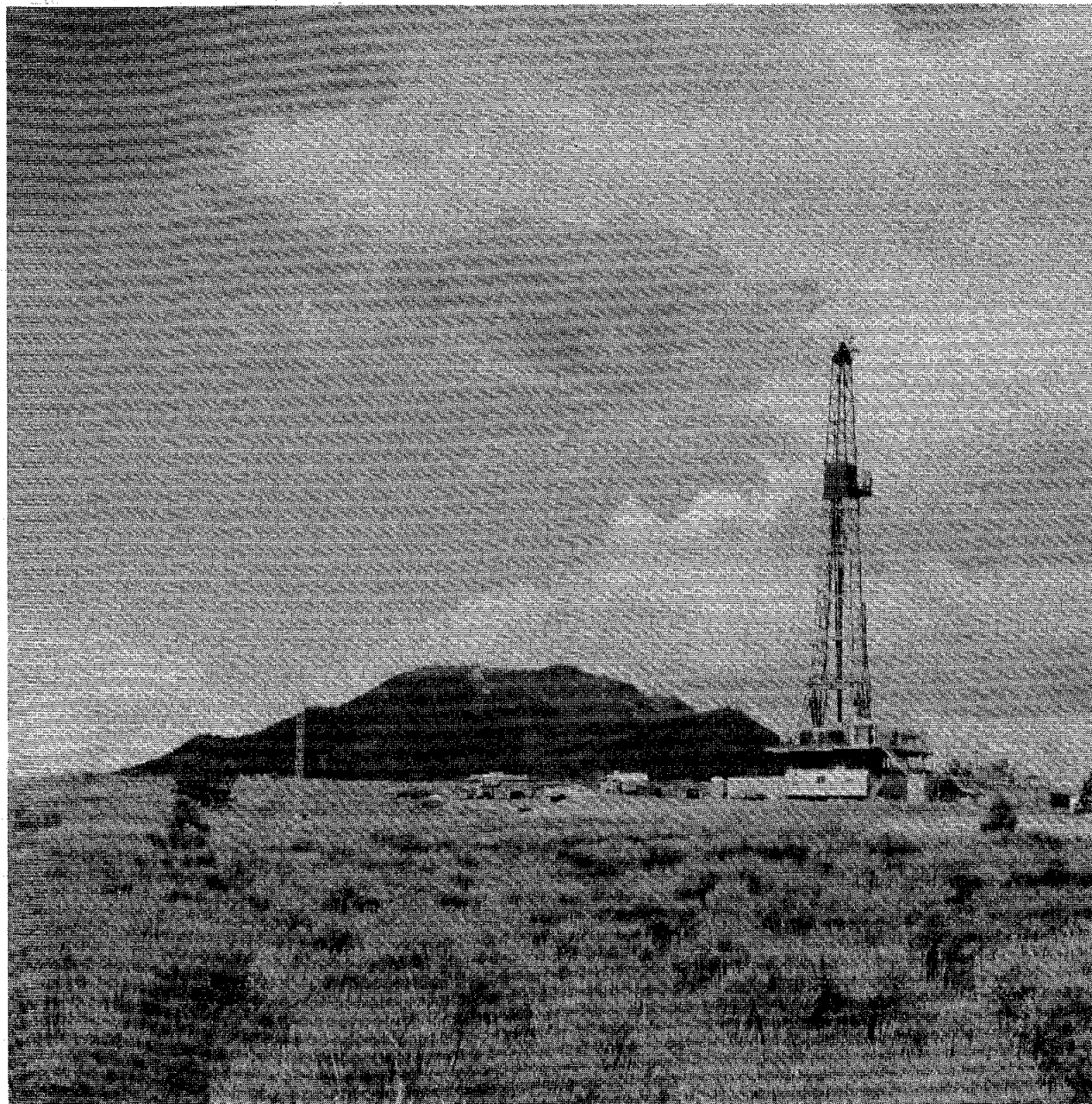


the GEOTHERMAL HOT • LINE

December 1991

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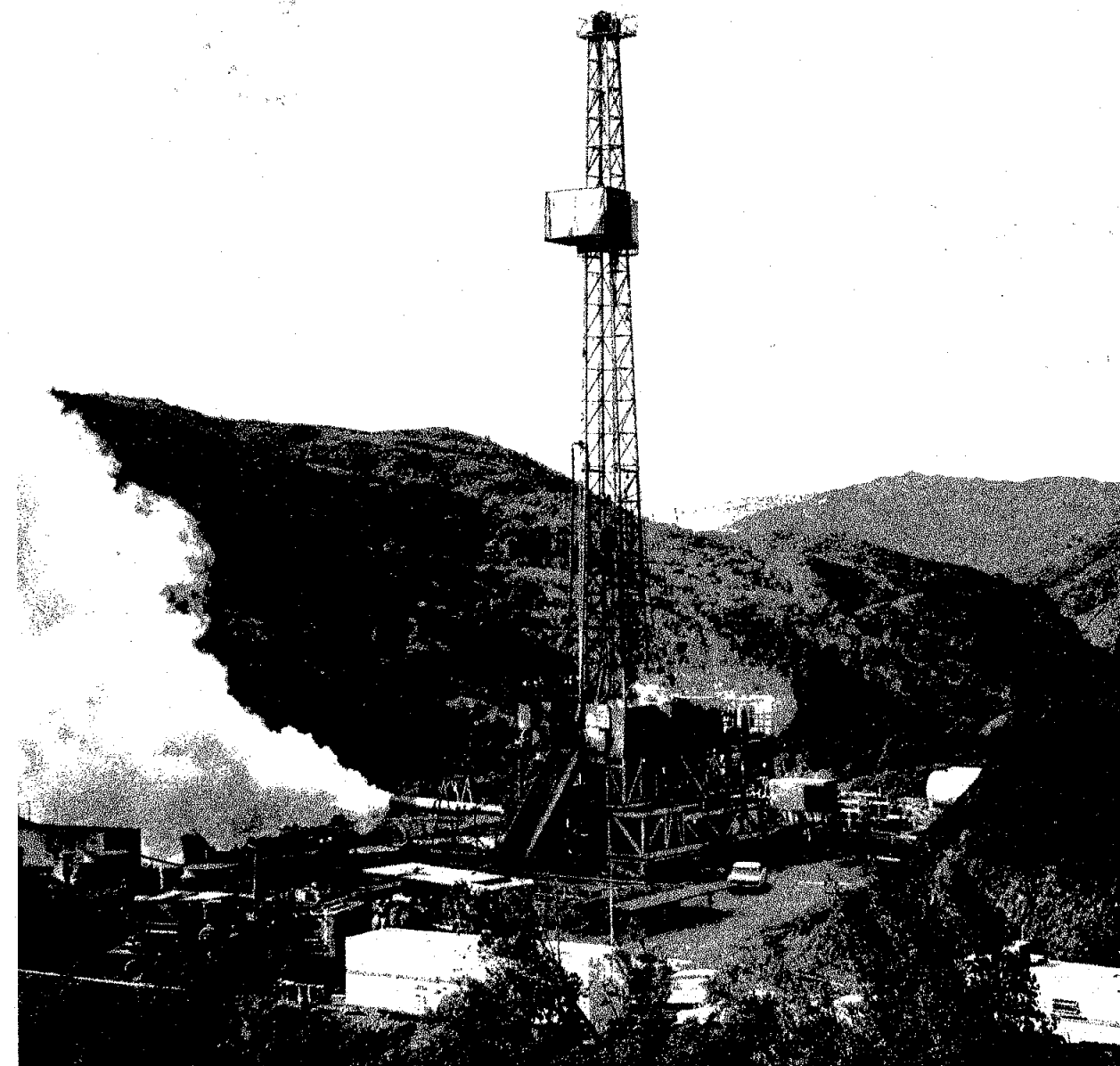


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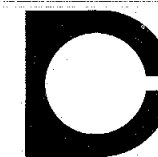
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Cover photo: Pacific Energy well "SF" 35A-32, drilled in August 1990 near Mammoth Lakes, California, in Casa Diablo Geothermal field. Photo by Stephen Mulqueen.



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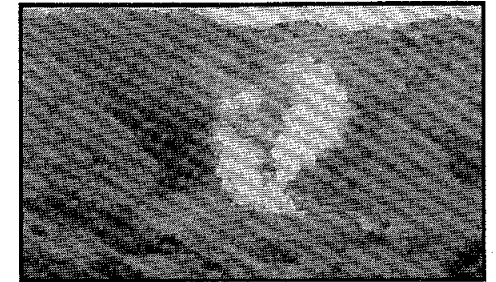
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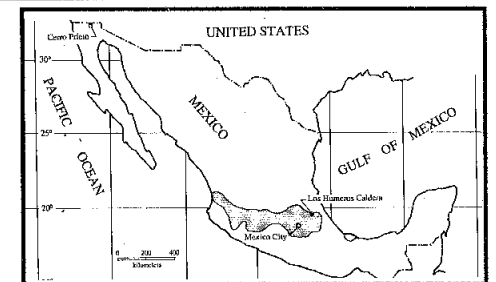
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CONTENTS

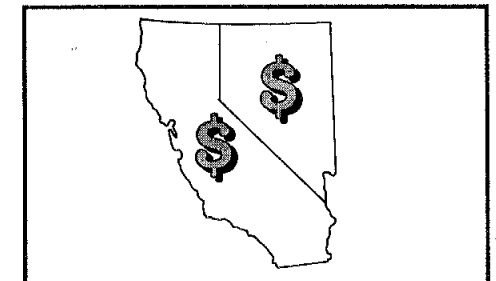
1	California
15	Other Western States
25	Worldwide
33	Development
48	Technology Transfer
60	California Wells



October 1991: The Geysers electrical output.
Page 2.



Mexican geothermal history. Page 30.



PUC and PSC price power-plant emissions.
Page 33.



New public information brochures. Page 41.



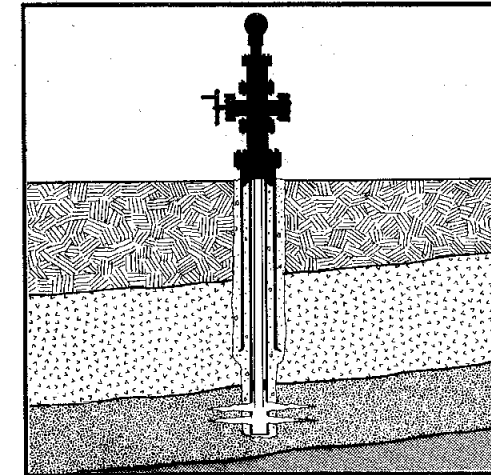
Harbin Hot Springs. Page 52.

CALIFORNIA

GEOTHERMAL INJECTION WELLS

Division Regulates Geothermal Injection Wells

On July 30, 1991, a Memorandum of Agreement was signed by M.G. Mefferd, State Oil and Gas Supervisor of the Division of Oil and Gas, and Harry Seraydarian, Director of the Environmental Protection Agency (EPA) Region IX Water Management Division. As part of the agreement, EPA Region IX assigned to the Division of Oil and Gas "The responsibility for administering the geothermal energy injection program until procedures for formal pro-



gram delegation of subclasses of Class V injection wells are developed or when the State of California receives primary enforcement authority for all classes of injection wells." This responsibility extends to injection wells drilled on state and private lands in California. The EPA is working on another agreement with other state and federal agencies for administering geothermal injection wells on federal lands in California.

NORTHERN CALIFORNIA

New Steam Well at The Geysers

On April 30, 1991, Calpine Corporation announced the completion of a new geothermal steam well, "Wolfe" No. 1, in The Geysers Geothermal field.

"Wolfe" No. 1 confirmed the existence of a substantial new steam resource in a previously undrilled area of the field. Development of this area would offset recent declines in output from the existing steam field.

The well required 67 days to drill, reaching a total depth of 8,496 feet on April 22, 1991. The total cost exceeded \$2 million. Tests indicate the well is capable of producing enough steam to generate 14,000 kilowatts of electricity an hour. Steam from the well will be produced for Pacific Gas and Electric Company (PG&E) Power Plant Unit 13, which has a maximum generating capacity of 135,000 kilowatts and is the largest geothermal plant in the world.

Ron Walter, Calpine's vice president of geothermal development, said, "We are very pleased with the results from

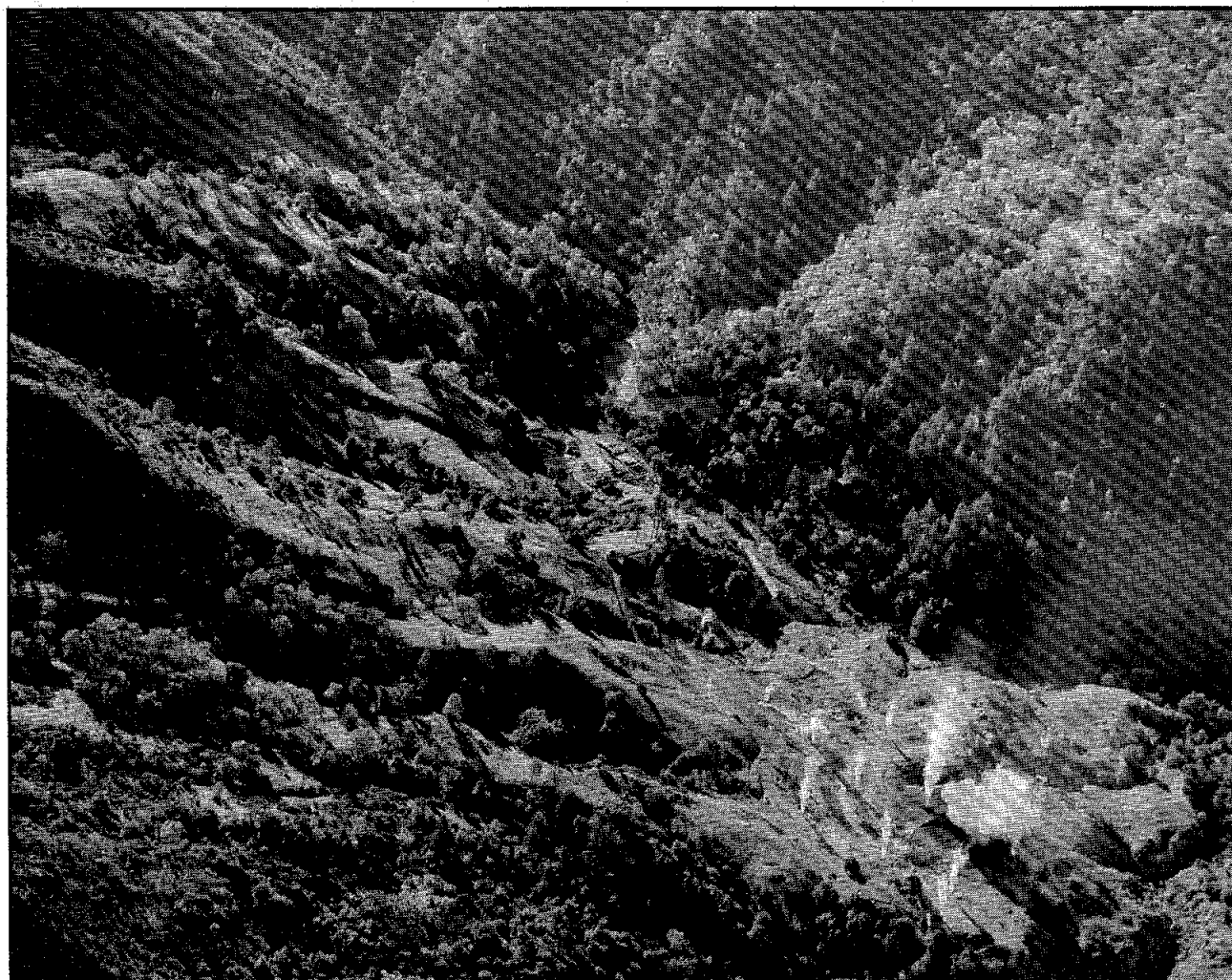
the Wolfe well. The purpose of drilling in this area was to prove the existence of additional reserves to the north of the steam field, which currently supplies steam to PG&E's Unit 13 and Unit 16 facilities. If we can reach agreement with PG&E on the use of additional steam from this new area, we can significantly improve the output capability of Units 13 and 16."

Calpine Corporation is a leading participant in the power industry and a developer, owner, and operator of cogeneration and geothermal facilities throughout the United States. Calpine is the general partner of Santa Rosa Geothermal Company, which owns the geothermal wells that supply PG&E's Units 13 and 16, Sacramento Municipal Utility District's power plant SMUDGE No. 1, and the West Ford Flat and Bear Creek Canyon power plants, which it owns, as well. Electricity generated at these two plants is sold to PG&E. Calpine's total power production at The Geysers exceeds 330 megawatts.

Wells Drilled in The Geysers Geothermal Field, Including Private, State, and Federal Wells

	Active	Abandoned	Total
Temperature-Gradient Wells	10	20	30
Production Wells	521	92	613
Injection Wells	42*	8	50

*Some are used as back-up wells.



Current Geysers Power-Plant Production

A table in the *76th Annual Report of the State Oil & Gas Supervisor*, 1990, shows the gross steam produced from geothermal power plants at The Geysers Geothermal field from 1968 to the present. The table shows that the steam production at The Geysers has declined from a high of 111,821,897,000 kilograms in 1987 to 95,654,893,000 kilograms in 1990. With the decline in production, several older, less efficient power plants have been placed

on standby in the field, others have been suspended, and most are operating at a reduced capacity.

The following table indicates the current output/status of the power plants as of late October 1991, along with their rated gross capacities.

Steam Supplier	Power Plant Owner ¹	Power Plant Unit	Date On Line	Gross Capacity (Megawatts)	Output, Oct. 1991 (Megawatts)
UNION OIL CO. OF CA.	PG&E	Unit 1	9/60	12	Standby
		Unit 2	3/63	14	8
UNION OIL CO. OF CA.	PG&E	Unit 3	4/67	28	Standby
		Unit 4	11/68	28	Standby
UNION OIL CO. OF CA.	PG&E	Unit 5	12/71	55	42
		Unit 6	12/71	55	48

(continued, p. 3)

by Kenneth F. Stelling
Geothermal District Engineer

Steam Supplier	Power Plant Owner ¹	Power Plant Unit	Date On Line	Gross Capacity (Megawatts)	Output, Oct. 1991 (Megawatts)
UNION OIL CO. OF CA.	PG&E	Unit 7	11/72	55	31
		Unit 8	11/72	55	37
UNION OIL CO. OF CA.	PG&E	Unit 9	11/73	55	44
		Unit 10	11/73	55	44
UNION OIL CO. OF CA.	PG&E	Unit 11	5/75	110	70
UNION OIL CO. OF CA.	PG&E	Unit 12	3/79	110	81
GEO OPERATOR CORP.	PG&E	Unit 15*	6/79	62	Retired
SANTA ROSA GEOTHERMAL	PG&E	Unit 13	5/80	138	109
UNION OIL CO. OF CA.	PG&E	Unit 14	9/80	114	64
UNION OIL CO. OF CA.	PG&E	Unit 17	12/82	119	51
NORTHERN CA. POWER AUTHORITY	NCPA	NCPA 1	1/83	122	75
UNION OIL CO. OF CA.	PG&E	Unit 18	2/83	119	82
SANTA ROSA GEOTHERMAL	SMUD	SMUDGE 1	10/83	78	78
SANTA FE GEOTHERMAL	SANTA FE GEOTH.	Santa Fe 1	4/84	85	80
DEPT. OF WATER RESOURCES	DWR	Bottlerock**	3/85	55	Suspended
UNION OIL CO. OF CA.	PG&E	Unit 20	10/85	119	84
SANTA ROSA GEOTHERMAL	PG&E	Unit 16	10/85	119	98
NORTHERN CA. POWER AUTHORITY	NCPA	NCPA 2	11/85	124	75
COLDWATER CREEK OPER. CORP.	CCPA	Unit 1	5/88	65	55
SANTA ROSA GEOTHERMAL	SANTA ROSA GEOTHERMAL	Bear Canyon Creek	9/88	22	22
COLDWATER CREEK OPER. CORP.	CCPA	Unit 2	10/88	65	Standby
SANTA ROSA GEOTHERMAL	SANTA ROSA GEOTHERMAL	West Ford Flat	12/88	30	30
GEOTHERMAL ENERGY PARTNERS	GEOTHERMAL ENERGY PARTNERS	Aidlin 1	6/89	25	18
Totals				2,093	1,326

¹ CCPA = Central California Power Agency
DWR = Calif. Dept. of Water Resources
NCPA = Northern California Power Agency

PG&E = Pacific Gas and Electric Company
SMUD = Sacramento Municipal Utilities District

*Sale of PG&E's Unit 15 is in negotiations with a new corporation, Geysers Power, Incorporated. The sale should be completed by the end of 1991. After refitting, the unit is expected to produce power by mid-1992.

**The Department of Water Resources' Bottlerock Power Plant has all of its production wells suspended, with cement plugs placed in the well bores. Currently, the power plant is not scheduled to resume operation.

The Geysers Technical Advisory Committee Update



In the mid-1980s, reservoir pressures and steam supply rates from wells at The Geysers Geothermal field unexpectedly began to decline more rapidly than predicted, yielding a corresponding decline in electrical power generated from the field.

The California Energy Commission (CEC) responded to the news by forming a Technical Advisory Committee (TAC) in late 1989, composed of representatives from the CEC, Division of Oil and Gas, California State Lands Commission, and utility and steam suppliers at The Geysers. The TAC was overseen by CEC's Siting and Regulatory Procedures Committee (SRPC). One of the primary tasks of the TAC was to evaluate cost-effective alternatives for efficient management of the steam reserves. During the first year of existence, the TAC:

1. Funded a study that recommended the TETRAD simulator as being most appropriate for modeling the performance of the reservoir; and
2. Chose Stone & Webster Engineering Corp. to report on major power plant modifications that could increase the efficiency of the field.

Further developmental work on the reservoir model and power-plant improvement report came to a virtual standstill during early 1991. During this period, CEC Commissioners Kevorkian and Bilas took over direction of the SRPC, and new CEC staff was assigned to the TAC. In addition, members of the Consortium (a group within the TAC limited to steam suppliers and utilities) had difficulty in coming to terms on an agreement to fund the work of Stone & Webster. Citing the TAC's lack of progress on the model and report, the SRPC held a hearing on July 9, 1991.

*by Richard Thomas
Geothermal Officer*

The members of the TAC were asked by the SRPC to answer questions regarding causes of the declines and offer solutions for reducing the decline. Following the hearing, the SRPC issued an Order, which, in part, directed steam suppliers and electric generators to prepare a coordinated resource plan for The Geysers. According to the Order, the plan should be meaningful, comprehensive, and voluntary. The Order further stated that "in the absence of meaningful and comprehensive solutions from industry, the Committee (SRPC) will pursue other options at its disposal, including available regulatory and/or legislative remedies." The SRPC further indicated that it intends to submit its recommendations to the full CEC in time for adoption by its meeting in December 1991.

At an October 10, 1991 prehearing workshop, and again at an October 16, 1991 hearing, the Consortium presented to CEC staff and the SRPC the conceptual plan for changing operations in the field. The plan emphasized five elements for increasing the efficiency of operations in four distinct regions of the field. The Consortium emphasized that the plan was conceptual, not fully approved by the myriad of interested parties, and not tested against the computer models that are in the early stages of development. They concluded that "further technical and economic evaluation of these elements are needed prior to the development of any option."

Also, during the prehearing workshop, the Consortium announced that an agreement was signed on September 17, 1991, between Lake County and the TAC Consortium. Lake County's subcontractor, GeothermEx, has begun developing the computer model of the reservoir that would be instrumental in testing the conceptual plans. The Consortium also announced the signing of a funding agreement between the Consortium and Stone & Webster to complete the power-plant report.

Calistoga Update

The City of Calistoga will receive a grant of \$244,000 from the California Energy Commission to continue development of the city's district heating system. Under funding from an earlier grant, a geothermal well, "CDHS"

1, was drilled for the system in June 1990. The new monies will be used for long-term well testing and formulating plans for handling cooled geothermal water.

CEC-City of Clearlake HDR Project

Phase 2 of the California Energy Commission-City of Clearlake hot-dry-rock project entails a basic scientific evaluation of the geological regime in and near the City of Clearlake. The evaluation will include a study of six factors:

- (1) Geological structures, with a compilation of subsurface lithological boundaries, volumetric textures, and an assessment of the fault control of the reservoir permeability;
- (2) Thermometry, with an assessment of heat flow at the surface from various wells;
- (3) Geohydrology, with a geochemical evaluation and an assessment of the subsurface fluid types, sources, and flow paths;
- (4) Seismicity, with a study of natural earthquake distribution and influence on fluid-coupled mechanical processes and fluid sources at depth;
- (5) Geothermal regimes that combine subsurface materials data, temperature, and boundary conditions into a fluid-transport model;
- (6) Surface-water hydrology for assessing water (input and output) sources and identifying sources of hot-dry-rock reservoir fill, and make-up water.

Phase 2A will include the following:

- (1) Additional work under the geological structure task of Phase 2, utilizing commercially available, three-dimensional models to investigate the causes of the resistivity anomaly;
- (2) An isotope (tritium) survey will be made under the geohydrology task, plus a microprobe of geothermometry and geobarometry, if possible.

A wellbore stability task will be undertaken to assess existing deep wellbores and to derive engineering parameters such as fracture opening pressures, induced flow rates, and lithostatic stress.

Total CEC funding for Phase 2 and Phase 2A will be \$280,000. The final report on these phases of the project will be released in early 1992. For further information, contact Roger Peake, Geothermal Project Manager, California Energy Commission, at (916) 654-4609.

Lake County Receives Clean Air Designation

The Lake County Air Quality Management District is the only air district in California officially designated as operating in compliance with all of the state's Clean Air Act Ambient Air Quality Standards. Extensive monitoring and a consecutive three-year perfect record were needed by the county to win the designation.

Lake County officials characterize the award as a "shared achievement" among many industries, agencies, and individuals who have helped to improve county air quality. Together, they have moved from frequent violations to almost a 4-year period with no violation of air standards. The county gives credit to the implementation of the best available control technologies in the extensive geothermal and mining industries, and a progressive open-burning

*by Elizabeth Johnson
Geothermal District Engineer*

program. For example, hydrogen sulfide concentrations at The Geysers Geothermal field were reduced from highs of 0.6 ppm in the late 1970s to the current attainment level of 0.02 ppm.

A celebration of the designation was held on May 17, 1991. During the ceremony, a resolution of the Assembly and Senate commending Lake County, sponsored by Assemblywoman Bev Hansen and Senator Mike Thompson, was presented to the Lake County Board of Supervisors. The resolution was signed by Governor Wilson. Over 200 environmental, industry, governmental, and legislative representatives attended the ceremony.

California's air quality standards are significantly more stringent than are the Federal Clean Air Standards.

California Energy Company

According to the Geothermal Resources Council *Bulletin*, California Energy Company has announced that it will move its headquarters office from San Francisco, California, to Omaha, Nebraska. The move is aimed at cutting costs, situating the geothermal producer for nationwide expansion, and putting its executives in the same city as its largest shareholder, Peter Kiewit & Sons.

California Energy also announced it will reacquire Kiewit's one-half interest in geothermal properties in Nevada and Utah. In return for this acquisition, Kiewit receives the

options to buy an additional 2.5 million shares of the company -- one million of them at 11 5/8 per share and the remainder at 9 per share. This transaction gives Kiewit 24 percent of California Energy's stock. Under a revised standstill agreement also announced, Kiewit can purchase up to 49 percent of California Energy's stock.

Since becoming CEO of California Energy in February 1991, David Sokol has lowered the company's overhead costs by \$12 million a year.

Geothermal Well Drilled in Alturas

The Modoc Joint Unified School District, in conjunction with the California Energy Commission, drilled a low-temperature geothermal well, called "AL" 2, near the middle and elementary schools in Alturas, California. This well was the second well drilled for the school district. The first was drilled in 1988, and is used to heat most of the high school campus. The well saves the school district nearly \$10,000 a month in heating costs for the gymnasium, alone. The school district also hopes for big savings from the second well, with which it plans to heat

both the elementary and middle schools, currently heated by electricity.

Well "AL" 2 was completed in October 1991 at a depth of about 600 meters. Geothermal water temperatures were measured at about 80° C. The school district is having the water chemistry analyzed, and hopes to get a surface-discharge permit to pump test the well.

After "AL" 2 was completed, the drilling rig was moved to "AL" 1, the first well drilled. "AL" 1 was deepened to increase the fluid volume and temperature. With these increases, the well will be used to heat the remaining buildings on the high school campus.

by Robert S. Habel
Geothermal District Engineer

Susanville Update

The City of Susanville has received promising news from the Lahontan Regional Water Quality Control Board, in regard to the disposal methods to be used for produced geothermal fluids from the city's geothermal district-heating project. In July 1991, the regional board asked its staff to meet with the city staff to develop mutually acceptable disposal methods. The board felt it was not in

the best interest of the state at that time to issue a cease and desist order for the surface disposal of the geothermal fluid.

After making this decision, the regional board's staff toured the city's geothermal district heating system to fully understand the impacts, if any, from surface discharge to the surface waters near and around Susanville. However, the board continues to be interested in finding an acceptable injection site for the geothermal fluid used in the city's geothermal district heating project.

by Robert S. Habel
Geothermal District Engineer

The Deep Magma Well: Phase 2

"The primary purpose of the U.S. Department of Energy (DOE), Magma Energy Program in Long Valley is to confirm the results of surface measurements in the Long Valley caldera and evaluate the extent of the magmatic resource there," said John Rundle of the Earth Science Division, Lawrence Livermore National Laboratory, and chief scientist of the project. "The well is drilled in the resurgent zone area of the caldera," Dr. Rundle continued.

"So far in 1991, we've drilled the well to about 7,000 feet, and are in Phase 2 of the overall well program. The well was drilled through the Bishop Tuff and into basement rock.

"During the last week of October, we will start coring the well for 500 feet. We expect a continuous core recovery.

Phase 2 drilling and coring costs are shared equally by the California Energy Commission and the DOE.

"Next summer," Dr. Rundle said, "the DOE will pay for many tests to be made in the well. This activity will be considered as part of Phase 2. Among the measurements are seismic, stress, heat flow, magnetotelluric, and borehole gravity.

"The core extracted this year will be studied by geologists and wind up in the DOE core repository in Grand Junction, Colorado.

"Phase 3 drilling won't start until at least 1993 and maybe later, depending on funding," Dr. Rundle concluded.

Mammoth Lakes T-G Well Successful

A temperature-gradient well has been completed successfully at Juniper Ridge, in Mammoth Lakes, California. Dubbed "Ohwell" 1, the well was drilled on private land to a depth of 2,177 feet by Longyear Drilling Company of Dayton, Nevada. As of September 30, 1991, the bottom-hole temperature was 174°F, which is ideal for use in the district heating system proposed for Mammoth Lakes. The system would deliver warm water to heat buildings, replacing heat generated from fossil fuels.

Consulting geologist Gene Ciancanelli of Cascadia Exploration Corporation said, "Between 2,035 and 2,055 feet, we encountered formations that appear to contain geothermal fluids suitable for district heating. We also discovered a freshwater production zone at 670 feet, which we are recommending as a supplement to the town's limited freshwater production."

Mammoth Lakes has retained Cascadia Exploration Corporation, a company with over 15 years of experience in geothermal exploration and development, to provide technical expertise for its district heating system. Primary funding for the project comes through a grant from the California Energy Commission.

Drilling operations were not without difficulty. While drilling at 2,175 feet, the crown of the diamond-core bit broke off in the bottom of the hole. A new bit was installed, and the drill spun for 17 hours trying to go through the diamond-studded drill bit debris. This

operation overstressed the drill pipe and caused it to break at 1,845 feet, leaving the lower 330 feet of the drill string with the new diamond bit at the bottom of the hole. Unsuccessful attempts were made to extract this material, but, as the costs of the attempts mounted, Project Manager George Fetzter decided to cut the fishing operations short.

"Our target depth was 2,400 feet, but we had already found the hot-water aquifer at 2,035 feet," Fetzter said. "Going deeper was not essential for the success of the project."

However, the drillers felt that they could recover the bottom 330 feet of the hole for future temperature measurements by placing a string of smaller-diameter pipe inside the broken off portion of the pipe. Although this was a delicate operation, likened to trying to hit a straw with a piece of spaghetti while blindfolded, the drillers were successful after several hours of painstaking work, and the hole was saved.

According to Ciancanelli, Mammoth Lakes now has found two of the three ingredients necessary for geothermal success -- heat and water. The third ingredient, reservoir permeability, is still unknown. To learn this, the town plans to drill a geothermal production well, now scheduled for the spring of 1992. Through this well, the town will pump test the aquifer to determine if acceptable quantities of geothermal fluids can be delivered.

Casa Diablo Geothermal Field History

Introduction

Casa Diablo is a small geothermal field on the eastern side of the Sierra Nevada in the Long Valley cauldron, near Mammoth Lakes, California. Prior to geothermal development, most of the power in the area came from some 200 miles to the south. However, with high electrical demands in the area (peaking at about 40 megawatts), geothermal power generation has become vital to the community's energy grid and tax base.

In 1991, electrical generation from the field increased from 10 to 40 megawatts. Local and special-interest groups have voiced concerns of the potential impacts of this increase on hydrothermal features in the area. To help clarify the situation, a history follows of caldera hydrology, geology, geothermal development, and political issues.

Geology

"The Long Valley caldera is in east-central California, in southern Mono County, about 40-70 km northwest of Bishop. The caldera floor is elliptical in plan, 17 by 30 km, with its long axis aligned east-west. The area of the floor is about 450 km² and the total area of the caldera and its tributary drainage basins is about 830 km².

"The caldera margin is formed by the Sierra Nevada on the south and west, by a prominent ridge from Bald Mountain to Glass Mountain on the north, and by an unnamed dissected volcanic tableland on the east. Altitudes along the rim range from as low as 2420 m in the northwest and 2067 m at Lake Crowley (spillway level) in the southwest to 3390 m at Glass Mountain in the northeast, 3823 m at Bloody Mountain in the south, and 3367 m at Mammoth Mountain in the southwest.

"Long Valley proper occupies the lower, eastern two-fifths of the caldera. The higher, western three-fifths of the caldera includes a complex series of postcaldera rhyolite flows which have been arched and subsequently faulted to form a resurgent dome 10-12 km in diameter. The annular moat between the resurgent dome and the caldera rim is occupied in the north, west, and south by still younger rhyolite to basaltic lavas and in the east chiefly by alluvial and lacustrine deposits. Altitudes within the area of the caldera floor range from 2067 m at Lake Crowley in the southeast to 2860 m at the summit of a lava dome within the southwestern moat. The

resurgent dome rises to maximum altitude of 2545 m at Lookout Mountain in the northern part, or about 340-460 m above the floor of the adjacent moat.

"The caldera is drained by the Owens River, which flows eastward across its northern part and then southward onto Lake Crowley, and by several tributaries around the periphery. Mammoth, Hot, and Convict Creeks are the chief tributaries, flowing generally eastward across the southern part of the caldera into Lake Crowley. Drainage on the resurgent dome has a roughly radial pattern."³

Michael Sorey of the United States Geological Survey (USGS) believes that the "Regional hydrology of the Long Valley caldera is characterized by a generally west-to-east ground-water flow from recharge areas in and near the base of the Sierra Nevada, around the western and southern margins of the caldera, to points of discharge along Mammoth Creek, Hot Creek, and Lake Crowley. Some of the recharge waters circulate along deep fault zones, and are heated to about 220°C by hot rock less than 1 million years old. After rising toward the surface, hydrothermal fluids flow laterally eastward in one or more aquifers underlying the shallow nonthermal groundwater system. Those hydrothermal fluids discharge at various places in the central and eastern parts of the caldera where northwest-trending normal faults provide paths for flow to the surface."¹

The geothermal developer, Mammoth-Pacific, has a different model of the reservoir. Consultants for the operator believe geothermal fluid may be moving horizontally from northwest to southeast, but that the geothermal fluid inside the boundaries of Casa Diablo Geothermal field rises through faults from a much deeper source, independent of the horizontal lateral flow. Mammoth-Pacific, also feels that the geothermal resource supplying its power plants is within an isolated block-faulted area. Thus, using this geothermal fluid will not affect users of the geothermal resource down gradient from the power plants, such as the State of California's, Department of Fish and Game Hot Creek Hatchery and the Hot Creek Gorge Recreational Area.

The existence of different geologic and hydrothermal models for the geothermal resources in the caldera has resulted in confusion and concern during the geothermal permitting process.

Early Field-Development History

Casa Diablo Geothermal field sits in an area long referred to as the Casa Diablo (House of the Devil). The name was probably inspired by the hydrothermal manifestations in

hot springs.

Such manifestations caught the attention of Magma Energy, Inc., which drilled the first well, "Mammoth" 1, in November of 1959. The data obtained from "Mammoth" 1 was encouraging enough that the company drilled 7 more wells to evaluate the geothermal reservoir. These 7 wells are referred to as the Endogenous wells. In 1978, 2 of the Endogenous wells were used in a demonstration project to heat a nearby lumber yard building. A temperature of nearly 166° C was recorded in "Endogenous" 2 at 122 meters, near the bottom of the surface-casing shoe. For nearly 4-1/2 months, well data were used to verify the geothermal potential of the reservoir for direct-use application. The project was the first step in developing a direct-use geothermal district heating project in Mammoth Lakes, California, nearly 5 kilometers to the west.

Power Plant Mammoth Pacific I (MP I)

Data obtained from the 8 wells drilled in Casa Diablo Geothermal field suggested that the field could support a geothermal power plant. This was important because Mammoth Lakes was purchasing nearly 40 megawatts of its electricity from Southern California Edison Company via power lines from the Mojave Desert, nearly 200 miles to the south.

In September 1983, a joint venture of Pacific Energy Resources Incorporated and Mammoth Binary Power Company was formed and named Mammoth-Pacific. Mammoth-Pacific began working with Southern California Edison Company on power sales contracts to supply the Mammoth Lakes area with electricity generated in Casa Diablo Geothermal field.

At this point, Ben Holt Company, an affiliate of the Holt Geothermal Company and a general partner of the Mammoth Binary Company, signed a contract to design an air-cooled binary power plant.

One advantage of an air cooled binary system is the low environmental impact of the power-plant operations. Because the geothermal fluid is never flashed or exposed to the atmosphere, it has very low emissions. The emissions are from the extremely low leakage of isobutane used in the power plant as a secondary fluid (see sidebar). In addition to the binary design, the power plant is air-cooled and does not require any water for cooling, an important issue in an area of limited water availability.

The power plant was designed to be just 35 feet high, resulting in a very low profile with little visual impact. This was also very important because the power plant was

The MP I power plant uses a binary cycle of pumped geothermal fluid and a secondary working fluid of isobutane. The geothermal fluid (166° C) travels in a closed loop system at a flow rate of about 640,000 lb/hour, and passes through a heat exchanger where the isobutane is heated. At a temperature of 138° C, 500 psi, and a flow rate of 580,000 lb/hour, the isobutane is flashed to steam, which turns a turbine, thus generating electricity. Next, the isobutane is air cooled and returned to the isobutane reservoir.

The geothermal fluid remains under pressure to prevent scaling and to keep it in a liquid state. The geothermal fluid exits the heat exchanger at temperatures of 66° C to 82° C, depending on the ambient air temperature.²

to be constructed next to Highway 395, a scenic corridor.

Construction of the 10-megawatt, gross, power plant, to be named MP I, was started in August 1983, and the plant came on line in February 1985.

The first production well, "MBP" 1, was drilled in 1983. Since then, 5 production wells and 2 injection wells have been drilled. The last well, "MP" 6, is a make-up well completed in 1990.

Well "MBP" 2 was completed on November 5, 1983. On July 16, 1984, about one week after the well was flow tested, a new fumarole erupted about 15 meters from the well, and about 30 meters from the Casa Diablo fumarole. This occurred because geothermal fluid from the reservoir was channeling its way to the surface, independent of the well bore.

The operator worried about controlling the well, knowing that once fluid started flowing up around the well casing, this would be difficult. Therefore, Mammoth-Pacific decided to produce the well to see if the fumarole's flow could be reduced significantly, which it was not. Thus, to avoid a well blowout, Mammoth-Pacific requested and received a permit from the Division of Oil and Gas to plug and abandon the well, and on September 6, 1984, abandonment operations were begun. On September 10, after three cement plugs were placed in the

by Robert S. Habel
Geothermal District Engineer

September 10, after three cement plugs were placed in the well bore, hot water began bubbling out on the surface around the rig substructure, threatening the rig's stability. Finally, after 13 cement plugs and 95 cubic meters of cement were in place, the well was plugged and abandoned.

The need to abandon this well altered evaluations of future drilling and cementing operations in the geothermal field. Proposed well programs were either changed or well locations moved to avoid similar problems.

Field Monitoring Programs

At first, the impacts from geothermal development in Casa Diablo Geothermal field were not monitored closely. In fact, the environmental documentation for the MP I geothermal project was handled by the Mono County Planning Department, which prepared a Negative Declaration to satisfy California Environmental Quality Act requirements for the issuance of a use permit. The environmental review was short and was accepted by the county. In contrast, today in 1991, proponents of geothermal projects must have prepared adequate environmental analysis, usually in the form of an environmental impact report which thoroughly evaluates potential adverse impacts from the geothermal development.

In 1984, with the increase in the geothermal activity in Casa Diablo field and an increasing concern over environmental impacts from the geothermal projects, Mono County created the Energy Management Department (EMD) to review and process geothermal use-permit applications, and to be the lead agency on environmental-review documentation for geothermal-development projects in the county.

In 1984, the EMD received a use permit application from Bonneville Pacific for the Mammoth/Chance geothermal project, which was slated to be sited about 2 miles to the southeast of the MP I geothermal project.

The Mammoth/Chance project included the drilling of exploration, production and injection wells, and the construction of a 10-megawatt, gross, power plant across a meadow from the California Department of Fish and Game, Hot Creek Hatchery. This area is near other hydrothermal features, such as the Hot Creek Bubbling Pool. Because project activities could affect these features, the EMD required a series of monitoring wells to be drilled around the proposed site. Baseline data on cold water and geothermal reservoirs had to be collected before any geothermal development could begin.

As baseline data were being collected and evaluated, separate hydrothermal models were developed by the

USGS and by the developers. Reviewing these models, the EMD realized that too many geological and hydrological unknowns existed in the area. This uncertainty made it difficult for the county to develop threshold limits on changes to the baseline condition and to regulate development adequately.

Thus, the EMD suggested that an advisory committee be organized to evaluate the geology, hydrology, and the planned geothermal development in the Long Valley caldera. The committee would make nonbinding recommendations to the appropriate regulatory agencies on monitoring programs and project conditions, with a goal of using the geothermal resources wisely. Advisory committee members included representatives from the Bureau of Land Management, U. S. Forest Service, California Division of Oil and Gas, California Regional Water Quality Control Board, California Department of Fish and Game, California Air Resources Board, Mono County, Mammoth Pacific and Bonneville Pacific (the geothermal developers), and all other interested or affected organizations.

In 1986, the Mono County Board of Supervisors passed a resolution creating an advisory committee, which it called the Long Valley Technical Advisory Committee. The name was changed later to the Long Valley Hydrological Advisory Committee (LVHAC), reflecting more clearly the committee's focus.

The LVHAC developed a monitoring program of all the geothermal and nongeothermal projects that could impact the Long Valley caldera's hydrothermal features. The monitoring program includes more than 25 sites including wells, springs, streams, and a precipitation gauge. Today in 1991, data are still collected at these sites to evaluate the hydrology of fresh cold water and of hydrothermal fluids.

By 1987, several monitoring wells had been drilled for the Mammoth/Chance project, and baseline data were being collected. In February 1988, the Mono County Board of Supervisors issued a use-permit for the Mammoth/Chance power plant. The decision was appealed immediately by the Sierra Club, Cal-Trout, and the California Department of Fish and Game. In January 1989, the Mono County Superior Court issued a decision in favor of the petitioners, subsequent to a Writ of Mandamus hearing held in July 1988. The decision set aside the certification of the project's EIR on the grounds it did not address the cumulative impacts of the project as stated in guidelines of the California Environmental Quality Act (CEQA). A new EIR would have to be prepared and approved before the project could continue. An appeal of this ruling was filed by Bonneville Pacific to the Third District Appellate Court. In the spring of 1991, the appellate court agreed

with Mono County Superior Court's decision. The operator filed an appeal to the State Supreme Court, and was denied a hearing based on the lack of merit. This left the operator with options to either write a supplementary EIR to evaluate the cumulative impacts or abandon the project.

Power Plants MP II, MP III, and PLES 1

After Mammoth-Pacific put power plant MP I on line and had evaluated its impacts on the reservoir, the company began the permitting process for building three additional power plants in Casa Diablo Geothermal field: MP II, MP III, and PLES 1.

On October 5, 1987, the Mono County Planning Commission issued a use-permit to Mammoth Pacific for power plant MP II and denied without prejudice a permit for power plant MP III. The MP II plant would be of the same design as MP I, but rated at 15 megawatts, gross. The Sierra Club and the Department of Fish and Game had concerns that the proposed power plant would cause negative visual impacts and possibly impact surface waters if a geothermal spill were to occur. Eventually, the Sierra Club filed an appeal with Mono County Board of Supervisors to rescind the use permit.

As a result, on February 22, 1988, the Mono County Board of Supervisors denied the MP II project by a 3 to 2 vote. The denial was based upon concerns of possible negative visual impacts and potential impacts to the mule deer migration caused by the project. The operator asked that the project be denied "without prejudice," which was granted, allowing the operator to resubmit the project with information to show that the MP II power plant would not negatively impact the community and environment.

Mammoth-Pacific did resubmit the project, and in December 1988, the Mono County Board of Supervisors voted 5 to 0 to approve a use-permit for the MP II power plant. Shortly thereafter, the California Department of Fish and Game appealed the Board's decision. Finally, in the fall of 1989, an out-of-court settlement was reached by the Department of Fish and Game, Mammoth-Pacific, and Mono County. Mammoth-Pacific gave an undisclosed sum of money to Fish and Game to fund biological surveys, studies related to the surrounding area, or land purchases of other potential geothermal land that could impact the fish hatchery. Now with the appeal withdrawn, Mono County issued a use-permit for the MP II project.

In the same period, Pacific Energy, parent company for Mammoth-Pacific, had filed for a permit from the U.S.

Forest Service, through the U.S. Bureau of Land Management, to construct a plant identical to MP II, to be called PLES 1. The plant would be less than 10 meters from MP II, on U.S. Forest Service land. The Final EIS for PLES 1 was completed in June 1989. On November 15, 1989, the BLM granted Pacific Energy a permit to construct and operate the 15 megawatt, gross, power plant.

Power-plant construction and drilling operations began simultaneously for both projects in the spring of 1990. On December 7, 1990, Power Plant MP II went on line, as did PLES 1 on December 22. These plants brought the generating capacity of the geothermal field to 40 megawatts, gross.

In Summary

Potential environmental impacts from all types of development in the Long Valley caldera are being monitored closely by federal, state, and county officials. Of primary concern are changes to hydrologic and thermal features. Because of Mono County's scenic beauty, world-renowned fishing, and world-class skiing facilities, the issues of geothermal development and an "industrial look" are topics of political controversy. Throughout the permitting process for the geothermal projects, concerns were raised about possible negative impacts to these assets, which are the primary sources of income to Mono County and to Mammoth Lakes.

The LVHAC has evaluated monitoring data for impacts to the hydrothermal features in the Long Valley caldera since 1987. It has sent recommendations for additional monitoring to a geothermal operator and permitting agencies. Through extensive discussions, the permitting agencies and the operator have developed a plan to obtain the additional data.

At this writing, work is progressing on permitting an additional monitoring well to be drilled in Chance Meadow between current geothermal development and the State of California Fish Hatchery. The well would allow the LVHAC to obtain data that could indicate changes in the hydrothermal system caused by the geothermal development. The changes would be evaluated to see what impacts, if any, the geothermal development has had on the hydrothermal resources used at the fish hatchery and on the hydrothermal features enjoyed by tourists in the Hot Creek swimming area.

Thus, the development of geothermal resources in the Casa Diablo Geothermal field has been, and continues to be, carefully planned and reviewed by federal, state, and local agencies. With the development of the Long Valley Hydrologic Advisory Committee, and the close working

relationship of all the regulatory agencies and the geothermal operators in the area, geothermal development has been made an environmentally safe, reliable, and eco-

nomically viable source of energy for the State of California.

References

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2. Holt, B., and Campbell, R.G., "The Mammoth Geo-

thermal Project." *Geo-Heat Center Quarterly Bulletin*, Vol. 8, No. 4, Fall 1984.

3. Sorey, M.L., Lewis, R.E., and Olmsted, F.H. The hydrothermal system of Long Valley Caldera, California. U. S. Geological Survey Professional Paper 1044-A, 1978.

Casa Diablo Geothermal Field Time-Line

Early Development and MP I Power Plant

First well drilled ("Mammoth" 1), 1959
 "Endogenous" wells drilled, July 1960 - 1962
 Demonstration Project, Aug. - June 1978
 Negative Declaration for MP I power plant, Jan. 1982
 Formation of Mammoth Pacific, Sept. 1983
 MP I power plant construction, Aug. 1983 - Feb. 1985
 "MBP" wells drilled for MP I power plant, Nov. 1983 - Jan. 1985
 Well "MBP" 2 drilled and abandoned, Nov. 1983 - Sept. 1984

Monitoring

Founding of the Mono County Energy Management Department, Jan. 1984
 Founding of the Long Valley Hydrologic Advisory Committee, Jan. 1987
 Well "CA-11667" 65-32 drilled, Nov. 1987

Mammoth/Chance Project

Mammoth/Chance geothermal well exploratory project submitted, Nov. 1983
 Mammoth/Chance power plant proposal, 1984
 Mammoth/Chance monitoring wells drilled, May - Nov. 1985
 Mono County Board of Supervisors approve Use-Permit, Feb. 1988
 Sierra Club, Dept. of Fish and Game, and Cal Trout appeal, March 1988

Writ of Mandamus Hearing, July 1988
 Mono County decision on the appeal, Jan. 1989
 Appeal to the Third District Appellate Court, March 1989
 Third District Appellate Court decision, spring 1991
 Appeal to the State Supreme Court and denial, summer 1991

MP II Power Plant

Mono County Use-Permit Hearing for MP II, Oct. 1987
 Sierra Club appeal of County Use-Permit, Dec. 1987
 Mono County Board of Supervisors deny Use-Permit, March 1988
 Mono County Board of Supervisors approve Use-Permit, Dec. 1988
 Dept. of Fish and Game files appeal, Jan. 1989
 Out-of-court settlement, Mammoth Pacific and Dept. of Fish and Game, fall 1989
 Construction of power plant, May - Dec. 1990
 MP II on line, Dec. 1990

PLES 1 Power Plant

Completion of EIS for PLES 1, June 1989
 Bureau of Land Management issues power-plant permit, Nov. 1989
 Construction of power plant, May - Dec. 1990
 PLES 1 on line, Dec. 1990

Mammoth-Pacific Power Plant Dedication

On June 5, 1991, two new power plants in the Casa Diablo Geothermal field were dedicated with a ribbon cutting ceremony hosted by the Inyo National Forest, U.S. Bureau of Land Management, Mono County, and Mammoth-Pacific, the power plant owner. The two new power plants, known as MP II and PLES 1, started producing electricity in December 1990. Both of the new power plants are rated at 15 megawatts, gross, bringing the electrical generation capacity of the field to 40 megawatts, gross.

The masters of ceremony at the dedication were Dennis Martin, Inyo National Forest Supervisor, and Daniel Lyster, Director of Energy Management, Mono County. Speakers at the ceremony included Ross Sargent, chief of staff for Senator Patrick Johnson; Assemblyman David Knowles; Lynn Sprague, director of the Washington Office, Minerals and Geology, USDA Forest Service; Chris Sherman, president of Pacific Energy; Dan Paranic, chairman of the Mono County Board of Supervisors; Joyce Muraoka, deputy regional forester, Region Five, USDA Forest Service; Robert Anderson, deputy director for the Bureau of Land Management; Michael Smith, acting manager, Research and Development, California Energy Commission; Sylvia Arbelbide, director, Minerals Area Management, Region Five, USDA Forest Service; and Robert Habel, Division of Oil and Gas.

A common thread in the speeches was the hard work put forth by Mammoth-Pacific, and the benefits of using geothermal energy, a clean energy source.

The ceremony was concluded with a self-guided tour of the two new power plants.

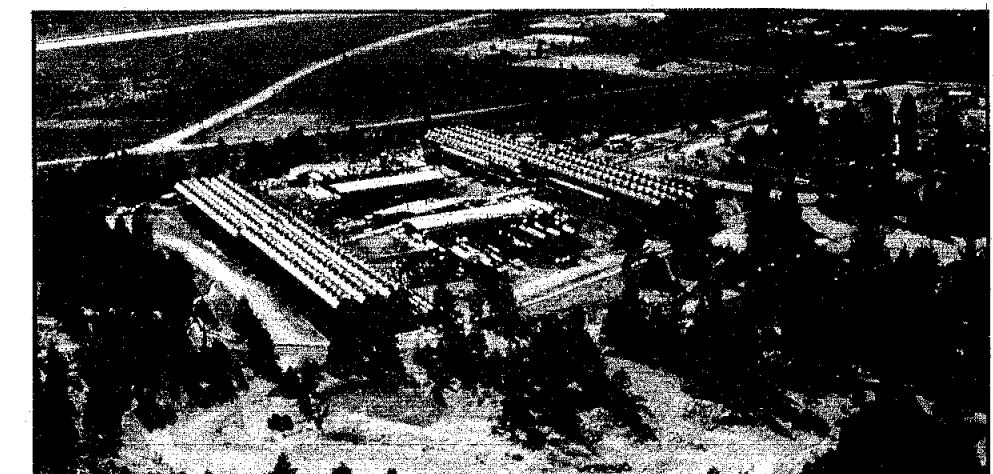
Mammoth-Pacific Geothermal Power Plants MP II and PLES 1 are in the foreground. Each is rated at 15 megawatts, gross. Mammoth-Pacific Plant MP I, shown in the background (right), is rated at 10 megawatts, gross. Photo courtesy of Mammoth-Pacific.



The ribbon cutting ceremony was hosted by the Inyo National Forest, U. S. Bureau of Land Management, Mono County, and Mammoth-Pacific. Photo by R. Habel.



Ribbon cutting ceremony for the two new power plants in Casa Diablo Geothermal field. Cutting the ribbon are Assemblyman David Knowles (left) and Ross Sargent, chief of staff for Senator Patrick Johnson (right). Photo by R. Habel.



by Robert Habel
 Geothermal District Engineer

The Cost of Geothermal for PG&E

Pacific Gas and Electric Company is a large public utility in Northern California. The types of electrical energy resources it uses and their costs follow. These data are from an article by Jeff Pelline, published November 12, 1991, in the *San Francisco Chronicle*.

PG&E Electrical Energy Resources				
Type	Cost per kilowatt hour	Percentage 1990	Percentage projected, 2000	
Hydroelectric	0.1 cent	23	25	
Geothermal	2 cents	4	2	
Fossil fuel	3 cents	38	27	
Cogeneration	7 cents	11	13	
Nuclear	9 cents	10	9	
Imports	8 cents	8	11	
Energy conservation	0 cents	6	13	

SOUTHERN CALIFORNIA

New Hot Mineral Spa Fish Farm

On September 28, 1991, Ernest Schwander completed a well in the Hot Mineral Spa area, which is known as a winter tourist center in northern Imperial County, California.

The well, drilled to a depth of 177 meters, flows at a rate of about 1514 liters/min. Mr. Schwander is constructing

a fish farm where he plans to use geothermal water to raise tilapia for the fresh-fish market.

A total of 20 geothermal wells have been drilled in the Hot Mineral Spa area. Most are used in fish farming operations. The spa area, itself, is about 16 kilometers northwest of Niland, and has mineral waters at 60°C to 74°C.



Portions of three of the four concrete fish ponds. Two ponds are 36.6 meters in diameter, and two are 30.5 meters in diameter. Photo by T. Boardman.

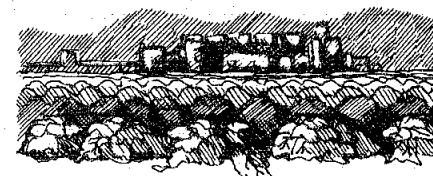
by Timothy Boardman
Geothermal District Engineer



Geothermal well "Imperial" 20, with Ernest Schwander, well owner. Photo by T. Boardman.

Magma to Expand Three Power Plants

In September 1991, Red Hill Geothermal Inc., a subsidiary of Magma Power Company, submitted an application to the Imperial County Planning Department to expand the Del Ranch, J.J. Elmore, and J.M. Leathers Power Plants, all in the Salton Sea Geothermal field. Magma Power Company and its subsidiaries own a 50 percent share of these plants.



"IID agreed to a 25-year power purchase agreement."

Currently, each power plant generates 35 megawatts of electricity. The proposed expansion to 45 megawatts for each plant takes advantage of some of the unused and under-utilized capacity of each plant. The change will increase brine flow through the plants. Thus, in-plant brine handling, cooling, electrical, and instrumentation systems will be expanded.

by Timothy Boardman
Geothermal District Engineer

The Imperial Irrigation District (IID) has agreed to a 25-year power purchase agreement to buy 18 of the 30 megawatts of electricity. According to the contract, IID will pay Magma 5.04 cents per kilowatt-hour. The price of electricity under the contract will increase with the cost-living index, according to the terms of the agreement.

This is the first time the IID has entered into a contract with any of Imperial County's 16 geothermal plants. At one time, electricity generated from geothermal energy was considered too expensive for IID to purchase. However, this contract, according to IID officials, compares

favorably with those purchasing electricity generated from other sources. The Imperial Irrigation District supplies water and power to the residents of the Imperial and Coachella Valleys.

Magma plans to drill new wells for the power plants in January 1992, and to have the expansion for each plant in commercial operation by May 7, 1992. Magma Power Company will make an initial investment of \$19.8 million in the expansion. The project should increase annual revenue by about \$4.5 million. Magma's annual revenue is about \$95 million.

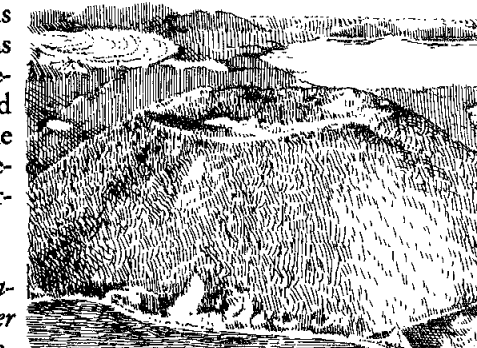
OTHER WESTERN STATES

NORTHWESTERN REGION

Geothermal in the Northwest

The geothermal resources of the Northwest may offer the potential for producing several thousand megawatts of cost-effective energy. While geothermal energy has been proven in other areas of the country, geothermal energy from the type of fields found in the Cascades has not been proven. Moreover, environmental and other constraints on the development of this resource are poorly understood.

The Northwest Conservation and Electric Power Plan recommends implementation of a geothermal research, development, and demonstration agenda including (1) monitoring of geothermal technology and development activities occurring outside the Northwest; (2) collecting environmental baseline data at promising geothermal resource areas; (3) identifying and preparing plans for resolving constraints to geothermal development at favorable resource areas; and (4) confirming the feasibility of generating electricity from geothermal resources in the Northwest through development of a series of pilot projects.



"...implementation of a geothermal research, development, and demonstration agenda..."

The key uncertainty here is whether or not the geothermal resources of the Cascades can support electrical power generation. The Council recommends that Bonneville and the utilities acquire at least 10 megawatts of geothermal energy from each of the three separate fields ultimately capable of producing at least an average of 100 megawatts each. These acquisitions should be secured through output contracts, where the developer bears the risk of development in return for guaranteed sales of electricity at a price higher than current avoided costs.

If successful, these demonstration projects would result in shortening the lead time for development of 300 megawatts of geothermal power currently in the plan and potentially confirm a much larger resource.

The plan estimates the "High megawatt forecast" for geothermal as 350; the "Levelized nominal cost in cents per kilowatt hour" as 10.7; and the "Levelized real cost in cents per kilowatt hour" as 5.4.

Excerpted from the 1991 Northwest Conservation and Electric Power Plan by the Northwest Power Planning Council, Portland, Oregon.

Unalaska Geothermal Project

In October 1991, OESI Power Corporation signed a letter of agreement with the Alaska Energy Authority (AEA), outlining the initial actions to be taken by the AEA and OESI toward developing a 12-megawatt geothermal power-plant project on Unalaska Island, which is one of the Aleutian Islands. The letter of agreement specifies that OESI will submit a detailed project development plan to the AEA, and the AEA will negotiate and execute agreements for the sale of electricity from the power plant. The AEA will also negotiate certain other agreements and retain a consulting engineer and a geothermal consultant to assist in its project review.

Earlier this year, the AEA authorized the use of \$60 million of tax exempt bonds to finance the project, subject to further study. The bonds would finance the cost of the power plant, transmission line, construction support and management, engineering, overhead, and construction fees. The tax exempt bond financing is expected to be in

place by March 31, 1992. Under the terms of the agreement, OESI will construct and operate the power-plant facilities, which will be owned by the AEA. OESI will also develop and provide geothermal fluid from its geothermal resource leasehold.

The project purpose is to provide base-load power to the residents of the City of Unalaska, as well as to the shipping and fishing industries at the International Port of Dutch Harbor.

James W. Porter Jr., chief executive officer of OESI, said, "As an integrated development company, OESI is capable of providing the full range of services required by the AEA, from planning to construction to operation of the project. We are very excited about being the first commercial geothermal project in the State of Alaska."

Geothermal Activity in Oregon, 1990

Geothermal exploratory activity in Oregon decreased in 1990 relative to 1989. Only one hole was completed, and the amount of leased federal land and lease revenues continued to decline. The total amount of federal land leased for geothermal resources has declined steadily since the peak in 1983 (Table 1).

No Known Geothermal Resource Area (KGRA) lands were offered for bid in 1990. Some KGRA lands at Newberry volcano have been incorporated into the Newberry Volcanoes National Monument. The monument area, combined with buffer zones of restricted access, encompasses about 85 percent of the land classified by the federal government as a KGRA.

Anadarko Petroleum Corporation applied for permits to drill 2 new test wells near Borax Lake in the Alvord Desert area. Drilling is stalled pending review of appeals filed by various environmental organizations concerned about potential threats to the Borax Lake chub. In a related action, U.S. Representative Bob Smith introduced a bill to create an 812,870-acre Steens Mountain National Conservation Area. The bill failed to make it through Congress.

The Oregon Water Resources Department (WRD) wrote and amended administrative rules that addressed several geothermal issues pursuant to new legislation. The rules defined terms such as "thermal interference" and "sub-

stantial thermal alteration". They specified 65°F as "a temperature below which low-temperature geothermal appropriations shall not be protected from thermal interference caused by groundwater appropriations for other purposes."

The direct use of relatively low-temperature geothermal fluids continued in 1990 at about the same level as over the last several years. Most of the activity was centered in Klamath Falls and Vale.

The U.S. Geological Survey (USGS) continued its Cascade Range research of igneous processes, hydrothermally altered rock, thermal waters, hydrothermal systems, and regional geology during the year.

In its 1990 Resource Program, the Bonneville Power Administration (BPA) offered to purchase, in joint ventures with regional utilities, 10 megawatts of output from each of three geothermal pilot projects in the Northwest. The main goal is to initiate development at three sites with potential for large-scale power production. Informal discussions with developers are underway, with letters of intent due September 3, 1991. Formal negotiations will begin on October 1, 1991.

The BPA initiated research to estimate local economic impacts of a 100-megawatt geothermal power-plant project. These impact estimates are being done for hypothetical projects in Deschutes and Harney Counties, Oregon. (The Washington State Energy Office is doing

similar studies for such a project in Skamania and Whatcom Counties.) Further research for BPA (to be completed in 1991) will include land-use impact estimates and assembling a database of geothermal power plants in the United States.

To identify land use, environmental, and other issues associated with geothermal development and to provide

Table 1. Geothermal leases in Oregon in 1990.

Types of leases	Numbers	Acres
Federal leases in effect:		
Noncompetitive, USFS	142	220,536.08
Noncompetitive, USBLM	2	942.79
KGRA, USFS	1	100.00
KGRA, USBLM	7	16,465.12
Total leases issued:		
Noncompetitive, USFS	358	686,064.05
Noncompetitive, USBLM	266	406,157.79
KGRA, USFS	8	11,924.61
KGRA, USBLM	62	118,307.85
Total leases relinquished:		
Noncompetitive, USFS	216	465,527.97
Noncompetitive, USBLM	264	405,215.00
KGRA, USFS	7	11,824.61
KGR, USBLM	55	101,842.73
Lease applications pending	121	—

a basis for informed resolution of these issues, several supporting activities are underway. It should be noted that many of these activities focus on specific areas, but do not necessarily predict the locations of pilot projects.

The Deschutes National Forest, Oregon Department of Energy, and the BPA are working on a study to assess the land-use impact of geothermal development in the Bend highlands area south of Sisters. The two federal agencies are funding jointly a wide range of public information and involvement activities related to geothermal development.

The BPA is cooperatively funding designs of environmental baseline monitoring programs for several areas. The U.S. Geological Survey Water Resources Division expects to begin collecting data this summer for a hydrological network at Newberry volcano and the Alvord Desert. Design work will begin this year for programs to monitor air quality, flora, fauna, seismicity, and subsidence at Newberry.

The Oregon Department of Geology and Mineral Industries planned a scientific drilling program in 1987. Funding to support the program came in 1989 from contributions of \$200,000 by the U.S. Department of Energy and \$100,000 by Oxbow Power Corporation. Under the program, a hole was drilled in 1989, and casing was set to 141 meters near Santiam Pass. In 1990, the hole was cored to about 928 meters, and geological and geophysical data were collected. The temperature-depth profile for the hole is irregular, with a high (120° C/km) gradient in the lowermost part. Data analysis will help in understanding the geological history and regional heat flow near the axis of active Cascade volcanism.

The Oregon Water Resources Department low-temperature geothermal program evaluated numerous proposals to inject spent geothermal effluent. This activity resulted from a City of Klamath Falls ordinance now requiring such injection within the city. By year's end, proposals from 18 institutional, commercial, and domestic users were received. Injection rates under the proposals range from 2 to 450 gallons per minute. In addition, an institution near Bend has submitted a proposal to inject 1,500 gallons per minute.

Jack Dymond and Robert Collier of the Oregon State University College of Oceanography continued the investigation at Crater Lake National Park. Their objective is to determine whether or not geothermal input exists on the lake floor. Data collected in 1989 from a surface ship and a submarine were analyzed and summarized in a draft final report to the National Park Service. The report is expected to be finished in 1991.

NEVADA

Commercial Operations Start at Soda Lake Geothermal No. 2

In August 1991, OESI Power Corporation (OESI) announced the completion of commercial-operations testing at its Soda Lake No. 2 facility. The geothermal power plant passed its acceptance tests at a contracted capacity rating of 13 megawatts. The test results were verified by Sierra Pacific Power Company, the purchaser of the plant's electrical output, under a 30-year power purchase agreement.

The Soda Lake Power Purchase Agreement provides for initial energy payments of 2.4 cents per kilowatt-hour and capacity payments starting at 2.7 cents. The payments will escalate under provisions in the power-purchase agreement. The Soda Lake No. 2 power plant is next to OESI's Soda Lake No. 1 facility.

By George R. Priest, Oregon Department of Geology and Mineral Industries. Excerpted by permission from Oregon Geology, vol. 53, no. 4.

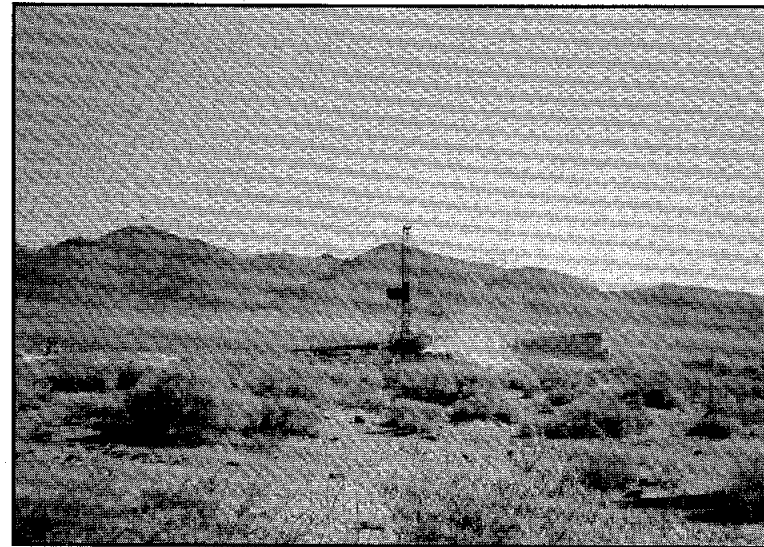
Brady Hot Springs Power Plant

A 20-megawatt geothermal power plant contract was awarded to The Ben Holt Company of Pasadena, California, for engineering design, procurement, and other services for a power plant owned by Brady Power Partners.

The plant is at Brady Hot Springs, 60 miles northeast of Reno, near Fernley, Nevada. The power plant is scheduled to be on line in August 1992.

San Emidio Power Plant

San Emidio Resources, Inc. has filed an application with the Public Service Commission of Nevada, identified as Docket No. 91-9058, for a permit to construct a geothermal power plant and its associated facilities. The project site is in Washoe County in the San Emidio Desert Basin, about 10 miles south of Gerlach, Nevada. Included in the application is an Environmental Assessment of the utility facility. The application was filed pursuant to the Utility Environmental Protection Act.



Temperature-gradient well being drilled by San Emidio Resources, Inc. in the San Emidio Desert Basin, along the fault line that controls the San Emidio geothermal resource. Photo by S. Hodgson.

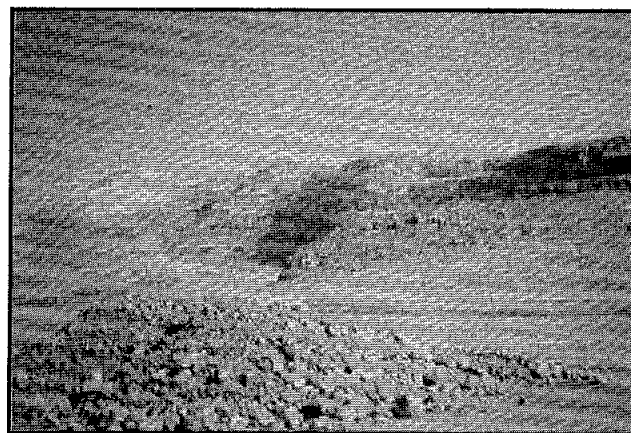
Wind Mountain Mine

The Wind Mountain Mine is operated by Amax Gold Inc. in Washoe County, Nevada, about 106 kilometers north of Reno. According to a paper written by John D. Wood for Amax, in June 1988 the company had defined a 13.7 million metric ton orebody averaging 0.72g Au/t

and 11.4g Ag/t. Widespread hydrothermal alteration and rock alteration products (opal, illite, montmorillonite, kaolinite, and alunite) at the mine indicate the deposit was formed in a near-surface environment from a hot-spring type geothermal system.

Mining is by conventional open-pit methods using blast-hole drills. The crushed ore is taken to the leach pad, where the cyanide heap-leaching process is undertaken to recover the silver and gold. Water from a geothermal well drilled at the open-pit mine is used directly as process water.

The mine will be decommissioned in early 1992. At this time the ore heaps will be rinsed until the effluent measures no more than 2 ppm of cyanide. Some chemicals may be needed for this process.



Wind Mountain Mine. Photo by S. Hodgson.

The Dixie Valley Geothermal Project

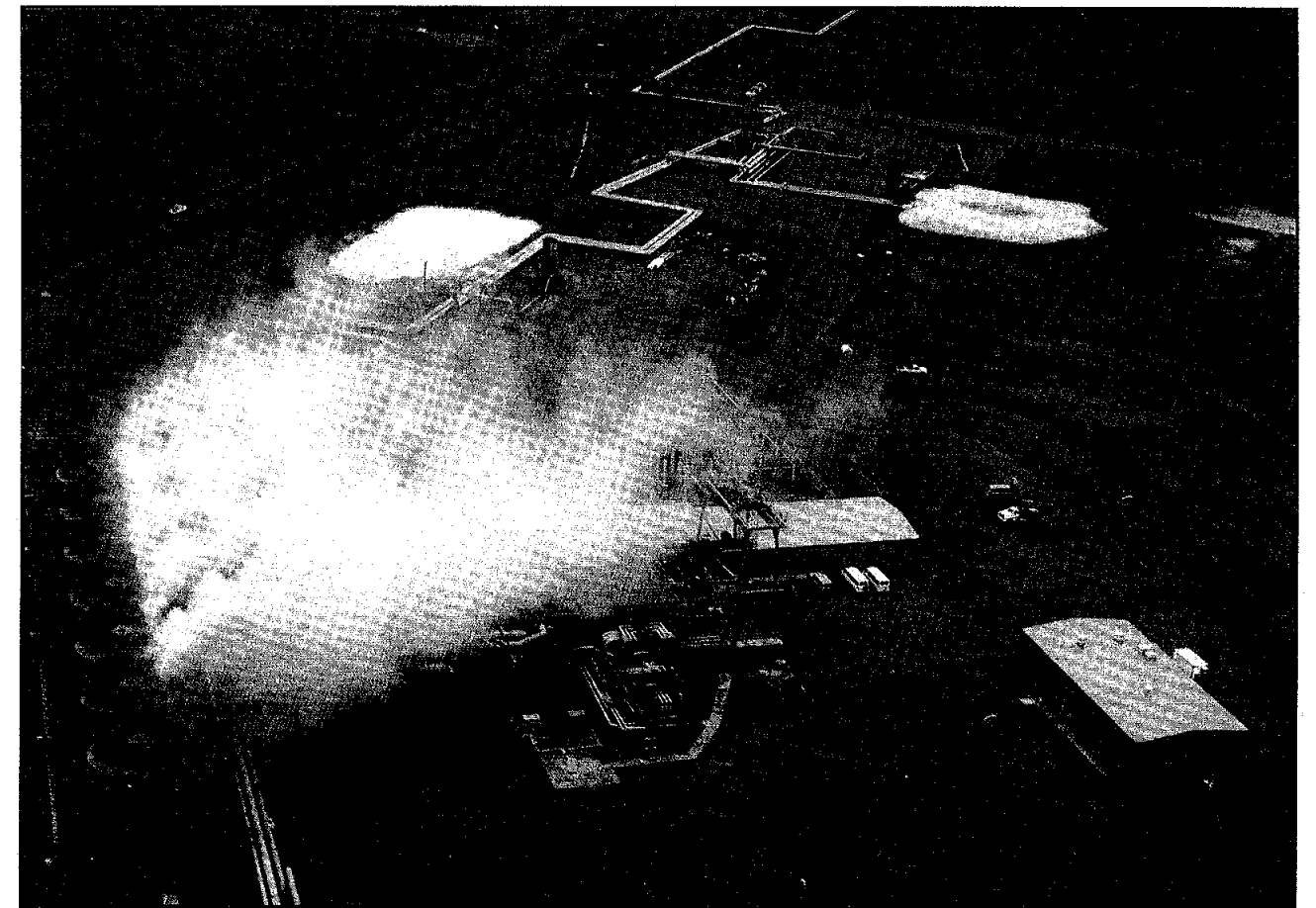
The Dixie Valley geothermal project, owned and operated by Oxbow Geothermal Corporation, is in Churchill County, Nevada, about 120 miles northeast of Reno. The project includes a geothermal power plant with a maximum production rate of 67.6 megawatts, gross, the largest geothermal power plant in Nevada.

In 1974, Sunoco Energy Development Company (SUNEDCO) began an exploration program in Dixie Valley. The program included geophysical surveys and temperature-gradient wells. In 1978, the discovery well for Dixie Valley Geothermal field was drilled and completed by SUNEDCO in fractured basalt with a reported temperature of 218°C, according to the "Geothermal Resources of Nevada" map. SUNEDCO drilled several additional exploratory wells in the late 1970s and early 1980s. Trans-Pacific drilled 2 productive wells in 1983 and obtained power sales contracts with Southern California Edison. In 1985, Oxbow Geothermal Corporation purchased the leases, wells, and contracts from SUNEDCO and Trans-Pacific. Oxbow Geothermal is

one of the group of Oxbow companies owned privately by William Koch of West Palm Beach, Florida.

In the next few years, additional wells were drilled and tested by Oxbow, and the power plant and a 210-mile transmission line were permitted and constructed. The power plant came on line in July 1988 when 6 production wells and 4 injection wells were in service. Since 1988, 3 additional production wells and 2 injection wells have been drilled. Currently, 9 production wells supply about 5.25 million pounds per hour of 480°F fluid to the power plant, and 8 injection wells are used to return about 8,000 gallons per minute of water to the reservoir.

The Dixie Valley power plant may be the world's largest single-unit, dual-flash geothermal power plant. It includes a Fuji, single-cylinder, mixed-pressure, counter-flow condensing turbine. The high-pressure steam is measured at 90 psia, and the low-pressure steam at 20.8 psia. Temperatures are 162°C for the high-pressure steam and 113°C for the low-pressure steam. Since coming on

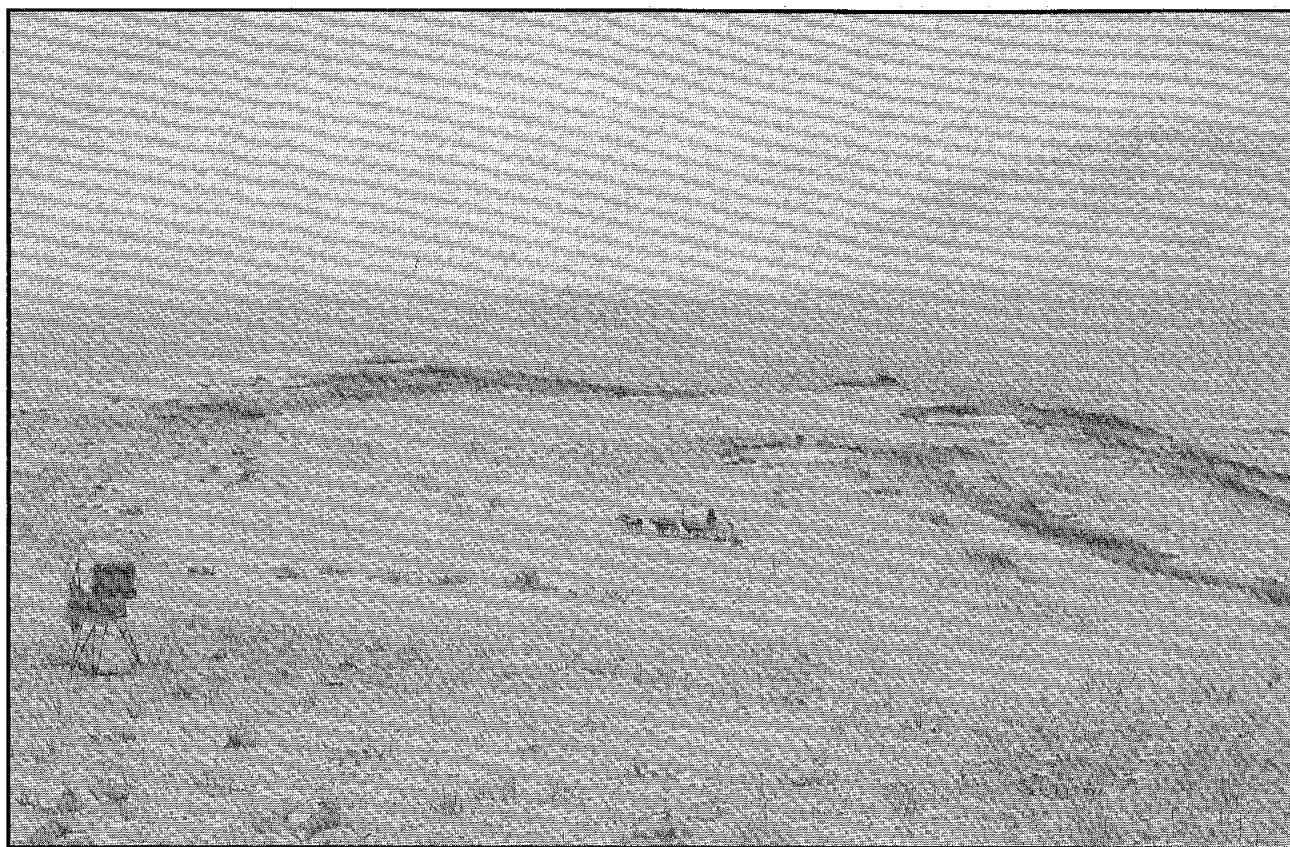


Dixie Valley Geothermal Power Plant. Photo courtesy of Fuji Electric Co., Ltd.

line, the power plant has performed well. The availability factor is in the upper 90 percent range, and the output has been consistently above 62 megawatts, gross.

As a footnote, Oxbow Power Services Inc. owns and

operates the geothermal power plant in Beowawe Geothermal field and the wells connected to the plant. The land itself and the leases at the field are owned by California Energy Company.



Humboldt Hot Springs, probably present-day Dixie Hot Springs in Dixie Valley near the eastern slope of the Stillwater Range, Churchill County, Nevada. Drawn by Jim Spriggs from a photo by Timothy H. O'Sullivan, taken during the King survey, probably in 1868. O'Sullivan's equipment wagon and photographic outfit are shown. Photo from the U.S. Geological Survey and reprinted in *Western Views and Eastern Visions* by Eugene Ostroff, Curator of Photography, National Museum of American History.

Sierra Pacific Power Company, Geothermal Fact Sheet

Sierra Pacific Power Company's interest in geothermal power began in the 1960s. This interest led the company to propose to the Public Service Commission of Nevada several pilot geothermal contracts in the early 1980s, two of which resulted in geothermal plants that provide Sierra Pacific with considerable information the company has used to determine the viability of this resource as a supply for its customers. With the advent of the Public Utility Regulatory Policies Act (PURPA), electric utilities such as Sierra Pacific became obligated to purchase power generated by small power producers and cogeneration facilities, called "qualifying facilities" or QFs.

Sierra Pacific has found that geothermal producers, because of their smaller capacities, are often a good match to

Sierra Pacific's yearly resource needs. To meet its future capacity needs, Sierra Pacific has signed 11 long-term purchase contracts in the last 3 years. Eight of these are with geothermal QFs.

In 1990, Sierra Pacific Power's internal generating capacity was 835 megawatts. An additional 46 megawatts of capacity was purchased from geothermal QFs. Of 6,259,354 megawatt hours of energy demand, 400,245 megawatt hours were purchased from 15 QFs. The majority of the QF projects from which Sierra Pacific purchases power are geothermal, with the remainder being wind, hydro, and woodwaste. Some 312,489 megawatt hours were purchased from 10 geothermal QFs in 1990. In August 1991, an additional 13 megawatts of

capacity was added from a geothermal producer at Soda Lake.

Sierra Pacific wheels about 90,000 megawatt hours of electricity per year for geothermal QFs. An additional 50 megawatts of electricity produced by a geothermal QF with no interconnection to Sierra Pacific is sold out-of-state.

In reviewing recent proposals to provide long-term energy supplies, Sierra Pacific negotiated contracts for purchased power that offered the "best value" electricity to match the company's need. As a result of Sierra Pacific

Power's 1990 Request for Proposals, seven contracts to provide a total of 107 megawatts of power were signed. The power is expected to be on line between 1992 and 1995. Six of the seven contracts are for geothermal QFs, supplying 82 megawatts of the 107 megawatts.

In 1992, Sierra Pacific anticipates purchasing to 99 megawatts of capacity from geothermal QFs, or 507,000 megawatt hours, out of a total demand of 6,403,500. In 1996, the expected purchases from geothermal QFs are projected to increase to 162 megawatts, or 1,203,000 megawatt hours out of a total demand of 7,041,000 megawatt hours.

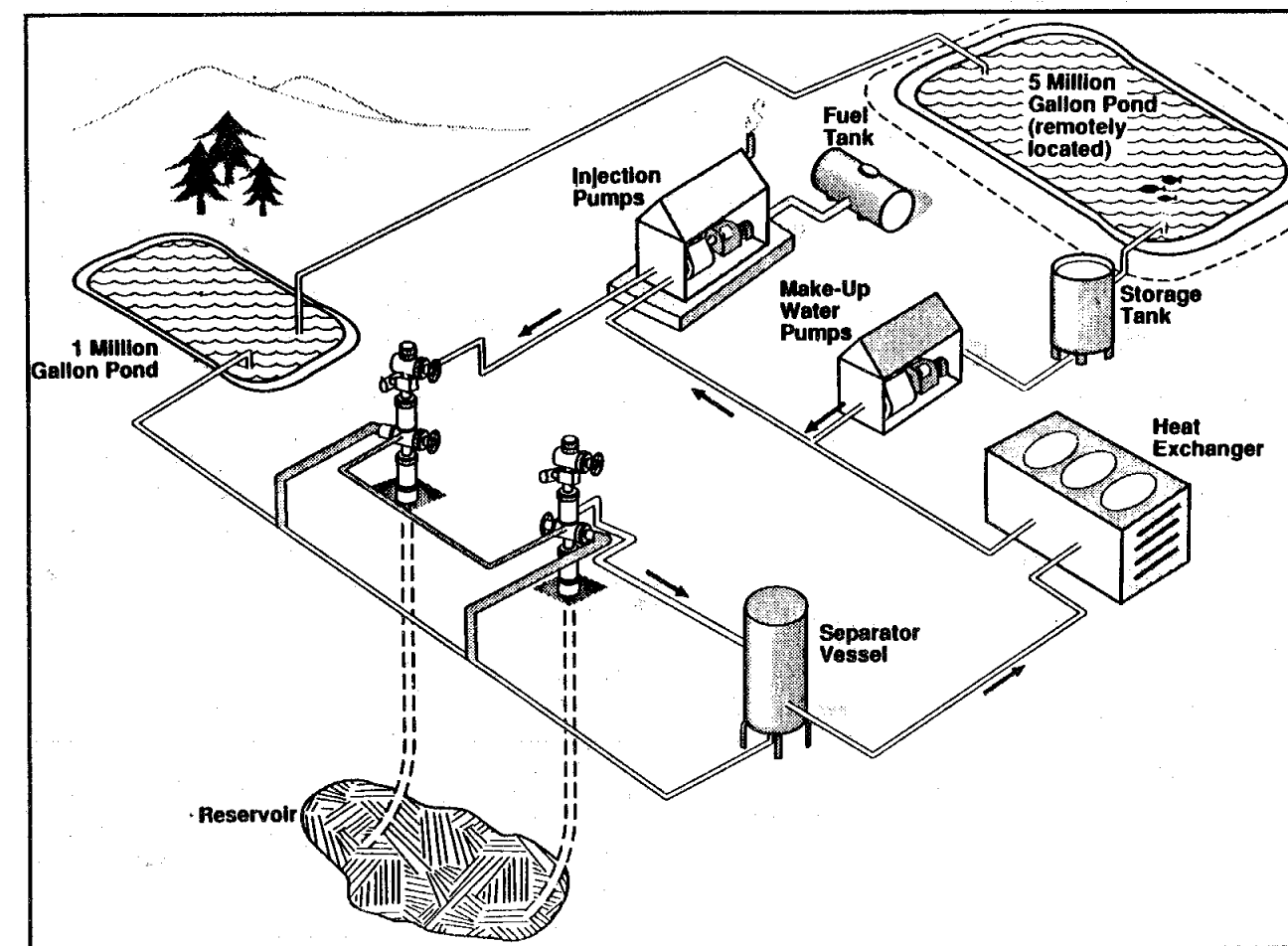
NEW MEXICO

Los Alamos Hot Dry Rock Update

The design, construction, and installation of the surface plant is nearing completion for the Phase II system at Fenton Hill in Los Alamos, New Mexico. Basic process-design work is completed, and all major components of

Excerpted from the Annual Report for FY 1990 for the Hot Dry Rock Geothermal Energy Development Program.

the system have been procured except the gas/particle separator. Design problems for the separator have been resolved, and purchase during the first half of FY91 is anticipated. Installation of the surface plant is well underway. The system will be completed and ready for operation by the end of FY91 under the current schedule.



The Fenton Hill Phase II surface plant.

What happens next will depend upon the program funding level, with long-term flow testing beginning as soon as possible.

Field tests in the deep, hot, Phase II reservoir at Fenton Hill have shown that it should be possible to operate hot-dry-rock reservoirs with water losses of 1 to 3 percent or less. These test results contrast sharply with the significant water losses seen by Japanese and British scientists working in shallower, cooler, hot-dry-rock reservoirs. Calculations and modeling based on field data have shown that water consumption declines with the log of time in a manner related to water storage in the reservoir. This work may be crucial in proving that hot-dry-rock is an economically viable means for producing energy, even in areas with water in short supply.

We are better able to conduct, analyze, and understand the long-term flow test of Phase II. For example, an engineering model was developed to predict and explain water consumption in hot-dry-rock reservoirs under pressure; collecting and processing seismic information was more fully automated; and the detection limits for reactive tracers were lowered below 1 part per billion.

Water-rights acquisition activities, site clean-up, and improvements in the 1-million gallon storage pond at Fenton Hill have ensured adequate water to carry out a vigorous testing program in a safe and environmentally sound manner. The 1-million gallon pond was recontoured and lined with a multi-layered plastic barrier.

HAWAII

Geothermal Management Plan

Introduction

A 31-hour blowout at Puna Geothermal Venture's (PGV) KS-8 well near Pahoa occurred on June 12, 13, and 14, 1991. The blowout resulted in the evacuation of some nearby families and in numerous complaints of acute health symptoms from the released gases, the noise, and odor nuisance. The blowout also raised a question as to whether or not the geothermal resource in the Kilauea East Rift Zone can be developed safely and without impacting the health of the nearby residents.

On June 14, the Hawaii County Planning Director suspended all drilling activities at PGV's present site. On June 16, immediately after the well was temporarily secured, State of Hawaii and County of Hawaii officials met to outline a strategy which has since been followed.

Investigations

With joint state-county participation, three concurrent investigations of the blowout were undertaken: A review of KS-8 well drilling equipment and procedures (Element I) conducted by four mainland government and private drilling, geologic, and regulatory experts; a review of the emergency response procedures (Element II) conducted

by the Department of Health and Hawaii County Civil Defense; and a review of air and noise mitigation, and monitoring and enforcement (Element III) conducted by two mainland government and private engineering and regulatory experts. The final reports from the three groups were made available to the state and county on July 24, 1991. A community meeting was held the following day at which time the reports were presented to the public by the investigative teams. Based on the experts' recommendations, the County of Hawaii extended the suspension order to include all further activities at the PGV site exclusive of efforts to fully control KS-8.

On July 30, 1991, the Mayor proclaimed a State of Emergency at PGV's well site because there were subsurface symptoms, confirmed by the state and county investigators, that the KS-8 well was not fully under control. This proclamation allowed the cognizant agencies to expeditiously approve the drilling of a nearby water well by the developer for the purpose of quenching and finally killing the KS-8 well.

A conclusion of the investigations was that the blowout did not occur as a result of "unusual or unmanageable subsurface geologic or hydrologic conditions." All three of the investigative reports recommended specific developer and government actions to minimize the potential for future adverse impacts on health and safety of personnel involved in the project and residents of nearby communities.

Excerpted from the plan prepared by the State of Hawaii and the County of Hawaii Geothermal Task Force, October 1991.

EIS for Hawaiian Geothermal Development

As part of the National Environmental Policy Act (NEPA) of 1969 planning process, the Department of Energy (DOE) intends to prepare an Environmental Impact Statement (EIS) for the development of a geothermal well field on the island of Hawaii, State of Hawaii; the subsequent construction and production of up to 500 megawatts of power; and the transmission of this power by overland and submarine cable to Oahu, and possibly, to one or more of the other Hawaiian Islands.

The EIS will evaluate the significance of environmental impacts associated with the proposed Hawaii Geothermal Project (HGP), the culmination of research and development efforts begun in the mid-1970s to explore the feasibility of using Hawaii's indigenous geothermal resource as an alternative energy source for the production of electricity. Currently, the State of Hawaii uses petroleum for about 90 percent of its power production, the highest usage among all 50 states.

The four-phase HGP, as defined by the State of Hawaii, consists of (1) exploration and testing of the geothermal resource beneath the slopes of the active Kilauea volcano on the island of Hawaii, (2) demonstration of deep-water cable technology in the Alenuihaha Channel between the Big Island and Maui, (3) verification and characterization of the geothermal resource identified in Phase 1, and (4) construction of commercial geothermal power production facilities on the Big Island, with the potential for overland and submarine transmission of electricity from the Big Island to Oahu and other islands. Phases 1 and 2 have been completed; the DOE prepared appropriate NEPA documentation for separate federal actions related to early research projects. Future activities under Phases 3 and 4 will be the subject of this EIS.

The DOE has issued an Advance Notice of Intent (NOI) to encourage early public involvement in the NEPA process and to solicit comments on the proposed scope and content of the EIS. Comments are expected regarding potential sites for geothermal development; alternatives to geothermal power; and environmental issues, such as land use, habitat disturbance, effects on cultural resources, air quality degradation, and impacts to the terrestrial and marine environment. The precise location of sites for geothermal power plants will not be known until the state completes currently planned resource verification and characterization activities on the Big Island.

Excerpted from an Advance Notice of Intent to Prepare an Environmental Impact Statement for the Hawaii Geothermal Project, Phases 3 and 4: Resource Verification and Characterization, and Construction and Operation of Geothermal Power Plants. The document was signed in August 1991 by Peter N. Brush, Acting Assistant Secretary, Environment, Safety and Health, U.S. Dept. of Energy.

Land areas having the greatest potential for development, as defined by past research and exploration, are located within three designated Geothermal Resource Subzones on 22,000 acres in the lower and middle Kilauea East Rift Zone in the Puna District on the Big Island.

The DOE will publish an NOI in the fall of 1991 to solicit further public input and to announce a schedule for public scoping meetings to be held prior to the completion of an EIS Implementation Plan and initiation of EIS preparation.

Written comments, questions, and requests for general information on the Hawaiian Geothermal Project should be directed to

Dr. Lloyd Lewis, CE-121
Office of Conservation and Renewable Energy
U.S. Department of Energy
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Telephone: (202) 586-6263

General information on the procedures followed by the DOE in complying with the requirements of NEPA may be obtained from

Ms. Carol Borgstrom, Director
Office of NEPA Oversight (EH-25)
U.S. Department of Energy
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Telephone: (202) 586-4600

Geothermal exploration began in Hawaii in 1972 with funding from the National Science Foundation (NSF). A potential geothermal resource site was identified on the Kilauea East Rift on the Big Island. Subsequent exploratory drilling (also funded by NSF) between December 1975 and April 1976 resulted in a productive geothermal well at a depth of about 6,000 feet. In 1976, the Energy Research and Development Administration (ERDA), a predecessor to the DOE, funded testing of the geothermal well, which was named HGP-A. Subsequently, the DOE was established, and it funded the development of a 3-megawatt demonstration power plant at the HGP-A site. In 1986, the HGP-A well and power plant were transferred by the DOE to the State of Hawaii to be used for further research. The state has referred to this early exploration and testing of the geothermal resource as Phase 1 of the HGP.

The DOE also provided funds for the Hawaii Deep Water Cable Program initiated in 1981, and referred to by the

State of Hawaii as Phase 2 of the HGP. The goal of the program was to determine the technical and economic feasibility of constructing and operating a deepwater, submarine power-transmission cable that would link the islands of Hawaii and Oahu and would operate for a 30-year period. This project was completed in 1991 and proved the feasibility of a deepwater transmission cable. In all, over an 11-year period, the DOE has provided about \$33 million for geothermal and cable research in Hawaii.

In April 1989, the State of Hawaii requested additional federal funding for what it defined as Phase 3 of the HGP, called Resource Verification and Characterization. Congress subsequently appropriated \$5 million for use in Phase 3. Because Phase 3 work is by nature "research" rather than development or project construction, Congress indicated to the Secretary of Energy that it is not a "major federal action" under NEPA and would not typically require an EIS. However, because the project is highly visible, somewhat controversial, and involves a particularly sensitive environmental resource in Hawaii, Congress directed that "...the Secretary of Energy shall use such sums as are necessary from amounts previously provided to the State of Hawaii for geothermal resource verification and characterization to conduct the necessary environmental assessments and/or environmental impact statement (EIS) for the geothermal initiative to proceed." In addition to the Congressional directive, the U.S. District Court of Hawaii rendered a judgment, in response to litigation filed by several environmental groups, that requires the federal government to prepare an EIS for Phases 3 and 4 prior to disbursement of additional funds to the state. The Advance NOI by the DOE is being issued to begin the NEPA process for Phases 3 and 4.

The State of Hawaii considers the unknown extent of the geothermal resource as the primary obstacle to private investment and commercial development of geothermal power production facilities and cable system. Both state and private industry experts estimate that at least 25 commercial-scale exploratory wells will need to be drilled to verify the generating potential of the resource. Phase 3 activities would include well drilling, logging cores from holes, measuring temperatures, collecting and analyzing geothermal fluid samples, and taking downhole geophysical and geochemical measurements.

Once the geothermal resource has been characterized, the construction of 10 to 20 separate geothermal power

plants from 25 to 30 megawatts, net, each, is forecast by the State of Hawaii. The actual number of geothermal plants will depend on the extent of the resource defined in Phase 3. The exact location of the plants will not be known until Phase 3 is completed and facility design and layout are underway. Based on current knowledge of the resource, the State of Hawaii estimates a total of about 125 production wells and 30 injection wells may be needed. The plants would most likely be connected by a network of roads, plumbing, and overland transmission lines in the East Rift area. Overland and underwater transmission lines (300 kV AC or DC) would be constructed to distribute power across the Big Island and to the other Hawaiian Islands, particularly Oahu.

The current timetable for Phases 3 and 4 of the HGP calls for the State of Hawaii to initiate permitting and financing in 1991, with resource verification to be conducted after NEPA documentation is completed. Procurement and installation of power plants by the State of Hawaii and other nonfederal entities is anticipated to begin in the 1994-1996 period, with initial transmission to Oahu no sooner than 1995. The state hopes to have 500 megawatts of geothermal power on line by 2005.

The EIS format and content will correspond to that which is recommended in the Council on Environmental Quality regulations and DOE guidelines. Chapter 1 of the EIS will discuss the purpose of and need for the action, provide background on the proposed project, and define the scope of the EIS. In Chapter 2, the activities to be carried out as part of the proposed action and alternative actions will be described, the project location will be defined, and a tabular summary comparison of impacts of alternatives will be presented. Chapter 3 will describe the environment that could be affected by the proposed action. In Chapter 4, the environmental consequences of alternatives will be discussed.

DOE has conducted a preliminary screening of environmental issues that could arise as a result of the HGP. The EIS will include, as appropriate, consideration of the following categories of impacts at alternative sites for power plant construction and operation and for alternative cable routings over land and in the marine waters of the Hawaiian Islands: land use, air quality, water resources, ecological resources, geological resources, noise, health and safety, socio-economics, and scenic and visual resources.

WORLDWIDE

ICELAND

Geologic Saga of.....

ICELAND: ISLAND OF VOLCANOES AND GLACIERS

Iceland--a land of sparse vegetation and with an atmosphere almost unpolluted by man--includes volcanic cones, lava flows and lava cliffs, geysers and other manifestations of extensive geothermal resources, high interior uninhabited deserts, glaciers, glacial outwash plains, waterfalls, fjords, and grabens.

The total area of Iceland is 102,999 square kilometers (39,768 square miles): 1 percent cultivated, 20 percent grazing, 11 percent covered by glaciers, 11 percent lava flows, 3 percent lakes, 4 percent sand. Much of the other land (50 percent) is high desert plateau.

The terrain varies in elevation from sea level to 2119 m (6,952 feet). The population of the country is about 255,000 with about 87,000 of these people living in Reykjavik, the capitol city. Icelanders have a long history of success in coping with volcanic eruptions of ash and lava, with glacial debris floods, and with the severe climatic conditions just south of the 66th parallel in the vicinity of the Arctic Circle.

Like California, Iceland is situated on two tectonic plates. The mid-oceanic ridge diagonally bisects the island, with the northwestern portion on the North American plate spreading westward and the southeastern portion on the Eurasian plate spreading eastward. The ridge occurs as an ocean-floor mountain range and extends in a north-south direction from Iceland for 65,000 kilometers beneath the Atlantic Ocean. The two plates are separating along the spreading ridge at an estimated rate of a few centimeters per year. The island of Iceland has been built up by crustal material issuing from the spreading center as it forms a rift valley on the ocean floor ridge.

In Iceland, the surface evidence of the mid-oceanic ridge occurs as a volcanic zone that begins on the southwestern edge of the Reykjanes Peninsula and trends generally northeastward to the northern coast. This corridor is called the neo-volcanic zone, and is marked by volcanic peaks (Mount Hekla, Mount Krafla, and others), fault scarps, lava flows, volcanic cones near Lake Myvatn, and lava cliffs to the northeast near Melrakannes. The oldest age determined for Icelandic lava is 16 million years.

by Mary C. Woods, Geologist
Adapted, with permission, from California Geology,
February 1986

Volcanic activity of the mid-Atlantic spreading zone has been manifested in the Westman Islands, which consist of 15 volcanic islands off the southern coast of Iceland. Surtsey is one of these islands. In November 1963, this submarine volcanic vent began erupting basalt lava and gases, building up a cone that rose above sea level. The lava buildup continued until early June 1967, ending when the cone was 170 meters (560 feet) above sea level.

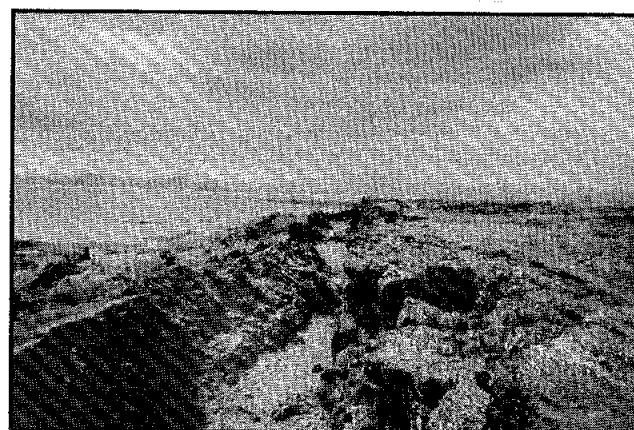
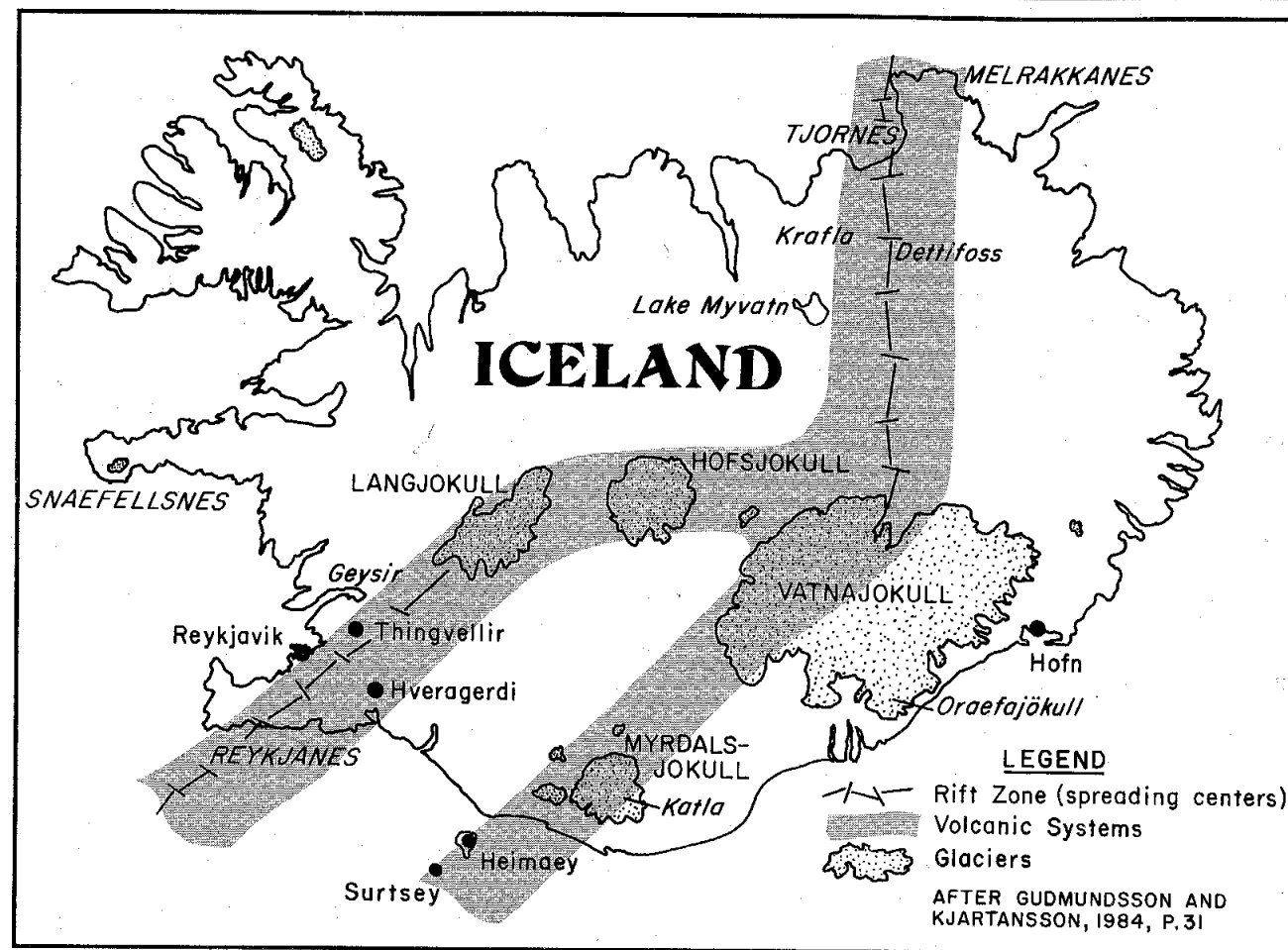
In 1973, further activity along the mid-oceanic ridge brought forth lava flowing from a fissure on the eastern side of Haimaey, the only inhabited island in the Westman group. This activity has added more than 1.5 kilometers of new land surface to the 4-square-mile island.



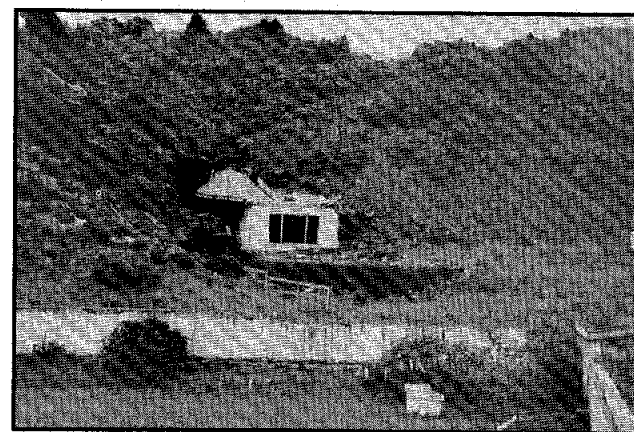
Detifoss, the largest waterfall in Europe. Photos by M. Woods, except as noted.



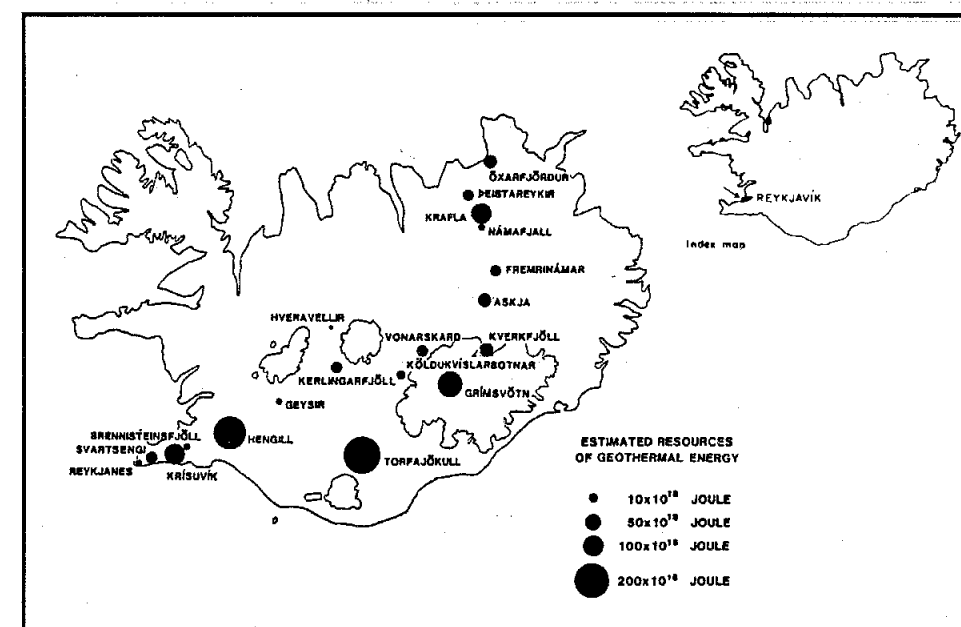
Tjörnes. The Plio-Pleistocene geological history and climatic changes in Iceland are recorded in the thick sediments of the sea cliffs on Tjörnes Peninsula.



An ancient portion of the mid-oceanic spreading ridge. The lava flows are separated by a graben created by dynamic spreading forces. The Viking settlers selected this site for their open-air parliament in 930 A.D. The parliament (called Althing) was held for about three weeks each year in mid-summer. This area, and the natural amphitheater formed by lava flows, is called Thingvellir. The Icelandic parliament met here annually until the mid-1700s.

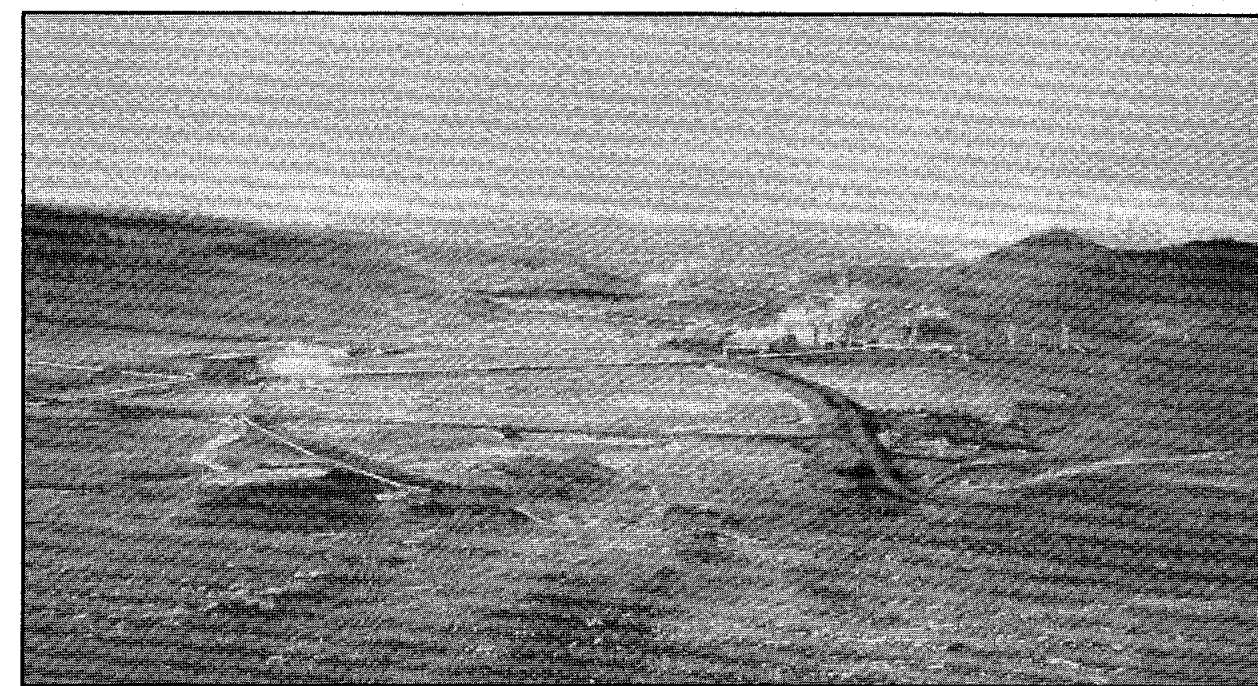


Haimaey, Westman Islands. Houses were buried by lava and tephra when a fissure erupted in January 1973 on the island of Haimaey, a fishing center off the southern coast of Iceland. Photo by E. Joan Baldwin.



Major geothermal steam fields and their estimated resources of thermal energy. Reprinted from Reseaux & Chaleur, no. 11, 1991.

During the period of eruption starting in January 1973, more than 300 homes on Haimaey were covered with lava, scoria, and ash (tephra). No lives were lost as the area was evacuated. Later, many homes were dug out of ash that was 50 meters thick in some places, but the buildings buried in lava could not be saved.



The geothermal power plant near Mount Krafla.

Geothermal Activity

The island country of Iceland has many geothermal sites, another testimony to the hot magma along the spreading ridge that lies just below the land surface. In the City of Reykjavik, hot water from natural hot springs and from drilled wells at Warm Springs Valley is used to heat homes, buildings, outdoor swimming pools where residents swim during the entire year in comfort, and numerous greenhouses.

According to the magazine *Reseaux & Chaleur*, Reykjavik District Heating

Services (Hitaveita Reykjavíkur) was established in 1930. The company serves about 140,000 inhabitants of Iceland, or 58 percent of the nation. The Hitaveita uses resources from four low-temperature fields and one high-temperature field. The geothermal water from the low-temperature fields is used directly in radiators and as tap water. The geothermal water from the high-temperature field is used to heat fresh water.

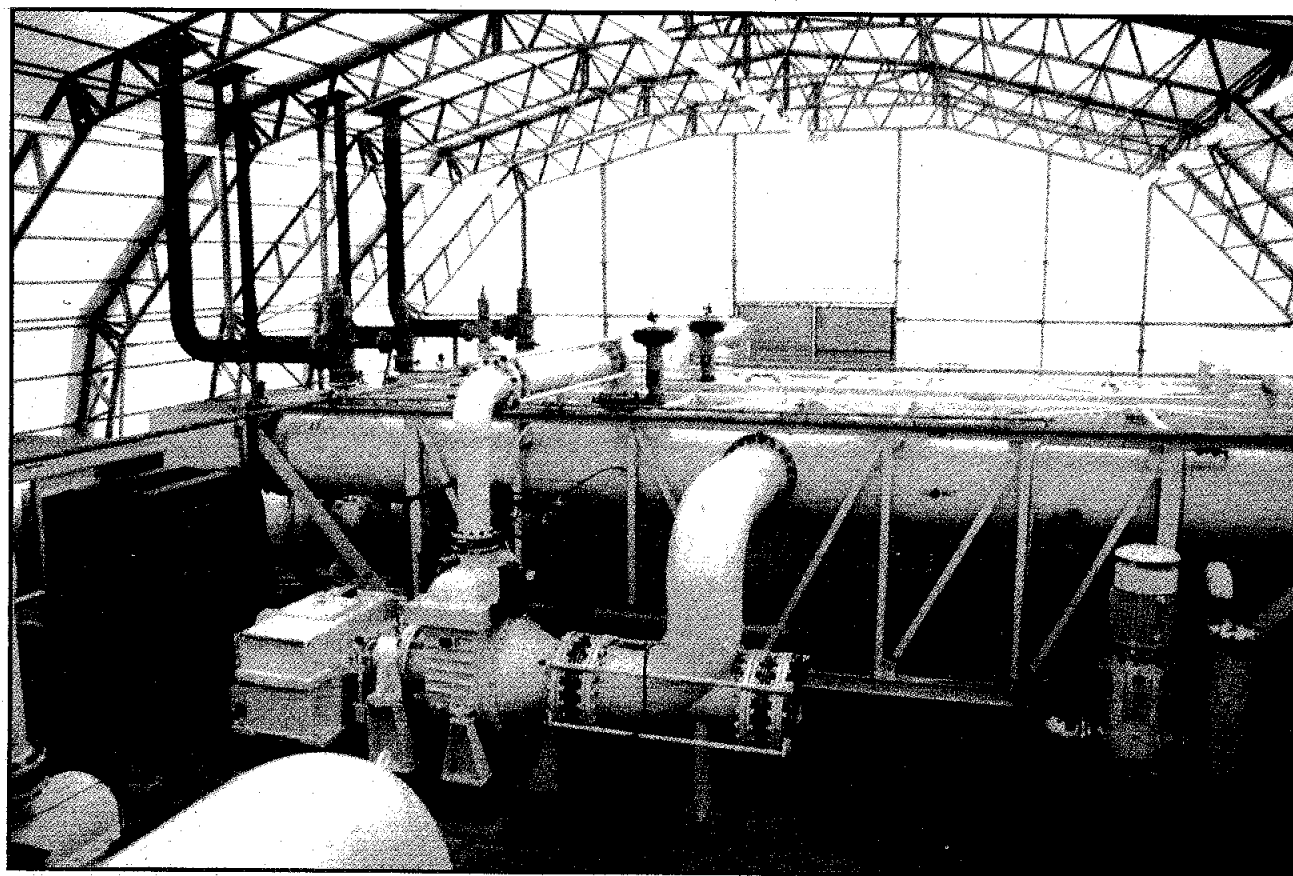
Geothermal energy from the Hitaveita is mainly used for space heating. The cost of the energy is 1.5 US cents/kWh. The nearest alternative energy options are electricity and fossil fuels. The cost of heat from those sources is over 5 US cents/kWh.

At Hveragerdi, farmers use geothermal energy for heating vast greenhouses where fruit, vegetables, and flowers are grown.

In addition, Icelanders use low-temperature geothermal resources as industrial process heat, for air conditioning, agricultural drying, fish and animal farming, and snow melting.

At the 30-megawatt geothermal power plant near Mount Krafla in the eastern area, the hot steam is used to produce electrical energy.

Three other geothermal power plants (two at Svartsengi and one at Námafjall) brought the 1989 total installed capacity to 44.6 megawatts. In addition, plants to produce 50.2 megawatts were under construction or planned. (These statistics are reprinted from "Iceland Country Update" by G. Palmason and A. Gudmundsson, from the 1990 *International Symposium on Geothermal Energy, Part I*, published by the Geothermal Resources Council.)



OESI Power Corporation, binary installation at the Svartsengi Geothermal Power Plant, Reykjanes Peninsula, Iceland. Here, three OESI energy-converter modules produce an output of about 3.9 megawatts, gross. The installation, commissioned in mid-1989, is the first stage for a 12-megawatt power plant.

The three OESI units generate power from back-pressure steam that measures 217°F (103°C). By condensing the steam, the units help to reduce pollution and outdoor corrosion on the power plant. The heat rejected from the water-cooled condenser is used to preheat the district heating water.

The three power plant units installed at Svartsengi increase the electrical capacity of the existing power plant from about 8 to 11.8 megawatts. From 1.4 to 1.7 megawatts of the total generated power is used in the plant, itself. The remaining 10 megawatts go to the local electrical grid.

The power plant is owned and operated by Sudurnes Regional Heating Corporation, the sole distributor for electrical and heat energy on the Reykjanes Peninsula.

CANADA

Meager Creek Update

Canadian Crew Energy Corporation will resubmit a proposal to supply electrical power from its Meager Creek Geothermal Project to B.C. Hydro and Power Authority. Crew was the only company to respond to B.C. Hydro's 1990 Request for Proposals to Supply Power from Geothermal Resources. The company's revised proposal will be based on preliminary turnkey plans for the construction of the proposed pilot plant it received from three Canadian engineering and construction companies.

Canadian Crew Energy is presently developing Canada's first geothermal energy project at Meager Creek, 100 miles north of Vancouver, B.C. The project represents development of an economically viable, renewable source of alternate energy that will provide major benefits to the Province of British Columbia. The generating potential is estimated at 260 megawatts.

MONTSERRAT

Montserrat

The geothermal potential of the island of Montserrat has been evaluated, according to the *Export Bulletin* of the California Energy Commission. "Prospects look excel-

lent for a 2- to 5-megawatt geothermal power plant in the near future on the island." Montserrat is a 32-square mile island in the Leeward Islands of the Lesser Antilles.

MEXICO

A Geothermally Sustained City for Mexicali, Baja California

The Municipality of Mexicali, in the Sonoran Desert, faces the arrival of large concentrations of immigrants from local and southern rural areas in Mexico. Agricultural land is lost to urban sprawl, and the municipal budget is strained by demands for infrastructural development.

Dr. Marco Vilchis is planning a geothermal community he calls an urban cell for an area away from Mexicali, but near the California-Mexican border. He is paying special attention to areas between East Mesa Geothermal field and Cerro Prieto Geothermal field. Developing the urban cell will lessen the strain on the Municipality of

Mexicali and increase the quality of life for many people.

The urban cell will include its own public services, government, industry, housing, commerce, education, and energy infrastructure. Eventually, it will become part of a regional, urban cell system.

Dr. Vilchis plans to use geothermal resources of 100° C to 140° C at 2 to 4 bars pressure, for heating and cooling, electrical generation, and industrial direct uses. Heat would be extracted from 4 geothermal wells and moved through an absorption cooling system into cold- and hot-water distribution networks.

Excerpted from a paper by M. C. Marco A. Vilchis C., Facultad de Arquitectura, Universidad Autónoma de Baja California, P. O. Box 16287, 111 1st St., Calexico, Ca. 92231.

History of Geothermal Development in Mexico

Geothermal development in Mexico was begun in the early 1950s by the Comisión Federal de Electricidad (CFE) that, by Mexican law, is the public utility in charge of electrical energy service. Data gathered at this time by the CFE from known thermal areas throughout the country indicated there were more than 60 potential sites for geothermal development.

Pathé Geothermal field, in the State of Hidalgo, was developed first, and 12 wells were drilled there. Although the reservoir was determined to be rather limited, Mexico's first geothermal power plant, with 600 kilowatts of capacity, was built in the field and went on line in 1959. (This was one year ahead of the first modern geothermal plant in the United States at The Geysers Geothermal field, although a 35-kilowatt geothermal power plant had been operated at The Geysers in the late 1920s and early 1930s.)

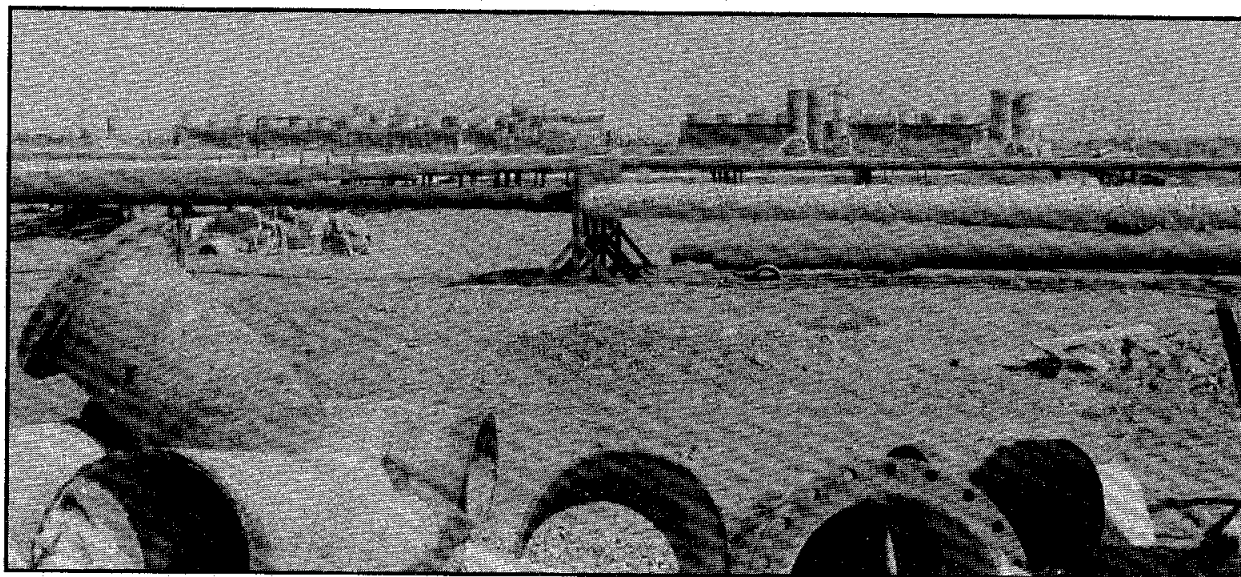
The success at Pathé caused exploration to be contemplated for Los Negritos and Ixtlán de los Hervores Geothermal fields, in the State of Michoacán in the neovolcanic belt crossing central Mexico, and at Cerro Prieto Geothermal field in Baja California, just south of the U.S. border. Of these three, Cerro Prieto was selected by CFE for immediate development because of its greater potential.

Deep exploratory drilling started in Cerro Prieto Geothermal field in 1960 and 1961. The first two turbo-generators of 37.5 megawatts each went on line in the

field in 1973 (almost a decade before the first geothermal power plant went on line in the Imperial Valley, just across the border in California).

During the 1970s and 1980s, CFE continued exploring for geothermal resources throughout Mexico, identifying among other areas, the fields of Los Azufres in the State of Michoacán, La Primavera in the State of Jalisco, and Los Humeros in the State of Puebla.

Over the years, the CFE has formed a very well known team of geothermal scientists and engineers, who have installed 725 megawatts of electrical power generated from geothermal resources (620 megawatts in Cerro Prieto, 90 megawatts in Los Azufres, and 15 megawatts in Los Humeros). Another 28 megawatts are under construction (15 in Los Humeros and 13 in Los Azufres, including 3 megawatts in a binary-cycle plant); and 120 megawatts are being contracted out, 40 megawatts each at Los Azufres, Cerro Prieto, and Los Humeros. Another 170 megawatts are under study (40 megawatts at Cerro Prieto, 60 megawatts at Los Azufres, and 70 megawatts at La Primavera, near Guadalajara). The CFE also has 5 geothermal areas under exploration, 2 in Baja California and 3 in Central Mexico. According to the CFE, by the end of 1993 Mexico will have an installed capacity of 873 megawatts from geothermal development. The CFE has made recent, significant efforts to increase efficiencies and reduce costs in its geothermal operations. For example, fluid production at Cerro Prieto has been increased, so there is now sufficient steam available to supply the 620



View of Cerro Prieto Geothermal field. Photo by S. Hodgson.

megawatts of installed capacity. The CFE has reduced significantly the steam losses at the surface at Cerro Prieto, attaining a plant factor of about 95 percent. Because of these efforts, the cost per kilowatt hour at Cerro Prieto has dropped by about 30 percent.

In October 1991, in recognition of Mexico's pioneer achievements in geothermal development through the

efforts of the CFE, and the continued high level of geothermal activity in the country, the Geothermal Resources Council (GRC) awarded its Pioneer Award to the Comisión Federal de Electricidad. The presentation was made by Marcelo Lippmann at the GRC's annual meeting to Ing. Miguel Ramírez Gutiérrez, who is Gerente de Proyectos Geotermoeléctricos of the CFE.

CENTRAL & SOUTH AMERICA

Costa Rican Geothermal Development

"I support the development of Costa Rica's geothermal resources at Miravalles Geothermal field," Dr. Oscar Arias told me. I had asked him for his position on alternative energy sources. Dr. Arias, a former President of Costa Rica, received the Nobel Peace Prize in 1987.

In his public remarks at a speech presented in Davis,

by Susan Hodgson

California, on October 23, 1991, Dr. Arias said that rich and poor nations alike must share responsibilities for protecting the world's natural resources. However, the richest countries must help the developing countries in this matter. The developing countries must have as their immediate priorities the questions of employment, housing, and health. They cannot afford to give primary emphasis to the preservation of natural environments.

Guatemalan Activity at Zunil

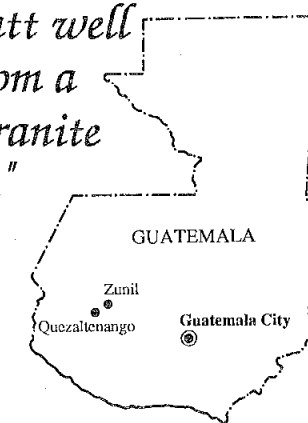
"At Zunil Geothermal field, the expansion spool on a well was cut by the landslide, allowing the well to flow," said Dr. Andrés Caicedo, Executive Coordinator, Unidad de Desarrollo Geotérmico, INDE. "The well explosion theory has been laid to rest," he continued, "because the well cellar was left intact. We have now replaced the well head and cleaned the cellar."

Dr. Caicedo was referring to the landslide that occurred on January 5, 1991, at Guatemala's Zunil Geothermal field, near the city of Quetzaltenango. The slide, which came at the end of the rainy season, damaged a geothermal well, No. ZCQ-4, located beneath the toe of the slide area.

"Now well ZCQ-4 will be used as a backup well. In addition, as the landslide risk at the field remains, the entire area has been mapped for geological risks. Armed with this additional knowledge, we continue with our program at Zunil," Dr. Caicedo said.

by Susan Hodgson

"We have drilled 6 wells in the ZCQ series. Four are production wells (Nos. 3, 4, 5, and 6) and one (No. 2) may be used as an injection well, depending on reservoir engineering results and our ability, from a civil engineering standpoint, to site the injection pipeline. We have placement problems because of the landslide. One well (No. 1) was not productive and has been abandoned."



"We are now drilling the ZD well series," said Dr. Caicedo. Well ZD No. 1 is finished, a 12-megawatt well producing from a fractured granite reservoir. No other well has produced over 4 megawatts. Also,

well ZD No. 1 shows that geothermal production can occur in fractured granite.

"There are two reservoirs penetrated by the ZD series. One is shallow, a series of volcanic rocks 800 to 1000 meters deep. The second, deeper reservoir is in the fractured granite and is 1000 to 2000 meters deep.

"Our power plant will generate 15 megawatts of electricity. We will begin construction in 1993 and complete it in 1994," Dr. Caicedo concluded.

Chilean Geothermal Activity

Chile's National Energy Commission (NEC) is preparing a law to promote the development of geothermal resources. The State Development Corporation (CORFO) will probably end up controlling Chile's best-known geothermal deposits. A number of U.S. companies have expressed an interest in the country's geothermal potential. If the proposed law is passed and exploration begins, Chile could become a significant producer of geothermal energy. The U.S. can be expected to play a dominant role in this area. This is the second time the Aylwin government has demonstrated its willingness to work with foreign governments and the private sector to develop sound resource and tax legislation.

A draft of the proposed NEC law has been reviewed by interested private companies. This draft is now being reviewed by the Ministries of Mines and Public Works, CORFO, and the Presidential Secretariat. The Ministry of Mines is involved because of the potentially conflicting issue of mineral rights and the Ministry of Public Works is being consulted because of its jurisdiction over water rights. CORFO is being considered because it is the only governmental organization that has ever been involved in the attempted development of Chile's geothermal energy resources. Once the approval of these organizations is obtained, the law will be forwarded to President Aylwin before being sent to the Chilean congress.

Chile's best known geothermal deposits are the El Tatio and Puchuliza deposits, in the Second Region east of Calama near the Bolivian border. CORFO drilled 13 exploratory wells in the El Tatio area between 1967 and 1975 with the financial assistance of the United Nations Development Program. The Sociedad Geotérmica del Tatio was subsequently established to develop the deposit. The Sociedad is 51 percent owned by CORFO and 49 percent owned by private interests in Antofagasta, and now controls surface and mineral rights to the deposit. This is the only extensive geothermal exploration ever conducted in Chile.

The proposed geothermal law has a transitory article (reportedly adopted from U.S. geothermal legislation) that will allow those parties that have conducted geothermal explorations and studies to have first claim on the geothermal rights for these deposits. As a result, CORFO will probably end up controlling the El Tatio and Puchuliza deposits, which it will then try to develop in

Excerpted from an unclassified U.S. Department of State Economic/Business Affairs cable.



Osorno volcano and the Petrohué River, in the Chilean lake country. Drawing by Jim Spriggs.

association with private companies.

Chile has a large number of lesser-known geothermal deposits. Some of these were studied at the beginning of the century by public and private organizations. The most studied is the Surire deposit in the First Region near the Bolivian border. Other potentially interesting deposits in northern Chile include the Polloquere, Quitariri, Pampa Lirima, Alitar, and Aguas Calientes deposits. In central and southern Chile, a number of deposits have been developed for medicinal uses and for tourism.

ENERSIS, a 12 percent owner of ENDESA, Chile's largest electricity producer, reportedly is interested in forming a joint-venture with a U.S. company to produce geothermal energy.

The U.S. Department of Energy's Office of Planning and Environment and Office of Energy Conservation and Renewable Energy have given the NEC extensive data on

federal and California geothermal legislation. As a result, Chile has included several aspects of U.S. geothermal legislation in its proposed legislation.

DEVELOPMENT

PUBLIC UTILITIES

CPUC Quantifies Residual-Emission Costs

In June 1991, the California Public Utilities Commission (PUC) implemented a new procedure to quantify the costs of residual power-plant emissions, which are defined as the emissions from power plants after permitted emission requirements are met. The residual emission costs are added to the overall calculations for the costs of new power plants. The change allows power plants with low residual emissions to be more competitive with other types of power plants.

"We are looking at resource plans now for the utilities. These residual emissions values will be used in computing the costs," said Thomas Thompson, Senior Utilities Engineer with the PUC. "For example, if a plant burns fossil fuels, we will internalize the emissions-negated costs. Alternate technologies may have higher private costs but no imputed costs," he added.

Oak trees at The Geysers Geothermal field. Photo by S. Hodgson.



by Susan Hodgson

Costs assigned to residual power-plant emissions by the California Public Utilities Commission.*

Category	Source of numbers	¹ SCE and SDG&E	Source of numbers	¹ PG&E
NO _x	South Coast Air Quality Mgmt. Dist.	\$24,500/Ton	South Coast Air Quality Mgmt. Dist.	\$7,105/Ton
SO _x	South Coast Air Quality Mgmt. Dist.	\$18,300/Ton	Pace University Study	\$4,060/Ton
Particulate Matter	South Coast Air Quality Mgmt. Dist.	\$5,300/Ton	Pace University Study	\$2,380/Ton
Reactive Organic Gases	South Coast Air Quality Mgmt. Dist.	\$17,500/Ton	ER #90 by California Energy Commission	\$3,300/Ton
CO ₂	ER #90 by California Energy Commission	\$26/Ton	ER #90 by California Energy Commission	\$26/Ton

* The numbers are based on the costs of emission control for each utility. The amounts are in 1987 dollars and must be increased about 5 percent each year to reflect 1991 dollars.

¹SCE - Southern California Edison
SDG&E - San Diego Gas and Electric Company
PG&E - Pacific Gas and Electric Company

Nevada PSC Computes Environmental Costs

As explained in the January 1991 issue of the *Geothermal Hot Line*, the Nevada Public Service Commission (PSC), through Final Rule for Docket No. 89-752, gives preference to the cleanest alternative energy sources, such as solar, wind, and geothermal. The regulation calls for utilities to consider environmental costs and benefits to the state when planning new plants or purchasing power from other sources.

As quoted from the docket,

"Environmental costs and economic benefits to the state means costs and benefits inuring to the state from electricity produced for consumption within the state whether the generation source is located within or outside Nevada. To calculate environmental costs of generation from sources outside the state, the cost should be calculated the same as if the electricity were generated in the State of Nevada.

"The environmental costs to the state associated with operating and maintaining a plan for supply or demand must be quantified for air emissions, water, and land use. Environmental costs are those costs, wherever they may occur, which result from harm or risks of harm to the environment after the application of all mitigation measures required by existing environmental regula-



Pyramid Lake, Nevada. Photo by S. Hodgson.

tion or otherwise included in the plan.

"The utility must use the general emission rates and the environmental damage costs established by the Commission unless the utility justifies deviating from these values."

Tables attached to the docket are reprinted here. For the complete document, contact the Nevada Public Service Commission, Dawson Building, 4045 S. Spencer Street, Suite A-44, Las Vegas, Nevada 89158-3920.

VALUATION OF ENVIRONMENTAL COSTS

Pollutant	Valuation (1990 dollars/lb)
Carbon Dioxide (CO ₂)	0.011
Methane (CH ₄)	0.11
Nitrous Oxide (N ₂ O)	2.07
Nitrogen Oxides (NO _x)	3.4 ¹
Sulfur Oxides (SO _x)	0.78
Volatile Organic Compounds (VOC)	0.59 ²
Carbon Monoxide (CO)	
Ambient Air Quality +	0.43 ¹
Global Warming Contribution	0.03
Total	0.46
Total Suspended Particulates/ Particulate Matter (Diam<10MM) TSP/PM ₁₀	2.09 ¹
Hydrogen Sulfide (H ₂ S)	NA ³
NH ₃	0
Water Impact	Site Specific (Determined by Utility)
Land Use	Site Specific (Determined by Utility)

¹The value is applicable to EPA attainment areas. The value for an EPA non-attainment area is equal to or greater than the amount and is likely to be site specific.

²The value for VOC has been adjusted to reflect the State of Nevada's status as attainment for VOC. This value is representative of an actual cost incurred in Nevada to control fugitive VOC emissions from gasoline. The value for an EPA non-attainment area is \$2.75/lb.

³A national marginal control cost for H₂S in attainment areas would be approximately \$0.9 per lb. (OTA, 1989). The valuation of H₂S is in progress at this time.

Electric Facilities Emissions Factors and Water Use

New Utility Facilities	Emissions (lbs/MMBtu in)										Water Use (gals per MMBtu in)
	NOx	SOx	TSP	CO	VOC	CO2	CH4	N2O	H2S	NH3	
Baseload											
1a. Combined Cycle NG	0.3933	0.0006	0.001	0.021	0.033	117	0.0019	0.0078	NA	NA	17.5
b. Combined Cycle NG w/SWI	0.0787	0.0006	0.001	0.021	0.033	117	0.0019	0.0078	NA	NA	17.5
c. Combined Cycle NG w/SWI + SCR	0.0283	0.0006	0.001	0.021	0.033	117	0.0019	0.0078	NA	0.037	17.5
2a. Combined Cycle Distillate Oil	0.5	0.315	0.001	0.018	0.0165	163	0.0016	0.0325	NA	NA	17.5
b. Combined Cycle Distillate Oil w/SCR	0.1	0.315	0.001	0.018	0.0165	163	0.0016	0.0325	NA	0.039	17.5
3a. Combined Cycle Residual Oil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4a. Coal, Pulverized w/scrubbers	0.6	0.6	0.03	0.024	0.004	238	0.0015	0.0325	NA	NA	48.4
5a. Coal, Atmospheric Fluidized Bed	0.5	0.6	0.01	0.15	0.0028	238	0.0015	0.0325	NA	NA	1590
6a. Coal, Integrated Gasification Comb. Cycle	0.20	0.33	0.003	0.01	0.003	198	0.0015	0.0325	NA	NA	NA
7a. Geothermal Flashed steam w/injection	NA	NA	NA	NA	NA	0.03	1E-05	NA	0.00166	NA	55.6
8a. Solar, Thermal	0	0	0	0	0	0	0	0	0	0	69
b. NG, Boiler back-up unit	0.150	0.0006	0.00290	0.038	0.0013	119	0.0002	0.028	NA	NA	93
c. NG, Boiler back-up unit with LNB	0.031	0.0006	0.0029	0.038	0.0013	119	0.0002	0.028	NA	NA	93
d. NG, Boiler back-up unit with LNB + SCR	0.012	0.0006	0.0029	0.038	0.0013	119	0.0002	0.028	NA	NA	93
9a. Solar, Photovoltaic	0	0	0	0	0	0	0	0	0	0	0
10a. MSW, Steam Boiler	0.308	0.38	0.4700	0.93	0.0300	165	0.001	0.033	NA	NA	NA
b. MSW, Steam Boiler w/FFB	0.308	0.38	0.00470	0.93	0.0300	165	0.001	0.033	NA	NA	NA
11a. Wood, Steam Boiler	0.155	0.0083	0.4862	0.221	0.0773	212	0.033	0.033	NA	NA	NA
b. Wood, Steam Boiler w/FFB	0.155	0.0083	0.00486	0.221	0.0773	212	0.033	0.033	NA	NA	NA
12a. Wind	0	0	0	0	0	0	0	0	0	0	0
13a. Small Hydroelectric	0	0	0	0	0	0	0	0	0	0	0
14a. Purchases	Check source note.										
Peakers											
1a. Combustion Turbine NG	0.3933	0.0006	0.0133	0.1095	0.012	119	0.012	0.018	NA	NA	0.03
b. Combustion Turbine NG w/SWI	0.0787	0.0006	0.0133	0.1095	0.012	119	0.012	0.018	NA	NA	0.03
c. Combustion Turbine NG w/SWI + SCR	0.0283	0.0006	0.0133	0.1095	0.012	119	0.012	0.018	NA	0.037	0.03
2a. Combustion Turbine Distillate Oil	0.6	0.212	0.03	0.116	0.0359	164	0.0016	0.0211	NA	NA	0.03
b. Combustion Turbine Distillate Oil w/SWI	0.2	0.212	0.03	0.116	0.0359	164	0.0016	0.0211	NA	NA	0.03
3a. Reciprocating Engine, Diesel	3.3500	0.0557	0.2393	0.7266	0.2293	162	NA	NA	NA	NA	NA
b. Reciprocating Engine, Diesel w/SCR	0.5025	0.0557	0.2393	0.7266	0.2293	162	NA	NA	NA	0.039	NA
4a. Pump-storage Hydroelectric	Check source note.										0
5a. Purchases	Check source note.										

Electric Facilities Emissions Factors and Water Use

	Heat Rate	Emissions (lbs/MWhr out)										Water Use (gals per MWhr out)
		NOx	SOx	TSP	CO	VOC	CO2	CH4	N2O	H2S	NH3	
New Utility Facilities												
Baseload												
1a. Combined Cycle NG	8140	3.2	0.005	0.01	0.17	0.27	952	0.015	0.063	NA	NA	142
b. Combined Cycle NG w/SWI	8140	0.64	0.005	0.01	0.17	0.27	952	0.015	0.063	NA	NA	142
c. Combined Cycle NG w/SWI + SCR	8140	0.23	0.005	0.01	0.17	0.27	952	0.015	0.063	NA	0.3	142
2a. Combined Cycle Distillate Oil	8140	4	2.56	0.01	0.15	0.13	1330	0.013	0.265	NA	NA	142
b. Combined Cycle Distillate Oil w/SCR	8140	0.8	2.56	0.01	0.15	0.13	1330	0.013	0.265	NA	0.32	142
3a. Combined Cycle Residual Oil	8250	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4a. Coal, Pulverized w/scrubbers	9400	6	6	0.3	0.23	0.038	2240	0.014	0.306	NA	NA	455
5a. Coal, Atmospheric Fluidized Bed	10000	5	6	0.1	1.5	0.03	2380	0.015	0.325	NA	NA	15900
6a. Coal, Integrated Gasification Comb C	9280	1.9	3.1	0.03	0.09	0.03	1840	0.014	0.302	NA	NA	NA
7a. Geothermal, Flashed steam w/injectio	40000	NA	NA	NA	NA	NA	1.20	0.0004	NA	0.0664	NA	2224
8a. Solar, Thermal	14600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1007
b. NG, Boiler back-up unit	11000	1.65	0.007	0.032	0.42	0.014	1310	0.002	0.31	NA	NA	1023
c. NG, Boiler back-up unit w/LNB	11000	0.34	0.007	0.032	0.42	0.014	1310	0.002	0.31	NA	NA	1023
d. NG, Boiler back-up w/LNB + SCR	11000	0.13	0.007	0.032	0.42	0.014	1310	0.002	0.31	NA	NA	1023
9a. Solar, Photovoltaic	24000	0	0	0	0	0	0	0	0	0	0	0
10a. MSW, Steam Boiler	16800	5.17	6.4	7.896	16	0.504	2770	0.02	0.55	NA	NA	NA
b. MSW, Steam Boiler w/FFB	16800	5.17	6.4	0.079	16	0.504	2770	0.02	0.55	NA	NA	NA
11a. Wood, Steam Boiler	16740	2.59	0.14	8.139	3.7	1.29	3550	0.55	0.55	NA	NA	NA
b. Wood, Steam Boiler w/FFB	16740	2.59	0.14	0.08136	3.7	1.29	3550	0.55	0.55	NA	NA	NA
12a. Wind	7600	0	0	0	0	0	0	0	0	0	0	0
13a. Small Hydroelectric	3800	0	0	0	0	0	0	0	0	0	0	0
14a. Purchases		Check source note.										
Peakers												
1a. Combustion Turbine NG	13100	5.152	0.008	0.174	1.434	0.16	1560	0.16	0.24	NA	NA	0.4
b. Combustion Turbine NG w/SWI	13100	1.03	0.008	0.174	1.434	0.16	1560	0.16	0.24	NA	NA	0.4
c. Combustion Turbine NG w/SWI + SC	13100	0.371	0.008	0.174	1.434	0.16	1560	0.16	0.24	NA	NA	0.4
2a. Combustion Turbine Distillate Oil	13100	8	2.78	0.4	1.52	0.470	2150	0.021	0.276	NA	NA	0.4
b. Combustion Turbine Distillate Oil w/S	13100	3	2.78	0.4	1.52	0.470	2150	0.021	0.276	NA	NA	0.4
3a. Reciprocating Engine, Diesel	10000	33.500	0.557	2.393	7.286	2.293	1620	NA	NA	NA	NA	NA
b. Reciprocating Engine, Diesel w/SCR	10000	5.025	0.557	2.393	7.286	2.293	1620	NA	NA	NA	0.39	NA
4a. Pump-storage Hydroelectric	4900	Check source note.										
5a. Purchases		Check source note.										

Source Notes:

Bibliographic Key.

Tellus (a)	"Evaluation of Repowering the Manchester Street Station". A report to the Rhode Island Division of Public Utilities and Carriers, Rhode Island Division of Statewide Planning, and Rhode Island Governor's Energy Office of Energy Assistance.
Tellus (b)	"The Role of Hydro-Quebec Power in a Least-Cost Resource Plan for Vermont". A Report to the Vermont Department of Public Service, January 19, 1990.
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CEC (b)	California Energy Commission, "Energy Technology Status Report, July, 1990. Draft Copy.
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ADL	Arthur D. Little, Inc., "Selective Catalytic NOx Reduction Technology for Cogeneration Plants", November, 1988
LUZ	Personal Communication with LUZ Development and Finance Corporation, 1990.
Goddard & Goddard	Goddard & Goddard, "Global Warming and Geothermal Energy", Geothermal Resources Council Bulletin, January, 1990
Mintzer	Mintzer & Hedman, Externalities Associated with Electric Power Supply and Demand-Side Technologies.

New Utility Facilities

Baseload

- 1a. Combined Cycle NG. Sulfur content 0.0007%. Oxidation catalyst at 80% control for CO. Source: Tellus (a) for emissions (except NOx which is from CEC (a)) and chosen CO control level. Water consumption from CEC (b).
- b. Combined Cycle NG w/SWI. Sulfur content is 0.0007%. Oxidation catalyst at 80% control for CO and SWI at 80% control for NOx. Source: Tellus (a) for emissions and chosen CO control level, CEC (a) for chosen NOx control level. Water consumption from CEC (b).
- c. Combined Cycle NG w/SWI + SCR. Sulfur content is 0.0007%. Oxidation catalyst at 80% control for CO. SWI + SCR at 92.8% control for NOx which corresponds to 9 ppm. SWI reduces NOx emissions by 66.4% going from approximately 125 ppm to 42 ppm. This is followed by an additional 78.6 % reduction from SCR going from 42 ppm to 9 ppm. In the Northeast, this was considered the least cost combination of NOx control to achieve the NESCAUM regulation of 9 ppm. Source: Tellus (a) for emissions and chosen CO control level, CEC (a) for chosen NOx control level. NH# emissions are a Tellus calculation (see explanatory notes). Water consumption is from CEC (b).
- 2a. Combined Cycle Distillate Oil. Sulfur content is 0.3%, and ash is less than 0.1%. Oxidation catalyst at 80% control for CO. Source: Tellus (a) for emissions and chosen CO control level. Water consumption is assumed equivalent to CC NG
- b. Combined Cycle Distillate Oil w/SCR. Sulfur content is 0.3%, and ash is less than 0.1%. Oxidation catalyst at 80% control for CO and SCR at 80% control for NOx. Source: Tellus (a) for emissions and chosen CO control level, CEC (a) for chosen NOx control level. The NH3 emissions are a Tellus calculation (see explanatory notes). Water consumption is assumed equivalent to CC NG.
- 3a. Combined Cycle Residual Oil. NA
- 4a. Coal, pulverized w/scrubbers. Sulfur content is 2.5% and ash content is 12%. Scrubbers at 83% control for SOx and 90% control for TSP. Source: Tellus (a) for emissions (except CO2 which comes from Gleick to reflect Western coal). Internal calculation to estimate control levels. Water consumption from ETH.
- 5a. Coal, Atmospheric Fluidized Bed Combustion. Sulfur content is 2.5% and ash content is 12%. Source: Tellus (a) (except coal which comes from Gleick to reflect Western coal). Water consumption from CEC (b).
- 6a. Coal, Integrated Gasification Combined-Cycle. Sulfur content is 1.4% and ash content is 6.25%. Source: Tellus (a) (except CO2 which comes from Gleick to reflect Western coal).
- 7a. Geothermal, Flashed steam w/injection. Average of the 9 CECI Coseo plants, 8 under construction. Air Emissions Control Systems (AECS) utilizing noncondensable gas injection. Heat Rate is assumed 40000 Btu/KWhr. Source: Goddard & Goddard for emissions, Tellus for Heat Rate.

Geothermal Emissions

The geothermal emissions presented here are not considered wholly representative of potential geothermal emissions in Nevada. Geothermal emissions are very site-specific and emission values should be submitted by potential developers if anticipated emissions are substantially different from those presented here.

New Utility Facilities

Baseload

- a. Combined Cycle NG. The potential range for the CO control using oxidation catalyst is 80 - 90%. Source: CEC (a) for control range.
- b. Combined Cycle NG w/SCR. The potential range for CO control using oxidation catalyst is 80 - 90%. The potential range for NOx control using SCR is 80 - 90%. Source: CEC (a) for control ranges.
- a. Combined Cycle Distillate Oil. The potential range for CO control using oxidation catalyst is 80 - 90%. Source: CEC (a) for control range.
- b. Combined Cycle Distillate Oil w/SCR. The potential range for CO control using oxidation catalyst is 80 - 90%. The potential range for NOx control using SCR is 80 - 90%. Source: CEC (a) for control ranges.
- a. Combined Cycle Residual Oil.
- a. Coal, pulverized w/scrubbers.
- a. Coal, Atmospheric Fluidized Bed Combustion.
- a. Coal, Integrated Gasification Combined-Cycle.
- a. Geothermal, Flashed steam w/injection.
- a. Solar, Thermal.
- b. NG Boiler back-up unit.
- c. NG Boiler back-up unit w/LNB.
- d. NG Boiler back-up unit w/SCR.
- a. Solar, Photovoltaic.
- 0a. MSW, Steam boiler.
- b. MSW, Steam Boiler w/FFB.
- 1a. Wood, Steam Boiler.
- b. Wood, Steam Boiler w/FFB.
- 2a. Wind.
- 3a. Small Hydroelectric.
- 4a. Purchases.

Peakers

- a. Combustion Turbine NG.
- b. Combustion Turbine NG. The potential range for NOx control using SWI is 70 - 82%. Source: CEC for control range.
- a. Combustion Turbine Distillate Oil.
- b. Combustion Turbine Distillate Oil w/SWI. The potential range for NOx control using SWI is 70 - 82%. Source: CEC for control range.
- a. Reciprocating Engine, Diesel.
- b. Reciprocating Engine, Diesel w/SCR. The potential range for NOx control using SCR is 80 - 90%. Source: CEC for control range.
- a. Pump-storage Hydroelectric.
- a. Purchases.

PUBLIC INFORMATION

Sun Day 1992

Sun Day 1992: A Campaign for a Sustainable Energy Future, is a nationwide educational campaign to promote improved energy efficiencies and renewable energy technologies, such as geothermal, solar, wind, biomass, solar-hydrogen, and hydroelectrical.

Sun Day 1992 will include at least one national day (Earth Day - April 22, 1992) and possibly a second in early fall 1992. In addition, Sun Day's sponsors will encourage related activities throughout 1992, such as the United Nations Conference on Environment and Development in June 1992. Sun Day's organizers will develop and

distribute written materials on energy conservation and renewable energy to students and teachers throughout the United States.

The event's initial sponsors include many state and national energy trade associations, representatives of municipal electrical utilities, and national and local environmental organizations.

For further information, contact Sun Day 1992, 215 Pennsylvania Ave., S.E., Washington, D.C. 20003. Phone (202) 546-4996.

Six New Geothermal Brochures

For a long time, the geothermal community has needed literature geared to the general public explaining geothermal energy and development. Such materials are becoming available, several in the last few months.

The most inclusive is a handsome, full-color publication called *Geothermal Energy* written by Mike Wright of the Earth Science Laboratory, University of Utah Research Institute. It includes six, well-illustrated pages that explain geothermal -- the what, why, how, and how much; the "net positive" environmental impact; the enhanced energy security and reduced trade deficit; and the costs. For a free copy, write to UURI at 391 Chipeta Way, Suite C, Salt Lake City, Utah 84108.

Another general-interest brochure, this one concentrating on low-temperature resources, is titled *Geothermal Services of The Geo-Heat Center*. The brochure describes technical assistance available; advice and referrals; a speaker's bureau; tours; publications; and a library. For a copy, write Paul J. Lienau, Director, The Geo-Heat Center, Oregon Institute of Technology, 3201 Campus Drive, Klamath Falls, Oregon 97601.

An informative, full-color brochure now available from Unocal Corporation is called *Imperial Valley Geothermal Operations*. The geothermal resource is described, as are Unocal's power plants and geothermal operations in the Imperial Valley. For a copy, write Unocal Corporation, Corporate Communications Dept., P.O. Box 7600, Los Angeles, Ca. 90051.

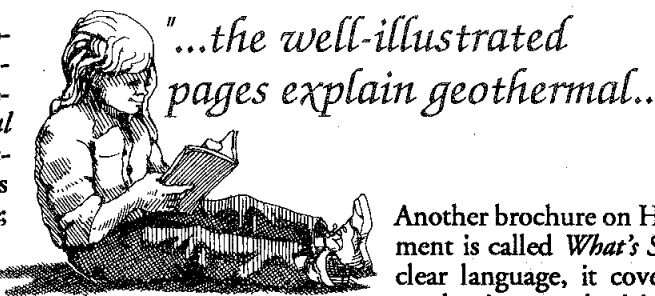
Two new brochures describe Hawaii's geothermal development. *Geothermal, Part of the Mix in Hawaii's Energy Future*, reports that in 1881, King David Kalakaua and his

attorney general discussed with Thomas Edison the possibility of using power from Hawaii's volcanoes to produce electricity for lighting Hawaii's capital, and transmitting this power by submarine cable to the other islands.

The brochure is very attractive and informative, listing advantages and disadvantages of geothermal development and describing the worldwide use of geothermal resources. The brochure is actually one in a series of nine informative pamphlets describing alternative energy sources, planning, and management. The scope and sophistication of information provided by these brochures is sorely needed. For copies, write to the Energy Office, Department of Business, Economic Development & Tourism, 335 Merchant Street, Room 110, Honolulu, Hawaii 96813.

Another brochure on Hawaiian geothermal development is called *What's So Hot About Geothermal?* In clear language, it covers the basics of geothermal production, emphasizing comparisons of geothermal development versus solar and wind; also, the brochure covers CO₂ emissions from geothermal plants versus those from oil- and coal-fired plants. The brochure is available from The Pro-Geothermal Alliance, 737 Bishop Street, Suite 2880, Honolulu, Hawaii 96813.

Los Alamos National Laboratory has reprinted an article from *Energy Watch* titled "Hot Rocks". It is an informative, two-page description of the hot-dry-rock program, printed in an attractive manner on recycled paper. For copies, write Dave Duchane, Hot Dry Rock Program Manager, MSD443, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.



Geothermal Information Needs

Reprinted from "Developing Advocacy for Geothermal Energy in the United States" by Phillip M. Wright, Earth Science Laboratory, University of Utah Research Institute.

Group	Technical Level	Emphasis	Mechanisms
Market Makers and End Users	S 3-7 E 7-9 SO 5-9 LR 7-9	Economic, environmental and social advantages of geothermal energy.	Direct presentations, factual marketing material.
Administrators	S 4-7 E 6-9 SO 6-9 LR 6-9	Energy security and how geothermal can help. Environmental and other advantages. Voter support for alternative energies and geothermal.	Briefings for top officials, position papers. Articles in respected publications and major newspapers.
Legislators	S 4-7 E 6-9 SO 6-9 LR 6-9	Specific needs of geothermal community. Energy security and how geothermal can help. Environmental and other advantages. Voter support for alternative energies and geothermal. Economics of geothermal development.	Briefings for legislators and staffers. Congressional testimony. Letters dealing with a single issue. Published articles in journals and major newspapers.
Regulators	S 7-9 E 3-5 SO 4-7 LR 7-9	Specific needs regarding regulations. Advantages of geothermal energy. Multiple land-use context. Development sequence and its impacts.	Responses to FR announcements of regulations. Letters and briefings. Developing local-level relationships.
Special Interests	S 3-9 E 3-9 SO 3-9 LR 3-9	Environmental and other advantages of geothermal energy. Energy security and energy policy. Economic and social effects of development. Development sequence and its impacts. Needs of geothermal community.	Support for special interest groups. Developing working relationships. Articles and letters in their journals. Articles in widely-read publications. In-depth newspaper and TV documentaries.
General Public	S 1-5 E 1-5 SO 1-5 LR NA	General energy and geothermal information. Environmental and other advantages. Economic and social effects of development.	Newspaper and TV spots on geothermal projects and energy issues.
Educators			
College	S 4-9 E 4-9 SO 4-9 LR 4-9	Scientific, economic, legal, social, environmental, energy security aspects.	Text books and chapter for texts. Journal publications. Educational material for libraries.
Secondary (Grades 9-12)	S 2-5 E 2-5 SO 2-5 LR NA	General information on geothermal energy, advantages, Environmental impacts. General energy information.	Material for inclusion in texts. Pamphlets and other educational aids.
Primary (Grades K - 8)	S 1-3 E 1-3 SO 1-3 LR NA	Basic energy and geothermal concepts. Advantages of geothermal energy.	Material for inclusion in texts. Pamphlets and other educational aids.

S = Scientific	E = Economic	SO = Social	LR = Legal/Regulatory
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Technical Level Scale	1	2	3	4	5	6	7	8	9
	Basic Non-Technical		General Non-Technical		Semi-Technical		Technical		Highly Technical

ENERGY PLANNING

California Energy Plan Announced

On October 31, 1991, Governor Pete Wilson released the 1991 California Energy Plan. The plan establishes energy policies for the next two years, and was developed by the California Energy Commission.

"The future economic growth of our state is directly linked to the price and availability of energy in all its forms," Governor Wilson said. "An energy source that is cheap to develop and consume may also be very expensive in terms of its environmental and health impacts. An energy efficiency improvement which is initially a bit more expensive may actually save thousands of dollars over its useful life.

"During the public hearing on the California Energy Commission's proposed report, and also during the public hearing on the commission's proposed 1991 California Energy Plan, a number of witnesses expressed dismay that neither report recommends establishing a statewide carbon-dioxide (CO₂) reduction goal. Subsequent to these hearings, Southern California Edison Company and the Los Angeles Department of Water and Power announced that they would each reduce their CO₂ emissions by 10 percent over the next decade, and they each established a goal to achieve another 10 percent reduction by the year 2010.

"At issue is whether or not the California Energy Commission's 1991 Energy Plan and Global Climate Change report should, in fact, establish a CO₂ reduction goal for California, and whether or not this goal should be

announced in conjunction with the Governor's approval of the energy plan. As the lead state agency responsible for global climate change issues, and as the state's energy agency whose policy decisions affect nearly all CO₂ emissions within the state, I am today directing you (the CEC) to hold appropriate public proceedings to determine whether California should establish such a goal and, if so, what level that goal should be.

"From an emphasis on conservation to allowing clean renewable technologies to more fairly compete with conventional energy sources, this (document) is a comprehensive blueprint for California's energy future. The 12 policy recommendations and the 66 specific actions steps represent a careful balance between market principals and respect for environmental values. I endorse its adoption and urge the legislature, the federal government, and all affected state agencies to expeditiously implement its recommendations," Governor Wilson concluded.

California's Energy Plan was prepared by the California Energy Commission (CEC), pursuant to Public Resources Code, Section 25309. The report forms the basis for action by the Legislature, the Governor, other state agencies, utilities, and the private sector in meeting California's future energy needs. It is supported by five CEC technical reports: *The Energy Efficiency Report*, *The Fuels Report*, *The Energy Development Report*, *The Electricity Report*, and *The California Contingency Plan*.

Population Growth for California

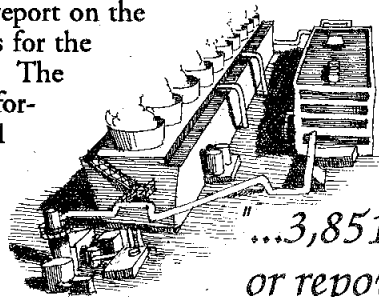
On October 31, 1991, Richard Sybert, chairman of the State Council on Growth Management, released a study delineating dramatic changes in the population growth patterns of California.

In the study, the California Department of Finance predicts that California's population will reach 36 million

by the end of the century. Furthermore, it is projected that the state's current population of 30.7 million will increase by 30 percent by the year 2005, about three times more than the national population growth rate. These changes are set forth in a new publication, *Analysis of the 1990 Census in California*.

California's Electrical Needs

The Division of Ratepayer Advocates (DRA) of the California Public Utilities Commission (PUC) has released a report on the need for new resources for the state's electric utilities. The report shows that California will need 3,851 megawatts of new or repowered power plants in the next 8 years to accommodate increases in demand and to replace older existing power plants with new, more efficient, and less polluting models, using PUC planning criteria.



"...3,851 megawatts of new or repowered power plants in the next 8 years..."

While the DRA endorses the PUC criteria, the DRA recommends that 2,244 megawatts be put out for bid immediately. This amount will ensure adequate power supplies, maintain a healthy economy, and balance the PUC criteria with the findings of the California Energy Commission (CEC). This activity will also make significant progress toward improving air quality.

How much capacity is needed?

The DRA recommendations on needs by 1999, in megawatts, follow.

	Need	To Bid	Recommended by CEC
Southern Calif. Edison	1,574	1,000	1,317
San Diego Gas & Electric	2,033*	1,000	1,392
Pacific Gas & Electric	244	244	188
Total	3,851	2,244	2,897

*By 1992.

Energy Efficiency Defined

On September 26 and 27, the Northern California Power Agency held its 1991 annual meeting in Sacramento. Charles Imbrecht, Chairman of the California Energy Commission, was moderator for a panel on Energy Efficiency.

In his remarks, Mr. Imbrecht stated that improved efficiency in the way we use existing energy resources is the most cost-effective method of energy conservation. "Over the next 10 years, 75 percent of all capacity requirements for California will be met through conservation efforts," Mr. Imbrecht said.

S. David Freeman, General Manager for the Sacramento Municipal Utility District and a member of the Energy Efficiency panel, called "conservation" a very conservative point of view, when looked at through the economics of energy efficiency.

by Susan F. Hodgson

He said he believes most utilities pay only lip service to energy efficiency, and that a utility's money goes into power plants. "The utility has incentives to sell more and more electricity," he said. Instead, Mr. Freeman believes utility companies should have taken Thomas Edison's advice to sell light, not kilowatt hours. "If we did this," he said, "we would be getting as efficient with the whole system, instead of stopping at the point where the electricity is used. If we had abundant sales at the lowest price, we knew we were doing well."

"We don't have to justify efficiency on any grounds except business sense," Mr. Freeman continued. "The Sacramento Municipal Utility District invests 5 percent of its revenues in efficiency programs. This is among the highest percentage spent by a utility for such matters," he concluded.

EIA Consolidates Modeling and Energy Forecasting Efforts

Dr. Calvin A. Kent, Administrator of the Energy Information Administration (EIA), has announced a reorganization of the EIA, an independent arm of the Department of Energy, which provides comprehensive energy statistics and information, and objective analyses of energy issues.

A major office has been created in the reorganization to develop and maintain the National Energy Modeling System and other modeling systems necessary to analyze energy information and data used for midterm and long-term energy forecasting.

"The modeling systems are needed in order to analyze the complex interactions of demand, supply, and conversion for all energy sources and their economic and environmental impacts," said Dr. Kent.

The newly formed Office of Integrated Analysis and Forecasting will undertake analytical studies of integrated energy markets and the ways the markets are affected by differing energy policies. Forecasts released by the office will involve energy markets, environmental and macroeconomic issues, and international developments.

SERI Becomes National Energy Laboratory

On September 16, 1991, President George Bush designated the Solar Energy Research Institute (SERI) in Golden, Colorado, as the National Renewable Energy Laboratory.

President Bush said, "One of the most important themes in our National Energy Strategy is the more efficient use of energy resources. We must keep America on the cutting edge of new technologies, like alternative fuels, electric cars, solar and geothermal energy, high-speed rail, and advanced, even safer nuclear energy facilities. We must encourage environmentally responsible development of all U.S. energy resources, including renewable energy. Renewable energy does reduce demand upon our other finite natural resources, it enhances our energy security and, clearly, it protects the environment."

In the last two years, U.S. Department of Energy (DOE) funding for research and development of renewable energy technologies has increased by 78 percent, from \$138 million to \$246 million. In the last decade, the cost of producing electricity from solar thermal has declined by 83 percent, from photovoltaics by 60 percent, and from wind by 75 percent.

"Much of the outstanding progress in these areas took

place at SERI," Deputy Secretary of Energy W. Henson Moore said. "Elevating its status to the elite group of National Laboratories is both a recognition of these accomplishments and a commitment to continue this renewable energy progress."

SERI is the nation's lead institution for solar and renewable energy research and development, with an annual operating budget of about \$95 million and a staff of over 500. It was authorized by the Solar Energy Research, Development, and Demonstration Act of 1974. Midwest Research Institute of Kansas City, Missouri, operates SERI for the DOE. The DOE has requested that SERI receive a new \$20 million, 100,000-square foot laboratory. Congress approved \$4.5 million to begin construction in 1991.

Since SERI went into operation in 1977, the laboratory's mission has grown to include all aspects of solar and renewable energy research, including photovoltaics, solar thermal, biomass, wind, building systems, resource assessment, analytical studies, and energy storage. The laboratory's cooperative programs and technology-transfer initiatives with private industry have helped bring renewable energy technologies into practical use.

Geothermal Sampling Device Used for Deep Sea Testing

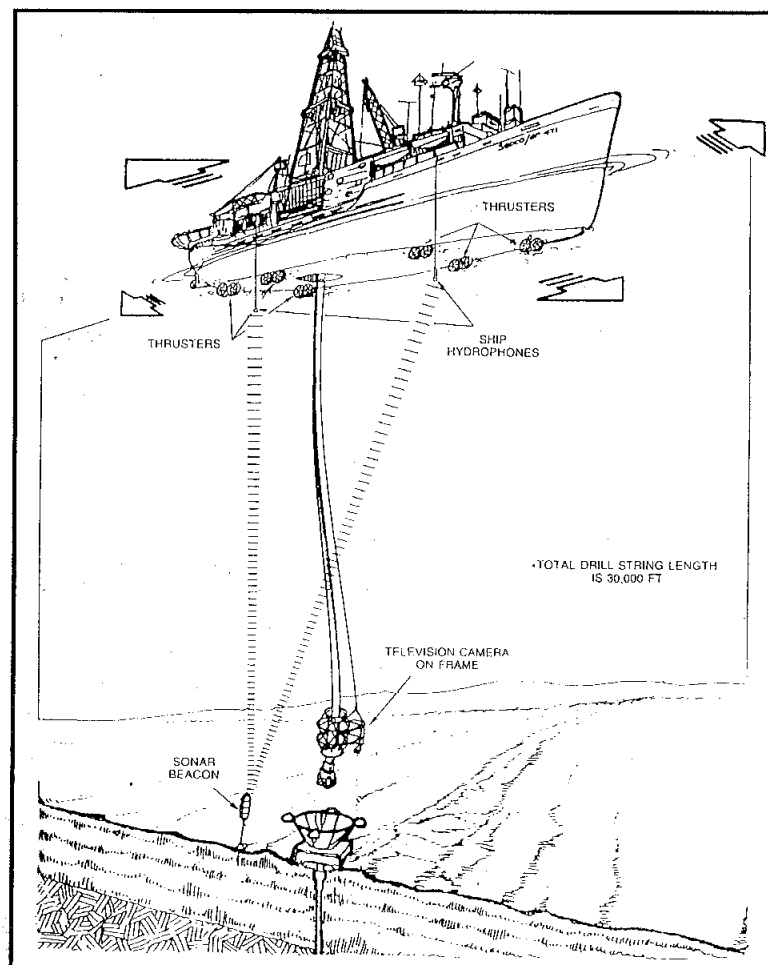
With a device designed by Lawrence Berkeley Laboratory, scientists obtained an uncontaminated fluid sample from a well south of Costa Rica, the deepest well ever drilled into the oceanic crust. The sample was extracted with a downhole sampler designed at Lawrence Berkeley for gas- and fluid-sample collection from geothermal wells. The laboratory modified the device for undersea use.

The fluid drawn from the offshore well was very hot (about 165°C or 330°F). As the surrounding ocean water was near freezing, the sampler was modified to equalize pressure conditions inside and outside of the sample chamber.

A piece of flexed tubing was inserted into the sampler to act as a volume compensator. Thus, oceanic waters, instead of rushing into the sample chamber when the pressure dropped, entered the tubing through its one open end, forcing the tubing to elongate until pressure inside and outside the chamber were equalized.



A chemist attaches sample-extraction equipment to the fluid sampler. Photo by R. Solbau.



The research vessel JOIDES Resolution as preparations were underway to reenter the deepest well ever drilled into oceanic crust. Eventually, the downhole fluid sampler, actually developed for geothermal wells, would be lowered down the well from inside the drill string. Drawing courtesy of Lawrence Berkeley Laboratory.

Geothermal Grant and Loan Program

In September 1991, the California Energy Commission (CEC) began the 12th funding cycle of the Geothermal Grant and Loan Program. With this program, the CEC funds geothermal projects for cities, counties, special districts, Indian tribal governments, regional planning agencies, and certain municipal utility districts.

The CEC accepts applications for resource and technology development, impact mitigation, and planning. Recent legislation allows the CEC to award funds to private applicants, but such solicitations will not begin until calendar year 1992.

It offers grants for projects not expected to generate savings or revenues. These include impact mitigation, planning, resource assessment projects, and certain high-risk research and development projects. Applications for impact mitigation, and/or planning projects from coun-

ties of origin, and from local jurisdictions within a county of origin must provide a matching contribution of at least 50 percent of the total project cost.

Contingent awards are available to local jurisdictions developing products that are expected to generate energy cost savings or revenues. The minimum matching contribution is 20 percent of the total project cost. Based on the success of the project, a contingent award is converted to a grant or a loan. The interest rate is 4 percent for contingent awards converted to loans. The maximum repayment term for loans is 20 years. Funding is awarded competitively.

If you are interested in the program, contact Kelly Birkinshaw, Geothermal Grant and Loan Program, CEC, 1516 Ninth Street, MS-43, Sacramento, Ca. 95814. Phone: (916) 654-5129.

Direct-Use Proposals Sought for Geopressured Resource

EG&G Idaho, Inc., a management and operating contractor for the Department of Energy, requested written expressions of interest to provide proposals for direct uses of a geopressured-geothermal resource. It was anticipated that the proposals would be on a 50/50 cost-share basis. According to Tonya Pearson, subcontract administrator for EG&G, a fair response was received to the request. The next step will be for EG&G to mail out Requests for

Proposals for an industry cost-shared, direct-use evaluation project over an estimated 3-year period.

Possible direct-use projects include agriculture, aquaculture, thermally-enhanced oil recovery using hot geopressured fluids, supercritical fluids used to process organic waste, desalination, and soil remediation.

LEGISLATION

California Legislation

AB 1970 **AUTHOR:** Klehs
TITLE: Taxation: natural resources
INTRODUCED: 03/08/91
LOCATION: Assembly Revenue and Taxation Committee
SUMMARY: Makes nonsubstantive technical changes to provisions of the Personal Income Tax Law and Bank and Corporation Tax Laws relating to percentage depletion in the case of oil, gas, and geothermal wells.
STATUS: 04/01/91 To ASSEMBLY Committee on REVENUE AND TAXATION.

SB 634 **AUTHOR:** Rogers
TITLE: Mineral resources: revenues: leases
INTRODUCED: 03/04/91
ENACTED: 10/05/91
CHAPTER: 520

SUMMARY:

Authorizes the State Energy Resources Conservation & Development Commission to make grants to private entities engaged in the exploration and development of geothermal energy, subject to specified conditions. Imposes an additional requirement that projects approved by the Commission be submitted for review & comment to the Department of Finance, & Legislative Analyst, & the Joint Legislative Budget Committee when the Legislature is in session.

STATUS: 10/05/91 Signed by GOVERNOR.

Federal Legislation

H 409 **AUTHOR:** Quillen
TITLE: ALTERNATIVE ENERGY SOURCES
INTRODUCED: 01/04/91

SUMMARY:

Creates a commission to grant exclusive franchises for the exploration and for the commercial development of geothermal energy and for the right to market any such energy in its natural state.

STATUS: 01/04/91 INTRODUCED. To HOUSE Committee on ENERGY AND COMMERCE.

H 780

AUTHOR: Sharp

TITLE: ALTERNATIVE ENERGY SOURCES
INTRODUCED: 02/04/91

SUMMARY:

Provides incentives for generating electricity using solar, wind, or geothermal energy. Encourages energy and water conservation.

STATUS: 02/04/91 INTRODUCED. To HOUSE Committee on WAYS AND MEANS.

H 929

AUTHOR: Sharp

TITLE: ALTERNATIVE ENERGY SOURCES
INTRODUCED: 02/06/91

SUMMARY:

Makes certain technical corrections in the Solar, Wind, Waste, and Geothermal Power Production Incentives

Act of 1990.

STATUS: 02/06/91 INTRODUCED. To HOUSE Committee on ENERGY AND COMMERCE.

H 1652

AUTHOR: Thomas W

TITLE: ALTERNATIVE ENERGY SOURCES
INTRODUCED: 03/22/91

SUMMARY:

Amends the Internal Revenue Code of 1986 to extend for 5 years the energy investment credit for solar energy and geothermal property and to allow such credit against the entire regular tax and the alternative minimum tax.

STATUS: 03/22/91 INTRODUCED. To HOUSE Committee on WAYS AND MEANS.

H 3359

AUTHOR: Williams

TITLE: ALTERNATIVE ENERGY SOURCES
INTRODUCED: 09/17/91

SUMMARY:

Amends the Geothermal Steam Act of 1970.

STATUS: 09/17/91 INTRODUCED. To HOUSE Committee on INTERIOR AND INSULAR AFFAIRS.

TECHNOLOGY TRANSFER

CONFERENCES

CALL FOR PAPERS

SYMPOSIUM ON THE GEOTHERMAL SYSTEM IN THE LONG VALLEY CALDERA

Background: Once geothermal development was proposed in the Long Valley caldera, the need became apparent for systematic monitoring of the geothermal operations. In late 1986, it was proposed to the Mono County Board of Supervisors that an advisory committee be formed to help formulate and implement a hydrologic monitoring program within the Long Valley caldera, focusing upon early detection of changes in unique hydrologic and thermal features in the caldera. In 1988, the Long Valley Hydrologic Advisory Committee (LVHAC) was formed, and the committee's bylaws were ratified. The committee's role is to provide permitting agencies and developers with information and data necessary to monitor new or existing activities that might affect the hydrology of the Long Valley caldera.

Symposium: The LVHAC is sponsoring a "Symposium on the Geothermal System in the Long Valley Caldera" in Mammoth Lakes, May 1992, to encourage discussion and expand knowledge about geothermal development in the caldera.

Objective: The Symposium will focus on the geology and hydrology of the Long Valley caldera, as well as the monitoring activities in the Long Valley caldera and other similar geothermal systems.

Presentation Selection

Those interested in making presentations should submit an abstract of no more than 500 words to the LVHAC by March 2, 1992. Mail the abstracts to:

Robert Habel
Department of Conservation
Division of Oil and Gas
1416 Ninth Street, Room 1310
Sacramento, California 95814

An Advisory Committee will review the abstracts and select the presentations deemed most relevant to the symposium objectives.

For further information, contact Robert Habel at (916) 323-1786 or Dan Lyster at (619) 934-6704.

Energy Sources Technology Conference and Exhibition, Adam's Mark Hotel, Houston, Texas, January 26-30, 1992.

The event is organized by the American Society of Mechanical Engineers, Petroleum Division. For information on the technical sessions and on program planning, contact Dr. John C. Rowley, Pajarito Enterprises, 3 Jemez Lane, Los Alamos, NM 87544. Details on registration and the advance program are available from Mr. Frank Demarest, ETCE-ASME Pet. Div., 1950 Stemmons Frwy., Ste. 5037C, Dallas, Texas 75207.

Seventeenth Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 29-31, 1992.

The aim of the workshop is for researchers, engineers, and managers involved in geothermal reservoir studies and developments to report on their progress and discuss geothermal matters.

For further information, contact Ms. Jean Cook, Program Manager, Petroleum Engineering Dept., 360 Mitchell Bldg., Stanford, California 94305-2220. Phone (415) 723-4745.

National Energy/Environmental Education Network Conference, February 25 through 28, 1992, Peppermill Hotel, Reno, Nevada. \$150 if registered before January 10; after this date, \$200. Sponsored by the State of Nevada, U.S. Department of Energy, the California Energy Extension Services, the Energy Offices of Arizona and Illinois, Bonneville and Western Area Power Administrations, Sierra Pacific Power Company, Nevada Power Company, Southwest Gas Corporation, and OESI Power Corporation.

This new organization hopes to develop a strong network for energy education professionals; to identify and undertake strategies for information exchange, and to form direction for the 1990s to educate youth, consumers, and communities on energy and environmental issues.

For further information, call Ms. Cathy Fischer at (702) 784-4921.

Symposium on Sustainable Development of Energy and Mineral Resources in the Circum-Pacific Region and the Environmental Impact of their Utilization, March 9 to 12, 1992, Bangkok, Thailand. Sponsors include the Circum-Pacific Council for Energy and Mineral Resources, the Petroleum Institute of Thailand, and other Asian and international associations.

The symposium will evaluate the natural endowment of energy and mineral resources, the factors affecting their utilization, and the environmental consequences of their development.

Particular emphasis is given to the western Pacific region, which includes the most rapidly growing areas of economic development and population. These are also the areas with the greatest potential for increased use of fossil fuels and increasing rates of greenhouse emissions.

For information/registration contact, Ms. Mary Stewart, Secretary-Treasurer, Circum-Pacific Council, 5100 Westheimer, Suite 500, Houston, Texas 77056. Phone (713) 622-1130.

The Earth Summit, the final event of the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, June 1-12, 1992.

The United Nations Conference on Environment and Development is a worldwide series of conferences and events scheduled between July 1991 and June 1992. The final activity will be The Earth Summit held in Rio de Janeiro in June 1992.

Maurice F. Strong, the conference secretary-general, says that Brazil is preparing to receive 6,000 conference participants. He says it will be the largest earth summit ever. At least 100 heads-of-state are expected.

James Gustave Speth of the World Resources Institute told the Senate Committee on Foreign Relations in May that "The 1992 Earth Summit presents an extremely important, once-in-a-generation opportunity for the world community."

Mr. El-Ashry, environmental director of the World Bank, has proposed as agenda items for the conference: integrated land resources management; sustainable energy strategies; forests and biological diversity; international finance; and international technology transfer.

Among the conference organizers is Gabriel Sánchez Sierra, a committee member of the Working Party for the Atmosphere. Dr. Sánchez Sierra is the Secretario General of OLADE (Organización Latinoamericana de Energía), P.O. Box 6413 CCI, Quito, Ecuador. OLADE is well-known to the geothermal community for its work in geothermal development in Latin America.

The Danish Organization for Renewable Energy, in collaboration with interested nongovernmental organizations, is formulating a proposal to the United Nations Conference on a world strategy for sustainable energy development. This will include the goal of reducing CO₂ emissions. For information on this Danish organization,

contact OVE International Secretariat, Willemoesgade 14, 2100 Copenhagen, Denmark.

To receive an invitation to attend the Earth Summit, you must present yourself to the conference organizers as a member of a nongovernmental organization. Such a presentation involves filling out an application form. To receive this form or for more conference information, write Ms. Yolanda Kakabadse, 160 Route de Florissant, P.O. Box 80, CH-1231, Conches, Switzerland.

7th International Symposium on Water-Rock Interaction, Park City, Utah, July 13-22, 1992.

The symposium will focus on all environments with water-rock interaction, from low- to high-temperatures and pressures, to methods applications.

The symposium is organized by the National Water-Rock Interaction Organizing Committee, selected by the Working Group on Water-Rock Interaction. A post-session field trip will be held in Yellowstone National Park, July 19-22.

For further information, contact Dr. Yousif Kharaka, Secretary General WRI-7, USGS, 345 Middlefield Road, Menlo Park, CA 94025.

International Conference on Industrial Uses of Geothermal Energy, Cleaner Energy for the Future, Reykjavik, Iceland, September 2-4, 1992.

The conference will focus on the technical and economic parameters of using geothermal steam in industrial manufacturing processes. The conference is aimed at technical and management personnel in energy intensive industries, but academics and others interested in geothermal energy are encouraged to attend.

For information, contact the Federation of Icelandic Industries, P.O. Box 1407, 121 Reykjavik, Iceland.

2nd World Renewable Energy Congress, Reading, UK, September 13-18, 1992.

A forum where those responsible for and involved in renewable energy, including geothermal, can discuss large-scale implementation of these energy resources.

For further information, contact Professor A.A.M. Sayigh, Congress Chairman, Dept. of Engineering, Univ. of Reading, Whiteknights, P.O. Box 225, Reading RG6 2AY, United Kingdom.

1992 Annual Meeting of the Geothermal Resources Council, October 4-7, 1992, Town and Country Hotel, San Diego, California.

The meeting will mark the 20th anniversary of the GRC, and a gala celebration is planned. There will be at least six separate sessions, including exploration, turbo-machinery maintenance, corrosion, fractured reservoirs, hot dry rock, and geothermal hazards. Possible field trips include the geology of the Salton Trough, flash and binary power plants, and hardware supply and service centers in the Imperial Valley. For further information, contact Grace Mata, GRC, P.O. Box 1350, Davis, Ca. 95617.

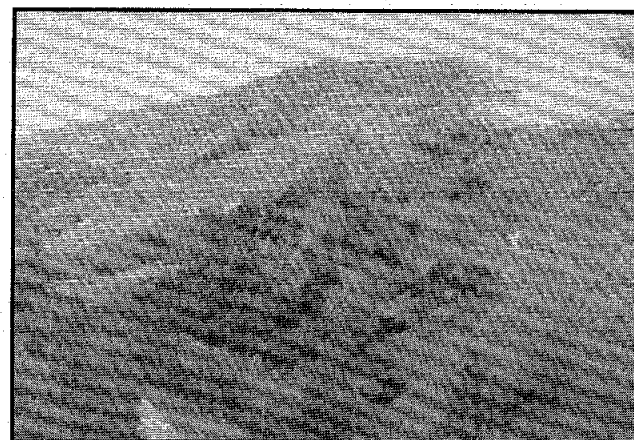
Symposium on Tectonic Framework and Energy Resources of the Western Margin of the Pacific Basin, Shangri-La Hotel, Kuala Lumpur, Malaysia, November 29 - December 2, 1992. Organized by the Circum-Pacific Council for Energy and Mineral Resources.

At the symposium, discussion will center on the relationship of the tectonic framework and dynamic geological processes to the potential- and actual-energy resources along the western rim of the Pacific basin. Subjects to be reviewed are the existing knowledge; the distribution of energy resources in relation to sedimentary basin dynamic processes; future research; and existing and planned uses for this energy.

For further information, contact The Symposium Secretary, c/o Geological Society of Malaysia, Dept. of Geology, Univ. of Malaya, 59100 Kuala Lumpur, Malaysia.

Problems in Geothermal Energy, the International Symposium on Geothermal Energy, June 1993, Leningrad, USSR. Sponsored by the Leningrad Mining Institute and the Soviet Geothermal Association.

The goals of the symposium are to advance theoretical knowledge and practical application of the development



of geothermics, geothermal resources evaluation, technology and utilization of thermoelectroenergetics and balneology; to establish and develop scientific contacts among specialists from different countries; and to improve and expand on the contents of *Geothermal Energy*, a collection of scientific papers to be published in 1994, in Russian and English.

The main topics to be discussed are geotemperature fields and geothermal resources; the technology of geothermal energy and fluids extraction; and the utilization of geothermal energy and thermal water.

Papers are solicited in all aspects of theoretical and applied geothermics, geothermal technology, geothermal energetics, and balneology.

For further information, contact the Leningrad Mining Institute, Dom 2, 21 Linia, Leningrad, 199026, USSR. Phone 2136137, 2188460. Telex 121494 LGIP SU. Fax (812) 2132613. The co-chairman of the program committee is Prof. Paul Kruger, Civil Engineering Dept., Stanford Univ., Stanford, Ca. 94305.

CORE REPOSITORY

Geothermal Well-Sample Storage Available

The California Well Sample Repository is looking for more geothermal well materials to add to its collection of rock-sample suites from geothermal areas.

The repository is on the campus of California State University, Bakersfield. It is the state's only facility for permanent storage and public use of cores, sidewall samples, drill cuttings, outcrop samples, microfaunal slides, foundation borings, and mineral suites.

Cores, ditch samples, and sidewall samples from more than 10,000 exploratory and development oil and gas wells throughout the state are in the collection. Whenever possible, cores are center-sliced to enhance study. Materials are placed in standardized cardboard boxes, labeled for retrieval, and stored on steel shelving. Ancillary data

such as well histories, core descriptions, photos, analyses, and electric logs are on file for many wells.

The repository is open to anyone wishing to study its materials, either on or off the site. Materials are used for seminars, schools, and conventions. Grants, contracts, donations, gifts, and other funds received in support of the repository are administered by the California State University, Bakersfield Foundation solely for the benefit of the repository.

For more information, contact Russ Robinson, the repository curator, at (805) 664-2324. The repository is located at California State University, Bakersfield, 9001 Stockdale Hwy., Bakersfield, California 93311-1099.

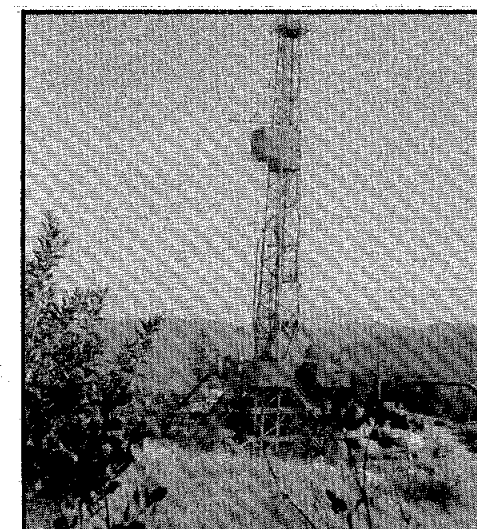
AUDIOVISUAL

Before the Drilling Begins

The environmental documentation process and well-pad engineering practices used at The Geysers Geothermal field are the topics of a 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 the VHS format.

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



Hawaii volcanism: impact on the environment (20 slides). 1991. \$25.00 plus \$10 handling charge. Order product no. 739-A11-005. Available from the National Geophysical Data Center, 325 Broadway, E/GC4, Dept. 863, Boulder, Colorado 80303-32328.

The set of 20 color slides (35 mm) illustrates the impact of volcanism on communities, vegetation, marine life, roads, and coastlines. Also illustrated are the benefits of volcanism such as geothermal power, increase in island land areas, and opportunities for viewing and studying volcanism in relative safety. Views of eruptions are included at Kilauea and Mauna Loa volcanoes in the 1980s.

PUBLICATIONS

Harbin Hot Springs

Come... Let's take a stroll with Ellen Klages, author and resident of Harbin Hot Springs, a famous hot springs resort south of the City of Clearlake. Turn the pages of her book, *Harbin Hot Springs: Healing Waters, Sacred Land* and watch how legends literally spring to life. This is not only an anthropological study of the area and its past inhabitants, but also a detailed historical account of a Lake County retreat center, recording all the various owners, proprietors, and patrons.

In the beginning, we meet the First People--the Pomos and the Lake Miwoks--whose shamanic rituals 125 years ago drew them to the "hot place." We next watch the Victorian ladies and gentlemen eagerly "take their cures" after a nine-hour tortuous, dusty ordeal of a train and stagecoach ride from the Bay Area to Lake County. The most popular doctor's prescription for a cure was the "waters"--whether one had dropsy, consumption, or other maladies. (You have to bear in mind people did not bathe on a regular basis in those days.)

Next, the retreat evolved into a "paradise for pugilists." Here we hang out with the good ole boys, boxing celebrity Jim Jeffries, and Ruby Bob Fitzsimmons, "that bald kangaroo." These men sparred, hunted snipe, and played a hoax that went awry (with local townspeople and the sheriff in on it) that was even reported in a San Francisco paper. It was fun times for the sports celebrities and their camp followers.

by Barbara Baylard
Geothermal Section, Santa Rosa

Relief globe slides (set of 20 slides). 1991. \$40.00. Available from the National Geophysical Data Center, 325 Broadway, E/GC4 Dept. 874, Boulder, Colorado 80303-3328. Ask for Product #931-A11-001.

The set of 20 slides contains 14 global views of the Earth in full-color shaded relief, with land and undersea topography. The planet is seen from vantage points over the poles and each major ocean and land mass. A rectangular Mercator projection view of the whole Earth is included, as well as displays of crustal plates and their relation to world seismic activity. The images are computer-generated from a digital database of oceanic bathymetry and land topography. The original data points were spaced every 5 minutes of latitude and longitude. The images represent a reduced resolution while preserving important physiographical features. Other views may be generated on request, either as slides or as computer files.

Prohibition did not really have much of an effect on Harbin. The Depression came and left. Surprisingly, the resort boomed. "We not only have a right, but an obligation to take vacations," wrote Eleanor Roosevelt in her weekly newspaper column. Although tires and gasoline were rationed (in one month Lake County was allotted 8 new tires and 14 retreads), every cabin and room was booked to capacity. Indeed, it was the age of the automobile that made the resort boom into a family sporting lodge.

Through the years, several debilitating fires took their toll. But the Phoenix always rose up amidst the ashes at Harbin. Now, a new surprise was in store. Harbin Hot Springs became a university, Harbinger University. Although the original intent was for it to become a think factory for scientists to study the connections between religion and science, an enlightened few, trying to find a legitimate journey to higher consciousness, were joined by a mass of young imitators. In the late '60s and early '70s, hundreds of people arrived--expecting to attend a great party, to be fed and housed with nothing asked in return. The bullet-riddled carcass of a car with red paint dripping, "WELCOME," sitting in front of the iron-wrought gate to the inn, plus scattered beer cans served as appropriate symbols of the time.

Bob Hartley, who had invested in the Harbin resort, was a man with a dream. His vision of scientists, seers, and hippies commingled to form a throng for his Heart Consciousness Church came nigh to being destroyed both by a civil war with squatters at the resort, and by the

reactions of outside townspeople. However Hartley, known as "Ishvara," diligently set up a teaching center and workshops specializing in the New Age. Holistic, natural living, and health were to be primary focal points at Harbinger U., now called New Age University.

His dreams, hopes, and tenacity are reminiscent of those of the other owners, beginning with the founder, James Matthew Harbin.

Where is Harbin Hot Springs? Follow Highway 29 through California's Napa Valley, enter Lake County, and travel to Middletown. There, in a secluded canyon to the northwest lie the hot springs, the site where Harbin Hot Springs was founded--"the hot place."

What are hot springs? They are pools of naturally heated (geothermal) waters coming to the earth's surface. Here at Harbin, the geothermal water is channeled into soaking pools. A natural, cold-water spring fills a swimming pool.

Harbin Hot Springs: Healing Waters, Sacred Land (1991, Harbin Springs Publishing) is available for \$11.95 from this company at P.O. Box 1132, Middletown, California 95461.

Schlumberger sounding near Medicine Lake, California. By A. A. Zohdy and R. J. Bisdorf. 1990. Published in *Geophysics*, v. 55, no. 8 (August), p. 956-964. Journal available in most libraries.

Geothermal program review IX proceedings, March 19 to 21, 1991, sponsored by the U.S. Department of Energy, Conservation and Renewable Energy, Geothermal Division. CONF-913105. Available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Reports are included from the annual Department of Energy, Geothermal Division conference on research and development. The papers cover hydrothermal and hot-dry-rock projects, geopressured resources, and the Long Valley exploratory well.

U.S. Department of Energy Publications

The following documents are available, free of charge, from Geothermal Division (Mail Code CE-122), U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, D.C. 20585 or Meridian Corporation, Attention: Perle M. Dorr, 4300 King Street, Suite 400,

Alexandria, VA 22302, Phone: (703) 998-3600; Fax: (703) 998-0887.

Geothermal energy R&D program, annual progress report for fiscal year 1990. 1991. Prepared for U.S. Department of Energy by Meridian Corporation.

The report includes a description of the objectives of each project in the FY90 R&D program; the fiscal year activities; project milestones, variances, and deliverables; and the progress that has been made during the fiscal year toward meeting the objectives.

Geothermal progress monitor no. 12. 1991. Prepared for the U.S. Department of Energy by Meridian Corporation.

This issue of the annual publication synthesizes information on all aspects of geothermal development in this country and abroad to permit identification and qualification of trends in the commercial use of geothermal energy technology. It covers the advances, progress, and activities through 1990.

Geothermal technology evolution rationale for the National Energy Strategy. 1990. Prepared for U.S. Department of Energy by Meridian Corporation.

The report contains the rationale for projections of cost, performance, and market penetration by geothermal resources and energy systems; addresses figures of merit for evaluating the economic viability of geothermal electric projects and technology trends affecting cost; examines three scenarios of projected change in cost and performance; and presents the rationale for achieving the improvements.

Geothermal energy program, multiyear plan, FY 1992-1997. By the Geothermal Division, U.S. Department of Energy. June 27, 1991.

The plan, and accompanying budgetary figures, are for internal planning and management purposes. They have not been approved as U.S. Government budget figures or projections.

The purpose of the plan is to translate programmatic goals and objectives into a definitive strategic plan for the development of geothermal energy and to identify the resources, schedules, and milestones required to carry out the program. The plan also provides a baseline against which progress can be measured.

To comment on the plan, contact Dr. Allan Jelacic, Geothermal Division, Conservation and Renewable Energy, U.S. Department of Energy, Washington, DC 20585.

Lisa and Jason prepared to land.

Uncle Frank and Aunt Helen met them at the airport.

'Geothermal' means the heat from the earth.

Oh, yes. Even though it may be cold outdoors, the deeper in the earth you go, the hotter it gets. All the way to the center, about 4,000 miles below us. Enough heat is in the earth to supply our energy needs for millions of years. But, most of the heat is too deep for us to use.

You mean, the earth is hot inside?

In oil fields, water and oil pumped from wells over 2 miles deep are almost as hot as boiling water," said Aunt Helen, as she lifted a pan of eggs from the stove.

"In fact, the inside of the earth is something like the inside of this hardboiled egg."

Uncle Frank, we drank mineral water from Calistoga.

And we flew over steaming mountains. Have you ever been to The Geysers Geothermal field?

Yes, I've been there many times. Your Aunt

Could you tell us about geothermal energy?

Sure.

GEOTHERMAL IN CALIFORNIA, by Susan F. Hodgson. Illustrated by Jim Spriggs. 1988. No charge when distributed to students. Free classroom sets available. For nonstudent distribution: up to 50 copies free; then, \$1 per copy. Published by and available from the Division of Oil and Gas, 1416 9th St., Room 1310, Sacramento, California 95814.

Illustrated summary of the formation, production, and uses of geothermal resources in California. Prepared for 4th- to 9th graders, but a useful overview for adults.

In 1988, the publication was awarded the Second Place prize for "Writing" by the California State Information Officers Council.

"The Indians and early settlers bathed in them, soaking away aches and pains."

"People cooked in the hot springs, too. In some countries, they've collected minerals like boron and sulphur from hot springs that dried up."

"About 125 years ago," said Uncle Frank, as they returned to the car, "people in Calistoga advertised the hot springs and built health resorts. Soon, the hot springs weren't large enough for all the tourists who came. So, wells were drilled to reach more hot water, and pools were made to hold it."

"Some cooled, geothermal water is also called mineral water," Aunt Helen said. "The amounts and kinds of chemicals and minerals in mineral water are different from those in the water we use everyday. Some people think that mineral water is especially healthful. Not only do people like to drink mineral water, as you did on the airplane, they like to bathe in it, too."

"How else is geothermal water used, Uncle Frank?" asked Jason.

For heating buildings and houses like ours.

for heating businesses like greenhouses and food-drying plants.

for fish farms.

for heating soil in cold climates.

and for melting snow and ice on streets and sidewalks.

"Several businesses in town bottle and sell mineral water," said Uncle Frank.

Here is the history of California's Oil, Gas, and Geothermal Development

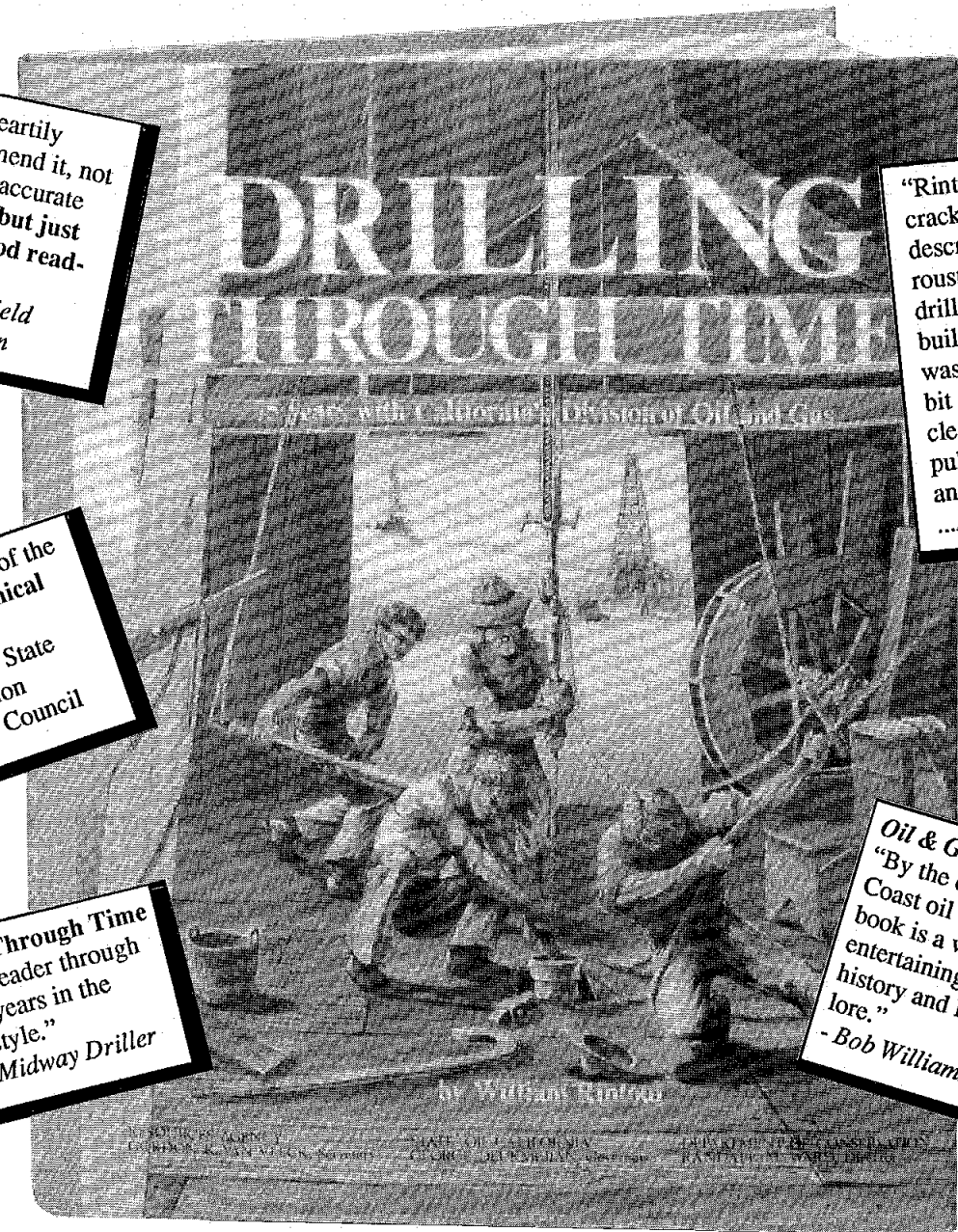
"We heartily recommend it, not only as accurate history, but just plain good reading."
...Bakersfield Californian

1990 winner of the "Best Technical Report,"
California State Information Officers Council

"Drilling Through Time takes the reader through those 75 years in the Rintoul style."
...Daily Midway Driller

"Rintoul's writing crackles with descriptions of roustabouts, drillers, rig builders, boiler washers, tool and bit dressers, well cleaners and pullers, pumpers and oilers."
...Fresno Bee

Oil & Gas Journal says:
"By the dean of West Coast oil writers...the book is a well-written, entertaining collection of history and legend and lore."
- Bob Williams



75 years with California's Division of Oil and Gas.

A history of California's oilfield and geothermal development and regulation, with 227 photographs and illustrations, many never before published. Hardcover. \$10.00 a copy (tax and shipping included). Written by William Rintoul for the Division of Oil and Gas. Published by and available from the division, at 1416 Ninth Street, Room 1310, Sacramento, Ca. 95814.

Geothermal energy in the Western United States and Hawaii: resources and projected electricity generation supplies, 1991. DOE/EIA-0544. Free. 70 p. Available from the GRC, P.O. Box 1350, Davis, Ca. 95617.

This report includes the current status of the industry and the electric-power generation potential of geothermal energy. It concludes that the prospects for geothermal development depend upon finding large, new resources, predicting operational performance, competing with other energy technologies, meeting environmental and other constraints, improving technology, and satisfying market demand.

California statewide wilderness study report, parts 1, 2, and 3. Free. 1991. Published by and available from the Bureau of Land Management, Federal Building, 2800 Cottage Way, Sacramento, Ca. 95825.

These are important reference volumes. They include the wilderness recommendations for 209 wilderness study areas in California. Basically, 2.3 million acres in 62 study areas are recommended for designation as part of the National Wilderness Preservation System. Also, 4.8 million acres in 147 study areas are recommended for release from wilderness study, for uses other than wilderness. Part 2 includes a full-color Wilderness Status map.

1990 Energy Efficiency Report, No. P400-90-003. By the California Energy Commission. 1990. Available free on request from the California Energy Commission, Publications Office, MS-13, 1516 Ninth Street, Sacramento, California 95814-5512.

The report identifies energy use trends in residential, commercial, industrial, agricultural, and transportation sectors; identifies conservation reasonably expected to occur over the forecasted period; indicates the potential for additional conservation; specifies improvements to existing programs; and recommends legislative or administrative actions, programs, and policies.

"Imperial Valley's Geothermal Resource Comes of Age," by Vince Signorotti. Reprinted separately from the Summer 1991 issue of *Valley Grower*. Free. Available from Vince Signorotti, Unocal, 461 West Main St., Brawley, Ca. 92227.

The article offers an interesting, historical overview of the development of geothermal energy in the Imperial Valley.

Temperatures and natural gamma-ray logs obtained in boreholes MLGRAP #1 and #2, Mammoth Lakes, California; data and preliminary interpretations, U.S. Geological Survey, Open-File Report 90-0460. By W.H. Diment and T.C. Urban, 1990. 132 p. Microfiche \$4.00; paper copy \$20.25. Available from U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. Phone (303) 236-7476.

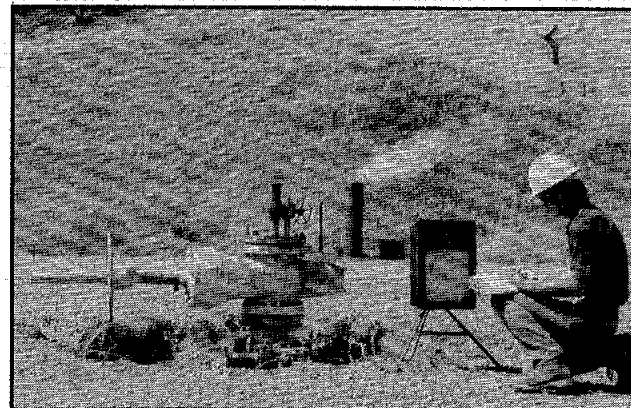
Magmatic unrest at Long Valley Caldera, California, 1980-1990 (abstract). By R.A. Bailey. 1990. Program with Abstracts, Geological Association of Canada; Mineralogical Association of Canada; Canadian Geophysical Union, Joint Annual Meeting, May 1990, p. 6. Journal available in university libraries.

Interim coordinated resource management plan, P800-91-003 CD. Free. Published by and available from the California Energy Commission, 1516 Ninth St., MS-13, Sacramento, Ca. 95814.

The plan for The Geysers Geothermal field was prepared by members of the Commission's Geothermal Technical Advisory Committee.

Monograph on The Geysers Geothermal Field. 1991. \$28.50, hardbound, including shipping and handling. International orders other than Mexico and Canada, add \$5.00 for surface deliveries. Published by and available from the Geothermal Resources Council, P.O. Box 1350, Davis, Ca. 95617.

"This is the most definitive work ever written on The Geysers," said Dave Anderson, executive director of the GRC. "It includes 34 papers on all aspects of geothermal development in the field. Two chapters describe the history of development. All in all, this is a landmark publication," he concluded.



The following reports are available on request from EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, Idaho 83415.

The feasibility of applying geopressed-geothermal resources to direct uses, by B. C. Lunis, J. Negus-de Wys, M. M. Plum, P. J. Lineau, F. J. Spencer, and G. F. Nitschke.

Feasibility study: application of the geopressed-geothermal resource to pyrolytic conversion or decomposition/detoxification processes, by W. A. Propp, A. E. Grey, J. Negus-de Wys, M. M. Plum, and D. R. Haefner.

The feasibility of hydraulic energy recovery from geopressed-geothermal resources, by G. C. Thurston and M. M. Plum.

Feasibility of recovering medium- to heavy-oil using geopressed-geothermal fluids, by J. Negus-de Wys, C. E. Kimmell, G. F. Hart, and M. M. Plum. 1991. Prepared for the U.S. Department of Energy Field Office, Idaho.

Mineral resources newsletter, spring 1991 issue. Free. Published by and available from the Office of Mineral Resources, Geologic Division, U. S. Geological Survey, 913 National Center, Reston, Virginia 22092.

This quarterly newsletter is very interesting. It presents highlights from the U. S. Geological Survey minerals-related programs, research results, and news.

The spring 1991 issue highlights international resource activities currently conducted in the Americas by the Office of Mineral Resources under the Center for Inter-American Mineral Resources Investigations (CIMRI) in Tucson, Arizona. CIMRI fosters cooperative mineral-resource investigations, data exchanges, training, and research activities.

Also included are news notes from USGS Minerals Information Offices, a list of new publications, and ordering information.

Renewable energy excursion: supporting analysis for the National Energy Strategy, SR/NES/90-04, UC-98. December 1990. Free. Available from the Energy Information Association, Office of Coal, Nuclear, Electric, and Alternate Fuels, U.S. Dept. of Energy, Washington, D.C. 20585.

During the development of the National Energy Strategy, the Energy Information Administration, an independent

agency within the U.S. Department of Energy responsible for collecting and disseminating information about energy use, conducted substantial modeling and analysis, including a series of energy forecasts of renewable energy use in the utility, transportation, residential, commercial, and industrial sectors.

The geothermal category in the report includes geothermal heat pumps (GHP), also known as ground-source heat pumps. Exclusive of liquid fuels, GHPs are the most promising dispersed, renewable technology, with a potential of 2.7 quads by 2030, up from less than .1 quad in 1990. GHPs outperform conventional heat-pump systems, which are dependent on widely fluctuating outside air temperatures.

Energy Information Administration news releases. DOE/EIA-0204 (91/02). Distribution category UC-98. Free. Published bimonthly by the National Energy Information Center, EI-231, 1000 Independence Avenue SW, Washington D.C. 20585. Phone (202) 586-8800.

The publication is a favorite government publication. Interesting summaries are included on aspects of many energy issues. All sorts of recent energy data are listed.

EIA publications directory, 1990. Compiled by Paula L. Altman. 1991. DOE/EIA-0149(90). Free. Available from the National Energy Information Center, EI-231, Energy Information Administration, Forrestal Building, Room 1F-048, Washington, DC 20585. Phone (202) 586-8800.

The *EIA Publications Directory* contains titles and abstracts of periodicals and one-time reports produced by the EIA in 1990. The citations and abstracts are arranged by broad subject categories, such as energy, coal, petroleum, and natural gas, and by subcategories such as reserves, products, and byproducts. All reports are indexed alphabetically by subject and title and numerically by report number.

2061 Today, education for a changing future--mathematics, natural sciences, social sciences, technology. Spring 1991, v. 1 no. 1. Published by the American Association for the Advancement of Science. Available from Project 2061, AAAS, 1333 H Street, N.W., Washington, DC 20005. Phone (202) 326-6666.

Each issue of *2061 Today* will be addressed to teachers of all grade levels and subjects, school administrators, educators, educational policy makers, developers of educational materials, mathematicians, engineers, scientists,

and to anyone engaged in educational reform projects. The first issue, spring 1991, explains Project 2061 accomplishments and current activities.

Project 2061 was started in 1985 by the American Association for the Advancement of Science. Phase I (1985-1989) spelled out learning goals and published these goals in *Science for All Americans*, available from the Oxford University Press, Trade Paperbacks, 200 Madison Avenue, New York, NY 10157-0913, \$9.95 plus \$1.50 shipping and handling.

Phase II is now underway to transform these learning goals into alternative curriculum models and to devise Blueprints for Action dealing with teacher education, testing, teaching materials, and educational policies. The goal is to recommend curriculum reform for school systems, including graduate levels. Phase III will strive to implement the reforms, nationwide.

REVIEW, the quarterly magazine of renewable energy. Issue 15, Spring 1991. Free. Available from the Renewable Energy Enquiries Bureau, Renewable Energy Promotion Department, ETSU Building 149, Harwell Laboratory, Oxfordshire, OX 11 0RA.

The spring issue of this British publication includes articles about wood as an energy source; the use of hydroelectric power in Scotland; a geothermal district heating scheme at Southhampton; the use of daylighting and passive solar energy, especially in school buildings; the redevelopment of a former industrial site in Consett based on the key element of renewable energy; and renewable energy options from Sweden.

Also, ask for the list of General Publications, which includes 16 geothermal publications.

Dictionary of environmental information sources, third edition. 1991. 300 p. \$65, plus \$3 shipping and handling in U.S.; elsewhere shipping charge is \$5. Available from Government Institutes, Inc., 966 Hungerford Drive, #24, Rockville, Maryland 20850-1714. Phone (301) 251-9250.

The directory includes all major sources of environmental data. It provides addresses, telephone numbers, and some other data including basic guidelines on how best to find information, a comprehensive index system, and hot-line numbers for quick reference. There are five sections: (1) federal government resources; (2) state government resources; (3) professional, scientific, and trade organiza-

tions, including a detailed listing of more than 100 environmentally oriented organizations; (4) newsletters, magazines, and periodicals; and (5) databases.

Regulatory choices, a perspective on development in energy policy. By Richard J. Gilbert. 1991. \$39.95. Published by and available from the University of California Press, 2120 Berkeley Way, Berkeley, California 94720. To order, call 1-800-822-6657; quote code number 434-000 to receive a 20 percent discount for orders in the continental United States.

The volume provides the first comprehensive economic history of energy policy and its consequences for California.

The author's focus is on bringing prices in alignment with the true cost of producing power and delivering it to the customer. The first part of the book outlines the issue of setting utility rates and considers some of the proposals to provide regulated industries with incentives to respond to economic and environmental concerns. Energy supply problems are discussed in the second part of the book, which includes a survey of the costs of alternative energy sources and estimates of their environmental impacts.

Agents of chaos, earthquakes, volcanoes, and other natural disasters. By Stephen L. Harris. 1990. \$12.95. Published by and available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806. (406) 728-1900.

The book is a reminder to all that the earth is dynamic and subject to sudden change due to volcanoes, earthquakes, meteorite impacts, and other cataclysmic events. Thermal areas are prone to be in the midst of places most vulnerable to such events. About two-thirds of the book is dedicated to describing destructive changes that volcanic processes have caused in California, Oregon, Washington, Hawaii, Alaska, and other areas along the Pacific Coast. Earthquakes, so well known to California residents, are thoroughly covered.

"Because we are passengers on Earth's tectonic plates, we live in the realm of natural disasters and cannot expect to travel free of risk!"

Geothermal direct-use engineering and design guidebook, second edition. 445 pages. \$25 hard cover; \$20 soft cover. Foreign orders add \$3.00 for surface mail or \$15 for airmail. Published by and available from the Geo-Heat Center, Oregon Institute of Technology, 3201 Campus Dr., Klamath Falls, Oregon 97601. Phone (503) 885-1750.

The guidebook contains up-to-date technical information on low- and moderate-temperature (100°-300°F) geothermal development. Chapters cover exploration, well drilling, space heating and cooling, greenhouse heating, aquaculture, industrial processes, economics, regulations, and the environment.

Roadside geology of Idaho. By David Alt and Donald W. Hyndman. 1989. \$14.95. Available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806.

Idaho's interesting geological history includes geothermal activity. The story begins with the 2.7 billion-year-old basement rocks. The ancient sedimentary formations of northern Idaho, the batholith in the central part of the state, the continental hot-spot track, a possible meteoric impact crater on the Snake River Plain, and active faults in the Basin and Range province, all are part of Idaho's geological record. The lava flows, vents, craters, and hot springs throughout the state include a wealth of geothermal activity.

Geothermal resources of the western arm of the Black Rock Desert, northwestern Nevada: Part II, Aqueous geochemistry and hydrology. Water-Resources Investigations Report (WRI 87-4062). By A. H. Welch and A. M. Preissler. 1990. 91 p. Microfiche \$4; paper copy \$14.50. Available from the U. S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, Colorado 80225. Phone (303) 236-7476.

Survey notes. Free. Published by and available from the Utah Geological Survey, 2363 South Foothill Drive, Salt Lake City, Utah 84109-1491. Phone (801) 467-7970.

Volume 24, No. 4, 1991, of this periodical has a long, interesting article titled "The Newcastle Geothermal Area, A Study of a Concealed Hydrothermal System" by Robert Blackett. The article discusses results of an extensive geological research program at the Newcastle area. Either this issue or a subscription to the periodical may be requested.

Roadside geology of Utah. By Halka Chronic. 1990. \$12.95. Available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806.

The scenery of Utah features its splendid rocks in their bright colors, intricate patterns, and dramatically eroded structures.

Utah's abundant mineral resources include geothermal, oil, natural gas, phosphate, uranium, copper, and helium. In Tertiary time, 35 to 45 million years ago, volcanism associated with regional uplift created vast areas of basalt flows and ashflow tuff. Remnants of intrusive igneous rocks and plugs contribute to the scenic landscape. There are some hot springs related to the volcanic rocks at depth.

Texas energy and mineral resources, newsletter. Free. Available from the Center for Energy and Mineral Resources, Texas A&M University, College Station, Texas 77843-1243. When requesting fact sheets, specify geothermal information. Texas Energy Hotline: 1-800-643-SAVE.

The March 1991 issue of the *Texas Energy Newsletter* contains basic information on geothermal energy, including the source; the types, such as steam, hot water, geopressured, and petrothermal (hot dry rocks); development of geothermal energy as an energy supply; the advantages and disadvantages; Texas' geothermal resources, and a list of references for further reading.

Texas has three main regions of geothermal resources. In the Trans-Pecos region in the extreme western part of the state, geothermal resources are known from surface hot springs in the Big Bend Area and from hot water encountered in drilled holes. Deep hot waters apparently rise along the natural conduits provided by steeply-dipping normal faults and fractures in this region, and locally heat shallow groundwaters.

A second region, called the Balcones-Mexia-Talco fault system, extends from west of San Antonio, through Austin and Waco, to the north and east of the Dallas-Fort Worth area. Springs and wells produce hot water at scattered locations along this zone.

The third and largest potential source of geothermal energy in Texas appears to be in the geopressured-geothermal waters along the coast of the Gulf of Mexico, from Brownsville to Beaumont.

Roadside geology of Texas. By Darwin Spearing. 1991. \$15.95. Available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806.

The geologic panorama of Texas includes volcanic mesas and thrusting mountains in the west, red canyons in the Panhandle, tropical sand barriers along the Gulf Coast, and the limestone plateaus deposited onto hard granitic terrain in the center of the state. Rocks of all ages, from crystalline gneiss of ancient Precambrian time to the loose sands of Holocene beaches, are found at the surface in the state, as well as every major rock type, from igneous to metamorphic to sedimentary.

Texas also has an incredible array of natural geologic resources, ranging from its famous oil and gas fields through practically every rock and mineral resource, including geothermal. There is a vast potential for development of geothermal resources in the Trans-Pecos region of West Texas, in a belt across central Texas, and in the Gulf Coast area.

Roadside geology of Pennsylvania. By Bradford B. Van Diver. 1990. \$12.95. Available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806.

The journey through geological time is traced in the study of rocks. In Pennsylvania, there is incredible variety and

intricacy to be read in this geological record.

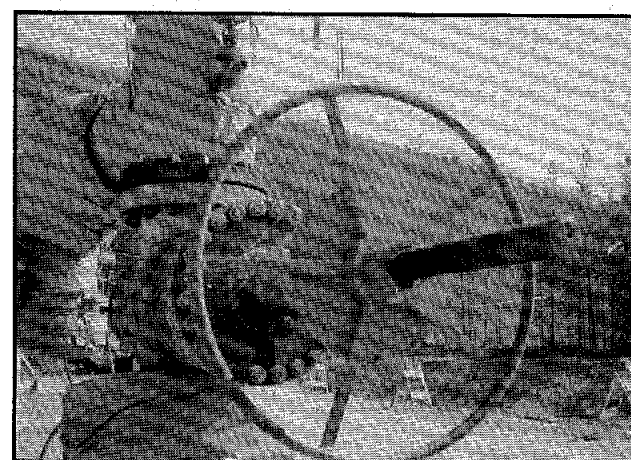
Earth dynamics are brought to life by the author as he guides the reader/traveler through roadcuts to view in the mind's eye the vast inland sea where Ordovician limestone was deposited; the scene of continental collision between ancestral Africa and North America some 300 million years ago, which folded and faulted sedimentary rocks of Mississippian and Pennsylvanian age; and the billion-year-old mountain range core of Precambrian gneiss and schist in the Pennsylvanian Piedmont region.

About one-third of the state is underlain by coal deposits. The fabulous Pittsburgh seam of bituminous coal, perhaps the world's single most valuable mineral deposit, was responsible for the development of Pittsburgh as a major industrial center of the United States.


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 at cost from the Division of Oil and Gas in Sacramento.



Drilling Permits for Geothermal Wells Approved January-November 1991 by the Division of Oil and Gas

<u>Date Notice Received</u>	<u>Operator & Well Name & No.</u>	<u>API No.</u>	<u>Sec. T. R.</u>	<u>Location & Elevation</u>
				
DISTRICT G1				
MODOC COUNTY				
09/11/91	MODOC JOINT UNIFIED SCHOOL DISTRICT "AL" 2	049-90036	11 42N 12E	Fr SW cor 191m N, 634m E, el 1336m gr
MONO COUNTY				
03/13/91	TOWN OF MAMMOTH LAKES "Ohwell" 1	051-90155	3 4S 27E	Fr NW cor 135m S, 105m E, el 2465m gr

<u>Date Notice Received</u>	<u>Operator & Well Name & No.</u>	<u>API No.</u>	<u>Sec. T. R.</u>	<u>Location & Elevation</u>
				
DISTRICT G2				
IMPERIAL COUNTY				
02/27/91	VULCAN POWER COMPANY "M" 6B	025-91193	33 11S 13E	Fr SE cor 52m N, 883m W, el -69m gr
02/27/91	RED HILL GEOTHERMAL, INC. "River Ranch" 14	025-91194	25 11S 13E	Fr SE cor 675m N, 1541m W, el -69m gr
RIVERSIDE COUNTY				
04/26/91	BAKER, GARY "Baker" 1	065-90167	4 3S 5E	Approx. center Sec., el 52m gr
SAN BERNARDINO COUNTY				
CITY OF TWENTYNINE PALMS				
02/21/91	"TNP" 2	071-90066	29 1N 9E	Fr NW cor 960m S, 1366m E, el 634m gr
02/21/91	"TNP" 3	071-90070	23 1N 9E	Fr SW cor 396m N, 305m E, el 610m gr
02/21/91	"TNP" 4	071-90067	14 1N 9E	Fr NW cor 1554m S, 46m E, el 549m gr
CITY OF LOMA LINDA				
02/22/91	"LL" 1	071-90069	26 1S 4W	Fr SE cor 964m N, 110m W, el 326m gr
02/22/91	"LL" 2	071-90068	25 1S 4W	Fr SW cor 671m N, 293m E, el 326m gr
				
DISTRICT G3				
LAKE COUNTY				
02/04/91	SANTA ROSA GEOTHERMAL COMPANY "Wolfe" 1	033-90727	26 11N 8W	Fr SW cor 656m N, 653m E, el 661m kb
NAPA COUNTY				
04/19/91	CALISTOGA MINERAL WATER COMPANY "CMW" 3	055-90124	31 9N 7W	Fr NW cor 538m S, 50m E, el 108m df
SONOMA COUNTY				
03/05/91	SONOMA COUNTY PLANNING DEPT. "SV" 1	097-90820	2 5N 6W	Fr NE cor 107m S, 76m W, el 37m gr

DIVISION OF OIL AND GAS GEOTHERMAL OFFICES AND MAPS

OFFICES

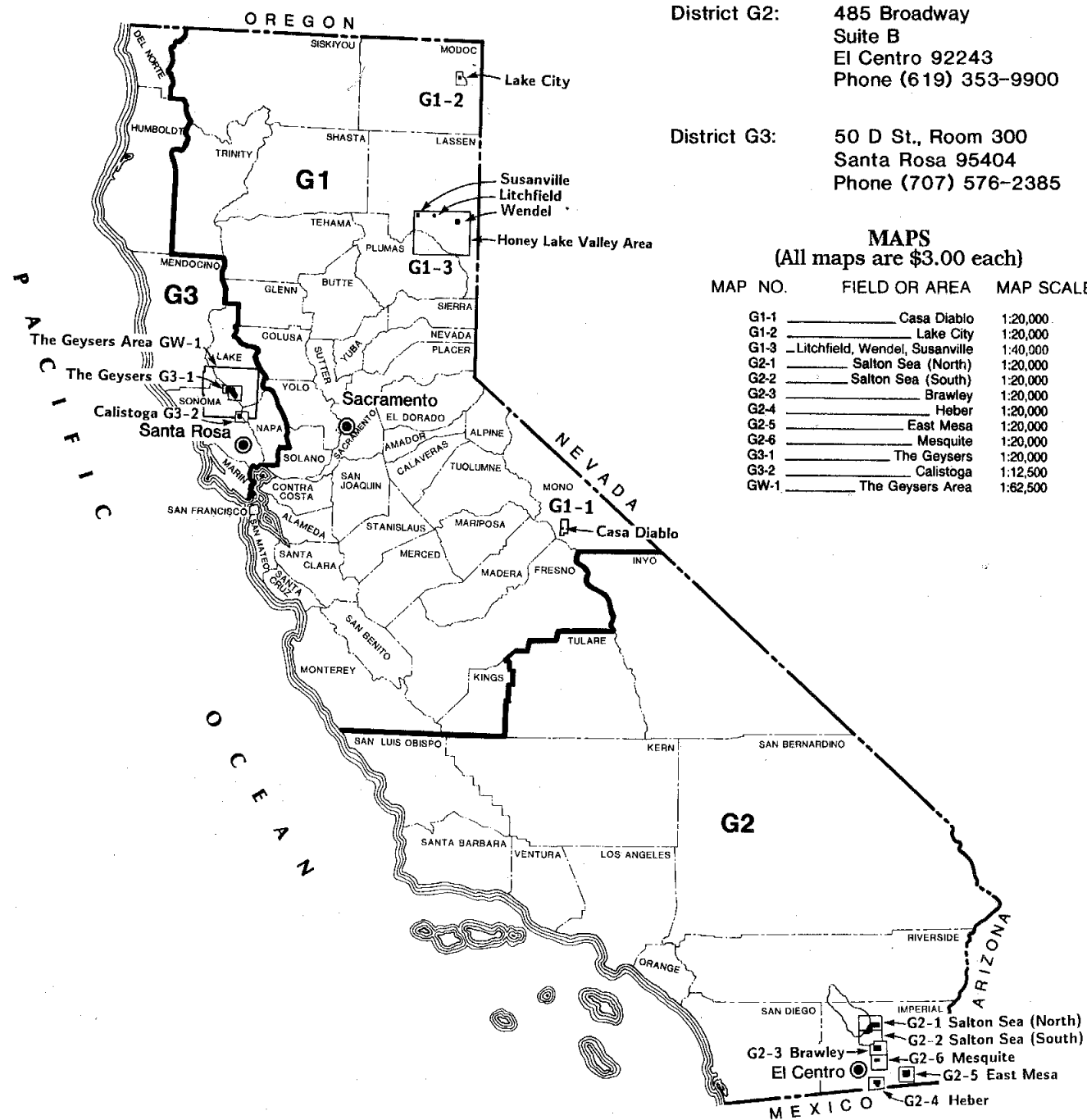
Headquarters
& District G1: 1416 Ninth St., Room 1310
Sacramento 95814
Phone (916) 323-1788

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



Division of Oil and Gas
1416 Ninth Street, Room 1310
Sacramento, CA 95814

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