

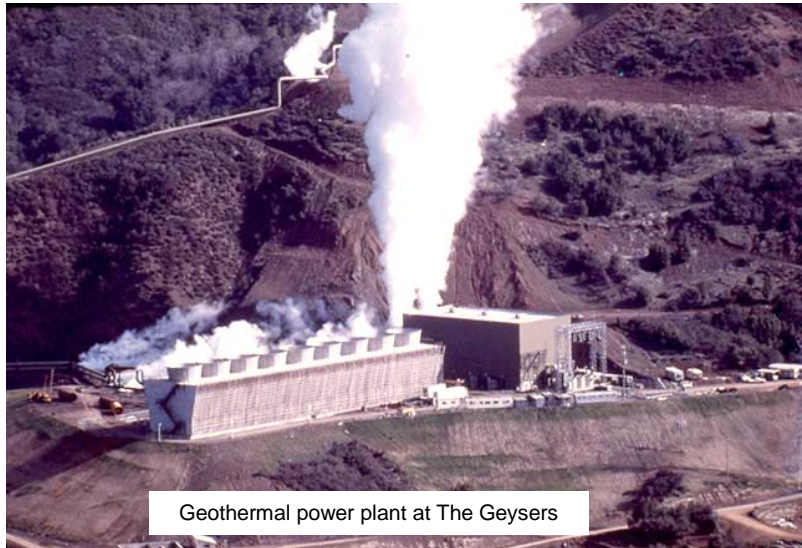
The Geysers and Salton Sea Geothermal Fields

Updated June-2015

THE GEYSERS

The Geysers field is in Sonoma and Lake Counties, covering roughly 35 square miles in the Mayacamas Mountains. California has a reserved mineral interest in roughly 1/3 of this area, with more than 7,000 acres currently under lease. Wells located on state leases include about 25% of the total steam production and wells on federal leases include about 30%. Wells on private leases include about 45%. At present, 424 wells produce a combined total of 125 billion pounds (62.5 million tons) of steam per year, with 21 turbine-driven generating units converting it into about 8.4 million megawatt-hours per year; or an instantaneous output of 955 megawatts, enough to supply power to approximately 1.2 million Californians.

The Geysers is a vapor-dominated geothermal resource, meaning gaseous steam exists in the reservoir. The reservoir is found at a depth of a mile or more, and at a temperature of 500-600 degrees F. The Geysers was first developed commercially in 1960, with Union Oil Co. drilling wells and supplying steam to a power plant built by Pacific Gas and Electric Co. (PG&E). During the 1960s through the 1980s, more wells were drilled and more power plants were built as companies competed to harness this unique energy resource. When steam production and generation peaked in 1987, it revealed that the reservoir could not “renew” itself as quickly as it was being depleted. The problem was not a depletion of heat, but rather a depletion of the fluid to carry the heat to the surface. A number of power plants had to be retired and operations had to be consolidated and coordinated to make the best use of the steam.



Water injection at The Geysers was for many years solely for the disposal of fluid condensed from the steam as it passed through the power plants. When it was discovered that injection could help replenish the reservoir, operators began searching for additional sources. But the only source was from local streams, and such water could only be extracted during seasonal rains and under strict control by other agencies, such as the California Department of Fish and Wildlife and others.

In the 1990s, as the population grew in the region surrounding The Geysers field, local municipalities began having wastewater disposal problems. Seasonal precipitation overwhelmed sewer systems and treatment facilities and forced the dumping of treated wastewater into local streams and rivers. A proposal was made to transport treated wastewater to The Geysers by pipelines for injection into the geothermal reservoir. This would solve both the wastewater

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disposal problem and help replenish the geothermal resource. The water was tertiary-treated and was classified as “reclaimed” water, suitable for agricultural use, and even human consumption. In 1997, the 29-mile Lake County Pipeline was constructed from the east to bring reclaimed water to the southeast portion of The Geysers. The water was injected into the reservoir and the results were immediate. Five years later, the Santa Rosa Pipeline was built to transport more reclaimed water 40 miles from the southwest, from the City of Santa Rosa. That water is injected into the central and northwest portions of the Geysers geothermal field. The supplemental injection projects have helped to stabilize steam production rates and increase steam quality during the past decade. Operators have also made improvements to power plants to increase the power generation derived from a given amount of steam.

At present, there are 424 production wells at the Geysers producing 125 billion pounds (62.5 million tons) of steam per year and 88 wells used for injection of water. Those injection wells handle 96 billion pounds of water (48 million tons) per year, equating to 22,400 gallons per minute, or 248 gallons per minute per well. Therefore, 77% of the mass withdrawn from the reservoir is replaced on an annual basis.

Water injection at The Geysers occurs into the geothermal reservoir, a mile or more deep, and not into near-surface aquifers. The geothermal reservoir is completely isolated from near-surface water supplies by a sealing caprock which precludes injection waters affecting the ground water supply.

THE SALTON SEA FIELD

The Salton Sea field is in Imperial County, in the southeast corner of California, about 95 miles east of San Diego. The largest geothermal development, the Salton Sea geothermal field, is located on the southeast shore of the Salton Sea. This geothermal reservoir is liquid-dominated--the resource exists as high-temperature, hyper-saline brine. When brought to the surface, a portion of the brine flashes to steam, which is used to generate electricity. The remaining brine is injected back into the reservoir.

The Salton Sea geothermal reservoir is about one mile deep with a temperature of 575-600 degrees F. The field was first developed in the early 1980s, more than two decades after The Geysers was first developed. The dissolved solids in the brine caused pipelines and injection wells to become plugged with precipitates. It took years of research to mitigate this problem – one method was to remove the solids prior to injection, another



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was to keep the salts in solution by modifying the pH. The Salton Sea field was also more expensive to develop, as the production facilities and power plants require more specialized hardware and equipment to accommodate the chemicals.

The developed portion of the Salton Sea field covers about 10 square miles. There are presently 10 power plants with 437 megawatts installed capacities. There are 28 production wells in the field producing over 265 billion pounds of brine per year, and 41 injection wells injecting just over 220 billion pounds of spent brine per year. Injection is primarily for the purposes of brine disposal, reservoir pressure maintenance, and to prevent subsidence of the land surface from subsurface withdrawal of fluids. The land elevations are closely monitored because the region is one of the most productive agricultural areas in the state.

The state's mineral ownership in this area is relatively small compared to The Geysers. Most of the lands around the Salton Sea are privately-owned. The state has four active leases totaling 1980 acres. Three of the four leases, totaling 1940 acres, involve lands owned by the California Department of Fish and Wildlife. The lands are used for wildlife habitat and hunting, and the state's geothermal lessee is prohibited from using the surface. Directional drilling is conducted from adjacent lands.

The Salton Sea field has significant potential for further development. Geologic evidence reveals that the reservoir extends to the northwest beneath the Salton Sea. Some estimates put the total potential for the field at 2,000 megawatts. Development at the Salton Sea geothermal field has been slowed by the high up-front costs involved with brine-based geothermal power, and the lack of power transmission capacity from this isolated region to Los Angeles and San Diego.