed to overcome impediments, demonstrate technologies, and offer successful models for private business to duplicate.
Funds for testing at the 45 MWe Heber binary plant are reported by CEC staff to be under consideration. However, due to some points of disagreement between CEC and San Diego Gas and Electric Co., operators of the plant, a contract has not been executed as of the end of November 1986.

This program is not to be confused with CEC's Geothermal Grant and Loan Program funded by California's share of federal geothermal leasing royalties. This program is open only to local governments. The 19 jurisdictions receiving funding under the Round 6 cycle will variously use the funds for resource development, planning studies, and assistance in identifying and mitigating the effects of geothermal development on the environment. The total outlay for Round 6 is over $2 million. Through the Commission's first 5 cycles, 89 grants have been approved totalling $8.1 million, matched by local government commitments of over $6.8 million.

Source: Geothermal Report 11/1/85; Geothermal Resources Council Bulletin 5/86; Personal Communication 11/86

CALIFORNIA ENACTED STATUTE TO ENCOURAGE DIRECT USE

As of January 1, 1986, geothermal developers will be allowed to use property owned by California's State Lands Commission for non-electrical geothermal heating for less than the 10 percent royalties required of geothermal power producers. The legislation enacting this incentive for the use of geothermal energy for direct heating of offices and other buildings was signed into law in late July 1985. The areas in California most favorable for taking advantage of the incentive are the periphery of The Geysers and Mono, Inyo, and Imperial Counties.

Source: Geothermal Resources Council Bulletin 11/85

GEOTHERMAL ENERGY PROMINENT IN CALIFORNIA'S ENERGY PLANNING

The 1985 California Energy Plan, the 5th biennial report of the California Energy Commission, projects that the state's electric power generating capacity demand will increase by 21,400 MWe by 1996. After subtracting capacities of presently planned plants -- 6,300 MWe of capacity remain for which no production facilities have as yet been sought or assigned. To meet this reserved need, the Commission has allotted 1,400 MWe to conservation; 900 MWe to natural gas cogeneration; 850 MWe to geothermal; 350 MWe to biomass; 250 MWe to hydro; 300 MWe to solar and wind combined; and 650 MW for importation from out of state; leaving just over 1,600 MW unreserved for now. To compete successfully for a portion of the unreserved capacity, geothermal developers must meet criteria set forth in Section 25309 of the State Public Resources Code dealing with availability of unreserved need, price of electricity to be produced, and load requirements of the service area involved. Direct uses of geothermal energy were apparently not considered in the plan.

Source: Geothermal Report 7/15/85, 12/16/85

NEW CALIFORNIA LAW REQUIRES PRODUCTIVE RESOURCE FOR POWER DEVELOPMENT

The California Energy Commission is required in the future to make as-
surances in writing that sufficient steam is available before authorizing construction of geothermal electric generation plants, under a bill that passed the legislature late in the session that closed in mid-September 1985. The bill has been signed by Governor Deukmejian. The consensus is that the legislation was spurred by the insufficient steam problem at the state's Department of Water Resources South Geysers plant.

Source: In part, Idaho National Engineering Laboratory Regional Geothermal Progress Monitor 10/85

NO SALES TAX ON GEOTHERMAL STEAM

The sale of geothermal steam will bear no sales tax in California as a result of legislation which overrides a ruling by the Sonoma County Superior Court that overturned a long-standing interpretation of previous law by the Board of Equalization that the steam was sales-tax free.

Operators in The Geysers were relieved of $123-million in back taxes when the Governor signed the bill in July 1986. The new law is effective throughout the state.

Source: Geothermal Report 8/15/86

HDR TECHNOLOGY MAY BE COMING TO THE GEYSERS

An initial investment of $30,000 may usher in a new era at The Geysers -- an era when hot dry rock technology may be used to extend one of the most fertile heat resources on the globe. The cause of this optimistic speculation is the California Energy Commission's decision to amend a grant to the City of Clear Lake by $30,000 to allow for some preliminary assessment of HDR potential in the Clear Lake Geysers area. At present, the City is negotiating with Los Alamos National Lab, architects of the HDR experiments at Fenton Hill, New Mexico, to analyze existing geological and geophysical data and prioritize, as potential HDR candidates, existing wells currently not in use.

Source: Geothermal Report 8/15/86

HAWAII

GEOTHERMAL WELLS ON ISLAND OF HAWAII MAY SUPPLY ELECTRICITY TO POPULOUS OAHU

The Department of Energy and the state of Hawaii are planning to build the deepest and longest undersea electrical cable in the world. They recently commissioned the Pirelli Cable Corp. to produce a 3,500-foot test cable for Hawaiian Electric Co. The cable will undergo extensive laboratory testing, with sea testing scheduled for 1988. When fully developed, 150 miles of cable will be installed more than 6,000 feet deep between the islands of Hawaii and Oahu.

Hot steam from volcanoes on the island of Hawaii will be converted into electricity and cabled to Oahu, which houses 75 percent of the state's population. If the plan proves economically competitive with oil-fired electric generation, a three-cable system using 30,000 tons of cable will be installed, providing 50 percent of Oahu's electricity before the turn of the century.

Pirelli's cable bested over 250 candidates for the program. Five inches in diameter, weighing about 25
pounds per foot, it can carry 250 MW of power. The cable's aluminum central conductor is insulated with oil-impregnated paper, covered with a reinforced lead alloy sheath, protected by a polyethylene jacket and covered by a double layer of flat galvanized steel armor.

Source: The Energy Daily 1/7/86

HAWAII DUE COMMERCIAL GEOTHERMAL PLANT

Thermal Power Co. and Hawaii Electric Light Co. have agreed to develop Hawaii's first commercial geothermal power plant. Thermal, a unit of Diamond Shamrock Corp., will operate the venture and drill five to seven wells at the Puu Honauula site in the Puna district of the island of Hawaii. Average well depth will be 7,000 ft. A third exploratory well has recently been completed, testing average steam production of 65,000 lb/hr.

The electricity sales contract for the venture, known as Puna Geothermal Venture (PGV), calls for development of 25 MWe of geothermal power by 1993 with half that being provided before 1993. Thermal has a 75 percent interest in PGV, after acquiring the 25 percent interest of Dillingham Geothermal Inc., and Amfac Energy Inc., holds the balance. Hawaii's State Public Utilities Commission approved purchase of electricity by Hawaii Electric under rules implementing state and federal laws passed to encourage development of alternative energy. More than 90 percent of Hawaii's electrical generation comes from oil produced outside the state.

"We are continuing negotiations with Hawaii Electric for an expanded contract which would provide an additional payment for generation capacity supplied by the geothermal plant," said Richard Pittenger, Thermal's vice president. "Instead of bearing the costs of building new generating facilities, the utility would pay us for supplying new capacity."

It is also reported that permitting is underway for geothermal exploration and development for a 100 MWe capacity installation in the Kilauea Middle East Rift Zone, about 15 miles from Kilauea center and 8 miles from the HGP-A plant at Puna. The developer is a joint venture of True Energy Co. and Mid-Pacific Geothermal.

Source: Oil & Gas Journal, 5/19/86, 9/15/86; Hot Line 12/85

HAWAII LEADS WAY TO USE OF GEOTHERMAL POWER PLANT DISCHARGES FOR DIRECT APPLICATIONS

Noting that considerable heat is wasted when geothermal fluid is used only for power generation, University of Hawaii staff said that with private companies developing power plants at Puna, there could be an abundance of geothermal fluids for direct heat applications. According to their paper presented to the International Symposium on Geothermal Energy in August 1985, the small (3MWe) wellhead power plant, currently operating at Puna, alone discharges nearly 18 million kilojoules, or about 17 million Btu, per hour, equivalent to almost a million dollars per year of oil. The temperature of the discharge is 187°C (368°F).

This temperature is sufficient to serve any direct use, including all industrial process uses listed in
the authoritative Direct Utilization of Geothermal Energy: A Technical Handbook, a 1979 joint publication of the Geothermal Resources Council and the Geo-Heat Center at the Oregon Institute of Technology, and the volume from even such a small plant would satisfy the needs of a broad range of direct industrial uses.

Since Hawaii spends over $1.3 billion per year on imported fuel, almost 10 percent of the Gross State Product leaves the state for imported oil. Thus, a major function of the Puna Geothermal Research Facility, described in GPM No. 9, is to promote industrial park or small business development to utilize potential electric power and heat available from the geothermal fluids.

In addition to providing space for what is hoped to be the finest of engineering facilities conducting research on renewable energy engineering problems, the facility will also be open to individuals and small businesses to develop geothermal energy applications. The Community Geothermal Technology Program will provide starter grants and, as necessary or requested, university faculty members working at the facility will be assigned to assist grantees in conducting research. Research under the grants of up to $10,000 may be performed off-site if it meets other program criteria.

The first grants of federal and private funds were announced in January 1986. Totaling $37,000, the grants will provide the opportunity to researchers to prove the commercial feasibility of five projects:

- glass-making using silica recovered from power plant wastes
- koa lumber drying
- cloth drying

IDAHO

GEOTHERMAL GREENHOUSES POPULAR AND PROFITABLE IN SOUTHERN IDAHO

Greenhouses in operation in southern Idaho grow a variety of products, ranging from bedding and potted plants, including poinsettias at Christmas and lilies at Easter, to tomatoes, lettuce, and exotic mushrooms. The operators of these facilities credit the use of geothermal energy for their success, with a consensus that using this resource in the greenhouse industry is both an economical and efficient way to heat.

In mid-1985, eight of these facilities encompassed 482,975 square feet of greenhouse space, ranging in size individually from 3,600 to 93,000 square feet. The smallest was doubling its size at the time, and others have since come on-line. Well temperatures of the eight range between 37°C (99°F) and 82°C (180°F).

One facility in the area grows pleurotis, an exotic mushroom, which has the appearance of elephant ears. Current production is about 125 pounds a day, and before a significant production increase is effected a gourmet market must be developed.

Source: Leah Street, Idaho Department of Water Resources
NEVADA

NEW NEVADA LEGISLATION CONTINUES PROCESS OF SEPARATING GEOTHERMAL RESOURCES FROM WATER RESOURCES

The most recent Nevada legislation related to geothermal energy, signed into law on June 3, 1985, specifically exempts from water appropriation statutes:

- any water removed from an aquifer or geothermal reservoir to develop and obtain geothermal resources if the water is returned to or reinjected in the same aquifer or reservoir; or
- the reasonable loss of water during a test of a geothermal well or because of the temporary failure of a system for reinjection.

Historically, regulation of geothermal resources was vested in the Office of the State Engineer who governed water resources and appropriation thereof. Earlier 1983 legislation created the Department of Minerals which was given authority to regulate geothermal resources. The new legislation reinforces this authority.

Source: Geothermals Resources Council Bulletin 7-8/85

ELKO COUNTY LEADER IN DIRECT USE APPLICATIONS

In addition to the privately-owned district heating system in the City of Elko, partially funded by DOE under its Project Opportunity Notice (PON) program, a variety of other applications of geothermal energy are in use in Elko County. The new sewage treatment plant of the City of Elko uses hot water in conjunction with methane, a byproduct of the treatment process, to heat and power the plant. A well drilled for heating the new Elko Junior High School only was so productive -- 88°C (190°F) and 300 gpm artesian flow rate -- that piping was installed to connect 12 additional school buildings, convention center, hospital, city offices, and the city swimming pool to the system. Hot water wells -- 31°C (87°F) -- and heat pumps are also employed to heat schools at Wells and Carlin.

Source: Geothermal Resources Council Bulletin 3/85, 4/85, 3/86

NEW MEXICO

STATE AUTHORIZES CITIES TO ACQUIRE GEOTHERMAL UTILITIES

The Governor of New Mexico has approved legislation that allows cities to acquire and operate geothermal utilities.

Source: Idaho National Engineering Laboratory Regional Geothermal Progress Monitor 3/85

NEW MEXICO STATE UNIVERSITY RESEARCH GREENHOUSE COMPLETED

Construction of a 12,000-square-foot research greenhouse facility at the New Mexico State University at Los Cruces was completed in May of 1986. A primary objective of this project was to attract commercial
greenhouse operations to southern New Mexico, an objective which was successfully achieved with the formation of two new companies to occupy the two 6,000-square-foot areas. Two months after the first section was completed, one company was growing roses commercially, and the other has an option on the second building and will probably grow chrysanthemums.

The well being used is one that was originally drilled to 982 feet with funding from DOE and other parties for use in the campus district heating system. Lost circulation problems were encountered at that depth, and it was not a productive well. The well was redrilled, and after only an additional 15 feet, production of 700 gpm at 63°C (146°F) was achieved. The flow from this well will also be used in the campus heating system starting in the fall of 1986.

Source: New Mexico State University 6/20/86

OREGON

OREGON Deregulates Geothermal District Heating

In response to investor-owned utility urging, the 1985 Oregon Legislative Assembly enacted House Bill 2202, which completely removes geothermal district heating from Public Utility Commission oversight. Under the terms of the new legislation, geothermal non-electric systems are clearly not defined as "public utilities" and, therefore, are excluded from PUC rules and regulations. The legislation also exempts non-electric uses of solar, wind, and biogas.

Source: GRC-Pacific Northwest Chapter Newsletter 7-8/85

NEW GEOTHERMAL ORDINANCE FOR KLAMATH FALLS

The City of Klamath Falls, Oregon, adopted a new ordinance in June 1985 requiring that the discharge of spent geothermal fluids into the city storm drain system be discontinued. Well owners are required to comply with this new ordinance within a five-year period. The need for this requirement became evident during extensive reservoir studies. It was found that water levels in the reservoir drop drastically during the winter when numerous individual well owners are producing geothermal fluids and dumping the water after a portion of the heat is removed. This move will bring the exploitation of the Klamath Falls geothermal reservoir into compliance with generally accepted reservoir operating policies.

Exceptions can be granted if specific criteria are met. The plan also calls for the establishment of a geothermal data center and requires permits to alter an existing well or drill a new well.

This plan replaces an ordinance adopted in July of 1981 that requires injection of waste geothermal fluids only for new geothermal wells.

Source: Geothermal Resources Council Bulletin 9/85

GEOTHERMAL WASTE WATER HEATING SYSTEM PROPOSED FOR KLAMATH FALLS, OREGON

The city of Klamath Falls has contracted with Balzhiser/Hubbard & Associates to design a recovery/reuse system for many wells discharging into open drainage in the Mills Addition. Nearly 100 geothermal wells discharge into open drainage in the Klamath area, and it is estimated
about 1,000 gpm will be available for space heating homes and commercial buildings in the Mills Addition area. The siting of an injection well is planned for final disposal of the reused water. This will assist well owners in complying with the new City Geothermal Resources Management Act which requires that all surface discharge be eliminated within 5 years.

Source: Geo-Heat Center, Oregon Institute of Technology

OREGON SUPREME COURT REFUSES TO HEAR NEWBERRY CALDERA CASE

When the Oregon Supreme Court denied a petition to review a lower court's decision upholding a ruling by the Oregon Land Use Board of Appeals against a petition to develop a patented claim by La Pine Pumice Co. in the interior of Newberry caldera, it apparently killed any hope of geothermal development anytime soon inside that promising feature. As reported by OREGON GEOLOGY in July, the 157-acre claim was in the midst of the developed recreational area. Also, the draft Deschutes National Forest Plan would ban geothermal development in the entire caldera. The area surrounding the caldera, however, has been unitized under a claim granted by the BLM to Geothermal Resources International, Inc., which has geothermal rights on about 170,000 acres in the 240,000-acre unitized area.

Source: Geothermal Report 9/1/86

WASHINGTON

WASHINGTON STATE ENACTED SIMPLIFIED UTILITY REGULATION OF GEOTHERMAL DISTRICT HEATING SYSTEMS IN LIEU OF COMPLETE DEREGULATION

Addressing the "State Programs
and Policies" session of the Fourth National District Heating and Cooling Conference in Washington, D.C. in January, 1986, Gordon Bloomquist, geothermal energy specialist of the Washington State Energy Office, said that the "best of both worlds" was achieved in a new state statute governing geothermal district heating systems. Unlike California and Oregon where such systems have been completely deregulated, Washington maintained a degree of consumer protection with the simplified regulations, but also made geothermal utilization more attractive to developers.

Full utility regulation would result in a return on investment inconsistent with the financial risk involved in confirming economically exploitable geothermal resources, Dr. Bloomquist noted, and full deregulation would leave open the possibility of consumer abuses from unregulated suppliers of essential services.

To avoid either consequence, the regulations provide for:

- a nonexclusive operating permit for qualified and financially responsible applicants within a designated service area
- an adequate system design to serve the purpose
- UTC approval of customer contracts specifying the period of service, rates or formula for determining rates, and adequacy of service
- rate approval based on the reasonableness of rates in relation to the rates for comparable heating services such as electricity, oil, and natural gas rather than on the cost of

YAKIMA COUNTY JAIL BACK ON GEOTHERMAL

In December 1985, the geothermal heat pump system for heating and cooling the Yakima County jail was put back in service. Originally installed in early 1984, the system developed serious corrosion problems, primarily due to oxygen entering the system from the cooling tower, storage tank, and production pump column. The system was shut down, and an electric boiler was used until an isolation heat exchanger was installed between the wells and heating system as recommended by the Geo-Heat Center of OIT. The heating bill for the last month the electric boiler was in use was $17,000.

Source: Geo-Heat Center, Oregon Institute of Technology
A geothermal power generating unit at Tiwi, the Philippines. The installation at Tiwi and the units at Makiling-Banahao provide about 20 percent of the power for this country. The UNOCAL Corp. provides the geothermal fluids.
CANADIAN GOVERNMENT ISSUED REPORT TO SPUR GEOTHERMAL DEVELOPMENT

In a document entitled "Regulatory and Commercial Aspects of Geothermal Energy Development," the Canadian government undertook to spur commercial development of the resource by outlining the potential available in that country. The greatest promise is in the near-surface, high-temperature fluids in British Columbia that may be an efficient source of power generation. Considerable evidence also indicates that exploitable lower temperature resources are available for district heating projects. O’Brien Energy Ltd. has acquired exploration rights to a tract of land near Squamish north of Vancouver, at the north end of the Cascades, and has committed $4.3 million to a 5-year development program.

The report also states that representative resource temperatures in the prairie provinces of Alberta, Saskatchewan, and Manitoba are between 50-125°C (122-302°F), suitable for direct heat applications, with higher temperatures attainable only in the deeper parts of the Western Canadian Sedimentary Basin. In the Yukon and Northwest Territories, the resource potential is greatest in the western regions, with both high- and low-grade resources available in the displaced western component of the Yukon Cordillera. An area west of Whitehorse is thought to have economically exploitable high-temperature resources.

The eastern part of Canada -- New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland -- has the potential for two types of low-temperature resources: gradient heat in deep sedimentary basins and hot dry rock resources in Paleozoic granite intrusions. Data are being gathered to determine whether geothermal applications are warranted.

Copies of the report are available from the National Research Council, Montreal Road, Ottawa, Ontario K1A OR6 Canada.

Source: Geothermal Report 8/1/85

U.K. INVESTING MORE MONEY IN HOT DRY ROCK R&D

The British government will invest a further $10.3 million in the development of geothermal energy from hot dry rocks. It has already spent some $30.1 million on work by the Cambourne School of Mines in developing a site in Rosemanowes in Cornwall. The technique involves "mining" the heat caused by radioactive decay in natural granite formations by sinking a doublet of wells and pumping cold water down one and drawing hot water up the other.

It is estimated that recoverable reserves of such heat in the United Kingdom are sufficient to provide 2,500 terawatt-hours of electricity -- the equivalent of about 10 years consumption. Research at Rosemanowes began in 1977, and currently there are three wells on the site. There is a doublet at 6,560 feet tapping an artificially created underground reservoir 5,000 feet deep and 3,280 feet wide. Hot water is produced at up to 90°C (194°F), but there have been difficulties sustaining flow rates.

The project leader says the Cornwall site would sustain a 50-megawatt installation producing power cheaply enough to allow payback of the development costs in six or fewer years. The government has been uncertain about its commitment to the project, and earlier this year there
were reports that American interests were considering buying up the technology and employing the team developing it.

Now, the government has announced additional money for a 2-year program, beginning in October, to examine the cost and technical requirements of scaling up to commercial development at 20,000 feet. The European Commission also has some $16.5 million tied up in the project.

Source: International Solar Energy Intelligence Report 6/24/86

GEOTHERMAL DEVELOPMENT CONTINUES IN SOVIET UNION

Exploration of the large Mutnovsky geothermal field in the far eastern Soviet Union's Kamchatkan Peninsula is underway, and 10 wells are being drilled before construction begins on a 200 MWe plant. The first 50 MWe section of the plant, originally slated for completion in 1985, will be commissioned during 1986-1990. More than 200 hot springs and outlets of hot streams have been discovered on Kamchatka. According to Soviet News & Views published in Ottawa, Canada; the Mutnovsky field is unique in that the temperature of its steam and water mixture is 270°C (518°F), and the pressure is 25 atmospheres (367 pounds per square inch).

An article in Soviet Weekly, printed in London, stated that several geothermal power stations may be built on Kamchatka with a total capacity up to 2,000 MWe. However, the European, or Western, territory of the USSR is estimated to contain about half of the total 150,000 MWe of hydrothermal resources claimed for the whole country. Three experimental hot dry rock installations are being built in Stavropol Territory, Dagestan, and Transcarpathia in European USSR.

Source: Geothermal Report 10/1/85; 6/1/85 Geothermal Resources Council Bulletin 1/85

LARGE GEOTHERMAL RESOURCE UNDER STUDY FOR FURTHER DEVELOPMENT OF NEW ZEALAND

The New Zealand Ministry of Energy is reviewing that country's considerable geothermal resources to determine if an effective management system can be established to balance the conflicting requirements of energy, tourism, science, and culture. The largest mid-term development underway is at the Broadlands field where the 50 MWe Ohaaki power station is under construction. Ohaaki No. 1 is to begin operating in 1988-89, and Ohaaki No. 2 -- also 50 MWe -- is expected to follow by about a year.

A longer term prospect is the Mokai field with its high enthalpy fluids and high temperatures, up to 320°C (608°F), the hottest yet found in New Zealand. Existing but unused wells there could be used to supply small power plants, and it is estimated that the Mokai field could also support a 100 MWe power station. The feasibility of small plants of 2 to 15 MWe using steam from Tauhara and Ngawha fields is also under study.

The Wairakei power station remains the largest user of geothermal energy with an estimated capacity of 157.2 MWe after four of the oldest units commissioned from 1958 to 1962 were dismantled due to insufficient steam. It may be found
technically and economically feasible to use the hot waste water at Wairakei -- up to 4000 tons per hour -- to operate binary plants.

Source: Geothermal Report 8/15/85

GEOTHERMAL TRAINING UNDERWAY IN CHINA

A new 24,000 square foot building is under construction at Tianjin University, People's Republic of China, according to Derek Freeston, University of Auckland New Zealand, to house a Geothermal Research and Training Center. The building will provide facilities for research into utilization of geothermal fluids and an information center for the collection and dissemination of published literature on geothermal energy, as well as providing accommodations and facilities for both short and long courses in China on geothermal technology. The first geothermal training course to be held in China in October 1985 was attended by 59 students from all parts of the country.

Source: Geothermal Resources Council Bulletin 1/86

TWO NEW GEOTHERMAL POWER PLANTS TO BE BUILT IN JAPAN

Despite widespread resistance from hot springs resort owners and innkeepers, Japan's geothermal electric development was bolstered by news of two new power plant projects. Idemitsu Kosan Co., oil refiner-distributor, wants to build a 25 MWe plant at Kokonoe-machi in Oita Prefecture where drilling has discovered steam of 200°C (392°F) and hot water of 140°C (284°F). Japan Petroleum Exploration Co. (Japex) has obtained enough 250°C (482°F) steam from wells outside a national park near Ibusuki, Kagoshima Prefecture, to operate up to a 30 MWe plant. Both companies are negotiating power sales to Kyushu Electric Power. This company already operates 12.5 MWe and 55 MWe geothermal plants in Oito Prefecture.

Source: Geothermal Report 3/15/85

GEOTHERMAL AND FLORICULTURE JOIN FORCES

In July 1985, Geothermal Energy N. Z. Ltd. (GENZL), Auckland, New Zealand, was awarded a contract to provide geothermal engineering services to a floriculture company, Greenhouse Park Limited, which is seeking a listing on the New Zealand Stock Exchange.

Greenhouse Park Ltd., an $8 million flower and orchid growing venture, will purchase two properties in the Bay of Plenty area and develop greenhouse and support facilities to ensure a planned growth of high quality orchids and other exotic flowers primarily for the export market. A hot water bore was drilled to a depth of 1,640 feet and tapped a field of good quality hot water with a flow of 5,812 gallons per hour at a temperature of 49°C (120°F).

Source: Geothermal Resources Council Bulletin 9/85

LANL WORKING IN CENTRAL AMERICA UNDER AID GRANT

The Los Alamos National Laboratory is working under a $10 million grant from the U.S. Agency for International Development to conduct
a survey of the geothermal resources of Costa Rica, El Salvador, Guatemala, Honduras, and Panama; and to provide technical support for resource development. The LANL team will also be working with technical organizations and training local scientists in Central America, and will be enlisting the support of universities and technical experts in the United States. This project is being carried out under the President's Caribbean Basin Initiative.

**MITSUBISHI OF JAPAN WON CONTRACT FROM GREECE FOR PORTABLE 2 MWe GEOTHERMAL GENERATOR**

Mitsubishi Heavy Industries and Mitsubishi Corp. won a contract for a 2 MWe portable turbine generator for the first pilot geothermal plant in Greece on the island of Milos. Greek national energy policy is to reduce current coal (lignite) fired power production, and is emphasizing geothermal development. Plans are to build a 60 MWe geothermal plant, transmitting part of the output from Milos to the mainland via undersea cable.

Source: Geothermal Report 3/15/85

**GENZL RECEIVED NEW DEVELOPMENT CONTRACTS IN BOTH INDONESIA AND KENYA**

Geothermal Energy New Zealand Ltd. (GENZL) won back-to-back contracts with Indonesia to engineer expansion of the Kamojang power plant from 30 MWe to 140 MWe, and with Kenya for development of the Ebburu Field. Both are World Bank-funded projects for $12 and $6 million, respectively. The Kenya contract was awarded just 6 weeks after New Zealand Prime Minister David Lange visited the project site during an African tour. GENZL faced strong competition from the U.S., Italy, and Iceland, a company spokesman noted. Due to the desire of Kenya to develop its indigenous resources and reduce its dependence on foreign oil, the training of Kenyans and the transfer of New Zealand technology is a key element in the GENZL contract.

Source: Geothermal Resources Council Bulletin 6/85; 7-8/85; 1/86

**GEOTHERMAL PROJECT IN THE AZORES**

The Financial Times of London reports that a plan is afoot in the heights of Serra de Agua de Pau in the center of Sao Miguel to harness geothermal resources to produce 25 percent of the island's electricity. Sao Miguel, at 288 square miles, is the largest island of the Azores and is located in the eastern part.

Negotiations, which are apparently in the final stages, would involve a joint venture of General Electric in the United States, with financial backing from General Electric of Portugal and a consortium of Portuguese banks and insurance companies, and the consulting firm of Stone and Webster.

At full operation, which is expected to occur in 3 years, the project would generate 10 MWe of electricity, which would be sold to Electricidade dos Azores (EDA), the Archipelago's electricity corporation. If the project is a success, it could be a spur for similar projects on the island of Terceira (153 square miles, lying in the central Azores).

Source: Geothermal Report 6/2/86
1985 INTERNATIONAL SYMPOSIUM
DREW REPRESENTATIVES FROM 35 COUNTRIES

More than 630 geothermal specialists representing 35 countries met at the Kona Surf Hotel in Kailua, Kona, Hawaii, for more than a week of speeches, technical presentations, special courses, tours to geothermal sites and social events in August 1985. This International Symposium, sponsored by the Geothermal Resources Council, was the first full spectrum international meeting to be convened in 10 years. The last time a group with this capability and representation met was in San Francisco in 1975.

Of special note were the keynote speeches by Geronimo Velasco, Minister of Energy, Philippines, and Dr. Carel Otte, of UNOCAL Geothermal. Mr. Velasco dwelled upon the phenomenal geothermal development in the Philippines, and concluded his remarks by inviting the Geothermal Resources Council to hold its next international meeting in the Philippines.

Dr. Otte made the point that there are no easy solutions to the world’s energy problems, but at present, the geothermal countries of the world have a special opportunity to make significant advances. Because of the present oil glut and the subsequent low oil prices, governments now have a unique opportunity to develop their indigenous energy sources. To do so would maximize their total efficiency, and provide for long-term energy and strategic security. Mr. Otte also feels that this special opportunity will only be a few years into the 1990s when oil prices will again begin to rise drastically.

The opening session was followed by two days of single sessions of invited papers (which included 22 speakers from more than 15 countries). These papers are included in an "International Volume" along with over 30 national updates from various countries that are active in geothermal development.

On Tuesday evening, a poster session was attended by approximately 300 to 400 registrants and their families and included over 85 poster presentations on many diverse subjects. On Wednesday there was a field trip to Kilauea crater, the 3 MWe power plant near Pahoa, and the nearby well field. Various stops along the planned route included volcano eruption areas, the Black Sands Beach, and state parks.

The final two days of the Symposium included the presentation of more than 100 technical papers delivered in quadruple sessions by scientists from throughout the world. Subjects discussed ranged from geology, geophysics, power plant systems, well testing, reservoir engineering, geopressured resources, and economics. All of these papers plus many more have been published in Parts I and II of the Transactions (Volume 9) of the Symposium.


Source: Geothermal Resources Council Bulletin 10/85

DOE HELD GEOTHERMAL PROGRAM REVIEW IV

In September 1985, about 90 members of the geothermal community gathered in Washington, D.C. for a
two-day review of the geothermal program of the U.S. Department of Energy, the fourth such annual review. A comprehensive overview of the research and development program of the Geothermal Technology Division was presented with papers on each of the program elements by representatives of the operations offices, the national laboratories, contractors, and headquarters personnel.

The annual program review meetings are an important element of the effort to develop, refine, and expand the technology base through which the nation's vast geothermal resources can be technically and economically utilized. These meetings provide a forum through which conference participants can obtain an up-to-date report on DOE's geothermal research and development programs, and where significant R&D thrusts can be explored. The annual Program Review Meeting also provides an invaluable opportunity for participants to compare and exchange information, thus facilitating the transfer of technology among DOE, state and local governments, and industry organizations.

The next program review was held April 14-16, 1987, at DOE headquarters in the Forrestal Building, Washington, D.C.

L.J. Patrick Muffler, the Survey's chief geothermal investigator, explained his Circular 790 U.S. geothermal assessment of 1978, suggesting igneous-related systems may be 100 times greater than all identified and undiscovered hydrothermal convection systems, and maybe 1,000 times greater than the energy in all hydrothermal convection systems identified up to now. "From this comparison it can be inferred that very large amounts of geothermal energy yet remain to be found," said Muffler.

Marianne Guffanti of the USGS Reston headquarters pointed out that in 1981 Muffler estimated that about half of the igneous-related geothermal energy for young systems in the western U.S. exists as magma and nearly that much as solidified intrusion and hot surrounding rock, "with only a few percent expressed by hydrothermal convection systems." Eleven Cascades systems totaling about 3900 x 10^18 joules represent about 8 percent of the igneous-related energy in the U.S. (not including energy of the very large Yellowstone-Island Park system, non-exploitable as a National Park).

Source: Geothermal Report 7/1/85

NEVADA BUREAU OF MINES AND GEOLOGY PUBLICATIONS AVAILABLE

The following publications may be obtained by writing to the Sales Office, Room 310, Scrugham Engineering-Mines Building, University of Nevada-Reno, NV 89557-0088:

Catalogue listing 1985 NBMG publications and all available NBMG publications on Nevada's geology and mineral resources. Free

USGS HELD WORKSHOP ON CASCADE RANGE RESOURCES

More than 100 earth scientists attended a U.S. Geological Survey workshop on the geothermal resources of the Cascade Range on May 22-23, 1985, at Menlo Park, California. The purpose was to discuss the Survey's multidisciplinary effort since the late 1970's to study and understand the total energy resource of "this young volcanic belt."
List of out-of-print publications. Free

The Nevada Mineral Industry 1984, Special Publication MI-1984. $3.00 plus 10% postage and handling.

Nevada Bureau of Mines and Geology Map 86, "Bouguer Gravity Map of Nevada -- McDermitt Sheet." Latest in a series of maps published at the 1:250,000 scale to provide statewide coverage of gravity data. Such data are now available for about 80 percent of the state. $5.00 plus postage and handling.

"Geology of Northern Nye County, Nevada," Bulletin 99A. Describes the stratigraphy, structural geology, glacial geology, and geomorphology of Northern Nye County. A 1:250,000-scale geologic map accompanies the text. $13.00 plus 10% postage and handling.

HEATPLAN SOFTWARE PROGRAM TO BE REVISED

The Washington State Energy Office (WSEO) has signed a joint venture contract with the Swedish Council for Building Research to revise the HEATPLAN software program. HEATPLAN, previously developed by WSEO, is designed to aid in the evaluation of the feasibility of district heating systems. This venture calls for revisions of the economic and geothermal resource modules. The IBM compatible program, to be completed by the end of June 1986, will be made available in TURBO PASCAL language. Gordon Bloomquist, geothermal specialist for WSEO, is serving as the project manager for the task that will be primarily performed in Sweden.

Source: Idaho National Engineering Laboratory Regional Geothermal Progress Monitor 11/85
1987-1989 MEETINGS, CONFERENCES, WORKSHOPS

JUNE 1987

RETSIE/IPEC '87, Anaheim, California, June 1-4.

International Meeting on Terrestrial Heat Flow and Structure of Lithosphere, Castle of Bechyne, Czechoslovakia, June 1-6.


AAPG Annual Meeting, Los Angeles, June 7-10.

Cogeneration Congress, Cherry Hill, NJ, June 1-19.


AUGUST 1987

Pacific Rim Congress 87, Gold Coast, Australia, Aug. 26-29.

SEPTEMBER 1987

Co-Energy '87, Hartford, CT, Sept. 2-3.

AAPG Rocky Mountain Section Meeting, Boise, Idaho, Sept. 13-16.


OCTOBER 1987

Geothermal Connection, Convention, Elko, Nevada, Oct. 8-10.


JANUARY 1988

FEBRUARY 1988

AAPG Southwest Section Meeting, El Paso, Texas, Feb. 21-23.

AUGUST 1988


OCTOBER-NOVEMBER 1988

Society of Exploration Geophysicists 58th Annual International Meeting, Anaheim, California, Oct. 30 - Nov. 3.

Geological Society of America Annual Meeting, Denver, Oct. 31 - Nov. 3.

APRIL 1989

AAPG Annual Meeting, Las Vegas, April 9-12.

JULY 1989


NOVEMBER 1989

Geological Society of America Annual Meeting, St. Louis, Nov. 9-12.
MAJOR SOURCES OF GEOTHERMAL INFORMATION

This section of GPM presents a representation sample of geothermal literature which has been reported since the last issue. Wider coverage of the literature may be found in a semimonthly bibliography of geothermal publications entitled "Geothermal Energy Technology, A Current Awareness Bulletin," published by DOE's Office of Scientific and Technical Information. This publication may be obtained from the National Technical Information Service, Springfield, VA 22161 as PB 86-914700. The annual subscription price is $45.00 (domestic) and $90.00 (outside the North American continent). This publication typically lists each separate paper, article, as report derived from another publication, such as conference proceedings, as a separate entry. Space does not permit separate listing in GPM; thus, the following:

Geothermal Resources Council Bulletin
Monthly Publication of GRC, P.O. Box 1350, Davis, California 95617-1350.


Stanford University Annual Workshop on Geothermal Reservoir Engineering, Stanford Geothermal Program, Dept. of Petroleum Engineering, Stanford, California 94305


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