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A Practical Application of Geothermal Steam

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A variety of new energy sources is getting increased attention from the public and from electric utilities because of the growing scarcity and cost of environmentally acceptable fossil fuels. At or near the top of almost every list of such new sources is geothermal energy.

Geothermal energy is thought to originate primarily from the decay of radioactive elements in the interior of the earth. Small amounts of this heat are conducted to the earth's surface everywhere. However, in some areas there are large deposits of heat near the surface resulting from relatively recent intrusions of molten rock, commonly called magma. In some of these areas, surface water comes into contact with the hot rock and naturally heated water or steam rises to the surface as hot springs, geysers, or fumaroles.

Man has used this form of geothermal energy for heating and body therapy for centuries. In a few of these areas wells have been drilled to produce steam or hot water for the generation of electric energy.

The world's first geothermal power plant is near Larderello, Italy, where electricity has been generated since 1904 using steam from a dry-steam geothermal reservoir. The Larderello project currently produces 365,000 kilowatts.[1] On New Zealand's North Island, 192,000 kilowatts of generation is installed using hot water from the Wairakei geothermal field.[2] In northern Mexico, a 75,000-kilowatt plant was recently placed in operation which uses steam flashed from hot brine which has about the same salinity as sea water.[3] Smaller geothermal power plants are operating in Japan, Russia, and Iceland.

Geothermal power in the United States is still a fledgling industry, and it appears now as if it will be largely confined to the West.

Dr. Chauncey Starr, president of the Electric Power Research Institute, estimated that 6 million kilowatts of geothermal energy might be in operation in the United States by the year 2000.[4] The National Petroleum Council estimated in 1972 that the nation's geothermal generating capacity, specifically in California and Nevada, could increase to between 7 million and 19 million kilowatts by 1983.[5] A much more enthusiastic appraisal was given by the Geothermal Resources Research Conference which indicates that, with an extensive research and development program, 132,000 megawatts of geothermal power could be developed by 1985 and 395,000 megawatts by the year 2000.[6] This wide range of estimates indicates that much more needs to be learned about the real potential of this emerging resource.

The Geysers Power Project

In the rugged Mayacmas Mountains of northeastern Sonoma county, some 80 miles north of

[1] *"Geothermal Energy – Resources, Production, Stimulation,"* by Kruger and Otte, p. 23, Stanford University Press, 1973.

[2] "Wairakei Geothermal Project," New Zealand Ministry of Works, March, 1972.

[3] "Clean Power from Inside the Earth," by John Lear, *Saturday Review*, December 5, 1970.

[4] "Energy and Power," by Chauncey Starr, *Scientific American*, September, 1971.

[5] An Initial Appraisal by the New Energy Forms Task Force. Other Energy Resources Subcommittee of the National Petroleum Council Committee on U. S. Energy Outlook, 1972.

[6] "Geothermal Energy," a special report by W. J. Hickel, University of Alaska, 1972.

San Francisco, is Pacific Gas and Electric Company's The Geysers Power Plant. It is the largest geothermal installation in the world and the only geothermal power plant in the United States. The ten units now in service produce 396,000 kilowatts, using steam at about 100 pounds per square inch and 350 degrees Fahrenheit piped directly from wells tapping a dry-steam reservoir. By comparison, water boils at atmospheric pressure at 212 degrees Fahrenheit.

PG&E's experience with geothermal energy began in 1957 when it tested several wells which had been completed by the Magma and Thermal Power Companies. It was found that a small turbine generator unit could produce power at competitive cost and so a steam purchase contract was negotiated. Unit 1, rated 11,000 kilowatts, went into operation in 1960. Since then nine more units, ranging in size from 13,000 kilowatts to 53,000 kilowatts, have gone into service.

In 1967 Magma Power Company, Thermal Power Company, and the Union Oil Company of California pooled their interests in a joint venture which now holds some 15,000 acres of geothermal property. A surrounding area of about 165,000 acres has been identified by the U. S. Department of Interior as a Known Geothermal Resource Area (KGRA). A KGRA is an area which is believed prospective enough to warrant leasing and exploration. In 1970, PG&E signed contracts with the joint venture for which Union Oil Company acts as the operator.

One important feature of these later contracts was PG&E's agreeing to accept reservoir engineering data as a basis for estimating the ability of the field to deliver steam over a long period as is done in natural gas and petroleum developments. These estimates are the basis for PG&E's decisions to install additional generating capacity. These contracts provide that as additional steam reserves are proved, PG&E will install approximately 100,000 kilowatts about five years hence. Installation at a faster rate is not precluded if adequate reserves are proven in advance. Similar contracts were signed with the Signal Oil and Gas Company and Pacific Energy Corporation in 1973, covering steam from nearby holdings.

As a result, The Geysers' present geothermal generating capacity – already the largest in the world – will more than double by the end of 1977. At that time The Geysers project will total more than 900 megawatts in 15 generating units.

Despite this accelerated development program and the enthusiasm with which many people view the potential of geothermal energy, this natural source of steam has not been without its problems. Technology, however, has solved many of them at The Geysers where, for instance, the mildly corrosive of steam condensate has been overcome by the use of special stainless steel in the cooling towers, condensers, and pumps.

Geothermal energy has its own set of environmental problems too. It was found that some hydrogen sulfide gas in the steam escapes to the atmosphere. Results of our studies and pilot tests indicate that this hydrogen sulfide release can be controlled.

About 80 percent of the steam is evaporated in the cooling tower after it leaves the turbines. The remaining condensate contains small amounts of boron, ammonia, and sulfur. The effluent from the early units was released into nearby Big Sulfur Creek, but after Unit 4 went into service the quantity of effluent was too large for adequate dilution in the creek. As the result of research by both the steam suppliers and PG&E, this effluent is being successfully reinjected into some of the suppliers' less productive steam wells.

The 15 units at The Geysers projected for 1977 are distributed geographically over an area of about six miles by three miles. The capacity installed at each site is largely governed by the steam reserves, the pressure drop in the suppliers' steam gathering piping system, and the cost of the piping system. About 100,000-kilowatt blocks of generation supplied by 15 steam wells are located at sites about a mile apart.

Estimates of the geothermal generation capacity that can be developed at The Geysers area also vary widely. One report estimated that 25,000 megawatts of capacity is possible in The Geysers KGRA, but this estimate is based largely on theoretical studies.[7] However, real proof of the extent of this resources requires drilling successful test wells distant from existing producing areas. While it is

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[7] USAEC, In the Matter of Pacific Gas & Electric Co., Diablo Canyon Units 1 and 2, Docket Nos. 50-275, 324, p 624. May 19, 1972.

virtually impossible to give a definite estimate of the capacity that will ultimately be developed in The Geysers area, we now believe it could approach 2,000 megawatts. Geothermal capacity might well become 10 per cent of the total available to the PG&E service area in Northern and Central California.

Role of Government and Industry in Geothermal Development

The historic relationship that government has had with the mining and petroleum industries should also be maintained with the geothermal industry. The government should continue to outline prospective areas and it should disseminate this information widely. Industry should evaluate the geothermal deposits and carry out their development and production. The Geothermal Steam Act of 1970 should be implemented immediately in a manner that will encourage commercial development of geothermal resources on federal land. There is a great need for the geothermal exploration program this could stimulate.

But exploration must also be accompanied by more research. PG&E and others in the electric utility industry have carried out extensive research on those geothermal power systems that use dry steam directly in turbines, as is done at The Geysers, and on systems using steam flashed from hot water, such as exist in New Zealand and Mexico.

Water and steam characteristics will vary from area to area and may require the modification of equipment and materials. However, the point to emphasize is that there is considerable existing technology in this area. Therefore, it would seem that any federal research and development efforts in geothermal activities would be better spent on less developed technologies.

Many believe hot water may comprise the largest part of the nation's geothermal resources. Therefore, interest in the geothermal "binary power cycle" has intensified. In this system, hot water vaporizes another fluid, such as freon or isobutane, which is then used to turn a turbine to generate power. This system appears quite promising for generating power from hot brine or water at relatively low temperature (less than 350 degrees Fahrenheit). A research and development program related to utilization of the energy from hot water in the Imperial valley of California and in Arizona for electric power generation is being spearheaded by southwestern utilities and geothermal developers.

Some geothermal resources do not have hot water or steam associated with them. These are the so-called "hot dry rock" resources which will be more difficult to develop. To "mine" this energy, water will have to be introduced into these areas and then brought back to the surface as hot water or steam.

The established utility industry should participate in the research and development of any geothermal system that produces fresh water and electric power. Further, if there is economic potential for mineral by-products in either water or power production, the chemical industry should be invited to join in R&D.

Fossil fuels are in short supply and their cost is escalating rapidly. Utilities are looking at all energy resources, some of which may have seemed quite unorthodox several years ago. Because it is a domestic resource unaffected by international policy, geothermal development must be expanded into new areas in our national interest.

Currently, there are no geothermal resources in the country other than The Geysers that are commercially proved for electrical generation. Even if the several prospective geothermal areas in the West should be successfully developed, it seems unlikely within the next two decades that geothermal power could exceed 5 to 10 per cent of the required electric generation capacity of the West. While this is not a cure-all for our energy ills, it does represent an important supplemental resource that should be encouraged.