

Dual-flash, geothermal power plant, Heber Geothermal field, in California's Imperial Valley. A production well is in the photo foreground.

Low salinity (14,000 ppm total dissolved solids), 360°F geothermal brine is piped from the wells to the power plant at a rate of 26 million gallons a day. This amount equals 8.1 million pounds of brine an hour or 30,000 acre feet a year. Photo by Susan F. Hodgson. (Story on page 70.)

RESOURCES AGENCY GORDON K. VAN VLECK, Secretary

GEORGE DEUKMEJIAN, Governor

An Open Memo to the Geothermal Community

From: A. D. Stockton

Several geothermal personnel changes have been made within the California Department of Conservation, Division of Oil and Gas. Among these is the appointment of Dick Thomas to my former position of geothermal officer. I will still have an interest in geothermal regulatory matters for the division, but not as directly as before.

Nine years ago, when I came to Sacramento as the geothermal officer, I came from the division's Long Beach office where I'd worked in oil and gas regulatory matters. Working with the Geothermal Unit meant quite a change, and I wondered what I was getting into--just what were geothermal resources? I wasn't the only one with questions. The courts were still out, trying to decide whether to call geothermal resources water, energy, or a mineral. If the courts didn't know, who did?



Well, it turns out that the entrepreneurs knew what geothermal resources were: a very risky way to try to make a profit. However, they were survivors. Many had worked at The Geysers, and others were pursuing projects throughout the state, from El Centro to Alturas.

To those pioneers and the people working with geothermal today, I salute you. I feel that every megawatt generated or Btu extracted from a geothermal resource testifies to the hard work and dedication of people working in the industry, utilities, and governmental agencies. So, just in case I can't thank everyone in person, may I thank you here for making my job as geothermal officer of the Division of Oil and Gas one of the most enjoyable I've ever had.



DIVISION OF OIL AND GAS M. G. MEFFERD, State Oil & Gas Supervisor



IN THIS ISSUE



page 77.



New geothermal power plant near Wendel, Ca., page 82.





The Hot Line is a biannual publication of the California Division of Oil and Gas. Subscriptions to the Hot Line are free. To subscribe, send your name and address to the California Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Susan F. Hodgson, Editor Richard Thomas and Robert Habel, Editorial Board Shirley Russell, Typist Jim Spriggs, Graphic artist

A look at the Vulcan Power Plant. page 74.

Governor Deukmejian visits The Geysers,

Tilapia raised in the Imperial Valley, page 86.

Desert Peak power plant on line, page 88.

Worldwide summary of geothermal power development, page 95.

Power Plants

Dual-Flash Plant Dedicated at Heber

The dual-flash, geothermal power plant in Heber Geothermal field was dedicated in a ceremony held on October 31, 1985, at the geothermal field. The \$130 million plant is in California's Imperial Valley.

The 47-megawatt net power plant includes 9 production wells, 8 injection wells, and a 14-mile injection pipeline.

"A lot of people think that geothermal is kind of an odd-ball thing, it's just a drop in the bucket, and why should we even worry about it if it's such a struggle," said R.E. Daniel, President of Chevron Resources Company, in a speech delivered at the dedication ceremony. "The beauty of geothermal," he continued, "is that it's a long-lived thing.

"We're confident that this field will produce for at least 30 years, and perhaps 60. It depends on the natural recharge.

"To put it in another perspective, we are probably looking at the possibility of upward to 10 such plants in this field. That means supplying enough electricity for 500,000 people, and all of the industry and all of the associated needs that go with a population of that size. That's a pretty big drop in the bucket," he concluded.

Developers of the Heber Geothermal Unit include Chevron Geothermal



Dual-flash geothermal power plant, Heber Geothermal field. Photo courtesy of Chevron Geothermal Company of California.

Company of California, Unocal Geothermal Division, Dravo Corporation, and Centennial Energy, Inc.

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

The Heber Geothermal Unit dual-flash operation involves delivery of 360°F, geothermal brine to the power plant from wells drilled between 4,500 and 10,500 feet deep on an adjacent 5-acre production island. The brine is flashed to steam that drives a turbine generator, producing electricity.

The cooler, 200°F brine is piped from the power plant to the injection island, where it is pumped back into the reservoir near the outer limits of the geothermal field.



High-pressure flash tank, auxiliary flash tank, and brine inlet area. Photos by Susan Hodgson.



Low-pressure flash tank.



Electrical transmission substation.

Heber Binary Plant Dedicated

On December 6, the Heber Binary Project was dedicated at ceremonies held on the 20-acre power plant site, near Heber, California, in the Imperial Valley.

The plant is the largest (45 megawatts net) binary power plant in the world. Binary-cycle technology offers a way to use moderate-temperature geothermal brines (150° to 210°C or 300° to 410°F) to generate electricity, effectively doubling the geothermal resources available for development through the next 15 years, according to an article in the January-February issue of the EPRI Journal.

The Heber plant began a 3-year operation and test period in June 1985. An important part of this program is studying how long before corrosion,

erosion, and scaling problems develop, how they develop, and how they can be resolved. The demonstration phase is scheduled to end in mid-1988, after which the plant may operate commercially. It is hoped the Heber Geothermal Project will demonstrate that large-scale binary cycle technology is able to generate electricity economically from moderate-temperature geothermal brines.

At the production island, $182^{\circ}C$ (360°F) geothermal brine is pumped from four production zones ranging from 2,000 to 10,000 ft. (610-3050m) deep. Each of 13 slant-drilled wells delivers 76 kg/s (600,000 lb/h) of brine at a pressure of 1.72 MPa (250 psia) to the plant's heat exchangers.

Hot geothermal brine flows through two, parallel brine-hydrocarbon heat exchanger trains of four units each. There, the hydrocarbon fluid is heated from a 38°C (101°F) liquid to a 152°C (305°F) supercritical vapor.

The spent brine is injected back into the reservoir, where it will be reheated.

The superheated hydrocarbon vapor spins the turbine that drives the 70 megawatt electrical generator.

The 44 ft. diameter (13.4m) carbonsteel hydrocarbon storage sphere can hold the entire hydrocarbon inventory when the plant is not operating. When the plant is running, the sphere is about 10 percent full.

The working fluid is a mixture of isobutane and isopentane. Over 8 million pounds of working fluid move through the plant every hour.

In the condensers, the hydrocarbon vapor is condensed to a liquid and cooled. Then, it is pressurized by the hydrocarbon circulation pumps and sent back to the heat exchangers for reheating.

The nine-cell cooling tower reduces the temperature of the cooling water, which circulates in the two condensers at 140,000 gal./min. (8830 kg/s), from 36° to 24° C (96 to 76 F).

Out in the electrical switchyard, the plant's electrical output is transformed from 13,800 Vac to 34,500 Vac and connected to the Imperial Irrigation District's distribution system for delivery to customers.

The Heber Binary Project is operated by San Diego Gas and Electric Company. Chevron Geothermal Company and Unocal Corporation developed the wells, which are operated by Chevron.

Other consortium members include:

Project Participants	Funding	Ownership
U.S. Department of Energy	50.0%	
Electric Power Research Institute (EPRI)	10.0%	
San Diego Gas & Electric	31,1%	82.5%
Imperial Irrigation District	3.8%	10.0%
Calif. Department of Water Resources	1.2%	3.2%
State of California	1.7%	4.3%
Southern California Edison	2.0%	

Heber Binary Project Statistics

Heber Reservoir

- Enough heat to generate an estimated 500 megawatts of electricity for 30 years.
- Average temperature 360°F ranging up to 375 F.
- Dissolved solid content of 14,000 parts per million.

Production Wells

- 13, ranging from 4,500 feet to 10,500 feet deep.

Injection Wells

- 9, located $1\frac{1}{2}$ miles northwest of the production wells.
- Injection temperature 160 F.

Heat Exchangers

- 8, weighing 319,000 pounds (160
- tons) each.
- 80 feet long and 80 inches diameter.

Hydrocarbon Storage Sphere

- Contains working fluid, 90% isobutane and 10% isopentane.
- 43 feet in diameter, capacity 300,000 gallons.
- Turbine Generator
- 70 MW rated capacity.
- Generator: 25 feet long, $13\frac{1}{2}$ feet wide, $11\frac{1}{2}$ feet high; Turbine: $15\frac{1}{2}$ feet long, $10\frac{1}{2}$ feet wide, $7\frac{1}{2}$ feet high; Together: 61 feet long.



Valley. Photo courtesy of San Diego Gas and Electric Company.

- 460,000 pounds (230 tons).

Hydrocarbon Condensers

- 2, weighing 610,000 pounds (305 tons) each.

- 82 feet long, 11 feet diameter.

Cooling Towers

- 9-cell tower.
- 135,000 gallons per minute water flow.
- 432 feet long, 58 feet wide, 51 feet high.

Cost

- \$188,500,000 (including 2-year demonstration).

The Heber binary geothermal power plant, near Heber, California, in the Imperial



The Vulcan Power Plant

Initial operation of Magma Power Company's Vulcan Power Plant began on December 4, 1985.

The overall cost of the Vulcan Power Plant was \$70 million, \$55 to \$60 million for the plant and the rest for the wells.

Electricity generated at the plant is being sold under the California Public Utilities Commission Standard Offer No. 4 to Southern California Edison. Twenty people are needed to operate the plant and the wells.

The geothermal power plant and wells are owned as a partnership, 50 percent by a subsidiary of Magma Power Company and 50 percent by a subsidiary of Burlington Northern.

(For more detailed information on the Vulcan Power Plant, see the article by Russ L Tenney, Manager of Operations, The Magma Power Company, in the July 1985 edition of the Hot Line.)



Model of the Vulcan dual-flash, geothermal power plant. The clarifier is in the left foreground and cooling towers, right background. The 32megawatt (net) power plant has 6 cooling towers, not 2 as depicted here.



View of the Vulcan Power Plant from the cooling towers. The clarifier is the domed structure in the background, center photo. Photos by Susan F. Hodgson.



Two, low-pressure flash-crystalizers (foreground) and two, high-pressure flash-crystalizers (background), all designed by Dow Engineering Company of Houston, Texas. The geothermal brine flows from a high-pressure flashcrystalizer into a low-pressure flashcrystalizer.



Close-up of a low-pressure flashcrystalizer. The brine first enters a high-pressure flash-crystalizer. Here, the brine is seeded to prevent silica scaling as the pressure is reduced to flash sufficient steam to drive the high-pressure turbine generator.

The unflashed brine, now heavily seeded, flows to the low-pressure flash-crystalizer. Here, the pressure is further reduced to generate sufficient steam to drive the low-pressure turbine.



After leaving the low-pressure flashcrystalizer, the unflashed brine flows to the reactor-clarifier, photo left. The fully developed crystals begin to settle and are pushed to the center by a rake. Here, they agglomerate and thicken. Clarified brine then flows out the top of the clarifier and is filtered to remove any suspended solids (bank of containers, photo right) before it is injected at temperatures around $220^{\circ}F$.

The solids are drawn off the bottom of the clarifier and flow to a thickener, where they are further concentrated. Then, a portion of this sludge is used to seed the inlet brine. The remainder is discarded.



The plant has independent, high-pressure (about 29 megawatts gross, photo foreground) and low-pressure (about 8 megawatts gross, photo background) turbine generators. Each turbine generator has its own condenser, but the two use a common cooling system.



View of the high-efficiency, Marley counterflow cooling towers.



Control room, Vulcan Power Plant.



Injection island. To date, 6 injection wells have been completed in the production zone. The necessary injection pressures are still undetermined. The Vulcan Power Plant, itself, is on the horizon.



On November 5, 1985, Unocal Corporation announced that operations at the Brawley Geothermal-Electric Project will be discontinued. The plant was operated for 5 years as a research and development facility for evaluating the feasibility of extracting geothermal steam from the highly saline brines found in the North Brawley Geothermal field in California's Imperial Valley.



Twelve production wells on 4 production islands have been drilled to supply brine to the power plant. The bottomhole temperature of the hottest well is about 575°F. The power plant was designed for 482°F geothermal brine.

Unocal Corporation is the developer of the geothermal steam resource for the facility. Southern California Edison operates the 10-megawatt generating plant on behalf of a partnership that includes Edison, the Los Angeles Department of Water and Power and the city-owned utilities of Burbank, Pasadena, and Riverside.

The Brawley pilot plant provided operating experience in extracting steam and producing electricity from a highly

saline, liquid-dominated geothermal resource. The project began operation in mid-1980 and has generated in excess of 134 million kilowatt-hours of electrical energy.

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

"Due to the declining energy market, it is not economically feasible to

25th Anniversary Fete at The Geysers

by Susan F. Hodgson



The 25th anniversary of commercial. electrical power generation at The Geysers Geothermal field was celebrated on October 23, 1985, at the field, which is about 90 miles north of San Francisco, California. Commercial electrical power generation began at The Geysers with the start of Pacific Gas and Electric Company (PG&E) power plant Unit 1 in 1960. Since 1973, the field has been the site of the world's largest complex of geothermal power plants.

Governor George Deukmejian, in his opening remarks at the anniversary ceremony, said "The Geysers is indeed

continue operating this small developmental project, " said Otte. "While it is unfortunate that we have to close the plant, the project did fulfill its major goals. We wanted continuous experience in operating a geothermal fluid production and injection system, and we wanted to evaluate methods of controlling corrosion, scaling, and well-plugging problems."

Brawley was the first demonstration project of its type.

On January 8, 1986, the last of the wells was plugged and abandoned. The steam-gathering and generating plant equipment will be removed from the site.

Scene at The Geysers Geothermal field. Left to right, electrical transmission lines, power plant, cooling towers. producing well with pipelines to plant, and drilling rig.

> the world's largest geothermal power system, and a very critical component of California's energy supply.

> "Our state and nation have learned the hard way we cannot bury our heads in sand when it comes to energy. We have determined that you have to help the energy producers in California if we're going to be able to provide more access to energy for consumers throughout our state."

> Frederick W. Mielke, Jr., PG&E chairman and chief executive officer who also spoke at the ceremony, said that

25 years ago, PG&E's "...dedication of a small 11 megawatt geothermal plant might have seemed of small significance in terms of size. But we now know that it was an epoch-marking event, because that plant demonstrated what could be done here. It was the forerunner of a series of 19 geothermal plants built by PG&E, a geothermal generating complex that is the largest in the world."

In 1984, PG&E power plants at The Geysers provided about 95 percent of the U.S. geothermal production and about 10 percent of PG&E's distributed electricity. Unocal Corporation, PG&E's largest steam producer at The Geysers, supplies geothermal energy to fuel nearly 1,000 megawatts of PG&E's total capacity. Other PG&E steam suppliers are GEO Operator Corporation and Geysers Geothermal Company.

"Geothermal steam in commercial quantities was first discovered at The Geysers in 1955 by Magma Power Company under the leadership of B.C. McCabe," Fred Hartley, Chairman and President of Unocal Corporation, said at the ceremony. "In 1969, we committed the company to an all-out exploratory drilling campaign to establish the size of existing reserves. In 1970, we signed our first sales contract with PG&E."

The Geysers Geothermal field is one of PG&E's most economical electrical generating facilities. Over the expected life of the field, electricity generated from geothermal energy will cost about 25 to 35 percent less than electricity generated from fossil fuel. Each 110 megawatts of capacity at The Geysers offsets the need to burn about 1 million barrels of oil. In d984, electrical generation at The Geysers saved PG&E customers about \$300 million.

PG&E employs several hundred people at The Geysers. By 1990, PG&E will have paid an estimated \$19.5 million to Sonoma County and \$9.3 million to Lake County in geothermally-related property taxes.



<section-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header>

National Historic Mechanical Engineering Landmark award presented to Pacific Gas and Electric Company by the American Society of Mechanical Engineers, the 109th such award of the ASME. UNIT 1 The Geysers Power Plant

On September 25, 1960, Unit 1 of The Gaussers Power Plant started commercial operation as the first geothermal electric generating station run by a utility in the United Status. The genus and vision of the pioneers who harnessed the earth's natural powers for the benefit of others are commercisted on this day. September 25, 1985, the 25th anniversary of the start-up of Unit 1.

"It's my pleasure and privilege to be able to unveil a plaque which will commemorate the 25th anniversary of the first commercial operating unit by PG&E at The Geysers," said Governor George Deukmejian during ceremonies commemorating this event at The Geysers Geothermal field. Photos by Susan F. Hodgson.

Power Plant Units 16 and 20 On Line at The Geysers

Pacific Gas and Electric Company (PG&E) placed two geothermal power plants in commercial operation on Friday, October 18, 1985, at The Geysers Geothermal field, raising the total generating capacity at the field to 1,667 megawatts net.

Both of the new units, Unit 16 and Unit 20, went into operation about 6 weeks ahead of schedule and are estimated to be completed about \$62 million under budget, according to George A. Maneatis, PG&E executive vice president - facilities and electric resources development. Each unit is capable of generating 113 megawatts (net) of electricity. Unit 16 is in Lake County; Unit 20 is in Sonoma County.

The expected cost to complete Geysers Unit 16 is \$132 million, \$30 million less than the pre-construction estimate of \$162 million. For Geysers Unit 20, the final cost is expected to be \$117 million, \$32 million less than the \$149 million estimate.

PG&E Will Build Largest Geothermal Unit at The Geysers

On June 12, 1985, Pacific Gas and Electric Company (PG&E) received permission from the California Energy Commission (CEC) to build what will be the largest electrical generating unit at The Geysers Geothermal field.

The Application for Certification approved by the CEC allows PG&E to build and operate a 140 megawatt electrical generating unit in Lake County, about 2 miles west of Pine Grove, on the northwestern slopes of Cobb Mountain. The plant will be known as Unit 21 and will be the 20th PG&E power plant in the field. It is scheduled to begin commercial operation in 1988.

The new unit will bring PG&E's generating capability at The Geysers to about 1,500 megawatts in 1988. That will be enough electricity to meet the needs of a community of about 1.5 million people.

Costs for constructing Unit 21 are estimated at \$210 million.

Unocal/Natomas will drill and operate the wells necessary to provide more than 2.25 million pounds of natural dry steam per hour to run the new power plant's turbine-generator.

Unit 21, after it begins commercial operation, will account for nearly 22 percent of PG&E's geothermallyrelated property taxes to Lake County.

South Geysers Power Plant: Update

Full construction on the California Department of Water Resources, South Geysers geothermal power plant has been suspended because of a steam supply problem. Construction costs of the 55 megawatt power plant have reached about \$50 million and about \$30 million in expenditures are needed to complete the project.

Construction was suspended because wells drilled by the steam supplier, Geothermal Kinetics, Inc., could only supply about one-fourth or less of the steam needed to operate the power plant.

The Department of Water Resources is discussing arrangements with Pacific Gas and Electric Company for proceeding with the power plant completion and obtaining the necessary supplemental steam. Specifications for Pacific Gas and Electric Company Power Plants at The Geysers Geothermal Field, Northern California.

	UNIT 1	UNIT 2	UNITS	UNITS	UNITS 7 & 8	UNITS 9 & 10	UNIT
DATE OF COMMERCIAL OPERATION	9/25/60	3/19/63	11/2/68	12/15/71	11/23/72	11/30/73	5/31/75
COST	\$3,78	34,000	\$7,534,000	\$11,954,000	\$11,520,000	\$13,492,000	\$19,761,000
GROSS MW CAPACITY (NET)	12.5 (11)	14 (13)	28.8 (27)	55 (53)	55 (53)	55 (53)	110 (106)
LOCATION	SONOMA CO.	SONOMA CO.	EACH SONOMA CO	SONOMA CO.	EACH SONOMA CO.	SONOMA CO.	SONOMA CO
TURBINE DATA	e				-		
MANUFACTURER	GENERAL ELECTRIC	ELLIOT DIV & CARRIER CO	ELLIOT DIV & CARRIER CO	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
SPEED (RPM)	1800	3600	3600	3600	3600	3600	3600
NUMBER OF STAGES	6	1.	7	6 × 2	6 × 2	-6 × 2	6×4
STEAM FLOW (lbs./m)	240,000	232,750	517,000	907,530	907,530	907,530	1,906,000
GENERATOR							
MANUFACTURER	GENERAL ELECTRIC	ELECTRIC MACHINERY CO.	ELECTRIC MACHINERY CO.	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
TYPE OF COOLING	AIR COOLED	AIR COOLED	AIR COOLED	HYDROGEN CODLED	HYDROGEN COOLED	HYDROGEN COOLED	HYDROGEN COOLED
NUMBER OF POLES	4	2	2	2	2	2	2
RATING (KVA)	12,500	15,625	32000	66,000	66,000	66.000	132,000
POWER FACTOR	1.0	0.9	0.9	0.9	0.9	0.9	0.9
VOLTAGE (VOLTS)	11,500V	13,800V	13,800∨	13,800V	13,800V	13,800V	13,800V
CURRENT (AMPS)	628A	653A	1340A	2761A	2761A	2761A	5523A
MAIN TRANSFORMER							
MANUFACTURER	GENERAL	GENERAL ELELCTRIC	GENERAL ELECTRIC	McGRAW EDISON CORP	McGRAW- EDISON CORP.	McGRAW- EDISON CORP.	ALLIS CHALMER MFG CO.
TYPE	STEP UP	STEP UP	STEP UP	STEP UP	STEP UP	STEP UP	STEP UP
RATING (KV)	11.5 TO 60	13.8 TO 60	13.8 TO 60	13.8 TO 115	13.8 TO 115	13.8 TO 115	13.8 TO 115
CONDENSER		· · ·					
MANUFACTURER	INGERSOLL	INGERSOLL	ELLIOT CO.	INGERSOLL	INGERSOLL BAND	INGERSOLL RAND	WESTINGHOUSE
ТҮРЕ	BAROMETRIC	BAROMETRIC	BAROMETRIC	DIRECT	DIRECT	DIRECT	DIRECT
CONDENSER PRESSURE (IN Hg. Abs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COOLING WATER USED (GPM)	11,000	12,500	11,625	42,650	42,550	42,550	84,280
COOLING TOWER							
MANUFACTURER	FLOUR CO.	FOSTER WHEELER CORP	FLUOR CO.	MARLEY CO.	ECODYNE CORP.	ECODYNE CORP.	MARLEY CO REPLACEMENT TOWER
ТҮРЕ	COUNTER FLOW	CROSS FLOW	COUNTER FLOW	CROSS FLOW	CROSS FLOW	CROSS FLOW	CROSS FLOW
NUMBER OF CELLS	3	3	3(6 FANS)	5 5	5 5	5 EACH	9 9
COOLING CAPACITY (GPM)	12,000	14,000	29,000	50.000	50,000	50,000	100,000
TEMPERATURE COOLING BATE	120 ⁰ TO 80 ⁰	120 ⁰ 7O 80 ⁰	120 ⁰ TO 80 ⁰	120 ⁰ TO 80 ⁰	120 ⁰ TÒ 80 ⁰	120 ⁰ TO 80 ⁰	124 ⁰ TO 79 ⁰
CRANE			-		an a		
MANUFACTURER	MOFFET	MOFFET	CHECO	CHECO	SIERRA CRANE	SIERRA CRANE	SIERAA CRANE
NUMBER OF CRANES	ENG CO. 1	1	1	t	1	1	1
LIFTING CAPACITY	20 TONS	20 TONS	20 TONS	25 TONS 5 TONS AUX HOOK	25 TONS 5 TONS AUX HOOK	25 TONS 5 TONS AUX HOOK	32 TONS W/ 12 TONS AUX HOIST
STEAM SUPPLY	and the second		1 · ·				
SUPPLIER	UNION-			UNION- THERMAL	UNION	UNION- THERMAL	UNION THERMAL
NUMBER OF WELLS	19E 8MAL	4	4	9	10	10	18
ABATEMENT SYSTEM	INCINERATOR	INCINERATOR	IRON/CATALYST SYSTEM	IRON/CATALYST SYSTEM	INCINERATOR	IRON/CATALYST SYSTEM	IRON:CATALYST SYSTEM
SUPPLEMENTAL ABATEMENT	H ₂ O ₂ & NaOH	H ₂ O ₂ & NaOH	H202 & NaOH	H2O2 & NaOH	Н ₂ О ₂ & №ОН		H ₂ O ₂ & №OH

Reprinted, with permission of the American Society of Mechanical Engineers, from the publication "The Geysers - Unit 1, a National Historic Mechanical Engineering Landmark."

UNIT 12	UNIT 13	UNIT 14	UNIT 15	UNIT 16	UNIT 17	UNIT 18	UNIT 20	UNIT 21
3/1/79	5/15/80	9/12/80	6/17/79	DEC. 85 (SCHED.)	12/18/82	2/15/83	DEC. 85 (SCHED)	DEC. 88 (SCHED.)
\$35,000,000	\$56,000.000	\$65,000,000	\$37,000,000	UNDER CONST	\$ 93,000,000	\$83,000,000	UNDER CONST.	BEING DESIGNED
110. (106).	139 (134)	. 118 (114)	60 (57)	120 (113.4)	120 (113.4)	120 (113.4)	120 (113.4)	151 (144)
SONOMA CO	LAKE CO.	SONOMA CO	SONOMA CO	LAKE CO.	SONOMA CO	SONOMA CO.	SONOMA CO.	· LAKE CO.
and the second								
TOSHIBA	GENERAL	TOSHIBA	GENERAL	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	MITSUBISHI
3600	ELECTRIC 3600	3600	3600	3600	3600	3600	3600	3600
6 × 4	5×4	6 x 4	5 x 2	6 × 4	6×4	6 x 4	6 x 4	6×4
1,906,000	2,490,000	1,873,000	973,000	1,905,550	1,905,550	1,905,550	1,905,550	2,100,000
TOSHIBA	GENERAL	TOSHIBA	GENERAL	TOSHIBA	тозніва	TOSHIBA	TOSHIBA	MITSUBISHI
HYDROGEN	ELECTRIC HYDROGEN	HYDROGEN	ELECTRIC HYDROGEN	HYDROGEN	HYDBOGEN	HYDROGEN	HYDROGEN	HYDROGEN
COOLED 2	COOLED 2	COOLED 2	COOLED 2	COOLED 2	COOLED	COOLED	COOLED	COOLED
132,000	155,300	132,000	70,000	137,800	137,800	137,800	137,800	187,000
0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
13,800V	13,800V	13,800V	13,800V	13,800V	13,800V	13,800∨	13,800∨	13,800V
5623A	6497A	5523A	2950A	5.766A	5.766A	5,766A	5.766A	7,824A
FEDERAL	EEDEBAI	EEDERAL	FEDERAL	FEDERAL	EGDERAL	ffDCB AL	CEDED A)	FEDDANTI DAGKADD
STEP UP	STEP UP	STEPLIP	STEP UP	STEP HP	STEPLIP	STERING	PEDENAL	FERRAN I PALKARO
13.8 TO 230	13.8 TO 230	13.8 TO 230	138TO 115	13.8 TO 230	13.8 TO 230	13.8 TO 230	13.8 TO 220	13.8 TO 220
			101010110	10.0 10 200	10.010200	10.010200	10.0 10 230	13.0 10 230
WESTINGHOUSE	ECOLAIRE	ECOLAIRE	ECOLAIRE	TRANSAM-DELAVAL	TRANSAM-DELAVAL	TRANSAM-DELAVAL	ECOLAIRE	COMBUSTION ENGINEERING
CONTACT	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE
4.0	5.0	3.0	4.0	3.0	3.0	3.0	3.0	2.0
84,280	116,500	147,000	65,000	139,750	139,750	139,750	139,750	178,250
:								
ECODYNE COAP	MARLEY CO.	MARLEY CO.	MARLEY CO.	MARLEY CO.	MARLEY CO.	MARLEY CO.	MARLEY CO.	LILIE-HOFFMAN
CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH DRAFT	CROSS FLOW MECH. DRAFT	CROSS FLOW MECH. DRAFT
9	10 .	10	5	11	11	· 11	11	17
100,000	135,000	152,000	68,000	165,000	165,000	165,000	165,000	242,000
120° TO 80°	120 ⁰ TO 80 ⁰	10 ⁰ TO 80 ⁰	120 ⁰ TO 80 ⁰	105 ⁰ TO 80 ⁰	105 ⁰ TO 80 ⁰	105 ⁰ TO 80 ⁰	• 105° TO 80°	97° TO 79°
							-	
SIERRA CRANE & HOIST CO 1	SIERRA CRANE & HOIST CO 1	SIERRA CRANE & HOIST CO	SIERRA CRANE & HOIST CO. 1	SIERRA CRANE & HOIST CO 1	SIERRA CRANE & HOIST CO 1	SIERRA CRANE & HOIST CO. 1	SIERRA CRANE & HOIST CO 1	SIERRA CRANE & HOIST
32 TONS W 12 TON AUX HOIST	45 TONS W/ 10 TONS AUX HOIST	32 TONS W/ 12 TONS AUX HOIST	25 TONS W/ 10 TONS AUX HOIST	32 TONS W 12 TONS AUX HOIST	32 TONS W/ 12 TONS AUX HOIST	32 TONS W: 12 TONS AUX HOIST	32 TONS W 12 TONS AUX HOIST	45 TONS W 12 TONS AUX HOIST
UNION THERMAL 18	PHILLIPS USA INC 21	UNION THERMAL 15	GEOTHERMAL RESOURCES, INC TO	PHILLIPS USA INC 15	UNION THERMAL 15	UNION- THERMAL 15	UNION THERMAL 15	UNION THERMAL
IRON CATALYST	STRETFORD	STRETFORD	STRETFORD	STRETFORD	STRETFORD	STRETFORD	STRETFORD	STRETFORO
SYSTEM	н ₂ 0 ₂ 8	H202 &	H202 &	H ₂ O ₂ &	H202 &	н ₂ 0 ₂ &	H202 &	н ₂ 0 ₂ &
<i>∠ ∠</i>	CATALYST	CATALYST	CATALYST	CATALYST	CATALYST	CATALYST	CATALYST	CATALYST
				L	1			

80

Geothermal Power Plant On Line Near Wendel

by Susan F. Hodgson

The Wineagle Power Project is in northeastern California, near Wendel. The binary-cycle, geothermal power plant went on line June 11, 1985. Electricity generated from the power plant equals about 0.75 megawatts, gross, and about 0.60 megawatts, net (an amount that fluctuates seasonally). The electricity is transmitted through CP National, a local utility, to the Pacific Gas and Electric Company (PG&E) grid, where it is purchased by PG&E.

An on-site attendant is not necessary to operate the two power-plant modules as both are computer-operated, and automatically carry out most of the required operations. The units restart automatically after a forced power outage. Periodically, a maintenance worker checks the Freon and hot-water flows and lube pressure, and checks for any malfunctions in the systems. As long as everything is normal, the power-plant modules continue to run by themselves.

When asked about plans to expand the Wineagle Power Project, project manager Brite Bowker said that presently, there are two ways being considered.

One is to drill a second, backup well at the site and add a 0.3 megawatt power-plant module. The second, more ambitious plan, called Phase Two, would be to drill two more wells and add power-plant modules capable of generating 1.35 megawatts of electricity.

The Wineagle Power Project is owned by Wineagle Developers, a California Limited Partnership, and managed by Carson Development Company, Inc. of Sacramento, California. The power plant modules were designed and manufactured by Barber-Nichols Engineering, Arvada, Colorado. For further information, contact Brite Bowker, Carson Development Company, Inc., 1722 Third Street, Sacramento, CA 95814; phone (916) 443-3797.



The two, identical power plant modules at the Wineagle Power Project are mounted on 10 ft. by 40 ft. cement slabs. Each unit is self-contained and includes the heat exchangers, a turbine generator, and controls.

The fans on top of the units are evaporative condensers. Airflow from the fans and water pumped into the units are used to cool the working fluid, which is Freon R114. Photos courtesy of Carson Development Company, Inc.



Side view of a power plant module.



Well "Wineagle" 1, the geothermal production well for the Wineagle Power Project. The spent geothermal fluid is disposed of at the surface. Total dissolved solids in the fluid equals about 1,000 ppm, and no corrosion problems have occurred. A shaft-driven pump is on the well.



Top cylinder, photo right, is the separator. The cylinder beneath it is the evaporator. A preheater, just out of the photo, is under the two cylinders.

The hot, geothermal fluid passes through a pipe encased in a larger pipe filled with Freon Rll4, the working fluid. The Freon is heated and vaporizes, turning the turbine to generate electricity.



The generator, center photo, is just to the right of the "caution" sign. A single-stage, axial flow turbine is to the left of the sign.

"The plant is running very well," said Ken Nichols of Barber-Nichols Engineering. "In December, it ran over 98 percent of the time."

Freeport-McMoRan Begins Geothermal Enterprise

Geysers Geothermal Company became a subsidiary of Freeport-McMoRan Inc. of New Orleans, Louisiana, on November 22, 1985. Steam from Geysers Geothermal Company wells at The Geysers Geothermal field in Northern California is purchased by the Sacramento Municipal Utility District to operate power plant SMUDGEO 1, and by Pacific Gas and Electric Company to operate power plant Units 13 and 16 (and Unit 19, when it goes on line).

"At Freeport-McMoRan, we want to develop geothermal electrical generation projects in other parts of California, as well," said Jack Von Hoene, president of Geysers Geothermal Company. "We plan to undertake electrical generation and minerals extraction projects on our geothermal leases in the Imperial Valley."

Freeport-McMoRan is a company with a large variety of oil, gas, and mineral

Division of Oil and Gas

Division Geothermal Personnel Change

Richard Thomas has been named the new Geothermal Officer of the California Department of Conservation, Division of Oil and Gas. He has been employed by the division since 1974. He will manage the division's three geothermal districts, which have offices in Santa Rosa, El Centro, and Sacramento.

Thomas replaces A. D. (Doug) Stockton, who has been promoted to Technical Services Manager for the division.

Rob Habel will assume Thomas' former position of Assistant Geothermal Officer in charge of Geothermal District Gl. This district covers much of Northern California except for The Geysers Geothermal field and the northern coastal counties.

development interests, worldwide. In 1912, the company was extracting molten sulphur from wells by injecting 325°F water into sulphur-bearing formations, a method called the Frasch process. In the 1940's, the company began to inject brine instead of fresh water into these wells. It is this experience using hot brines and minerals extraction processes that will be brought to the development of the geothermal properties.

"We look forward to developing this valuable California resource to its fullest potential," said Milton Ward, president and chief operating officer of Freeport-McMoRan.

Mono Power Company is selling its geothermal resource interests in California and Nevada.

For further information, contact Richard Grass, Morrison-Knudsen Engineers, (208) 386-6256.

Habel comes to the division from the California Department of Conservation. Division of Mines and Geology, where he worked as an Assistant Geologist. Prior to this, he worked for the Division of Oil and Gas as an Energy and Mineral Resource Engineer.

Personnel and Cost Changes for the CEQA Unit

The Division of Oil and Gas is designated by the California State Legislature as the lead agency under the California Environmental Quality Act (CEQA) for all geothermal exploratory drilling projects on private and state lands in California. A lead agency is responsible for preparing project environmental documentation.

Bernd Beutenmuller, once in charge of the division's CEQA Unit, has left the division for a position in another state agency.

The division's CEQA responsibilities will now be handled by the Assistant Geothermal Officer, Rob Habel.

In the past, division expenses for preparing and overseeing CEQA documents have been reimbursed by charging for time worked, overhead, and travel expenses. To simplify the accounting process, the division now charges flat fees for providing these same services. These fees are based on the average billings for division

General

Program Geothermal Te U.S. Departs (\$ Th

HYDROTHERMAL INDUSTRIALIZATION • STATE R&D PROJECTS

GEOPRESSURED

GEOTHERMAL TECHNOLOGY DEVELOP

- HOT DRY ROCK RESEARCH
- HARD ROCK PENETRATION RESEA
 - HYDROTHERMAL TECHNOLOGY R
 - BRINE INJECTION
 - RESERVOIR TECHNOLOGY - HEAT CYCLE RESEARCH
 - PERMEABILITY ENHANCEMENT
 - MATERIALS/IN-LINE INSTRUMENTATION
- SALTON SEA SCIENTIFIC DRILLING PROGRAM - CASCADES
- GEOTHERMAL TEST FACILITY
- MAGMA ENERGY EXTRACTION

TECHNOLOGY TRANSFER

CAPITAL EQUIPMENT

PROGRAM DIRECTION

TOTAL

***** Included in individual projects

services during the last 4 years and are as follows:

Notice of Exemption	\$	500
Negative Declaration	\$2	,000
Environmental Impact Report	\$5	,000

In spite of the staff reduction, which will reduce the amount to be raised by the annual geothermal well fee, the division intends to maintain the level of environmental review service that has been provided in the past to operators drilling geothermal exploratory wells in California.

Budget Table		
chnology Division	1	
ment of Energy	_	
ousands)		
	<u>FY 1985</u>	<u>FY 1986</u>
	\$ 1,002	\$ 2,000
	5,303	4,600
	9.344	7.925
ARCH	4,060	2,500
RESEARCH	10.090	8,475
1	(1.639)	(1,900)
	(2,087)	(1,900)
	(1,300)	(800)
	(750)	(500)
	(1,410)	(775)
	(1,037)	(1,000)
	(1,535)	(1,400)
	(332)	(200)
	1,380	1,900
	900	0
	401	0*
	401	Ū.
	1,031	800
	\$33,511	\$28,200

0*

Geothermal Trade Association Formed

A new geothermal trade organization was formed on October 22, 1985. Called the Geothermal Resources Association (GRA), the group will perform certain trade association functions, such as lobbying for companies in all phases of the geothermal industry. The GRA is an organization independent of the Geothermal Resources Council.

The GRA will concern itself with governmental affairs as they affect the geothermal industry. It will monitor and report on congressional and federal administrative activities that may impact the industry. Where

Imperial Valley

Tilapia Raised in the Imperial Valley

"If you see tilapia in a restaurant, try one. Pretty soon, they'll be everywhere," said Bill Engler of Pacific Aquafarms.

Bill raises tilapia, a genus of African freshwater fish resembling the American sunfish. The fish live in geothermal waters extracted from his 480 foot well at a temperature of 147[°]F. His business is in the northern Imperial Valley, near Niland, California.



A pond at Pacific Aquafarms near Niland, California. Photos by Susan F. Hodgson.

the interests of members are particularly affected by such governmental activities, the GRA will conduct informational and lobbying efforts to explain the needs of the geothermal industry to decision makers.

The GRA will be incorporated in California as a nonprofit mutual benefit corporation. It will be organized under Section 501(c)(6) of the Internal Revenue Code and its operation office will be located in Washington, D.C.

To contact the GRA, write the Geothermal Resources Association, P.O. Box 598, Davis, CA 95617; (916) 758-2356.

Bill sells the fish, live, to his customers in San Diego and Los Angeles. It takes about 8 months for a fish to reach sale weight.



Tilapia from Pacific Aquafarms.

Salton Sea Deep Drilling Project: Diabase Found

Drilling began at the U.S. Department of Energy - Salton Sea Scientific Drilling Project (SSSDP) on October 23, 1985. The 10,000-foot well is being drilled at a site in the Imperial Valley close to Niland, California. The Division of Oil and Gas drilling permit for the well, called a Report on Proposed Geothermal Operations, was printed in the July 1985 issue of the Hot Line.

What follows are two portions of the drilling record for the well. The first is reprinted from the Dept. of Energy periodic report of progress at the well site. The second is the result of an interview with Raymond Wallace, US-DOE program manager for the SSSDP.

Part I: 3,515 ft. to 5,336 ft.

"On November 14, 13-3/8 inch casing was run into the well, hung to a depth of 3,515 ft., and cemented into place. Drilling then continued to 3,790 ft., where the USGS ran a temperature survey of the well, measuring a maximum temperature of 400°F (204°C) in 4 hours. Estimated equilibrium temperature at this depth was not greater than 437°F (225°C). The expected value was 500°F (260°C), based upon a nearby well--River Ranch No. 1. The 8th core was taken from 3,790 to 3,850 ft., with little or no fracturing and minimum alteration noted.

"Drilling and coring continued to 4,678 ft., where the USGS ran another temperature survey, measuring a maximum temperature of 414°F (212°C) and climbing. Equilibrium temperature estimates ranged from 500-588 F (260-309°C). The lower than expected temperatures being encountered in the SSSDP well are supported by the observation that alteration minerals (epidote and chlorite), which were pervasive in Cores 4, 5, and 6, occurred only in trace amounts in Cores 8 through 11. Core #12 (4,643-4,676 ft.), however, contained abundant epidote and specular hematite veins in extensively fractured sandstone and siltstone. Core #13 was similar, but contained large chalcopyrite crystals.

Based upon the fracturing and mineralogy observed in Cores 12 and 13 and the results of temperature surveys, it was decided to conduct a miniinjection test of the open-hole interval from about 3,515 to 4,686 ft. The test indicated that the permeability in this interval was too low to sustain flow, and drilling was resumed.

On November 26, four welded stabilizer blades broke off and were lost in the hole. Fishing operations resulted in the recovery of about 1 ft. of epidotized mudstone (Core #14), but no junk from a depth of about 4,718 ft. Three mill bits were used in this operation. When drilling resumed at 4,722 ft. on the 27th, penetration was slow and torque high. Hole deviation increased from $4^{\circ}15'N$, $13^{\circ}E$ at 4,764 to $3^{\circ}45'N$, $45^{\circ}E$ at 5,138 ft.

On December 1st, Core #15 was cut from 5,188 to 5,218 ft., with 100% recovery of a black indurated mudstone exhibiting pyrite and minimum alteration. A "slip and dog" core catcher was used in this coring operation because of the poor recovery of Core #13.

"Concern over wellbore deviation continued as directional surveys on December 2, at depths of 5,228 ft. and 5,336 ft., showed an increase from 4 45'N, 58°E (83 ft. E, 149 ft. N) to 6°15'N, 73°E. An attempt at controlling deviation by decreasing weight-on-bit (and drilling rate to 4 ft./hr.) was unsuccessful. This problem is to be corrected after the 9-5/8 casing is set and cemented."

Part II: Diabase Discovered, 9,443 ft. to 9,473 ft.

On or about February 11, 1986, in the 9,443 ft. to 9,453 ft. interval, the mudlogger reported cuttings of 50% claystone-mudstone-siltstone and 50% recent diabase.

The drillstring was pulled from the hole to change to a coring bit, and circulation was lost.

The well was reentered and cored from 9,453 ft. to 9,458 ft. (Core #32). 2.4 ft. of recent diabase fractured with veins of chlorite, epidote, and quartz was recovered.

About February 13, 1986, the well was cored from 9,458 ft. to 9,473 ft. (Core # 33). Dr. Wilfred Elders, Chief Scientist for the project, identified the core material as fresh, medium- to fine-grained diabase with 1 mm-thick veins of fresh olivine. The bottom of the dike forms a contact zone with very highly altered sandstone containing thin, diabase-filled fractures. This may be the beginning of the heat source penetration.

"I think we will reach 10,000 ft., barring serious problems, and anything beyond that will be gravy. We will drill until the drilling funds are expended," said Raymond Wallace, US-DOE program manager for the deep drilling project.

"\$225,000 has been set aside for the final flow test and \$135,000 for securing the site for 6 months while the scientists run down-hole well tests.

"The first flow test occurred in the 6,120 ft. to 6,160 ft. interval. The preliminary flow rate equaled 475,000 lb./hr. The downhole pressure was 2,492 psi and the reservoir tempera-

Drilling State Well 2-14, the U.S. Department of Energy - Salton Sea Scientific Drilling Project, at the southern end of the Salton Sea in California's Imperial Valley, Photo by Susan F. Hodgson.

ture 305[°]C. Total dissolved solids equaled 245,000 parts per million.

"The last good temperature measurement of the well was 326.7°C at 6,227 ft., " Wallace concluded.

Nevada

Phillips Desert Peak Project On Line

A 9-megawatt Phillips Petroleum Company geothermal power plant at Desert Peak, Nevada, 65 miles northeast of Reno, has begun generating electricity. Steam flashed from hot water extracted from geothermal wells is used to operate the plant, which began commercial

operation on December 20, 1985. Commercial generation of electricity at the site marks the end of a threeyear cooperative pilot project between Phillips and Sierra Pacific Power Company, according to Jim Rosser, Phillips' project engineer at Desert Peak.



Phillips Petroleum Company geothermal power plant at Desert Peak, Nevada, 65 miles northeast of Reno.

A 10-year contract with Phillips calls for Sierra Pacific to purchase a maximum of 9 megawatts of geothermal power from the pilot project.

The Desert Peak plant operates on a operations in October. unique hybrid "flash cycle" whereby a Biphase rotary separator turbine The Desert Peak project is the first is used in conjunction with a dualadmission steam turbine to generate designed, built, and operated by electricity. In the process, the Phillips. Phillips Petroleum developed and operates a geothermal hot geothermal brine that reaches the surface is quickly depressurized or field at Roosevelt Hot Springs "flashed" by the rotary separator near Milford, Utah. turbine to turn it into steam for use as a working fluid in the steam turbine, as well as converting the kinetic Elko Junior High School Geothermal energy to shaft power. Well

Rosser said that highly efficient separators and steam purifiers will be used to prevent minerals in the geothermal steam from collecting on and damaging the turbine and other equipment in the plant.

To transport electricity generated at the plant, a 120,000-volt transmission line to Desert Peak and a substation were built. Both new facilities were connected and began

geothermal electric generating plant

by David Carlson William E. Nork, Inc.

In September 1984, construction began on a geothermal production well for the Elko County School District at the



Elko Junior High School well construction and lithologic log.

site of the junior high school, Elko, Nevada. The 1,971 foot-deep well was completed February 4, 1985. The major production zone is fractured quartzite or silicified siltstone below a depth of 1,950 feet.

The well was constructed to isolate the production zone from the shallow, alluvial, cold-water aquifer used by the City of Elko for its municipal water supply. This was accomplished by installing blank casing to a depth of 1,347.5 feet and sealing the annulus with a cement and bentonite slurry. The production zone (1,876 to 1,971 feet) was completed as an open hole to minimize well losses and to maximize the artesian flow from the well.

Ŷ

Aquifer stress tests were conducted February 8-11, 1985. The testing sequence consisted of a variable-flow test followed by a 48-hour constanthead flow test. Pumping of the well was unnecessary due to flowing artesian conditions. Testing results indicate that this well can be expected to yield about 300 gpm of 190°F water on a sustained basis under flowing artesian conditions.

More than 15,000,000 Btu an hour of heat energy will be utilized for a district space-heating system designed by Petty and Associates, a Reno-based mechanical engineering firm. The system will eventually include school buildings, a convention center, hospital, and other public facilities, and result in an estimated yearly energy savings of \$300,000. The distribution system is installed, and work on retrofitting the existing heating systems is expected to start before spring of 1986.

A unique feature of the system is the method of fluid disposal. Treated, thermal effluent will be introduced into the City of Elko water-supply system. With the exception of iron and hydrogen sulfide, the effluent meets State of Nevada and federal drinking-water standards, and its quality equals that of groundwater pumped from some of the city's municipal wells.

Veterans Administration Medical Center Geothermal Well

by David Carlson William E. Nork, Inc.

During January through July 1985, a 1,370 foot-geothermal exploration well was constructed and tested at the Veterans Administration Medical Center, Reno, Nevada. The purpose of the exploration well was to determine the geothermal resource potential at the hospital site.

Based on experience in the Moana Geothermal Area, about 2 miles to the southwest (see <u>Hot Line</u>, July 1982), the contact between the alluvium and underlying fractured volcanic rock was a likely drilling target. Beneath the hospital, however, there was no evidence that the volcanic rocks were highly permeable or contained groundwater of a temperature significantly higher than water in the alluvium.

Seven temperature surveys were conducted at various stages of well completion. The surveys indicated a temperature gradient of about 4.3°F per 100 feet of depth compared with a normal gradient in the Reno-Sparks area of about 2.9°F per 100 feet.

Step-drawdown and constant-discharge aquifer pumping tests were conducted in July 1985. Static water level prior to testing was 33.65 feet below the top of the well casing. A 24hour constant-discharge test was conducted July 19-20, 1985. Test results indicate that a production well at this site would be capable of yielding as much as 300 gpm of 115 F water. As many as 749,000 Btu an hour may be generated by direct use of the geothermal fluid by using fan coils.

At Reno climatic parameters, this is sufficient to heat an area of 38,000 square feet. Mechanical amplification of the temperature through the use of electrically powered water-source heat pumps could provide as many as 7,497,000 Btu an hour, enough to heat an area of 380,000 square feet. A system utilizing water-source heat pumps for both heating and cooling will provide 6,000,000 Btu an hour for heating and 6,000,000 Btu an hour for cooling (500 tons).

The anticipated payback for a geothermal production/injection/heat pump system versus a conventional gas heat/electric cooling system for a building of 100,000 square feet is less than 2 years.

Wells Rural Electric Company Geothermal Well

by David Carlson William E. Nork, Inc.

From September through October 1985, an 800 foot-deep geothermal production well was constructed for Wells Rural Electric Company Headquarters Building in Wells, Nevada. The geothermal water produced by the well comes from a depth below 475 feet.

Aquifer testing was conducted during October 1985. Test results indicate that the well is capable of yielding 250 gpm, possibly indefinitely. The water temperature is about 90 F.

Carlin High School Geothermal Well

by David Carlson William E. Nork, Inc.

In December 1984, construction began on a geothermal production well for the Elko County School District at Carlin High School, Carlin, Nevada. The 904 foot-deep production well was completed March 3, 1985. The well produces groundwater primarily from production zones in fractured limestone below a depth of about 875 feet. Secondary production zones exist between depths of 823 and 875 feet.

Final design of the well isolated all production zones from a shallow alluvial aquifer. This was accomplished by installing blank casing to a depth of 821 feet and sealing the annulus with a neat cement and bentonite slurry.

Step-drawdown and constant-discharge aquifer pumping tests were conducted in March 1985. Results of the testing indicate that the well is capable of sustaining, almost indefinitely, the continuous pumping rate of 50 gpm that is necessary to meet the average daily demand of the heating system. The well is also capable of meeting the maximum peak demand of 200 gpm. Temperature of the water is 87^oF.

Enhancement of Mineral Processing by Geothermal Heat

Enhancement of mineral processing in Nevada using geothermal heat will be the subject of a research grant from the U.S. Department of Energy. Researchers from the Division of Earth Sciences, University of Nevada, Las Vegas, and from the Chemical and Metallurgical Engineering Department, University of Nevada, Reno, are cooperating on a \$120,000 grant to assess the utilization of Nevada's geothermal fluids for several hydrometallurgical processes presently used in the mining industry.

The results of this research should demonstrate whether or not the use of geothermal energy will enhance recovery of minerals and provide a more economical processing technique for the mining industry. For further information please contact: Dennis T. Trexler, UNLV, (702) 784-6151 or James L. Hendrix, UNR, (702) 784-6960 at the Division of Earth Sciences

Utah

Utah Looks at Hot Dry Rock

The State of Utah may be interested in developing a hot dry rock program. "We've been monitoring the research at the Los Alamos National Laboratory. It looks pretty good, so far," said Kevin Higgins, Assistant Director of the Utah Energy Office. "True, there are many issues to be resolved before a similar project could be undertaken in Utah, but we see no major obstacles."

The Roosevelt Hot Springs area is the site in Utah that Higgins feels is possibly viable, and certainly worth investigating for a hot dry rock program. The area is one of known geothermal activity. And in it, along with the good wells, are several dry holes.

Higgins says that using these dry holes in a hot dry rock program could save a great deal of money. The wells could be reentered and fractures made that would connect the wells with other wells.

Utah Geothermal Development

by Dr. Ronald DiPippo

Two resources in southern Utah are being developed, but in different ways. A 20-megawatt single-flash plant, Blundell Unit 1, came on line in 1984 at Milford (Roosevelt Hot Springs). Because of the high temperature of the resource (260[°]C), the geofluid carries a significant amount of silica (510 ppm), and silica scaling has been a concern during operation. Environmental Research Center, University of Nevada, Las Vegas, 255 Bell Street, Suite 200, Reno, Nevada 89503.

The Utah Power and Light Company has contracted with Transamerica Delaval-Biphase Energy Systems to design and build a 14.5 megawatt unit at Roosevelt Hot Springs that will use a Rotary Separator Turbine in conjunction with a steam turbine. The plant is ready to be installed whenever electrical demand justifies additional capacity.

Furthermore, a similar power plant has been designed as a bottoming cycle for the existing Blundell unit. The new addition would increase the capacity by 9 megawatts, or 45 percent, with no increase in brine flow.

Mother Earth Industries (Cove Creek Geothermal) had four Ormat binary units in place at its Cove Fort-Sulphurdale prospect in June 1985. Each unit has a gross output of 0.8 megawatts. Net power for sale from the first four units is about 2.7 megawatts. The electricity is purchased by the City of Provo.

Phase 2 of the project will increase the power capacity of the plant to about 6.5 megawatts. A steam turbine will be added to the existing units. The turbine will efficiently use the dry steam produced at the wells. The exact arrangement of the equipment and other details are being worked out.

The author acknowledges the help of Wayne Portanova (Mother Earth Industries), Zvi Krieger (Ormat Systems), and Walter Studhalter (Biphase Energy Systems) in compiling this information.

Hawaii

Hawaiian Geothermal Update

by Gerald O. Lesperance Alternate Energy Specialist Department of Planning and Economic Development State of Hawaii

The Puna Geothermal Venture (Thermal Power Company is the lead partner) and the State of Hawaii are negotiating toward supplying the 3.0 megawatt HGP-A power plant in the Kilauea East Rift Zone, Island of Hawaii, with steam from the venture's recently completed Kapoho State 1A well to carry out a long-term flow test of that well. (A photo of the well being drilled just north of the HGP-A power plant is in the July 1985 <u>Hot</u> Line.)

The Department of Planning and Economic Development recently completed a report to the Hawaiian State Legislature addressing issues to be resolved in order to expedite geothermal development.

Mayor Dante Carpenter of the County of Hawaii has established a Geothermal Energy Advisory Commission as an advocacy group.

Considerable permitting activity is going on for geothermal exploration and development leading to a 100 megawatt electrical generation capacity in the Kilauea Middle East Rift Zone (about 15 miles from Kilauea crater and 8 miles from well HGP-A and the power plant). The developer is a joint venture of True Energy Company and Mid-Pacific Geothermal, Inc.

Five geothermal, direct-use research proposals were selected for small grants in conjunction with the Puna Research Center, which is adjacent to well HGP-A and the 3.0 megawatt power plant facility. The researchers, who submitted proposals as individuals or as small business owners, will be using hot geothermal fluid or waste silica produced at the HGP-A geothermal project in Puna.

The five projects selected for funding are:

- "Green Papaya Powder Drying," proposed by Peter Allen, president of Papaya Products of Hawaii, a fruit drying firm in Kea'au.
- "Bottom Heating System Using Geothermal Power for Propagation," proposed by James Downing of Leilani Foliage, a Puna nursery, and Ken May, also a Puna resident.
- "Hawaii Glass Making Project," proposed by Norman Miller and Bill Irwin, two artisans from Pahoa.
- "Experimental Lumber Drying Kiln," proposed by Bill Irwin and Denver Leaman, partners in King Koa, a Pahoa business.
- "Cloth Dyeing by Geothermal Steam," proposed by Mrs. Yukie Kimura and Mr. Motoyuki Kawagoe, who are involved in a family-run geothermal cloth-dyeing enterprise in Japan.

The total amount of funding requested for the five projects is \$37,131. The researchers will finish planning the projects in January 1986 and should be ready to begin work on their projects shortly thereafter.

The Community Geothermal Technology Program offers an opportunity for individuals, small businesses, and others to pursue research in the Puna Research Center, a state-funded facility managed by the Natural Energy Laboratory of Hawaii. Located next to the HGP-A power plant in Pohoiki, the research center offers access to hot, high-pressure geothermal fluids and their by-products, such as silica. The research center also includes a small, wet-chemistry laboratory with scientific equipment, as well as compressed air, potable water, and electrical power.

The Community Geothermal Technology Program, a joint effort of the State Department of Planning and Economic Development and the University of Hawaii---Manoa's Hawaii Natural Energy Institute, offered small grants up to \$10,000 for research and demonstration projects at the Puna Research Center. Proposals for this pilot year of the program were accepted between September 3 and November 1, 1985. The second cycle of the program is expected to be announced in late 1986.

Worldwide

Worldwide Geothermal Power Development

by Dr. Ronald DiPippo

Mechanical Engineering Department Southeastern Massachusetts University;

Division of Engineering Brown University

Brown University Up to the year 1978, geothermal power Status and Projected Development of Worldwide Geothermal Power.

	MW as of			MW	to be ins	talled ea	ch year				Planned;
COUNTRY	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Date Unspec
United States	2022.11	137.62	115.0	241,4							815.0
Philippines	894.0			55.0	92.5						1155.0
Mexico	645.0	50.0	50.0	55.0	55.0	110.0	55.0	220.0	50.0		
Italy	519.2										380.0
Japan	215.1										108.0
New Zealand	167.2			116.2		<u> </u>					
El Salvador	95.0										85.0
Kenya	45.0					·		60.0			
Iceland	39.0						****				
Nicaragua	35.0	35.0									
Indonesia	32.25		55.0	55.0	110.0	110.0	110.0	110.0	195.0	110.0	110.0
Turkey	20.6							-~			
China	14.321	÷									0.55
Soviet Union	11.0					80.0					150.0
France (Guadeloupe)	4.2				~~~~						
Portugal (Azores)	3.0										
Greece (Milos)	2.0										
Costa Rica	0					50.0					
Guatemala	0										15.0
Chile	0 .							· • • • •			15.0
Saint Lucia	0										30.0
India	0										1.0
Romania	0										1.0
Australía	0										0.5
Totals, each year		222.62	220.0	522.6	257.5	350.0	165.0	390.0	245.0	110.0	2866.9
Cumulative total	4763.981	4986.6	5206.6	5729.2	5986.7	6336.7	6501.7	6891.7	7136.7	7246.7	10113.6

Support for the Community Geothermal Technology Program came from both public and private sources. Initiated by a grant from the U.S. Department of Energy, it has been supported by the County of Hawaii and by donations from private businesses, including W.H. Shipman, Ltd.; Diamond Shamrock; Thermal Power Company; the Hawaii Electric Light Company; and HPM Building Supply.

The Puna Research Center is also available for research performed outside of the Community Geothermal Technology Program. Public and private researchers wishing to make use of the facility may contact the Natural Energy Laboratory of Hawaii at 220 S. King Street, Suite 1280, Honolulu 96813.

Adapted from a paper presented at the IIE/EPRI Geothermal Conference and Workshop, June 24-28, 1985. Printed with permission from the Electric Power Research Institute.

Summary



Worldwide Growth of Geothermal Power: 1975-1990.

development had progressed with an average annual growth rate of about 8.3 percent. From 1978 to 1985, the growth rate was about 17 percent. Most of the increase has been due to power plant activity in the Philippines, the United States, and Mexico. If this rate of growth were to continue, about 10,000 megawatts of geothermal power would be on line by 1990. However, there are indications that a significantly lower growth rate will take hold for at least the next 5 years.

In the table, the present status (i.e., through 1985) and projected developments out to the year 1994 are summarized for those countries that might reasonably be expected to have plants during the next 10 years. Based on information available in June 1985, by the year 1994, the cumulative potential geothermal power capacity, worldwide, is about 10,114 megawatts. Since 1,970 megawatts of this is classified as "planned", i.e., without a specific date (for

the United States and the Philippines), it is clear that 10,000 megawatts cannot be achieved by the year 1990. Indeed, it seems likely that an annual growth rate of about 6 percent will apply for the rest of the 1980's.

The rate could increase in the 1990's should the Philippines resume its initial rapid development of its impressive geothermal resources.

Mexico

The geothermal projects in Mexico include power plants at Cerro Prieto, Los Azufres, and Los Humeros Geothermal fields. A total power capacity of 1,290 megawatts is planned for these areas by the year 1993. This vigorous development program has propelled Mexico into third place among those countries generating electricity from geothermal energy. Other geothermal fields in Mexico, such as La Primavera, are being explored and may eventually reach the production stage.

Japan

In Japan, there are nine geothermal power plants, ranging in size from 0.1 megawatts at the Kirishima Kokusai Hotel to 55 megawatts at the doubleflash Hatchobaru plant. The plants are located on three of the Japanese islands: Honshu, Kyushu, and Hokkaido. Their total rated capacity is 215.1 megawatts, including 22 megawatts from a dry-steam plant (Matsukawa); 88.1 megawatts from six, single-flash plants (Otake, Onuma, Onikobe, Kakkonda, Suginoi Hotel, and Kirishima Kokusai Hotel); and 105 megawatts from two double-flash plants (Hatchobaru and Mori). Expansion of some of the existing plants is being given serious consideration. Step-out drilling is underway, for example, at Hatchobaru in preparation for the construction of another 55 megawatt unit.

The newest geothermal plant in Japan is at the Kirishima Kokusai Hotel.

Geothermal Power Plants in Mexico.

PLANT	YEAR	TYPE	MW	STATUS
Pathe	1959	1-Flash	3.5	De-commissioned
Cerro Prieto I:				
Unit 1-2	1973	1-Flash	2x37.5	Operational
Unit 3-4	1979	l-Flash	2x37.5	Operational
Unit 5	1981	2-Flash	30.0	Operational
Cerro Prieto II:	*			
Unit 1-2	1984	2-Flash	2x110	Operational
Cerro Prieto III:				
Unit 1	1985	2-Flash	110	Under construction
Unit 2	1985	2-Flash	110	Under construction
Cerro Prieto IV:				
Unit 1-2	1992	2-Flash	4x55.0	Planned
Los Azufres:				
W.H.*Unit 1-2	1982	Dry Steam	2x5.0	Operational
W.H. Unit 3-5	1982	l-Flash	3x5.0	Operational
Unit l	1986	2-Flash	50	Under construction
W.H. Unit 6-12	1987	l-Flash	7x5.0	Advanced planning
Unit 2	1988	2-Flash	55	Advanced planning
Unit 3	1989	2-Flash	55	Advanced planning
Unit 4	1990	2-Flash	55	Advanced planning
W.H. Unit 13-22	1993	l-Flash	10x5.0	Advanced planning
Los Humeros:				
W.H. Unit 1-3	1987	l-Flash	3x5.0	Under construction
Unit l	1990	2-Flash	55	Advanced planning
Unit 2	1991	2-Flash	55	Advanced planning
		Totals:	425	Operational
			710	Operational or u.c.
* W.H Well Head			1290	Oper., u.c. or planned

Geothermal Power Plants in Japan,

PLANT	YEAR	TYPE	MW	STATUS
Matsukawa	1966	Dry Steam	22.0	Operational
Otake	1967	l-Flash	12.5	Operational
Onuma	1973	l-Flash	10.0	Operational
Onikobe	1975	l-Flash	12.5	Operational
Hatchobaru	1977	2-Flash	55.0	Operational
Kakkonda	1978	1-Flash	50.0	Operational
Otake Pilot	1978	Binary	1.0	Dismantled
Nigorikawa Pilot	1978	Binary	1.0	Dismantled
Suginoi Hotel	1981	l-Flash	3.0	Operational
Mori	1982	2-Flash	50.0	Operational
Kirishima				- · · · ·
Kokusai Hotel	1984	l-Flash	0.1	Operational
Hatchobaru II	n.a.	2-Flash	55.0	Advanced planning
Kakkonda II	n.a.	Flash	50.0	Advanced planning
Suginoi II	n.a.	l-Flash	3.0	Early planning
		Totals:	215.1	Operational
			323.1	Operational or planned
·				-F or Fraunda



The Mori power plant. Photo courtesy of Dr. Nakamura, Japan Metals and Chemical Co., Ltd.

Roughly 20 percent of the power requirements of this hotel are supplied by a single-flash geothermal unit having a 100 kilowatt noncondensing turbine. The plant came on line in February 1984. The turbine-generator was built by Fuji Electric Co., Ltd.

Hot water from the wellhead separator is piped to the hotel for use in a bathing spa. The facility is located in Kagoshima in the southern part of Kyushu, within the scenic Kirishima National Park.

A 50 megawatt double-flash plant known as Mori was put on line in November 1982 at the Nigorikawa area in Mori-machi on the southwestern part of Hokkaido. The plant is operated by the Hokkaido Electric Power Co.. Ltd. The steam field was developed by Dohnan Geothermal Energy Co., Ltd., with the cooperation of Japan Metals and Chemicals Co., Ltd. Seventeen deep wells have been drilled: 6 are used for production, 7 for injection, and 4 were unsuccessful. Two more wells (D-7 and D-8) are scheduled to be drilled. (Ref. Dohnan Geothermal Energy Co., Ltd., "Geothermal Development in the Nigorikawa Area, Hokkaido, Japan", 1984.)

Dr. Hisayoshi Nakamura (Japan Metals and Chemicals Co., Ltd.) was very helpful to the author regarding information about the Mori power plant.



Cyclone separators for the Mori power plant at well pad D, 1 1/2 km from the geothermal power plant. The separators also receive two-phase fluid from two other production wells at well pad F, about 600 meters away.

Nicaragua

The following account is based largely on a paper entitled "Estado Actual del Proyecto Geotermico de Nicaragua" by the Instituto Nicaraguense de Energia (INE) presented at a meeting of Latin American countries and reported in "Estado Actual de la Geotermia en America Latina", Seminario Latinoamericano Exploracion Geotermia, Quito, Ecuador, Sept. 1983, OLADE/ BID/INECEL; in Spanish.

The first geothermal plant in Nicaragua, the 35 megawatt single-flash plant at Momotombo, began producing power in September 1983. It is near



Map of Nicaragua, with geothermal areas.

the northwestern shore of Lake Managua and on the southern flank of the Momotombo volcano. This is only one of many geothermal areas that stretch along Nicaragua's southwestern zone, roughly 50 km inland from the Pacific Ocean.

Exploration for geothermal anomalies in Nicaragua dates from 1966 when the Italian firm ELC-Electroconsult conducted a preliminary study. In 1969, a study by Texas Instruments resulted in a list of ten areas with geothermal potential. Of these areas, the fumaroles of the south Momotombo volcano were considered the best prospect when the study was completed in 1971. A power potential of at least 35 megawatts was estimated from these data. The San Jacinto area was also deemed a good prospect for commercial development.

Following the devastating Managua earthquake of December 23, 1972, all geothermal development work was halted temporarily. In May 1974, the Nicaraguan electrical authority, then called the Empresa Nacional de Luz y Fuerza (ENALUF), rehired the original consulting firm, ELC-Electroconsult, to complete the feasibility study at Momotombo. At the same time, a contract was signed with the Belgian drilling company, Foramines, to construct four dual-purpose wells to serve as both exploration and (if successful) production wells.

ENALUF began the production-drilling phase by hiring Energeticos, S. A. and the California Energy Company to drill 12 wells and to manage the drilling program, respectively. By 1978, this phase was completed.

In 1980, the current electrical authority, Instituto Nicaraguense de Energia (INE), secured financing for the project through the Organizacion Latinoamericana de Energia (OLADE) with the aid of a special OPEC fund. The decision was reached in 1981 to build a 35 megawatt plant at Momotombo.

The wells were drilled in two stages: Stage 1 from November 1974 to August 1978; Stage 2 from October 1982 to June 1983. During Stage 1, 32 wells were drilled resulting in 20 production wells and 4 injection wells. During Stage 2, three wells were completed: one producer (for the anticipated second power unit) and two injectors. The reservoir temperature is in the 230°C range.



Momotombo power plant, looking southsoutheast towards Lake Managua (which is in the background). Photo courtesy of ELC-Electroconsult, Milan, Italy. Shallow and deep production horizons have been penetrated in the field. Most of the wells intercept the shallower zone, which is much better understood than the deeper one. The deeper reservoir must be produced in a manner carefully integrated with the shallower zone to expand the power production of the field beyond the current rating of 35 megawatts. The deeper zone may have temperatures considerably in excess of 230°C.

At present, Unit No. 1 produces 39 megawatts although it is rated at only 35 megawatts, and generates roughly 20 percent of the electrical needs of Nicaragua. A second unit, identical to the first, has been designed and is ready to be built, pending final funding arrangements. Altogether, 8 production wells will supply the two units; 2 wells will be available on standby.

The geothermal area called El Hovo-Monte Galan appears to be several times larger than Momotombo, but is undeveloped at this time.

The author thanks Dr. A. Ten Dam (Société de Prospection et d'Études Geothermiques) for information on the current status of the power plant.

Indonesia

The ultimate geothermal power potential of Indonesia is estimated to be 10,000 megawatts, an impressive figure by any standards. Exploration and/or development are taking place at 18 areas in Sumatra, 29 areas in Java, 16 areas in Sulawesi, and 14 areas in Bali, Lesser Sunda Islands, and Moluccas. An ambitious program is underway to get power plants on line in eight different areas by the year 1994.



Geothermal Power Plants in Indonesia.

PLANT	YEAR	TYPE	MW	STATUS
Kamojang:				
Wellhead Unit	1978	Dry Steam	0.25	Operational
Unit l	1982	Dry Steam	30.0	Operational
Unit 2	1987	Dry Steam	55	Under construction
Unit 3	1988	Dry Steam	55	Under construction
Unit 4-5	n.a.	Dry Steam	2x55	Preliminary planning
Dieng:				
wellhead Unit	1980	1-Flash	2.0	Operational
Unit 1	1988-89	Flash	55	Advanced planning
Unit 2	1989-90	Flash	55	Advanced planning
Darajat:			• .	
Unit 1	1991	Flash	55	Planned
Unit 2	1992	Flash	55	Planned
Salak:				. <u>.</u>
Unit 1	1988-89	Flash	55	Advanced Planning
Unit 2	1989-90	Flash	55	Advanced planning
Unit 3	1992	Flash	55	Planned
Unit 4	1993	Flash	55	Planned
Lahendong			·	
Unit $1-2$	1992-93	Flash	2x15	Planned
Cisolok:				
Unit 1	1993	Flash	. 55	Planned
Unit 2	1994	Flash	55	Planned
Banten:				
Unit 1	1993	Flash	55	Planned
Unit 2	1994	Flash	55	Planned
Bedugal:				
Unit 1	1990-91	Flash	55	Planned
	. 4		· · · · · · · · · · · · · · · · · · ·	
		Totals:	32.25	Operational
			142.25	Operational or u.c.
			997.25	Operational, u.c. or planned

Research and Development

State of Washington and Swedish Council Develop District Heating Computer Program

A computer program to determine the feasibility of district heating plans, called HEATPLAN, is being developed under a joint contract between the Washington State Energy Office and the Swedish Council for Building Research.

The program is appropriate for direct use systems or those with heat pumps, and should be finished by July 1986. It will be used by the Washington State Energy Office to evaluate district heating plans for Washington cities. The program will be available to private consultants, as well.

When asked how the arrangement with the Swedish Council evolved, Dr.

101

Gordon Bloomquist of the Washington State Energy Office said he has been trying to come up with a good computer program for evaluating district heating plans for 4 years. He developed and tested two programs within this period, and felt that refinements were still needed.

He has lived in Sweden for 6 years, and he asked members of the Swedish Council if they would be willing to co-fund a study that would combine the Council's knowledge of district heating and the Washington State Energy Office's knowledge of geothermal energy.

"We started in December, and the program should be ready in July," said Dr. Bloomquist. "Now we've got a new plan on the drawing board that will turn HEATPLAN from a feasibility tool into a drawing tool," he added.

For further information, Dr. Bloomquist may be reached at the Washington State Energy Office, 400 E. Union, Olympia, Washington 98504; phone (206) 754-0774.

Scale Control in Geothermal Systems

Reprinted from the December 1985 issue of the EPRI Journal, p. 52 and 53.

Native geothermal fluids, whether steam or hot brines, are chemically complex and unstable substances. Resources throughout the western United States range between two extremes-the vapor-dominated resources of Northern California's Geysers field, with noncondensable gas content as high as 5 wt% and dissolved solids content as low as the parts-per-million level, and the hypersaline liquid resources of Southern California's Imperial Valley, with dissolved solids content approaching 30 wt%. Controlling the behavior of these fluids is critical to successful geothermal power generating facilities. The objectives of EPRI research in scale control are to understand the behavior of geothermal

fluids and to learn how to predict and control that behavior.

In the mid-1970's EPRI recognized the complexity of scale control in geothermal systems and developed a strategy to address the problem. Individual projects are working toward understanding, prediction, and control of scale formation, and proposed scalecontrol technologies are being evaluated for performance and characterized for applicability.

Mineral Precipitation

Selective mineral precipitation in flashed-brine power plants is the concept that led to the design and fabrication of a crystallizer unit by The Ben Holt Co. (RP1525-3). With this device, EPRI will investigate the feasibility of bulk scale removal by selective crystallization upstream of a power plant boundary.



This flash-crystallizer vessel was designed and built for the investigation of controlled mineral precipitation and removal at flashed-brine plants. In the vessel, steam is produced and solids are removed from geothermal brine under controlled conditions. During the production of steam by flashing, brine reaches supersaturation when mineral concentrations are increased by the loss of liquid water to steam and when the temperature decreases. In flashed-brine facilities, severe scaling is common in and just downstream of the flash vessels, with the flash temperature and pressure and the brine characteristics determining the precipitates formed. In general, carbonate and sulfide precipitate during a high pressure-high temperature flash, and silica precipitates during a low pressure-low temperature flash.

The EPRI flash-crystallizer vessel was designed with maximum flexibility

Conferences

The Tenth Annual EPRI Geothermal Conference and Workshop, "Expanding Geothermal Capacity with Modular Systems," Portland, Oregon, June 24-27, 1986.

The conference will be held at the Portland Marriott, 1401 Front Ave., Portland, Oregon 97201, (503)226-7600. Conference fees are \$25.00 for representatives of utilities affiliated with EPRI, and \$225 for all others.

For technical information, contact Ms. Mary McLearn, Project Manager, at (415)855-2487; for general information, contact Ms. Brooke Eldredge, Conference Coordinator. The address for either is EPRI, P.O. Box 10412, Palo Alto, California 94303.

Fifth International Symposium on Water-Rock Interaction, Reykjavik, Iceland, August 8-17, 1986.

The symposium is sponsored by the International Association of Geochemistry and Cosmochemistry. For further information, contact Halldor Armannsson, Orkustofnun--The National Energy Authority, Grensasvegur 9, 108 Reyjavik, Iceland.

to encourage mineral precipitation under controlled conditions. Brine containing scale-forming species enters the vessel and is flashed. Steam exits the top of the vessel, and stabilized brine, now a slurry, exits the bottom. The overall process combines steam production by brine flashing with mineral precipitation. The vessel will be tested in 1985-1986 on several brine types to evaluate the effects of temperature, pressure, scale type, supersaturation, particle contact, and recirculation rate. Optimal conditions for selective precipitation and improved design features of flashcrystallizer vessels for specific brine conditions will be determined during the field test.

International Meeting on Geothermics and Geothermal Energy, Sao Paulo, Brazil, August 10-14, 1986.

The meeting is being organized by the International Heat Flow Commission and the Institute of Technological Research of the State Government of Sao Paulo. The meeting is the first of its kind to be organized in the Southern Hemisphere and is of particular importance to the development of geothermal research in South America. The official language of the conference will be English.

Topics discussed in the meeting will include crustal heat-flow measurements, regional studies and geothermal maps, paleogeothermics, and geothermal energy. The advanced registration fee is U.S. \$50.00 before May 10, 1986, when the fee will be raised to U.S. \$70.00.

For further information, contact the IMGG, c/o Valiya M. Hamza, Instituto de Pesquisas Technologicas do Estado de Sao Paulo S.A., IPT CP71-41, 0010 Sao Paulo, Brazil.

Geothermal Resources Council 1986 Annual Meeting, September 29-October 1, 1986, Americana Canyon Hotel, Palm Springs, California. The meeting will include three days of technical sessions, special sessions, a poster presentation, photo contest display, and field trips.

On September 27-28, a pre-course will be held titled "Future of Geothermal Energy."

A post-course, "Well Testing," will be offered on October 2-3.

Contact the GRC for further information at P.O. Box 1350, Davis, California 95617.

Hawaii Volcano Observatory Diamond Jubilee and Symposium on How Volcanoes Work, Hilo, Hawaii, January 19-23, 1987

A symposium titled "How Volcanoes Work" will be held in celebration of the Diamond Jubilee of the Hawaii Volcano Observatory. (1987 will be the 75th anniversary of the United States Geological Survey's Hawaii Volcano Observatory). The symposium is sponsored by the U.S. Geological Survey, the American Geophysical Union, the Geological Society of America, the International Association of Volcanology and Chemistry of the Earth's Interior, the World Organization of Volcano Observatories, the University of Hawaii, and the Hawaii Institute of Geophysics.

Major symposium topics will include: Conceptual Models of How Volcanoes Work, Internal and Deep Structure of Volcanoes, Dynamics of Eruptions, Assessing Volcanic Hazards, and Reducing Volcanic Risk.

Lecture-discussion sessions and poster sessions will be offered. Field trips will be held before, during, and after the symposium on the islands of Oahu, Hawaii, and Maui.

For further information, write Robert Decker, U.S. Geological Survey MS 910, 345 Middlefield Road, Menlo Park, CA 95025.

Videotapes



Before the Drilling Begins

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

Publications

The decade of North American Geology. The complete suite of publications is available to Geological Society of America members for \$1,720.90 and to nonmembers for \$1,950.35. For a detailed order form and a full explanation of the purchase terms, write DNAG Publication Sales, Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301-9140.

The first publications are available for the decade of North American geology special project, commemorating the 1988 centenary of the Geological Society of America. The publications, when completed, will include the 28volume set, Geology of North America, a 6-volume Centennial Field Guide set, 4 Centennial Special Volumes, 23 Continent-Ocean Transects, and 7 Continent-Scale Maps of North America. Each of the five categories of publications may be purchased separately.

The following reports are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161. Prices vary.

Analysis of flow data from the T-F&S/ DOE Gladys McCall No. 1 Well. DOE/NV/ 10150-6. By J. Pritchett and T. Riney. 1985. \$13.00. Microfiche \$4.50.

Collection and analysis of geothermal gases. LA-10482-OBES. By L. Sherenell, F. Goff, L. Gritzo, and P. Trujillo, Jr. 1985. \$7.00. Microfiche \$4.50. The videotape, titled "Before the Drilling Begins," may be purchased for \$150 in $\frac{1}{2}$ " (VHS or Beta) or 3/4" formats. It may be rented for \$25 plus a \$25 deposit refundable upon return of the tape.

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

Geothermal technology development program annual progress report, Oct. 1983 - Sept. 1984. SAND85-1138. Edited by J. Kelsey. 1985. \$23.50. Microfiche \$4.50.

High-temperature borehole instrumentation. LA-10558-HDR. By B. Dennis, S. Koczan, and E. Stephani. 1985. \$8.50. Microfiche \$4.50.

Convective flows in porus media, ISBN 0-477-06758-1 (SIPC), ISBN 0-643-03809-4 (CSIRO). Edited by R.A. Wooding and I. White. NZ \$12.50 plus postage and packaging (New Zealand \$.60; overseas \$1.65). Available from the Publications Officer, Science Information Publishing Center, DSIR, P.O. Box 9741, Wellington, New Zealand.

The publication contains the proceedings of a seminar organized by DSIR and CSIRO Institute of Physical Sciences, Wairakei, New Zealand in May 1985. Among the papers reproduced in this book are "Existence and stability of vapour-dominated geothermal fields" by M.A. Grant, DSIR; and "Geothermal steam flow through porouspermeable rock" by R. James, DSIR.

Proceedings, workshop on geothermal reservoir engineering, Volumes 1-6. USA orders are US\$100 per set with no extra charge for postage, handling, or sales tax. Foreign orders are US\$110 per set, which includes postage and handling. Payment must accompany

105

each order. Please allow 6-10 weeks for delivery. Inquiries by telephone (415) 497-4744 and telex STANFRD STNU 348402. Available from the Stanford Geothermal Program, Department of Petroleum Engineering, Mitchell Building 360, Stanford University, Stanford, California 94305.

The first six volumes (1975-1980) of the Proceedings of the Stanford Workshop on Geothermal Reservoir Engineering have been reprinted as hardbound volumes, with author and subject indexes added.

Volumes 7-10 (1981-1985) are also being indexed and reprinted as in-

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 dividual hardbound volumes, and will shortly become available. Future volumes will be issued in hardbound form after each Workshop. The Stanford Geothermal Program organizes the Workshop on Geothermal Reservoir Engineering under sponsorship from the Geothermal Technology Division of the U.S. Department of Energy.

1985 list of publications. Free. Published by and available from the Nevada Bureau of Mines, University of Nevada-Reno, Reno, Nevada 89557-0088.

.

Division of Oil and Gas. All data are in metric units. The file may be purchased at cost (usually between \$50 to \$100) from the Division of Oil and Gas in Sacramento.

by the Division of Oil and Gas Date Notice Operator & Received Well No. API No. Sec. T. R. Location & Elevation DISTRICT GL

Drilling Permits for Geothermal Wells Approved August-December 1985

 10/22/85
 GeoProducts/North

 American Energy Corp.
 035-90074
 14 29N 15E
 Fr. SE cor. 49m N,

 "WEN" 3
 857m W. 1,228m GR.

 MONO COUNTY
 12/2/85
 Wood & Associates
 051-90049
 35 3S 28E
 Fr. SW cor. 820m N,

.2/2/85 Wood & Associates 051-90049 35 3S 28E Fr. SW cor. 820m N, "Chance" E 344m E. 2,158m GR.

DIST	RICT G2			
	:	IMPERIAL COUNTY		
8/2/85	Kennecott Corporation "State" 2-24	025-90632	14 11S 13E	Fr. SE cor. 313.94m N, 76.2m W. Ele74.07m
9/19/85	Union Oil Co. of Calif. "Vonderahe" l	025-90633	5 12S 13E	Fr. NE cor. 757.4m S, 745.2m W. Ele68.6m
9/26/85	William E. Engler "Niland" l	025-90639	1 9S 12E	Fr. SW cor. 560.5m N, 259.4m E. Ele30.5m

Date Notic Received	e Operator & Well No.	API No.	Sec. T. R.	Location & Elevation
DISTR	ICT G3	LAKE COUNTY		
9/1/85	County of Lake	033-90517	33 13N 8W	Fr. SW cor. 1181m N, 183m E. 573m GR.
11/8/85	Union Oil Co. of Calif. "NE Geysers Unit" 15	033-90518	5 11N 8W	Fr. SE cor. 350.5m N, 541m W. 891.5m KB.
12/18/85	Union Oil Co. of Calif. "NE Geysers Unit" 16	033-90519	5 11N 8W	Fr. SE cor. 350.5m N, 533.4m W. 891.5m KB.
	:	SONOMA COUNTY		
9/19/85	GEO Operator Corporation "TG" 69	097-90676	24 lln 9W	Fr. SW cor. 61m N, 732m E. 854m GR.
10/2/85	Union Oil Co. of Calif. "LF State 4597" 41	097-90677	20 11N 8W	Fr. SE cor. 609.6m N, 544.1m W. 935.7m KB.
10/18/85	GEO Operator Corporation "Prati" 4	097-90678	35 l2n 9W	Fr. SE cor. 365m N, 9.1m W. 792.2m KB.
10/28/85	Union Oil Co. of Calif. "LF State 4597" 39	097-90680	20 lln 8W	Fr. NE cor. 213.4m S, 731.5m W. 984.5m KB.
10/28/85	Union Oil Co. of Calif. "LF State 4597" 42	097-90679	20 11N 8W	Fr. SE cor. 451.3m N, 727.1m W. 935.8m KB.
10/30/85	GEO Operator Corporation "Rorabaugh" A-28	097-90681	14 11N 9W	Fr. NW cor. 777m S, 878m E. 387m KB.
11/19/85	GEO Operator Corporation "Prati" 37	097-90682	35 12N 9W	Fr. SW cor. 3m N, 678m E. 579m GR.

107



1985 Index

a

Assessing geothermal properties 45

b

Biphase Energy Systems 17 BLM bonding requirements 39 BLM lease sales 52 BLM mineral resources policy 38 Bottle Rock power plant 14 BPA study 16 Brawley Geothermal-Electric Project 76

С

Carlin High School well 92 CEC grant and loan program 42 Central American Energy Resources Project 23 CEQA Unit activities 7 Conferences 103 Costa Rica 23, 24 Costs of geothermal projects 46

d

Desert Peak power plant 88 District heating computer program 101 Division of Oil and Gas 7, 84

e

Electrical generation 7, 8 Elko Junior High School well 89

f

Federal geothermal personnel 36 Freeport-McMoRan 84

g

Geothermal Dev. Associates 17 Geothermal Resources Association 86 Geothermal Resources Council 53

h

Hawaiian development 18, 94 Heber binary power plant 12, 71 Heber dual-flash power plant 12, 70 Hot dry rock 93

July, p. 1-66: December, p. 67-110

• Imperial Valley releveling 8

Legislative update 39 Lost circulation studies 34, 35 Low-temperature geothermal projects 28

m

Mammoth Lakes direct-heating study 14 Maps 55, 108 Mineral processing enhancement 92 Miravalles Geothermal field 24 Mono Power Company 84 Multilateral lending institutions 50

0

Oregon geothermal development 15

ρ

Pacific Aquafarms 86 Publications 56, 105

S

Salton Sea Scientific Drilling
 Project 9, 87
Scale control in wells 102
Seminars and conferences 53
Shallow Salton Sea Drilling Program 10
South Geysers power plant 79
State Lands Commission 52

t

The Geysers Geothermal field: anniversary 77 Bottle Rock power plant 14 South Geysers power plant 79 statistics 7 Unit 16 79 Unit 20 79 Unit 21 79 TVA 33

U

US agencies assisting foreign governments 48 US-DOE budget 85 US-DOE core repository 36 USGS geothermal research program 37 Utah geothermal development 93 Utah hot dry rock program 93

V

Veterans Administration Medical Center 91 Videotapes 55, 104 Vulcan power plant 13, 74

W

Wells, California 62, 106 Wells Rural Electrical Co. 92 Wineagle power plant 82 Worldwide development 95

TR02(3-86-DWRR-16C)



DIVISION OF OIL & GAS 1416 NINTH STREET, ROOM 1310 SACRAMENTO, CA. 95814



BULK RATE U.S.POSTAGE PAID Sacramento,Calif. Permit No.337