Enhanced Geothermal Systems

The Navy I geothermal power plant near Coso Hot Springs, California.

PIX07667 J.L. Renner, INEEL

How to extract more energy and power from geothermal resources

The Coso geothermal project, located in California's Coso volcanic field and about 100 miles (161 kilometers) north of Los Angeles, produces 260 megawatts of geothermal energy. Without tapping into any new geothermal resources (just by fracturing the existing reservoir), Coso will soon produce another 20 megawatts of electricity. The additional power will come from applying technology designed to improve the production of fields like Coso. Known as enhanced geothermal systems (EGS), this technology should more than double the amount of recoverable geothermal energy in the U.S., as well as extend the productive life of existing geothermal fields.

EGS Benefits

- Increased Productivity
- Extended Lifetime
- Expanded Resources
- Siting Flexibility
- Sizing Flexibility
- Environmental Advantages

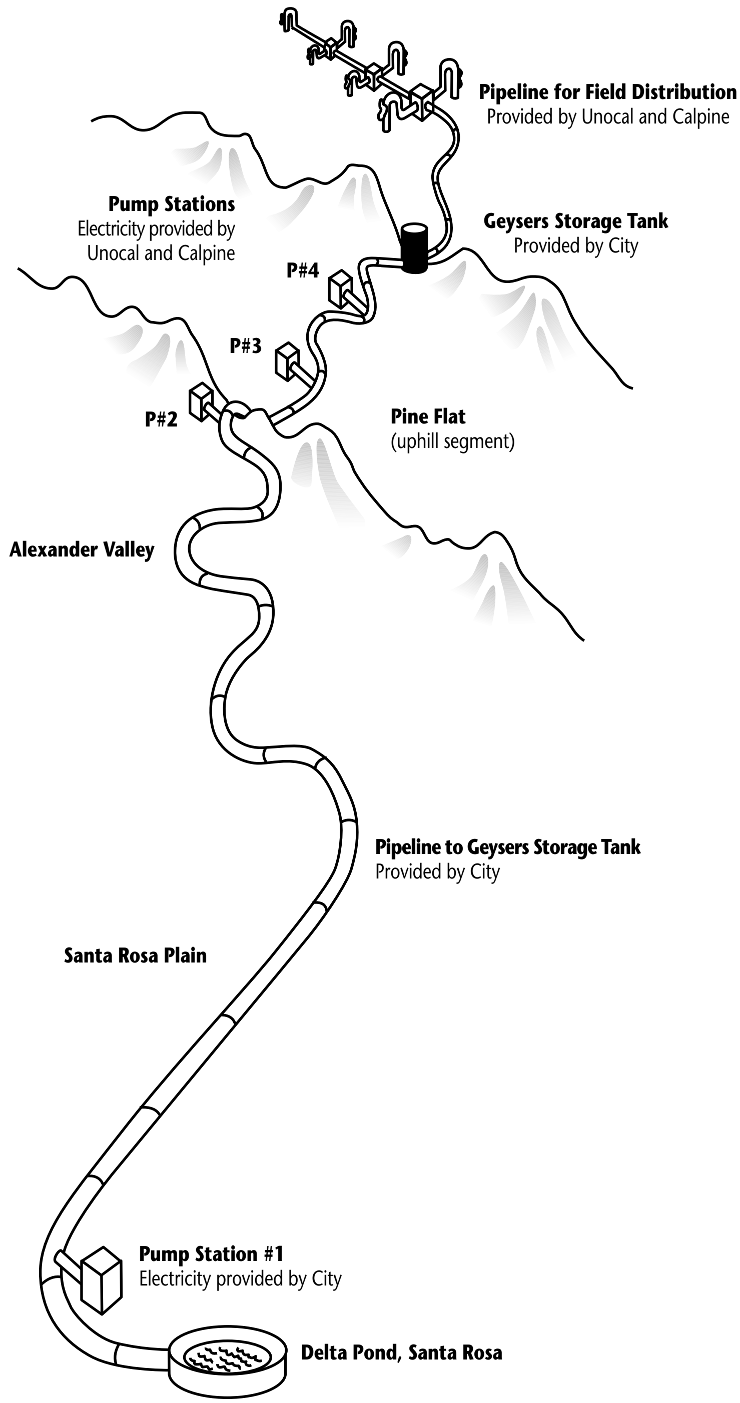
With EGS, a new reservoir is targeted within a volume of rock that is hot, tectonically stressed, and fractured. However, due to secondary-mineralization processes, those fractures have sealed over time, resulting in low permeability and little or no production of fluids. Through a combination of hydraulic, thermal, and chemical processes, the target EGS reservoir can be 'stimulated,' causing the fractures to open, extend, and interconnect. This results in the creation of a conductive fracture network and a reservoir that is indistinguishable from conventional geothermal reservoirs. EGS technology could serve to extend the margins of existing geothermal systems or create entirely new ones, wherever appropriate thermal and tectonic conditions exist.

The enhanced production at Coso will come as DOE's partners at the University of Utah's Energy & Geoscience Institute (EGI) and Caithness Corporation pump water under high pressure into a portion of the Coso field to reopen sealed fractures in subsurface rocks. Water pumped into the ground from injection wells will then circulate through the fractured rocks, flow to the surface through existing geothermal wells, and drive steam turbines. The process, called "hydrofracturing," is commonly used in oil and gas production. "We are attempting to tap into less permeable and less productive margins of existing geothermal systems," according to Peter E. Rose, coordinator of the Coso EGS project at EGI. For up-to-date information on this project, see the Coso EGS website at: *egs.egi.utah.edu/indexcoso.htm*.

Geysers Project, California

The Geysers, about 120 miles (193 kilometers) north of San Francisco, is the world's largest dry-steam geothermal steam field, reaching peak production in 1987, at that time serving 1.8 million people. Since then, the steam field has been in gradual decline as its underground water source decreases. Currently, The Geysers produce enough electricity for 1.1 million people.

EGS techniques will also increase the production and extend the life of The Geysers geothermal steam field. At The Geysers, Calpine Corporation and the Northern California Power Agency have found a way to generate more electricity without tapping additional geothermal resources. They are recharging existing reservoirs with treated wastewater from nearby communities. The companies, in partnership with the City of Santa Rosa, have built about 40 miles (64 kilometers) of pipeline to carry treated city wastewater to The Geysers.



PIX00060 Pacific Gas & Electric

A view of several geothermal power plants at The Geysers, northern California (showing water-vapor emissions during normal cooling operation).

The wastewater from the Santa Rosa project will be injected into underground wells at a depth of 7,000 to 10,000 feet (2,134 to 3,048 meters), and at a rate of 11 million gallons (50 million liters) a day for the next 30 years. This water will be naturally heated in the geothermal reservoir, and the resulting steam will be used in nearby power plants to produce electricity. The project should increase electrical output by 85 megawatts, enough for about 85,000 homes.

A similar project with the Lake County Sanitation District (website at: ***geysers-pipeline.org/index.htm***) called the Southeast Geysers Wastewater Recycling System has been operating successfully since 1997. This system delivers about 2.8 billion gallons (10.6 billion liters) of effluent annually, and has delivered more than 16 billion gallons (60.5 billion liters) of fluid to The Geysers since operations began. This project was described in the 1999 *Geothermal Today* in an article titled *Turning Wastewater into Clean Energy.*

EGS seeks to tap a continuum of geothermal resources, ranging from conventional hydrothermal resources to hot dry rock. Nature has been prolific in providing large quantities of heat in the earth's crust, but fluids and permeability are less abundant. With EGS, we hope to "engineer" new and improved reservoirs, and foster the economic production of that heat over long periods of time. Similar research and demonstration efforts are well underway in Europe (websites at ***www.dhm.ch/dhm.html*** and ***www.soultz.net***) and Australia (website at: ***hotrock.anu.edu.au***), and show the promise of EGS technology worldwide.

EGS technology will initially enable greater efficiency and sustainability in the extraction of heat energy from producing hydrothermal fields. The technology developed will also set the stage for eventually recovering the abundant heat contained in areas not associated with commercial hydrothermal fields, but with huge resource potential. This broadening use of geothermal resources will strengthen security and develop needed, clean, domestic energy resources. ■

DOE Program Goal – Enhanced geothermal systems should increase geothermal production to 20,000 MW by 2020.

EGS Around the West

Located in Siskiyou County, California, about 30 miles (48 kilometers) south of the Oregon border, Calpine Siskiyou Geothermal Partners is developing and demonstrating new EGS techniques. Specifically, they are developing stimulation technology to extract energy from reduced permeability zones around geothermal wells. This EGS project is part of a larger development that could result in two geothermal power plants that each produces 50 megawatts of electricity. The plant goes online in 2004, and Calpine already has a power purchase agreement with Bonneville Power Administration.

PIX 07655 Joel Renner, INEEL

The Steamboat geothermal power plant, originally built and now owned by ORMAT, in Steamboat Springs, Nevada.

ORMAT Nevada, Inc., a major geothermal operator, plans to apply EGS techniques at a prospective geothermal site east of the operating Desert Peak geothermal field in Churchill County, Nevada. They will fracture a low permeability zone under the ground to enable production of an estimated 2 to 5 megawatts of electricity. If successful, this project could have wide application to other geothermal sites in the Great Basin, due to the many similarities of subsurface features throughout this geologic province.

The DOE will share the cost of the Phase I feasibility study of a three phase, five-year program to develop a commercial EGS power plant project. ORMAT's objective will be to develop and demonstrate EGS techniques at its geothermal leasehold area, east of the existing Desert Peak Geothermal Facility in Churchill County, Nevada. The objectives of subsequent phases of this project will be the drilling, logging, hydraulic fracturing, and testing of the reservoir, followed by the construction and operation of a facility employing EGS technology for commercial power generation.

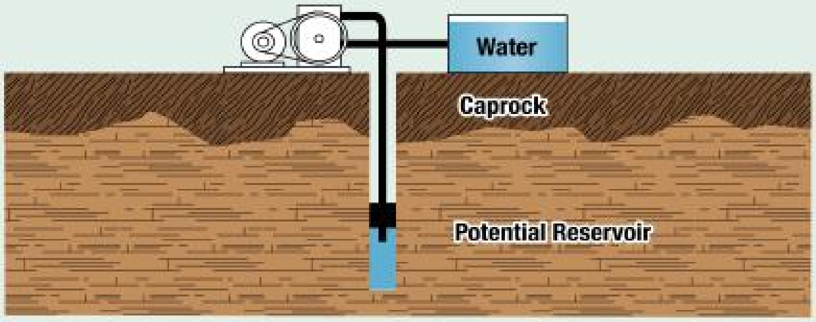
The project seeks to demonstrate that: 1) hydraulic fracturing technology can be applied commercially to geothermal systems; 2) adequate analytical techniques (such as subsurface stress analysis, fracture definition through seismic monitoring, numerical simulation of fluid flow and heat transfer in fractured media, etc.) required for an EGS project are already available; 3) neither water loss nor cooling of the produced fluid is a prohibitive barrier to a well-designed EGS project; and 4) commercial power can be generated reliably from an EGS project. The project relies upon proven technology for reservoir characterization and routine wellfield/power plant operation, and the application of existing fracturing technology to EGS.

How

an Enhanced Geothermal System works

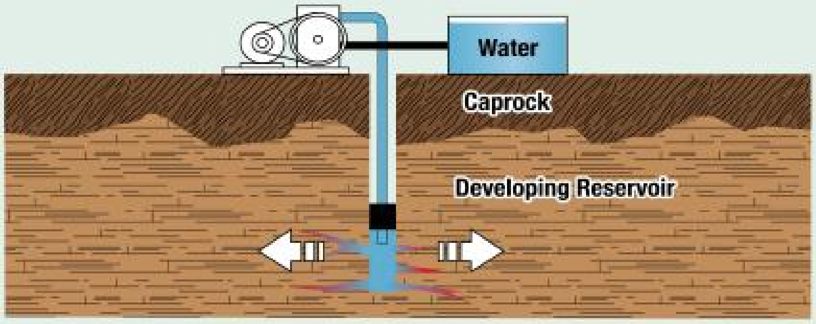
1 Drill an Injection Well

A production-injection well is drilled in hot rock that has limited permeability and fluid content.



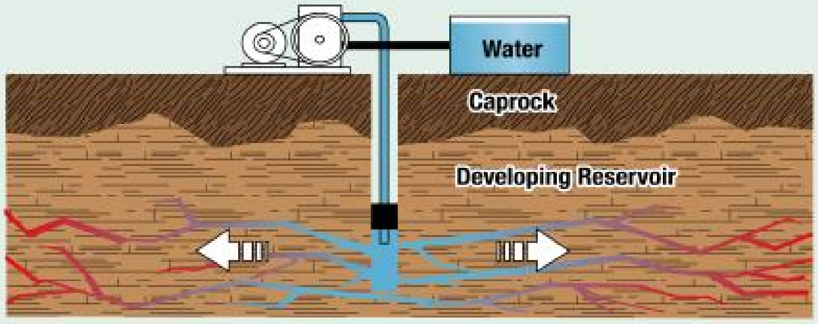
2 Inject Water

Water is injected at sufficient pressure to induce fracturing, or open existing fractures within the rock mass.



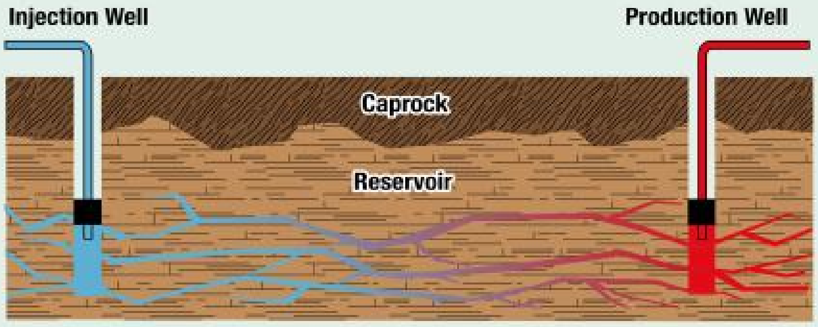
3 Hydro-fracture

Pumping of water is continued to extend fractures some distance from the injection wellbore.



4 Doublet

A second production well is drilled with the intent to intersect the stimulated fracture system, and circulate water to extract the heat from the rock.



5 Multiple Injection Wells

Additional production-injection couplets are drilled to extract heat from large volumes of rock to meet power generation requirements.