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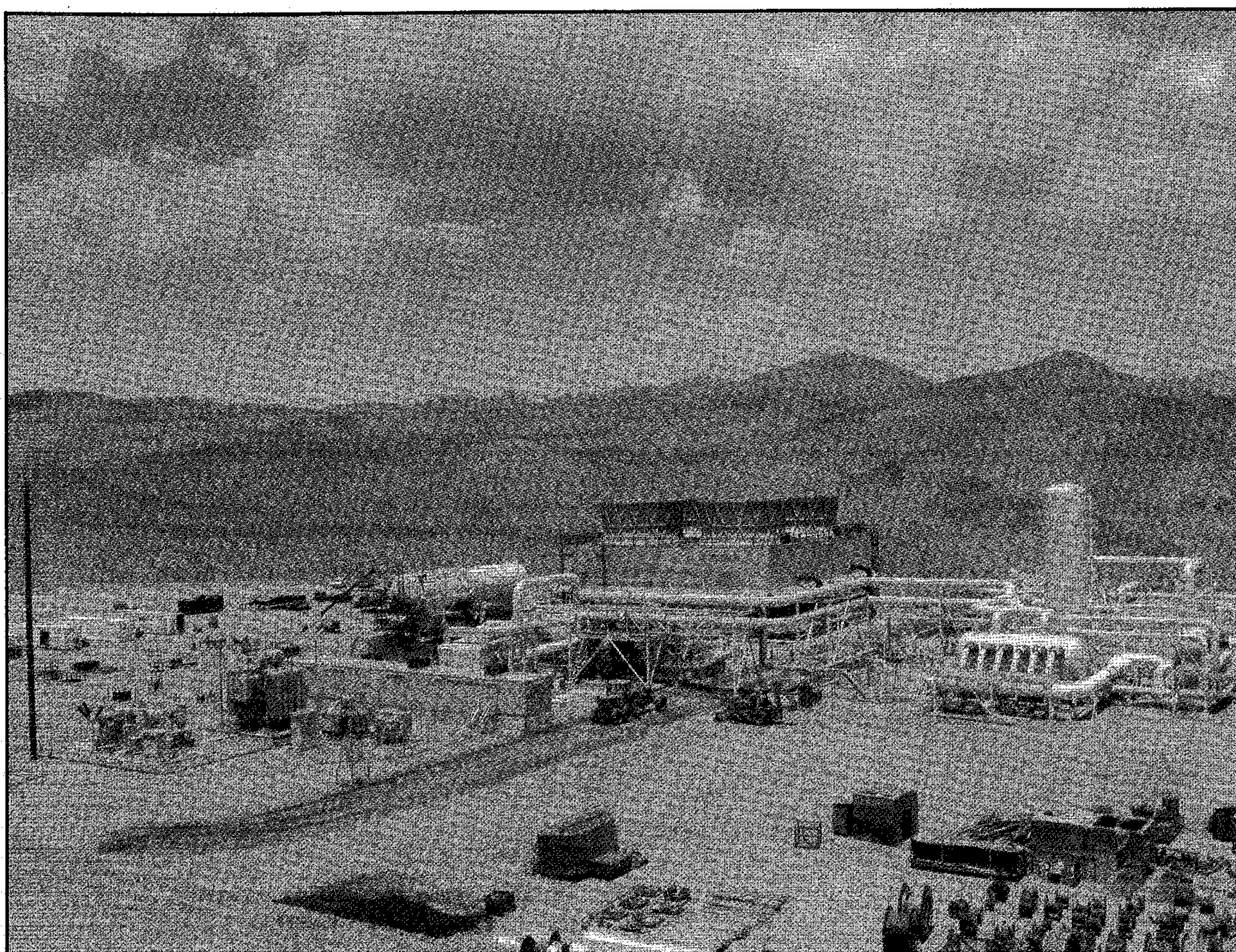

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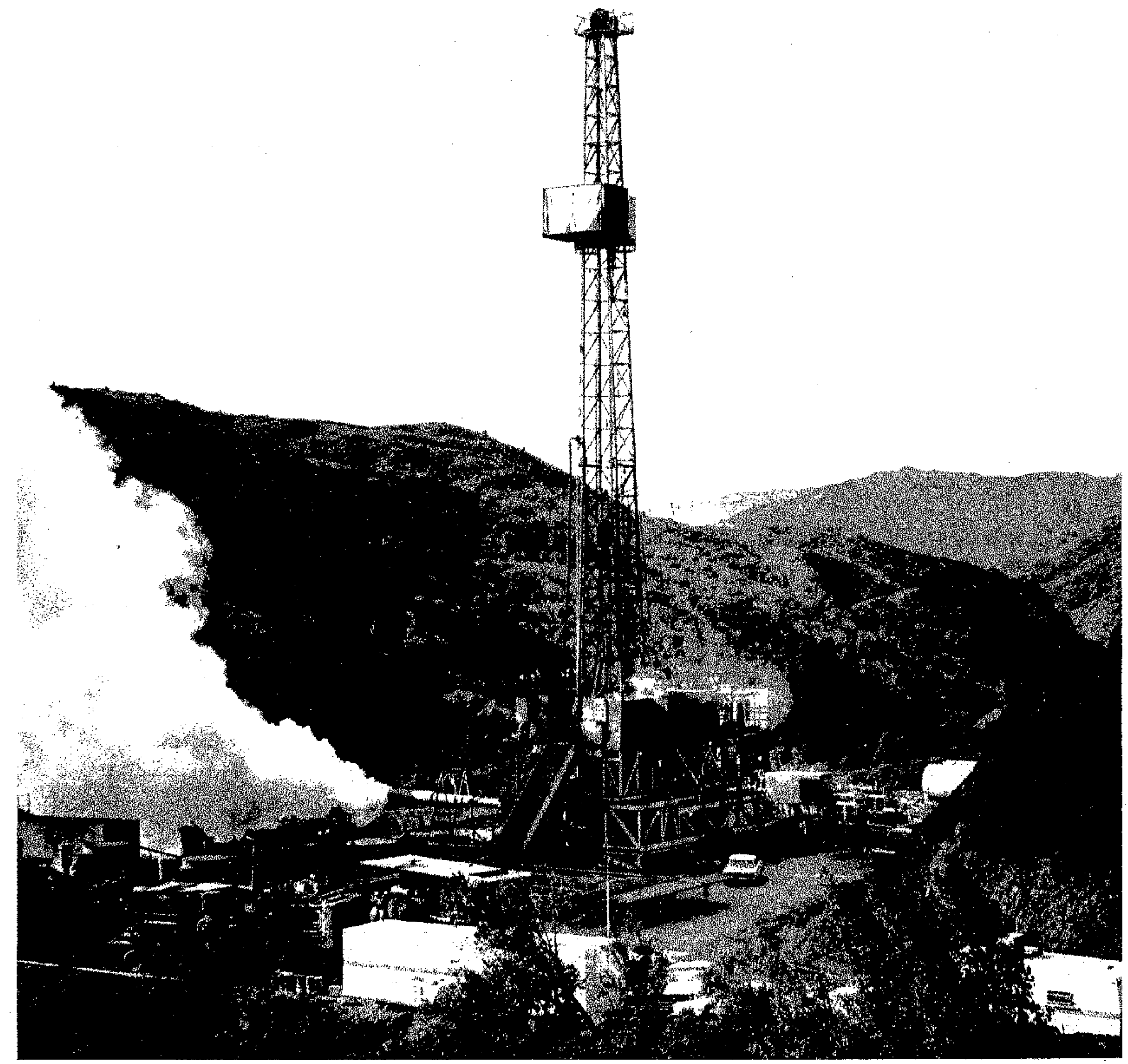

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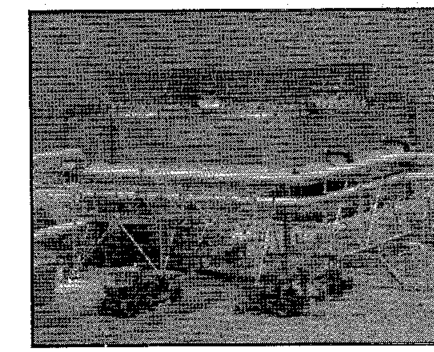
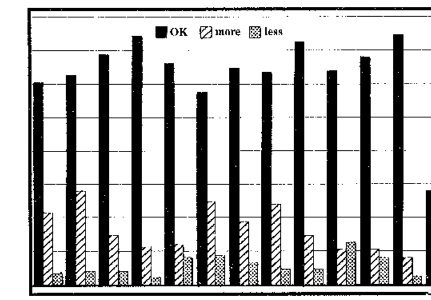


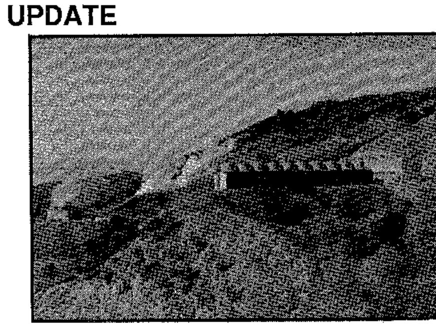
Geothermal power plant on line at Coso KGRA.

1 OUR READERS SPEAK



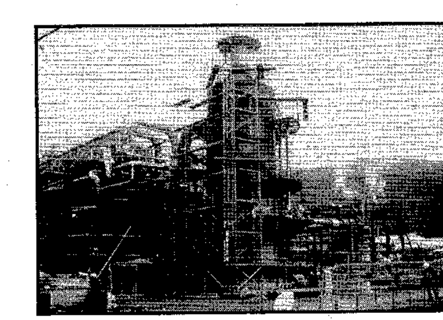
Opinions come in from the geothermal community.

12 GEYSERS UPDATE



1986 statistics from the Division of Oil and Gas.

24 GEOTHERMAL TWO-FOR-ONE



Japan combines direct-heat production and electrical power generation.

GEOTHERMAL HOT LINE SURVEY

Dear Geothermal Hot Line Readers:

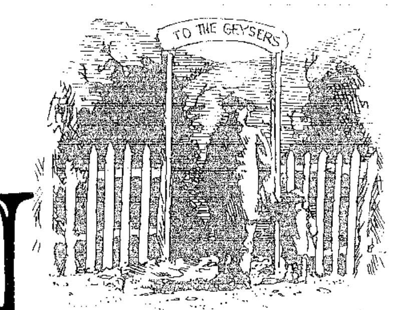
Thank you for responding to the Hot Line Readers' Survey and sending us your feelings about the publication. You included many kind comments that were gratifying to read. As part of the survey, you reviewed the Hot Line coverage of 12 geothermal subject areas and evaluated the level of technical detail in the articles.

Here are the survey results. Overall, most people expressed satisfaction with the journal as it is. However, a more unanimous agreement exists over the level of technical detail than over the subject matter chosen.

Where subject matter is concerned, most of you asked for more, not less, information on most topics. This shows the strong need, generally, for current, technical information on all aspects of geothermal energy.

What suggestions did you have for articles?

- More on markets and prices—utility and nonutility consumption data
- component and whole-system costs
- royalty and leasehold costs
- plant-component and plant-performance reviews
- scale control and corrosion control
- drilling and wellhead production techniques
- mineralization
- tectonics
- project progress reports
- actual operating problems in geothermal fields



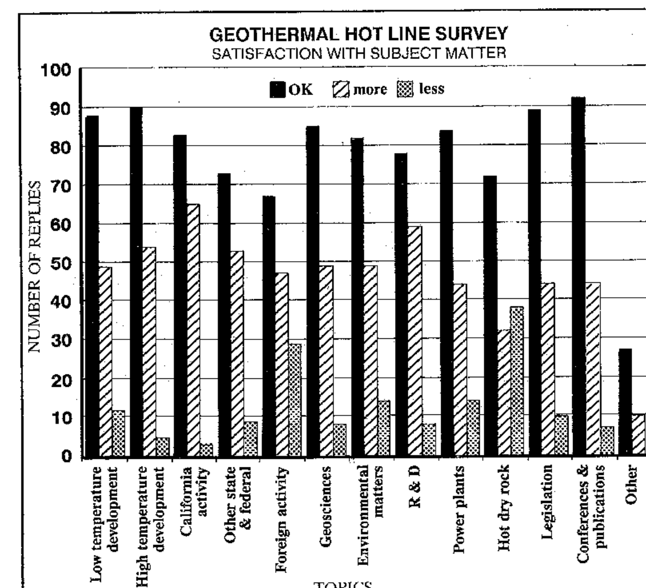
New Hot Line stories are always needed. Call with your news.

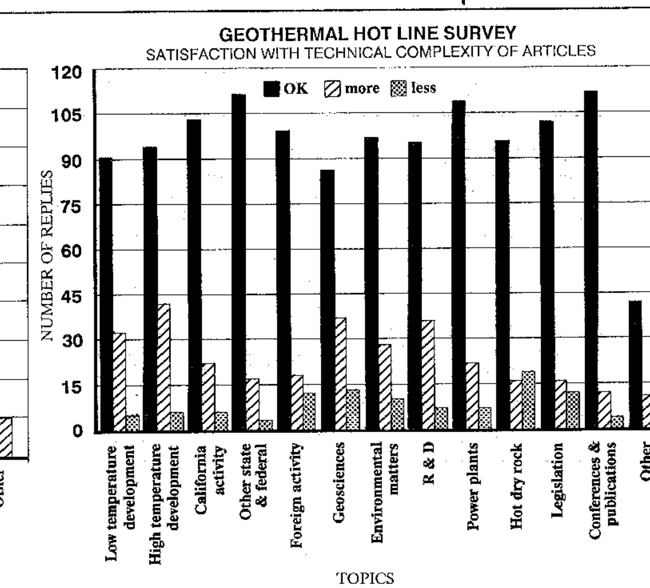
Sound interesting? If you have this kind of information, or can offer other news about your own geothermal specialty, let me know. New articles are always needed, and I can take the information down over the phone. We can prepare the final copies of any maps or diagrams you need. Photographs are always welcomed.

Some of you mentioned the Hot Line publication schedule. It is unpredictable. Officially, the Hot Line is published in July and December each year. However, deadlines are often extended due to our small staff and other project demands.

Again, thank you for responding to the questionnaire. Don't wait for another survey to get in touch. And call me with your geothermal news.

Susan

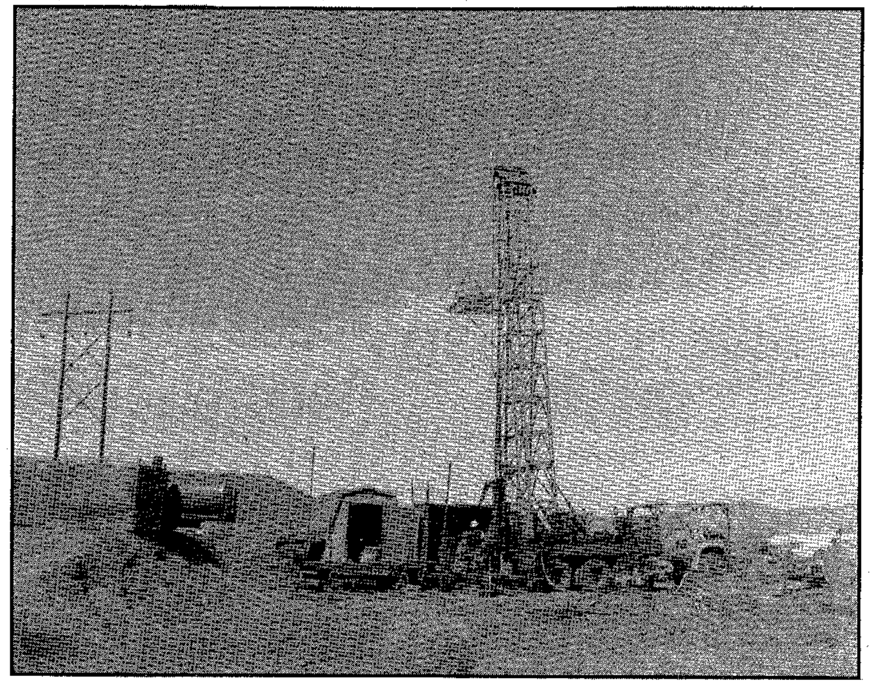




A History of the Coso Geothermal Project

July 15, 1987, 3:21 p.m., Pacific Daylight Time. This afternoon, the first geothermal power plant went on line at the Coso Geothermal Project, in the Coso Known Geothermal Resource Area on the eastern edge of the Sierra Nevada, 23 miles north of Inyokern, California.

The Coso project is the product of a unique partnership, begun in 1979, between the U.S. Navy and California Energy Company, Inc. Together, the two organizations are developing a large geothermal resource at an unusual site—on withdrawn and acquired lands in a major weapons test range. This article describes the history of the Navy-California Energy Company partnership and the Coso Geothermal Project.



Slim-hole core rig used to provide subsurface geologic data to depths over 4,000 feet. A new power line to serve the Coso area is in the background. (February 28, 1987.)

Since the 1920's, the site of the Coso Geothermal Project has been recognized in the literature as a geothermal prospect area and potential electrical power-generation site. The geothermal potential was addressed by the Navy, who became the area landlord in 1942 as a result of Public Land Order 431. The basic questions faced by the Navy were:

a. Should any sort of resource development be encouraged or allowed within the base boundaries?
b. Is there any reasonable way in which development could be done to benefit the Navy as well as private industry?

The answers have resulted in today's multiple, land-use program at the Naval Weapons Center, with surface management by the Navy, subsurface management by both the Bureau of Land Management (steam act leases) and the Navy (Navy development contract), and mutually separate geothermal development projects by private venture capitalists, private industry, and public utilities.

In 1964, the Navy began to evaluate the production potential of the Coso geothermal prospect, publishing a paper entitled "Coso Hot Springs - a Geologic Challenge (NOTS TS 64-180 June 1964), authored by Dr. Carl Austin. That paper presented the results of geothermal studies at Coso. The studies were sponsored, in large part, by Kevil Mining (Teck Corp., Vancouver, Canada).

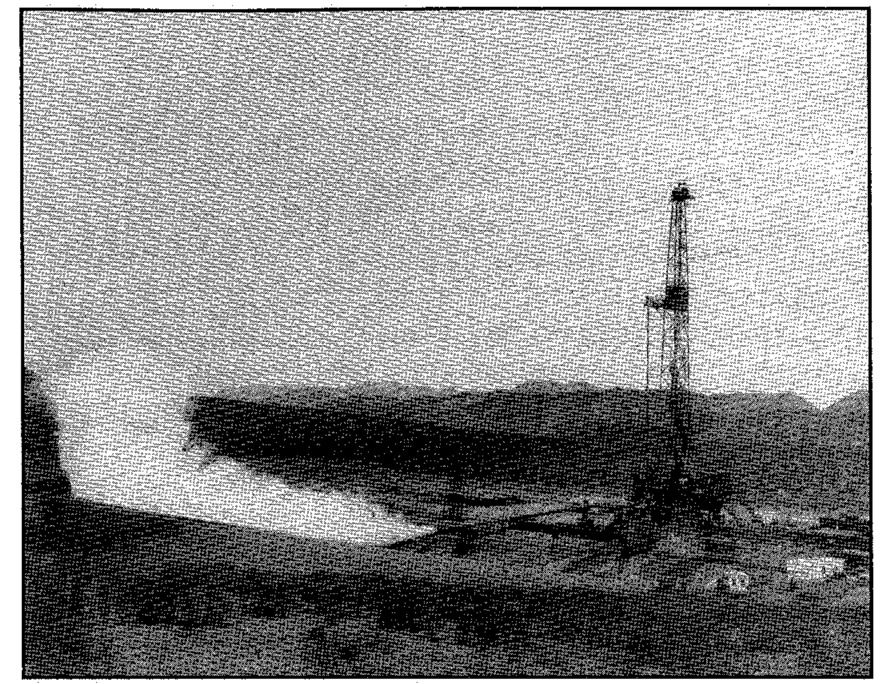
In 1966, the Navy drilled the first modern steam well at Coso to obtain data to conduct geochemical and reservoir temperature studies. The paper describing this work, titled "Geothermal Science and Technology - A National Program" by Dr. Carl Austin (Naval Weapons Center), Ward Austin (now of ICON Resources), and Dr. G.W. Leonard (now retired from the Naval Air Systems Command), provided the impetus that finally launched the Navy geothermal program. Support of the program was built at both the Naval Weapons Center and the Office of the Assistant Secretary of Navy for Research and Development.

by Carl F. Austin
Head of the Geothermal Program
Naval Weapons Center

and

James L. Moore
Senior Vice President, Exploration
California Energy Company, Inc.

In 1975, the Defense Advanced Research Projects Agency, envisioning a looming energy shortage, funded heat-flow drilling and geophysical studies at Coso, conducted under the direction of Dr. Jim Combs of the University of Texas at Dallas.



A production rig is drilling geothermal well "CSO/NVY" 76-B7 with air, within the Naval Weapons Center. (June 11, 1987.)

In 1976, the Department of Energy established the Coso Technical Coordinating Group. A heat-flow drilling program began in 1977 under an Energy Research Development Agency (ERDA) contract. The initial drilling was undertaken by Battelle Pacific Northwest Laboratories. A subsequent deep-hole well (4,845 feet) was drilled at Coso by ERDA. The well established that commercial temperatures and commercial flow rates were possible.

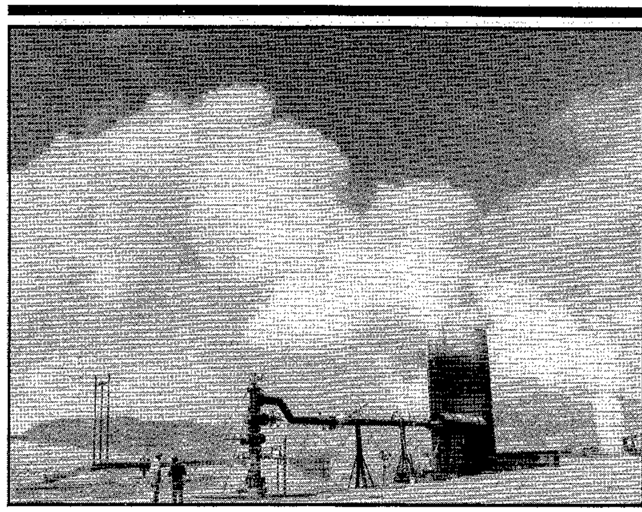
In 1977, the Naval Weapons Center asked key senior staff personnel (CAPT William Daniels, Public Works Officer; CDR Marvin J. Cowell, Staff Judge Advocate; and Dr. Carl Austin, then a geologist in the Research Department) to formulate a geothermal development program for Coso that would protect the Navy test range investment and still enable geothermal energy resource development. Under the Military Construction Authorization Act of 1979, the Navy received the authority for contracting to develop the acquired-lands portion of the Coso prospect. In the following year, this was expanded to withdrawn lands, as well. In December 1979, California Energy Co., Inc. was awarded a 30-year contract to explore, develop, and produce the Coso prospect with its own funds. They formed the China Lake Joint Venture, to enable funding.

In December 1981, drilling began on the first Coso-Navy well, "CSO/NVY" 75-7. On January 18, 1982, a formal announcement was made of a geothermal discovery. To date, 13 production wells and 3 fluid-injection wells have been drilled at Coso on the Navy contract lands. Since then, contract modifications have resulted in the inclusion of selected Navy withdrawn lands within the terms of the original Navy contract. In addition, work within the base boundary on lands released by the Navy for geothermal leasing by the Bureau of Land Management has resulted in the discovery of a substantial, commercial geothermal resource at Coso outside of the Navy contract lands. The California Energy Company and the Los Angeles Department of Water and Power made these discoveries.

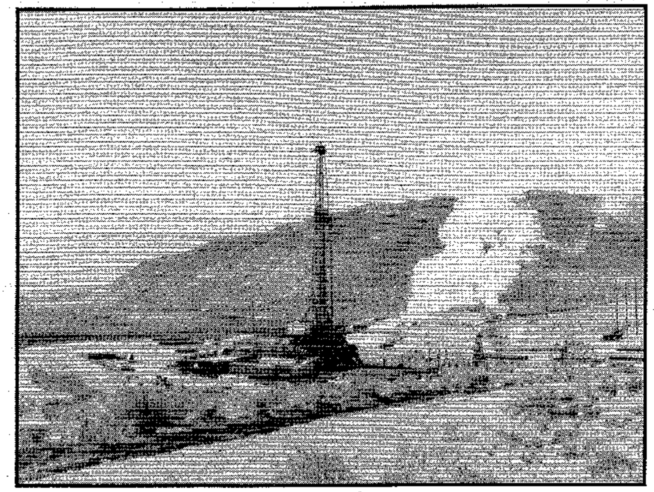
Reservoir production and injection testing on Navy lands at Coso began in May 1982, and continues today. Individual well production rates range from several hundred thousand pounds of total mass per hour to well over one million pounds of mass per hour. Well testing has established the existence of sufficient wellhead capabilities at Coso to supply the energy requirements of at least the initial 30 megawatt plant. Drilling will continue to define the reserves necessary to power additional plants.

In March 1986, construction began on the first plant unit, rated at 25 megawatts and expected to produce up to 32 megawatts during the cold winter season. The plant was designed by Mitsubishi and built by Guy F. Atkinson Construction Company. Basic plant design parameters for the first Coso plant are:

Type - double flash
Resource requirements - 2000 K lb./hr.
High pressure steam - 76 psia
Low pressure steam - 22 psia
Plant separation (two-phase gathering system)



Testing Coso Navy Project wells "CSO/NVY" 76-7 and "CSO/NVY" 76A-7. (March 23, 1987.)



In the foreground, Coso Navy project well "CSO/NVY" 15A-8. In the background, wells "CSO/NVY" 76-7 and 76A-7 are being tested. (January 28, 1987.)

A unique aspect of the injection system is that the power plant will be the first in the world to inject noncondensable gasses from the plant condenser into the spent fluid stream. Thus, the plant will have essentially no emissions other than clean water vapor.

The multiple development of the Coso area should result in the electrical generation of about 300 megawatts by the mid-1990's. The PURPA contracts are in hand for 240 megawatts to be developed by California Energy Company. The Los Angeles Department of Water and Power has plans for a 10 megawatt plant, with a 50 megawatt plant to follow by the mid-to-late 1990's.

By early 1991, Coso will rank as a major geothermal energy production center, if the planned expansion continues.

Further Coso Details

The Coso Geothermal Project is a $51 million, 25 megawatt geothermal power plant. In exchange for geothermal development rights for about 5,000 acres in the Naval Weapons Center, California Energy Company of Santa Rosa will discount electrical energy to the Navy for 25 years.

Eight similar power plant units are planned for installation during the next 2 years by the company. Together, they will comprise three, 80-megawatt facilities to be built by California Energy in the Coso Geothermal field at about 1.2 mile intervals.

by Bill Rintoul

Adapted and reprinted, with permission, from the Bakersfield Californian.

Each plant will consist of three Mitsubishi turbine-generator sets. The first plant is on land leased from the Navy, the second will be on land acquired from the Bureau of Land Management, and the third on Navy land.

Two recently drilled wells produced in excess of 1 million pounds of mass flow of geothermal fluids in preliminary tests. Long-term flow tests are under way. California Energy plans to drill an additional 20 wells at China Lake during the last half of 1987.

The heat source in the Coso Geothermal field is a shallow body of magma, with the reservoir described as basically a hot-water reservoir with some dry steam. Reservoir temperatures generally range from 400° to 450°F.

Power-sales contracts with Southern California Edison (SCE) are for an aggregate net capacity of 240 megawatts. Two-thirds, or 160 megawatts, have been earmarked in the contracts to the Navy lands and one-third, or 80 megawatts, to the BLM lands. California Energy will build 28.5 miles of 115 kilovolt transmission lines from the power-plant sites to a SCE substation at Inyokern.

California Energy, as operator of China Lake Joint Venture, has completed an initial $3.5 million private financing with an European investment group to support further development on Navy lands leased at China Lake.

Earlier, the company announced the commitment, subject to certain conditions, for a $160 million private financing with Drexel Burnham Lambert Inc. and Credit Suisse, as well as a $14 million initial public offering, underwritten by a syndicate managed by Laidlaw Adams & Peck Inc.

Charles T. Condy, chairman and chief executive officer of the geothermal electric power company, said that the primary objective of the financing efforts is the further development of geothermal resources to be utilized by the joint venture's first power plant at China Lake.

LAWP Power Plant at Coso

The Los Angeles Department of Water and Power (LAWP) plans to build a $20 million power plant in the Coso geothermal area north of Ridgecrest, perhaps as a prelude to much larger facilities.

Tapping underground steam to produce electricity, the 10-megawatt plant would be on leased Inyo County property within the China Lake Naval "This Weapons Center. The Coso area is viewed as one of the most promising geothermal power sites in the state.

The plant would be a demonstration facility, determining whether the geothermal reservoirs are suitable for commercial development.

Andrew Paredes, an environmental engineer with the LAWP, said the demonstration plant is geared to begin operation in the summer of 1991, with construction scheduled to start in mid-1990.

If the plant proves itself, according to Paredes, the LAWP could develop 200-250 megawatts of geothermal power in the Coso field. "A lot of this is crystal-balling," he acknowledged.

The LAWP holds leases on 6,825 acres in the Coso area. Paredes said long-term development could entail separate 40-50 megawatt units at about $100 million each.

"This project provides us with some diversity," Paredes said, noting that the department is broadening its long-term power base."

Paredes said the planned plant is about three-fourths of a mile from the China Lake Joint Venture power plant, the first plant at Coso to go on stream.

The LAWP made its debut in the geothermal field by paying $6.5 million in 1981 during competitive bidding for three tracts in the Coso field.

"When the demonstration plant is completed, with its geothermal wells and 11 miles of transmission lines to the department's nearest substation, the department's investment could add up to $75 million," Paredes said.

Because of less pressure to produce power, Paredes noted, the LAWP hasn't pushed development of the Coso holdings.

"In the power process, itself," Paredes said, "steam as well as hot water will be produced, with the hot water being reinjected back into the reservoir." The LAWP is now developing required environmental studies, but Paredes said no overt opposition to the plans has developed.

"Overall," Paredes said, "Coso should be highly productive in its power production."

"Coso," Paredes said, "ultimately might produce 1,000 megawatts."

Reprinted, with permission, from an article by James E. Bylin, published in the Bakersfield Californian, July 23, 1987.

Heber Dual-Flash Plant Update

The Heber Geothermal Company Power Plant is a dual-flash plant in Heber Geothermal field. The 47-megawatt, net, Imperial Valley power plant was dedicated in October 1985. The plant's cumulative capacity factor for the summer of 1987 is above 80 percent. Its availability factor is over 99 percent for the same period.

(A capacity factor is how much power a plant can produce. An availability factor is the on-line time in which a plant is available to produce the power.)

Developers of the Heber Geothermal Unit include Chevron Geothermal Company of California, Unocal Geothermal Division, Dravo Corporation, and Centennial Energy, Inc.

As operator of the geothermal resource, Chevron is responsible for the production wells (11), injection wells (10), and pipelines; as operator of the power plant, Dravo is responsible for the generation and delivery of electricity to Southern California Edison.

A new, 40-megawatt, net, dual-flash power plant of similar design is planned for the southern portion of the field. The plant, to be called the Second Imperial Geothermal Power Plant, will be owned by the Second Imperial Geothermal Company, subsidiaries of Dravo Corporation and Centennial Energy, Inc. Permits have been obtained for the power plant, but not for the related field development.

Heber Binary Project Closed

The following "response statement" from Chevron Resources Company and "press releases" from San Diego Gas and Electric Company explain these companies' positions concerning the shut-down of the Heber Binary Project in the Imperial Valley.

Press release issued by San Diego Gas and Electric Company:

On June 24, 1987, San Diego Gas & Electric (SDG&E) announced it is planning an indefinite shut-down of the Heber Binary Project, a geothermal research and development project located in the Imperial Valley.

Gary Cotton, SDG&E senior vice-president of electric operations, said it will be mid-1989 before the plant's heat suppliers, Chevron Geothermal Company of California and Unocal Corp., are able to complete the development of the project's underground heat source, called "brine".

He said the delay means that, unless other arrangements are made, the project will run out of funds before Chevron and Unocal can complete the development of the heat source.

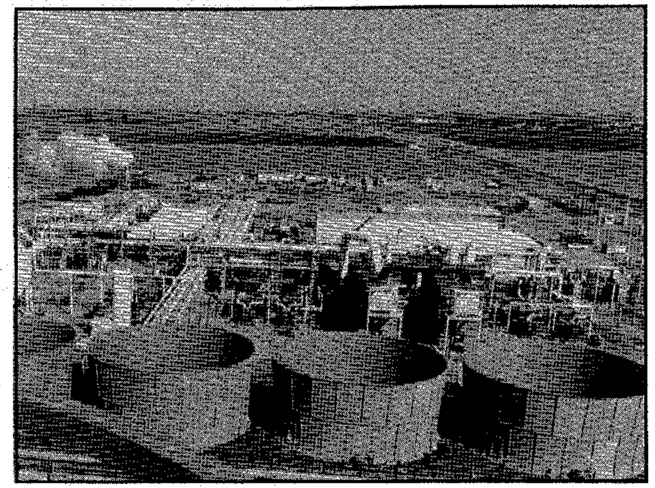
"Operating at low brine levels causes the plant to operate inefficiently, which increases the cost of the electricity the plant generates," he said. "We cannot continue to run the plant at the high cost at which it is running now."

"This is intolerable to us and to our customers," said Cotton.

"Because the contracted schedules have not been met by these two companies, our customers and the other project sponsors are not getting what they've been paying for. We must protect our sponsors and our customers."

He said SDG&E is asking Chevron and Unocal to renegotiate the geothermal heat contract in order to rectify the problem.

"To reduce the damages to SDG&E customers and other project sponsors, we plan to keep the plant closed following its current scheduled maintenance until an agreement is worked out," Cotton said.



The Heber Binary Power Plant, as it was dedicated in December 1985. The $188.5 million plant is near the City of Heber, in California's Imperial Valley.

He said, "The drilling schedule for the development of the heat supply was a fundamental factor leading to support of the Heber Binary Project by both the Department of Energy and the Public Utilities Commission. Failure to adhere to this schedule has seriously undermined or destroyed the value of the heat supply contracts."

He added that SDG&E has been pleased with the plant's performance as a research and development project.

"We believe the project can be successfully completed if SDG&E is compensated for the damages it has incurred due to the heat suppliers' nonperformance and a new heat supply arrangement is developed," said Cotton.

Response statement to SDG&E Heber Binary Plant News Release June 24, 1987, issued by Chevron Resources Company:

Neither Chevron nor Unocal have received official notification from San Diego Gas and Electric (SDG&E) that they intend to shut down the Heber Binary geothermal power plant. We would view such a shut-down as premature and clearly not an appropriate response to the concerns SDG&E has expressed in our supplying geothermal fluid to the plant.

We have completed installation of the first phase of production wells for the plant and are proceeding as rapidly as is technically feasible to complete the wells for bringing the plant to full production capacity. We have an active drilling assessment program underway at this time. We have been able to substantially supply all the geothermal fluid that the plant has been capable of handling since it started up. While the current drilling program has encountered delays as a result of unforeseen conditions in the reservoir, we fully intend to proceed with evaluations aimed at achieving full capacity for the plant. Development of full brine capacity for this plant has been impeded by the numerous unscheduled shutdowns and curtailments caused by equipment failures at the SDG&E binary plant.

We view the project as a cooperative demonstration project for new geothermal technology and recognize that such new technology is likely to have startup problems. We have worked cooperatively with SDG&E on their plant startup problems and are hopeful that the current problems can be resolved.

We are continuing our discussions with SDG&E and expect to proceed in a businesslike manner to resolve the problems at the Heber Binary Project, perhaps through contract renegotiations as may be appropriate. We have developed considerable information on the characteristics of the geothermal reservoir at Heber as we are certain SDG&E has, also, gained considerable technological information about the operation of binary technology in its plant. We hope the project is given the opportunity to benefit from the demonstration effort and continue operating.

Press release issued by San Diego Gas and Electric Company:

On August 12, 1987, San Diego Gas & Electric (SDG&E) officials announced plans to sell the Heber Binary Project, a geothermal research and development plant in California's Imperial Valley.

Terry Winter, acting division manager - engineering and operations, said the plant is being sold because of the heat suppliers' delay in completing the development of the project's underground heat source, called "brine". He said the delay is causing SDG&E to incur costs that are not in the project's budget.

"The plant has been operating at low brine levels, which is inefficient," he said. "As a result, the cost of the electricity the plant produces is greatly increased. This is unacceptable to us and to our customers. We simply cannot continue to run the plant at such high cost."

Winter said selling the plant is the best option for both the project and SDG&E customers.

"We see the sale as the best way to ensure the plant remains viable and achieves the project's technical objectives. At the same time, SDG&E customers will not be paying for the cost of running it," he said.

Winter said the company will pass the operational savings along to its customers.

"Reductions in expenses associated with the plant will be reflected in upcoming rate filings," said Winter.

He said prospective buyers have not yet been identified, and the company has not made a decision about an asking price. Winter said the project is by no means a failure.

"We have been very satisfied with the plant's performance as a research and development project," he said. "We believe it can be operated successfully if the heat suppliers increase the brine flow in a timely manner."

Salton Sea 3 Under Construction

In March 1987, Unocal Corporation announced that its Desert Power subsidiary began construction in Southern California's Imperial Valley of a 47-megawatt generating plant to be powered by geothermal energy. The power plant is expected to be operating by early 1989.

The new plant, called Salton Sea 3, will be at the southern end of the Salton Sea, about one-half mile from an existing 10-megawatt generating plant, also owned by Desert Power. Unocal will supply steam to both plants from the same major geothermal reservoir.

Stone & Webster Engineering Corporation has contracted to engineer and design the plant and the steam/brine separation facility. The company will also procure equipment and provide construction-advisory services for the two projects.

Two of the production wells for the plant have been drilled and tested. "We have conducted tests over the last 5 years that have confirmed that the reservoir may be one of the largest geothermal hot water fields in the world," said Dr. Carel Otte, president of Unocal's geothermal division and Desert Power.

The wells and production facilities will be owned by Unocal; the power plant will also participate in a joint industry project to construct a new electrical transmission line to increase transmission capacity out of the Imperial Valley. The 100-mile line to the Coachella Valley will be built in cooperation with the Imperial Irrigation District.

Unocal is the world's largest producer of geothermal energy, supplying steam to generate more than 1,500 megawatts of electricity worldwide. In the Imperial Valley, the company has advanced the technology to control scale and corrosion in pipelines, wells, and machinery.

"We have spent 10 years drilling and testing wells to prove the capacity of this reservoir," said Otte.

"Concurrently, we have been perfecting our technology. We are now confident that we can successfully tap this resource and put it into commercial operation."

Unocal Buys Power Plant

Southern California Edison Company and Unocal Corporation have reached an agreement under which Unocal assumes ownership and operation of Edison's 10-megawatt pilot Salton Sea geothermal electrical generating plant on July 1, 1987.

Unocal's geothermal subsidiary, Earth Energy, Inc., will assume ownership and operation of the pilot plant. It will purchase the 25-percent interest in the plant held by Mono Power Company, an Edison subsidiary, for $11 million.

Under the agreement, Edison will buy 10 megawatts of power produced from the plant. That will be increased to 30 megawatts by 1995, when the plant is expanded. Earth Energy also will acquire equipment from the nearby Brawley geothermal power plant, dismantled in 1987.

"Edison and Unocal have worked together on this research project for more than 10 years," said Glenn Bjorklund, Edison vice president in charge of system planning and research. "Our combined efforts have helped to enhance geothermal research and technology.

"We feel that future commercial expansion of the Salton Sea resources can be accomplished best by Unocal, with Edison purchasing the power."

"While continuing our existing commercial operations at the Salton Sea plant, we will expand our research efforts into alternative methods of producing geothermal energy from brine," said Dr.

Earth Energy, Inc., 10-megawatt geothermal power plant, viewed across an irrigated field in the Imperial Valley. Photo by Susan Hodgson.

Carel Otte, president of Unocal's geothermal division. "We will be looking also at new ways to control scaling and corrosion."

Magma's New Niland Plants

In the Imperial Valley, Magma Power Company will design and build up to three geothermal power plants at Niland, California, according to the Magma Power Company and Subsidiaries 1986 Annual Report. Plant design and engineering is underway for the first plant.

Each plant will have a nameplate capacity of 38 megawatts and will be based on Magma's proprietary crystallizer-reactor-clarifier technology. The electricity generated by the plants will be sold to Southern California Edison under three separate power purchase contracts currently held by Magma Power.

Dow Chemical will provide all of the engineering and construction management services for the three plants in exchange for additional shares of company stock. In addition, Dow has agreed to provide certain limited undertakings to prospective project lenders to support and finance the transmission lines for these projects.

Ways to finance the Niland plants are being analyzed. The expected cost of the three plants is a total of $240 million.

GEO Imperial Valley Activities

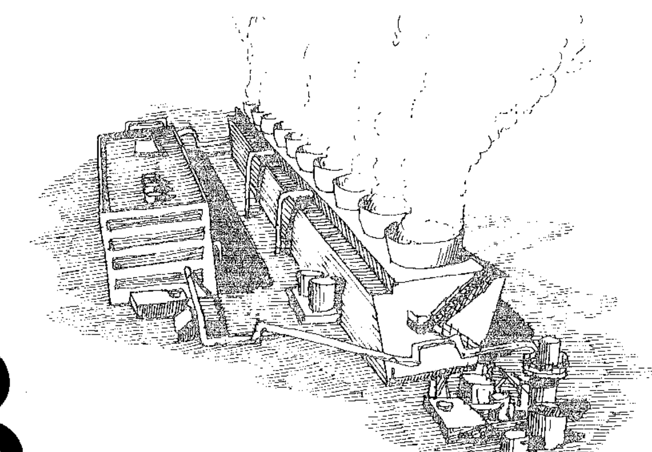
Geothermal Resources International, Inc. (GEO) in San Mateo, California, and PacifiCorp Credit, a subsidiary of PacifiCorp in Portland, Oregon, announced that since July 1987, the company has raised about $21 million to fund the initial development of GEO's East Mesa project. PacifiCorp Credit, Inc. will lend GEO about $11 million of this amount on a short-term basis.

GEO will use a portion of the funds to meet its commitment to share in the cost of a $50 million, 230-kilovolt transmission line. The line will carry electricity generated from geothermal power plants in the Imperial Valley to a Southern California Edison substation in Riverside County, California.

According to GEO's Chief Executive Officer Ronald P. Baldwin, GEO and other geothermal developers in Southern California's Imperial Valley, including Chevron, Magma Power Company, and Unocal Corporation, are financing a 104-mile transmission line capable of carrying about 600 megawatts of electricity. The transmission line, which is being constructed by the Imperial Irrigation District, is scheduled to be completed by the end of 1988.

"We began developing the East Mesa area of the Imperial Valley in early 1987," Baldwin continued. "By mid-1989, GEO plans to complete two 25-megawatt, net, power plants in East Mesa that will produce electricity to be purchased by Southern California Edison Company."

In September 1987, two GEO geothermal wells at East Mesa were completed, and GEO was drilling its third and fourth wells in the field. Test data results from these wells will be analyzed to decide whether GEO will construct a dual-flash or binary power plant. "Right now, we are considering a dual-flash plant," said Steven Morris, Vice President-Administration for GRI, Inc. (GEO).



By mid-1989, GEO plans to complete two 25-megawatt, net, power plants in East Mesa.

Further details of the GEO East Mesa project are included in the Magma Power Company and Subsidiaries 1986 Annual Report. The report states that an agreement was signed on April 2, 1987, between Magma Power and Magma Energy, Inc. (the company's 67-percent-owned subsidiary) and Geothermal Resources International, Inc. (GEO). The agreement allows GEO to develop the geothermal resources of about 2,000 of the 16,000 acres of leaseholds held by both Magma Power and Magma Energy in East Mesa, California, for a development fee of $1 million.

Should GEO's East Mesa wells prove commercially viable, GEO can build up to two 25-megawatt firm-capacity power plants on payment to Magma of an additional $1,150,000 for each plant. Electricity produced by those plants would be sold to Southern California Edison under power purchase contracts currently held by Magma Electric Company (Magma Power's wholly owned subsidiary). Beyond that, GEO would pay the Magma companies 14 percent of the gross revenue derived from electricity sales under those 30-year contracts.

GEO has the geothermal rights on about 300,000 acres in five western states. In addition to its operations and development projects in The Geysers and the Imperial Valley, the company is continuing exploration projects on the flanks of the Newberry Crater in Central Oregon and in Hokkaido, Japan. GEO also has an international geotechnical service group in the United Kingdom, GeoScience Ltd., which provides geotechnical services to clients around the world and to the company's geothermal operations.

Two Ormat Geothermal Projects at East Mesa

Subsidiaries of Ormat Inc. have undertaken two geothermal projects at East Mesa Geothermal field in California's Imperial Valley.

Ormesa Geothermal I, a project of Ormesa Geothermal, is a 30-megawatt project with 26 Ormat power units. The $86 million project includes 11 geothermal production wells and 4 injection wells. Walsh Construction Company, a subsidiary of Guy F. Atkinson Company, is under contract to construct the power plant. Testing is scheduled to begin in mid-September 1987.

Ormesa Geothermal II, a 20-megawatt, gross, power plant, is also under construction. The project is undertaken by a partnership called East Mesa Partners, between Ormat Geothermal and Harvert International Construction from Birmingham, Alabama. The plant construction for Ormesa Geothermal II is by Walsh Construction Company.

Twenty Ormat power units will be installed. The project includes 7 production wells and 4 injection wells. The startup date is February 1988.

Salton Sea Scientific Drilling Program

The Department of Energy, Geothermal Technology Division (DOE/GTD), has extended its prime contract with Bechtel National, Inc. for work on the Salton Sea Scientific Drilling Program (SSSDP). Funds have been allocated, but not contracted, for wellbore repair and construction of facilities for the performance of a long-term flow test injection experiment. After Kennecott Corporation's management agreed to fund and drill the "Wilson" 1-12 well, which will be used as an injection well, key activity during this reporting period became the planning and scheduling of wellbore repair, reconditioning of brine treatment equipment, drilling the injection well, and performing the long-term production and injection tests.

The Brookhaven National Laboratory's failure-analysis report provided observations and recommendations of significant value in planning the repair for well "State" 2-14. Assuming the repair operations are successful, reconditioning of flow-test equipment, construction of flow-test facilities, and connection of the "Wilson" 1-12 and "State" 2-14 wells by pipeline must be accomplished prior to the flow test. After drilling the "Wilson" 1-12 well to a depth of 3,500 to 6,500 feet, Kennecott plans to perform a short-term flow test, then allow the well to be used for injection of fluids produced during the flow test of the "State" 2-14 well. As of this quarter, the long-term flow test is planned for completion by the close of August 1987.

Data from scientific experiments performed in the "State" 2-14 well and samples acquired from the well continue to be analyzed. Technical aspects of SSSDP field operations have been analyzed and reported by Robert W. Nicholson of Well Production Testing, Inc. Conclusions and recommendations for drilling future scientific wells have been set forth in his report.

The information is adapted from the Salton Sea Scientific Drilling Program, Report of the Second Quarter, FY 1987, published by the U.S. Department of Energy.

NORTHERN CALIFORNIA

Mono County Update

Geothermal Moratorium

In May 1987, the Mono County Energy Management Department recommended that a two-year moratorium be placed on geothermal power production projects on private lands within the Mono-Long Valley KGRA. Subsequently, a U.S. Supreme Court case in Los Angeles County was decided in favor of required compensation to developers by local and state agencies that implement restrictive zoning measures. Considering that the finding in this case could have a direct bearing on the geothermal moratorium situation, the Board of Supervisors elected not to proceed with this action.

The monitoring data will provide important information to Mono County decision-makers.

The intent of the proposed moratorium was to allow for the collection and evaluation of hydrologic monitoring data in the Long Valley Caldera. Now, to still achieve this end, the Energy Management Department will suggest that mitigation measures and project-specific monitoring requirements be implemented via the California Environmental Quality Act (CEQA) documentation and the county use permit process. The monitoring program, itself, will be implemented soon by the Long Valley Hydrologic Advisory Committee (LVHAC). The monitoring data will provide important information to Mono County decision-makers regarding potential adverse impacts from geothermal production on such local resources as Hot Creek Gorge, the Hot Creek Fish Hatchery, and Hot Creek, itself.

The ultimate intent of Mono County is to provide a very comprehensive and thorough review of proposed geothermal power development projects, especially with regard to their potential impacts on those natural resources that attract many visitors to the area.

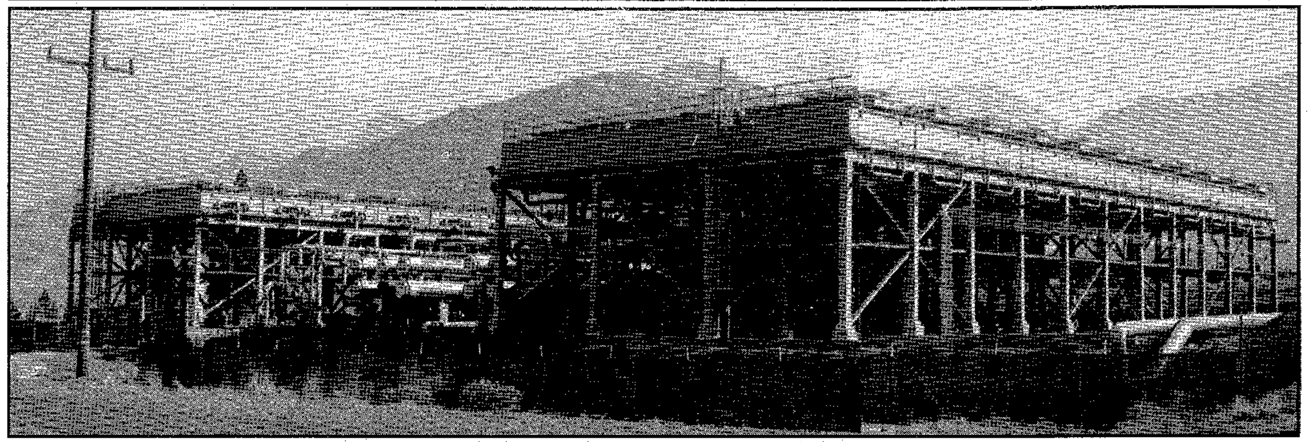
Mono County will take the opportunity, within the context of the upcoming Energy Element, to establish priorities as to the type and size of geothermal development activities that will be permitted on private lands within Mono County. Direct use and recreational/tourist-oriented projects may be given a higher priority than commercial power-development projects. In any event, the permitting of geothermal development activities on private lands within Mono County will proceed at a cautious and incremental pace to allow for information feedback from the monitoring program.

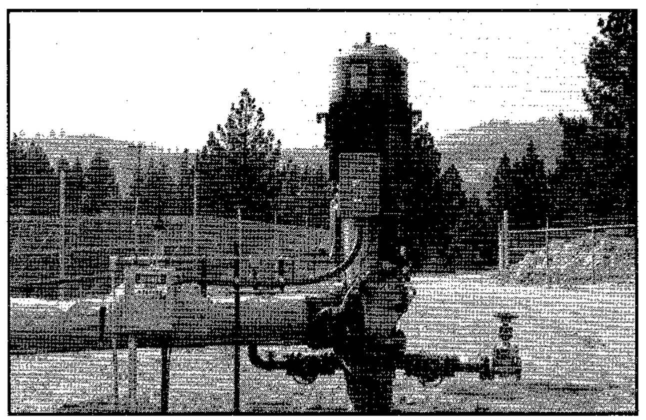
Mammoth/Chance Geothermal Project

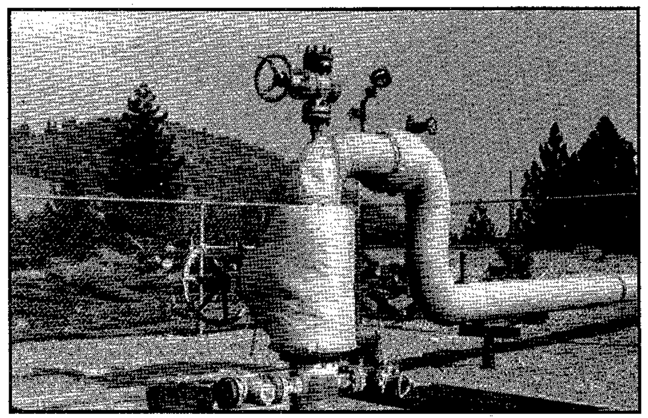
The Mammoth/Chance Geothermal Project is the proposed construction and operation of a 10 megawatt, net, geothermal binary-cycle power plant and production-and injection-well field by Bonneville Pacific Corporation. The project is currently under environmental review, pursuant to CEQA requirements. The revised Draft EIR has been circulated by the State Clearinghouse and by the Mono County Energy Management Department. Because of the proposed use of water cooling for the condensation of the binary working fluid, the issues of environmental concern are somewhat more extensive than those associated with an all air-cooled binary process.

The project proponent has been informed of the need to conduct hydrologic monitoring of the surface and groundwater resources, and the geothermal production aquifer(s). The proponent has demonstrated a commitment to participate in the LVHAC monitoring program.

by Daniel L. Lyster, Director
Energy Management Department
County of Mono
Mammoth Lakes, CA







Top: Mammoth Pacific I Geothermal Power Plant. Left: production well Mammoth Pacific "MBP" 1. Right: Injection well Mammoth Pacific "Mammoth" 1. Photos by Robert Habel.

Mammoth Pacific II and III Geothermal Project

The Mammoth Pacific II and III Geothermal Project includes the construction and operation of two, 10-megawatt, net, geothermal binary-cycle power plants and production-and injection-well fields. The project is in the environmental documentation and review process. The applicant, Mammoth Pacific, intends to locate this project adjacent to the existing 7 megawatt Mammoth Pacific I power plant in the Casa Diablo Geothermal field in Mono County.

Albeit the proponent intends to utilize an all air-cooled binary process, the potential for impacts to the local thermal systems that feed the Hot Creek area must be acknowledged. Accordingly, Mammoth Pacific will also be required to conduct extensive hydrologic monitoring of the geothermal production aquifer from which it is extracting fluids. The company has expressed an interest in participating in the LVHAC monitoring program.

Geothermal Resource Assessment Project

The Mono County Energy Management Director is providing assistance to the Town of Mammoth Lakes on its California Energy Commission (CEC) grant-funded resource assessment project. The grant of $220,000 provides for the drilling of at least two temperature-gradient wells (exploratory wells) within the town limits. If a geothermal resource is detected and found to provide adequate flows at a suitable temperature, the Town of Mammoth Lakes will proceed in the development of a geothermal space-heating system to provide heat to such users as the Centinela Mammoth Hospital, Mammoth elementary and high schools, the Gateway Industrial Park, and future residential development projects.

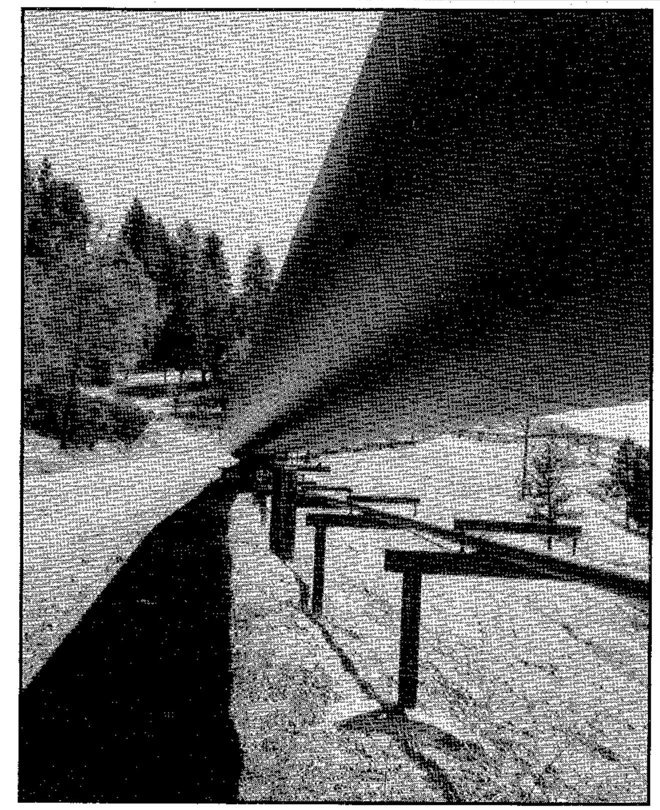
This resource assessment project provides a follow-on effort to the CEC grant-funded feasibility study conducted by Mono County Energy Management a few years ago. It is anticipated that the wells drilled for the project will be completed by the end of 1987.

The Geysers Geothermal Field: 1986 Update

Geothermal drilling activity on state and private lands at The Geysers Geothermal field continued its downward trend in 1986 as oil prices remained at depressed levels. Total new-well footage drilled on state and private leases decreased to 68,240 meters (223,827 feet) from 79,253 meters (259,950 feet) drilled in 1985. Drilling activity on federal leases almost equaled drilling activity on state and private lands. According to the U.S. Bureau of Land Management, drilling on federal leases in 1986 at The Geysers increased about 4 percent over 1985 activity.

Steam production in The Geysers Geothermal field increased by 11.2 percent, from 95.8 billion kilograms in 1985 to 106.5 billion kilograms in 1986. Injection of condensed steam and water from Big Sulphur Creek in creased from 26.7 billion kilograms in 1985 to 30.9 billion kilograms in 1986.

For further information on 1986 California geothermal activities, see the 1986 Annual Report of the State Oil and Gas Supervisor, available from the Division of Oil and Gas.



Coldwater Creek Well Field and Power Plant Update

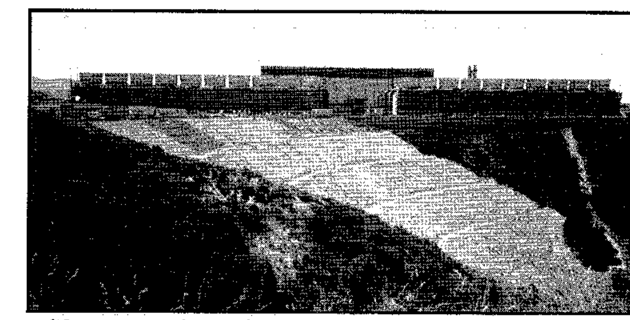
The Coldwater Creek Geothermal Power Plant is scheduled to go into commercial operation in 1988 in The Geysers Geothermal field in Northern California. The power plant, CCPA No. 1, is being built by the Central California Power Agency, composed of the Sacramento Municipal Utility District, the Modesto Irrigation District, and the City of Santa Clara.

"Since January 1981, Geothermal Resources International, Inc. (GEO) has completed successfully 16 geothermal wells in The Geysers Geothermal field," said Chief Executive Officer Ronald P. Baldwin. Fourteen of the wells will supply steam to the 130-megawatt Coldwater Creek Geothermal Power Plant.

The remaining 2 wells will function as injection wells. Based on initial well production tests, the 14 production wells are capable of delivering about 99 percent of the 2.2 million pounds per hour of steam required when the plant goes into commercial operation.

According to Baldwin, the company is drilling one final well for the project. Other development activities in the final stages include the steam gathering system and the computerized system for monitoring and controlling steam flows.

"GEO expects the Coldwater Creek Geothermal Power Plant to begin accepting steam for testing purposes by November 1987, and that the first of the two 65-megawatt electric generating units will begin commercial operation by early 1988. The second 65-megawatt unit is expected to begin commercial operation in late 1988. GEO estimates annual revenues of about $30 million from the Coldwater Creek Geothermal Project when the power plant goes into commercial operation. The development of the project will cost GEO about $105 million.



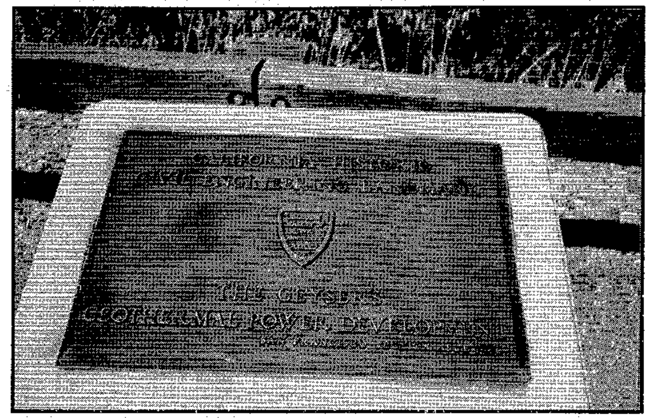
Coldwater Creek Geothermal Power Plant, with two, 65 megawatt units. Unit 1 is scheduled to begin commercial operation in May 1988, and Unit 2 in August 1988. Photo by Susan Hodgson.

Freeport-McMoRan Building Two Plants at The Geysers

Freeport-McMoRan Resource Partners has applied for a Land Use Permit from Lake County to construct and operate a 27-megawatt, net, geothermal power plant at The Geysers Geothermal field. Power plant engineering and design will be by SAI Engineers Inc.

The plant, called the West Ford Flat Power Plant, will be in the southwestern quarter of Section 23, Township 11N., Range 8W., M.D. B.&M.

Construction of the two-turbine plant is scheduled to begin in early 1988, with commercial production set for June 1989.



In May 1987, Freeport Geothermal Resources Company began construction on the Bear Canyon Creek Geothermal Power Plant, also in The Geysers Geothermal field. The site for the 20-megawatt, net, $50 million plant is near the center of Section 36, Township 11N., Range 8W., M.D.B.&M. The target date for commercial operation is November 1988. Plant engineering and design is by Stone and Webster Engineering Corporation.

GEO Offers to Buy Thermal Power Company

On October 5, 1987, Geothermal Resources International, Inc. (GEO) of San Mateo, California, announced it has signed an agreement in principle with Maxus Energy Corporation of Dallas, TX to buy the stock of Thermal Power Company (Thermal), a wholly-owned subsidiary of Maxus. Thermal owns a 25 percent interest in the world's largest operating geothermal project, the Union-Magma-Thermal (UMT) Project in The Geysers Geothermal field in Northern California. The UMT Project has a gross generating capacity of 1,103 megawatts, has leasehold interests on about 21,000 acres of geothermal properties in The Geysers, and is operated by Unocal Corporation. Thermal also has interests in geothermal prospects in Hawaii and Oregon.

The transaction, which has a value of about $140 million, is subject to a number of conditions, including Unocal's right of first refusal to purchase the stock of Thermal, GEO's completion of financing for the transaction, and the approval of the Boards of both GEO and Maxus. Morgan Guaranty Trust Company of New York is serving as GEO's financial advisor for the acquisition.

According to GEO's Chief Executive Officer, Ronald P. Baldwin, "GEO expects that the revenues from the acquisition of Thermal would add about $30 million a year to GEO's gross revenues and would increase GEO's earnings considerably. It also provides an opportunity for the company to increase its involvement in the exploration and development of geothermal resources in Hawaii and Oregon."

The UMT Project was formed in 1967 through an agreement between Unocal, Magma Power Company, and Thermal Power Company. In 1984, Magma sold its interest to Unocal. Each of these three energy companies, as well as GEO, has been involved in significant pioneering efforts to explore and develop the geothermal resources in The Geysers.

Clearlake Low-Temperature Resources Study

Four temperature-gradient holes have been drilled and temperatures are being measured in Clearlake, California.

Clearlake is about 15 miles northeast of The Geysers Geothermal field. The Clearlake City Council has been working under grants from the California Energy Commission and Lake County to assess the nature and extent of low-temperature resources underlying the city.

The firm of S.S. Papadopulos will conduct geophysical studies for the project.

Lake County Geo-Ag Heat Center

Lake County is proceeding with plans to develop a unique agricultural park called the Geo-Ag Heat Center Project. The project will combine vocational training, geothermal heat-transfer research, and commercial resources for greenhouse heating, crop drying, and other agricultural operations.

The decision to pursue project development follows the recent production testing of wells "AG Park" 2

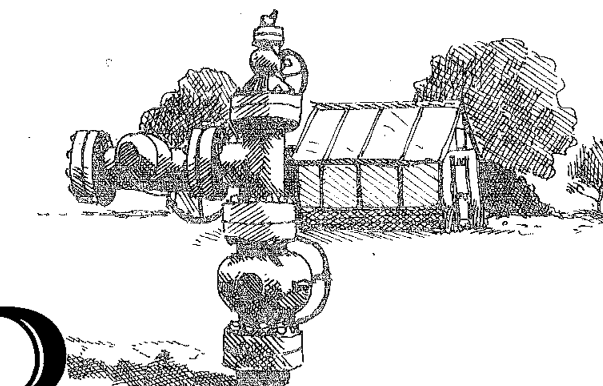
by David Sanchez

geothermal resource capable of heating the proposed project facilities. The project site is about 7 miles southeast of Kelseyville, California, south of Clear Lake on Highway 29.

The project was begun in 1984, when major funding was provided through a California Energy Commission grant of $385,000, awarded under the Geothermal Development Grant Program for Local Governments. The remainder of the estimated $600-$700,000 total project cost is being funded by Lake County and the Mendocino-Lake Community College District.

The first phase of the project involved drilling wells to confirm the availability of an adequate geothermal resource. The first well, "AG Park" 1, drilled in January 1986 to a depth of 1,614 feet, proved noncommercial; it will be used as an injection well.

Next, a geophysical program of seismic surveys was undertaken to pinpoint the more productive fracture zones. Wells "AG Park" 2 and 3 were drilled in these zones. Both wells were drilled in December 1986, to depths of 592 and 488 feet, respectively. In 3-day tests of continuous production, "AG Park" 2 and 3 yielded flowing wellhead temperatures of 143°F and 153°F, respectively, at flow rates exceeding 150 gpm, with minor drawdowns.



Potential greenhouse users should contact Gib Cooper.

The next phase of the project entails construction of a 7,000 square-foot greenhouse by the end of 1987. It will be operated by the Mendocino-Lake Community College District as an educational and demonstration facility. Geothermal-fluid and irrigation water-distribution and injection-pipeline systems will also be installed in preparation for future commercial leasing on the 3-acre site. The demonstration greenhouse will allow evaluation of the effectiveness of various heat-transfer systems. This would assist commercial operators in designing the most economical system for their needs.

The remaining land and geothermal resource will thereafter be made available for lease to commercial operators. It is anticipated that about 100,000 square feet of space will be available for commercial greenhouses. Operators would be charged for geothermal energy use at a rate equivalent to 50 to 70 percent of the cost of the least expensive competing fuel, currently propane.

Potential greenhouse operators interested in the project should contact Gib Cooper, Geothermal Greenhouse Coordinator, Mendocino-Lake Community College, (707) 263-4944.

For further information, contact Mark Dellinger, Lake County Geothermal Coordinator, (707) 263-2221.

OTHER WESTERN STATES

NEVADA

Nevada Geothermal Specialist Appointed

Richard Whiting has joined the Nevada Department of Minerals staff as a resource engineer for petroleum and geothermal. He will administer oil and geothermal regulations and provide staff support in departmental efforts to advance the development of oil and geothermal resources.

Geothermal Resources in Nevada

High-Temperature Development

Before 1986, the only industrial well producing electrical power in Nevada was operated by Tad's Enterprises at Wabuska, in Lyon County. This plant

Published by the Nevada Department of Minerals, February 1987.

started producing 600 kilowatts in June of 1984, and is still producing at the same rate. This past year, Tad's Enterprises drilled and completed its second production well. Plans are to produce and sell an additional 600 kilowatts. Power currently produced is sold to Sierra Pacific Power Company, entering its system at the Fort Churchill Station.

Chevron Resources - Crescent Valley Energy: A joint venture operated by Chevron Resources at Beowawe in Lander and Eureka Counties, is producing 14 megawatts of electrical power. The power is being generated from fluids from two geothermal production wells. The spent fluids are passed from the plant back into the aquifer through an injection well. The power is purchased by Southern California Edison Company. If daily power production exceeds 15 megawatts, the excess power will be purchased by Sierra Pacific Power Company.

Chevron Resources: A geothermal power plant at Desert Peak, in Churchill County, is producing 10 to 12 megawatts per day. Two production wells are being used at the plant. Spent geothermal fluid is returned to the aquifer through an injection well. The power is purchased by Sierra Pacific Power Company.

Geothermal Development Associates - Ormat Systems: This joint venture at Steamboat Hot Springs, in Washoe County, is producing 4 to 5 megawatts of electrical power from three producing wells. Two injection wells have been drilled, but only one is being used to return the spent geothermal fluids. The power generated is being purchased by Sierra Pacific Power Company.

Future Power Plants

Oxbow Geothermal: Oxbow Geothermal Corporation of Dedham, Massachusetts, will soon start construction of its new Dixie Valley power plant. The contract to design and build the power plant and a power transmission line was awarded to Ebasco Services Inc. The plant, in Churchill County, will begin with a capacity of 55 megawatts. The amount may be doubled when full capacity is reached. The power transmission line will run from Dixie Valley to Bishop, California, where the produced power will be purchased by Southern California Edison Company. The total investment for the plant and transmission line is estimated at $100 million.

Munson Geothermal: Munson Geothermal has a 10 megawatt contract with Sierra Pacific Power Company. The construction of its geothermal power plant is underway at Brady's Hot Springs, in Churchill County. Information as to a completion date is unavailable.

Chevron Resources - Yankee Caithness: The Chevron Resources-Yankee Caithness joint venture, at Steamboat Hot Springs KGRA in Washoe County, is planning to develop a 12.5-megawatt geothermal generating plant. The project is still in the permitting stage and is undergoing EPA studies at the present time. There are, however, three production wells and one injection well already drilled and completed for the project. Plans are to increase the capacity of the plant to a total of 25 megawatts per day.

Michael B. Stewart: This independent is planning and permitting a geothermal generating plant in the Empire Area of Washoe County. Two production wells and 2 observation wells have been drilled and completed for the project. Permit applications for 3 more wells have been filed. Plans are for Ormat generators to be used for generation, but the power output has not yet been determined.

Great Smoky Valley Geothermal Corporation: This corporation is planning and permitting for well drilling in the Darrough Hot Spring area of Nye County. Future plans are to produce electrical power from low-temperature geothermal resources.

Low-Temperature Development

There are several users of low-temperature geothermal resources in the State of Nevada.

In Churchill County, Gilroy Foods of Gilroy, California, is using geothermal fluid to dehydrate and process onions for food additives. Plans are to expand the processing plant at Brady's Hot Springs to dehydrate garlic.

In Elko County, geothermal heat is being used in many downtown buildings and the Elko Junior High School complex. The Carlin High School and the Wells Elementary School are using geothermal resources for space heating.

In Hawthorne, a casino and motel are space-heated by geothermal fluids.

In Big Smoky Valley, a mining company is planning to drill a production and injection well to use geothermal fluids for the leach-pad operations.

At Wabuska, the bleed-off water from Tad's Enterprises' generator is being used to raise tropical fish.

In Reno, two casinos, a hotel, several condominiums, and a nursery are using geothermal resources for space-heating. An application has been filed to drill a commercial well at Peckham and Virginia Street. Plans are to construct another hotel-casino at the site. A spa is operating at Steamboat Hot Springs.

In Nye County, catfish are raised in geothermally-heated pools at the Duckwater Indian Reservation.

In Douglas County, Wally's Hot Springs is successfully using geothermal resources for a resort, restaurant, and spa.

The Moana Hot Springs area in southwest Reno has well over 200 domestic wells that are used for space-heating single-family dwellings. There are also homes located in Carson City that use domestic wells for space-heating.

There are 27 Known Geothermal Resource Areas (KGRA's) totaling 657,000 acres in Nevada. Less than half of these KGRA's have been or are being utilized. However, the future of Nevada's geothermal resources looks promising, as more interest is being shown in the use of this resource for many types of projects.

During 1986, the Department of Minerals issued a total of 67 permits for geothermal resource development – 27 permits for industrial-class wells, 2 permits for commercial projects, 12 permits for domestic-class wells and 26 permits for nonclassified wells and thermal gradient holes.

NOTE: A Geothermal Users Guide for Regulations and Rules of Practice for the State of Nevada is available from the Department of Minerals, 400 W. King Street, Suite 106, Carson City, Nevada 89710; phone (702) 885-5050.

Second Ormat Unit at Wabuska

Electricity generated by a second Ormat Energy Converter at Wabuska, Nevada, was placed on Sierra Pacific Power Company's grid on June 19, 1987, according to an article in the GRC Bulletin. The installation, adjacent to the first unit, is the first geothermal project to come on line under the new power rates approved by the Nevada Public Service Commission. The first Ormat unit at Wabuska (about 50 miles east of Carson City) has over 20,000 hours of continuous operation. Its performance was studied by the Electric Power Research Institute.

The resource for both installations is a 224°F reservoir. Cooling is handled with a cooling pond. The owner and operator of both installations is Tad's Enterprises of Orinda, California. Ormat Energy Systems of Sparks, Nevada, supplied the power plants, supervised the installation, and provides maintenance services.

Ormat Unit at Steamboat Springs

The Ormat Systems, Inc. Steamboat Springs project has begun commercial operation, according to an article in the GEO-Heat Center Quarterly Bulletin. The system is generating an average of 5.5 megawatts, net, into the Sierra Pacific Power Company grid. The seven modular Ormat Energy Converters are operating with geothermal fluids a little over 325°F. The spent geothermal fluid is injected.

Nevada Geothermal Power Plant Project Approved

A proposal to construct and test a 12.5-megawatt geothermal power plant in the Steamboat Hot Springs KGRA in Washoe County, Nevada, has been approved by the Bureau of Land Management (BLM). The power plant could be completed by October 1987. Electricity will be sold to Sierra Pacific Power Company, which has a substation nearby.

BLM Nevada State Director Ed Spang says the Plans of Operation and Utilization, which the BLM approved, were submitted by Chevron Resources Company as an agent for the Western States Geothermal Company. The latter will be the Steamboat Hot Springs unit operator, developing the geothermal resource through the installation of production wells, pipelines, and injection wells. Yankee-Caithness Joint Venture is the developer of the power plant and holds the sales contract with Sierra Pacific Power Company.

Several stipulations are included in the BLM approval. They were developed by the BLM, following a period of public review and consultation with state and local agencies having jurisdiction over the plant.

The stipulations include a program to monitor groundwater, surface water, and hydrothermal features to detect any impacts on the hydrology in the Steamboat Hot Springs area. The Steamboat basin has the second largest concentration of active geysers in the United States, and is one of the oldest known locations of continuous hot spring depositions in the world.

When plant operations are tested, an emission test will be required to verify that noncondensible gas concentrations are within federal and state standards. No geothermal fluid will be discharged on the land's surface.

Other stipulations include the special construction of electrical distribution lines to protect birds of prey; the fencing of hazardous areas; and a minimal disturbance of surface areas.

Exploration and development activities at the Steamboat Hot Springs KGRA began 11 years ago with competitive lease sale of the area. Phillips Petroleum Company and Gulf Energy Company purchased leases and began active exploration. Chevron later purchased Phillips' interest and became the unit operator.

Facilities will be located on both federal and private lands within the Steamboat Geothermal Unit area.

Geothermal Heat Improves Mining Process

Extensive laboratory tests by University of Nevada, Las Vegas, scientists prove that geothermal heat can be used to enhance the recovery of gold and silver by the cyanide leaching process.

Lab tests conducted at the Mackay School of Mines (MSM), University of Nevada, Reno, demonstrated increased recovery of gold at 20 percent and silver at 40 percent.

Dennis T. Trexler, director of the Division of Earth Sciences Environmental Research Center from the university, announced these encouraging findings and other related details in a 46-page booklet published by the U.S. Department of Energy.

Trexler and his co-workers have been exploring whether heating gold and silver leaching solutions with geothermal energy can speed up and increase recoveries of gold and silver, and allow heap-leach projects to operate even in freezing weather.

Geothermal heat brought increased recovery of gold at 20 percent and silver at 40 percent.

In his report, Trexler identified 10 operating mines near existing geothermal sites in Nevada which, as such, are likely candidates for geothermal enhancement of leaching operations. These mines are:

— Pegasus Gold, 35 miles north of Lovelock;
— Smoky Valley Mining Company, Big Smoky Valley, Nye County;
— West Northumberland Mine, Toquima Range, Nye County;
— Jerritt Canyon Mine, Independence Valley, Elko County;
— Boot Strap Mine, Newmont Gold Company, Elko County;
— Maggie Creek Mine, central Carlin Mining District;
— Gold Quarry Mine, southern Carlin Mining District;
— Tonopah Divide Mine, between Tonopah and Goldfield in Esmeralda County;
— Rawhide Mine, west of Gabbs in Mineral County; and
— The 16-to-1 Mine, west of Silverpeak in Esmeralda County.

Pegasus Gold Corporation plans to participate in a full-scale test of geothermal heat augmentation of cyanide heap leaching. Bob Turner, general manager at Pegasus, looks forward to the possibility of year-round production even more than the potential for increased recovery levels.

Copies of the report are available for $7.00 from the Division of Earth Sciences Environmental Research Center, 255 Bell St., Suite 200, Reno, Nevada 89503. The phone number is (702) 784-6151.

This article is reprinted, with permission, from the Nevada Mining Association Bulletin, Vol. 11, No. 1.

Application for New Nevada Power Plant

Brady Hot Springs Geothermal Associates has filed an application with the Public Service Commission of Nevada for a permit to construct utility facilities. The application, designated Docket No. 87-494, was filed pursuant to the provisions of the Utility Environmental Protection Act (NRS 704.820 et seq.).

Brady specifically seeks approval to construct a 6-megawatt (net) geothermal power generating plant and associated facilities at Brady Hot Springs, about 13 miles northeast of Fernley, Nevada. Power generated at the plant will be sold to Sierra Pacific Power Company under the terms of a contract between Brady and Sierra Pacific. The application contains information on the plant specifications and design, location, and summaries of studies of the environmental impact of the facilities.

The application is available for public inspection at the Office of the Public Service Commission, 505 East King Street, Carson City, Nevada 89710.

HAWAII

Hawaiian Update

Puna Geothermal Venture

Puna Geothermal Venture, a partnership of the Maxus Energy Corporation's (once Diamond Shamrock's) Thermal Power Company, and Amfac Energy, has engaged Fluor Daniel to design a two-unit, 30 megawatt, gross, power plant. The plant will be near the site of the state-owned HGP-A geothermal wellhead generator plant in the Kilauea East Rift Zone on the Island of Hawaii.

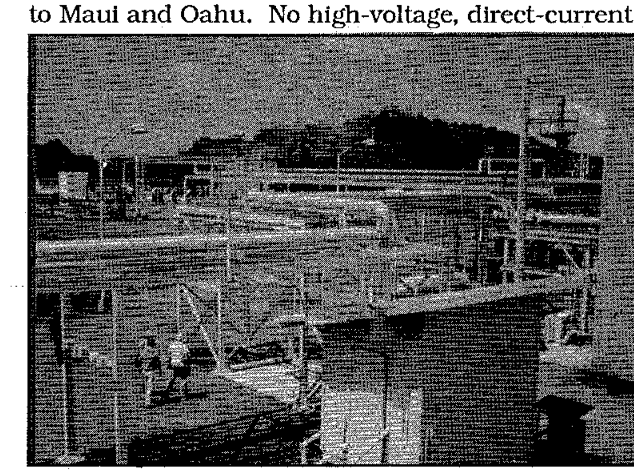
Puna Geothermal Venture's contract with the island's utility, Hawaii Electric Light Company, calls for delivery of 12.5 megawatts of geothermal power by 1989, and an additional 12.5 megawatts by 1993. A draft Environmental Impact Statement for the facility is expected to be delivered to the County of Hawaii Planning Department in August 1987.

True/Mid-Pacific Geothermal, Inc.

True/Mid-Pacific Geothermal, Inc., awaits a decision by the Hawaii Supreme Court before proceeding with major commitments leading to exploration for 100 megawatts in the Kilauea Middle East Rift Zone. Pele practitioners have appealed to the Supreme Court the decisions by the state's Department of Land and Natural Resources that allowed geothermal development activity. The practitioners claim that commercial exploitation of geothermal resources violates the goddess Pele.

Inter-Island Electric Cable System

This century, the market for geothermal energy is 25 megawatts on the Island of Hawaii. The major potential market for the Island of Hawaii's abundant hydrothermal resource is on Oahu, which has about 80 percent of the state's population and electrical demand. The Hawaiian Department of Business and Economic Development and the U.S. Department of Energy embarked on the eight-year, $29 million Hawaii Deep Water Cable Program. They will address the technical issues relating to a cable system that can transmit 500 megawatts of geothermally produced electricity from the Island of Hawaii to Maui and Oahu. No high-voltage, direct-current



The Hawaii Geothermal plant. The 3-megawatt plant is constructed at the well site.

by Gerald Lesperance

submarine cable has ever been installed over the distance and in the depths that would be encountered by this project. Recent bathymetric surveys have identified a viable submarine route.

Six thousand feet of a specifically designed cable for the project has been fabricated and will undergo laboratory testing. In 1988 or 1989, at-sea test laying and retrieval of a surrogate cable will be conducted in the most difficult portion of the proposed cable route.

An Environmental Assessment for the cable system was completed in July 1987. The Hawaiian Department of Business and Economic Development has selected a consultant to perform an Environmental Assessment for the development of up to 500 megawatts of geothermal power in the predesignated Geothermal Resource Subzones of Kilauea's Middle and Lower East Rift.

Direct-Use Applications

The initial demonstration of five direct-use geothermal projects has been completed at Noi'i O Puna (Puna Research Center), at the state-owned 3 megawatt HGP-A wellhead generator plant. The entrepreneurs for four of the projects are planning to continue on a commercial level. One of the four projects involves using raw geothermal steam to chemically enhance color dyes applied to cotton and silk. Another project uses geothermally-heated air to dry papaya puree to a powder valued for its papain, an enzyme that aids digestion. Another project speeds growth of decorative and landscaping palms by bottom heating. A computer-controlled kiln using geothermally-heated air has successfully dried indigenous lumber. A fifth project, fabricating glass art objects using silica extracted from brine, will continue on a small scale.

Hawaii's coordinator for geothermal commercialization is Gerald Lesperance, Energy Division, Department of Business and Economic Development, P.O. Box 2359, Honolulu, Hawaii 96804, phone: (808) 548-4020.

UTAH

Hot Dry Rock Project for Utah Moves Forward

A bed of hot, dry rocks beneath Beaver County, Utah, could pave the way for development of an important domestic energy resource, a legislative committee was told recently.

Bechtel National Inc. of San Francisco has launched a federally funded 5-year project to mine heat out of a granitic rock formation 12,000 feet below Roosevelt Hot Springs, an endeavor which project manager Janet Owen said could lead to development of a 50-megawatt power plant by the mid-1990's.

Research previously conducted by Los Alamos National Laboratory in New Mexico "...suggests, with advances in drilling techniques, it's plausible to tap hot dry rocks for commercial power," Ms. Owen told the Energy, Natural Resources, and Agriculture Interim Committee.

Bechtel has received a U.S. Department of Energy contract to conduct the research project, which was endorsed earlier this year by Utah Governor Norm Bangerter and members of the state's congressional delegation. Ms. Owen said the U.S. House of Representatives has approved funding for the research and Senate approval is pending.

Part of Roosevelt Hot Springs, which is southwest of Cove Fort, already is being utilized as a source of geothermal energy by Chevron Resources Company and its subsidiary, Intermountain Geothermal Company.

A fault has split the rock formation beneath the hot springs into two distinct sections, with Chevron tapping the wet eastern portion for geothermal energy to power a 20-megawatt power plant owned by Utah Power & Light Co., Ms. Owen noted.

The western half is composed of hot dry rocks that water cannot reach because of the fault. The Bechtel research is designed to determine if it is economically feasible to generate steam by drilling pairs of deep bore holes into the hot rocks and injecting highly pressured water into the cracks that form.

Ms. Owen said that, theoretically, the water would cause the cracks to gradually expand into reservoirs, where the water would be heated by the hot rocks and turned into steam that would be captured by the power plant.

The research project will try to assess how much energy can be produced and how long the resource will last.

Those are important questions to the banks that have been approached to finance the project, Ms. Owen said. "Directional drilling through granitic rock is expensive," she added.

by Mike Gorrell

This article is reprinted, with permission, from the July 18, 1987, edition of The Salt Lake Tribune.

Utah Roses Expands

Utah Roses, Inc. is developing an additional 1.6 acres of greenhouses at its Crystal Hot Springs site, according to an article in the GEO-Heat Center Quarterly Bulletin. The company's main facility is about 10 miles south of Salt Lake City, and its new Crystal Hot Springs site is 10 miles further south.

In the fall of 1979, a well was drilled at Crystal Hot Springs to a depth of 410 feet. Since then, flows of 400 gpm, 190°F geothermal water have been delivered to 3 acres of greenhouses, put into operation in 1980. With the new greenhouses operating, about $169,000 a year will be saved in natural gas heating costs.

FEDERAL PRODUCTION

Current Geothermal Production on-or-from Federal Lands
(Compiled by the Bureau of Land Management, May 1987)

1. The Geysers, Northern California		725 MWe*
- Northern California Power Agency Units #1 & #2	240 MWe	
- Sacramento Municipal Utility District/Geysers Geothermal Company	72 MWe	
- Santa Fe International Corporation	80 MWe	
- Steam from federal leases is utilized by 20 additional facilities. Federal portion =	333 MWe	
2. East Mesa, Southern California		20 MWe
- Magma Power Company	10 MWe	
- Ormesa Geothermal (in testing phase, ultimate capacity 19 MW)	10 MWe	
3. Roosevelt Hot Springs, Central Utah		20 MWe
- Chevron Resources Company	20 MWe	
4. Beowawe, Northeastern Nevada		16 MWe
- Chevron Resources Company	16 MWe	
5. Desert Peak, Northwestern Nevada		10 MWe
- Chevron Resources Company	10 MWe	
6. Cove Fort, Central Utah		10 MWe
- Mother Earth Industries	10 MWe	
TOTAL		801 MWe

* MWe = megawatts of electricity

United Nations Geothermal Activities in Developing Countries

The United Nations implements technical cooperation projects in developing countries through its Department of Technical Cooperation for Development (DTCD). The DTCD is mandated to explore for and develop natural resources (water, minerals, and relevant infrastructure) and energy—both conventional and new and renewable energy sources. It is responsible for economic and social development planning, and for public administration and energy training.

In the field of energy resources, the DTCD gives particular importance to new and renewable sources of energy, among which geothermal plays the most important role.

The DTCD is not a funding agency. The required funds are provided by the United Nations Development Programme (UNDP) or by other sources, including donor countries that may give "ad hoc" financial contributions under cost-sharing or trust-fund arrangements for specific projects in specific developing countries. All technical co-operation projects executed by the DTCD, including geothermal, are designed by the DTCD in close consultation with the recipient governments and UNDP resident representative offices.

Generally, a DTCD geothermal project has many components. The project may include the recruitment of short-term consultants and long-term experts; contract awards for geoscientific and engineering services (including deep drilling); the provision of training facilities in specialized centers overseas; and the procurement of high technology equipment.

In addition to the funds provided by the United Nations System, the recipient government, through its designated counterpart co-operating agency, provides all required locally available human resources, services, facilities, and equipment.

Until the late 1950's, the exploitation of geothermal energy was confined to a very few industrialized countries. It was almost unknown to developing countries. We in the United Nations feel proud to have initiated the dissemination of information on the importance of geothermal resources by convening in Rome in 1961 the first International Conference On New Sources Of Energy.

After the Rome conference, several developing countries requested United Nations assistance to carry out geothermal exploration projects. During the 1960's, major projects were executed by the United Nations in Chile, El Salvador, and Turkey, with very satisfactory results. In all three countries, geothermal fluids suitable for electrical power generation were discovered.

In the 1970's, the United Nations undertook other important geothermal exploration projects in Ethiopia, India, Kenya, and Nicaragua. The United Nations further promoted the worldwide importance of geothermal resources by convening two international symposia on the development and use of geothermal resources: in Pisa in 1970, and in San Francisco in 1975.

To date, the United Nations has been involved in over 30 geothermal exploration projects (completed or underway) in 20 developing countries: 8 in Africa (Djibouti, Ethiopia, Kenya, Madagascar); 8 in Asia (China, India, Jordan, Philippines, Thailand); 9 in Latin America (Bolivia, Chile, El Salvador, Honduras, Mexico, Nicaragua, Panama) and 6 in Europe (Greece, Romania, Turkey, Yugoslavia).

In addition, fact-finding missions to advise governments on the convenience of undertaking geothermal activities have been carried out by DTCD experts in Algeria, Argentina, Colombia, Comoros, Costa Rica, Ecuador, Egypt, Guatemala, Indonesia, Malaysia, St. Lucia, Somalia, Sudan, Syria, Tunisia, Uganda, Viet Nam, and Yemen.

The need to make more resources available to finance geothermal activities in developing countries was pointed out by the 1981 Nairobi Plan of Action, adopted at the United Nations Conference on New and Renewable Sources of Energy. In response, since 1982, the DTCD has worked to implement geothermal projects in developing countries by using UNDP financial support plus funds provided by donor countries in what is generally termed "third party cost-sharing".

Today, the DTCD has seven UNDP geothermal projects in 6 developing countries. Four of these (Bolivia, China, Honduras, and Kenya) are major exploration projects whose formulation and execution has been possible thanks to the generous contributions under "cost-sharing arrangements" from the government of Italy.

The project in China was undertaken with an international contribution of more than $10 million. It started in 1983, and is now almost completed, except for minor administrative issues. The main goal of the project is to strengthen the government capability to explore and exploit low-enthalpy resources in the Tianjin City area, and high-enthalpy resources in the Yanbajain area of Tibet. All objectives have been successfully achieved through:

- the provision of specialized consultancy services in low-enthalpy utilization;
- the construction of a mathematical model aimed at predicting the behavior of the Tianjin geothermal aquifers during the next 25 years under different extraction-reinjection scenarios;
- the implementation of a detailed geological, geochemical, and geophysical survey of the Yanbajain Valley, with a view of reconstructing the regional geothermal model of the area surrounding the presently exploited field;
- the implementation of a reservoir-and production-study of the Yanbajain field aimed at optimizing the power production of the existing plant, at defining the lateral extent of the reservoir, and at predicting its future behavior under different management scenarios;
- the provision of overseas training facilities in all disciplines involved in geothermal exploration, utilization, and power production for 30 Chinese experts, for a total of 160 person-months;
- the provision of a large amount of high-technology equipment, including a 3,000 meters depth capacity, high speed, mobile drilling rig and a very powerful computer configuration.

The project in Bolivia, with an international contribution of more than $7 million, started in 1986. It is expected to be completed in late 1988. Its main objective is to prove the existence of commercially exploitable geothermal resources for power generation in southwestern Bolivia (in the Laguna Colorada area). To date, a very detailed geological, geochemical, and geophysical survey has been completed in the project area. The sites for deep-drilling activities have been precisely located.

By next June or July, drilling operations will begin. Three to four wells, 1,000-1,500 meters deep, will be drilled in about one year's time. All necessary well logging measurements, production testing, and feasibility studies will be carried out. A strong likelihood exists of discovering high-enthalpy geothermal fluids. Besides the drilling rig and related equipment, the project will provide a large quantity of high technology scientific equipment and 160 person-months of overseas training to a number of Bolivian nationals.

The Kenya project started in 1985 and is expected to be completed in early 1988. It is funded with an international contribution of about $3.5 million. The project includes a pre-feasibility study in two areas of the Kenya Rift Valley (Menengai-Bogoria and Suswa-Longonot) with a view of locating sites for deep-drilling activities. The drilling will be undertaken during a future feasibility study, if funds are available. To date, all volcanological, petrological, hydrogeological, and geochemical studies have been completed in these areas. Study results confirm the interest in high-enthalpy geothermal resources in these areas. A detailed geophysical survey is now in progress. All results are expected to become available in late 1987. The project has also provided a large amount of equipment and 60 person-months of overseas training facilities for a number of Kenyan nationals.

The project in Honduras, with an international contribution of about $2.5 million, began in 1986. It is expected to be completed by early 1988. The object of the project is to assess the geothermal potential of the central region of Honduras and its suitability for electrical power generation and/or direct use of geothermal resources. By the summer of 1987, all geological, geochemical, and geophysical activities will be completed in all four project areas and the drilling

by Nicky Beredjick, Director
Natural Resources and Energy Division
Department of Technical Cooperation for Development
United Nations

The article is excerpted from a presentation by Mr. Beredjick at the U.S. Department of Energy, Geothermal Program Review V, April 1987. It is printed with the permission of Mr. Beredjick and the Department of Energy.

sites selected. Before the end of 1987, three, small-diameter bore holes, 500 meters deep, will be drilled in the most promising area. Although the geological environment of Honduras is not as favorable for geothermal development as those of other Central American countries, good chances exist to discover medium-high enthalpy geothermal resources. This has been proven by a 600-meter deep well drilled in western Honduras by the Central American Energy Resources Project (see article in this Hot Line issue). The UN project has provided all required equipment and 25 person-months of overseas training facilities to a number of Honduran nationals.

The total budget allocated to the above-mentioned United Nations projects over a 5-year period, is $23 million. Seventy-six per cent of this amount is in the form of a third-party, cost-sharing contribution from the government of Italy.

CANADA

Canadian Low-Temperature Resources Studied

A new study is underway of low-temperature geothermal resources in the Canadian Province of Alberta. Scientists, sponsored by the Canadian Federal Government (the Department of Supply and Service, Science Division) are evaluating the geothermal potential of Alberta. To do this, they are studying the brine data in provincial oil and gas drilling records.

The study is concentrating on the deep, saturated brines (about 10,000 feet deep and 200,000 TDS) with temperatures to about 120°C. Aquifer maps will be made illustrating the study findings. The project is scheduled for completion in early 1988.

The project was undertaken because the Canadian Government wishes to develop alternative energy sources, lessening the country's dependence on oil.

For further information, contact B.J. (Bev) Pfeffer, Ste. 1800, 840-7th Avenue S.W., Calgary, Alberta T2P 3G2. Phone: (403) 269-1777.

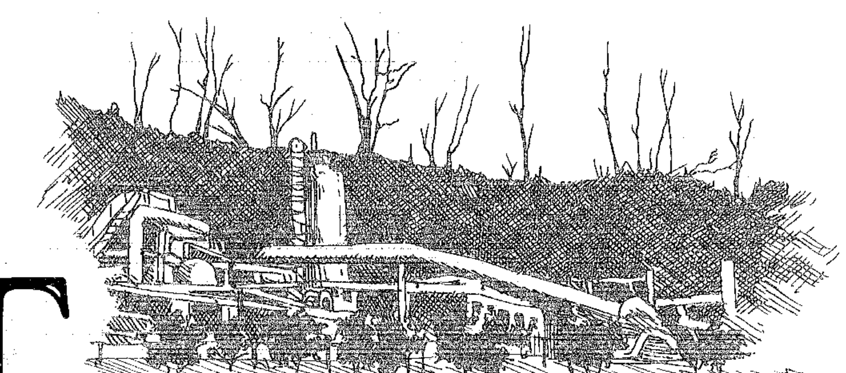
As an additional note, an article titled "Heat Flow and Heat Generation Estimates for the Churchill Basement of the Western Canadian Basin in Alberta, Canada" is printed in Volume 16, No. 1, 1987, of Geothermics. The article is written by R.D.W. Beach, F.W. Jones, and J.A. Majorowicz.

PACIFIC RIM

Kakkonda-Shizukuishi, A Combined Geothermal Power-and Heating-Plant

Introduction

The world's largest power plant incorporating electrical generation and direct-heat uses is nearing completion in Japan. When completed, the Kakkonda-Shizukuishi plant will produce 100 megawatts of electrical power and supply roughly 4,500 gal./min. (gpm) of hot water to private homes, industries, public facilities, and other users.



The idea is worthy of serious technical and economic consideration whenever population centers are near high-grade geothermal resources that will be developed for electrical power generation.

The plant is in the Shizukuishi District of Iwate Prefecture in the northcentral region of the Island of Honshu, just south of Mt. Iwate, an active volcano. The City of Shizukuishi, which will benefit from the district heating system, is about 11 miles west of Morioka, the capitol of Iwate Prefecture (Figs. 1 and 2).

by Dr. Ronald DiPippo
Mechanical Engineering Department
Southeastern Massachusetts University
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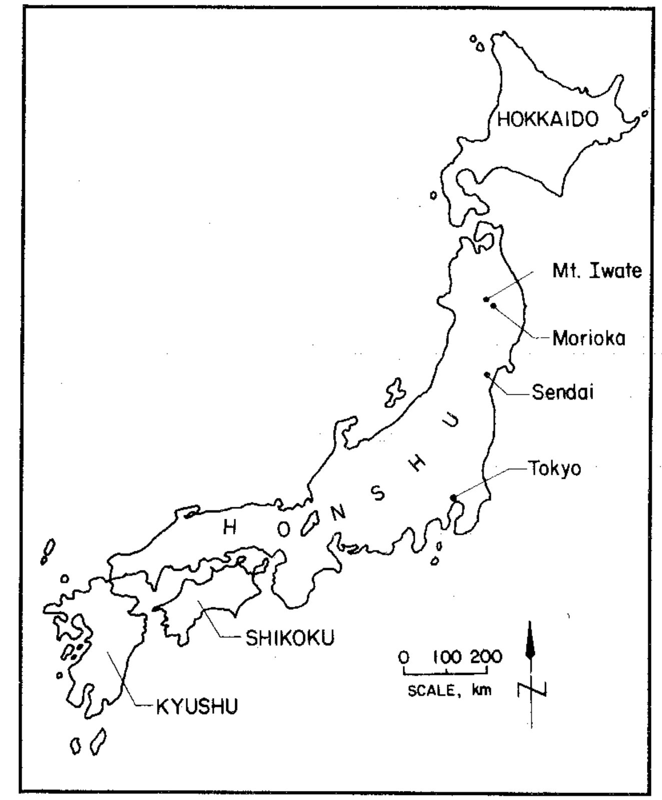

Figure 1. Map of Japan. Project area is near Mt. Iwate.

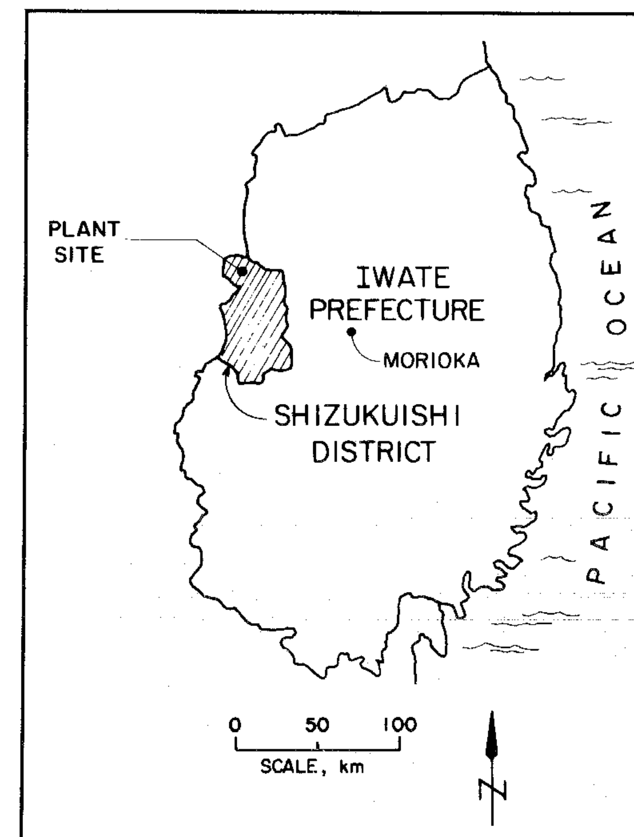

Figure 2. Map of Iwate Prefecture.

Currently, one 50-megawatt power unit is in operation at the plant; wells are being drilled for a duplicate second unit; the hot-water production plant is nearing completion; and the piping system to distribute the hot water is under construction.

Other Multiple-Use Plants

The Kakkonda-Shizukuishi plant will continue the established practice in Japan of geothermal multiple-use plants. At Matsukawa, a 22-megawatt power plant connected to a direct heating plant supplies hot water to a nearby resort area on the northern slope of Mt. Iwate. The heated, fresh water is transported about 2.8 miles from the power plant to the resort area[1]. The waste brine at the 12.5-megawatt Otake power plant is used to supply 675 gpm of fresh, hot water at 70°C (158°F) to the nearby town of Sujiyu Hot Springs. The Hatchobaru plant, only 1.2 miles south of Otake, generates 55 megawatts, while supplying 405 gpm of 70°C (158°F) water to the town[2]. The 3-megawatt power plant at the Suginoi resort hotel is coupled to public baths in Beppu. The electricity is used at the resort and the waste hot water is used in the baths[3]. A similar arrangement is used at another resort hotel, the Kirishima Kokusai Hotel, where a 0.1-megawatt plant is in operation[4].

In Iceland, the Sudurnes Regional Heating Company operates an integrated power and direct-heating plant at Svartsengi. The plant generates 6 megawatts of power for the company's customers on the Reykjanes Peninsula and supplies 603 gpm of hot water at 125°C (257°F) to nearby Keflavik[4,5].

Combined-use geothermal energy projects also occur at plants in the Soviet Union (Pauzetskaya) and in China, where several very small plants are in operation. Hardly any technical information is available on these plants.

Kakkonda-Shizukuishi Plant

The geothermal energy that powers the Kakkonda-Shizukuishi plant originates in the liquid-dominated

[1] *Superior figures refer to the list of Selected References at the end of the article.*

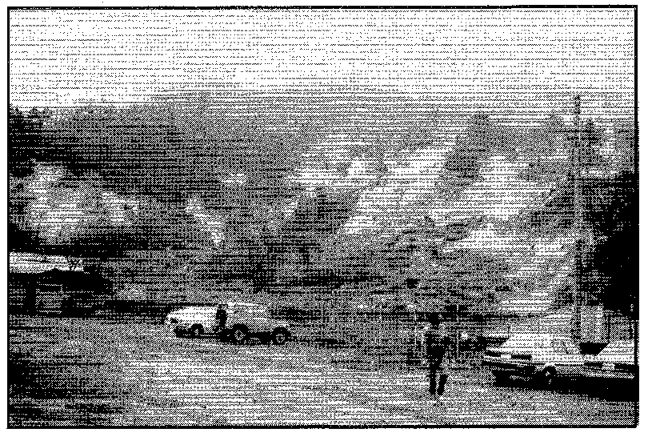

Photo 1. Takinoue hot-spring area. The large fumarole field is about 0.6 mile east of the Kakkonda power plant, just inside the Towada-Hachimantai National Park. Photo by R. DiPippo.

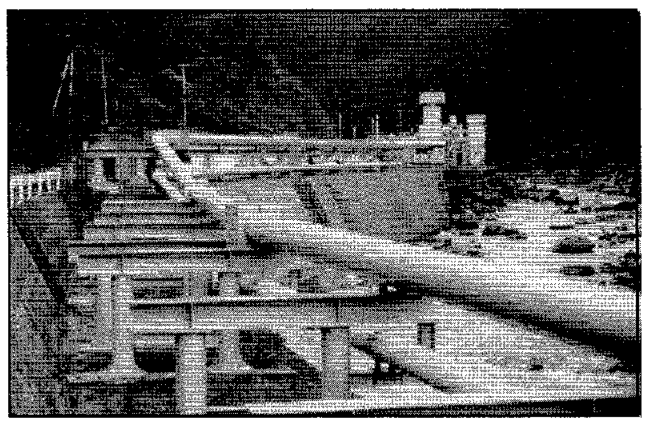

Photo 3. New pipelines for Unit No. 2. Well base areas 8 (near-rear) and A (far-rear) can be seen. The Kakkonda River flows past the well areas. Photo by R. DiPippo.

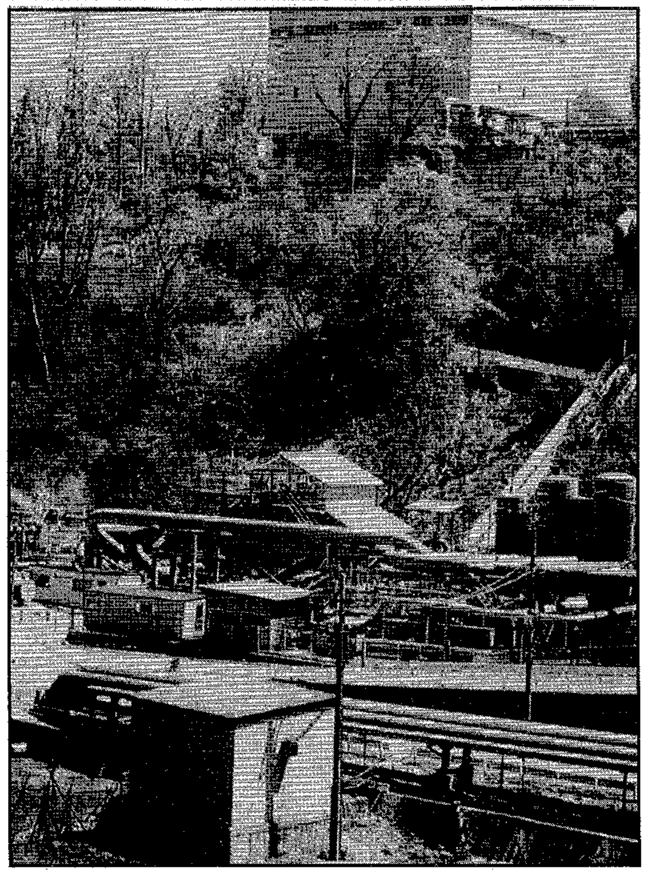

Photo 2. Kakkonda 50 megawatt, single-flash power plant. A portion of well base area B is shown. Steam pipes can be seen at the right, running up to the power house. Photo courtesy of Japan Metals & Chemicals Co., Ltd.

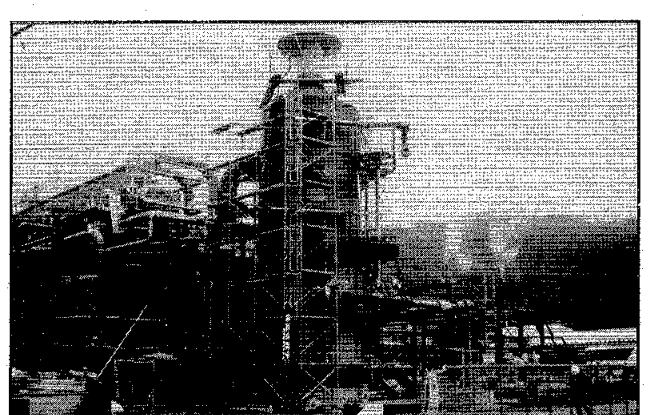

Photo 4. Brine/fresh-water, heat-exchange facility. At the left are the flash evaporators and the direct-contact heat exchangers. The tall vessel is a mixing tank in which the cooled brine is conditioned prior to injection. The facility will have two parallel trains of exchangers/tanks. Photo by R. DiPippo.

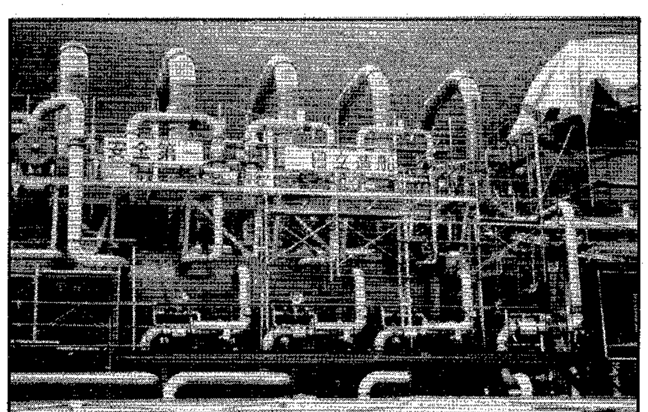

Photo 5. Flash evaporators (upper sections) and direct-contact heat exchangers (lower vessel). Brine is passed through 5 stages of flashing. The vapor from each stage is used in a direct-contact heat exchanger to heat fresh water obtained from the Kakkonda River. Photo by R. DiPippo.

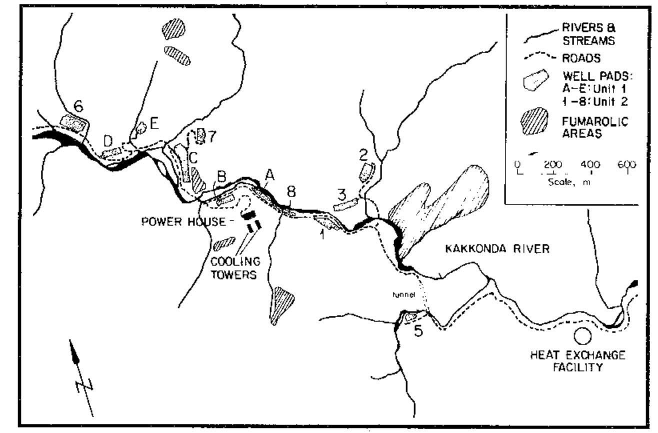

Figure 3. Plot plan of Kakkonda geothermal power plant and hot-water heat-exchange facility.

reservoir beneath the spectacular Takinoue hot springs area (Photo 1). Fluid temperature in the reservoir is about 240°C (465°F). The power plant is a single-flash plant, rated at 50 megawatts. It began operating in 1978 with 11 production and 16 injection wells (Photo 2)[6,7]. The wells are drilled from five well pads (A-E), as shown in Figure 3. Seven new pads (1-3, 5-8) are being prepared for the Unit 2 wells.

The heat-exchange facility is about 1.2 miles southeast of the power plant. Fresh water is taken from the Kakkonda River at a point roughly 0.6 mile upstream of the power plant. One-third of the 13,500 gpm of waste brine will be diverted to the heat-exchange facility, where it will be used in a five-stage, flash-evaporation process to heat the fresh water from 15° to 118°C (59° to 244°F). The facility will produce 3,600 gpm of fresh hot water, 1,350 gpm of which will be used in a variety of processes in an industrial park. The rest of the hot water will be blended with 1,100 gpm of cold water. The resulting water, at 85°C (185°F), will be distributed to the community for various uses (Photos 3-7).

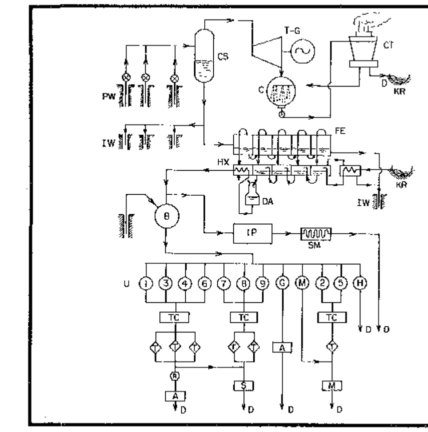

Figure 4. Schematic flow diagram of Kakkonda-Shizukuishi project. Nomenclature: PW = production wells, geothermal steam and hot water; IW = injection wells; CS = cyclone separators; T-G = turbine-generator, Kakkonda power station; C = condenser; CT = cooling towers; KR = Kakkonda River; D = drains; FE = flash-evaporator; HX = heat exchanger; DA = deaerator; B = blender; IP = industrial park; SM = snow melting; U = direct-heat users; 1-9 = districts; G = botanical gardens; M = miscellaneous users; H = hotels, motels, tourist-facilities, etc.; TC = temperature conditioning; T = total domestic use in private homes; R = radiant heating in private homes; A = aquaculture; S = swimming pool.

A schematic of the whole system is shown in Figure 4. A map showing the plants and the district-heating distribution in the town of Shizukuishi is in Figure 5. Table 1 contains data on a portion of the piping system. Table 2 lists the types of applications for the hot water. Table 3 summarizes the utilization for each district and the other users[8].

The thermodynamic efficiency of the system may be defined as the ratio of the total useful output to the available work (or exergy) of the original geothermal fluid[9]. If we adopt the conventional method of assessing the thermal output of the direct heating portion of the system[10] (i.e., the thermal output is the product of the mass flow rate, the specific heat, and the temperature drop), the following results are obtained:

Photo 6. Brine distribution station at well base area B. The brine separated in the cyclone separators is divided into the portion that is injected directly and the portion that is sent to the heat-exchange facility. Photo by R. DiPippo.

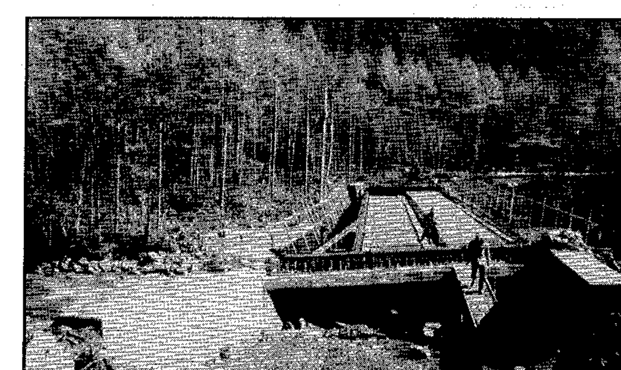

Photo 7. Bridge over Kakkonda River. Construction is underway on the bridge that will carry the hot water from the heat-exchange facility to the distribution and blending facilities. Photo by R. DiPippo.

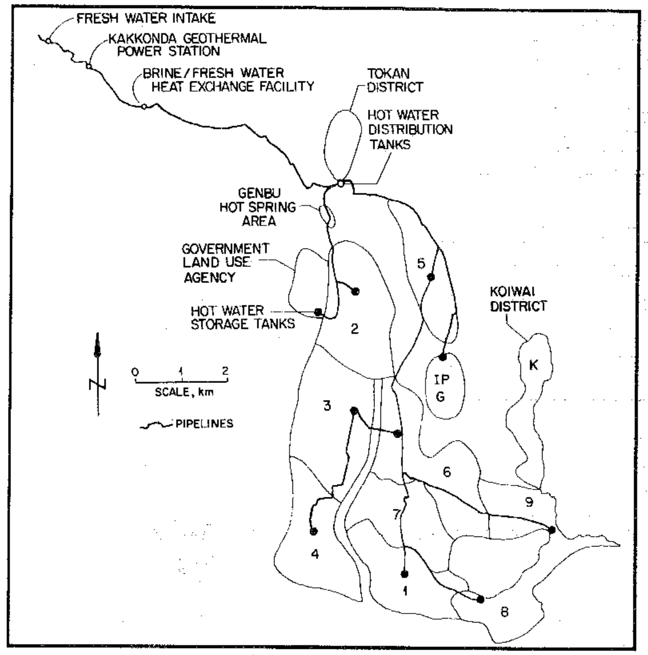

Figure 5. Shizukuishi hot-water heating system. Nomenclature as in Figure 4.

*Table 1. Pipe sizes and lengths.**

Piping	Diameter mm (in)	Length km (mi)
Fresh water (intake to HXer facility)	350 (14)	3.38 (2.1)
Brine (power plant to HXer facility)	500 (20)	2.37 (1.5)
Hot water (HXer facility to distribution tanks)	350 (14)	6.96 (4.3)

* This phase is scheduled for completion at the end of 1987.

Table 2. Types of end users.

Private homes:
- Total utilization
- Radiant heating

Apartments/Condominiums
Hospital
School
Town government office buildings
Day-care centers
Industrial Park:
- Food processing
- Plastics manufacture
- Particle board manufacture

Public facilities
Greenhouses
Agricultural processing
Botanical gardens
Fish farming
Swimming pools
Snow melting
Resort hotels
Tourist attractions

Electrical power output:	100,000 kW
Thermal power to industrial park:	31,500 kW
Thermal power to others:	52,500 kW
Total power output:	184,000 kW
Available power:	387,000 kW
Utilization efficiency:	47.6%

The available power is based on a dead-state at 15°C (59°F), and the hot water is assumed to be discharged after its thermal uses at 25°C (77°F).

This impressive efficiency is somewhat misleading, however, because on strict thermodynamic grounds it is not the 'heat' being delivered that matters, but rather the 'exergy' associated with that heat. However, it is customary to compute the thermal output in this way.

I have not included any power requirements for pumping the hot water. Since it appears that the system will be essentially gravity-flow, this should not affect the result very much. It is interesting to note that the power plant alone is only 25.8 percent efficient; the overall utilization improves significantly by adding the direct-heating system.

Concluding Remarks

The concept of combining geothermal electrical generation and low-temperature projects, like space-heating, is highly commendable. The idea is worthy of serious technical and economic consideration whenever population centers are near high-grade geothermal resources that will be developed for electrical power generation. In such projects, cascading the geofluid to meet demands at ever-lower temperatures improves the overall utilization of the available energy, and reduces the specific cost of the useful energy generated.

As with any geothermal project, one must be convinced that the resource will have a sufficiently long life to justify the expense of both the power plant and the hot-water generation and distribution system. In the case of the Kakkonda field, confidence has been acquired through commercial power production for nearly 9 years, and through detailed reservoir simulation studies[11]. The Kakkonda-Shizukuishi combined power- and heating- plant promises to serve as a model for systems of its type.

Table 3. Summary of overall utilization of direct heat.

District or User(1)	Flow rate m3/h	Private homes number	Public facilities number
1	135	905	16
2	21	150	1
3	31	250	1
4	45	335	2
5	6	60	0
6	37	300	0
7	34	280	1
8	27	210	1
9	30	180	1(2)
G	140	-	-
H	54	-	-
K	35	-	-
M	119	-	-
IP	300	-	-
Totals	1,014	2,670	23

(1) As in Figures 4 and 5.
(2) Private factory.

Acknowledgments

The author is grateful to Y.K. Kim of Southeastern Massachusetts University and to H. Kawamoto of Nanzan University, Nagoya, Japan, for their help in translating the Japanese reports cited in the article.

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A Look at NEDO

The New Energy Development Organization (NEDO), was established by the Japanese Government in 1980. Its goal is to develop new energy sources that will alleviate Japan's dependence on foreign oil. To achieve this, NEDO acts as a coordinating organization to promote research and development of new energy technologies.

NEDO is interested in developing oil-alternative, new-energy technologies and resources; rationalization of the domestic coal-mining industry; and alcohol production. The organization's budget is appropriated by the Minister of International Trade and Industry. Its capital was 165.4 billion yen, as of March 1987.

NEDO believes geothermal energy is a vital, indigenous energy resource. It conducts research and development projects in the areas of binary cycle power plants and hot dry rock. NEDO is investigating Japanese geothermal resources, along with new prospecting techniques. It surveys promising geothermal areas unexplored by private enterprise. NEDO has started geothermal surveys on 21 areas and completed surveys on 11. Three years are spent in each area.

NEDO may be reached at 28th and 30th Floors, Sunshine 60 Building, 1-1, Higashi Ikebukuro 3-chrome, Toshima-Ku, Tokyo 170, Japan.

NEW ZEALAND

Changes in New Zealand's Environmental and Governmental Policies

"There will be no new geothermal development in New Zealand without reinjection," said Mark McGuinness, of New Zealand's DSIR, the Department of Scientific and Industrial Research. "People are concerned about the effects of mixing geothermal brine with clean groundwater. For example, at Wairakei, the waste brine will eventually have to be injected instead of discharged into a river, as has been done in the past."

The new climate in New Zealand towards environmental protection comes with a major change in the country's policy toward geothermal development. Under the new plan, geothermal development is removed from governmental planning and control. For the first time in New Zealand's history, private companies may compete with governmental agencies to develop the country's geothermal resources. The governmental agencies will compete among themselves, as well, and be expected to make a profit.

All geothermal fields in the country will be developed by either a private company, the Electricity Corporation of New Zealand Ltd., or the Gas and Geothermal Trading Group under the Ministry of Energy. Before 1984, the New Zealand Ministry of Works and Development worked with DSIR to explore the country's geothermal fields.

The two changes affect each other in a manner that benefits the environment. This occurs because a developer must secure both land rights and water rights before undertaking a geothermal project. As geothermal water is under New Zealand groundwater law, local water boards issue the water rights for geothermal projects. These local boards must choose among all geothermal project applicants, both public and private. Such competition is presently underway for the rights to develop Mokai Geothermal field, the hottest and most promising new field in the country. Both governmental groups are competing in this venture, and are preparing environmental impact reports for the water board.

by Susan F. Hodgson

Mokai, a Field in Disguise

"Mokai Geothermal field is New Zealand's best new geothermal prospect, the hottest field in the country, and, for a long time, a field in disguise," said Mark McGuinness of DSIR, the New Zealand Department of Scientific and Industrial Research.

To date, 6 production wells have been drilled in the field, which is about 20 miles northwest of Wairakei Geothermal field on the North Island. The geothermal reservoir at Mokai is liquid-dominated, with significant boiling extending even deeper than at Wairakei. Wells at Mokai are drilled to up to 2.5 kilometers deep. Good production extends from 800 meters down. Fluids from the field reach temperatures of up to 320°C.

by Susan F. Hodgson

The first well drilled at Mokai was disappointingly cool. However, wells Mokai 2, 3, and 5 are excellent, very hot wells. Well Mokai 5 is a remarkable well. Its production is limited only by the well casing size, not by the permeability of the reservoir area around the well bore. Energy from this one well, alone, is sufficient to operate a 25-megawatt power plant. Mokai 4 is cooler, and may be used as an injection well.

The reservoir at Mokai consists of sequences of volcanics and sediments. As in many other New Zealand geothermal reservoirs, the main productive area in the Mokai reservoir is associated with the more brittle formations, consistent with the theory that fracturing is responsible for high permeability paths in the reservoir. This, with the layer-cake structure at Mokai, could account for the very high horizontal permeability seen there.

Mokai field was often omitted from lists of geothermal resources in New Zealand. The field was unknown for so long partly because it has almost no surface indications of geothermal activity. Only a few fumaroles and warm springs dot the landscape.

It wasn't until a resistivity study was made of the area in 1977 that the full extent of Mokai field was realized. At that time, the field was identified as a promising resistivity low. Geochemists sent to the field area reported that the fumaroles were above the reservoir's boiling zone. The chloride outflow zone was found to be north, and downslope from the field. This outflow tongue was deduced from warm chloride springs, and confirmed by later drilling.

Geothermal fluids from Mokai have high silica levels because of the high reservoir temperatures. High separation pressures will be used to separate the steam and hot water phases to avoid scaling problems in the injection wells and equipment. Current plans are to build four single-flash, 25-megawatt power plants in the field.

AUSTRALIA

Australian Geothermal Plant

The first successful geothermal power plant in Australia is operating from a hot artesian bore at Mulka Station on the Birdville Track in South Australia, according to an article in the GEO-Heat Center Quarterly Bulletin. A 20 kw, 415 V, 3-phase unit has been successfully operating since May 1986.

ENRECO PTY., Ltd., designers and manufacturers of organic Rankine cycle power generators, is in the process of designing larger machines, including a 120 kw plant to be installed in Southwestern Queensland.

LATIN AMERICA

Central American Update

"Geothermal development in Central America is impressive," said Bob Hanold, a Program Manager for Los Alamos National Laboratory. "It continues to move at a steady pace."

The Central American Energy Resources Project is designed to help the countries of Honduras, Costa Rica, El Salvador, Guatemala, and Panama develop their geothermal resources. Auxiliary project goals are to increase economic development and employment in Central America; to provide a scientific basis for the private sector to develop natural resources; and to provide scientific training to in-country scientists, engineers, and technicians. The energy resources project began in March 1985. Its progress is updated in every Geothermal Hot Line issue since that time.

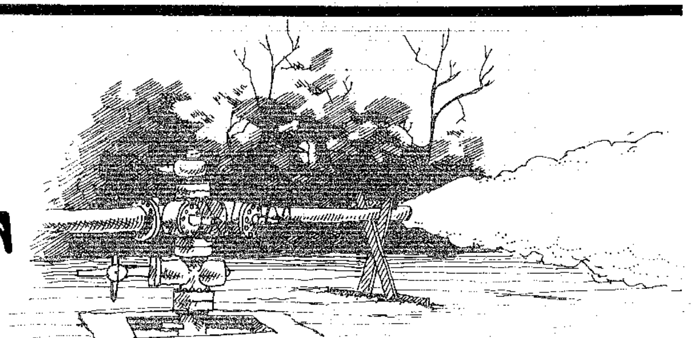
"In El Salvador," Hanold continued, "production well logging and geophysical operations will be conducted this summer with three goals in mind: characterizing the present state of the Ahuachapan geothermal reservoir; extending the Ahuachapan Field boundaries to the southeast; and exploring a nearby area with geothermal potential, called Chipilapa. We hope that additional structural information from the DC resistivity survey lines will guide the local utility in siting new wells. The field operations will be performed with a logging truck, logging tools, and a DC resistivity system that will remain in Central America

by Susan F. Hodgson

as a permanent part of the project."

"In Panama," Hanold added, "the Interamerican Development Bank-sponsored Panama Geothermal Advisory Panel has identified the drill sites for the first shallow, temperature-gradient wells. The locations were selected on the basis of extensive geovolcanological, geochemical, and geophysical investigations conducted by a number of international research organizations. The potential geothermal field is located about 125km west of Panama City, in an area called El Valle de Anton. The wells will be drilled in the southern and central portions of a caldera, in an area considered the most geothermally promising in Panama."

"In Honduras, two temperature-gradient wells have been drilled at the Platanares Geothermal field. The first, a very successful well, blew out at 250m when a pressurized supply of hot water was penetrated. Well drilling continued to a total depth of 650m, where an initial bottom-hole temperature of 165°C was measured. The second well, drilled to a depth of 420m, displayed a linear temperature gradient with a value of about 140°C/km below 200m. A third temperature-gradient well, co-funded by the government of Honduras and the United States Agency for International Development, is being drilled at the Platanares site. This core hole reached a depth of 596m on June 2, 1987.

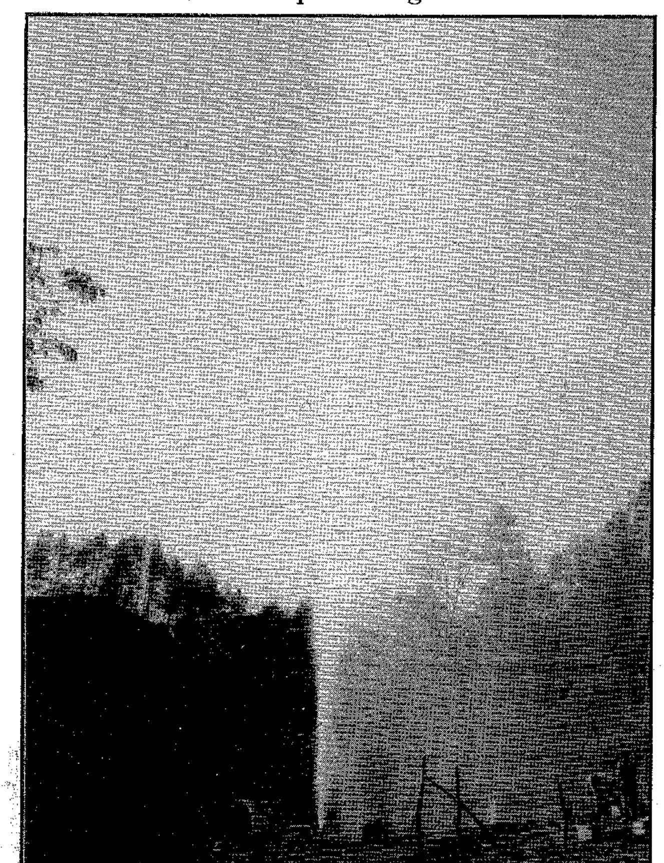


The President of Honduras visited the Platanares well site.

The President of Honduras visited the Platanares well sites. He is very interested in plans to generate electricity from geothermal resources in Honduras.

Funds for the Central American Energy Resources Project are issued to Los Alamos National Laboratory by the United States Agency for International Development. Los Alamos is assisted in parts of the project by staff from the U.S. Geological Survey.

For further information, contact Robert J. Hanold, Program Manager, Earth and Space Sciences Division, Los Alamos National Laboratory, P.O. Box 1663, Mail Stop 0446, Los Alamos, NM 87545; phone (505) 667-1698.



Steam and brine discharging from the first temperature-gradient well at Platanares Geothermal field. Photo courtesy of Robert J. Hanold.

Panamanian Mining Inventory Approved

In April 1987, the Inter-American Development Bank announced the approval of a $950,000 technical cooperation grant to help prepare a mining inventory in Panama and to strengthen the Direccion General de Recursos Minerales, the government mining agency.

The project provides for the preparation of geological maps for three areas in Panama, totaling 15,000 square kilometers.

The maps will identify deposits of metallic and nonmetallic minerals of potential economic value in the short and medium term.

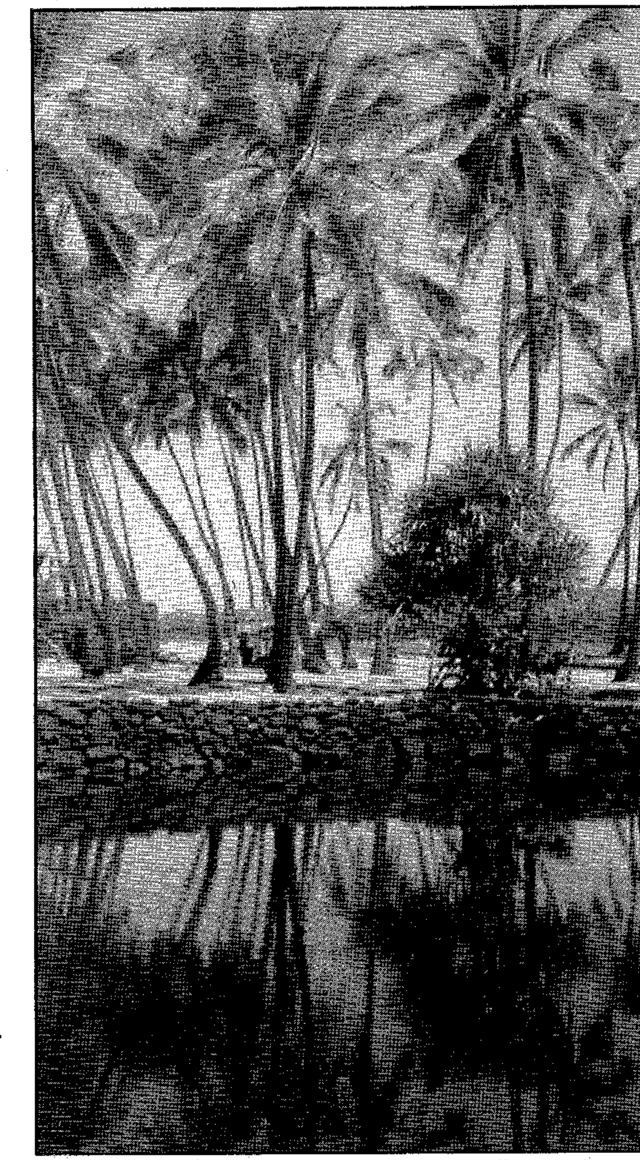
The assistance will also strengthen the technical capacity of the Direccion General de Recursos Minerales to carry out interdisciplinary geological studies by providing training in geology and mining.

The IDB Supports Environmental Protection

The International Development Bank (IDB) has funded many geothermal projects throughout the world. "The IDB believes that environmental protection is inseparable from economic development. An analysis of environmental aspects must be carried out at the earliest stage of the loan project evaluation process," said Jorge D. Ferraris, Manager of the IDB's Project Analysis Department.

"The IDB," he said, "is making a sustained, theoretical, and practical effort to improve its procedures in the analysis of projects. The experience of the bank demonstrates that if environmental issues are not addressed in the planning and design stage of projects, environmental harm can result.

"Although this type of analysis may appear costly, the costs ultimately prove to be minimal compared to the benefits. In the long term, and in the case of some projects, the incorporation of the environmental protection measures results in higher economic returns than in projects where these measures are not taken," Ferraris concluded.



Environmental Protection for Latin America

The Inter-American Development Bank helped finance a consultative meeting with public institutions responsible for environmental protection and the conservation of natural resources in Latin America and the Caribbean.

Strategies were developed at the meeting for improved cooperation among public agencies responsible for environmental matters and for the inclusion of such concerns in development projects which the bank finances.

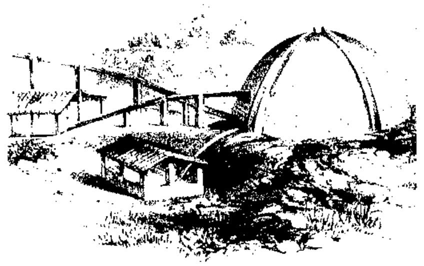
The meeting was held in response to a growing interest on the part of the countries of Latin America and the Caribbean to monitor the environmental effects of developmental projects and to minimize any negative changes.

ITALY

Italian Geothermal Development

The following information on Italian geothermal development is reproduced from a series of posters by Enel, the Italian electricity board.

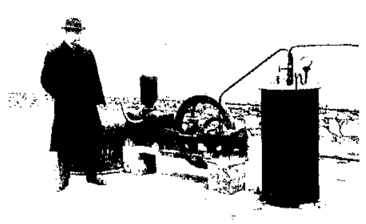
1775 - 1904
Chemical production



Covered lagoon

Old chemical factory

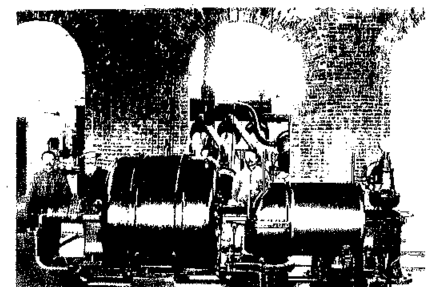
1904 - 1905
Start of geothermal power production: first experiments



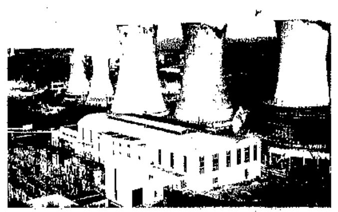
First experiments by P. Ginori Conti

Carriage-mounted sampling laboratory

1913
First power plant (250kW$_e$)

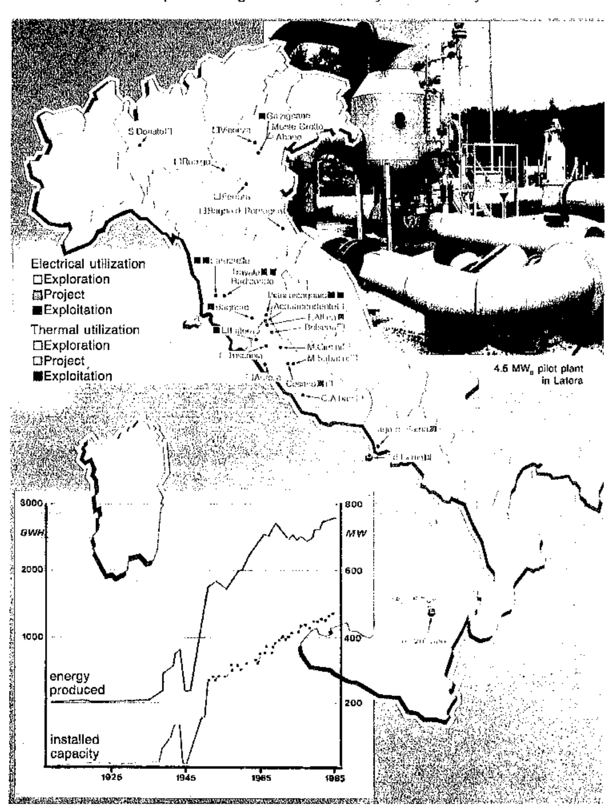


1913 - 1964
Combined electrical, chemical and thermal utilization



1965
End of chemical utilization of geothermal fluid and start of processing by geothermal fluid of imported minerals

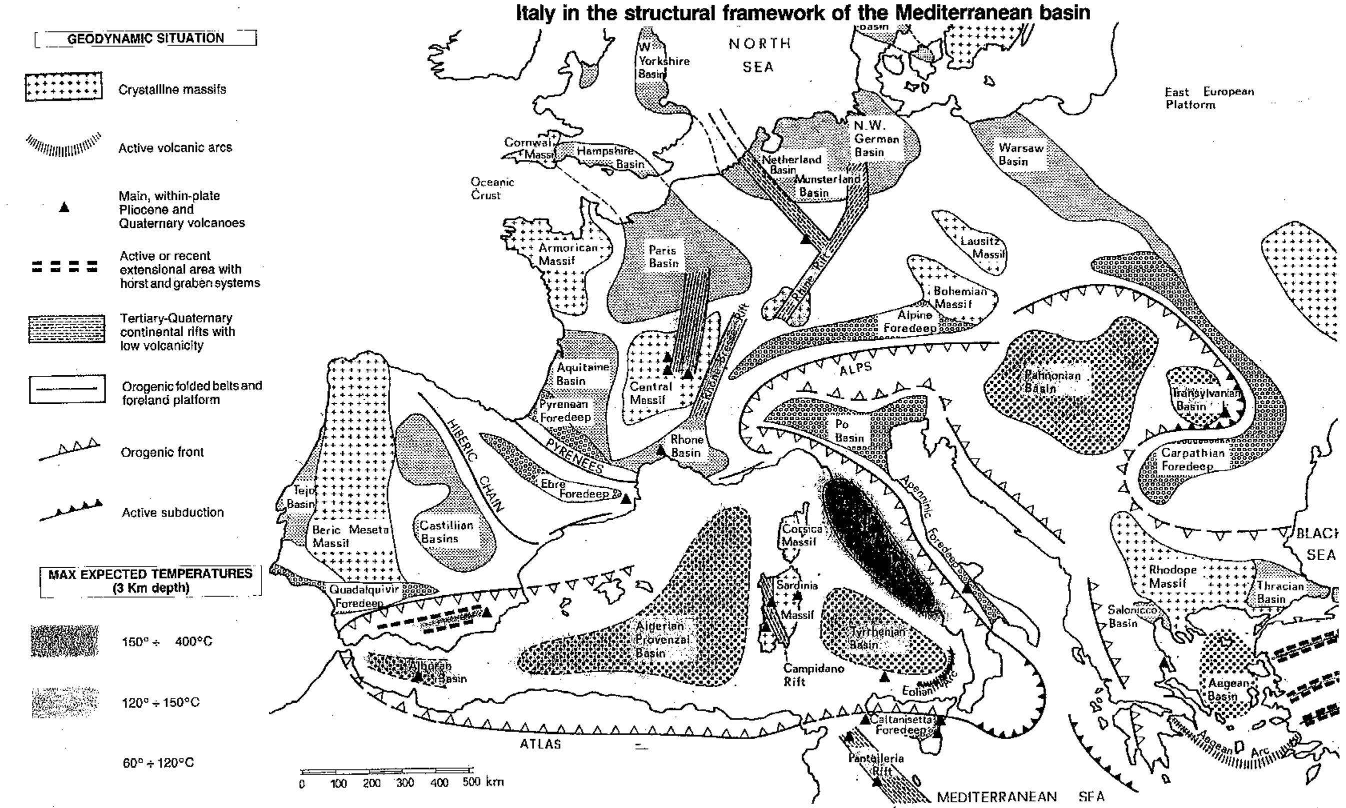
1965 - 1985
Development of geothermal activity in all of Italy



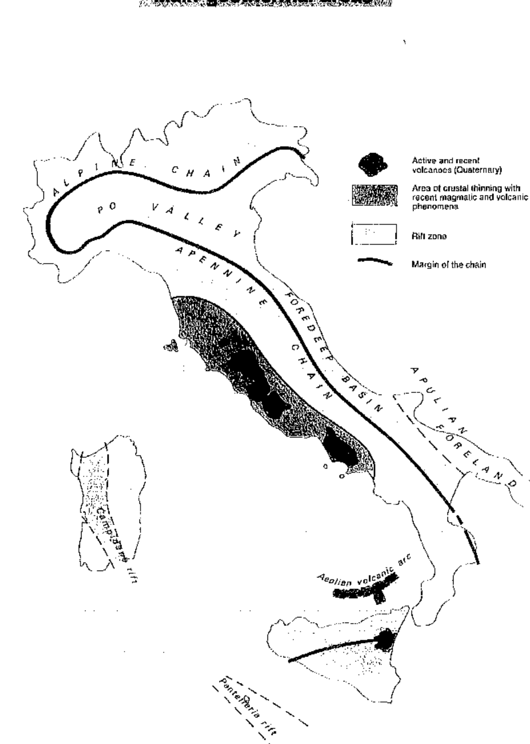
4.5 MW$_e$ pilot plant in Latera

AREAS OF GEOTHERMAL INTEREST IN ITALY

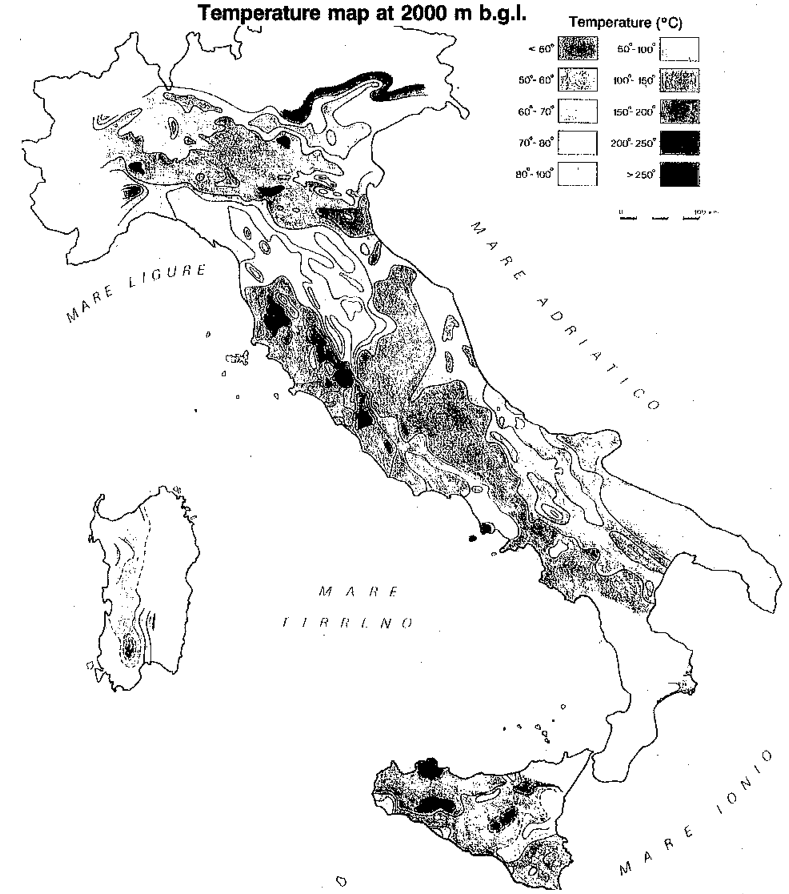
Italy in the structural framework of the Mediterranean basin



Main geothermal areas

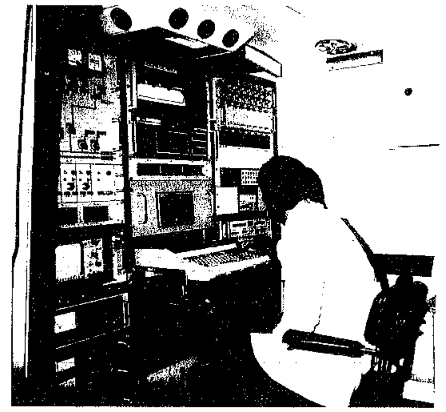


Temperature map at 2000 m b.g.l.

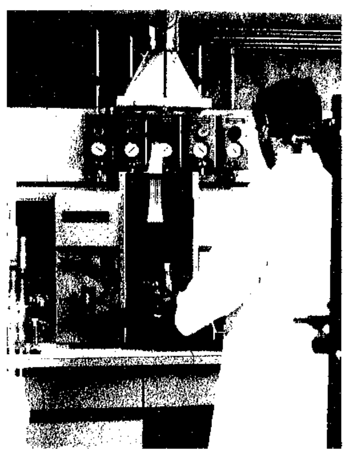


RESOURCES AND INVESTMENTS FROM 1985 TO 1995

Organizations involved

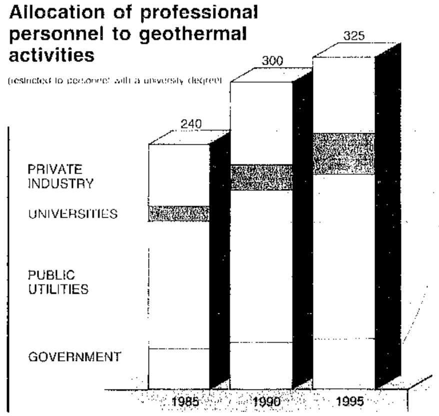


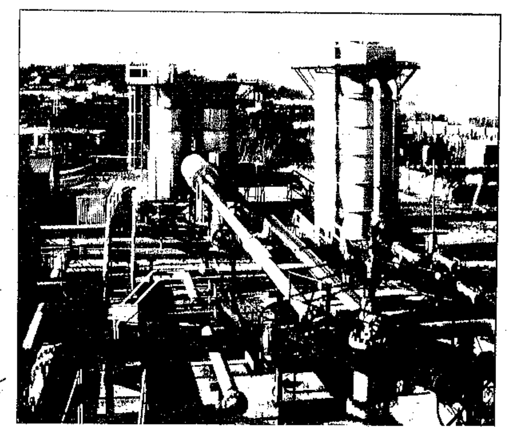
Industrial organizations	Scientific organizations
Chiefly: • ENEL	• C.N.R. (National Research Council) : Finalized Energy Project and International Institute for Geothermal Research
Subordinately: • AGIP	• UNIVERSITIES (Trieste, Milan, Turin, Florence, Pisa, Siena, Rome, Naples, Bari, Palermo, Cagliari, Padua)
• ENEL-AGIP Joint Venture, and others	• ENEL, AGIP and others



Allocation of professional personnel to geothermal activities

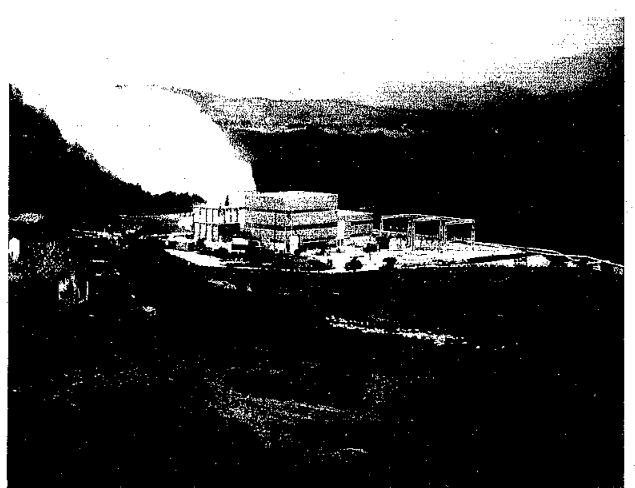
(restricted to personnel with a university degree)

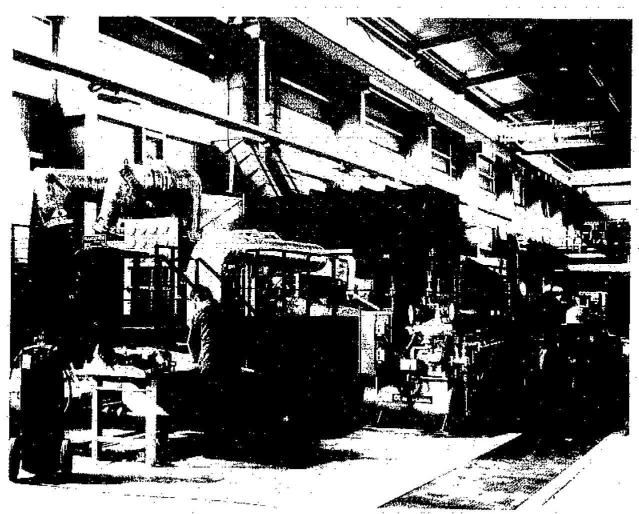




Investments

Investments of LIT 1500 billion, equivalent to U.S. $ 1.2 billion at December 1985 exchange rates, are foreseen to achieve the goals set for 1995.





GEOTHERMAL DEVELOPMENT FROM 1975 TO 1985

INSTALLED CAPACITY OF ITALIAN GEOTHERMAL POWER PLANTS

Region	Power Plant	January 1975 No. of Units	January 1975 Unit Rating (MW)	January 1975 Total Inst. Cap. (MW)	December 1985 No. of Units	December 1985 Unit Rating (MW)	December 1985 Total Inst. Cap. (MW)
LARDERELLO	LARDERELLO 2	4 1	14.5 11	69	4	14.5	58
	LARDERELLO 3	3 1 2	26 24 9	120	4 1	26 9	113
	GABBRO	1	15	15	1	15	15
	CASTELNUOVO	2 1 1	11 26 2	50	2 1 1	11 26 2	50
	SERRAZZANO	2 2 1	12.5 3.5 15	47	2 2 1	12.5 3.5 15	47
	SASSO PISANO	1 1 2	12.5 3.2 3.5	22.7	1 1 1	12.5 3.2 3.5	19.2
	LAGO	1 1 1	12.5 6.5 14.5	33.5	1 1 1	12.5 6.5 14.5	33.5
	MONTEROTONDO	1	12.5	12.5	1	12.5	12.5
	VALLONSORDO	1	0.9	0.9	—	—	—
	MOLINETTO	1	3.5	3.5	—	—	—
	LAGONI ROSSI 1	1	3.5	3.5	1	3.5	3.5
	LAGONI ROSSI 2	1	3	3	—	—	—
	LAGONI ROSSI 3	—	—	—	1	8	8
	SAN MARTINO	—	—	—	1	9	9
	SAN MARTINO 2	—	—	—	1	20	20
	LA LECCIA	—	—	—	1	8	8
	MOLINETTO 2	—	—	—	1	8	8
SUBTOTAL		33		380.6	32		404.7
TRAVALE/ RADICONDOLI	TRAVALE 2	1	15	15	1 1	15 3	18
	RADICONDOLI	—	—	—	2	15	30
SUBTOTAL		1		15	4		48
MT. AMIATA	BAGNORE 1	1	3.5	3.5	1	3.5	3.5
	BAGNORE 2	1	3.5	3.5	1	3.5	3.5
	PIANCASTAGNAIO	1	15	15	1	15	15
SUBTOTAL		3		22	3		22
LATIUM	LATERA	—	—	—	1	4.5	4.5
TOTAL		37		417.8	40		479.2

GEOHEAT OF ITALIAN DISTRICT HEATING AND GREENHOUSE PROJECTS UNDER DEVELOPMENT IN DECEMBER 1985

Project	District heating Volume (m^3)	Greenhouse area (m^2)	Annual geoheat (Gcal)	Annual oil saving (PET)
LARDERELLO	350,000	15,000	90,000	14,000
ABANO	100,000	20,000	150,000	20,000
AMIATA		220,000	350,000	54,000
FERRARA	2,140,000	—	75,000	9,000
CESANO	350,000	—	8,600	1,300
SAN DONATO	467,000	—	15,000	2,100
VICENZA	1,118,000	—	23,000	4,200
CASTELNUOVO V.C.	210,000	—	10,400	1,600
BULERA		5,500	2,200	300
RADICONDOLI	—	24,000	23,000	3,200
TOTAL	**4,735,000**	**284,500**	**747,200**	**109,700**

DRILLING IN THE PERIOD JANUARY 1975 - DECEMBER 1985

Zone	Situation as of Jan. 1975 Wells drilled (No.)	Situation as of Jan. 1975 Average depth (m)	From Jan. 1975 to Dec. 1985 Wells drilled (No.)	From Jan. 1975 to Dec. 1985 Average depth (m)	Situation as of Dec. 1985 Wells drilled (No.)	Situation as of Dec. 1985 Average depth (m)
LARDERELLO	539	656	39	1800	578	735
TRAVALE - RADICONDOLI	34	644	25	1874	59	1165
MT. AMIATA (Bagnore, Piancastagnaio, Poggio Nibbio)	60	780	12	2796	72	1115
LATERA	—	—	11	2130	11	2130
CESANO	—	—	12	2520	12	2520
TORRE ALFINA	5	749	4	1770	9	1200
PHLEGRAEAN FIELDS	—	—	12	2380	12	2380
OTHER ZONES	12	951	13	1860	25	1420
TOTALS	**650**	**—**	**126**	**—**	**776**	**—**

WORLD TRADE

Exporting California's Geothermal Expertise

An Energy Technology Export Program has been launched by the California Energy Commission (CEC). Included in the program is a wide variety of activities aimed at exporting the state's high-temperature geothermal expertise to developing and newly industrialized nations. The expertise rests in the fact that California's geothermal energy development represents over 95 per-cent of that in the United States, and that the majority of U.S. geothermal energy firms are in California.

During the first two weeks of October 1987, a trade mission of geothermal experts from 24 countries is coming to the state. The mission is sponsored by the U.S. Department of Energy, Los Alamos National Laboratory, the Geothermal Resources Council (GRC), the World Bank, some geothermal vendors, and the CEC.

The visitors will tour geothermal electrical generating sites in the Imperial Valley, The Geysers Geothermal field, the Wendel-

Amedee Geothermal Resource Area (visiting the plant designed by Barber-Nichols Engineering Company), the Mammoth Pacific Power Station at Casa Diablo, and the Steamboat Hot Springs area south of Reno, Nevada. At each site, representatives of geothermal businesses will explain their parts in the projects. The tour will focus on geothermal electrical generation projects for resources 300°F or higher. No low-temperature projects are included. The tour will end in Reno, with two days of workshops sponsored by the GRC.

For future visits, the list of 24 countries will be narrowed to the countries most actively involved in geothermal development. Also, a series of overseas trade forums and missions are planned. For these events, U.S. representatives from all the alternative energy technologies will go as a group to see foreign markets.

CEC Energy Technology Export Program activities for FY 87/88 and 88/89 include:

o Technical assistance to help California companies match equipment to application, and handle institutional trade barriers and export financing;

o Establishment of an energy trade lead system to supplement the general trade lead system of the California World Trade Commission;

o Informational exchanges with energy representatives of foreign governments;

o Tests measuring the effectiveness of trade missions and trade promotional activities; and

o Information seminars and workshops.

For more information on the Energy Technology Export Program, contact Tim Olson, CEC, 1516 Ninth Street, MS-45, Sacramento, California 95814; phone (916) 324-3444.

For publications describing the program, contact Linda Joy DeBoard at the same address and phone number.

Economic Studies in Pacific Rim Nations

A 3-year study is underway of Pacific Rim nations. The study, funded by a $190,000 grant from the National Science Foundation, is being undertaken by Gary G. Hamilton, Professor of Sociology at the University of California-Davis, and three other faculty members.

They will study the business institutions of countries along the Pacific Rim, concentrating on the complex enterprise groups into which individual firms are incorporated.

A second study will be undertaken by Dr. James J. Sullivan, director of the University of California Sea Grant College Program. He will research Japan's systems and policies for promoting scientific research and development. Sullivan is especially interested in institutional mechanisms for cooperatively moving knowledge from the research laboratory to industry for development of new products and processes.

DEVELOPMENT

GEOLOGY

Inside the Core of the Earth

Iron is the major constituent of both the earth's solid inner core and its liquid outer core. Williams et al. studied temperatures at which iron melts under high-pressure conditions using a static technique (a laser-heated diamond cell) and a dynamic one (subjecting iron to high-pressure shock waves). Resulting temperatures were adjusted to account for the melting of iron-rich alloy, not of pure iron, itself. The researchers found that the temperature at the core-mantle boundary (with pressure of 136 gigapascals) would be about 3800 Kelvin in order for the outer core to remain liquid.

At the boundary between the inner and outer cores (with a pressure of 330 gigapascals), the temperature should be about 6600 K. The temperature gradient across the inner core is not great, so the melting temperature of iron at pressures near those of the inner-outer core boundary can be considered close to the temperature at the center of the earth. The measurements place an upper limit of 6900 ± 1000 K on the temperature at the center of the earth.

The article is reprinted, with permission, from the April 1987 issue of Science, vol. 236, no. 479, p. 4,798.

Crater Lake Studied

The Bureau of Land Management, in response to an October 15, 1986, Act of Congress, suspended geothermal leasing on federal lands (see Section 115 (2)(a) of the October 15, 1986 Congressional Record). The act gave the Secretary of the Interior 120 days to publish a proposed list of "significant thermal features" in the National Park System. After publication of the proposed list, the Secretary was given 60 days to evaluate public comment and send the final list to the Committee on Energy and Natural Resources of the Senate, and Committee on Interior and Insular Affairs of the House of Representatives.

The proposed list was published on February 12, 1987. The list contained references to the heat-flow anomalies found by the USGS on the floor of Oregon's Crater Lake (Williams and Von Herzen, 1983). The Department of the Interior is gathering data on whether these heat-flow anomalies qualify as "significant thermal features" under the guidelines of the Congressional act.

As of September 10, 1987, this determination had not been made. However, extensive, fact-finding studies have been undertaken. During the summer of 1987, measurements were made of Crater Lake's water temperatures, and underwater areas were videotaped with remote-operating cameras. The results of these studies will be submitted to the National Park Service on September 17, 1987, and sent by the Park Service to Donald Hodel, Secretary of the Interior.

These studies will be used to pinpoint Crater Lake sites needing further research, which is planned for the summer of 1988. At that time, a small, light, one-person mini-submersible vessel will be flown by helicopter to Crater Lake. Underwater studies of significant areas will be made.

For more information on the Crater Lake research program, contact Dr. Diamond at Oregon State University (503) 754-2296.

NOTE: The first two paragraphs of this article are reprinted from Oregon Geology, June 1987.

ELECTRICAL TRANSMISSION

New Power Pool Begins

The Western Systems Power Pool (WSPP), an experimental power pool linking electrical utilities in 10 western states, began operating May 1, 1987. WSPP will make lower-cost power available to more than 30 million consumers. It will distribute intermittently- and seasonally-available surplus power more efficiently among member utilities.

The Federal Energy Regulatory Commission approved a 2-year operation of the pool to test the effectiveness of market-based pricing. The energy prices will fluctuate according to market pressure instead of regulatory requirements. Transmission prices will also fluctuate, reflecting economic value rather than historical costs.

The system depends on a central computer, operated by Arizona Public Service in Phoenix, which links every company belonging to the pool. WSPP members will use the computer as an electronic bulletin board, listing daily availability and prices of surplus electric supplies and transmission capacity.

When a utility finds surplus power offered at the right price, and if there is transmission capacity available for the right fee, the deal can be completed by the parties involved. Electricity will then be moved over transmission lines connecting the buyer and seller. Each member whose lines are used will be paid a fee.

WSPP is the largest power pool in the nation. It represents a unique joint effort by public and private utilities to serve their customers. WSPP members include Arizona Electric Power Cooperative Inc., Arizona Public Service, Bonneville Power Administration, California Department of Water Resources, El Paso Electric Company, Nevada Power Company, Northern California Power Agency, Pacific Gas and Electric Company, Pacific Power and Light Company, Portland General Electric Company, Public Service Company of New Mexico, Sacramento Municipal Utility District, San Diego Gas & Electric Company, Salt River Project, and Southern California Edison.

The California-Oregon Transmission Project

On April 7, 1987, California's three largest investor-owned electric utilities asked the California Public Utilities Commission (CPUC) for approval to build a transmission line that would give them increased access to economical electric power from the Pacific Northwest.

The California-Oregon Transmission Project is a planned 500-kilovolt transmission line between the California-Oregon border area and the San Francisco Bay area. The 330-mile line would create another link between the electrical-generating systems of the Pacific Northwest and those of California, allowing the transmission of 1.6 million kilowatts of low-cost power. Total cost of the project, which will be completed in 1991, is estimated to be $430 million.

The three utilities, Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E) will be entitled to 41 percent of the power from the project. Capital cost for the three utilities will be about $250 million. Other owners of the high-voltage transmission line and supporting facilities would include many municipal and government-owned utilities in California.

"Participating in this project will help us provide more economical power to our customers in California," said Robert J. Haywood, PG&E vice president, power contracts. "It will increase our access to low-cost Northwest power and improve the reliability of electric service we provide."

"Because the new line will provide California with more clean, low-cost power, it will allow utilities here to reduce their need to burn expensive fossil fuels to produce electricity," added Glenn J. Bjorklund, Edison vice president in charge of system planning and research. "That, in turn, will help keep rates down and improve local air quality."

"This project will also increase the opportunities for purchasing existing and future power from Canada," said Gary Cotton, SDG&E senior vice president in charge of engineering and operations. "Because of the expanded coordination of operations between the two regions, it will increase the efficiency of generating resources in both California and the Northwest."

Utah Sells Electricity to Nevada

Utah Power & Light Company (UP&L) has signed a long-term contract for the sale of electrical power to Nevada Power Company. Under the contract, UP&L will sell 140 megawatts of power to Nevada Power Company for up to a 20-year period.

The contract with Nevada would be renegotiated for the 1999-2010 time period to reflect any changes in power usage that may occur during the next decade.

The sale would require UP&L to complete construction of a 345,000-volt power line from the Richfield area to the Nevada border, where it would connect to a similar line to be constructed by Nevada Power Company. UP&L will seek approval of the sale from state regulators and the Federal Energy Regulatory Commission.

Fracture Mapping Tool Designed

Researchers at Sandia National Laboratories have designed and successfully tested a high-power, high-resolution tool. The tool can help exploration engineers recover more energy from geothermal, oil, and gas reservoirs by locating deeply buried rock fractures.

A prototype of the tool, built by Southwest Research Institute of San Antonio, Texas, has been successfully demonstrated at a special granite quarry test facility south of Albuquerque, New Mexico. During field tests, the tool has detected simulated fractures that were more than 30 feet away from a test borehole. No other mapping tool has this directional capability.

The tool, which fits in a typical uncased borehole, emits pulses, each of which lasts just eight billionths of a second. The frequency spectrum of the pulses ranges up to the VHF band.

Fracture direction is determined by transmitting powerful, highly directional radar pulses in a known direction from a borehole. Discontinuities in the rock will interrupt and reflect radar signals; therefore, signals that return to the tool's receiving antenna indicate the presence of fractures. The return signal's time delay translates into distance from the borehole. The transmitter and receiver rotate in place, permitting the tool to scan for fractures in all directions from the borehole.

The tool is 7 1/2 inches in diameter and 20 feet long. The prototype model uses an aluminum housing; however, advanced development models will have a steel housing and a smaller diameter.

New Pneumatic Turbine

A pneumatic turbine drill, designed to increase drilling efficiency and lessen drill pipe fatigue, probably will have its first high-temperature test in a well in The Geysers Geothermal field, according to an article in the April 27, 1987, issue of the Oil and Gas Journal.

The turbine drill is 16 feet long and 8 1/2 inches wide in outside diameter. The high-torque, low-speed turbine has drilled at rates of up to 200 feet an hour in shallow holes.

In the trial run at The Geysers, the turbine drill is expected to be used to drill the lower portion of a geothermal steam well. This part of the well is usually 3,000 to 4,000 feet long, with temperatures from 300° to 450°F.

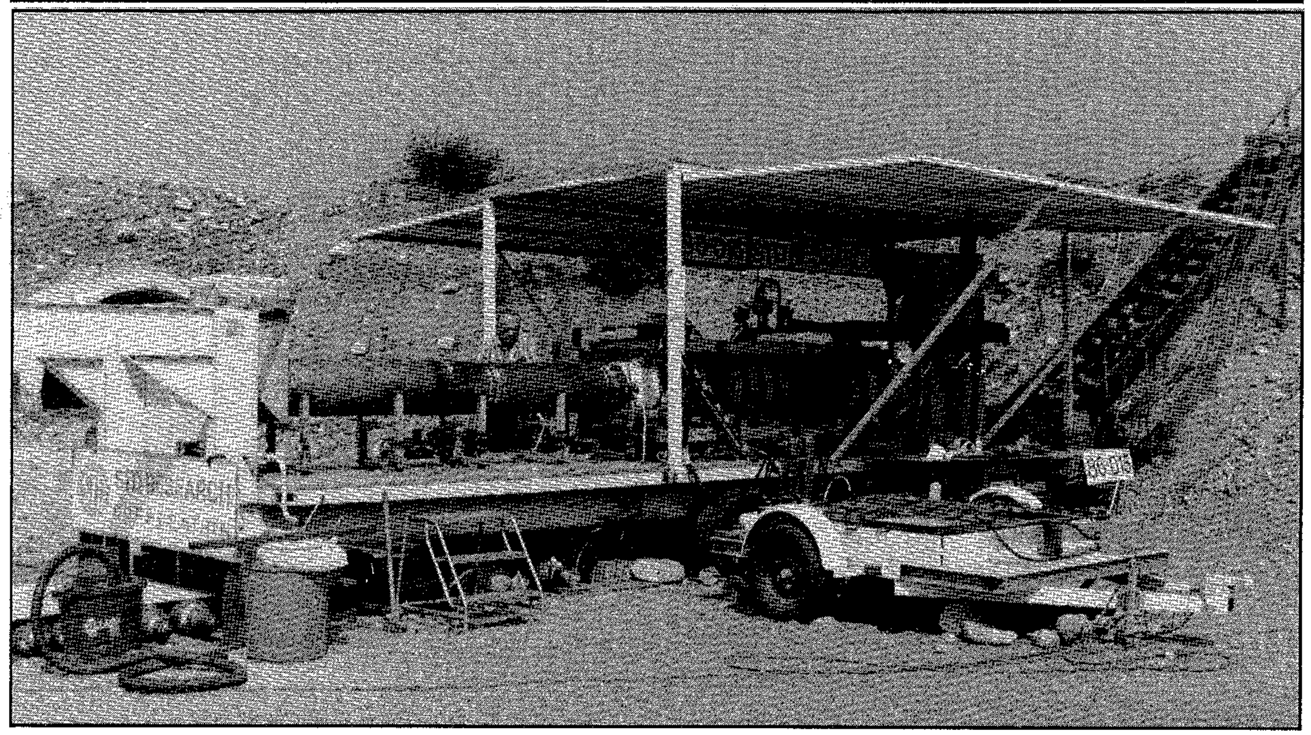
The turbine in the drill is spun by air. It could reduce drill pipe fatigue in the high-temperature environment by drilling the hole at a faster rate.

The tool was designed and patented by a research team led by William Lyons, professor of petroleum engineering at New Mexico Institute of Mining and Technology.

Portable Generator Tested for Sounding Earth's Crust

An engineering test has been conducted near Cajon Pass in Southern California, of a new compact, portable, electromagnetic generator able to explore the earth's crust to depths of 10 to 20 kilometers.

The tests indicate that the technique could complement seismic reflection geophysics and exploration drilling techniques used to map the structure of the earth's crust in the search for energy resources.



MHD generator, used in the pulsed MHD power experiment. Photo courtesy of Lawrence Berkeley Laboratory.

The device, a magnetohydrodynamic (MHD) generator that produces very strong current pulses, was developed and tested by scientists from Lawrence Berkeley Laboratory, the University of California, Berkeley, and STD Research Corporation of Monrovia, California. It is lightweight, self-contained, designed for transport on a 30-foot trailer, and easily maneuverable.

The MHD is a small solid-fuel hybrid rocket motor that can be turned on and off rapidly, producing short bursts of an electrically charged gas that expands at supersonic velocities through a magnetic field. The ionized plasma generates a current in the wall of the duct through which the plasma passes. While current pulses of up to 100,000 amperes are possible, three-second pulses of 10,000 amperes were generated in the Cajon Pass experiment.

District Heating and Geothermal Energy

District heating is making a comeback in the United States, a country that pioneered the concept. As early as 1877, Bird-Sill Holly operated a system in Lockport, N.Y. In the early part of this century, many American cities had extensive systems, featuring central boiler plants and steam piping to downtown buildings. Nearly 50 cities still operate their old systems.

But with inexpensive energy after World War II, district heating declined in this country. Utilities began producing electricity on a massive scale, and the old steam districts became minor and unprofitable parts of their operations. Utilities stopped promoting district heating, leading to the decline of its use.

This following article is excerpted, with permission, from the July 1987 issue of Compressed Air.

Europe, which has long faced expensive fuel, has successfully applied district heating for years. In Germany, Sweden, Denmark, and the USSR especially, large baseload plants produce both heat and electricity. In Russia, many of these plants are nuclear.

Paris' district heating dates from 1925. In the last quarter century, it expanded almost fivefold, adding about 6 miles per year. The network stretched 170 miles in 1984, the longest in France. Providing a quarter of the city's heating needs, it serves both residential and industrial customers.

The steam comes from eleven industrial boilers, fired by coal, gas and oil, refuse, and even a geothermal operation. A central dispatcher controls the system's operation, being able to adjust immediately system efficiency. Much of the generating and distribution equipment has been automated.

The Paris system brings familiar advantages. A building connected needs neither a boiler nor a chimney. No more chimneys to sweep...and air quality improves. The system can connect to any central heating system. Because of the success in Paris, the French government made this technology a leading objective of its national energy policy. This has led to systems in cities such as Grenoble, Chambery, Metz, and Lyons.

FUNDING

ETAP Program Underway

The State of California is reducing the risk of developing new, innovative energy technologies through its Energy Technologies Advancement Program (ETAP), administrated by the California Energy Commission (CEC). ETAP provides loans and research contracts for energy technology research, development, and demonstration. Nearly $3.3 million is available to assist public and private sector projects that enhance California's energy mix by:

- o Making existing energy technologies more cost effective;
- o Increasing the efficiency of an existing energy technology; or,
- o Developing new, alternative sources of energy.

ETAP was established in 1984 under the Rosenthal-Naylor Act. Many energy technologies are eligible for the program, including geothermal, wind, fuel cells, clean coal, biomass, photovoltaics, advanced conservation, load management, advanced oil and gas, and solar thermal. Widespread acceptance of new and advanced technologies will be accelerated by providing financial assistance to projects that can serve as models for future public-or private- sector development.

ETAP applications are tentatively scheduled for release on September 28, 1987, with proposals due about December 4, 1987.

For more information on eligibility or how to apply, contact Mike DeAngelis of the CEC's Research and Development Office at (916) 324-3490.

CEC Geothermal Grant and Loan Program

The California Energy Commission (CEC) is beginning the eighth funding cycle of the Geothermal Grant and Loan Program for Local Jurisdictions. Through this program, the CEC provides funding to local governments for geothermally related projects. For this funding cycle, the CEC has about $2.5 million available and will accept applications for any of the following types of projects:

1. Resource Development. This may include projects to assess and explore for geothermal resources; to drill production and injection wells; and to design and construct geothermal heating, cooling, and electrical generation systems.

2. Impact Mitigation. This may include projects to identify and mitigate impacts to the environment and public services caused by geothermal power plant development.

3. Planning. This may include projects to develop general plan elements, ordinances, or other policies relating to the planning and development of geothermal power plants and direct-use projects.

The CEC will award either a grant, loan, or a contingent award for projects funded through this program. A grant or loan will be awarded for projects that do not produce revenue or energy savings. These include planning, impact mitigation, and certain resource development projects, such as resource assessment and exploration activities. The decision to receive a grant or loan for this type of project is entirely up to the applicant.

A contingent award will be made for resource development projects that produce revenue or energy savings. Once the project is completed and has been sufficiently tested, the contingent award will become a loan. These loans will have a maximum term of 6 years, an interest rate of 4 percent, and a principal that cannot exceed 80 percent of the total project cost.

Applications for contingent awards must include a detailed feasibility study. The feasibility study must include at least the following information:

- o a summary of conclusions;
- o a description of the proposed geothermal project;
- o a discussion of the resource and its availability;
- o a schematic drawing of the proposed project;
- o a table describing new equipment needs, sizes, and itemized capital costs, and annual energy savings; and
- o a cash flow analysis of annual energy costs, proposed operating and maintenance costs, net energy savings, debt service, and net cash flow.

Assistance is available from the CEC to prepare a feasibility study or conduct preliminary resource assessment analyses.

The schedule for the eighth funding cycle is as follows:

Preapplications Deadline
October 5, 1987
Results of Preapplications Evaluation
November 4, 1987
Final Application Deadline
January 31, 1988
Energy Commission Approval
March 1988
Legislative Approval
July 1988

Important revisions have been made to the Application Manual for this funding cycle. Please obtain a new copy if you have not already done so. Also, all applicants are required to submit a preapplication.

If you are interested in this program, contact Michael Smith, California Energy Commission, 1516 Ninth Street, MS-43, Sacramento, California 95814; Phone (916) 324-3502.

Projects Awarded CEC Grants

The following California Energy Commission (CEC) grant loan proposals have been approved by the California Legislature for inclusion in the 1987-88 state budget.

Lake County Air Quality Maintenance District
$46,565

Conduct a field measurement study to assess and characterize geothermal noise sources in The Geysers and identify appropriate mitigation.

Lake County Air Quality Maintenance District
$33,925

Develop and install a MADAM-based, computerized data relay system at three existing aerometric monitoring stations in The Geysers.

Sonoma County
$134,500

Conduct a two-year, 3-county study of chemical concentrations in targeted streams and fish populations in The Geysers.

City of Loma Linda
$370,368

Conduct a resource assessment/temperature-gradient drilling program and feasibility study for a proposed geothermal district heating system in downtown Loma Linda.

Plumas County
$145,450

Conduct a resource assessment/temperature-gradient drilling program at White Sulphur Springs in eastern Plumas County in conjunction with a planned resort complex.

Sonoma County
$238,920

Conduct a resource assessment/temperature-gradient drilling program in the lower Sonoma Valley, including the Sonoma State Hospital.

Kern Council of Governments
$149,300

Conduct a resource assessment/temperature-gradient drilling program in the Kern River Valley, eastern Kern County.

Modoc County/Modoc Unified School District
$585,536

Drill a production and injection well, retrofit the high school complex, and conduct a feasibility study of a larger district heating system that may also include the elementary school complex and certain public and private structures in the downtown area.

City of Clearlake
$81,000

In 1985, the CEC awarded the City of Clearlake a grant to conduct a resource assessment/temperature-gradient drilling program. This augmentation will allow the city to complete the assessment/drilling project and conduct a feasibility study for a proposed geothermal district system in downtown Clearlake.

Surprise Valley Hospital
$80,000

In 1985, the CEC awarded the Surprise Valley Hospital District a grant to retrofit the space-and water-heating systems at the main hospital building and the clinic facility in Alturas. This augmentation will allow the hospital to complete design modifications that were not known at the time of the award and required by the State Fire Marshall and the Office of Statewide Health Planning and Development.

City of Calistoga
$70,000

In 1986, the CEC awarded the City of Calistoga a contingent award (loan) to design and construct a geothermal district-heating system. This augmentation will allow the city to drill and test a moderate-temperature geothermal production well and conduct a two-year monitoring program. The monitoring program will ensure proper resource management.

City of Susanville
$30,000

In 1984, the CEC awarded the City of Susanville a grant to resolve the unexpectedly low capacity of the city's present injection well used in its downtown district-heating system. This augmentation will allow the city to drill and test a new injection well.

City of Lake Elsinore
$70,000

In 1984, the CEC awarded the City of Lake Elsinore a grant to drill up to three exploratory wells, a production well, and retrofit the space-and water-heating systems in the community center. This augmentation will allow the city to conduct a long-term production test and prepare a feasibility plan for additional users.

Lake County/Mendocino College
$106,660

In 1984, the CEC awarded Lake County and the Mendocino Community College District a grant to develop a geothermal commercial park and vocational training center for greenhouse operation and management. This augmentation will allow Lake County and the college district to cover-purchase additional equipment required by project design modifications.

City of Susanville
$40,670

In 1986, the CEC issued a contingent award (loan) to the City of Susanville to expand its geothermal district heating system by: (1) constructing a pipeline extension from the main geothermal transmission line; and (2) retrofitting the City Maintenance Shop. The pool was retrofitted under an earlier CEC grant. This augmentation will allow the city to purchase additional Btu metering-and testing-equipment for the system.

Funding Sources Information

The Funding Sources Information Center is in the California State Library, Sacramento. The center was established in response to an increased demand for basic grants information.

The center includes directories of foundations, foundation grant lists, directories of government grants, guides on proposal writing, and fundraising guides.

The center is affiliated with the Foundation Center in San Francisco (415) 397-0902.

REGULATION

CEC-Proposed Siting Regulation Changes

In August 1987, the Siting and Regulatory Procedures Committee of the California Energy Commission (CEC), Commissioner Robert Mussetter presiding, published a "Notice of Proposed Amendments" scheduling a hearing on Wednesday, October 7, 1987 for the adoption of the committee's proposed amendments to the commission's power plant site certification regulations. The purpose of the proposed amendments is to clarify the CEC's 50-megawatt jurisdictional threshold over thermal power plants, and to provide a process by which power plant developers can obtain CEC determination of its siting jurisdiction concerning their projects.

Because of the substantial amount of comments received both in writing and orally at a committee hearing held on September 10, 1987, the committee has decided not to proceed with adopting the amendments, as currently proposed, and is therefore cancelling the previously noticed hearing on October 7, 1987.

The committee is currently evaluating all pertinent comments and will publish revised amendments in the near future. The time and place of any future hearings will be established by a future notice when the revised amendments are distributed.

In the meantime, the committee still welcomes any written comments on the proposed regulations until the date that the regulations are finally adopted. Written comments should be sent to the CEC, 1516 Ninth Street, Sacramento, California 95814. Please reference Docket No. 87-SIT-1. Twelve copies of all materials should be provided unless it would impose an undue hardship on the commenting party.

Full and free participation in this proceeding is encouraged. The Public Advisor, Christopher Heard, is available to facilitate the participation of any person in this proceeding, at (916) 324-3009 or toll free in California at (800) 822-6228. If you have any questions about this proceeding, please contact the Staff Project Manager, Chuck Najarian at (916) 324-3589, or the Committee Counsel, Steven M. Cohn, at (916) 324-3248.

LEGISLATION

Federal Legislation

The following material is a federal legislative status report, with information on the status of geothermal legislation from the 100th Congress, current as of June 1987. It was compiled by Senate LEGIS.

H.R. 235
DATE INTRODUCED: 01/06/87
SPONSOR: Quillen
REFERRED TO: House Energy and Commerce
House Interior and Insular Affairs

SHORT TITLE AS INTRODUCED:
Geothermal Energy Control Act of 1987

A bill to create a commission to grant exclusive franchises for the exploration for and the commercial development of geothermal energy and for the right to market any such energy in its natural state, and for other purposes.

LEGISLATIVE ACTIONS:
01/06/87 - Referred to House Committee on Energy and Commerce.
01/22/87 - Referred to Subcommittee on Energy and Power.
01/06/87 - Referred to House Committee on Interior and Insular Affairs.
02/05/87 - Referred to Subcommittee on Mining and Natural Resources.

ABSTRACT:
Establishes the National Geothermal Energy Commission to grant exclusive licenses for the exploration for and commercial development of geothermal resources and for the marketing of such energy in its natural state.

DIGEST:
Geothermal Energy Control Act of 1987 -
Establishes the National Geothermal Energy Commission.Requires the Commission to determine those areas in the United States which have a potential for the extraction of geothermal resources and to publish a list of such areas in the Federal Register.
Directs the Commission to grant exclusive 99-year licenses to persons capable of carrying out exploration and development of geothermal resources in such areas. Sets forth conditions for the granting of such licenses and for extensions of license terms.
Authorizes the termination of a license for any violation of the terms of the license prescribed by the Commission. Permits a licensee under this act to apply for a license to market the geothermal resources from the licensee's area in their natural state. Requires the Commission to grant a marketing license for a geographic area which is the most reasonable area to market successfully the geothermal resources.
Provides that there shall be only one marketing license per geographic area.
Provides that a marketing license shall be valid for as long as the licensee holds the exploration and development license.
Permits the transfer of exploration and development licenses and marketing licenses with the Commission's approval.
Requires that a licensee under this act be a U.S. citizen or a person owned or controlled by a U.S. citizen.
Restricts the sale of geothermal resources which have been converted to electrical or other energy forms to existing utility companies or other persons licensed to transmit such energy. Permits the sale of geothermal resources to such a company or person for conversion into other energy forms.

H.R. 1662
DATE INTRODUCED: 03/17/87
SPONSOR: Shumway
REFERRED TO: House Interior and Insular Affairs
House Agriculture

COSPONSOR(S): Current (51)
Pashayan; Smith, of OR, (2); Horton; Bosco; Oberstar; Olin; Wilson; Emerson; Montgomery; Smith, of OR, (5); Coelho; Williams; Clinger; Schuette; Lehman, of CA; Staggers; Grant; Bevill; Nichols; Craig; Flippo; Roemer; Herger; Hansen; Boucher; Stallings; Dellums; 13/87); Moorhead (A-05/13/87); Watkins (A-05/13/87); Stump (A-05/13/87); Tallon (A-05/13/87); Davis, of MI (A-05/13/87); Swift (A-05/13/87); Cambell (A-05/27/87); Schaefer (A-05/27/87); Wortley (A-05/27/87); Cheney (A-05/27/87); Defazio (A-05/27/87); Spratt (A-06/02/87); Nielson (A-06/02/87); Bonker (A-06/02/87); Bentley (A-06/02/87); Derrick (A-06/16/87); Holloway (A-06/16/87); Synar (A-06/16/87); Smith, of NH (A-06/16/87); Marlenee (A-06/16/87); Panetta (A-06/16/87); Richardson (A-06/29/87):

SHORT TITLE AS INTRODUCED:
Federal Lands Receipts Clarification Act

A bill to provide for a clarification of the receipt-sharing of amounts received from the National Forest System, geothermal leasing, mineral lands leasing, and oil and gas royalties.

LEGISLATIVE ACTIONS:
03/17/87 - Referred to House Committee on Agriculture.
03/23/87 - Referred to Subcommittee on Forest, Family Farms, and Energy.
03/17/87 - Referred to House Committee on Interior and Insular Affairs.
04/10/87 - Referred to Subcommittee on Mining and Natural Resources.

ABSTRACT:
Amends the Mineral Lands Leasing Act, the Mineral Leasing Act for Acquired Lands, and other Federal law to specify that the States' share of certain revenue be determined on the basis of gross receipts.

DIGEST:
Federal Lands Receipts Clarification Act - Amends the Mineral Lands Leasing Act, the Mineral Leasing Act for Acquired Lands, and other Federal law to specify that the States' share of certain revenue from

National Forest System timber sales, from oil and gas royalties, and from mineral and geothermal leases be determined on the basis of gross receipts.

S. 1006
DATE INTRODUCED: 04/09/87
SPONSOR: Hecht
REFERRED TO: Senate Committee on Energy and Natural Resources

COSPONSOR(S): Current (11)
Inouye; McClure; Garn; Matsunaga; Stevens; Murkowski; Nickles; Symms; Hatch; Wilson (A-05/06/87); Domenici (A-06/30/87):

SHORT TITLE AS INTRODUCED:
Geothermal Steam Act Amendments of 1987

A bill entitled the Geothermal Steam Act Amendments of 1987.

LEGISLATIVE ACTIONS:
04/09/87 - Read twice and referred to the Committee on Energy and Natural Resources.
04/09/87 - Referred to Subcommittee on Mineral Resources and Development.
07/14/87 - Subcommittee on Mineral Resources and Development. Date of scheduled hearings. SD-366 10:00a.m.
06/03/87 - Committee on Energy and Natural Resources requested executive comment from Interior Department, OMB.

LEASES

Geothermal Competitive Sales on BLM Land

The Bureau of Land Management (BLM) is leasing Nevada public land with potential for geothermal development. Competitive bids are being accepted on about 52,450 acres in Churchill, Lyon, Pershing, and Washoe Counties. Competitive bids on the parcels are being received until September 24, 1987.

Eight tracts are being offered for competitive lease within the Brady-Hazen KGRA. Those 16,995.89 acres lie in Churchill and Lyon Counties. In the Dixie Valley KGRA, Churchill and Pershing Counties, a total of 29,046.98 acres are being offered for lease. At the Rye Patch KGRA, Pershing County, there are three tracts totaling 6,407.74 acres. In Washoe County, one tract of 676.98 acres is being offered within the Steamboat KGRA.

Further information on the lease bidding and on the parcels may be obtained from the BLM's Nevada State Office, P. O. Box 12000, Reno, Nevada 89520.

TECHNOLOGY TRANSFER

CONFERENCES

9th New Zealand Geothermal Workshop, Geothermal Institute, University of Auckland, New Zealand, November 4-6, 1987.

The meeting will act as a forum for the exchange of new and significant information on all aspects of the development and use of geothermal resources, worldwide.

The Geothermal Institute was founded in 1979. A 1-year Diploma Course for earth scientists and engineers is offered by staff of the Institute and University, in cooperation with members of the New Zealand geothermal community. The Institute is jointly sponsored by the United Nations Development Programme and the New Zealand Government.

For further information, contact the Convenors, 9th Geothermal Workshop, Geothermal Institute, University of Auckland, Private Bag, Auckland, New Zealand.

Symposium on Geothermal Energy, at the Energy-Sources Technology Conference and Exhibition, New Orleans, Louisiana, January 10-14, 1988.

The Symposium (two days during the conference) is cosponsored by the Geothermal Resources Council and the American Society of Mechanical Engineers (Petroleum and Advanced Energy Systems Divisions). The main emphasis will be on acquainting ASME members with geothermal resources and their development. Technical papers will be presented on aspects of geothermal drilling and production.

For further information, contact Dave Anderson, Executive Director of the GRC, P.O. Box 1350, Davis, CA 95617-1350.

Thirteenth Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 19-21, 1988.

The workshop, sponsored by the Stanford Geothermal Program, is designed to bring together researchers, engineers, and managers involved in geothermal reservoir studies and developments to discuss their progress and exchange ideas. For further information, contact Jesus Rivera, Petroleum Engineering Dept., Mitchell Bldg., Room 360, Stanford University, Stanford, California 94305.

The 2nd International Congress on Energy; The Ministry of Energy and Infrastructure, Academic Institutions in Israel, Israel National Committee, World Energy Conference; Tiberias, Israel, June 5-10, 1988.

The focus of the conference is "International Energy Cooperation." The agenda includes lectures, discussions, and site visits to energy facilities. Session B includes the topic: Geothermal sources in oil-rich countries.

For further information, write the Congress Secretariat, c/o International Ltd., P.O. Box 29313, 65121 Tel Aviv, Israel.

Deposition of Solids in Geothermal Systems, sponsored by Orkustofnun, the National Energy Authority of Iceland and co-sponsored by the Hawaii Institute of Geophysics, United States, in Reykjavik, Iceland, August 16-19, 1988.

The workshop will address the scientific and technical aspects of solids deposition in geothermal systems, including the reservoir, wellbore, pipelines, equipment, direct use, and electric power plants.

The organizers invite engineers and scientists to submit research results on theoretical and experimental studies in geothermal systems of the chemistry of silica, calcite, sulphides, and other geothermal deposits; the surface and colloidal chemistry of these materials; field and design studies of solid-liquid separation; reaction scaling and heat exchanger fouling; steam quality and turbine deposits; process chemistry; and the injection of spent fluids.

In addition to submitting research results, the organizers encourage geothermal engineers and scientists to submit papers that review the state-of-knowledge in solids deposition sciences and the state-of-the-art in the application of this knowledge to design technology and field practices. Discussion sessions will be organized to consider future design and field strategies, and to identify research needs.

At the workshop, engineers, scientists, and managers from the geothermal community worldwide, will have an opportunity to share established theories and practices, and to report recent laboratory and field experiences. The technical papers offered for the workshop will be reviewed for acceptance by a programme committee, consisting of the organizers and representatives of academia and industry. The workshop programme will consist of three days of technical sessions and discussions. The technical papers will be distributed at the workshop and later printed in a proceedings volume for general distribution.

The workshop will be held at the University of Iceland in Reykjavik. Field trips will be arranged to local geothermal fields and power plants, as an afternoon trip during the workshop and as a one-day trip the last day. The registration fee will be set to cover direct expenses. No funds are available to aid participants.

Further information on the workshop will be sent upon request. Hotel and other arrangements are being made for the participants. Authors planning to submit technical papers should note the following deadlines:

- Abstracts of 200-300 words by 2/1/88.
- Author notification of paper acceptance by 3/1/88.
- Paper in camera-ready form by 6/1/88.
- Registration no later than 6/1/88

Organizers (Technical Program)

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Secretariat (Hotel, Travel, and Registration)

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Phone: 354-1-25855
Telex: 2049 turist is

International Symposium on Geothermal Energy, Kumamoto and Beppu, Japan, November 10-14, 1988.

The theme of the symposium is the exploration and development of geothermal resources. The symposium is organized by the Geothermal Research Society of Japan. The program will include invited lectures, oral and poster presentations, and excursions. A circular will be sent in December 1986 to all interested persons.

MAPS

The map catalog; every kind of map and chart on earth and even some above it. Edited by Joel Makower. $14.95. 252 pages, paperback. Available from Random House Inc., 400 Hahn Rd., Westminister, Md. 21157.

The Map Catalog is a potato chip of books—once you start thumbing through it, you can't put it down. Just how many types of maps are published is amazing. Many could prove useful in geothermal projects.

European Community atlas of groundwater resources. Atlas of subsurface temperatures in the European community. Available in English, French, German, Italian, Dutch, and Danish. For information, contact Verlag, Th.Schafer GmbH, POB 5469, TivolistraBe 4, D-3000 Hannover 1, Germany.

Nevada Bouger gravity anomalies, depth to bedrock, and shallow temperatures in the Humboldt House geothermal area, Pershing County, Nevada. By D.H. Schaefer. 1986. $2.40. Sheet 30 by 42 inches. Published by and available from the USGS, Books and Open-File Reports, Federal Center, Bldg. 41, Box 25425, Denver, Colorado 80225

Susanville Map Revised

The Division of Oil and Gas has expanded the area covered by the Susanville Geothermal field map (Map G1-3) to encompass most of Honey Lake Valley, which includes Litchfield and Wendel Geothermal fields.

The map may be purchased for $3.00 from any geothermal district office or by writing to the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, CA 95814.

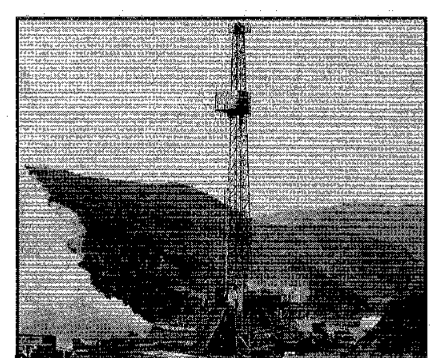
VIDEOS

Before the Drilling Begins

The environmental documentation process and well pad engineering practices used at The Geysers Geothermal field are the topics of a new videotape available from the Division of Oil and Gas. The videotape is about 13 minutes long and was taped on location at The Geysers Geothermal field.

The videotape, titled "Before the Drilling Begins," may be purchased for $25 in 1/2" (VHS or Beta) formats.

Contact Susan Hodgson for further details at (916) 323-2731.



PUBLICATIONS

Energy security, a report to the President of the United States. U.S. Dept. of Energy Report No. DOE-5-0057. $16.00. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

A national energy plan, submitted to the President, that includes a section on geothermal energy.

72nd Annual Report of the State Oil and Gas Supervisor. 1987. Free. Published by and available from the California Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, CA 95814.

Statistical and verbal summaries of 1986 California geothermal activities.

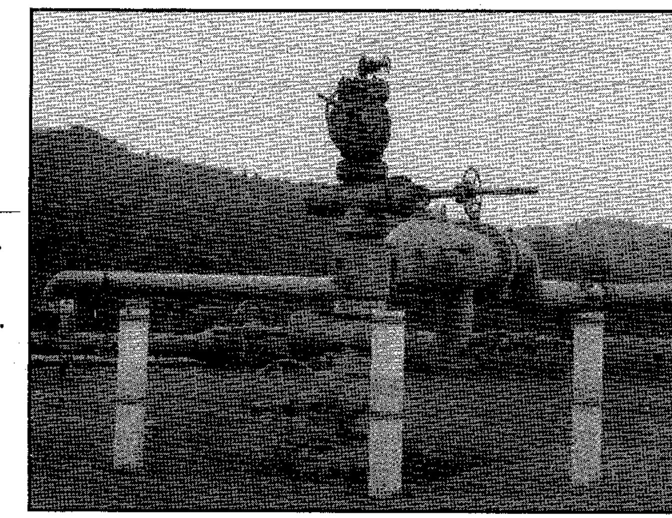
Geothermal science and technology. A periodical published by and available from Gordon and Breach, Marketing Department, P. O. Box 786, Cooper Station, NY, NY 10276.

This new geothermal periodical will be published four times a year. A corporate subscription is $286, a university or academic subscription is $176, and an individual subscription is $88 (the amount must be paid directly to the publisher with personal check or credit card).

For a free copy of Vol. 1, No. 1, write the publisher or call (212) 206-8900.

APDU Links Sources of Information

The Association for Public Data Users (APDU), organized in 1976, is an active network of data users, producers, and distributors of



federal, state, and local governmental statistical data. The association facilitates the utilization of public data through sharing knowledge about files and software, exchanging documentation, and jointly purchasing data. Members include state data centers, government agencies, academic institutions, nonprofit organizations, commercial vendors, and individuals. Members inform each other about how to locate and obtain public data files; how to apply public data to their research and planning projects; how to process large, complex data files with available software; and how to distribute data files most effectively.

APDU publishes 10 newsletters a year for its members, convenes an annual meeting each fall in Washington, DC, facilitates joint data acquisition, sponsors a nationwide electronic conference and mail system, and actively represents data-user interests in Washington, DC.

Most APDU members are organizations, but individual memberships are available. The annual membership fee for an organization (represented by one person) is $250 (the fee for each additional representative is $30). The cost for an individual without organizational affiliation is $125.

For further information about the association, or for a membership application, contact: Susan Anderson, Association of Public Data Users, Princeton University Computing Center, 87 Prospect Avenue, Princeton, NJ; 08544, (609)452-6025.

Environmental radon update. Oct./Nov. 1986 issue. Published by and available, free of charge, from Terradex Corporation, 3 Science Rd., Glenwood, Illinois 60425.

Three articles on radon emissions in geothermal fields are printed in this issue. One, "Monitoring Radon near Geothermal Sites with Passive, Integrating Detectors," is by Richard A. Oswald. The second, "Surface Geochemistry and Track Etch" is by Richard S. Della Valle. The third, "Wellhead Radon Measurements of Geofluid Reservoirs" is by Paul Kruger.

Energy profiles II. $195 plus 6 percent California sales tax. Available from and published by Barakat, Howard & Chamberlin, Inc., 2150 Shattuck Avenue, Berkeley, CA 94704.

The publication is a guide to utilities, independent power producers, pipeline companies, gas marketers and regulators in California. It includes key management, operating, and financial data on the state's 53 gas and electric utilities and almost 250 independent power producers.

The economic impacts of self-generation. P500-87-022. $5.15 plus a self-addressed mailing label. Published by and available from the California Energy Commission, Accounting Office, 1516 Ninth Street, MS-2, Sacramento, CA 95814.

The economic impacts of self-generation development on utilities, utility customers, qualifying facilities (QF's), and society in general are analyzed.

Relative cost of electricity production, P300-86-006. By the California Energy Commission. 1987. $2.50 (send a self-addressed mailing label). Available from the California Energy Commission, Accounting Office, 1516 Ninth Street, MS-2, Sacramento, CA 95814.

CEC estimates of the annualized costs of electricity on a generic basis for 30 different technology-fuel combinations for 1997-2027. Cost generation is calculated using the assumption that either a public or investor-owned utility constructs, owns, and operates the power plant.

Physical geology, seventh edition. By Sheldon Judson, Marvin E. Kauffman, and L. Don Leet. 1987. 484 pages, hardback. $27.50. Published by and available from Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632.

This wonderful textbook has been reprinted and updated. The information is accurate, extensive, and clearly presented. Drawings, tables, and photographs are abundant. A great deal of information about geothermal systems is included. A study guide is also available.

As Georgius Agricola wrote in De Re Metallica in 1556,

> *"And since the art (of mining) is one of the most ancient, the most necessary, and the most profitable to mankind, I considered that I ought not to neglect it."*

Geology of the Great Basin, a natural history. By Bill Fiero. 1986. 198 pages. $22.50 hardback. Published by and available from the University of Nevada Press, Reno, Nevada 89557-0076.

Geology of the Great Basin is the story of a major geographical region, mostly in Nevada. Written for the armchair reader and active nature enthusiast, it is clearly illustrated with maps, charts, and beautiful, large color photographs.

Though not complex enough to be a textbook—and edited differently than a textbook would be—the range of information and the clear way it is presented add up to an enjoyable and informative book.

Excerpted from Chapter 1:

> *"Here in the Black Rock Desert of what would become northern Nevada, the emigrants would watch for a large dark knob across the shimmering sands and beeline straight for it. Below this black rock and slightly to the north is Double Hot Springs. Here the parched people and stock would find boiling hot water, confirming the Devil's role in fashioning this land. Downstream, where the water had cooled sufficiently to allow the growth of thick mats of grass, they found respite from the drought lands. This is an unforgiving land, a land of rapid change and contrast. This is the Great Basin of the American desert."*

Airborne electromagnetic mapping of geothermal systems in the Basin and Range and Cascade provinces, USA. Paper by the Geologic Survey of Canada in Airborne resistivity mapping (G.J. Palacky, editor). 86-22, 1986. p. 139-143.

The Nevada mineral industry 1986. No. MI-1986. $5.00 in person or $5.50 by mail. Published by and available from the Nevada Bureau of Mines and Geology, University of Nevada-Reno, Reno, NV 89557-0088.

Oil, gas, mining, and geothermal activities in Nevada are summarized in the report, the eighth annual report of a series.

Nevada Roadlogs Available

Copies of several geologic roadlogs developed by the Nevada Bureau of Mines and Geology (NBMG) are now available. NBMG Open-file Report 87-4 includes roadlogs of a loop from Reno through Wadsworth and the Pyramid Lake area; a loop from Steamboat Springs through Virginia City and Carson City; and a loop from Steamboat through Carson Valley, Dagget Pass, Lake Tahoe, and Mount Rose Summit. Each has detailed information on features of geologic interest along the way.

Xerographic copies of the 79-page report are $15.00 at the Sales Office (Room 310 in the Scrugham Engineering-Mines Building on the University of Nevada campus in Reno) or $16.50 by mail (Nevada Bureau of Mines and Geology, University of Nevada-Reno, Reno, NV 89557-0088). For further information, call (702)784-6691.

Geothermal exploration in Oregon, 1986, published in the June 1987 issue of Oregon Geology. $.75 at the counter; $1.00 mailed. Available from Oregon Geology, 910 State Office Bldg., Portland, Oregon 97201.

The thorough article includes a list of drilling permits issued in 1986; leasing data; direct-use projects; mapping activities by the Oregon Dept. of Geology and Mineral Industries; geothermal research by state, federal, and university entities; and pertinent geological investigations. This is a worthwhile addition to a geothermal library.

Investigation of the thermal regime and geologic history of the Cascade Volcanic Arc: first phase of a program for scientific drilling in the Cascade Range. Open File Report 0-86-3. By George R. Priest et. al. for the U.S. Dept. of Energy. $9.00, prepayment required. Available from the Oregon Dept. of Geology and Mineral Industries, 910 State Office Bldg., 1400 SW Fifth Avenue, Portland, OR 97201.

The report has the broad outlines of a program for scientific drilling for the Cascade Range in Oregon, Washington, and California, plus a detailed plan for the first phase of the project.

The final phase of the program would be drilling an ultra-deep hole to depths of 7 to 10 km. An extensive bibliography on Cascade research is included.

Greek-English Mineralogy Newsletter

A newsletter on Greek mineralogy is published in Greek and English by Dimitris G. Minatidis.

A geologist and geochemist, Mr. Minatidis writes that Greece, located in a zone of active plate margins, has many geothermal areas with good development potential.

The annual subscription fee for the newsletter, called Oryktologika NEA-News on Minerals, is $38.00.

Contact Mr. Minatidis at 70 Queen Sophia Avenue, Piraeus 185 32, Greece; phone 4171-680.

The following publications are available from the **National Technical Information Service,** U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Geothermal technology publications and related reports: a bibliography, January 1984 through December 1985, SAND86-1923. 1986. Edited by D. Cooper. $11.95 paperback, $5.95 microfiche.

A study of pumps for the Hot Dry Rock Geothermal Energy Extraction Experiment, LA-10862-T. By C. Tatro. 1986. $11.95 paperback, $5.95 microfiche.

Hot dry rock geothermal development program, Annual Report, FY 1984, LA-10661-HDR. By P. Franke, et al. 1986. $9.95 paperback, $5.95 microfiche.

Core lithology, Valles Caldera #1, New Mexico, LA-10957-OBES. By J.N. Gardner, F. Goff, S. Goff, L. Maassen, K. Mathews, D. Wachs, and D. Wilson. 1987. $22.95 paperback, $5.95 microfiche.

Evaluation of geothermal drilling fluids using a commercial bentonite and a bentonite-saponite mixture, SAND86-7180. By N. Guven, L.L. Carney, and B.E. Ridpath. 1987. $16.95 paperback, $5.95 microfiche.

An experimental investigation of pressure drop of aqueous foam in laminar tube flow, SAND85-1921. By B.F. Blackwell and K.B. Sobolik. $9.95 paperback, $5.95 microfiche.

Thermal stress fracturing of magma simulant materials, SAND86-0538. By R. Wemple and D. Longcope. 1986. $11.95 paperback, $5.95 microfiche.

The scientific driller. James L. Ruhle and Associates. 12 issues a year. Annual subscription: $100 U.S. or $120 foreign. Published by and available from James L. Ruhle and Associates, P.O. Box 4301, Fullerton, CA 92634.

The publication tracks the many deep-drilling projects throughout the world, the geology penetrated in the deep regimes, drilling technology advancements, and meetings on these issues.

The company also offers for sale a long list of 35 mm color slides and filmstrips on energy topics. Write for a list of available materials.

Geotextiles. By N.W.M. John, Lecturer in Civil Engineering, Queen Mary College, University of London. 1987. $69.95. Published by and available from Methuen, 29 West 35th Street, New York, NY 10001.

Geotextiles are polymer-based textiles produced for geotechnical applications. Rapid developments in the field in recent years have led to an ever-broadening range of applications and products. Some of the most common uses of geotextiles include erosion control for embankments, retaining walls, and foundations—common features in some geothermal fields.

The book describes the different classes of geotextiles and their properties. Design methods and applications are considered, together with practical construction details.

Such information enables the reader to identify cases where geotextiles offer a cost-effective solution, and offers ways to select the most appropriate material. The book will benefit practicing geotechnical, foundation, and civil engineers, and researchers and contractors.

Multilingual thesaurus of geosciences. Edited by G.N. Rassam, J. Gravesteijn, and R. Potenza. 1987. $95.00. Published by and available from Pergamon Press, Maxwell House, Fairview Park, Elmsford, New York 10523.

Geoscientific terms are entered in English, French, German, Russian, Spanish, and Italian. Indexes have been compiled for each language.

CALIFORNIA WELLS

Division Well Data Available

A computer-generated file of geothermal production and injection statistics for wells and records open to public inspection is available from the Division of Oil and Gas. All data are in metric units. The file may be purchased for $50.00 from the Division of Oil and Gas in Sacramento.

Drilling Permits for Geothermal Wells Approved January-June 1987 by the Division of Oil and Gas

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	DISTRICT G1			
	Lassen County			
4/20/87	PIT RESOURCE CONSERVATION DISTRICT "BV" 3	035-90077	23 38N 7E	Fr NW cor 250m S, 457m E, El 1,256m gr
	"BV" 6	035-90078	31 39N 9E	Fr NE cor 1412m S, 517m W, El 1280m gr

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	DISTRICT G2			
	Imperial County			
3/2/87	CHEVRON GEOTHERMAL CO. "HGU" 6	025-90668	34 16S 14E	Fr NE cor 946m S, 1397m W, El -1.5m gr
3/23/87	"HGU" 110	025-90680	33 16S 14E	Fr SW cor 358m N, 271m E, El -1.5m gr
4/1/87	IMPERIAL MAGMA "Del Ranch" 1	025-90669	33 11S 13E	Fr SE cor 503m N, 259m W, El -60.9m gr
	"Del Ranch" 2	025-90670	33 11S 13E	Fr SE cor 503m N, 228m W, El -60.9m gr
	"Del Ranch" 3	025-90671	4 12S 13E	Fr NE cor 31m S, 52m W, El -61m gr
	"Del Ranch" 4	025-90672	4 12S 13E	Fr NE cor 246m S, 52m W, El -61m gr
	"Del Ranch" 5	025-90673	4 12S 13E	Fr NE cor 466m S, 52m W, El -61m gr
	"Del Ranch" 6	025-90674	4 12S 13E	Fr NE cor 496m S, 52m W, El -61m gr
	"Del Ranch" 7	025-90675	4 12S 13E	Fr NE cor 720m S, 52m W, El -61m gr
	"Del Ranch" 8	025-90676	4 12S 13E	Fr NE cor 751m S, 52m W, El -61m gr
	"Del Ranch Inj" 1	025-90677	34 11S 13E	Fr SW cor 1146m N, 759m E, El -61m gr
	"Del Ranch Inj" 2	025-90678	34 11S 13E	Fr SW cor 1113m N, 759m E, El -61m gr
	"Del Ranch Inj" 3	025-90679	34 11S 13E	Fr SW cor 1082m N, 759m E, El -61m gr
5/7/87	"Elmore" 14	025-90681	27 11S 13E	Fr SW cor 378m N, 358m E, El -69m gr
5/14/87	CHEVRON GEOTHERMAL CO. "HGU" 111	025-90682	33 16S 14E	Fr SW cor 385m N, 276m E, El -1.5m gr
5/21/87	KENNECOTT EXPLORATIONS "Wilson" 1-12	025-90685	12 11S 13E	Fr NW cor 50m S, 61m E, El -69m gr

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
DISTRICT G3				
	Lake County			
1/15/87	LEISEK, JOSEPH A. "Clearlake" 1	033-90553	21 13N 7W	Fr NE cor 151m S, 852m W, El 420m gr
	"Clearlake" 2	033-90554	21 13N 7W	Fr NE cor 1542m S, 684m W, El 420m gr
2/2/87	"Clearlake" 3	033-90556	21 13N 7W	Fr NE cor 1408m S, 1026m W, El 420m gr
	"Clearlake" 4	033-90557	21 13N 7W	Fr NE cor 1328m S, 578m W, El 420m gr
2/25/87	FMRP "Davies State 5206" 2	033-90558	36 11N 8W	Fr SE cor 266m N, 666m W, El 568m gr
3/2/87	COUNTY OF LAKE "AG Park" 3	033-90559	33 13N 8W	Fr SW cor 549m N, 31m E, El 610m gr
	Sonoma County			
2/13/87	GEO OPERATOR CORP. "Prati State" 12	097-90720	1 11N 9W	Fr NW cor 289m S, 504m E, El 742m gr
2/25/87	"Prati" 50	097-90721	36 12N 9W	Fr SW cor 549m N, 794m E, El 923m gr
3/18/87	UNION OIL CO. OF CALIF. "LF State 4597" 49	097-90723	20 11N 8W	Fr SE cor 300m N, 594m W, El 867m gr

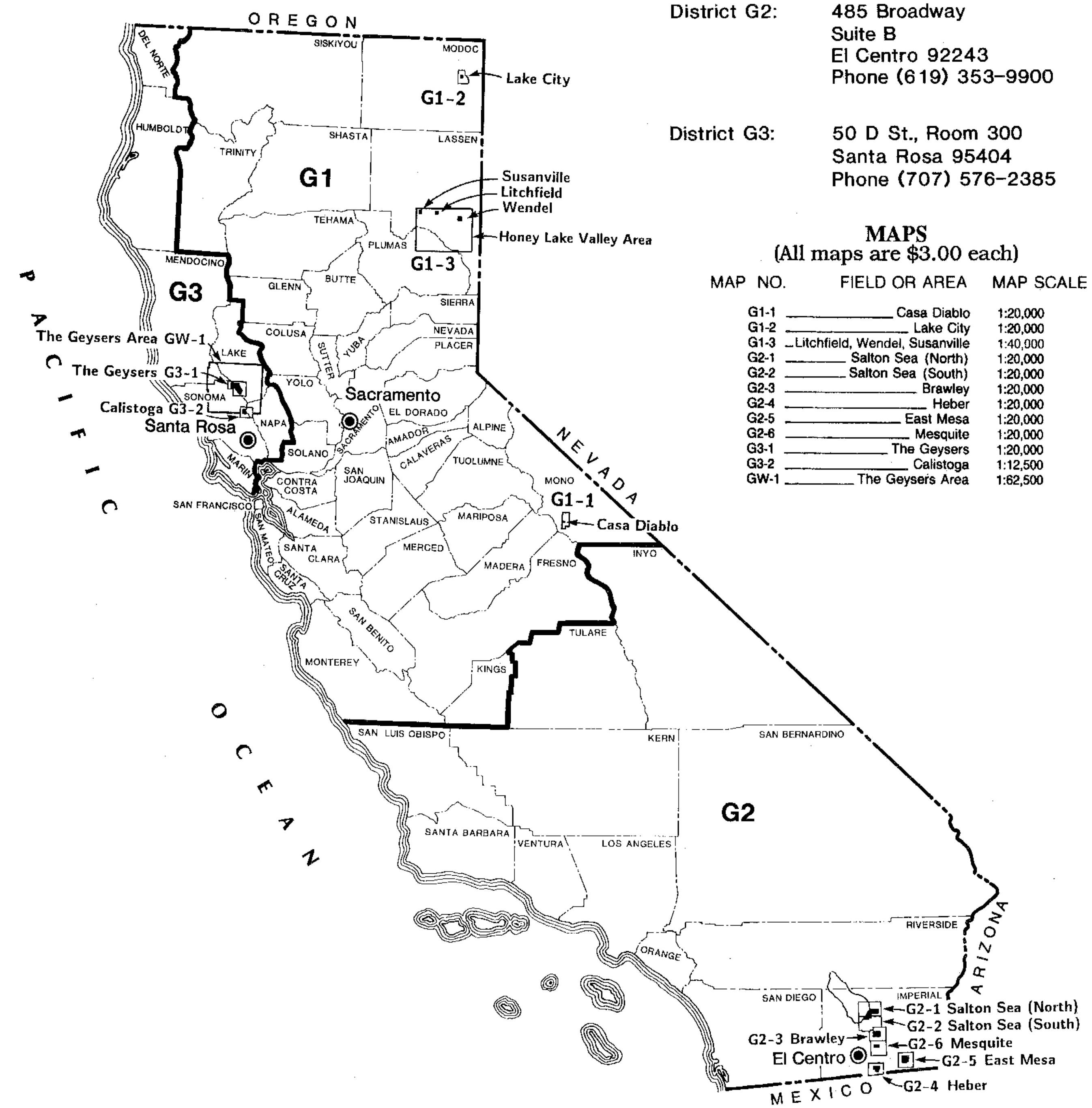
DIVISION OF OIL AND GAS
GEOTHERMAL OFFICES AND MAPS

OFFICES

Headquarters & District G1:	1416 Ninth St., Room 1310 Sacramento 95814 Phone (916) 323-1788
District G2:	485 Broadway Suite B El Centro 92243 Phone (619) 353-9900
District G3:	50 D St., Room 300 Santa Rosa 95404 Phone (707) 576-2385

MAPS
(All maps are $3.00 each)

MAP NO.	FIELD OR AREA	MAP SCALE
G1-1	Casa Diablo	1:20,000
G1-2	Lake City	1:20,000
G1-3	Litchfield, Wendel, Susanville	1:40,000
G2-1	Salton Sea (North)	1:20,000
G2-2	Salton Sea (South)	1:20,000
G2-3	Brawley	1:20,000
G2-4	Heber	1:20,000
G2-5	East Mesa	1:20,000
G2-6	Mesquite	1:20,000
G3-1	The Geysers	1:20,000
G3-2	Calistoga	1:12,500
GW-1	The Geysers Area	1:62,500



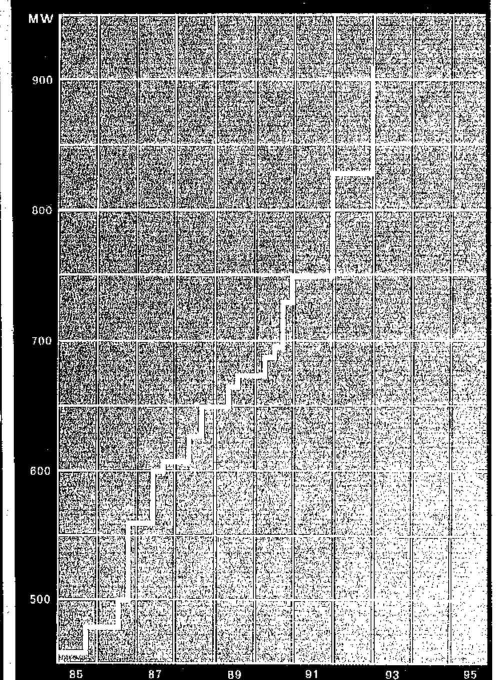
TRO2(11-87-DWRR-19C)

ENEL'S GEOTHERMAL PROGRAM OBJECTIVES BY 1995

Location of new main installed capacity

Electric production

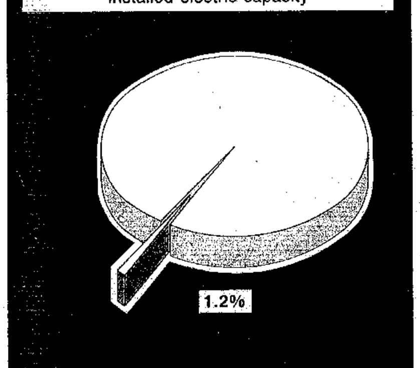
- New plants (unified size 20 MW_e)
- Modernization of old plants (unified size 60 MW_e)

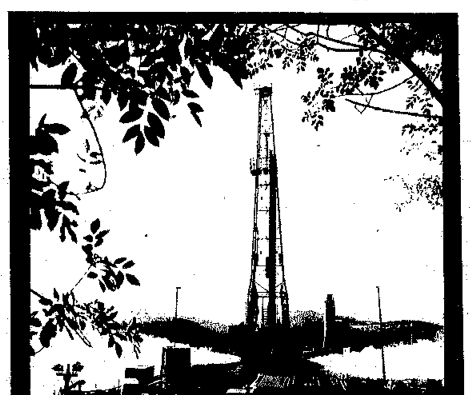


Planned increase of installed capacity

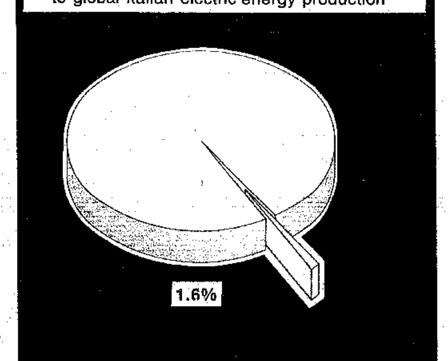
Role of geothermal energy

- Geothermal capacity referred to total Italian installed electric capacity





- Electric energy from geothermal source referred to global Italian electric energy production



Thermal utilization

- Geoheat of present projects: 190,700 TOE/year
- Geoheat of future projects, by 1995, according to the National Energy Plan: 300,000 TOE/year

AREAS OF ACTIVITY

ACTIVITIES AIMED AT PRODUCTION

Exploration and development:

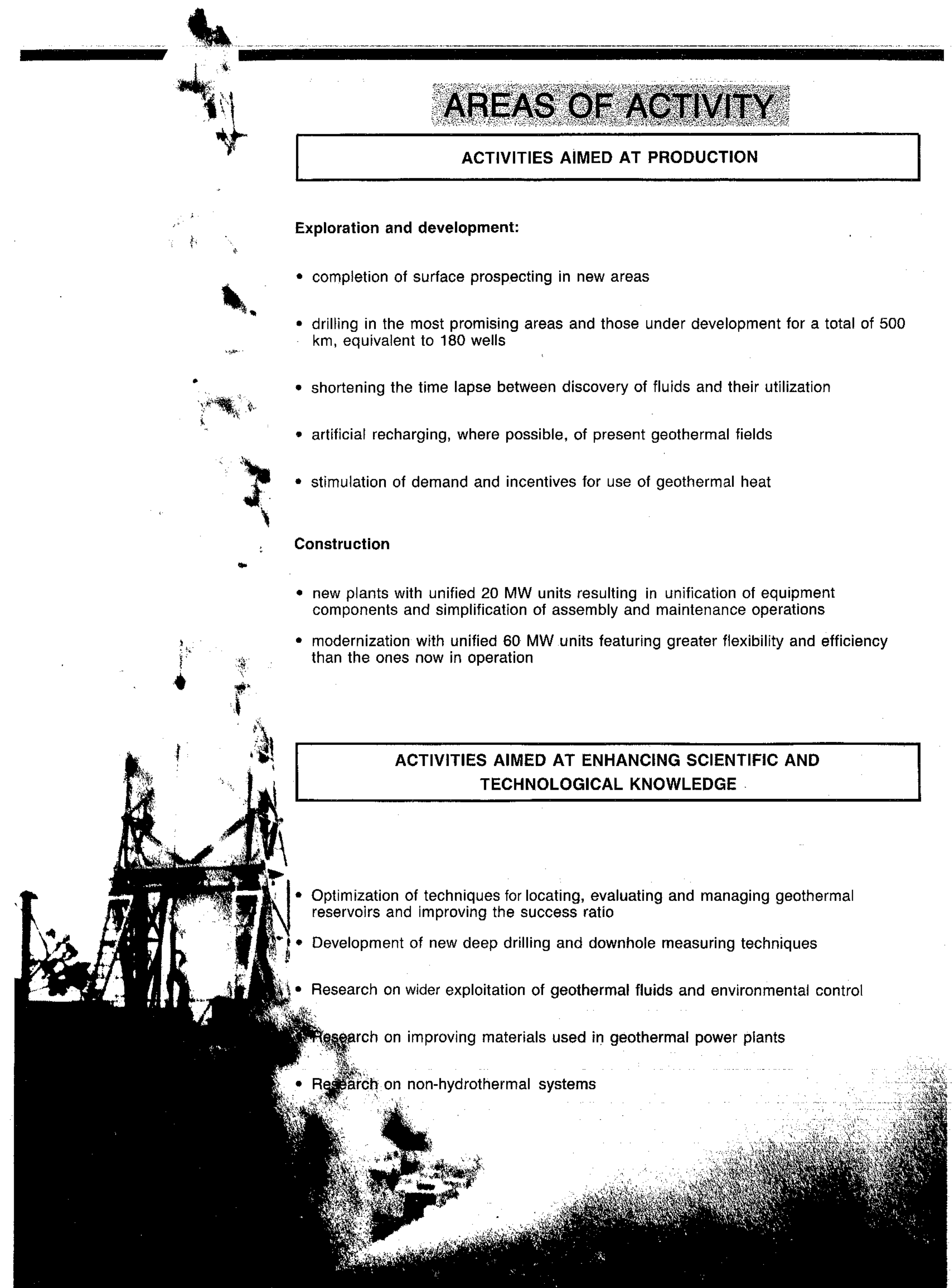
- completion of surface prospecting in new areas
- drilling in the most promising areas and those under development for a total of 500 km, equivalent to 180 wells
- shortening the time lapse between discovery of fluids and their utilization
- artificial recharging, where possible, of present geothermal fields
- stimulation of demand and incentives for use of geothermal heat

Construction

- new plants with unified 20 MW units resulting in unification of equipment components and simplification of assembly and maintenance operations
- modernization with unified 60 MW units featuring greater flexibility and efficiency than the ones now in operation

ACTIVITIES AIMED AT ENHANCING SCIENTIFIC AND TECHNOLOGICAL KNOWLEDGE

- Optimization of techniques for locating, evaluating and managing geothermal reservoirs and improving the success ratio
- Development of new deep drilling and downhole measuring techniques
- Research on wider exploitation of geothermal fluids and environmental control
- Research on improving materials used in geothermal power plants
- Research on non-hydrothermal systems



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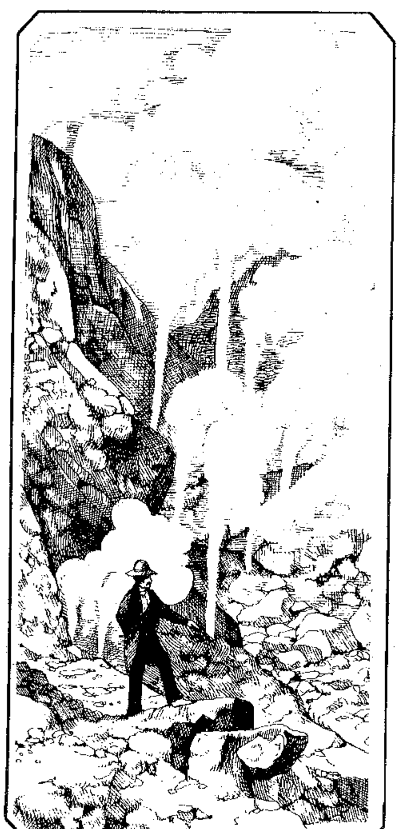
SACRAMENTO, CA. 95814



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