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California Heats Up over Natural Steam

Pumping water into the Geysers geothermal steamfield in Napa Valley will provide power companies with free steam energy and residents with possible earthquakes

By Naomi Lubick

In October, Santa Rosa, Calif., came one step closer to pumping its treated wastewater into the ground. The city settled the fifth lawsuit threatening to block construction of a pipeline to carry the water east to the Geysers geothermal steamfield in Napa Valley. Injected into the ground there, the wastewater will replenish the steam that provides energy for cities in the Bay Area. Unfortunately, it will also create an undesirable by-product: many very small earthquakes.

Although some residents are concerned, the plan is attractive to power companies because the geothermal field offers steam for free, without the need for an energy source to convert liquid to vapor. The field is like an open-face sandwich, with hot rocks at the bottom, a sandstone layer in the middle that holds steam in its pores like fat in bologna, and a thin layer of a caprock above that. The caprock keeps pressure on the reservoir of steam below, such that the steam continuously seeps up through the rocks on top. (In fact, there are no geysers in the Geysers; William Bell Elliott misnamed them in 1847 when he stumbled across hot springs.)

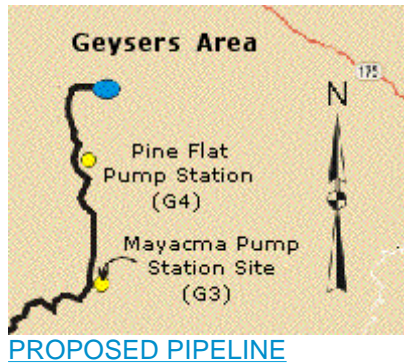


Image: F. C. WHITMORE, USGS
FIRST GEOTHERMAL WELL on federal land, above, was at the Geysers steamfield.

The first geothermal power plant in the U.S. called the Geysers home, and in 1922 it produced 30 kilowatts for the local resort and tourist trade that sprang up around the springs. Not until the 1950s did major power companies, such as Unocal and PG&E, start to pump steam from the Geysers. At its peak in 1987, the field produced almost 2,000 megawatts (MW), enough electricity to supply an estimated two million homes and businesses with power.

That rate of production soon dropped, though, says Mitch Stark, a seismologist at the Calpine Corporation, "because the steam supply was no longer sufficient to keep up with all the new plants and wells that had been drilled." By the late 1980s, companies had drilled about 600 wells. Today the field produces about 1,000 MW from only 350 wells. In 1999 Calpine bought out most of the other producers, "unifying the field" under one management strategy. Calpine runs 19 of the 21 powerhouses in the Geysers field; the Northern California Power Association, a group of towns that includes Palo Alto and Healdsburg, runs the other two. Calpine sends 850 MW of electricity into the grid, supplying power to Santa Rosa, San Francisco and other communities in the northern Bay Area.

To keep the Geysers producing that much electricity, the power companies started pumping lake water and treated wastewater into the field from nearby Lake County in 1997. "By injecting the water, they're keeping the pressure in the reservoir up and thereby stabilizing the rate of decline for the steam generation," says Cathy Janik, a geochemist with the Volcano Hazards Group of the U.S. Geological Survey (USGS).



(click here to enlarge).

northeast neighbor the Geysers.

The water is pumped 5,000 to 10,000 feet into the ground, where it is heated by hot rocks and gases. "What they're doing," Janik explains, "is injecting the water deep enough so that it's flashing in the reservoirs and then flowing back to the wells, so it's mining the heat from the rock." The liquid water heats enough to vaporize, or "flash," as Janik says, "because the pressure in the reservoir is less than it needs to be for this water to boil almost immediately." The Geysers is one of about five vapor-dominated geothermal fields in the world (Lardarello, Italy, has a similar field) and is the largest steam producer, pumping out 15 tons a day.

"Geothermal systems are most often related to areas where there is a lot of faulting and volcanism," Janik says. A young volcanic system called the Clear Lake volcanic field supplied heat to the Geysers through intrusive magma dikes miles below the earth's surface, some of which are dated 250,000 to one million years old. That molten rock is most likely gone, but the heat remains in deep crystallized rocks. Now two major fault systems—an extension of the Hayward fault to the southwest and the Colliame Fault to the

Despite recent controversy, it is unlikely that pumping water into the Geysers will trigger activity on those fault systems, says Dave Oppenheimer, a seismologist who works with Janik at the USGS. He and Donna Eberhart-Phillips first documented series of small earthquakes in the Geysers steamfield in the early 1980s and showed that the seismicity increased near each new power plant. "Just production activity causes earthquakes, whether there's injection or no injection," Oppenheimer notes. "You're going to have small earthquakes that may not have occurred at a rate that you're seeing now because your rate of stress change is higher," which affects the strain on area faults. Calpine geologists estimate that there are 40 percent more earthquakes now than before they started injecting wastewater into the Geysers.

But Oppenheimer hastens to explain that even though "you have all the requirements to change the state of stress in an area that's in the San Andreas Fault Regime," the faults within the Geysers are too small and scattered to create anything much larger than a magnitude-5 earthquake. "From a hazards point of view as a seismologist," he said, "if they [small earthquakes] were to all coalesce on one clear fault, it would be a different situation than what we see up there." The only way to get a big earthquake, Oppenheimer says, is to have a "big, well-developed, long, extended fault—like the San Andreas, Hayward and so on."

Of interest, Stark notes that, coincident with the rise in small microearthquakes, they've seen a drop in the number of larger earthquakes (magnitudes 3 or 4) in the region. Although he says it is speculative, injecting more water into the Geysers might actually stop larger earthquakes by relieving stress on local faults and causing them to rupture in smaller temblors.

Still, Janik worries that those smaller earthquakes could disrupt the caprock and potentially release what liquid vapor remains trapped below. "The steam carries quartz and components to make calcite, and that would tend to seal up the cracks," she says. "If it shakes, that would keep the cracks open, so the fluid can flow along the cracks, regardless of whether or not the fault is slipping." Changes in hydrogen sulfide emissions have led Janik to wonder about explosive events, in which liquid vapor escapes to the surface too quickly. Other consequences include carbon dioxide emissions, which could seep up into the surface and poison tree roots—or people.



Image: USGS

AERIAL VIEW shows the Geysers, one of about five vapor-dominated geothermal fields in the world.

"The bad news," Oppenheimer says, "is that as they produce power, there are some undesirable side effects. The good news is that if they shut it down, we observe that the seismicity stops. It seems to stop as fast as it starts, which is useful to feed into how you want to manage the field if things get out of hand."

That's little consolation to Jeffrey Gospe, whose family recently bought a house in Andersen Springs in the southeast part of the Geysers. He became concerned when his in-laws expressed worry over hydrogen sulfide emissions and other possible risks of living near the geothermal field. At a recent meeting of the Geysers seismic monitoring advisory committee, which includes local residents, county officials and power company representatives, Gospe recalled statistics Calpine shared: compared to a three-year period before the wastewater injections began, the number of earthquakes more than doubled in the three years after.

"Well, that got me thinking," Gospe said in an interview on the porch of his current home in Santa Rosa, "because if there was one thing that was a common theme as I talked with people throughout the area, it was the deep concern about the earthquakes. The earthquakes were something that everyone, regardless of scientific background, could feel." Calpine officials have expressed concern over the earthquakes but, in general, consider them small enough as to pose no real threat. Hamilton Hess, who has lived in the northeast Geysers since 1936, fears that the constant shaking could damage older wooden structures in the area, which often lack foundations.

In the meantime, a portion of the 41-mile pipeline that will carry Santa Rosa's treated wastewater is already built, and if all goes smoothly, the project will be pumping water to the Geysers by the end of 2002. After that, the Geysers will become a large laboratory for observing the evolution of a geothermal steamfield. Says Janik, "We just have to wait and see what the overall effect will be over time."