Geothermal Power

By John Beca, Director of Communications, ITT Industrial Process Group

Tourists watching Old Faithful at Yellowstone National Park quickly learn about the power of geothermal energy. It's a sight to behold, and the science behind it tells a fascinating story about the Earth beneath our feet.

Chambers of magma at temperatures of up to 2,700 degrees
Fahrenheit (1482 degrees Celsius) reside in the Earth's crust and heat the rock layer above. When aquifers come into contact with the superheated rock, hot springs can occur, but when that heated water and steam encounter a constricted access to the surface—just like a fire hose nozzle–those showy geysers can form. Old Faithful, the most famous geyser, sprays its water and steam up to 200 feet (61m) in the air, but Steamboat geyser, also at Yellowstone, has been known to erupt at heights up to 400 feet (122m). That's a massive display of geothermal power.

It's no surprise, then, that man has attempted to harness the power of geothermal energy. For centuries, people around the world have used hot springs to clean, cook, and heat. The first electric generator using geothermal energy was built in Italy in 1904. It simply used the steam erupting from a geyser to drive an electric turbine.

Efforts to use geothermal energy in the United States began in 1922, at The Geysers steam field in Northern California. The plant's operators quickly found out that the particles carried by natural steam and hot water are corrosive to the pipes and turbines that were in use. That early effort failed, but in 1960, a small hydrothermal plant opened in the area, and today, 28 plants are operating there.

Because geothermal energy is renewable–using only water and the continually replenished heat from the Earth's core–it is celebrated by environmentalists. There are few if any byproducts from the resulting steam, so the process is clean, and many sources of geothermal energy are very reliable in terms of producing continually high levels of the heat needed to produce powerful plumes of steam. Perhaps best of all, geothermal energy is homegrown. In fact, it's not an energy source that can be exported. It must be used at its sources.

Using geothermal energy sources
Most of those sources in the U.S. are found in the western states, and in Alaska and Hawaii. These are the domestic areas where magma is close enough to the surface to heat rock and, in turn, the groundwater that often finds a path to the surface in the forms of hot water and steam. Today, harnessing geothermal power takes a number of forms. Three types of plants are in commercial use.

Dry steam plants
These are very efficient vapor-dominated reservoirs that result from a drilled well 7,000 to 10,000 feet (2134m to 3048m) deep. From these exceeding rare wells, natural steam comes to the surface to power turbine generators.

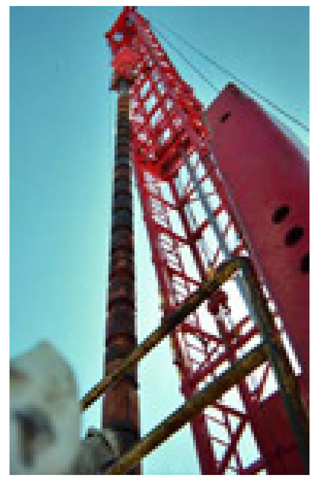
The depleted steam becomes condensed water and can be used in the plant's cooling system, then injected back into the well to keep the process going. The Geysers in California is an example of a dry steam plant.

Flash steam plants
Steam is created in a different way in these facilities. Water is sent through an injection well to the geothermal source, where it is heated to above 360 degrees F (182 degrees C). A production well carries the hot water to the surface, where it is sprayed into a tank, causing some of the water to rapidly vaporize, or "flash." The vapor drives a turbine, which powers a generator that creates electricity. Excess liquid in the first tank can be flashed in a second tank to recover further energy in the same cycle.

The resulting water then is sent back down into the injection well to repeat the process. Downhole pumps such as the ones made by ITT Goulds Pumps sometimes are used in conjunction with flash plants, but their most common use is in binary plants.

Binary-cycle plants
These plants are called "binary" because they use both hot water from their geothermal sources and a fluid that has a much lower boiling point than water. This allows operators to bring the water–which is not hot enough to flash on its own—up from the geothermal source from 600 to 2,000 feet (183m – 610m) under the surface, then use it to heat the tank containing the secondary fluid, which flashes and drives the plant's turbine. By containing the hot water in a closed system that doesn't flash, binary plants avoid the problems that flashing can bring–including calcium carbonate scaling and metal corrosion that result from impurities carried in the geothermal brine.

Experts believe that most of the geothermal plants of the future will be binary-cycle plants.



Performance monitoring on each geothermal pump is often done right on the job. Several instruments provide information that indicates how well the pump and well are working. Discharge pressure, flow rate, temperature, well bore pressure, water level, amperage, voltage, oil lubrication, cooling water pressure, motor bearing and winding temperatures are measured and recorded every three to six hours, to ensure that the pump is running properly.

In the event of a pump failure, it's necessary to remove it from the well with an oil-field workover rig. If the rig is close by, a typical removal time is three days. If time allows, a rebuilt unit can be on site within 10 days.

Pumps endure for varying periods on the job, largely depending on the sand content and temperature of the geothermal brine. Some pumps may last only two years before a failure or drop in performance, and others have been in place for more than 15 years. It wasn't always that way. In the past, early geothermal pumps–mostly adaptations of pumps used in agricultural water wells–lasted only about 30 days each.

As with nearly every industrial application, safety is an important consideration when working around geothermal wells. There are reasons why the U.S. Park Service keeps curious tourists away from erupting geysers at Yellowstone, and the same safety concerns apply for geothermal well workers. Similar to oilwell fires, geothermal wells can create geysers of hot water and steam if something goes wrong at the site. These dangerous geysers are much larger than Old Faithful, and can kill people in their paths. The most dangerous period during geothermal well construction is just before the pump is being installed in the well, because the well is not fully controlled at that point. Once the pump is in place, it becomes a much safer environment for the workers.

A hot future for geothermal energy
The future of geothermal power depends on a combination of economics and technology. Californians get six percent of their electrical power from geothermal energy–more than any other state. In Nevada, where the whole state rates highly for potential geothermal resources, governments and power utilities both see the possibilities and are moving to build more geothermal power facilities.

With the cost to produce geothermal energy rivaling that of traditional power sources such as coal plants, more utilities and other companies are finding ways to take advantage of geothermal resources.

Today's worldwide output of geothermal power is equivalent to the output of 10 to 15 coal or nuclear power plants, and provides

power for about 30 million people. In the United States alone, utilities produce about 2,300 MW of geothermal electricity, and serve nearly 4 million Americans.

In other parts of the world, geothermal resources also are available and are beginning to be harnessed. Indonesia, Mexico and the Philippines all largely operate flash steam plants from high-temperature resources. However, because some locations did not re-inject the geothermal brine back into the wells–instead letting the water flow out onto the adjacent ground–the result was mounds of unneeded salt and depleted geothermal resources.

Today, with more understanding of what it takes to operate a sustainable geothermal power plant, political and corporate leaders around the world are learning to appreciate that geothermal energy is one of the environmentally friendliest ways to generate electrical power. In fact, geothermal energy is ideally suited to provide new, clean power sources in developing countries.

However, geothermal energy has had its environmental challenges in the past. Because geothermal steam and hot water contain traces of hydrogen sulfide and other gases and chemicals, flash steam plants can release those compounds into the atmosphere. For that reason, operators use scrubber systems to minimize environmental releases. Today's plants emit less than four percent of the carbon dioxide that coal- and oil-fired plants produce, and sometimes the gases can be converted into marketable products such as liquid fertilizer. Properly designed binary-cycle plants, because geothermal fluids travel through them in a closed system, release nothing to the atmosphere.

In a complementary re-use scheme, The Geysers power plant in California pumps in wastewater from surrounding communities to replenish the water that is brought up from its geothermal wells.

Climate is not a barrier for geothermal power plants. They operate around the world in areas as diverse as deserts, fertile farmlands and in mountainous forests. Of course, geothermal features that have become national treasures, such as those in Yellowstone, are protected by law and will not be developed as power sources. Other federal lands have been used for geothermal plants, in part because they do not significantly harm the environment.

These benefits, all found in a single fuel source, combine to make geothermal power the promising energy source that it is today.

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