MINING ECONOMIC BENEFITS FROM GEOTHERMAL BRINE

CalEnergy Mineral Recovery Project Creates Jobs and Increases Revenues from Geothermal Power Operations in California's Imperial Valley

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On January 31, 1999, CalEnergy Operating Corp. (CalEnergy) unveiled a $400 million expansion of their geothermal power complex on the shores of the Salton Sea in southern California's Imperial Valley. The new construction includes nearly 60 megawatts (MW) of new geothermal electrical capacity, and a unique project to "mine" commercial-grade zinc from geothermal brine produced for power generation. CalEnergy is a subsidiary of Mid-American Energy Holdings Co. (Des Moines, IA).

CalEnergy currently operates eight geothermal power plants with a capacity of 288 net MW at the Salton Sea. Construction underway for completion by late-July includes Unit 5, a 49-MW facility that will utilize high-temperature waste brine from four of the company's existing power plants to fuel the minerals recovery project and produce electricity. In addition, a 10-MW turbine will be on-line by mid-March to upgrade power production at CalEnergy's Del Ranch and Vulcan power plants. Construction companies heading up the projects include Stone & Webster Engineering Corp. (Denver, CO) and Kvaener U.S., Inc. (San Ramon, CA), which are subcontracting work to local firms.

Funded entirely by CalEnergy, the $200-million mineral recovery project will produce 30,000 metric tonnes of 99.99-percent pure zinc annually for Cominco Ltd. under a contract signed last September. The facility will be the lowest cost producer of zinc in the world, and the first and only operation specifically designed to harvest minerals from high-temperature geothermal brine. "The minerals recovery project will make the geothermal energy we produce more cost effective and tap valuable minerals from the brine we bring to the surface for power production," says CalEnergy Vice-President of Operations Jim Turner.

Thought a number of companies have sought to recover valuable minerals from Salton Sea geothermal brines over the years, it wasn't until 1997 that CalEnergy put its ideas to work. For a 10-month period extending into 1998, CalEnergy proved those concepts with a small demonstration plant at its Elmore power plant that successfully produced 41,000 lbs. of high-grade zinc. Under the leadership of Turner and CalEnergy Chief Technical Officer John Featherstone, company engineers scaled up the process to the full-sized facility now under construction.

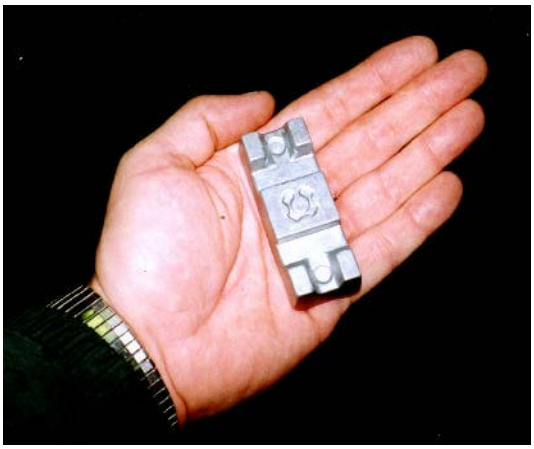
Unlike CalEnergy's other power plants at the Salton Sea, Units 1, 2, 3 and 4 apply a pH modification process to the 500°F (260°C) geothermal brine rising to the wellhead from the geothermal reservoir. By increasing the brine's acidity by about half of a pH unit (to a value between 5.0 and 4.5), the process prevents silica precipitation and scaling during power production, but leaves behind spent fluid for injection at a temperature of 360°F (182°C). "We were basically leaving Btus on the table," says Turner. In addition, he explains, "The brine temperature from Units 1, 2, 3 and 4 is too high after power production for our zinc extraction ion exchange process."

From left to right: CalEnergy Vice President of Operations Jim Turner, Mid-American Vice President of Legislative and Regulatory Affairs Jonathan Weisgall, California Energy Commission Vice Chairman David Rohy, and CalEnergy Chief Technical Officer John Featherstone discuss the company's $400-million expansion project, which includes the 49-megawatt Unit 5 geothermal power plant under construction in the background.

The solution was to build the $150-million, 49-MW Unit 5, scheduled to come on-line concurrently with CalEnergy's zinc recovery facility. Unit 5 will use spent brine from Salton Sea Units 1, 2, 3 and 4 to produce electricity for the minerals recovery operation, which will tap about 20 MW of the power plant's production. Excess power from Unit 5 will be sold into the California deregulated electricity market.

"To tap the remaining energy potential of brine from Units 1, 2, 3 and 4, the new power plant will use low-pressure technology that employs multiple turbine inlets," Turner explains. After electricity is produced, brine temperature for use in the zinc recovery ion exchange facility falls to the

desired temperature of less than 240°F (116°C). "We get the last squeal out of the pig for power production from our other power plants, and create brine that is ready for mineral extraction at the same time," says Turner.



A miniature zinc ingot from the CalEnergy minerals recovery process using Salton Sea geothermal brine. Ingots of the same shape weighing 2,400 lbs. will be shipped to Cominco Ltd. under a contract with CalEnergy signed last September.

The minerals recovery facility uses a combination of already existing technologies that were modified for the task. Besides ion exchange, the facility will employ solvent extraction and "electrowinning" to extract zinc from the spent brine from all of CalEnergy's Salton Sea geothermal power plants, supplied at a flow rate of 20 million lbs/hr. After the metal is extracted, the remaining brine will be injected back into the geothermal reservoir underlying the area.

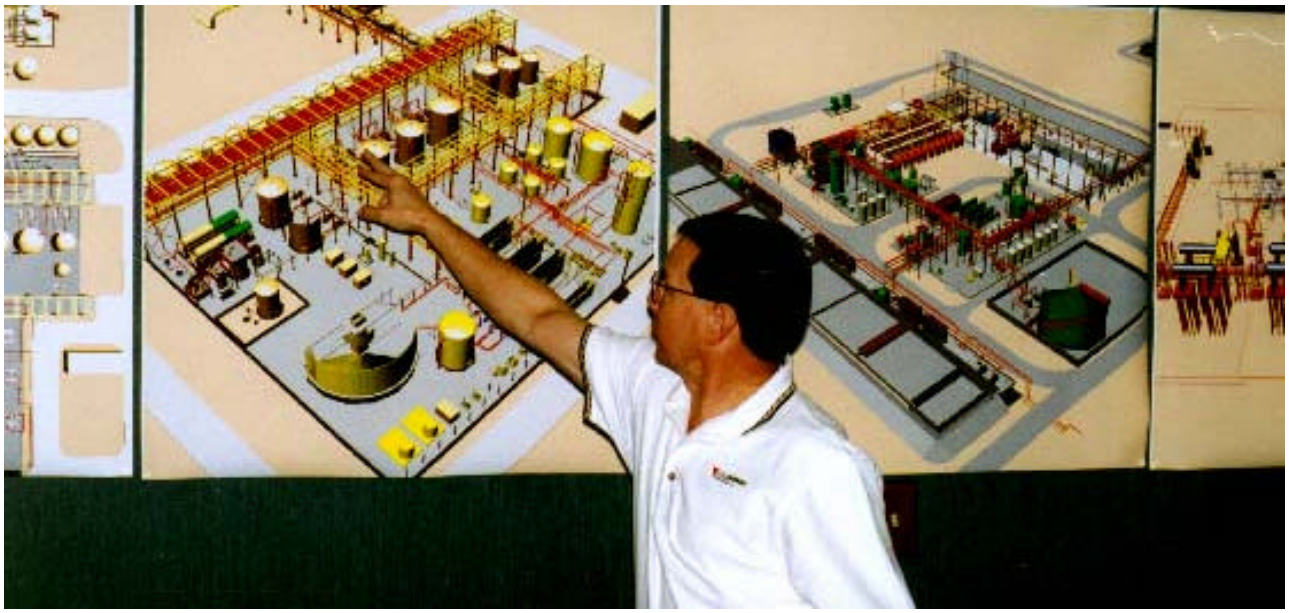
"The brine first passes through an ion exchange resin similar to that used in water softening equipment–but modified with organic molecules that are very specific to zinc under the right conditions," Turner explains. After being pumped to a second facility, a solvent extraction process then transforms resultant zinc chloride into zinc sulfate, which is passed across electrowinning cells that separate sulfate molecules from zinc atoms.

The result is nearly pure zinc deposited on large cathodes. The metal builds up to more than 1/4" in thickness on the cathodes in 24 hours, when it is removed. The metal will then be melted into 2,400 lb. ingots for sale to Cominco. "The end product is SHG, or special high-grade zinc, better than 99.99-percent pure and ready for manufacturing with no further processing necessary," Turner continues.

Even with the success of their minerals recovery project, CalEnergy continues to seek other potentially profitable products from its geothermal brine at the Salton Sea. These include manganese, lithium, boron, and small amounts of precious metals. But the most voluminous mineral contained in the brine is silica, which is produced by the company's Elmore, Del Ranch, Leathers and Vulcan power plants (without pH modification technology) at a rate of 100 tons per year.

In a new research project, the company is seeking economical methods of transforming precipitated silica from its power operations into a saleable product, and removal of manganese from brine already processed for zinc. "Once you have the zinc out of the way, it is much easier to get at the manganese," says Turner. "We're looking at several ways to do it, including ion exchange (with different organic ingredients than those used to extract zinc), solvent extraction, or a combination of the two methods like we use for zinc."

To assist CalEnergy develop methods to recover manganese, purify waste silica into a saleable product, and build a pilot facility, the California Energy Commission (CEC) awarded the company a $904,340-matching grant last summer from the agency's Geothermal Resources Development Account. If successful, the CEC-supported pilot



CalEnergy Vice President of Operations Jim Turner describes the company's minerals recovery facilities, which include an ion exchange and solvent extraction plant (right), and an electrowinning facility (left).

project will help reduce waste, conserve landfill space, and reduce operation and maintenance costs while extracting additional products for market.

"By perfecting ways to extract valuable minerals in the geothermal process, we help to bring down the cost of geothermal power and make it more attractive," said CEC Vice Chairman David Rohy at a press conference held at CalEnergy's Salton Sea project on January 31, 1999. "As the Energy Commission celebrates its 25th anniversary, we are proud to continue our long history of support for the geothermal industry."

That support is appreciated by CalEnergy. "Without the involvement of the CEC, and the positive signal it provides from the State of California, this kind of project would be much more difficult to accomplish," said Mid-American Vice President for Legislative and Regulatory Affairs Jonathan Weigall. "The dollars are important, but even more important is that the state promotes renewable energy production and its benefits for the economies of California and Imperial County."

Indeed, CalEnergy's Salton Sea expansion has created an average 700 construction jobs over the life of the project, and will provide 48 full-time jobs, bringing the company's total number of employees to about 220. For its part, the California Employment Training Panel (ETP) granted CalEnergy a $167,580 contract in January for hiring and training 28 new employees, and to retain 24 current employees for the zinc recovery facility,

Imperial County officials hope that CalEnergy's expansion activities could mean even more jobs–and business development–for the area. If Turner has his way, they won't be disappointed. "We've got a great team here, and I have every confidence that when they are finally perfected, our silica and manganese extraction methods will add another 50 to 60 full-time jobs to the Imperial Valley economy."