The Geysers

Geothermal energy, (underground steam and hot water) is being harnessed by a growing number of nations to spin the turbine-generators that make electricity. The Geysers Power Plant, in Sonoma and Lake counties about 90 miles north of San Francisco, is the only power project in the United States, and the largest in the world, using such "geothermal" steam.

The "geysers" here are not really geysers but fumaroles. The difference is that real geysers, like famed Old Faithful in Yellowstone National Park, send up fountain-like jets of hot water and steam at intervals. Fumaroles emit steam steadily.

Discovery

Hiking through the mountains between Cloverdale and Calistoga in search of grizzly bears one day in 1847, explorer-surveyor William Bell Elliott came upon a frightening sight: puffs of steam coming from the hillside. He had discovered The Geysers. The awe-struck hunter later told friends he thought he had come upon the gates of hell itself.

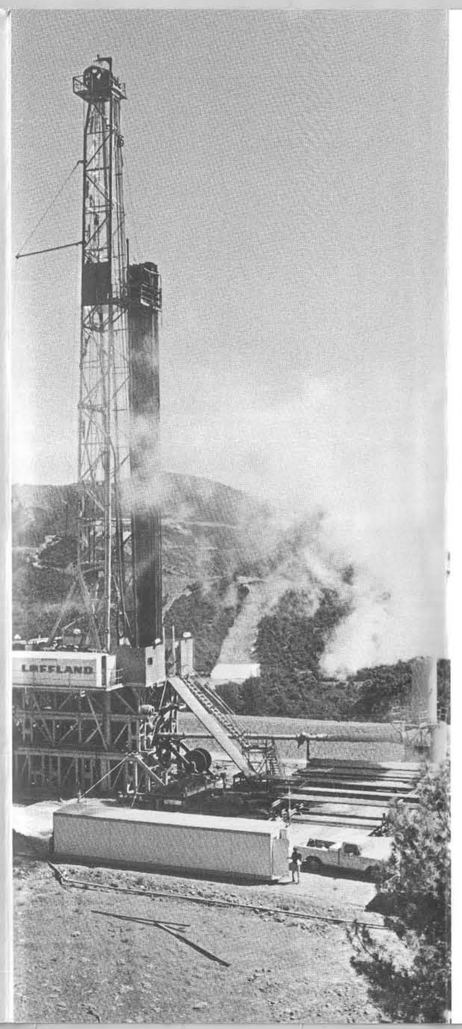
Failure, Then Success

The first attempt to develop The Geysers power potential was made in 1922. Drillers successfully tapped the steam source. But the pipes and turbines of the era could not withstand the corrosive and abrasive effects of natural steam and the impurities it contained.

Nor was the time ripe. Hydroelectric sites, then more economical, were still available. So the project was abandoned.

Magma Power Company and Thermal Power Company, working jointly, again tapped the area in 1956. By then, stainless steel alloys had been developed which could withstand corrosion. Now geothermal steam could be produced economically, so Pacific Gas and Electric Company contracted to build a plant and buy steam from the Magma-Thermal wells.

In 1967, Magma and Thermal merged their holdings at The Geysers with those of Union Oil Company of California. Union was named operator of the steam production phase of the project. The technical and financial resources made available by this development resulted in



a stepped-up exploration program for new geothermal steam resources.

For the next several years, an average of more than one well per month was drilled. This increased pace of exploration and development enabled PG&E to accelerate plant expansion at The Geysers to 11 generating units by 1975. Today there are about 200 wells at The Geysers.

In 1973, PG&E signed steam supply contracts with Thermogenics, Inc., a Hughes Aircraft subsidiary, and Aminoil USA, one of the RJR Industries companies. These firms have contracts to supply steam for additional generating units over the next several years.

Here is the record of that expansion year by year, at a pace making The Geysers the world's largest geothermal power plant from 1973 onward:

Year of Operation		Net Kilowatt Capacity	Cumulative Plant Capacity In Kilowatts
1960	Unit 1	11,000	11,000
1963	Unit 2	13,000	24,000
1967	Unit 3	27,000	51,000
1968	Unit 4	27,000	78,000
1971	Unit 5	53,000	
	Unit 6	53,000	184,000
1972	Unit 7	53,000	
	Unit 8	53,000	290,000
1973	Unit 9	53,000	
	Unit 10	53,000	396,000
1975	Unit 11	106,000	502,000
1978	Units 12, 15	161,000	663,000
1979	Units 13, 14	245,000	908,000
1981	Units 16, 17	220,000	1,128,000
1982	Units 18, 19	220,000	1,348,000
1983	Units 20, 21	220,000	1,568,000

Unit 13 marks the first expansion of the field into Lake County, and at 135,000 kilowatts, is the world's largest single geothermal generating unit.

Steam Spins Turbines

Steam is supplied to the turbines at 355°F temperature and 100-125 pounds per square inch pressure. About 2,000,000 pounds of steam per hour are required to operate a 110,000-kilowatt generating unit. About 18 million pounds per hour will be needed for the first 15 units.

As the steam leaves the well, it is first cleansed of minute fragments of rock by "whirling" them off in centrifugal separator chambers. Otherwise, they could damage the turbine blades.

The steam is then delivered in insulated pipes to the power plants to spin the turbine blades, which drive generators that produce electricity. After leaving the turbines, the steam flows to a condenser where it changes to warm water. Here, the warm water is in a partial vacuum which helps extract 50 percent more energy from the steam than would otherwise be available. The still-warm water is pumped from the condenser to the cooling tower where its temperature is further reduced by partial evaporation as it flows over a series of baffles.

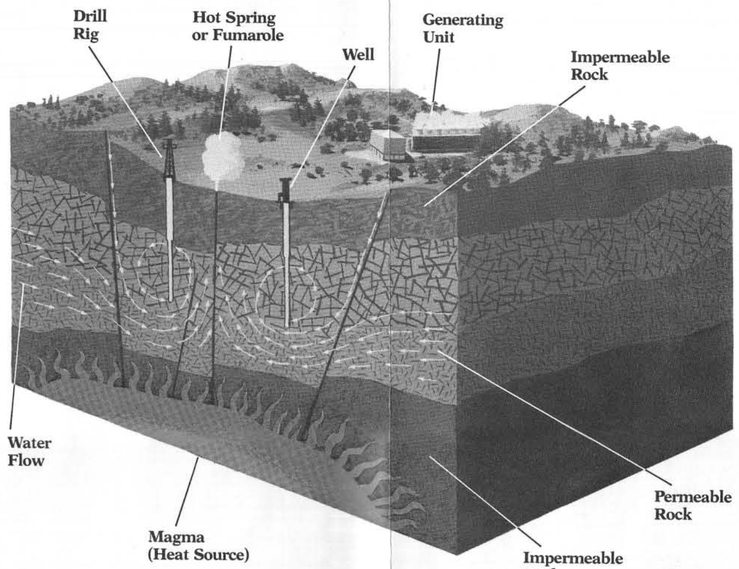
One of the unique aspects of the operation is that no new water is required for the cooling tower because it is supplied by the condensing geothermal steam. The excess water from the cooling process is reinjected into the steam-producing reservoir.

Mother Nature's Boiler

At its birth, the earth was a hot mass of molten liquids and gases. As much as 10 percent of this mass was steam. As the earth cooled, an outer crust formed over the hot interior mass and the steam condensed to form surface seas and lakes.

About 20 miles below the crust of the earth, the molten mass—called magma—is still in the process of cooling. In some places the magma is relatively close to the surface: five to ten miles down. In a geothermal field, water trapped in fractures in the near-surface rocks is heated by the cooling magma. Natural gases and water vapor released from the magma mix with the near-surface water and may escape along fractures to the surface as hot springs and fumaroles. When such a reservoir is tapped by drilling, pressure is released. This allows hot water or steam to flow to the surface, where it may then be used to generate electricity.

Fairly clean, slightly super-heated dry steam like that at The Geysers is extremely rare. Hot water, less useful and filled with more impurities, is much more common in other known geothermal-resource areas.



Geothermal Energy At The Geysers

Magma, the molten rock found deep within the earth, radiates heat energy through the solid rock above it and comes in contact with water from underground sources and some surface runoff. The intense heat and pressure transforms the water to geothermal steam. Some of the steam finds its way to the surface through cracks (fissures) in the underground rock and natural surface openings called "fumaroles."

Early Power Source

Natural steam spouts from the earth in few places around the world. Roman documents 2,000 years old tell of a steam field at what is now Larderello, west of Florence, Italy. During the 19th Century, this natural steam was harnessed for industrial heating and mechanical power. Today, Italy can produce about 390,000 kilowatts of geothermal electricity. A hot water field at Wairakei, New Zealand, supplies a 192,000 kilowatt plant. Russia, Japan and Iceland also are using geothermal power.