DOE/CE-0303T

GEOTHERMAL PROGRESS MONITOR

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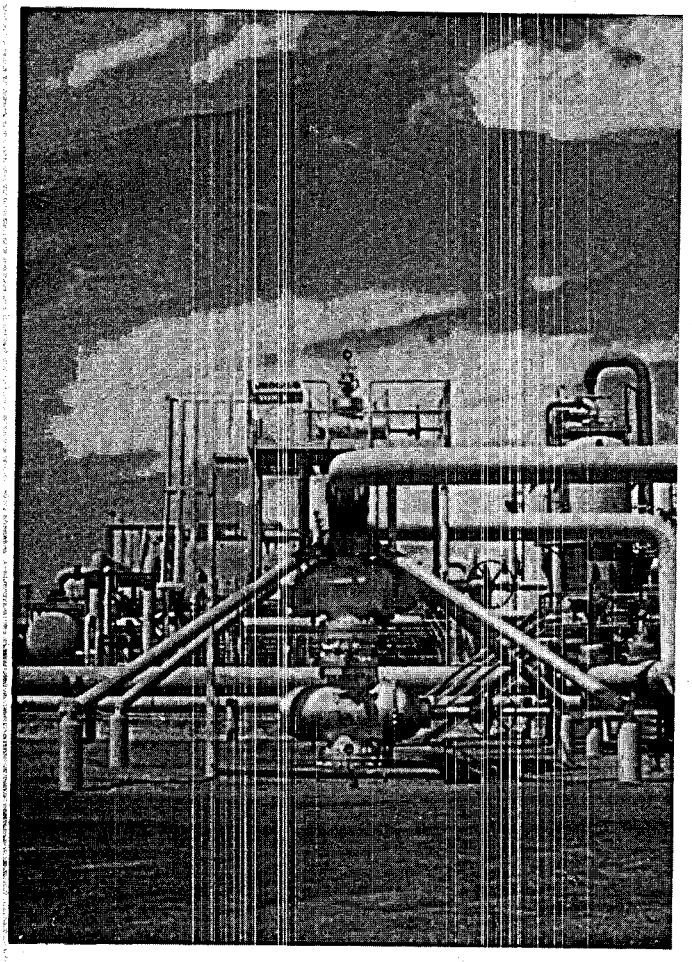

DECEMBER 1990

U.S. Department of Energy
Assistant Secretary for Conservation
and Renewable Energy
Geothermal Division

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GEOTHERMAL PROGRESS MONITOR

REPORT NO. 12

DECEMBER 1990

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

Prepared in Cooperation with the
Interagency Geothermal Coordinating Council
with the Assistance of
Meridian Corporation, Alexandria, Virginia

CONTENTS

COVER PHOTO: UNOCAL Vonerahe well at the Salton Sea Plant, the largest geothermal well in the world. (Photo by Bob Witkowski under contract to Unocal)

INTRODUCTION

Before preparation of this issue of the Geothermal Progress Monitor began, the reported power glut in U.S. areas of high geothermal promise, combined with low oil prices worldwide, suggested a possible pessimistic outlook for geothermal development. Instead, however, the available information points to very favorable circumstances for growth in the use of this resource, both at home and abroad.

A major development is the dissipation of the surplus of cheap electricity in the Pacific Northwest by rapid growth in the area. It is projected that power demand could nearly double by 2010, and both the Northwest Power Planning Council and Bonneville Power Administration expect that geothermal energy will supply part of that demand. This opens a market that did not exist until now for the vast reservoirs of hot geothermal fluids thought to occur in the Cascades Range.

In addition, it is reported that the California Energy Commission (CEC) has revised its energy demand forecasts over the next 20 years to show a much larger increase than previously expected for the state. Importantly, the bulk of the demand is expected to occur in areas of plentiful and high-quality geothermal resources, and where both utilities and independent power producers are already operating successful geothermal enterprises. The City of Los Angeles is preparing to develop its geothermal leases at Coso Hot Springs where 240 MWe of private power capacity is being produced, and is seeking to purchase an additional 800 MWe of capacity by the year 2000, in a market where geothermal energy is likely to compete successfully with other fuels.

A further impetus to geothermal use is suggested by the current climate for environmental improvement through reductions in fossil fuel combustion. Geothermal energy is described as "perhaps the most benign of all available power generation technologies." At both the local and national levels, regulatory officials are beginning to recognize that this geothermal characteristic can, for example, help to reduce smog in Southern California and reduce this nation's contribution to acid rain and the "greenhouse" phenomenon. It is noted that the CEC will balance environmental, energy security, and economic concerns and goals in determining how California utilities can meet future power demand. The state's indigenous geothermal resources readily meet all of these criteria.

Perhaps the most important environmental development reported is the successful compromise reached by competing interests in establishing the Newberry National Volcanic Monument to protect this highly scenic resource in central Oregon, while at the same time providing for orderly commercial geothermal development in adjacent areas. This effort provides a case study of reasoned resolution of energy/environment confrontation.

DEVELOPMENT STATUS reports on the proliferation of geothermal heat pumps as a means of reducing power demand. Many utilities, it is noted, are looking to this technology to eliminate or postpone construction of costly new power plants. Thus, geothermal energy is shown to be an important factor in both power supply and demand considerations.

The INTERNATIONAL section contains an announcement by the World Bank that developing countries plan to more than double their geothermal power capacities during the 1990s. Dr. Carel Otte, past president of Unocal's Geothermal Division, notes that in developing their own geothermal resources, oil-importing developing countries increase their security against volatile oil prices and supply interruptions, save foreign currency, and develop a greater self-reliance. Oil exporting countries, such as Indonesia, Otte added, are developing geothermal power to permit greater oil exports to help their balance of payments. Other articles in this issue detail the efforts of both the U.S. government and the U.S. geothermal industry to improve the industry's competitive posture in tapping the large international market.

Thus, GPM Issue No. 12 documents that the attributes of geothermal energy as a reliable, cost-effective, and environmentally sound energy source are being recognized by policy- and decision-makers worldwide as a replacement for more traditional fuels. This recognition was necessary to the optimum use of this resource and will contribute to its reaching its full potential as an energy alternative.

The GPM has been published by the Department of Energy since 1980 to synthesize information on all aspects of geothermal development to permit identification and quantification of trends in the use of this energy technology. 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 interested in the development pathway of the resource. In sum, the Department of Energy prepares the GPM for the many diverse interests that make up the geothermal community and for the multiple uses it may serve.

DOE ANNUAL PROGRAM REVIEW ADDRESSES THE ROLE OF GEOTHERMAL TECHNOLOGY DEVELOPMENT IN THE NATIONAL ENERGY STRATEGY

Taking as its theme "The National Energy Strategy -- The Role of Geothermal Technology Development," the geothermal community convened for DOE Program Review VIII in San Francisco, April 18-20, 1990. John E. Mock, Director of DOE's Geothermal Division, pointed out that President Bush, early in his administration, had directed Energy Secretary James D. Watkins to develop such a strategy.

"We cannot wait for the next energy crisis to force us to respond," the President said. "Our task -- our bipartisan task -- is to build the national consensus necessary to support this strategy and to make it a living and dynamic document, responsive to new knowledge and new ideas, and to global, environmental, and international changes." Thus, Mock said, "the NES is to be a dynamic strategy to provide the U.S. with adequate supplies of clean, competitively priced energy."

He pointed out that the recent NES Interim Report found that renewable energy resources (geothermal, hydroelectric, solar, biomass, and wind) are currently providing about 9 percent of the nation's domestic energy supply and about 12 percent of all domestic electric power. Broad support for renewables was expressed by many witnesses at the NES fact-finding hearings held by Secretary Watkins over the country on the basis of:

- their large potential and capability to provide a significant and reliable energy supply
- their assistance in reducing risks and vulnerabilities associated with imported oil
- their environmental benefit.

Mock noted that geothermal energy accounts for nearly 40 percent of the total U.S. resource base, but only 4 percent of the total reserve, making it only the third largest reserve. "Our job for the present, as I see it, and our legacy for the future," he concluded, "is to increase the geothermal portion of the nation's energy reserves. I want to see the gap between geothermal and coal and biomass (the two largest reserves) dwindle each year that we devote to geothermal technology enhancement."

Mock then announced that Secretary Watkins had already selected renewable energy as a "mature" energy option, and put it on a "fast track" by forwarding this option for early consideration by the Presidents's Economic Policy Council. Options pertaining to other energy sources remained under review by DOE and other agencies participating in the NES process.

"Renewable energy in general -- and geothermal energy in particular -- are beginning to gain increased visibility and acceptance at the National level," Mock concluded. "It is the challenge to us in the research community to use this opportunity to demonstrate clearly to decision-makers, as well as society as a whole, that geothermal energy can help satisfy the Nation's energy needs in an environmentally acceptable manner."

The Program Review was attended by 110 members of the geothermal community from federal, state, and local government, industry, academia, and the national laboratories.

(NOTE: At press time, DOE was on schedule for the completion of the NES. The remaining analytical work was to be completed and a set of policy options presented to the President in December.)

DOE SUPPORTS REMOVAL OF SIZE LIMITATIONS UNDER PURPA

Testifying before the Senate Committee on Energy and Natural Resources on May 15, 1990, J. Michael Davis, DOE Assistant Secretary for Conservation and Renewable Energy, called for the removal of size limitations on all renewable energy facilities under the Public Utility Regulatory Policies Act of 1978 (PURPA). The Act created a market for small power production facilities by requiring utilities to purchase their output and providing other incentives. The size limitations, first 30 MWe and now 80 MWe, were imposed on PURPA treatment in the belief that renewable technologies would not exceed these limits. Today, however, renewable technology, including geothermal, has advanced substantially, and the 80 MWe cap on facility size in some cases does not allow facilities to be built large enough to maximize the economies of scale.

The legislation under consideration, S.2415, the Solar and Geothermal Power Production Incentives Act of 1990, called for removal of the cap on only two technologies. Davis said, however, that DOE supports elimination of the cap across the board for all energy sources covered by PURPA. "As part of the National Energy Strategy development process," he added, "we are examining the option of opening up competition for all energy technologies, rather than providing incentives for selected technologies. Our guiding principles are to pursue policies which promise efficient and reliable power supplies." A similar House bill which would remove the cap on geothermal, solar, and wind facilities (H.R. 4808) passed the House in June where it encountered little opposition. The author of the Senate bill, Pete Domenici of New Mexico, is reported to be ready to offer his legislation as an amendment to a pending global warming bill when it reaches the Senate floor. Geothermal spokesmen at both the NES hearings and the House committee hearing urged removal of the limitation.

(NOTE: At press time, the "Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990" was signed into law removing the 80 MWe cap for application of PURPA.)

DOE CONSERVATION AND RENEWABLE ENERGY OFFICE ORGANIZES RESEARCH COMPONENTS BY END USE

To more effectively address an emerging National Energy Strategy with increased emphasis on energy efficiency and renewable energy technologies, Assistant Secretary for Conservation and Renewable Energy, J. Michael Davis, has reorganized his office into five components.

"The aim is to make our organization more user-friendly," Davis said. The four end-use sectors to be served by research components after the restructuring are utilities, industry, transportation, and buildings. There will also be a cross cutting component to develop more effective strategies for coordinating the sectoral programs with the needs of the end-users, as well as identify and consider technical, economic, and environmental factors in planning research.

The new organization was developed following a 7-week study of the Conservation and Renewable (CE) structure by a specially formed task force. The group determined that CE could better accomplish its mission through end-use oriented offices.

Deputy Assistant Secretaries (DASs) and Associate Deputy Assistant Secretaries (ADASs) have been established for each of the five new components, which are: Utility Technologies, Industrial Technologies, Building Technologies, Transportation Technologies, and Technical and Financial Assistance.

DOE SUPPORTING RESEARCH ON PROBLEMS AT THE GEYSERS

With nearly 2000 MWe of power generation capacity constructed, the geothermal complex at The Geysers dry steam field in California is the largest in the world. The field has been producing continuously since 1960 and has served an ever-increasing demand since that time. Recently, however, serious problems have developed for which investigations will be required to identify the causes and develop remedial technologies.

Briefly, the problems include a decline in productivity, appearance of corrosive chlorides, increases in noncondensible gases, and the adverse effects of pressure decline on turbine efficiency. More details on the problems reported and DOE's preliminary steps to organize a research strategy may be found in GPM #11, December 1989.

While operations at The Geysers are, and always have been, an industry pursuit, industry has requested government assistance in research aimed at restoring the productivity of the field. The Department of Energy is pleased to assist because The Geysers complex offers an opportunity to devise new technological approaches to managing mature geothermal fields, the first such opportunity in the U.S.. In addition, the original success of The Geysers, and now its decline, have attracted worldwide attention. Restoration of productive operations at The Geysers will raise industry confidence in the longevity and productivity at all proven and yet-to-be-proven geothermal fields.

An effective program of remedial research at The Geysers is critically dependent on two factors. One is industry's willingness to share existing data pertaining to the characteristics of the field. The second is industry cost-sharing. Funding available from DOE (over $1 million in FY 1990) is not, by itself, sufficient to solve the problems.

Despite the fact that The Geysers may have been the subject of more study than any other geothermal reservoir, several parameters remain poorly understood. These include:

- the initial distribution and amount of liquid water
- reservoir thickness
- matrix permeability
- characteristics of the fracture network.

In order to fill these information gaps, to address the other problems plaguing operations at The Geysers, and to determine whether water injection is the optimum "cure" for The Geysers, the Division funded 11 research projects for FY 1990. The geochemical research projects are as follows:

- A thermodynamic investigation of hydrogen chloride in steam by the Oak Ridge National Laboratory.
- Development of new vapor phase tracers by the University of Utah Research Institute (UURI) that can be used to quantify the mass recovery of injected fluids.
- A study of steam chemistry by the U.S. Geological Survey (USGS) with the cooperation of operating companies and the International Institute for Geothermal Research.
- Fabrication of a six-liter downhole fluid and gas sampler by Lawrence Berkeley Laboratory (LBL) based on a smaller version used successfully in the Imperial Valley and in a Continental Scientific Drilling Project well in the Valles Caldera, New Mexico.

The geophysical research projects include:

- Microearthquakes studies at The Geysers by LBL in conjunction with the Coldwater Creek Operator Corporation

using the 16-station CCOC array presently in place in the northwest portion of the field.

- Continuation of the ongoing Lawrence Livermore National Laboratory seismic attenuation study to locate steam.

The reservoir engineering projects include:

- Investigation of the phenomenon of water adsorption in porous rocks at Stanford University through lab experiments with Geysers core material. In parallel, engineering methods for using adsorption to plan development and forecast results will be explored.

- Examination by Stanford of all the tritium survey data collected by several operating companies in light of physical information on the wells (such as feed point depth) as well as subsequent performance (e.g., temperature and pressure).

The reservoir modeling projects include:

- Development by LBL of a data base for The Geysers, incorporating all available geological, geochemical, and reservoir engineering data, to be subjected to theoretical and applied studies to quantify the impact of increased injection.

- Documentation by LBL of several of the MULKOM fluid property modules so that the simulation capabilities of the code can be made available to the public.

The only geological research project funded so far involves fluid inclusion studies by UURI on Geysers core samples where the age relationships among the secondary minerals can be defined. Results of this initial work will provide the necessary background for interpreting similar data to be obtained from cuttings.

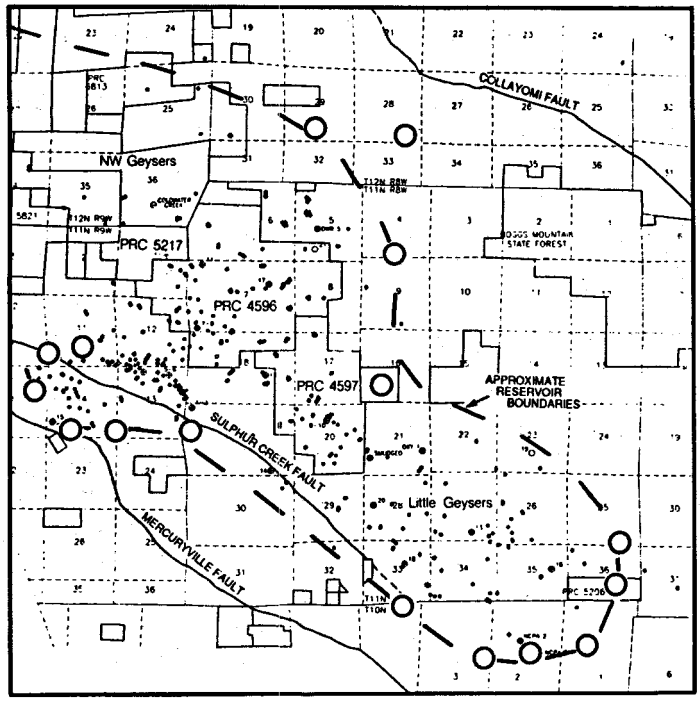
Some of these projects are continuing into 1991. Selection of new research areas was in progress at GPM press time. (See related articles in DEVELOPMENT STATUS.)

LONG-TERM FLOW TEST OF HOT DRY ROCK SYSTEM TO BEGIN IN FISCAL YEAR 1992

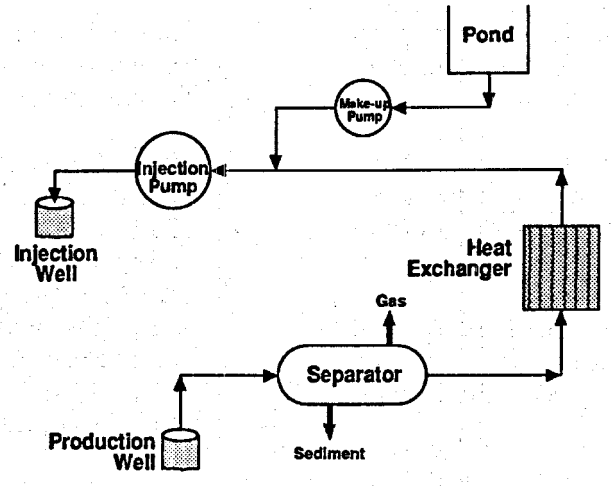
A long-term flow test of the hot dry rock reservoir at Fenton Hill, New Mexico, is set to begin in Fiscal Year 1992 (October 1, 1991 to September 30, 1992). The man-made reservoir to be tested is centered at a depth of approximately 12,000 feet in rock at a temperature of 240°C (464°F). Work is now underway to design and construct the surface portion of the circulation loop for the LTFT. Safety, reliability, and flexibility of operation are all important considerations in the design of the surface loop. The design presents unique challenges in the areas of materials of construction, fluid handling and treatment, and equipment specification. Safety and equipment reliability in particular must be considered in light of the extremely cold winter weather encountered at Fenton Hill. The hot geothermal fluid from the production well will be passed through a separator to remove sediment and noncondensible gases, and fed to a heat exchanger where the temperature will be reduced to about 35°C (95°F) or less. The excess heat will be discharged to the atmosphere. The cooled fluid then will flow to the injection pumps for repressurization and return to the reservoir. A makeup water line incorporated in the surface loop will replace fluid that is lost during circulation.

The surface loop is being designed to provide injection pressures of up to 4,500 psi, using two diesel-driven, five-cylinder, reciprocating pumps. The production side of the loop will be capable of running at 1,000 psi pressure to allow for high back pressure operations.

The LTFT will be used to evaluate reservoir lifetime, flow impedance, water loss rates, production fluid temperatures, and energy production on an extended basis.



An ongoing joint California State Lands Commission/DOE project to evaluate the resource at The Geysers is being accelerated as part of the effort to restore the field's productivity. This project includes development of a comprehensive data base, a geological model, and a numerical model and continuing analysis of the reservoir engineering data. The open circles on this map prepared by Lawrence Berkeley Laboratory indicate locations of dry wells close to the assumed Geysers reservoir boundaries.



Schematic of the Surface Loop for the Long-Term Flow Test of the Phase II Hot Dry Rock Reservoir

Long-term operational and maintenance conditions will be established, environmental effects will be thoroughly assessed, and predictive models will be tested, adjusted, and confirmed. Reactive tracers will be used to predict the ultimate useful lifetime of the reservoir on the basis of one year's collection of data.

Upon completion of the LTFT, most of the data needed to validate the commercial viability of HDR should be in hand. Analysis and understanding of this information will provide industry with the basis for future decisions regarding the exploitation of HDR resources at other locations throughout the world. (See related article in DEVELOPMENT STATUS.)

DOE STATE COOPERATIVE GRANTS PRODUCING NEW RESOURCE INFORMATION

DOE's State Coupled Grants project consists of 12 cost-shared grants to various groups to study aspects of geothermal energy that are not now being pursued by private industry, but which have the potential for results that will be applicable to industry. With the majority of the grant projects scheduled for completion by December 1990, interim and final results so far indicate that they have been productive in developing new resource information. The grants and focus of studies are as follows:

- University of Alaska, Geophysical Institute -- geological and geochemical study of the Geyser Bight geothermal resource, Umiak Island.
- State of Alaska, Division of Geological and Geophysical Surveys -- fluid chemistry study in support of the Geyser Bight geologic study.
- State of Hawaii, Department of Business and Economic Development -- study of methods to control silica deposition from geothermal fluids.
- State of Idaho, Department of Water Resources -- geochemical study of the Wood River geothermal system and monitoring of the Banbury - Twin Falls reservoirs.
- Desert Research Institute, University of Nevada -- 13 month hydrologic monitoring program at the Moana geothermal system to provide data for a quantitative evaluation and numerical model of the Moana resource.
- University of Nevada Las Vegas, Division of Earth Sciences -- study of the genesis of the geothermal fluids of the Great Basin.
- New Mexico Research and Development Institute/New Mexico State University -- evaluation of the use of time integrated radon soil-gas surveys for geothermal resource assessment in the southern Rio Grande Rift.
- State of North Dakota, Mining and Mineral Research Institute in cooperation with the Geological Surveys of North and South Dakota -- comprehensive geothermal resource assessment.
- State of Utah, Geological and Mineral Survey -- multidisciplinary study of the Newcastle resource.
- State of Washington, Department of Natural Resources -- drilling of eight 500-foot temperature gradient holes to better define the southern Washington Cascade Range heat flow data. A related study integrated K-Ar age dates, geochemistry, and volcanic stratigraphy of the Indian Heaven Quartenary volcano to evaluate volcanic production rates.

- State of Washington, State Energy Office -- computer program (GEODIM) which optimizes the design of wells, pipes, pumps, and heat transfer systems.

- University of Wyoming, Department of Geology and Geophysics -- an improved 3-dimensional computational scheme for solving the combined heat conduction and forced convection equations for determining subsurface temperature.

Information and reports pertaining to these projects can be obtained from Dr. Howard Ross at the University of Utah Research Institute.

OTHER DOE GEOTHERMAL GRANT PROGRAMS PROMOTE LOWER TEMPERATURE TECHNOLOGIES AND OVERSEAS SALES OF U.S. GEOTHERMAL TECHNOLOGY

One grantee, the Geo-Heat Center of the Oregon Institute of Technology (OIT), performs research and development assistance in geothermal direct use applications and moderate-temperature wellhead power generation systems. Direct use development assistance ranges from answering technical questions and consultations on methods, equipment, and applications to providing technical and engineering economic feasibility studies. Applications areas include space and district heating, geothermal heat pumps, greenhousing, aquaculture, and industrial processing.

Recipients of technical assistance include individual home and business owners, district heating systems operators and maintenance personnel, and consulting engineers. Work consists of consultation during initial design phases of projects, trouble shooting and failure analysis, and recommendations for correcting problems.

The Geo-Heat Center also provides information services including: a quarterly Bulletin (2,000 subscribers), special technical papers and presentations, Geothermal Direct Use Engineering and Design Guidebook, published feasibility studies, a geothermal library, computer programs to aid in engineering design, and tours of geothermal facilities. Anyone interested in the technical assistance or information pertaining to this work should contact Paul Lineau, OIT, Klamath Falls, OR 97601.

Another grant, to the National Geothermal Association, is for the promotion of U.S. geothermal technology worldwide. A number of the projects pursued under the NGA grant have had significant cost share from state governments and industry. To date, the grant has resulted in a number of accomplishments. Among them are: (1) conferences between foreign geothermal developers and U.S. power plant companies to allow foreign developers to see first hand the services which exist in the U.S.; (2) a briefing to the World Bank on geothermal energy; (3) a report titled "A National Strategy for the Export of U.S. Geothermal Technology"; and (4) support of a team of U.S. geothermal developers to visit the Magati Soda Company located in Kenya and to Central America to assess the U.S. geothermal industries opportunities.

Activities currently underway include the development of a worldwide power plant data base and a Geysers Monograph.

The work done under this grant has been most productive in helping U.S. geothermal industries assess their opportunities worldwide. Reports for each project can be obtained from David N. Anderson, National Geothermal Association, P.O. Box 1350, Davis, CA 95617-1350.

SIGNIFICANT MILESTONES REACHED IN PREDICTION OF BEHAVIOR OF INJECTED FLUIDS

Injection of spent fluids from geothermal power plants is usually necessary to avoid

surface discharge of large quantities of fluids, to recharge the reservoir, and to prevent ground subsidence. Effective injection strategies will become even more critical as production declines become more commonplace in mature fields, requiring management of the resource through injection.

Improper injection practices can, however, lead to premature thermal breakthrough in the producing zone, which results in cooling fluid temperature below power plant design limits -- an economic disaster. Thus, injection research centers to a large extent on prediction of the behavior of injected fluid through the use of tracers to monitor the migration of the injectate.

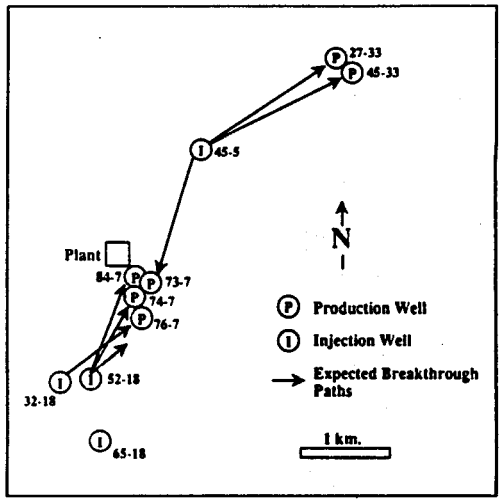
The usefulness of this approach has been confirmed by a successful cooperative test by government researchers and industry. A multi-well, multi-tracer test was conducted at the Oxbow Geothermal Plant in Dixie Valley, Nevada, by personnel of that company and UURI.

A numerical reservoir model was employed to estimate needed tracer quantities and sampling frequencies as well as to predict test results. Three injection wells were tagged with organic tracers -- benzoic acid, benzenesulfonic acid, 4-ethylbenzenesulfonic acid, and fluorescein -- previously tested for this purpose by UURI.

Six production wells were intensively sampled for 2.5 months. During this period, one well showed breakthrough, and the presence of benzoic acid and fluorescein identified the injection well of origin. Concentration ratios of these compounds varied during the test period, as predicted from laboratory experiments. These ratios predicted temperatures consistent with the observed temperatures in the reservoir. Thus, the velocity, direction and effective temperature of the dominant injection - production flowpath in the reservoir were defined.

This performance is considered a major milestone in injection technology development. Technical details of the test and final data analysis are found in Vol. 13, Geothermal Resources Council Transactions, October 1989.

Other areas of the DOE brine injection technology project are fluid-rock chemical interactions and injection well placement. The Idaho National Engineering Laboratory (INEL) and Stanford University are applying computer modeling techniques to the tracer return field data for the determination of physical, reservoir properties, and fluid interactions. LBL and UURI are performing theoretical studies of geophysical techniques to determine the effectiveness of existing equipment in detection of theoretically determined signals generated by injected fluids; new equipment will be designed as indicated. INEL is continuing to develop computer models with the capability to analyze and predict the flow of injected fluids and is investigating the potential for coupling the fluid flow computer model with models of chemical interactions between rocks and the injected fluid. As noted elsewhere in this section, UURI is studying potential tracer materials suitable for use in the steam field at The Geysers.



Bottom-Hole Well Locations and Expected Break-through Paths for Injected Tracers at Dixie Valley Geothermal Plant

GEOPRESSURED POWER GENERATION EXPERIMENT YIELDS GOOD RESULTS

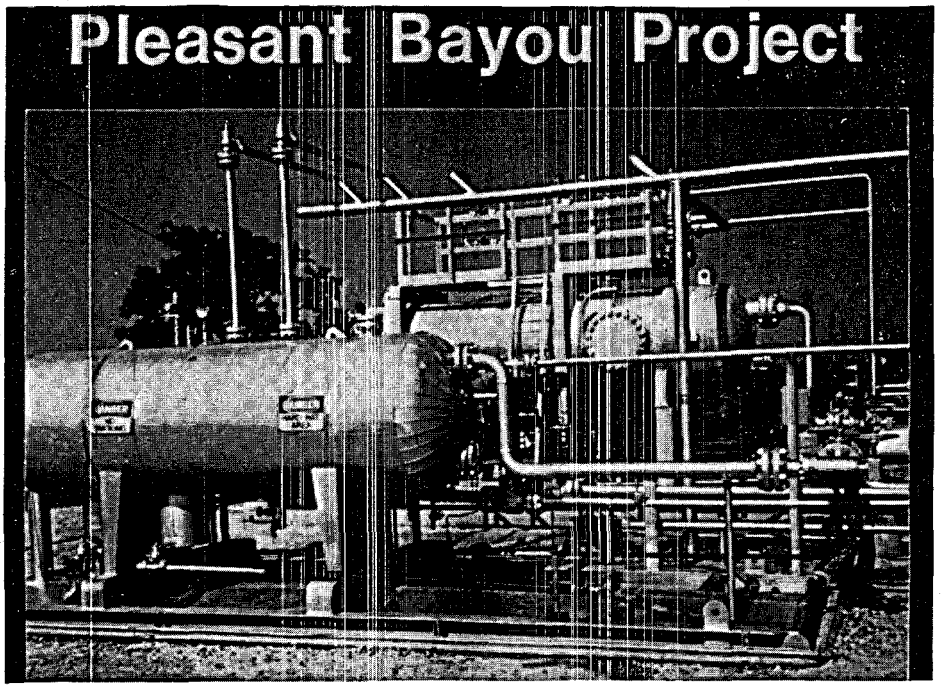
A successful 8-month test was completed with a 1 MWe experimental hybrid binary unit operated on geopressured brine at the Pleasant Bayou Well site near Houston from September 1989 to the end of May 1990. The experiment was co-sponsored by DOE and the Electric Power Research Institute.

In the system used, gas separated from the brine was burned in gas engines to produce electricity directly; exhaust heat from the engines supplemented heat from the brine to generate additional electricity in a heat exchanger using isobutane as the operating fluid. The high temperature of the gas exhaust improved the efficiency of the hybrid cycle by about 15 percent over what the two fuels used separately could provide. Hydraulic energy from the over-pressured brines was not harnessed by this system.

The two gas engines operated for more than 4,500 hours each with only routine maintenance, and gas utilization remained constant at the design value. A total of 3,445 MWh electricity were exported to the local utility. Plant availability was 97.5 percent of the time, and the capacity factor was over 80 percent for an extended run at maximum power production.

While a leaking seal in the binary turbine-generator was repaired, the system was successfully operated by using the gas engine alone with the binary working fluid circulating through the system, bypassing the turbine. The measures applied to minimize corrosion and scaling in the operation were successful, and, upon decommissioning, the interiors of the heat exchangers showed no evidence of scale. The valves and combustion chambers were also very clean, and the lube oil had not been contaminated.

Flow tests of the Pleasant Bayou well are continuing to generate reservoir drawdown data to assist researchers in developing a predictive reservoir model.



INDUSTRY AND CEC INTERESTED IN OBTAINING INFORMATION FROM DOE MAGMA EXPLORATORY WELL

A well was spudded by the DOE geothermal program in August 1989 to test a basic tenet of the magma energy concept -- that large bodies of partially-molten magma residing at relatively shallow depths could provide a very large source of energy. The well is located just south of the resurgent dome in the Long Valley caldera in California, a site selected over 21 other candidates.

In the first phase of drilling, the well was completed to over 2,500 feet. At this juncture, DOE policy on renewable energy was shifted to increase emphasis on projects of immediate interest to industry as evidenced by industry cost sharing and participation. Magma research, and the Long Valley well in particular, were suspended.

However, DOE is funding further work on the well to provide industry and the scientific community with hydrothermal information on the "enigmatic" Long Valley area. In addition, the California Energy Commission has allocated support funding for additional drilling at the site. Its expressed interest is the potential of magma as an energy source within the state for use in the 21st Century and beyond. Plans call for deepening the Long Valley well to 7,500 feet in 1991 with a period provided for scientific research.

Even though the Phase I drilling did not achieve the original target depth of the well, the core samples from the well represented the first from a central caldera location and included significant intervals of post-caldera intrusives. Thus, even at this early stage the hole has added significant insight to understanding the structure and history of the Long Valley caldera.

GEOTHERMAL DIVISION COSPONSORS GEOTHERMAL EDUCATION OFFICE

As part of DOE's policy initiative on science and mathematics education, the Geothermal Division is co-sponsoring a newly established Geothermal Education Office in conjunction with industry and the Geothermal Resources Council. The major goal of the Office is to introduce geothermal and other renewable energy resources to students at the K-12 level in a proactive way. For instance, the Office will provide teachers and students with current scientific evidence regarding geothermal characteristics, availability, cost to produce, renewal processes, and environmental impact. A Curriculum Advisory Committee, consisting of representatives from industry, government, and academia, provides program oversight to ensure that the Office's overall mission is consistent with established objectives.

The Education Office is located at 664 Hilary Drive, Triburon, California 94920, and can be reached on 1-(800) 866-4GEO. It is operated by Mary Condy and Marilyn Nemzer.

CALIFORNIA ENERGY COMPANY PLANS FOR GEOTHERMAL ENERGY DEVELOPMENT IN THE PACIFIC NORTHWEST

Speaking to the DOE Program Review VIII, Michael Heyes, President and Chief Operating Officer of the California Energy Co., announced his company's intention to have a total of 600 MWe of geothermal power on line by 1994. This would add 360 MWe to the 240 MWe the company is operating at Coso, "and we see the Pacific Northwest as a likely source for a good part of it," he added. "In fact," he said, "geothermal is probably the only alternative source (of energy) available in the Pacific Northwest that combines favorable economics with a readily available, ample domestic supply, and that is environmentally benign besides."

"So what's to stop us?" he asked. "In a word, information. To put it more precisely, it is the lack of information that often stymies us. To overcome it, we will need your help. For all the successes we've had at Coso, the project of ours that has received the most public attention aside from the financial press is our project in the Winema National Forest, near the boundary of Crater Lake National Park."

"This project," he continued, "which would unobtrusively tap geothermal resources several miles away from Crater Lake, has been under fire by a small but vocal portion of the very people we would expect to be the most vocal proponents of geothermal power. We think their quibbling is born of fear, the postscript to a lack of information, a lack of awareness of the interrelationship of the various parts of society."

"(Other) voices are beginning to be heard, however. The Northwest Power Planning Council, which recognizes a need for new power sources, calls geothermal power 'possible, practical, and desirable for the region's energy future.' The Council recognizes the technical achievements of the geothermal industry; the extent of the resource throughout the Northwest; and the social and environmental merits of this clean, renewable energy. (A council) report notes that safe, reliable operating histories in diverse settings testify to geothermal's 'good fit' with utility operations and 'good neighbor' reputation."

The full text of Mr. Heyes' remarks is available in the Proceedings of Program Review VIII which may be obtained from:

Geothermal Division
U.S. Department of Energy
CE342 Room 5H065
1000 Independence Avenue, S.W.
Washington, D.C. 20585

(A related story on Forest Service outreach efforts in Oregon is found in LEASING AND DRILLING.)

MAGMA'S 4 NILAND PLANTS CONQUER BRINES OF LIQUID-DOMINATED KGRA

Hot brines of the Niland geothermal field in California's Imperial Valley contain more than 300,000 ppm of total dissolved solids, but as its four major electric generating stations in the desert near the Salton Sea demonstrate, Magma Power Company, San Diego, has conquered them with its "Crystallizer Reactor Clarifier (CRC) Process," parts of which are patented.

The plants are: **Vulcan** (nameplate 34 MW, contract capacity 29.5 MW, commercial operation since Feb. 1986, "triple-flash process" produces steam to drive twin turbine-generators); **Del Ranch**, adjacent to

Vulcan, (nameplate 38 MW, contract 34 MW, commercial Jan. 1, '89, "triple-flash process" steam drives dual entry turbine-generator); **Elmore**, 1.2 miles northeast of Vulcan, (a look-alike of Del Ranch, also commercial since Jan. 1, '89), and **Leathers**, 2.5 miles east of Elmore (a second Del Ranch look-alike, commercial since Jan. 1, '90.)

"The processes utilized by the four plants are very similar," Magma reports in its Form 10-K for the year ended Dec. 31, 1989. "Geothermal brine entering the plants passes through a high pressure separator where noncondensible gases are separated from the brine/steam mixture. The remaining brine/steam mixture then enters the plant where additional 'flashing' occurs in two stages. The first occurs in a high-pressure crystallizer. Brine that remains in a liquid state after this flash then passes to a low-pressure crystallizer where an additional flash occurs as the brine is reduced to atmospheric pressure.

"The geothermal brine used in the plant contains a relatively high concentration of silica and other dissolved solids that become suspended in solution when the brine flashes. Suspended solids, if not agglomerated, cause scaling and mineral buildup on equipment and pipes. After the third flash, the brine (along with the silica particles) flows into reactor-clarifiers, where the precipitated solids are removed. These then are converted to a silica sand cake and are either disposed of at a disposal site or used for beneficial purposes. The brine is then returned to the reservoir through injection wells."

While the processes used by Del Ranch, Elmore and Leathers are alike and similar to those at Vulcan, they incorporate some advances over Vulcan. For example, the report explains, they use a more efficient, single turbine-generator system with dual steam inlets, in contrast to Vulcan's dual turbine (high and low pressure turbines) system.

Magma said that it does not expect much future revenue from patents on elements of the CRC process for the simple reason that there are few other KGRAs with brines so ornery that they will be needed. It expects them to be most useful to Magma, itself, in further development of its geothermal holdings in the Imperial Valley. Magma reported in its 1989 Annual Report that it is seeking to recover brine by-products: "Currently, laboratory test operations are focusing on recovery of zinc, lead, copper, and silver."

Magma operates the four Niland plants through subsidiaries and limited partnerships. Mission Energy Company, Irvine, a subsidiary of SCECorp, which also owns the SCE Company, has bought a 50 percent equity through its subsidiaries in each of the limited partnerships which own Vulcan, Del Ranch, Elmore, and Leathers, and it has acquired a 50 percent interest in GRI's East Mesa operation, which has now been expanded beyond the McCabe Plant.

Source: Geothermal Report 5/15/90

FACILITATING RENEWABLE ENERGY EXPORTS

As directed by DOE Deputy Secretary Henson Moore at the CORECT Annual Meeting in January, John Wisniewski of the Export/Import Bank is leading an effort to make one-stop financial application assistance available to the U.S. renewable energy businesses. Working with the U.S. Trade and Development Program, the U.S. Agency for International Development, the Overseas Private Investment Corporation, and US/ECRE, Mr. Wisniewski has developed a universal application form that will allow U.S. renewable energy companies to submit a simultaneous application for financial assistance to all four agencies. While each agency has programs that are directed at a different aspect of export

activity, the one-stop application approach will provide concise information on each agency's programs. This arrangement will make it possible for U.S. renewable energy companies to quickly receive consideration for all available assistance, an example of how CORECT can help U.S. agencies form a united front for export activity.

Source: CORECT News

TGC TO MARKET POWER TO PUDGET SOUND P&L FROM SURPRISE VALLEY

The first new geothermal power sale in 1990 appears to have been made by Trans-Pacific Geothermal Corporation (TGC), Oakland, California, which announced July 17 that it is planning to construct and operate a 10 MWe geothermal power project in Surprise Valley, near Alturas, California, using moderate-temperature brines, proved by Magma Power Company in 1959.

TGC reached agreement last year with Magma, which owns the leases, for TGC to develop the prospect. The site is in the vicinity of the free air explosion near Parman Hot Springs North of Lake City, that startled the neighborhood in 1951, disturbing rock formations, and drawing attention to the geothermal potential of the area.

The power purchase agreement with Puget Sound Power & Light runs for 30 years, with first project power deliveries scheduled in 1993. Detailed geophysical and geochemical investigations are expected to be completed in time for the beginning of construction in 1992. TGC is not a newcomer to the geothermal fields of northern California and Nevada. It did the initial development that resulted in the construction and operation of the 50 MWe Dixie Valley Project, and also did advance work on the 10 MWe Stillwater plant. It is the managing general partner in the 2 MWe Amedee plant in California, which it owns with the U.S. Energy Corp., and a private investor.

Source: Geothermal Report 8/15/90

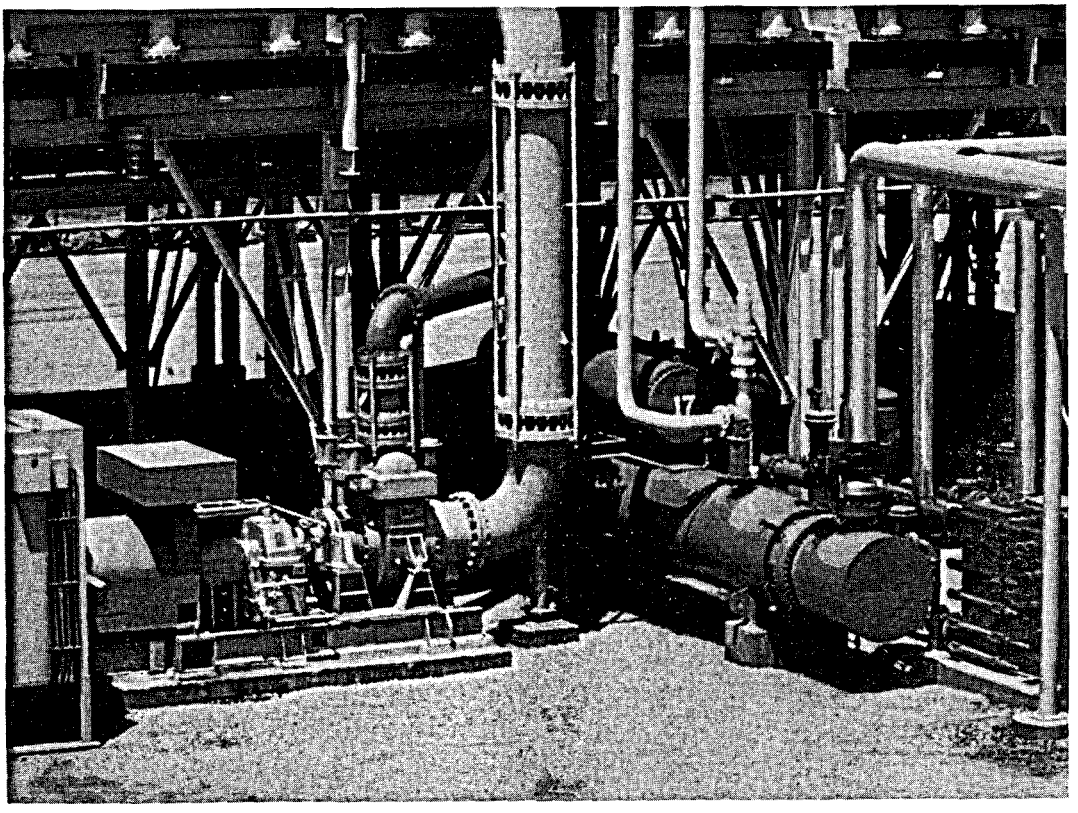
THREE GEOTHERMAL POWER PRODUCERS WIN AWARDS

The California Energy Co., Ormat Energy Systems, Inc., and Pacific Gas & Electric Co. have received prestigious awards related to their geothermal operations. At a White House ceremony in April 1990 hosted by President Bush, California Energy's Coso Project received the National Environmental Award for its role in reducing greenhouse gases and ozone depleting chemicals. The award, sponsored by Renew America, a coalition of environmental advocacy groups, was judged from more than 1,000 nominees by the officers of many leading U.S. environmental groups. The reductions in pollutants recognized by the award are achieved by a modification to the flash steam power process in which all noncondensible gases present in the geothermal fluid are injected back to the subsurface reducing surface emissions to virtually zero.

The Ormat award, presented by the American Society of Mechanical Engineers, recognized the company's proprietary development of technology that economically generates electric power using lower temperature heat sources than is viable today with other geothermal technologies. This ability may open up large additional quantities of geothermal resources in this country and abroad for power development. The closed binary systems generate no airborne emissions, and when air cooled condensers are used, there is no consumption of surface or ground water. ASME's Energy Resources Technology Awards recognize technologies less than five

years old that serve to enhance the industrialization of the energy resources industry and that contribute to the improvement of the U.S. position in the world market.

Pacific Gas & Electric Co. received California's first Air Pollution Reduction Award for developing and using a process to remove hydrogen sulfide gas from geothermal steam and reducing hazardous waste by as much as 90 percent at The Geysers power plant in Sonoma and Lake Counties, California. The process significantly reduces the volume of chemicals used at the plant.



This 13 MWe geothermal power plant of Ormat Energy Systems at the Stillwater KGRA in Nevada is virtually a pollution-free operation. It is the largest air-cooled binary plant in the U.S. with no consumptive use of surface or groundwater, and its completely closed systems permit no discharge of brine, gas, or water vapor. It began operation in April 1989, seven months after the start of construction.

CALPINE SHIFTS GEARS, BECOMES POWER DEVELOPER, OWNER, OPERATOR

As managing partner in the newly formed Santa Rosa Geothermal Company, which has bought the producing geothermal properties of the Freeport-McMoRan Resource Partnership (FRP) and Freeport-McMoRan, Inc.(FTX) in The Geysers, Calpine Corporation of San Jose has made the jump from a service business in the financing and operations areas of energy projects to developer, owner, and operator of power generating facilities, with a major stake in geothermal.

The complex deal involves the Bear Canyon 20 MW and the West Ford Flat 27 MW geothermal power plants, and three steam fields with a capacity of 319 MW that serve PG&E's large Unit 13 and SMUDGEO 1 plants. Calpine's subsidiary, Calpine-Geysers Plant Services, will operate the plants for the new partnership. It took over on July 2, operating out of the North Dutton St., headquarters of FRP in Santa Rosa, and has hired most of the previous owner's staff.

Calpine, owned by Electrowatt, Ltd. of Switzerland, acquired an interest in the 20 MW Aidlin geothermal power plant from Mission Power Engineering Company, Irvine, in May 1989 as its first step into its new role.

In announcing the purchase of the FRP properties in The Geysers, Calpine also said that it soon "will begin negotiations for another partnership with FRP to develop, manage, and operate FRP's undeveloped geothermal energy assets, which were retained by FRP." These are primarily geothermal prospects in Imperial Valley's Salton Sea KGRA and in the Medicine Lake KGRA in northern California. FRP has no remaining properties in The Geysers.

FRP sold its and FTX's producing geothermal properties in The Geysers to Santa Rosa Geothermal Co., in which Calpine has the lead, for $227 million cash, a promissory note for $27 million, and a residual 55 percent interest in the partnership after a "defined payout of the Calpine investment." According to the agreement, the promissory note, which represents the value of a certain partnership interest being acquired by Calpine in addition to its basic partnership interest, will be paid within six months after the closing, if Calpine elects to sell to a third party or to retain such interest. Otherwise, the note will be canceled, and the interest, will be conveyed back to FRP, increasing its residual interest in the partnership from 55 percent to 77.5 percent. A Calpine spokesman told the Geothermal Report that "the defined payout of the Calpine investment" will be completed in "eight or ten years" during which Calpine will receive all of the proceeds of the properties. After that, FRP, will get either 55 percent or 77.5 percent of the proceeds, whichever is the appropriate split at that time in accordance with the terms of the agreement.

Calpine arranged a $200 million non-recourse, long-term debt financing for the new partnership through Deutsche Bank, New York branch.

Source: Geothermal Report 8/15/90

ORMAT ENERGY SYSTEMS INC. ANNOUNCES COMPLETION OF FINANCING ORMESA IH PROJECT

Ormat Energy Systems, Inc., (Sparks, Nevada), announced on January 8, 1990, the closing of the permanent financing for the Ormesa IH project, located in the Imperial Valley of California. The $35 million facility was designed and built by Ormat under a turnkey contract. The facility was financially structured as a 20-year leveraged lease, with Constellation Development, Inc. providing the equipment funds. Bankers Trust Company of New York acted as the construction lender.

The project consists of 12 water-cooled Ormat Energy Converters and related equipment. Geothermal water at a temperature of about 149°C (300°)F is pumped from three production wells. The project is expected to sell 57,000 kWh of electricity per year to Southern California Edison Company under a Standard Offer No. 4 Power Purchase Agreement. Harbert International, Inc., was the primary subcontractor for the project.

The Ormesa Geothermal IH project is the tenth project developed and operated by Ormat, and the fourth project Ormat has developed in the Imperial Valley.

Source: Geothermal Resources Council Bulletin 1/90

CHEVRON OK'S SALES OF GEOTHERMAL UNITS

Chevron Corporation has agreed to sell its geothermal operations in Nevada and Utah to California Energy Company, Inc. for $68.7 million. The San Francisco oil giant said it was selling the units to focus on more attractive operations. Chevron put two of the units up for sale in late 1989, believing the geothermal business was too small an area to pursue under the company's present strategy.

Chevron also is selling its one remaining operating unit, in Soda Lake, Nevada, to Ormat Energy Systems of Reno. The geothermal units are operated by Chevron Resources Company. The San Ramon-based subsidiary also operates gold mines in western Australia, platinum mines in Montana, and uranium mines in Texas and New Mexico, among its numerous mining projects.

In the deal announced on May 5, 1990, California Energy Company will pay only $51.2 million for the three projects, if a partner in the Beowawe, Nevada, project exercises an option to buy out Chevron's interest. Under that scenario, the company, Crescent Valley Energy, would pay Chevron $17.5 million for its 50 percent stake in the 15.6 MW plant.

The two other projects being acquired are a 9 MW plant in Desert Peak, Nevada, and a 25 MW plant in Roosevelt, Utah, where Chevron, with 69 percent interest, is field operator. In addition, California Energy will acquire leasehold interests of some 17,600 acres in Utah and 70,000 acres in Nevada. The 33 workers now employed in the three geothermal projects are expected to be hired by California Energy.

After the sale of the four geothermal projects, Chevron will be left with a non-producing geothermal facility in Heber in southern California.

Source: Geothermal Resources Council Bulletin 5/90

SMUD COURT WIN MAY NET $12 MILLION

On April 29, 1990, it was announced that Sacramento Municipal Utility District (SMUD) potentially won a $12 million victory in a legal fight with Sonoma County over efforts to tax the utility's geothermal steam plants. If the taxes are eventually repaid to SMUD, the financial problems of the utility could be reduced. It paid the taxes under protest because as a public utility it contends it is exempt from property taxes.

Sonoma County will appeal a recent Sonoma County Superior Court ruling invalidating an "electricity generation tax" to the district Court of Appeals in San Francisco. Sonoma and SMUD lawyers estimated it may take 2 years to exhaust appeals. Sonoma County would continue to collect the tax, which is held in a special account outside the county's budget.

The tax, approved by Sonoma County voters, has been collected for several years. It is levied based on production at a wholly-owned SMUD geothermal plant that began

operation in 1983 and another plant half-owned by SMUD that began service in 1988. SMUD successfully contended that by imposing the special tax, the county rendered as worthless the publicly owned utility's constitutional exemption from property taxes. Private companies, principally Pacific Gas & Electric Co., pay county property taxes on their holdings in The Geysers region between Santa Rosa and Clear Lake. Sonoma contends that the electricity generation tax is justified to cover the "incredible burden" to build roads and provide other services to the plants, located in the mountainous, isolated region.

Source: Geothermal Resources Council Bulletin 5/90

PRODUCING GEOTHERMAL AREAS EXPLORED DURING INDUSTRY-COUPLED PROGRAM

The Industry-Coupled Program was initiated by DOE in the late 1970's to share the costs and risks with industry in developing public domain data on 14 promising geothermal prospects. Today, 8 of the 14 sites, as shown in the above map, are in commercial production, all of which are considered capable of greater production.

THE NATIONAL ENERGY STRATEGY -- THE ROLE OF GEOTHERMAL TECHNOLOGY DEVELOPMENT

Stephen C. Lipman
UNOCAL Geothermal Division

(Mr. Lipman's address to the DOE Program Review VIII in San Francisco in April 1990 is printed here in full. Since that time he has been transferred from his position as President, Geothermal Division, to President, Science & Technology & Energy Mining Division.)

Our topic today -- The Role of Geothermal Energy Development in The National Energy Strategy -- is one that you would think all of us in this room could all agree on.

We are here today because we believe that there is an important role for geothermal energy in our future. We all know of its successes and its potential. Even at The Geysers, though it is experiencing a loss of productivity because the reservoir pressure is going down, it is still the largest geothermal project in the world and is a major source of electricity for Northern California. We believe that field will continue to meet that demand for many years to come. I will address that field in more detail in a moment.

First, let us address why others do not share our faith in this resource development. I believe it boils down to a few simple facts of life:

- Not many movers and shakers on the national scene know what commercial development has taken place. We are considered to be in the class of technologies that most people think of as pure research -- undeveloped and unavailable for today's needs. Our story of past accomplishments is not getting across to those in control of our national direction.

- The choices that will be made in meeting our future energy needs will have more environmental forethought than before, but when it gets down to moving ahead with new developments I believe it will be based on short-term economics, pure market forces. In that kind of competition, many believe that geothermal energy will lose out because it is too expensive. I am not one of those. I believe we are, and will continue to be, a cost-effective source of electricity.

- The economic hardships of the past decade of low energy prices and the acquisition mania with its junk bonds have caused many major developers to leave our industry. So, can we maintain a significant role without Philipps, Sun Oil, Gulf, Oxy, Shell, Natomas, Southern Pacific, Grace, MCR, and now Chevron and possibly Freeport McMoRan? The burden to advance our industry is not on DOE, or the California Energy Commission or the national labs and participating universities. It is on those developers who are left -- UNOCAL, Magma Power, Oxbow, Ormat, California Energy Company, Pacific Enterprises, Mission Energy, Anadarko, Calpine, and Centennial Energy. I hope more of these companies do step forward and join those of us that are trying to keep geothermal in a prominent role.

Our story of accomplishments must be told on a national and regional level, and by more than a few spokesmen. I get concerned that we often hurt ourselves when we do speak out by focusing on things that we want from the government. Where, in reality, we are not in a bad situation at all.

Let's take a look at some of the common issues that other industries are confronted with.

- Are there enough lands available for industry to develop? I believe industry has a good land position in the western

United States. Probably the major land issue facing our industry is in Hawaii. I believe that is solvable with appropriate measures of education, negotiation, and compromise.

- Do we have adequate and appropriate technology available for commercial developments to proceed? I think we can all agree that industry has confronted a wide variety of resource problems and has moved ahead with successful solutions. I do not want to convey that these were the best or the optimum solutions.

- We need to keep up research and development on improving our exploration and production techniques and tools. Success in this effort can only result in additional geothermal development and keep our industry strong economically. But my main point is we are not limited by a lack of technical expertise or equipment.

- Are there institutional barriers to development? Certainly, not like there were in the early 1970s. The only one that comes to mind for today's developments is the 80 MW FERC limitation for a geothermal PURPA power plant. As we compete for market opportunities, our industry must not be restricted to this arbitrary limit, while our competition from fossil-fueled cogeneration has no limit whatsoever. I am sure that this playing field will eventually be righted, but we, as an industry, are going to have to get the message across in Washington.

- What R&D efforts are most needed by industry? In a broad context, any and all that reduce our costs and extend the beneficial recovery of the resource. Tools and techniques that reduce our drilling costs, keep the injectivity of wells from degrading with time, and also an area that is not studied by most funded research is in more efficient use of the resource in the energy conversion process. Industry spends large sums of money to find and produce these fluids; it is discouraging to see it used inefficiently.

I believe that the performance of our industry's commercial developments should be studied, evaluated, and brought to public awareness. This would highlight our success, provide a technical basis for future developments, and concentrate on finding better solutions for future commercial developments. The Geysers, along with other developments, should be given detailed technical analysis by scientific teams from academia and industry. Studies should not be limited to past performance, but should also include ways to improve future recovery and performance. The benefits from these examinations flow to all sectors of our industry:

- To the national labs and universities in advancing the knowledge of geothermal development,

- To the industrial developers in extending their resource developments,

- To industry and the public at large by opening up the potential of other geothermal developments and maintaining a viable alternative to conventional fuels.

This is a strategic plan for government and industry to embark on. It may not make the front page on our national energy strategy summary, but I believe we will reap many more benefits in advancing geothermal energy development.

Thank you for inviting me to speak today, and I wish you every success in this week's conference.

ENVIRONMENTAL MERITS OF GEOTHERMAL ENERGY NOTED AT CONFERENCE ON "ENERGY AND THE ENVIRONMENT IN THE 21ST CENTURY"

After reviewing the range of potential adverse environmental impacts of geothermal use -- from air and water pollution to catastrophic events -- and the range of control technologies available, Ronald DiPippo of Southeastern Massachusetts University concluded that, overall, geothermal plants emerge as perhaps the most benign of all available power generation technologies. Presenting his findings at a session entitled "Electric Power Systems," Dr. DiPippo itemized the following:

- Air Pollution -- Geothermal plants emit less carbon dioxide per kWh than any other plant type with CO_2 emissions -- typically only 5 percent of the CO_2 of a coal plant and about 8 percent of the CO_2 of an oil plant. At The Geysers, Stretford process systems achieve better than 90 percent reduction of total H_2S emissions. U.S. plants are the only geothermal plants in the world with H_2S abatement systems. Binary plants have no gaseous emissions.

- Water Pollution -- It is good practice to collect all discharged liquids, whether or not they contain high levels of dissolved minerals, and dispose of them by reinjection or in large, impermeable evaporation ponds. Ground water contamination can be essentially eliminated by careful design of reinjection wells and ponds, quality control during drilling and construction, and proper monitoring during operation. Reinjection is gaining in favor in countries other than the U.S. and Japan where it is standard practice.

- Thermal Pollution -- At the plant site, a geothermal plant is two or three times worse than a nuclear plant in terms of thermal pollution. However, this disadvantage is compensated by the heat dissipated during the mining, processing, fabrication, transportation, and reprocessing of the nuclear fuel.

- Noise Pollution -- Noise is mostly generated by drilling; no objectionable noise occurs during normal plant operations. Mufflers are routinely used to control the noise of venting steam.

- Land Use -- Geothermal power plants require less land per megawatt than competing power plants -- far less when compared to some solar technologies.

- Water Use -- Geothermal steam condensate may be used as the cooling medium with no outside water needed except for initial start-up and periodic blowdown. By contrast, binary plants have no condensate, and the cooled brine is too contaminated for cooling; however, small binary plants can be built with air cooled condensers.

- Land Subsidence -- With the exception of the Wairakei field in New Zealand, there are no known cases of significant subsidence at geothermal plants. The possibility of this occurrence is lessened by reinjection.

- Loss of Natural Beauty and Scenic Wonders -- While some of the best geothermal resources occur in or near national parks in the U.S. and elsewhere, geothermal plants can be designed to blend into the natural surroundings. Coal plants, on the other hand, often have stacks as high as 500 feet, nuclear stations have massive containment structures and tall natural draft cooling towers, and wind farms consist of thousands of wind turbines atop 100-foot supports arrayed on hillsides and in mountain passes.

- Catastrophic Events -- The likelihood of well blowouts is minimized by the proper use of blowout preventers during

drilling, a requirement of applicable regulations in the U.S. The rupture of a steam or hot water line is unlikely since pipelines are designed according to safe engineering practices with adequate margins of safety. Any spill would be brief since control valves would be activated. The potential danger of this occurrence is no worse than at fossil plants, and much less than at nuclear plants where the steam and water are radioactive. Careful geologic mapping of geothermal fields is necessary to avoid land slides, and areas of potential occurrence should be reinforced or buttressed. Studies have shown that reinjection does not cause significant seismic events, and, at most, microseismic events may be associated with the production or injection of geothermal fluids. The effects of the worst imaginable catastrophe at geothermal plants would be confined to a small area as opposed to the global repercussions of Chernobyl or the tragedies that may result from broken hydropower dams. The safety record of geothermal plants around the world is exemplary, mainly because of the safety precautions that are built in at every stage, from initial design to everyday operations.

The conference on Energy and the Environment in the 21st Century was held at the Massachusetts Institute of Technology March 26-28, 1990. Dr. DiPippo's paper, titled "Geothermal Energy: Electricity Production and Environmental Impact -- A Worldwide Perspective," also provided considerable current information on geothermal development worldwide which is presented in a separate article in the INTERNATIONAL section. He is a professor and chairman of SMU's Mechanical Engineering Department at North Dartmouth.

MIT STUDY FINDS HIGH-GRADE HOT DRY ROCK RESOURCES COMPETITIVE

A generalized economic model developed by Jefferson W. Tester and Howard J. Herzog of the Massachusetts Institute of Technology Energy Laboratory indicates that high-grade hot dry rock (HDR) resources are competitive for power generation "at today's energy prices." (Since the study was completed prior to the rapid increase in oil prices resulting from the Persian Gulf upheaval beginning on August 2, 1990, it is important to remember that this conclusion was based on oil prices of about $18/barrel.) The conclusion also assumes current high drilling and completion costs, but improved reservoir performance over that achieved in the experimental HDR system at Fenton Hill, New Mexico.

The HDR geothermal energy resource is associated with accessible regions of hot rock beneath the earth's surface that do not contain sufficient natural porosity or permeability for the presence of subsurface fluids. Energy can be extracted by creating artificial permeability using hydraulic simulation techniques to propagate and open joints as fractures. The resulting fracture network is connected to a set of production and injection wells where heat is removed by circulating water under pressure from the surface, down one well, through the fractured zone, and up a second well. This *heat mining* concept is closed-loop on the geothermal side so there are no effluents, thus minimizing the environmental impact of the entire HDR "fuel cycle" to site preparation, well drilling, and other land use issues.

Because HDR systems do not require natural, indigenous hot fluids and high permeability, the HDR resource base can be defined by the accessible thermal energy in the earth's crust above some minimum temperature level. Thus, the magnitude of the HDR resource is very large and more

widely distributed than natural hydrothermal systems.

The important parameters considered in the MIT model included:

- Resource quality -- average geothermal gradient (°C/km) and well depths
- Reservoir performance -- effective productivity, flow impedance, and lifetime or thermal drawdown rate
- Cost components -- drilling, reservoir formation, and power plant costs
- Economic factors -- discount and interest rates, taxes, etc.

Drilling costs and reservoir performance were established as the critical parameters affecting economic viability. For example, high gradient areas are attractive because shallower well depths and/or lower reservoir production rates are permissible. Under a reasonable set of assumptions regarding reservoir impedance, accessible rock volumes and surface areas, and mass flow rates (to limit thermal drawdown rates to about 2% per year with redrilling and restimulation every 5 years), predictions for HDR-produced electricity result in competitive breakdown prices in the range of 4 to 10 cents/kWh for resources with average gradients above 50°C/km.

The "high-grade" resource was considered to have an average gradient of 80°C/km. Mid-grade (50°C/km) resources were found to be only marginally competitive at $18/barrel oil, but would become competitive with higher oil prices (>$30/barrel), and/or if environmental costs associated with fossil-fuel systems -- e.g., an acid rain or carbon tax -- were included.

Low-grade (30°C/km) HDR resources would not be competitive for electricity production until significantly higher energy prices exist and/or lower drilling and reservoir stimulation costs can be achieved. Resources in this category would compete much more easily for direct heat space or process heating or for cogeneration applications.

DOE's Geothermal Division, Sandia National Laboratories, and the MIT Energy Laboratory provided partial support for this project. Results of the generalized model were compared to the results of several other published HDR economic assessments, and have been published as:

J. W. Tester and H. J. Herzog, "Economic Predictions for Heat Mining: A Review and Analysis of Hot Dry Rock (HDR) Geothermal Energy Technology," MIT Energy Laboratory report MIT-EL90-001, Cambridge, MA (July, 1990).

CEC JOINS THE EFFORT TO SOLVE GEYSERS PROBLEMS

After confirming the problems at The Geysers at a fact-finding hearing in the fall of 1989, the California Energy Commission adopted a fast-track, cooperative program to assess the threat posed to the field and identify options to maximize the resource potential. The program is being conducted by a Technical Advisory Committee composed of 15 corporate or agency members.

The TAC is under the general supervision of Commissioner Robert Mussetter; project managers are Darrell Woo of CEC's Energy Facility Siting and Environmental Division and Mike Smith of the Technology Development Division. Stone and Webster has been contracted to conduct the power plant research, and Allan Spivac, a Los Angeles petroleum engineer, was selected to conduct the reservoir modeling studies. The California Division of Oil and Gas is representing both its own land interests in the area and those of the federal Bureau of Land Management. However, with the diversity of interests of the TAC membership, the organization has gotten off to a slow start, and nearly a year

after the alarm was sounded, only slow progress can be reported.

The good news at The Geysers is that some areas have been stabilized, apparently as the result of a joint water injection effort by several steam producers. Unfortunately, water sources in the area are limited although Somona and Lake Counties have special committees trying to identify new sources.

CEC's action was motivated by its urgent need for comprehensive information to fulfill its mandate to certify new electric generating stations to meet foreseen growth of demand and maintain for the state an ample, but not extravagant energy supply.

Source: Based on information supplied by several issues of the Geothermal Report

FIRST UTILITY GEOTHERMAL POWER PLANNED FOR THE PACIFIC NORTHWEST

Geothermal energy, a new power source that has lured dozens of prospectors to central Oregon, is becoming more important as the Northwest makes plans to deal with a dwindling energy surplus. Under current plans, three small "pilot" geothermal plants in the Northwest could start generating electricity by 1994, and chances are good that one of those plants would be located amid the volcanic mountains and buttes of central Oregon, power officials said in Bend recently.

The Northwest Power Planning Council and Bonneville Power Administration have announced plans to foster the Northwest's fledgling geothermal industry. Both the NPPC and the BPA see development of geothermal energy as one step toward meeting an electricity demand that could nearly double by 2010, according to some forecasts. It is felt that to the extent that geothermal resources can be proven, they will provide a significant contribution to the region's power supply.

The Forest Service is likely to play a large role in geothermal development in the Northwest because it manages the land where most known geothermal energy sites are located. In central Oregon, numerous geothermal test wells have been drilled on Forest Service land southeast of Bend around Newberry Crater, and there are plans to drill new wells in the Bend Highlands area near Bearwallow Butte, west of the city.

The NPPC left geothermal energy out of a 20-year power plan written in 1986 because no one had successfully built and operated a geothermal power plant in the Northwest. Since then, dozens of geothermal test wells have been drilled and energy researchers have determined that geothermal energy could be commercially viable in the Northwest by 1997.

The Council has adopted recommendations to consider 350 MW of geothermal power available for the Northwest over the next 20 years and to analyze the potential for another 1,000 MW. To make the forecast a reality, however, the geothermal energy industry has to demonstrate that it can put a power plant into operation in the Northwest. That is where the Bonneville Power Administration comes in. The BPA's draft 1990 Resource Program, released in December 1989, includes a plan for the agency to award contracts for three 10 MWe pilot geothermal plants at different locations. The BPA also would hold the rights to as much as 100 MWe more geothermal development at those sites.

The agency would begin its geothermal development push this year by gathering data on geothermal energy, and by late 1994 could see the first power plants beginning operation. The major roadblock to geothermal development in the Northwest is the potential for conflicts over placing geothermal plants in environmentally sensitive areas.

(See announcement of related publications in TECHNOLOGY TRANSFER.)

Source: Geothermal Resources Council Bulletin 3/90.

OREGON GEOTHERMAL DISCOVERY

Anadarko Petroleum Corporation, a Texas company, confirmed a discovery in the Alvord Desert of southeastern Oregon. The 1,479-foot well drilled at the north end of Pueblo Valley in October 1989 was flow tested for 22 hours at 152°C (305°F).

This was the first geothermal resource flow test of a well on public lands in the Northwest. U.S. officials at the Bureau of Land Management believe that the geothermal energy resources in the Alvord Desert area could run as high as 90 MWe for a 30-year period.

Source: Geothermal Resources Council Bulletin 4/90

HAWAII POWER PLANT SHUT DOWN

In December 1989, the 3 MWe HGP-A geothermal power plant at Puna on the Island of Hawaii was shut down. The plant was designed as the Wellhead Generator Proof-of-Feasibility Project with funding from DOE, the State of Hawaii, County of Hawaii, and Hawaii Electric Light Co.

The original intent was to operate the plant for only a 24-month test period. However, it was operated by HELCO for nearly 7 years to obtain long-term information on equipment, materials, and reservoir characteristics. During that period, the small plant produced nearly 125 million kWh of electricity, serving 2,000 homes with a reliability factor in excess of 90 percent, and conserving 249,000 barrels of oil.

The Hawaii legislature has approved $3 million to continue geothermal research drilling, and $250,000 to reactivate the HGP-A well to sell the steam to the nearby Puna venture.

GEOTHERMAL ENERGY POISED FOR LARGER ROLE

Geothermal energy will compete easily with new coal-fired and nuclear energy plants, predicts Unocal, a holding company for the largest geothermal steam company in the world. This projection was made on September 25, 1989, at a Capital Hill briefing sponsored by the Environmental and Energy Study Institute (EESI) and the Environmental and Energy Study Conference. Congressional staff, policy makers, and media representatives met to be briefed on geothermal energy's contribution to U.S. energy supplies and recent developments in geothermal technologies.

The EESI panel discussion covered a broad range of issues pertaining to geothermal energy. Speakers on the panel included Dr. John E. Mock, Director of the Geothermal Division of the Department of Energy; Mr. Tom Sparks, Manager of Government Regulation and Affairs at Unocal; Mr. Charles T. Condy, Chairman and CEO of California Energy Company; and Mr. Jim Mielke of the Congressional Research Service.

This briefing provided an effective introduction for congressional staff and representatives on the potential of geothermal energy.

Source: Geothermal Resources Council Bulletin 10/89

MAMMOTH GEOTHERMAL SUIT SETTLED

Facing a deadline to settle litigation or go to court, the Mono County, California Board of Supervisors, and Pacific Energy reached agreement in mid-August 1989, with the California Department of Fish and Game (DFG) on a lawsuit DFG filed objecting to geothermal development near Casa Diablo.

The DFG lawsuit, filed in January of the same year, contended that the county and Mammoth-Pacific violated the California Environmental Quality Act during permitting of the Mammoth-Pacific's MP II geothermal power plant. Mammoth-Pacific countersued in February, alleging violation of the California Public Records Act.

Now, however, the three parties have dropped all court action, clearing the way for permitting processes on MP II and its sister expansion geothermal projects MP III and PLES I. The DFG agrees in the settlement not to oppose any application for governmental approval of Mammoth-Pacific's Casa Diablo projects as long as the applications conform to the environmental monitoring and mitigation measures in the agreement.

The agreement contains funding for a DFG survey of animal and plant life in the area, a process to amend the Mono County General Plan to include a Hot Creek Buffer Zone and restricted zones for deer migration at Casa Diablo, and provisions for binding arbitration on environmental protection. Mammoth-Pacific will put up $50,000 for the DFG studies, called "biotic surveys," to determine if unique or unusual life exists there.

In a Mono County press release, County Board Chairman, Bob Stanford said the agreement "should pave the way to a comprehensive and final solution to the geothermal development issue in the Casa Diablo area. It allows a project -- unanimously approved by the Board -- to be built, but it also obligates the County to hold public hearings which we hope will lead to general plan amendments."

Source: Geothermal Resources Council Bulletin 11/89

NATIONAL GEOTHERMAL ASSOCIATION FORMS EXPORT TRADING COMPANY

Thirty members of the National Geothermal Association have received a Certificate of Review (COR) under the Export Trading Company Act of 1982 and have formed an export trading company called the "U.S. Geothermal Industries Corporation" (USGIC). The COR exempts participants from state and federal antitrust action with respect to export activities.

Initial incorporators have bought stock in the corporation, and additional parties may "join" by doing likewise. Membership may be applied for by any U.S.-based geothermal entity interested in cooperating on overseas geothermal projects. USGIC is initially focusing on projects in the Caribbean and the Philippines, and has made specific proposals which are currently under consideration by CORECT for support and assistance.

Both the DOE Geothermal Division and CORECT assisted in organizing this concerted export thrust. The first step was taken in June 1989 when a CORECT-sponsored trade mission spent two weeks in Central America assessing geothermal energy opportunities.

GEOTHERMAL HEAT PUMPS -- EMERGING GIANT?

The geothermal heat pump (GHP) is the ideal heating/cooling system for the 1990s with benefits for the consumer, the utility,

and the environment. Although the GHP capital cost is comparable to the new high-efficiency air source heat pumps, GHPs use less energy, thereby offering homeowners and building operators lower life-cycle costs. The utility benefits by better load balance, thereby reducing need for new capacity; the consumer benefits by reduced utility bills and fewer brownouts; and the nation benefits by lower energy consumption, lower power costs for industry, and fewer adverse environmental impacts.

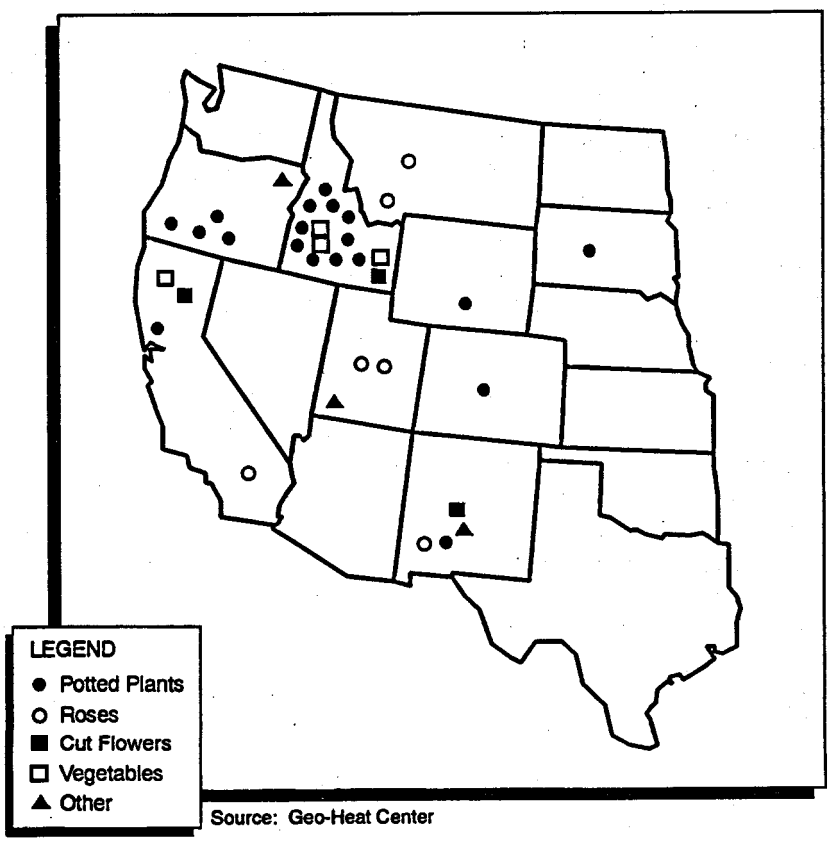
Since 1980, the geothermal heat pump (or ground-water heat pump) has been the fastest growing segment of the geothermal direct-use market, increasing its share from less than 10 percent to over 30 percent by 1990. Primary markets for geothermal heat pumps include new homes, apartments, commercial buildings, plus the 25 million to 35 million houses with no access to natural gas.

GHPs consist of two major types. One type, the earth-coupled GHP, uses sealed horizontal or vertical pipes as heat exchangers through which water is circulated to transfer heat. The second type, the water-source GHP, pumps water from a well or pond through the GHP, returning it to an injection well, a pond, or a stream for disposal. Because of their simplicity, earth-coupled systems have come to dominate the GHP market.

Currently, a few major utilities, hundreds of rural electric cooperatives, and a few states provide incentives valued up to $3,000 per GHP installation. As a result, the residential market share ranges from 10 percent of new homes for a major utility to 6 percent of all homes in a rural electric cooperative. If utilities are permitted to earn a slightly higher profit from investing in energy efficiency and environmentally clean capacity, the impact would be even more impressive. Moreover, the load leveling potential of GHPs complements the base load strengths of geothermal power, significantly reducing the seasonal peak demands on utilities.

More details on the markets and benefits of this technology may be found in the Geothermal Resources Council Bulletin of April 1990 in an article authored by Lew W. Pratsch, direct use program manager of DOE's Geothermal Division.

GEOTHERMAL GREENHOUSE LOCATIONS



This map shows the distribution of 35 geothermal greenhouses in the western United States. This is a popular application of geothermal energy because its use is both an economical and efficient means for heating these facilities. The low-temperature resources needed are widespread throughout the western states providing a significant potential for expansion of the geothermal greenhouse industry.

The key to the abbreviations used in the power plant tables is as follows:

Plant Type

DS	-	Dry Steam
DF	-	Dual Flash
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.
PSP&L	-	Puget Sound Power & Light Co.
SCE	-	Southern California Edison
SDG&E	-	San Diego Gas and Electric Co.
SPP	-	Sierra Pacific Power Co.
UPD	-	Utah Power Division of Pacific Corp.

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
CALIFORNIA							
Brawley			SEE SALTON SEA				
Coso Hot Springs	Navy Plant No. 1, Units No. 1, 2, & 3	DF	California Energy [a]	California Energy[a]	SCE	80	1987-1988
	BLM East (Units 1&2)	DF	California Energy[a]	California Energy[a]	SCE	48	1988
	BLM West	DF	California Energy[a]	California Energy[a]	SCE	28	1989
	Navy Plant No. 2, Units No. 4, 5, & 6	DF	California Energy[a]	California Energy[a]	SCE	80	1989
	NA	DF	Los Angeles Dept. of Water and Power (LADWP)	LADWP	LADWP	20	1994
East Mesa	GEM 1 (formerly B.C. McCabe)	B	GEO Operator/ Mission[b,c]	GEO/Mission[c]	SCE	12.5[d]	1980
	Ormesa I	B	Ormat Energy Systems Inc. (OESI)	OESI	SCE	24	1987
	Ormesa II	B	OESI/Harbert International	OESI/Harbert	SCE	17	1987

[a] Various venture partners are involved in all California Energy Coso plants
[b] Magma Power original owner
[c] Mission Energy, a subsidiary of SCE
[d] Enlarged from 10 MWe

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
CALIFORNIA (Cont.)							
	Ormesa IE	B	OESI	OESI	SCE	8	1988
	Ormesa IH	B	OESI	OESI/Harbert	SCE	6	1989
	GEM 2	DF	GEO/Mission[a]	GEO/Mission[a]	SCE	37	1989
	NA	DF	GEO	GEO	SCE	37	NA
Heber	Heber Dual Flash Power Plant	DF	Chevron Resources Co.	Calpine Corp./ERC International[b]	SCE	47	1985
	Heber Binary Project[c]	B	Chevron	Up for sale by SDG&E, IID, and State of Calif.	SDG&E	45	1985
Mono-Long Valley	Mammoth Pacific (MP) Unit I	B	Pacific Energy[d]	Pacific Energy[d]	SCE	7	1984
	MP Unit II	B	Pacific Energy[d]	Pacific Energy[d]	SCE	10	1990
	MP Unit III	B	Pacific Energy[d]	Pacific Energy[d]	SCE	10	1994

[a] Mission Energy, a subsidiary of SEC
[b] Partnership of Dravo Corp. and Centennial Energy original owner
[c] Demonstration plant supported by the U.S. Dept. of Energy; currently not in operation
[d] Subsidiary of Pacific Enterprises

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES (Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
CALIFORNIA (Cont.)							
	Pacific Lighting Energy Systems (PLES) Unit I	B	Pacific Energy[a]	Pacific Energy[a]	SCE	10	1990
	Mammoth-Chance B Development Project	B	Bonneville Pacific Corp.	Bonneville	SCE	10	1992
Salton Sea	Salton Sea Unit 1	SF	Earth Energy[b] (acquired full field ownership from partners Southern Pacific Land Co. and Mono Power)	Earth Energy[b,c]	SCE	10[c]	1982
	Unit 2	SF	Earth Energy[b]	Earth Energy[c]	SCE	17[d]	1990
	Vulcan	DF	Magma/Mission[e]	Magma/ Mission[e]	SCE	32	1985
	Del Ranch	DF	Magma/Mission[e]	Magma/ Mission[e]	SCE	36	1988
	Elmore I	DF	Magma/Mission[e]	Magma/ Mission[e]	SCE	36	1988
	Leathers I	DF	Magma/Mission[e]	Magma/ Mission[e]	SCE	36	1989

[a] Subsidiary of Pacific Enterprises
[b] Unocal subsidiary
[c] SCE original owner
[d] Will include 10 MWe SCE demonstration plant previously dismantled at Brawley
[e] Mision Energy Co., a subsidiary of SCE

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
CALIFORNIA (Cont.)							
	Salton Sea Unit 3	DF	Desert Power[a]	Desert Power[a]	SCE	50	1989
Surprise Valley	Surprise Valley, Trans-Pacific Unit 1	B	Trans-Pacific	Trans-Pacific	PSP&L	10	1993
Wendel-Amedee	Wineagle Project	B	Wineagle Developers	Wineagle Developers	PG&E	.7[b]	1985
	Amedee Geothermal	B	Trans-Pacific Geothermal Inc. (TPG)/U.S. Energy Corp.	TPG/U.S.	PG&E	2[c]	1988
	Honey Lake Power Facility	B[d]	GeoProducts Corp.	HL Power Co.	PG&E	30[e]	1988
HAWAII							
Puna[f]	HGP-A[g]	SF	University of Hawaii	University of Hawaii	HELCO	3	1981

[a] Unocal subsidiary
[b] To be increased
[c] Phase II will add 3 MWe
[d] A co-generation plant using wood waste and geothermal heat; geothermal fluid used only to preheat boiler feedwater.
[e] Original geothermal concept has not been abandoned; means to add it have been incorporated.
[f] Not a KGRA
[g] Plant dismantled; wells being reactiviated to sell steam to nearby Puna venture.

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
HAWAII (Cont.)							
	Puna Geothermal Venture	F/B	OESI[a]	OESI[a]	HELCO	25	1991
	NA	NA	True/Mid-Pacific Geothermal Resources	True/Mid-Pacific	HELCO	50	1992
NEVADA							
Beowawe	Beowawe	DF	California Energy (originally Chevron)	California Energy/ Crescent Valley Geothermal[b]	SCE	17	1985
Brady-Hazen	Desert Peak	DF	California Energy (originally Phillips; more recently Chevron)	California Energy (originally Chevron)	SPP	9	1985
Darrough Hot Springs	Big Smoky Valley	NA	Nevada Geothermal Associates (NGA)	NGA	SPP	10	NA
Dixie Valley	Oxbow	DF	Oxbow Geothermal (originally Sunedco; then Trans-Pacific)	Oxbow	SCE	57	1988

[a] Acquired interest of Maxus (Thermal Power) and Amfac Energy Corp.
[b] SCE Subsidiary

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
NEVADA (Cont.)							
San Emidio Desert	Empire Geothermal Project	B	OESI	OESI	SPP	3.1	1987
Steamboat Springs	Steamboat Geothermal I	B	Geothermal Development Associates (GDA)/OESI	Far West Electric Energy Fund, Ltd.	SPP	6.8	1986
	Steamboat Geothermal IA	B	OESI/GDA	Far West	SPP	1.2	1989
	Caithness/ Sequa Joint Venture	SF	Caithness Group/ Sequa	Caithness/ Sequa	SPP	12[a]	1988
Stillwater/Soda Lake	Soda Lake Geothermal Project	B	Chevron	Institutional Investors (OESI Operator)	SPP	2.7	1987
	Stillwater Geothermal I Project	B	OESI	OESI/ Constellation Development/ Chrysler Capital	SPP	13	1989
	Soda Lake II	B	Amor	Amor	SPP	13	1990
Wabuska[b]	Wabuska	B	Tad's Enterprises	Tad's Enterprises	SPP	1.5	1984

[a] Plans are underway to install a second unit.
[b] Declassified KGRA

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and KGRA)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
UTAH							
Roosevelt Hot Springs	Blundell I	SF	California Energy Co. (originally Phillips; subsequently Chevron)	Utah Power Div. (UPD) of PacifiCorp.	UPD	20	1984
Cove Fort-Sulphurdale	Cove Fort Geothermal No. 1	B	Mother Earth	City of Provo	Utah Municipal Power Agency	2	1985
	Cove Fort Steam Plant	DS	Mother Earth	City of Provo	Provo Power Co.	2	1988
	Cove Fort Steam No. 2	DS	Mother Earth	City of Provo	Provo Power Co.	8	1990

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
PG&E Unit No. 1	UNOCAL/Magma/Thermal	PG&E	PG&E	11	1960
No. 2	"	"	"	13	1963
No. 3	"	"	"	27	1967
No. 4	"	"	"	27	1968
No. 5	"	"	"	53	1971
No. 6	"	"	"	53	1971
No. 7	"	"	"	53	1972
No. 8	"	"	"	53	1972
No. 9	"	"	"	53	1973
No. 10	"	"	"	53	1973
No. 11	"	"	"	106	1975
No. 12	"	"	"	106	1979
No. 15	Geothermal Resources International	"	"	59	1979
No. 13	Santa Rosa Geothermal Co.[a]	"	"	133	1980
No. 14	UNOCAL/Magma/Thermal (Natomas)	"	"	109	1980

[a] Formed by Calpine Corp. and Freeport-McMoran as new owner of leases and steam supply operations; originally Aminoil properties

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
No. 17	UNOCAL/Magma/Thermal (Natomas)	PG&E	PG&E	110	1982
No. 18	UNOCAL/Magma/Thermal (Natomas)	PG&E	PG&E	110	1983
SMUDGEO No. 1	Santa Rosa Geothermal Co.[a]	Sacramento Municipal Utility District	SMUD	72	1983
NCPA No. 1[b]	Northern Calif. Power Agency (originally Grace Geothermal)	NCPA	NCPA	110	1983
Santa Fe Geothermal 1	Santa Fe Geothermal (originally Occidental)	Santa Fe Geothermal	PG&E	80	1984
Bottle Rock	NCPA	Calif. Dept of Water Resources	Calif. Dept. of Water Resources	55	1984
NCPA No. 2[b]	NCPA	NCPA	NCPA	110	1985
PG&E Unit No. 16	Santa Rosa Geothermal Co.[a]	PG&E	PG&E	110	1985
No. 20	UNOCAL/Thermal (Diamond Shamrock)	PG&E	PG&E	110	1985

[a] Formed by Calpine Corp. and Freeport-McMoRan as new owner of leases and steam supply operation; originally Aminoil properties
[b] Originally NCPA No. 2 and 3.
[c] Purchased from MCR Geothermal, Entex Petroleum, and Geothermal Kinetics, Inc.

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
Cold Water Creek	Cold Water Creek Operating Co.	CCPA[a]	CCPA[a]	124	1988
Bear Canyon Creek	Santa Rosa Geothermal Co.[b]	Santa Rosa[b]	PG&E	22	1988
West Ford Flat	Santa Rosa Geothermal Co.[b]	Santa Rosa[b]	PG&E	29	1988
Joseph W. Aidlin Power Plant	Geothermal Energy Partners[c]	Geothermal Energy Partners/ Cloverdale Geothermal Partners[d]	PG&E	20	1989

[a] Plant ownership divided among Sacramento Municipal Utility District (SMUD), Modesto Irrigation District (MID), and the City of Santa Clara.
[b] The new partnership of Calpine Corp. and Freeport-McMoRan owns both field and power plant operations; originally Geysers Geothermal properties.
[c] A subsidiary of Mission Power is general partner.
[d] Calpine Corp. and Metlife Capital Corp. (affiliate of Metropolitan Life Ins. Co.)

"CONSENSUS" LEGISLATION ENACTED TO ESTABLISH NEWBERRY NATIONAL VOLCANIC MONUMENT

In order to protect the spectacular natural features of the Newberry Caldera in central Oregon and at the same time permit geothermal development in adjacent areas, a local committee hammered out the provisions of "consensus" Federal legislation to establish the Newberry National Volcanic Monument which became law on November 5, 1990 (P.L. 101-522). This effort took "two laborious years," according to witnesses before the House Subcommittee on National Parks and Public Lands on June 18, 1990, an effort which was rewarded with prompt action in both the House and Senate.

Through the efforts of the U.S. Forest Service and many others, the National Monument Committee was formed, consisting of about 30 people representing environmental interests, users such as snowmobilers and hunters, and commercial interests such as timber, tourism, and geothermal energy as well as federal, state, and local governments. The Committee and its various subcommittees held hundreds of meetings to arrive at what is called a "win-win" situation.

The legislation places a large block of acreage in the Deschutes National Forest in the Cascades Range into the national monument. This acreage embraces parts of the Newberry Caldera Known Geothermal Resources Area, designated in 1974, which is considered to be the prime geothermal prospect in the Pacific Northwest. It is now withdrawn from use for mining or disposal under all mineral and geothermal leasing laws.

Since 1982, several geothermal leases were issued for the flanks of the volcano outside the KGRA, but no leases have been issued within the KGRA. The Forest Service had closed the acreage within the crater rim to development, and leases on the remaining acres were awaiting completion of an Environmental Impact Statement to determine where and under what conditions leasing should occur. The compromise legislation cancels existing geothermal leases within the monument and directs the Secretary of the Interior to issue leases on other lands as full compensation.

Use of the acreage immediately surrounding the monument for commercial purposes is also severely restricted, but the act recognizes the importance of the underlying geothermal resource in making special provisions for its exploitation. A "Transferral Area" is withdrawn from further leasing until completion of a well capable of producing geothermal steam in commercial quantities, as defined by the Geothermal Steam Act, on a valid existing lease; at that time the withdrawal would be revoked. Use of areas designated as "Transferral Area Adjacent" and "Special Management Area" are similarly dependent upon actual discovery of a commercial resource, and leases therein would carry a "No Surface Occupancy" stipulation requiring directional drilling from other leases. The Secretary is directed to hold a competitive lease sale for lands within the "Geothermal Lease Sale Parcels" within one year.

The language of the act establishing these various areas is tied to a map of the area which unfortunately is too large for reduction and presentation here. It can be seen at the office of the Deschutes National Forest in Bend, Oregon, (Sally Collins, (503) 388-2715) or at Forest Service Headquarters in Washington (Gene Zimmerman (202) 382-8215).

The geothermal industry will forego a major percentage of the potential resource value in the area, and the Federal government will potentially lose millions of dollars in royalties, but both parties express satisfaction with the legislation.

BANKRUPTCY OPENS LEASE OPPORTUNITY

Geothermal exploration leases involved in a key section of the above legislation to create a Newberry National Volcanic Monument may become available after a bankruptcy filing by a California geothermal company. Leases in the Newberry Crater area are among the assets of Geothermal Resources International, Inc., San Mateo, California, that could be sold or released as part of a financial reorganization of the company, according to a company official.

GRI controls 8,220 acres of leases owned by its subsidiary, GEO Newberry Crater, and other parties in the crater area 25 miles southeast of Bend. While the exchange pact described in the previous article might make GEO Newberry Crater's leases attractive to other geothermal companies, financial agreements that GEO Newberry Crater has made with the owners of many leases it controls may concern potential buyers, according to geothermal industry observers.The company secured the rights to explore numerous leases in the area by agreeing to pay lease holders a certain percentage of any profits from their leases.

If the financial encumbrances on the leases drive off all potential buyers, GEO Newberry Crater's leases could be relinquished under the company's reorganization plan, the source said. If that happened, the U.S. Bureau of Land Management -- which administers geothermal leasing of public lands -- probably would put the leases up for auction, according to the source.

Source: Geothermal Resources Council Bulletin 6/90

DOE COST-SHARED DRILLING RESUMES IN CASCADES

The fifth temperature gradient hole has been drilled in the Cascade Range of Oregon under the DOE/industry cost-shared Cascades Deep Thermal Gradient Drilling Program. Initiated in 1985, this program is designed to characterize the deep hydrothermal resource of the Cascades volcanic region and to develop analytical and interpretive tools for industry use in locating and evaluating geothermal reservoirs within young volcanic regions.

The fifth hole, completed in the summer of 1990, was drilled near the Santiam Pass in the Deschutes National Forest by Oxbow Geothermal Co. Previous holes were located on the northern and southern flanks of the Newberry Caldera, on the north slope of Mt. Jefferson near Breitenbush Hot Springs, and on the southeastern slopes of the Crater Lake caldera.

This volcanic region has long been suspected of containing considerable geothermal potential, as evidenced by recent volcanism -- e.g., Mount St. Helens -- and other thermal expressions. However, there are few known surface manifestations of geothermal energy in spite of the obvious occurrence of heat sources. One possible explanation is that the downward percolation of the extensive regional cold groundwater system forms a so-called "rain curtain" that suppresses surface evidence of the underlying hydrothermal systems.

While a number of holes has been drilled in the area, few have been of sufficient depth to adequately evaluate the temperature and hydrological conditions beneath the cold water zone. In order to support expansion of geothermal development into new areas, the cost-shared program was initiated in this potentially fruitful area to obtain core samples in specifically chosen areas and downhole well logs.

The data obtained have been studied extensively by both the companies involved and DOE-funded researchers. The University of Utah Research Institute is responsible for studies on DOE's share of the core samples and project data. The studies have included lithologic logging of the core, hydrothermal alteration studies, analysis of the geophysical well logs, and physical and chemical measurements on the core samples. The results derived have been placed in the public domain through papers presented in the annual Geothermal Resources Council Transactions. Core samples are also available to the public at UURI in Salt Lake City.

The new 3,046-foot hole at the Santiam Pass, the westernmost of the holes, is on the axis of the Cascades where the highest temperatures are expected. The hole will remain open for research through September 1991. Interested researchers should contact Brittian Hill, Geoscience Department, Oregon State University, Corvallis, OR 97331-5506, or by phone at (503) 737-1201, to coordinate studies.

UNOCAL SALTON SEA PLANT UTILIZES WORLD'S LARGEST GEOTHERMAL WELL

As shown on the cover of this issue of the GPM, the world's largest geothermal well is operated by UNOCAL at its Salton Sea Unit 3 plant in Imperial Valley. The production rate of the well -- the Vonderahe 1 -- is 2,500,000 pounds of fluid per hour at an average temperature of 270°C (520°F). The total depth of 5,524 feet was drilled in six weeks from mid-January to late - February in 1987. The completion is 14 3/4 inches in diameter.

The 47.5 MWe Unit 3 is unique in that it operates on only two geothermal wells -- the Vonderahe and the 7,400-foot Sinclair 10 which produces 1,750,000 pounds of fluid per hour. By contrast, the 50 MWe plant at Dixie Valley, Nevada, reportedly uses six production wells; the 47 MWe Heber flash plant, 10 wells; the 34 MWe Vulcan plant, also at the Salton Sea, 12; and the 30 MWe Coso Navy 1, Unit 1, 9 wells.

The Vonderahe 1 well is named after the family that owns the land on which it is located. The name is pronounced "Von der aye'."

OREGON'S DOGAMI REPORTS CONTINUED DECLINE IN FEDERAL ACREAGE UNDER LEASE FOR GEOTHERMAL DEVELOPMENT

In September 1989, the Oregon Department of Geology and Mineral Industries reported that the total amount of federal land leased for geothermal resources in that state has declined annually by small amounts since the peak in 1983. The consolidation of land holdings continued through 1988 with a total decrease in acreage of about 10 percent, resulting from a 53 percent decline in BLM leases and a 6 percent decline in Forest Service leases. There were 112 lease applications pending, all for Forest Service acreage. Fifty-seven were awaiting preparation of Environmental Assessments or Environmental Impact Statements, and the rest were awaiting reports from the National Park Service on the potential effects of geothermal development on thermal features.

Source: Oregon Geology, 9/89

INNOVATIVE CONCEPTS UNDER STUDY FOR LOST CIRCULATION CONTROL FOR GEOTHERMAL WELLS

The costs of the loss of circulating drilling fluids to rock fractures or pores represent an average of 10 percent of the total well costs in mature geothermal areas and often account for over 20 percent in exploratory wells and developing fields.

Thus, under the DOE geothermal R&D program, Sandia National Laboratories is researching new and less costly means of lost circulation control, including highly innovative concepts for use in major fracture loss zones -- or those greater than the diameter of the drill bit. In such cases, it is not possible to plug the loss zone with drilling mud additives without also plugging the bit nozzles. It is necessary to use a material that either solidifies after it flows through the bit or is emplaced downhole after first removing the bit.

In a joint study with Brookhaven National Laboratory, it has been found that rapid-setting, temperature-driven cement can be formulated by mixing conventional bentonite mud with ammonium polyphosphate and borax, along with magnesium oxide as a setting accelerator. To ensure that setting does not occur inside the drill pipe, two innovative concepts are being pursued.

In the first arrangement, the cement would be mixed at the surface and pumped downhole, but with the MgO accelerator shielded from the other cement constituents by an inert encapsulator. The inert material would be sheared off by fluid action at the bit nozzles, exposing the accelerator, and initiating the cement setting process. The chemical setting reaction would be further accelerated as the cementitious mud flows into the high-temperature formation. Another favorable characteristic of this material is that is expands by about 15 percent upon setting.

A downhole injector concept for emplacing cementitious mud is being developed as an alternative in case the encapsulation process proves unworkable. A coiled tubing unit or coiled hose would deliver a magnesium oxide slurry to a downhole tool (the injector), which contains a valve that opens to direct the slurry into the wellbore annulus above the bit. At the same time, a slurry of bentonite mud, ammonium polyphosphate, and borax would be pumped through the drill string and bit nozzles in the normal manner. If the bit is situated above the loss zone, the two slurry streams should enter the zone and mix, thereby initiating the chemical hardening. A feasibility study is currently underway of this concept. Its practicability will depend on the type of tubing or hose required and its cost.

Other innovative concepts under investigation include a drillable straddle packer, a tool that would employ two inflatable packer elements that straddle the lost circulation zone and divert cement into the zone, rather than allowing it to fall to the bottom of the hole; a velocity level flow transducer that would permit measurement of drilling fluid flow rates by detecting both the fluid level and the velocity in the inclined return line and combining the data to indicate flow rates.

CALIFORNIA

STATE'S ENERGY DEMAND TO INCREASE THROUGH YEAR 2010

According to a forecast adopted by the California Energy Commission, over the next 20 years peak demand for electricity by California's consumers, businesses, and industries will grow by more than 23,000 megawatts (the equivalent of providing energy to power 23 million additional homes). This represents an average growth rate of 2.7 percent per year and is approximately a 50 percent increase over current peak demand.

The forecast shows a demand increase of more than 2,000 MW compared to the last forecast the Commission prepared in 1988, with significant additional demand expected for the planning areas served by Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company.

"California is faced with important decisions about energy demands as we approach the next century," said Energy Commissioner Richard A. Bilas, presiding member of the 1990 Electricity Report Committee, which oversees electricity planning. "Energy is a driving force for our state's economy, and we must produce energy cleanly and cheaply if we are to grow and prosper."

For the first time, the adopted demand forecast explicitly takes into account the impacts of air quality rules adopted by the South Coast Air Quality Management District. The district has adopted control measures for reducing emissions from fuel combustion, including measures that require using electricity instead of other fuels in industrial facilities and fleet vehicles.

The Commission will determine the best mix of alternatives available to utilities for meeting future demand balancing environmental, energy security, and economic concerns and goals. The principal alternatives include:

- conservation and energy efficiency
- modernization of aging power plants
- construction of new, efficient gas-fired plants
- development of alternative technologies (such as solar, wind and geothermal)
- out-of-state power purchases

CITY OF LOS ANGELES SEEKING NEW POWER CAPACITY; WILL DEVELOP COSO GEOTHERMAL LEASES

The Department of Water and Power of the City of Los Angeles is soliciting offers to supply electrical generating capacity for a total of 600 MWe to be brought on line in increments between 1996 and 2000. The preferred generation resource characteristics are those that:

- Offer low-cost, reliable, and long-term supplies of electricity to the department's customers through the efficient utilization of fuel and generation facilities for both utility and non-utility processes.
- Increase the diversity of the department's generation resources.
- Allow the department's system operators full control over the scheduling and dispatching of the resource.
- Ensure that the department's supply of electricity is based on a fuel supply that is low-cost, reliable, and diversified.

- Will result in an overall improvement in air quality within the Los Angeles Basin and enhance the ability of the department of comply with the South Coast Air Quality Management District's regulations in a cost-effective manner.

- Provide identifiable social and economic benefits to the industries and people of the Los Angeles Basin.

- Provide a maximum of 250 MW from any single generation resource.

Further details on the solicitation may be found in the Geothermal Resources Council Bulletin of September 1990.

A separate Request for Proposal has been issued for development of the Department's geothermal leases at Coso.

LEGISLATION INTRODUCED TO EXPAND GEOTHERMAL GRANT PROGRAM

Legislation has been introduced in the California State Senate to expand and improve the Geothermal Grant and Loan Program operated by the California Energy Commission (CEC). Funding under this program may be used for geothermal planning, resource development, and impact mitigation. Since its establishment by the legislature in 1980, the program has provided funding totaling more than $17 million for over 100 projects throughout the state.

The legislation, if enacted, will modify the funding and repayment process to allow greater flexibility in the types of projects funded and will expand funding eligibility to include private entities, now allowed to participate only through partnerships with local government entities.

Project funds are currently awarded as part of the annual budget process and loans must be repaid within a maximum of 6 years. The legislation will change the funding process to a continuous one and extend the maximum repayment period for loans to 20 years.

Source: Geothermal Resources Council Bulletin 4/90

CALIFORNIA CEC ADOPTS GEOTHERMAL GRANT AND LOAN PROGRAM FOR FY 1990-91

Five projects were recommended by the California Energy Commission in April for funding from the geothermal grant and loan program for FY1991. Next step was to be appropriation by the legislature in the State budget, effective July 1, 1990. Based on the historical record, little or no opposition was expected in the legislature.

While not tops among the recommendations, a proposed grant of $554,000 would allow Lake and Sonoma Counties to conduct studies at The Geysers. The counties will contribute $73,500. The studies will seek to: (1) determine if additional sources of water for injection in the steam fields are available; (2) identify environmental, legal, and economic constraints associated with the use of the water; and, (3) share part of the costs of reservoir and power plant research, analysis, and testing (supervised by the Technical Advisory Committee) in determining the most efficient use of the declining steam reserves at The Geysers. (See related article in DEVELOPMENT STATUS.)

The largest award was for $1.5 million to Mono County to cost-share $1.2 million with the Sandia National Laboratories in the completion of Phase II of DOE's magma energy exploration well in the Long Valley Caldera and, when Phase II has been completed, to cost-share the remaining $300,000 in Phase III. The CEC would consider development risks at that time. (See related article in FEDERAL BEAT.)

Another large allotment was to the Modoc Joint Unified School District for a direct use project to (1) deepen the production well at the high school, $192,043, and, (2) drill a new production well near the middle and elementary schools, $326,704. The District will cost-share $518,746.

South Lake County Fire Protection District would be provided $12,215 to cost-share in hazardous material response and heavy rescue training for District personnel. An additional $19,700 would be provided for equipment on condition that the county match it from its county-of-origin funds. The maximum funding recommended by the CEC staff was $31,915, while the District would contribute $205,200. After a spirited defense of the District's original request by Jan Mariano, the District's Project Coordinator, the CEC contribution was raised to a total of $233,615, which would include specialized units, one to be stationed at Cobb and the other at Loch Lomond, where they would be closer than other rescue equipment to The Geysers.

Kelseyville Fire Protection District would be provided $6,000 to cost-share in hazardous material training for its personnel, and an additional $18,550 for equipment, provided Lake County will match it. The Department of Health Services also participates in the funding of this program.

Source: Geothermal Report 5/1/90

GEOTHERMAL LEASING OF CA SCHOOLS LANDS TOPPED $5 MILLION IN FY 89

The California State Lands Commission has reported that geothermal leasing of California School Lands in FY1989 exceeded $5 million and represented the "vast majority" of such revenues. These revenues go mostly to the Teachers Retirement Fund under a law enacted about 10 years ago. The SLC report was made to the Teachers Retirement Board and the legislature. It warned of The Geysers steam decline, and noted the work of The Geysers Technical Advisory Committee, in which the SLC participates.

Source: Geothermal Report 5/1/90

CEC INAUGURATES "ENERGY EXPORT BULLETIN"

The Energy Technology Export Program of the California Energy Commission has begun publication of an "Energy Export Bulletin" to enhance the competitiveness of California energy companies in the international marketplace. The bi-monthly Bulletin provides information on program activities as well as leads on energy project opportunities.

The following geothermal power plant projects were listed in the June/July 1990 issue:

Location	Size (MWe)	Tender Date
Dieng, Central Java, Indonesia	55	1991
North Sulawesi, Indonesia	15	1990
Darajat, Indonesia	110	1990
Salak, Indonesia	110	1994
Kerinci, Indonesia	5	1991

The export program assists California-based companies in areas such as government-to-government contacts, buyer/seller forums, trade missions, reverse trade missions, technical exchange missions, marketing plans, financing evaluations, trade laws and regulations, promotional materials, international conferences and workshops, and project development. For more information on the program call Tim Olson, Program Manager, at (916)324-3449 or FAX (916)327-1879.

HAWAII

HAWAII DEEP WATER CABLE TEST

The Flexservice 3 returned from the Alenuihaha Channel (between Hawaii and Maui) on November 22, 1989, after successfully completing a week-long series of deployment tests of a 26,000 foot surrogate deep sea cable similar to the type that could electrically interconnect Hawaiian Island energy sources and markets. The tests, which involved both the laying and retrieval of the cable, were the final major steps in the last phase of the Hawaii Deep Water Cable Program for which Hawaiian Electric Company is the primary contractor.

The cable-laying Flexservice 3 had the responsibility of properly positioning itself and feeding out cable following the direction from a sophisticated control system which was a marriage of several state-of-the-art computer programs and data-collecting devices. The programs and devices interacted with each other to constantly evaluate the conditions on the vessel, in the water, and on the ocean floor. The result was a "real time" model of the cable as it was suspended below the ship. On the basis of the model, ship operators were able to make forecasts of what would happen next. They then utilized the data to position other support craft and adjust cable tension as technicians laid or retrieved the cable.

Two other ships assisted in the tests. The Kila, mother ship of the submersible, Pices 5, examined the ocean floor and the cable. With the Pices 5, researchers were able to look for signs of improper tension or coiling of the cable. The second ship, the Kaimalino, monitored and evaluated environmental factors such as ocean currents and communicated data to Flexservice computers.

Source: Geothermal Resource Council Bulletin 12/89

MONTANA

MONTANA HOT SPRINGS GROWS FRUITS AND VEGETABLES

Hunter's Hot Springs, once a landmark in Park County, is now a growing greenhouse operation where fruits and vegetables are being grown by a Japanese businessman who eventually hopes to build a resort where guests will dine on the organically grown produce. Jukio Hashimoto, chairman and founder of the Tokyo-based firm Naturally Yours, acquired the hot springs and 2,000 acres last fall through Natural Foods U.S.A., a Beverly Hills, Calif., subsidiary. A 1,800 square foot greenhouse is currently in operation under the management of Ken and Suzie Hartwig, and Hashimoto has announced plans to add 12,000 to 13,000 square feet of space for further testing.

Hashimoto has also closed a deal for an additional 1,350 acres adjacent to his current land holdings. Plans call for eventually having a total of 5,000 acres.

Source: Standard, Butte, MT (As published in the Geo-Heat Center Quarterly Bulletin, Spring 1990.)

NEVADA

COURTHOUSE GEOTHERMAL SYSTEM UP AND RUNNING

Geothermal heating is now being used in the Elko County Courthouse. The geothermal system -- using geothermally heated water, a heat exchanger, and radiators -- cost the county $230,000, which included piping to the courthouse, repiping within the courthouse, engineering fees, and radiators for the individual offices and rooms. On top of that, the county was forced to spend $100,000 to remove

asbestos that was used to insulate the old pipes.

The savings of using geothermal heat rather than natural gas has been estimated at $5,000 a year, reported Mark Chilton. Chilton Engineering designed the system; Chester Plumbing and Heating installed the system; and the geothermally heated water is provided by Elko Heat Company. Chilton reported the bill for heating the courthouse in December 1988 was $2,082; in December 1989 after the system was in operation, $830.

The new system, Chilton said, involves bringing in the geothermally heated water at 77°C (170°F) to a heat exchanger in the basement of the courthouse. The geothermal water heats tap water in the exchanger; the geothermal water exits the building; and the heated tap water moves through the courthouse and into the individual radiators. These individual radiators have their own adjustments, which the old system did not.

Chilton noted that the courthouse was built in 1915, and each office has its own coal-burning pot-bellied stove. The system was modernized in 1920 by putting on oil-burning boiler in the basement and water pipes throughout.

Source: Geothermal Resources Council Bulletin 2/90

NEW MEXICO

NEW MEXICO GREENHOUSE INDUSTRY CONTINUES RAPID GROWTH

J&K Growers, originally from Pennsylvania, is the most recent commercial greenhouse operator to relocate to New Mexico with the assistance of the Southwest Technology Development Institute (SWTDI). In August 1988, following a nationwide search for a location to establish a new greenhouse business, John and Kerry Krumrine came to Las Cruces to gain production experience in the geothermal greenhouse research and incubator facility operated by SWTDI on the New Mexico State University campus. The Krumrines learned of the SWTDI activities through greenhouse industry associates and from a feature article published in the April 1988 issue of *Grower Talks*, a respected national greenhouse industry trade journal. Although other southwestern locations were considered, availability of space for lease in the incubator facility along with the responsive technical and business assistance provided by the SWTDI staff convinced the Krumrines to select Las Cruces.

Thirteen months after first occupying the incubator facility, J&K Growers broke ground for a 21,000-square-foot commercial greenhouse adjacent to the New Mexico State University campus. Current plans call for an orderly 10-fold expansion to 5 acres by 1994. The first products, a variety of potted plants and bedding plants, were shipped in April 1990.

J&K Growers is the third consecutive occupant of the research and incubator facility to construct new commercial greenhouses in New Mexico since the facility was completed in mid-1986. This facility is the first of its type in the United States. Design and construction of the facility was financed by New Mexico Research Development Institute, New Mexico State University, and a number of private-sector sponsors including greenhouse equipment suppliers.

Flores de New Mexico, Inc., the first occupant, built a 10-acre greenhouse complex on the NMSU campus in 1986-87. Aldershot of New Mexico, which has operated a 12.5-acre greenhouse south of Las Cruces since 1986, purchased this facility in late 1989. The second leasee, Masson Southwest, Inc., erected four acres of state-of-the-art geothermal greenhouses near Radium Springs, north of Las Cruces in 1987. Masson Southwest has three and

one-half additional acres of greenhouses under construction and has plans for a total of 40 acres at the Radium Springs site.

The SWTDI 12,000-square-foot incubator facility has been continuously under lease to commercial growers since June 1986. Clients typically remain in the facility for one to two years. One of the present lesses, Plant Production Technologies, was founded by an NMSU student, to grow and market tree seedlings for reforestation projects in the U.S and Mexico. Several international and domestic companies have expressed interest in leasing space as soon as current tenants complete their testing programs.

Information on the greenhouse research and incubation facility and technical assistance available may be obtained from Dr. Rudi Schoenmackers, SWTDI director, at (505)646-1846

Source: Geo-Heat Center Quarterly Bulletin, Spring 1990.

OREGON

LOAN SOUGHT FOR GEO SYSTEM

The city of Klamath Falls has received an Oregon Department of Energy loan to help put the city-operated downtown geothermal heating system, off-line since February 1986, back in operation. Members of the Klamath Falls City Council authorized the application for a $224,380 loan through the department's Small Scale Energy Package program. Construction is expected to be completed by the end of December 1990.

Reconstruction of a little more than a mile of the system in the downtown core will cost about $593,700, Joe Riker, city planning director, reported to the council. The city recovered $394,530 in a settlement with contractors it sued after leaks occurred in the system in late 1985. The loan is estimated to pay the difference.

Funds for repayment of the loan will come from revenues paid by customers on the heating loop. Estimates indicated the annual repayment amount would be $26,050, but income from the heating system would be enough to make the payment and still leave 5 percent for a contingency fund and roughly $18,100 a year for operation and maintenance of the system.

An economic analysis on the system done by VBB Pacific, a Salem consulting firm, assumed nine government buildings in the downtown area would be connected to the geothermal heating system. The study was underwritten by a grant from the state Energy Department.

Customers on the geothermal loop will see a 10 percent per year savings in their heating costs, according to the study. Assuming an annual fuel escalation rate of 5 percent over the next 10 years, and the non-inflationary nature of the downtown heating system's geothermal "fuel," it is projected that the system's customers could receive savings of up to $23,000 a year by the year 2000, with nine buildings on-line, Riker reported.

Source: In part, Geothermal Resources Council Bulletin 2/90

CONFERENCE ON ENERGY AND THE ENVIRONMENT TAKES LOOK AT WORLDWIDE GEOTHERMAL DEVELOPMENT

The conference on Energy and the Environment in the 21st Century, held at the Massachusetts Institute of Technology, March 26-28, 1990, featured presentations on geothermal energy in two sessions -- "Electric Power Systems" and "Advanced Energy Supply Technologies." This article focuses on the information provided on worldwide geothermal development during the former session; the environmental implications of geothermal development are reported under DEVELOPMENT STATUS.

Appearing as a panelist in the session on electric power systems, Ronald DiPippo, professor and chairman of the Mechanical Engineering Department, Southeastern Massachusetts University, noted that 20 countries -- representing all six of the non-polar continents -- now have operational geothermal power plants. Thirty-five additional countries have power plants either under construction or in the advanced planning stage, exploration programs underway or planned, or appear to hold promise for geothermal development. All commercial development uses or is directed toward the use of hydrothermal fluids, the only form of geothermal energy so far proven commercially and economically feasible, Dr. DiPippo said.

He noted that from 1960 -- when the first geothermal plant came on line in the U.S. -- to 1989, worldwide growth in installed capacity has been impressive, particularly in the U.S. On average, the U.S. has increased its geothermal capacity by 30 percent annually over this period. During the 1980s the average annual growth rate was 13 percent. The total worldwide capacity -- now nearly 6000 MWe -- grew at an average annual rate of nearly 14 percent from 1960-1989, and at about 12 percent in the 1980s.

Carel Otte, consultant and retired president of Unocal's Geothermal Division, stated that geothermal power plants of 50 to 100 MWe appear to be an optimum size for the number of wells required, well spacing, pipeline distance, and size and cost of the power generating facilities. At increments of 100 MWe, geothermal power is economically competitive, he said, with energy produced by fossil fuel and nuclear plants of 750-1,000 MWe that have the advantage of economy of scale. This makes geothermal power a very attractive resource for power generation in the developing countries which cannot accommodate such large increments of power, he concluded. In addition, the shorter lead time and construction period for geothermal plants allow for more system flexibility.

As an example, he noted Unocal's involvement in the development and operation of two geothermal hot water fields on the island of Luzon in the Philippines, each with an installed generating capacity of 330 MWe, providing approximately 30 percent of the power produced on Luzon. Unocal is also developing a geothermal field on the island of Java in Indonesia with planned installation of 165 MWe consisting of three 55 MWe plants. Additional potential exists in those countries, he said.

Dr. Otte added that countries that do not have indigenous fossil fuels, such as the Philippines, consider the development of geothermal power as an insurance against volatile world oil prices and supply interruptions. It adds to national security, saves foreign currency, and assists in developing a greater self-reliance. In Indonesia, geothermal power is developed to permit the country to export more oil to help their balance of payments.

A monograph volume of the conference proceedings will be published by the MIT Press in January 1991. This GPM article was prepared from the Preprint Volumes with the permission of the individual authors.

Countries With Very Good Prospects for Geothermal Power Generation by the Year 2000

- Bolivia
- Canada
- Chile
- Costa Rica
- Djibouti
- Ethiopia
- Guatemala
- Honduras
- India
- Saint Lucia
- Thailand

Source: Ronald DiPippo, Southeastern Massachusetts University

Countries with Interesting Geothermal Prospects Where Further Exploration May Prove Commercial Geothermal Prospects

- Algeria
- Austria
- Brazil
- Burma
- Columbia
- Dominica
- Dominican Republic
- Ecuador
- Grenada
- Greece
- Haiti
- Hungary
- Iran
- Israel
- Jordan
- Madagascar
- Nepal
- Pakistan
- Panama
- Peru
- Portugal (Cape Verde)
- Spain (Canary Islands)
- Sri Lanka
- Tanzania
- Uganda
- Venezuela
- Vietnam
- Yugoslavia

Source: Dickson and Fanelli, 1988; DiPippo, 1980.

DEVELOPING COUNTRIES PLAN TO MORE THAN DOUBLE GEOTHERMAL POWER CAPACITIES DURING THE 1990s

According to a World Bank study, the electric utilities and governments in some developing countries that are struggling with debt repayment problems and low economic growth rates are continuing with ambitious expansion plans for electricity production. Plans call for an increase of about 82 percent in the 1990s, from 471 GW at the end of 1989 to 855 GW at the end of 1999 which will include an increase of geothermal power from 2 GW to 5 GW, or an increase of 0.4 percent to 0.6 percent of the total. The comparison of developing country installed capacities is as follows:

	1989		1999	
Type	GW	%	GW	%
Hydro	185	39.3	32.2	37.7
Geothermal	2	0.4	5	0.6
Nuclear	14	3.0	38	4.4
Oil thermal[1]	70	14.8	84	9.7
Gas thermal[2]	31	6.7	65	7.8
Coal thermal	169	35.8	341	39.8
TOTAL:	471	100.0	855	100.0

[1]Includes steam, combustion turbine, combined cycle and diesel.

[2]Includes steam, combustion turbine and combined cycle.

The projections are not a World Bank forecast, but a compilation of the programs reported by the developing states themselves. Nevertheless, it was noted, the figures send several clear messages to multilateral agencies and to companies servicing the power and construction sectors. One is the perception among developing countries that an adequate energy supply is a prerequisite for economic development. Another is the magnitude of the funds needed to support electricity generation efforts, estimated at $1 trillion.

The foreign exchange requirement is expected to average $38 billion per year, or roughly 15 times the World Bank's present level of annual power lending. Thus, the report concluded that there will be a great need for power lending to developing countries from many sources in the 1990s.

The report is titled *Capital Expenditures for Electric Power in the Developing Countries in the 1990's.* It is World Bank Energy Series Paper No. 21 and is available from the Bank.

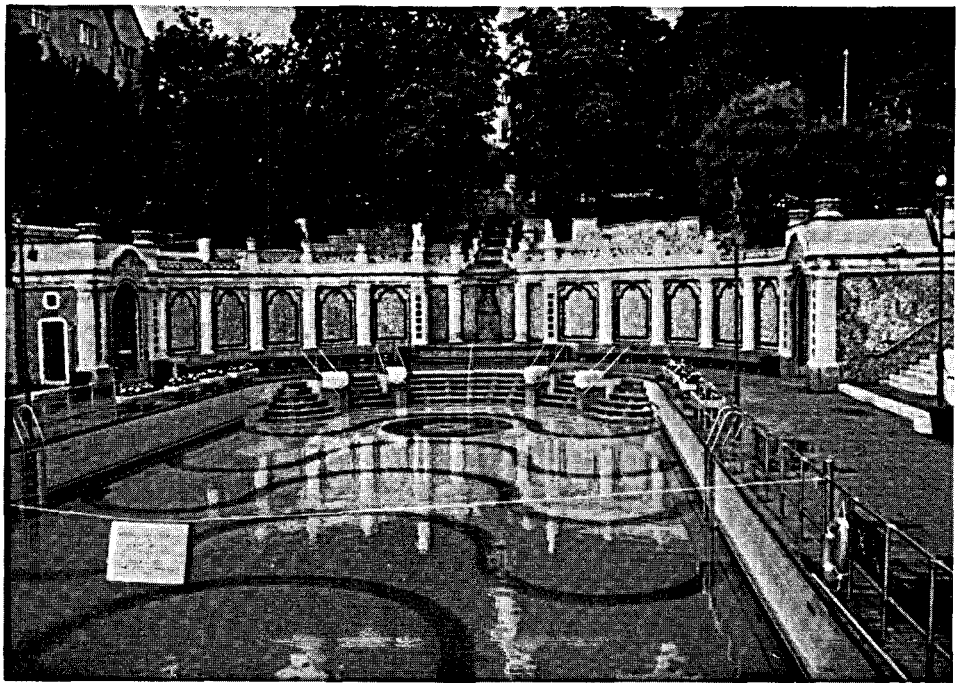
Source: United Nations's "Development Business," 5/90.

GEOTHERMAL DEVELOPMENT IN HUNGARY

HUNGAROPRESS, Budapest, in late 1989 issued an interesting review of the status of geothermal development in Hungary, one of the eastern European countries that is moving toward re-entrance into the main stream of the world's economy.

The review contended that Hungary "occupies about third place, worldwide, in the utilization of thermal waters of less than 100°C (212°F)." In the past four years, the Geothermal Technical Development Cooperative "has converted 5,000 flats in six towns to geothermal energy from oil and gas, both for the heating of homes and for warm water." The review added that the cooperative believes an additional 20,000 to 30,000 flats could be converted.

The report said, "Hungary possesses excellent resources for the recovery and utilization of geothermal energy. Best results have been achieved in agriculture, where many hot houses are heated with thermal water. Other uses include poultry breeding stations, drying equipment, etc."



Geothermal Pool in the Hotel Gillieret in Budapest

(courtesy of John Lund, Geo-Heat Center)

The cooperative has entered a 50-50 joint venture, known as Geotherm Consulting LLC, with Virkir Orkint Co., Reykajavik, for the purposes of prospecting for and development of "geothermal energy and thermal waters both for power generation and thermal-medicinal purposes." The joint venture will operate in Hungary and in "third-Eastern and Western states."

The Nordic Investment Bank, the joint development bank of the Nordic states, was said to be ready to grant special-preference loans to finance continuation of Hungarian projects, "subject to the Icelandic partner participating in the project." The bank's board, it was reported, approved a $10 million revolving credit for use in development of Hungarian geothermal projects, "including the expansion of thermal-medical facilities." Hungary has several noted geothermal health spas and baths.

Source: Geothermal Report 4/15/90

DIRECT USE PROJECT HEATS AND COOLS CANADIAN UNIVERSITY

A $2.8 million project using warm water from five 120-meter wells began operation in mid-February 1990 heating nine of the 26 buildings of Carleton University in Ottawa. It is expected to save $450,000 in the university's annual gas and electricity bill. It will provide cooling services in the summer.

The direct use geothermal project was conceived in 1984 and constructed by Dalton Minty, a former engineering professor at Carleton, who has been associated in similar community-type projects in Scandinavia. The central government contributed $400,000, the Ontario government $224,000, and the University the remainder.

Source: Geothermal Report 4/15/90

ASIAN DEVELOPMENT BANK WILL ASSIST PHILIPPINE GEOTHERMAL EXPANSION

The Asian Development Bank has extended a $160 million loan to the Philippine National Power Corporation to initiate six 20 MWe geothermal stations among other facilities to improve and expand the national power system. *Modern Power Systems* of London said, in reporting the action in February 1990, that the work will include transmission links of major islands to the Luzon grid. Small generators are scheduled for 15 lesser islands of the archipelago. The new geothermal stations are planned for Mindanao, the large southern island.

Source: Geothermal Report 3/15/90

IGA CALLS FOR PROPOSALS TO HOST THE SECRETARIAT

In accordance with the Bylaws of the International Geothermal Association (IGA), it is intended that different organizations and countries should be offered the opportunity of hosting the Secretariat at different times. The Secretariat is currently based at the International Institute for Geothermal Research in Pisa, Italy, and its term of office is due to expire at the end of June 1991. Accordingly, the IGA invited bids to host the Secretariat for its second term, to commence on April 1, 1991 (allowing a 3-month hand-over period) and continuing for a minimum of 3 years.

The Secretariat is responsible to the Secretary, an elected officer of the Association, for administering the procedures, finances, personnel, and other routine business of the Association. The Secretariat is also expected to maintain offices and office hours suitable for the reception of visiting members, for the maintenance of the Association's records and files, and for the conduct of daily business. As the official language of the Association is English, a good knowledge of English would be required on the part of at least the key personnel.

The function of Head of the Secretariat is formally separate from that of the Secretary. Experience suggests that this person would need to devote at least 50 percent of his/her time to this work, and would require the support of at least two part-time clerical/secretarial staff.

Any country, or organization, is eligible to submit a proposal to host the Secretariat, provided only that such hosting would not infringe the Charter of the Association (non-profit, non-political, etc.) In preparing proposals, however, it should be recognized that IGA has only limited funds available; financial support from the host organization would almost certainly be essential. The deadline for receipt of proposals was October 30, 1990.

Source: Geothermal Resource Council Bulletin 4/90

GRADUATION AT THE GEOTHERMAL INSTITUTE

This year marks the graduation of the 12th class of the Geothermal Institute, at the University of Auckland in New Zealand. The Institute was founded in 1979 on the initiative of a small group of people in the United Nations Development Programme Headquarters in New York, the New Zealand government, and the University of Auckland. Funding for the Institute was initially provided jointly by the United Nations Development Program and the New Zealand government, but currently all funding is by the Ministry of External Relations and Trade (MERT) of the New Zealand government. To date, 300 students from 28 countries have graduated from the Institute, and each year a workshop is held to which students past and present have contributed. The

workshop provides students with the opportunity to exchange experience and information on an informal basis, and this is one of the most important aspects of this meeting.

This year, 30 students from 15 countries are studying at the Institute. The Convener is Dr. C. C. Harvey, Geothermal Institute, University of Auckland, Private Bag, Auckland, New Zealand.

REVIVAL OF CANADIAN CREW ENERGY'S MEAGER CREEK PROSPECT

BC Hydro, of Vancouver, Canada, advertised in June 1990 for proposals for development of geothermal energy for the domestic market, giving rise to reports that Canadian Crew Energy Corp., with its 30-year lease on the Meager Creek prospect, may yet be able to find a market for a substantial block of power. BC Hydro, a Provincial utility, is marketing much of its large hydroelectric surplus in the U.S. Crew offered to develop Meager Creek a year ago, but BC Hydro, which itself had earlier drilled three exploratory wells at Meager Creek, decided on other sources for the energy it needed on that occasion. BC Hydro abandoned the Meager Creek lease, reportedly because of spending strictures, which Crew then picked up. Meager Creek is near Pemberton, about 100 miles north of Vancouver.

Actually, BC Hydro made two additional geothermal prospects near Terrace available for bids in its call, but Meager Creek is the only geothermal lease so far issued in British Columbia. John Schreiner, writing the *The Financial Post*, Toronto, said that "with Crew's head start" he found "it hard to conceive" how any competitor could meet BC Hydro's August deadline for receipt of bids. John Darch, Crew's President, was quoted by Schreiner as saying, "...there is only one contender."

After last year's failure, Crew sold 40 percent of its interests to Pennant Holdings, Ltd., of Australia. It has recently been rumored to be seeking a U.S. joint venture. Heretofore, Crew has been contemplating a 20 MWe station for a starter. The call by BC Hydro may change all of its plans.

Source: Geothermal Report 8/1/90

1989 GRC MEETING HELD IN SANTA ROSA FOCUSED ON THE GEYSERS

In October 1989, 556 members of the geothermal community convened at the GRC annual meeting in Santa Rosa, California -- the gateway to The Geysers. About 45 percent of the 98 papers submitted concerned The Geysers field, covering environmental issues, production facilities, reservoir exploration, nature of the field, and power generation. In addition, a field trip to The Geysers was offered with on-board experts to discuss everything from exploration drilling to plant operation.

Non-Geysers sessions covered exploration -- with several papers devoted to foreign fields -- geochemistry in development, operational techniques, and power generation. In addition, one session was devoted to alternative uses of geothermal energy, and a second field trip visited several geothermal direct use applications in areas adjacent to The Geysers.

The Joseph W. Aidlin Award for outstanding service to the GRC was presented to Jim Combs, president of GEO Inc. It was noted that his service goes back to the early 1970s, and his contribution in time and energy have been matched by only a few of his peers. The Pioneer Award for outstanding service to the geothermal community was given to ENEL, the Italian National Utility, best known for development of the dry steam reservoir at Larderello. Raffaele Cataldi of ENEL accepted the award.

Source: Geothermal Resources Council Bulletin 12/89; Transactions, Vol. 13, 1989.

1990 INTERNATIONAL SYMPOSIUM ON GEOTHERMAL ENERGY COVENED IN HAWAII

A five-day International Symposium on Geothermal Energy was convened by the Geothermal Resources Council at Kailua Kona, Hawaii, in August 1990. The symposium, which also served as the GRC annual meeting, provided a forum for exchange of new and significant information on all aspects of the exploration and use of geothermal resources. The symposium consisted of two major sessions:

- Country Updates: In papers summarizing progress in exploration, development and utilization since 1988, the year of the last international symposium, and
- International Research and Development: Major advances since 1985 in technology, utilization, and understanding of geothermal resources.

Financial assistance provided by the following sponsoring organizations supported the attendance of 55 international participants:

- ENEL - The National Power Authority of Italy
- Estate of James Campbell (Hawaii)
- Hawaiian Electric Company
- Kamehameha School/Bernice Pauahi Bishop Estate
- U.S. Agency for International Development
- U.S. Department of Energy
- U.S. Trade and Development Program
- World Bank

DOGAMI REPORTS 1988 GEOTHERMAL ACTIVITIES IN OREGON

In a section titled "Geothermal Exploration in Oregon, 1988," the publication *Oregon Geology* of the Oregon Department of Geology and Mineral Industries describes the agency's applied geothermal research on areas in the Cascade Range. It also identifies USGS work in the area, and notes that papers presented at the USGS-sponsored Red Book Conference on the Geological, Geophysical, and Tectonic Setting of the Cascade Range have been published in USGS Open File Report 89-178. DOGAMI Open File Report 0-88-5, entitled Geology and Geothermal Resources of the Breitenbush-Austin Hot Springs Area, Clakamas and Marion Counties, Oregon, is available from the Department.

GEOTHERMAL RESOURCES COUNCIL FORMS AD-HOC PUBLIC INFORMATION COMMITTEE

The GRC Ad-Hoc Public Information Committee held its first meeting on December 5, 1989, at the GRC office in Davis, California. Its purpose is to develop strategies, relationships, educational materials, and responses to promote a broad understanding of geothermal energy and its role in energy and environmental issues.

Noting that news articles written by uninformed or special interest writers frequently paint an incorrect or adverse picture of the resource, the committee will attempt to set the record straight and fill information gaps. The California Division of Oil and Gas is supporting this effort by collecting and making available nontechnical or semitechnical literature on geothermal energy.

Source: Geothermal Resources Council Bulletin 12/89

PUBLICATIONS OF NORTHWEST POWER PLANNING COUNCIL LOOK TO GEOTHERMAL POWER

On August 27, 1990, the Northwest Planning Council issued a Working Draft Summary (Paper #90-14) of the Northwest Power Plan. Emphasizing that the summary is not in itself a draft action plan, the Council said its purpose was to "get regional input on whether we are headed in the right directions before we get down to the major decisions on policy choices the region faces within the next decade." A full draft of the power plan was expected to be completed in November 1990, and after a lengthy public comment period including hearings, to be finalized around March 1991. (NOTE: The draft Plan was released at GPM press time: Paper No. 90-18.)

The principal purpose of Issue Paper 89-36, October 16, 1989, of the Northwest Power Planning Council is to assess the prospects for meeting future Pacific Northwest electrical needs using geothermal power. The paper provides an overview of the technology of geothermal generation, and describes the geothermal resources of the Pacific Northwest, to the extent that these resources are currently understood. Estimates of the likely cost and performance of geothermal power plants in the Northwest are developed, and the environmental characteristics of these plants described. The paper concludes with a discussion of issues associated with geothermal resource development and estimates of the potential cost and availability of geothermally-generated electric energy in this region. Possible actions for resolving these issues are identified.

The Council's Issue Paper 90-5, March 19, 1989, addresses three renewable resources -- geothermal, wind, and solar -- and proposes agendas for confirming these

resources. By confirming, the Council Staff means actions that can be taken to prove their availability, performance, cost, environmental, and other relevant characteristics. The agendas were mandated by the 1986 NPPC Power Plan and are prepared for incorporation in the Action Plan of the new power plan.

The Council may be reached at 851 S.W. Sixth Avenue, Suite 1100, Portland, Oregon 97204-1348, for copies of the Issue Papers or current information regarding the power plan.

Source: In part, Geothermal Resources Council Bulletin 12/89

INDUSTRIAL CONSORTIUM FORMED FOR THE UTILIZATION OF THE GEOPRESSURED-GEOTHERMAL RESOURCE

In January 1990, the first meeting of the Industrial Consortium for the Utilization of the Geopressured-Geothermal Resource was held with 75 participants at Rice University in Houston, Texas. A second meeting was held in September 1990, at The University of Texas at Austin, Texas. The mailing list is now over 300, and the next meeting is planned to be held at Louisiana State University Rural Life Museum at Baton Rouge, Louisiana, according to Cosortium Director, Dr. Jane Negus-de Wys at the Idaho National Engineering Laboratory (INEL).

This technology transfer activity has resulted in increased industrial interest in the Department of Energy Geopressured-Geothermal program activities. A thermal enhanced oil recovery (TEOR) proposal to use geopressured-geothermal fluids is being considered for funding with cost-share from industry and the State of Texas. Industry has supplied data for collocation studies of hot brine and oil in Texas and Louisiana. The California Energy Commission has now initiated a collocation study focusing initially on Kern County in the San Joaquin Basin and on the Los Angeles Basin.

Four feasibility studies have been developed by the INEL on TEOR, direct use, use or supercritical fluid processes for detoxification of pollutants, and hydraulic conversion to electricity. The studies provide information bases for potential industrial partners in the resource utilization.

Western Resources Technology has begun development of a dozen geopressured well projects. British Gas Exploration America has leased 4,000 acres around the Hulin Well and plans to spud their first well 3/4 mile northeast of Hulin February 1, 1991. Additionally, they are proposing a cooperative effort on the Hulin testing. Dr. Wayne Steele of Anglewood, Texas, a retired medical doctor, is proposing to raise fresh water Australian lobsters in the Pleasant Bayou Well fire water pond. Additional projects such as catfish farming, crayfish, desalination plant, and agricultural greenhouse use of the resource heat are "waiting in the wings" for the DOE wells to become available for pilot use projects.

The first industry cost-share project with the Electric Power Research Institute (EPRI) was a 1 MWe hybrid power system successfully tested for eight months in 1990, at the Pleasant Bayou Well.

Interest in the resource and its use is now being shown by China, Iceland, Canada, and Japan.

Potential collaboration is being examined with the Solar Energy Research Institute (SERI), Fossil Fuel, Los Alamos National Laboratory, and several industrial components.

The CRADA document has been developed to assist and streamline cost sharing and protection of intellectual property when private industry, government, and universities work together.

For more information on the consortium please contact Dr. J. Negus-de Wys at the INEL (208) 526-1744.

UPCOMING MEETINGS, CONFERENCES, WORKSHOPS

JANUARY 1991

Winter Meeting of the National Society of Professional Engineers, New Orleans, Louisiana, January 13-19.

14th Energy-Source Technology Conference and Exhibition, Houston, Texas, January 20 -24.

First International Conference on Frontiers of Polymer Research and Industrial Exhibition on Emerging New Technologies, New Delhi, India, January 20-25.

16th Annual Workshop on Geothermal Reservoir Engineering, Stanford, California, January 22-24, Phone: (415) 723-4745.

Gas Technology Symposium, Houston, Texas, January 23-25.

FEBRUARY 1991

International IUPAC Symposium on Polymer Materials: Preparation, Characterization, and Properties-Polymer '91, Melbourne, Australia, February 10-15.

Annual Meeting of the American Association for the Advancement of Science: Earth Science, Washington, D.C., February 15-19.

International District Heating and Cooling Association 1991 Annual Meeting, University of Illinois, February 28-March 1, Phone: (202) 429-5111.

MARCH 1991

Energy in the 90's, Pittsburgh, Pennsylvania, March 11-13, Phone: (412) 624-9874.

National Geothermal Association Annual Meeting, San Fransisco, California, March 18.

Ninth Annual U.S. Department of Energy Geothermal Program Review, San Fransisco, California, March 19-21.

Demand-Side Management and the Global Environment, Arlington, Virginia, March 22-23.

APRIL 1991

23rd International Congress and Council Meeting of the International Association of Hydrologists, Puerto de la Cruz, Spain, April 15-19.

HVAC and Building Systems Congress, Anaheim, California, April 23-24.

36th International SAMPE Symposium and Exhibition: Advanced Materials - How Concepts Become Reality, San Diego, California, April 15-18.

8th Thematic Conference on Geologic Remote Sensing: Exploration, Engineering and Environment, Denver, Colorado, April 29-May 2.

MAY 1991

53rd Annual Meeting and Exhibition of the European Association of Exploration Geophysicists, Florence, Italy, May 29-June 2.

JUNE 1991

4th World Congress of Chemical Engineering, Karlsruhe, Germany, June 16-21.

JULY 1991

Demand-Side Management: Building on Experience: 5th National Demand-Side Management Conference, Boston, Massachusetts, July 30-August 1.

AUGUST 1991

26nd Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts, August 3-9, Phone: (312) 352-6611.

Biannual National Energy Program Conference, Chicago, Illinois, August 20-23.

SEPTEMBER 1991

7th International Congress on Rock Mechanics, Aachen, Germany, F.R., September 16-20.

OCTOBER 1991

International Conference and Exhibit of the Instrument Society of America, Houston, Texas. October 18-23.

MAY 1992

Geological Association of Canada/Mineralogical Association of Canada, annual meeting, Wolfville, Nova Scotia, May 25-27, Phone: (902) 426-6759.

Geological Society of America, annual meeting, Cincinnati, Ohio, October 26-29, Phone: (303) 447-2020.

OCTOBER 1993

Geological Society of America, annual meeting, Boston, Massachusetts, October 25-28, Phone: (303) 447-2020.

MAJOR SOURCES OF GEOTHERMAL INFORMATION

This section of the GPM presents a representative sample of geothermal literature which has been reported since the last issue. Wider coverage of the literature may be found in a bimonthly publication of current abstracts entitled "Geothermal Energy" 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 88-914700. The annual subscription price for six issues is $90.00 (domestic) and $180.00 (outside the North American continent). This publication typically lists each separate paper, article, or report derived from another publication, such as conference proceedings, as a separate entry. Space does not permit separate listings in the GPM; thus the following are recommended:

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

Geothermal Resources Council Transactions,
Proceedings, GRC Annual Meetings.

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

Proceedings of the Annual Geothermal Program Review
Geothermal Division, U.S. Department of Energy
Available from the National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161 (No. VII held March 21-23, 1989,
No. VIII held April 18-20, 1990)

Electric Power Research Institute
Annual Geothermal Conference and Workshop
Technical Information Center
Palo Alto, California 94303

The Geothermal Hot Line
California Division of Oil and Gas
1416 Ninth Street, Room 1310
Sacramento, California 95814

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