Energy Conversion

Maximizing the power produced from a geothermal plant is crucial for cost-effective operation. The U.S. Department of Energy is researching a range of technologies that will improve plant operating efficiencies.

Converting the Earth's Heat to Electricity

Most power plants—whether fueled by coal, gas, nuclear power, or geothermal energy—have one feature in common: they convert heat to electricity. In the field of geothermal energy, the term "energy conversion" refers to the power-plant technology that converts the hot geothermal fluids into electric power.

Geothermal power plants have much in common with traditional power-generating stations. They use many of the same components, including turbines, generators, heat exchangers, and other standard power-generating equipment. However, there are important differences between geothermal and other power-generating technologies.

At The Geysers power plant in California, DOE researchers are studying ways to improve power conversion and increase power output. One of the areas of focus is cooling strategies—researchers have designed advanced direct-contact condensers that reduce steam consumption.

David Parsons, NREL/PIX01079

Every geothermal site has its own unique set of characteristics and operating conditions. For example, the fluid produced from a geothermal well can be steam, brine, or a mixture of the two; and the temperature and pressure of the resource can vary substantially from site to site. The chemical composition of the resource can contain dissolved minerals, gases, and other hard-to-manage substances. Geothermal power plants are designed to optimize power generation by taking these site-specific conditions into account.

Achieving the best plant efficiency is crucial if the geothermal power station is to be operated profitably. Compared with traditional fossil-fuel or nuclear-powered plants, which operate over temperature ranges of about 1022°F (550°C), geothermal power plants operate over relatively low temperature ranges, usually between 122° and 482°F (50° and 250°C). At these relatively small temperature differences, heat-to-electricity conversion efficiencies are inherently low. Even small gains in conversion efficiency can have a great influence on the overall economic viability of a geothermal system. Engineers, therefore, strive to fine-tune geothermal conversion technology, precisely matching plant designs to the site-specific conditions.

Three Designs

Geothermal power plants fall into one of three categories: direct steam, flash, and binary plants. The type of plant built at a given site depends on the type and temperature of the geothermal resource. Direct steam plants are used at sites where the geothermal resource consists of high-quality steam. As the name implies, the steam is routed directly through a steam turbine for generating electricity. Flash plants are used at sites that produce high-temperature waters (between 347° and 572°F [175° and 300°C]). In these designs, the geothermal fluid is brought to the surface under pressure. When the fluid reaches the surface, where pressures are lower, the fluid "flashes" to steam, which again turns a turbine generator. Binary cycle plants convert lower temperature geothermal waters (194°– 347°F [90°–175°C]) to electricity by first routing the fluid through a closed-loop heat exchanger, where it heats a hydrocarbon working fluid. The hot brine converts the working fluid, which has a very low boiling point, to its gaseous phase; the gas is then used to turn the turbine.

Research Supported by the U.S. Department of Energy

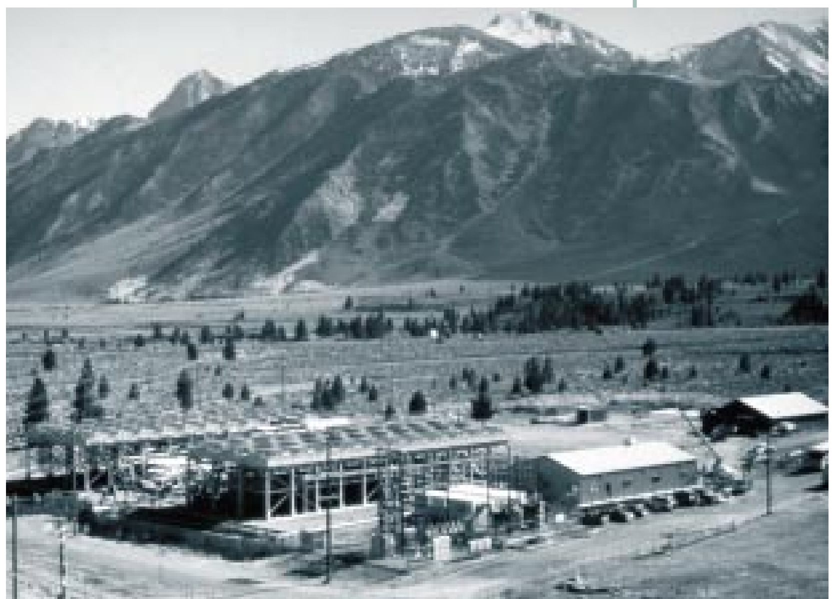
The U.S. Department of Energy (DOE) is involved in a variety of research projects to improve the energy conversion process. Researchers are working in four general areas: improving power conversion; developing durable materials for handling hot brine, steam, cooling water, and binary fluids; designing new methods for rejecting waste heat; and improving the efficient handling of waste products associated with some operations.

DOE's research in improving power conversion comprises a variety of activities. Researchers are investigating the use of supersaturated turbine expansion to increase power output. However, in a supersaturated regime, gains in efficiency can be voided by damage to the turbine caused by excessive moisture. In recent years, researchers have been testing several types of turbines and working fluids in supersaturated regimes, without any indication of consequent damage. Because of DOE's research, industry appears to be more receptive to this important technique for improving conversion efficiency.

DOE is also involved in engineering durable, resistant materials for handling power-plant fluids. Hot geothermal brine, with its myriad of dissolved metals and gases, can be highly corrosive. Program researchers are developing materials—such as thermally conductive polymer concretes—that can tolerate high temperatures and corrosive elements in pipes and heat exchangers. In addition to developing these resistive materials, researchers are working with industry to address manufacturing issues.

In all power plants, cooling technology is an important part of plant performance. Geothermal resources, though, are not necessarily found in areas that have an abundant supply of water that can be used for cooling processes. Program researchers are working on a number of advanced cooling strategies that reduce water consumption and improve power output. In one such project, researchers have designed an advanced direct-contact condenser that efficiently condenses the steam as it exits the turbine. This design, which could boost plant performance by 5%, is now in use at a geothermal power plant at The Geysers in northern California.

Residual waste is associated with some geothermal operations. To address this concern, researchers are developing low-cost, environmentally sound biochemical technology. The new biotechnology significantly reduces the cost of surface disposal of sludges derived from geothermal brines. Concurrent processes for concentration and recovery of valuable minerals are also being pursued. In bench-scale laboratory experiments, researchers have shown that better than 80% of the total metal concentration can be removed in less than 24 hours. DOE, in partnership with industry, is performing prototype field experiments to upscale and refine the process.



Geothermal Resources Council/PIX00062

Geothermal power plants, such as Mammoth Pacific Power Plant in California, use many of the same components used by traditional power-generating plants. However, the geothermal resource is relatively cool, and the wells can produce fluids, steam, or brine.

The Future

These and other DOE-sponsored research projects are helping the geothermal industry develop lower-temperature resources into usable sources of electrical power. Continued progress will allow us to tap a greater percentage of our geothermal reservoirs and increase the amount of clean, renewable energy used in our power generation network.

For more information on geothermal technologies, call the Office of Geothermal Technologies: (202) 586-5340

or visit the Web site: http://www.eren.doe.gov/geothermal

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