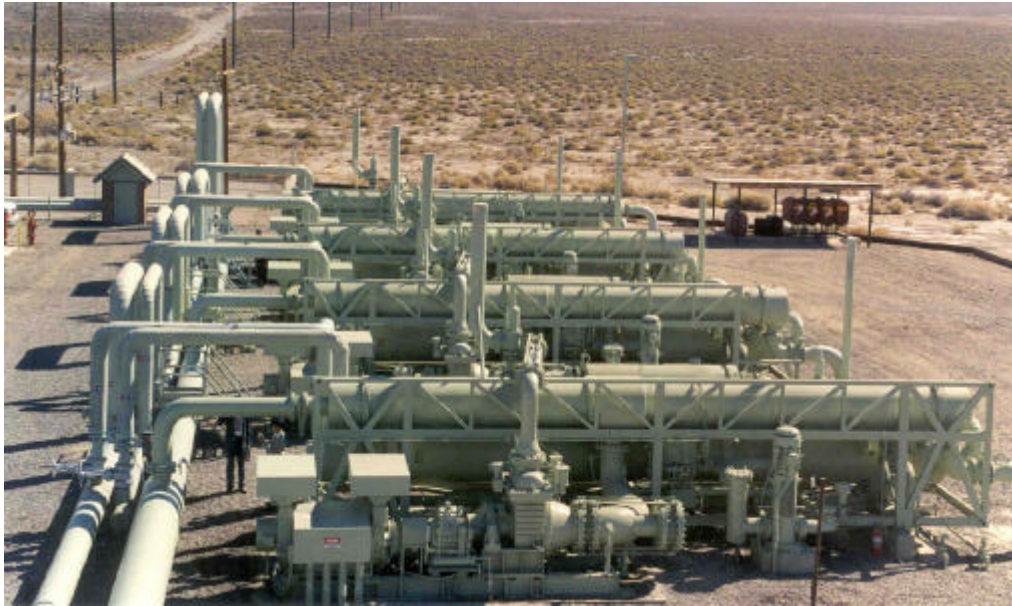


EMPIRE ENERGY, LLC

- A CASE STUDY -

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Empire Energy, LLC

LOCATION

Empire Energy, LLC is part of the Empire Group of companies including Empire Research and Empire Farms. Facilities owned by or to which Empire Energy supplies energy include an approximately 3.6-MWe net geothermal binary power plant and an onion/garlic dehydration plant operated by Empire Farms (Figure 1). Both facilities are located in the San Emidio Desert in northern Washoe County, Nevada. The site is located just south of Empire and Gerlach, and approximately 100 miles (161 km) north of Reno, Nevada. The power plant was constructed by ORMAT Energy Systems and went online in mid-1988. The plant consists of four 1.2-MWe ORMAT energy converters (OEC) designed to produce 3.6 MWe of net power at a design temperature of 285°F (141°C). The dehydration plant, originally built by Integrated Ingredients, was dedicated in May of 1994. The dehydration unit uses approximately 800-1200 gpm (50.47-75.71 L/s) of 298°F (148°C) geothermal water for the four-stage dryer. Present, capacity of the dehydration plant is 75,000 pounds (34,019 kg) of onions per day or 85,000 pounds (38,555 kg) of garlic (Stewart and Trexler, 2003).

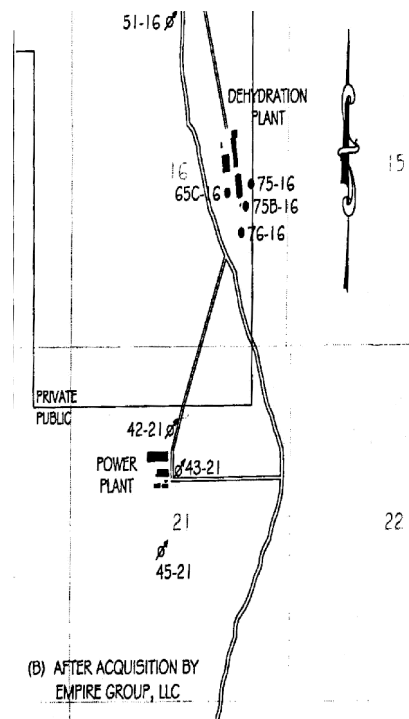


Figure 1. Location of wells, power plant and dehydration plant.

RESOURCE

The San Emidio geothermal area is located within the Basin and Range Physiographic Province. The distinctive features of the province are isolated, longitudinal fault-block mountain ranges separated by long, alluvial-filled basins. It is adjacent to the northern end of the Lake Range. The geology is dominated by a thick sequence of Tertiary lava flows, ash flow tuffs and volcanoclastic sedimentary rocks that accumulated on an irregular surface of Mesozoic metamorphic basement (Stewart and Trexler, 2003). Within the San Emidio Desert, the Tertiary rocks are covered by a layer of lake beds. A discontinuous line of hydrothermally altered rocks marks the boundary of the desert on the east (Mackelprang, et al, 1980). The northern portions of this zone show intense silicants and calcium carbonate deposits which, to the south of the zone, is marked by fumaroles, acid leaching and some deposits of native sulfur (Mackelprang, et al., 1980). Mapping has identified four north-south striking faults and one southwest-northeast striking fault in the area of geothermal development. The faults appear to have between 1,000 and 2,000 ft (305-610 m) of vertical offset (Stewart and Trexler, 2003).

UTILIZATION

During the 1970s, several geothermal exploration companies conducted exploration in the San Emidio Desert and in addition to extensive geophysical work, more than 60 holes from 40 to 2000 ft (12-610 m), were drilled. In the mid-1970s, Chevron drilled two deep exploration wells that encountered temperatures up to 260°F (127°C). The first production well for the Empire geothermal power plant encountered 285°F (141°C) water at 500 ft (152 m) and in all 17 production, injection or observation wells were drilled as part of the power plant development project.

In 1992, the first wells were drilled to serve the planned dehydration plant, and the first production well was found to be capable of producing 200°F (93°C) geothermal water at a flow rate of 650 gpm (41.01 L/s). Two additional wells, drilled in 1994 and 1997, are capable of producing in excess of 3,000 gpm (189.27 L/s) of geothermal water at or above 306°F (152°C). The water is a sodium-chloride type with a total TDS of 4150 mg/L. These three wells are now used to supply both the dehydration plant and the power plant (Stewart and Trexler, 2003).

The original use of the geothermal water was supply of the Empire Power Plant. This 3.6-megawatt net power plant consisted of four 1.2-MWe ORMAT energy converters (OEC) and was constructed by ORMAT Energy Systems. The plant went online in 1988. The plant was originally designed to produce maximum net output with an input resource temperature of 285°F (141°C). Cooling water for the condenser was provided by spray cooling ponds. However, due to increasing interference with cooler injection fluids, the wellhead temperature had fallen to as low as 237°F (114°C) by 1996 and output had fallen to 0.92 MWe (Stewart and Trexler, 2003).

However, subsequent drilling beginning in 1992 in anticipation of developing the geothermal resource for the

dehydration plant, and resource studies conducted in 1994 indicated that this much better resource was capable of providing geothermal energy to both the dehydration plant and the power plant. After fully acquiring the assets of the power plant, a fully insulated 1-mile (1.6-km) line was completed to the power plant. With the availability of hotter geothermal fluids, production was increased to 1.8 MWe. Additional wells drilled in 1997 increased output again. Unfortunately, output was still well below design due to the inefficiency of spray cooling ponds that resulted in temperatures as high as 80-85°F (27-29°C) during the summer. In 1997, a decision was made to construct a 3-cell, inline counter-flow cooling tower with makeup water supplied from a potable water well some 4.5 miles (7.2 km) to the northwest of the plant. The availability of better geothermal fluids and the increased cooling efficiency has boosted power plant net output to over 4.0 MWe in the winter and 3.6 MWe in the summer.

The dehydration plant operated by Empire Foods is capable of producing 75,000 pounds (34,000 kg) of dried onions or 85,000 lbs (38,600 kg) of dried garlic per day. The dehydration plant is supplied with from 800 to 1200 gpm (50 - 76 L/s) of geothermal fluid at a minimum temperature of 285°F (141°C). The dryer is a National 4-stage dryer. Delta T across the heat exchanger is approximately 60°F (16°C).

The spent geothermal fluid is being considered as the input for a planned 1-MWe binary power plant that will meet the power needs of the facility (Stewart and Trexler, 2003; Kutscher, 2001).

OPERATING COST

No capital cost relative to the project was available either in relation to the original 3.6-MWe net power plant project or the dehydration plant. Information concerning operation and maintenance costs was also unavailable. However, some information relative to the 1-MWe expansion has been accessible due to the fact that this is being done in partnership with National Renewable Energy Laboratory (NREL). Preliminary estimates place the cost of the project at approximately \$2,585,000, of which NREL's share would be 80% (Kutscher, 2001). This cost does not include the drilling of any additional wells as the plant would be supplied from the spent geothermal fluid exiting the dehydration plant at a temperature of between 230-245°F (110-118°C). Annual O&M is estimated at \$80/kW and cost of energy without cost share is 8.8 cents/kWh (Kutscher, 2001).

REGULATORY/ENVIRONMENTAL ISSUES

No major regulatory or environmental issues or obstacles have been identified. Permitting was under the jurisdiction of the Bureau of Land Management and Washoe County.

PROBLEMS AND SOLUTIONS

The only major problem was not specifically regulatory or environmental, but was related to the original restricted land position of the original power plant project that allowed for little offset between production and injection wells. The resulting interference from the low-temperature

injection resulted in a rapid cooling of the reservoir and an approximately 75% reduction in power plant output. Through land acquisition, this problem was resolved and production and injection wells are now appropriately spaced so as to minimize future interference problems.

The other significant problem was with the use of the spray cooling ponds as a means to cool water for use in the condensers. The ponds were found to be very insufficient during the summer months and temperatures reached 80 to 85°F (27-29°C). The very warm water resulted in a significant decrease in power plant output during the summer months. In 1997 a decision was made to replace the spray ponds with a 3-cell, inline counter flow cooling tower of fiberglass construction with a wet bulb design temperature of 58°F (14°C). Makeup water for the cooling tower is supplied from a potable water well on Empire Farms, 4.5 miles (7.2 km) to the northwest.

The only other major concern relates to the use of lineshaft pumps and associated requirements for an oil-drip lubrication system. Empire Energy expressed a strong desire to be able to go to submersible pumps.

CONCLUSIONS

The Empire Group of companies has been very successful in optimizing the use of the geothermal resources available in the San Emidio Desert. The collocation of both electric generation and direct use projects demonstrates the economic viability of such arrangements. Should the planned 1-MWe binary power plant be constructed to use the spent geothermal fluid from the dehydration plant, it will serve as further evidence of the benefits of integrating electrical generation and direct-use applications.

REFERENCES

- Kutscher, Charles, 2001. "Small-Scale Geothermal Power Plant Field Verification Projects." *Geothermal Resource Council Transactions*, Vol. 25, pp.577-580.
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Power plant cooling tower.



Sorting onions before drying.



Dried onions coming off the belt drier.