VTE Geothermal Desalination Pilot/Demonstration Project

Undertaken by Sephton Water Technology, Inc.
in Cooperation with CalEnergy Operating Company
Funded by the California Department of Water Resources
and the U.S. Bureau of Reclamation

Project Summary, December 2013

Objectives

We are in the process of demonstrating the Vertical Tube Evaporator (VTE) desalination process as a viable and cost effective technology for conversion of highly saline water to potable water in the Imperial Valley. Geothermal steam will provide the thermal energy source for the process. The Salton Sea is the primary saline water source being tested. The VTE process can operate with low or atmospheric pressure geothermal steam not needed for electrical power generation. This renewable energy resource is being provided by CalEnergy for use in an existing pilot and upcoming demonstration project. The specific research objectives of the project are:

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1. Demonstrate the ability to produce high quality potable water from Salton Sea water.
2. Quantify VTE heat transfer performance with Salton Sea water.
3. Demonstrate operation over time with minimal scaling or reduction in performance.
4. Control corrosive contaminants in the geothermal steam to preserve VTE equipment and identify suitable and economic materials of construction.
5. Demonstrate separation of an array of source water contaminants such as microbial agents, chemicals of environmental concern, and minerals from product water into concentrated brine or precipitated salts.
6. Demonstrate an environmentally benign brine management plan by producing brine concentrate chemically suitable for injection into geothermal wells or suitable for use in salinity gradient solar ponds.
7. Execute an information sharing program.

The project is focusing first on desalinating Salton Sea water as the most difficult saline water resource in the region. The distilled water produced could be used directly for environmental mitigation/restoration, or for local industries and municipalities by exchanging distilled water produced for agricultural drain water to replenish the source.

Background

The first phase of the project began in November 2004 and was funded by the U.S. Bureau of Reclamation from funds allocated by Congress for research related to Salton Sea restoration. A Vertical Tube Evaporator (VTE) Pilot Plant was assembled next to the CalEnergy Units 1&2 geothermal power plant and tests were run on several thousand gallons of Salton Sea water transported to the site by tank vehicle.

The second phase of the project is funded by a California Proposition 50 desalination grant awarded by the California Department of Water Resources (DWR) to Reclamation in September 2006 and by additional funding from Reclamation. Contracts were

completed in January 2008 to begin work on upgrading the existing VTE Pilot Plant from one effect to two effects. Tests with the VTE Pilot Plant were undertaken from 2009 through 2013.

The necessary environmental and encroachment permits were secured by mid 2009 and updated through 2014 to assemble a 5 fold larger capacity VTE Demonstration Plant adjacent to the Pilot Plant. The larger plant is needed to provide design quality thermal efficiency data that can lead to future commercial plants using this technology. A series of tests are planned with the VTE Demonstration Plant to test the chemistry and thermal efficiency of distilling Salton Sea water and possibly other local saline water using non-commercial geothermal steam as an energy source.

Technology

The VTE Pilot and Demonstration Plants will be used to simulate the process conditions in a commercial size Multi-Effect Distillation (MED) plant. MED technology has gained increasing acceptance in the Middle East and other areas where large-scale seawater desalination is common.

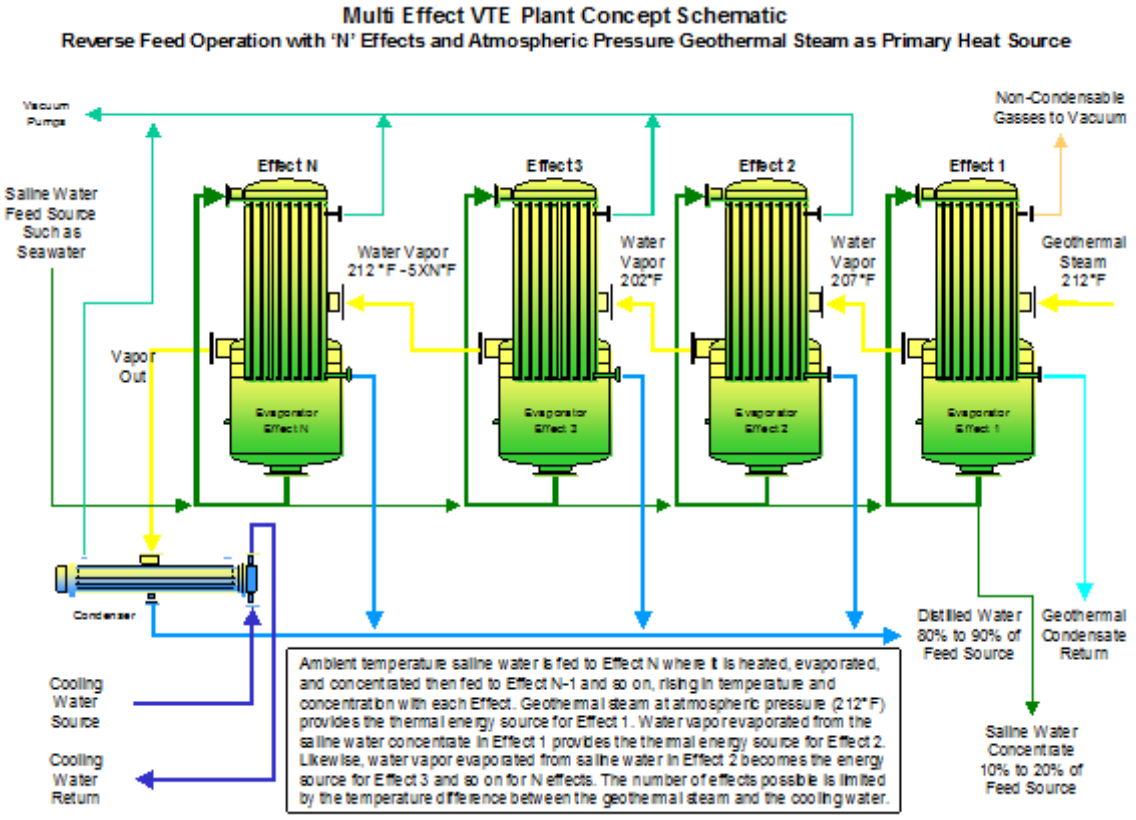
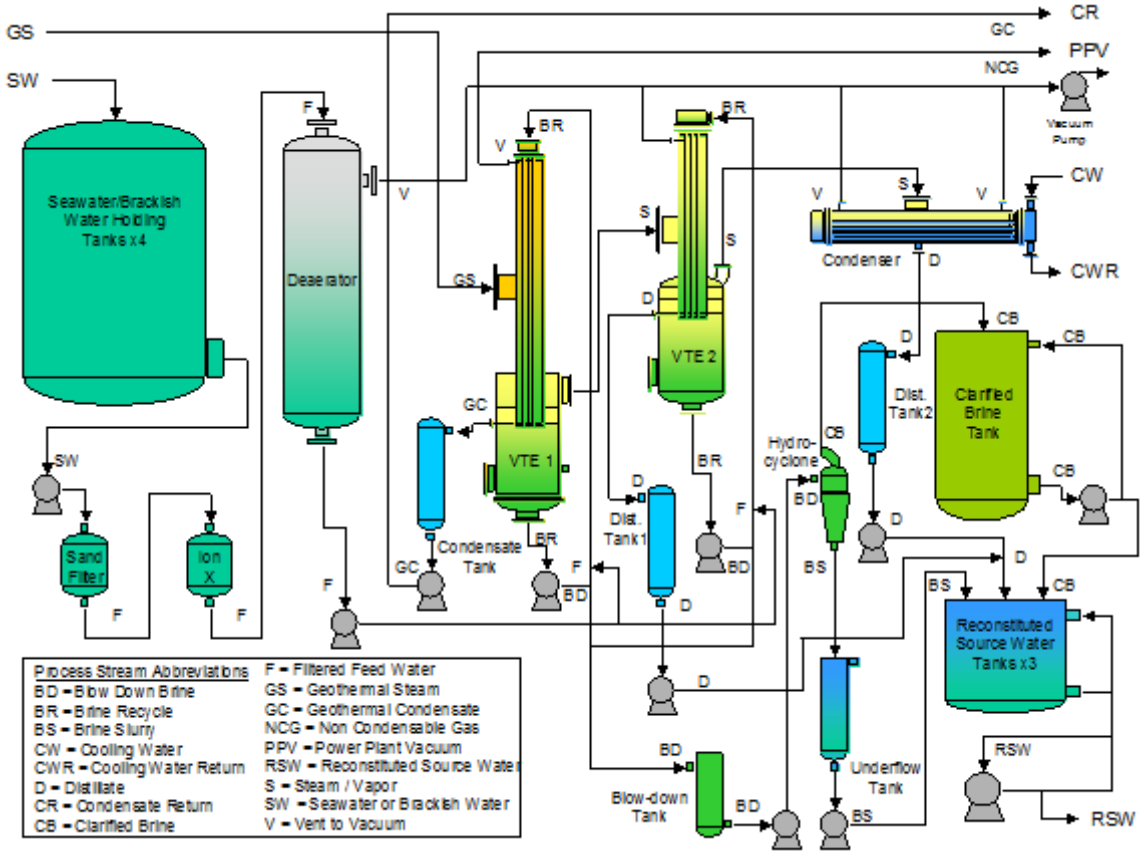


Figure 1.

The MED concept applies thermal energy from a primary steam source to distill saline water by transferring heat of condensation from the steam to the water through the wall of metal evaporation tubes. The tubes can be arranged in bundles vertically or horizontally with steam on the outside and saline water on the inside or vice versa. The

VTE configuration uses vertical tube bundles with steam condensing on the outside and saline water flowing as a thin film on the inside surface of the evaporator tubes. Figure 1 shows a schematic of a Multi-Effect VTE plant in the reverse feed operation mode.

Our tests simulate process conditions in several effects across the range of a 15 Effect VTE Plant. The VTE distillation process applied to an MED plant design with low cost non-commercial geothermal steam as an energy source may prove cost competitive compared to other desalination technologies. A 15-effect plant could produce up to 14 pounds of distilled water for each pound of geothermal steam used. VTE technology could also have the advantage of discharging much lower volumes of concentrated brine than other methods. A recovery rate in excess of 80% from a seawater source is typical.

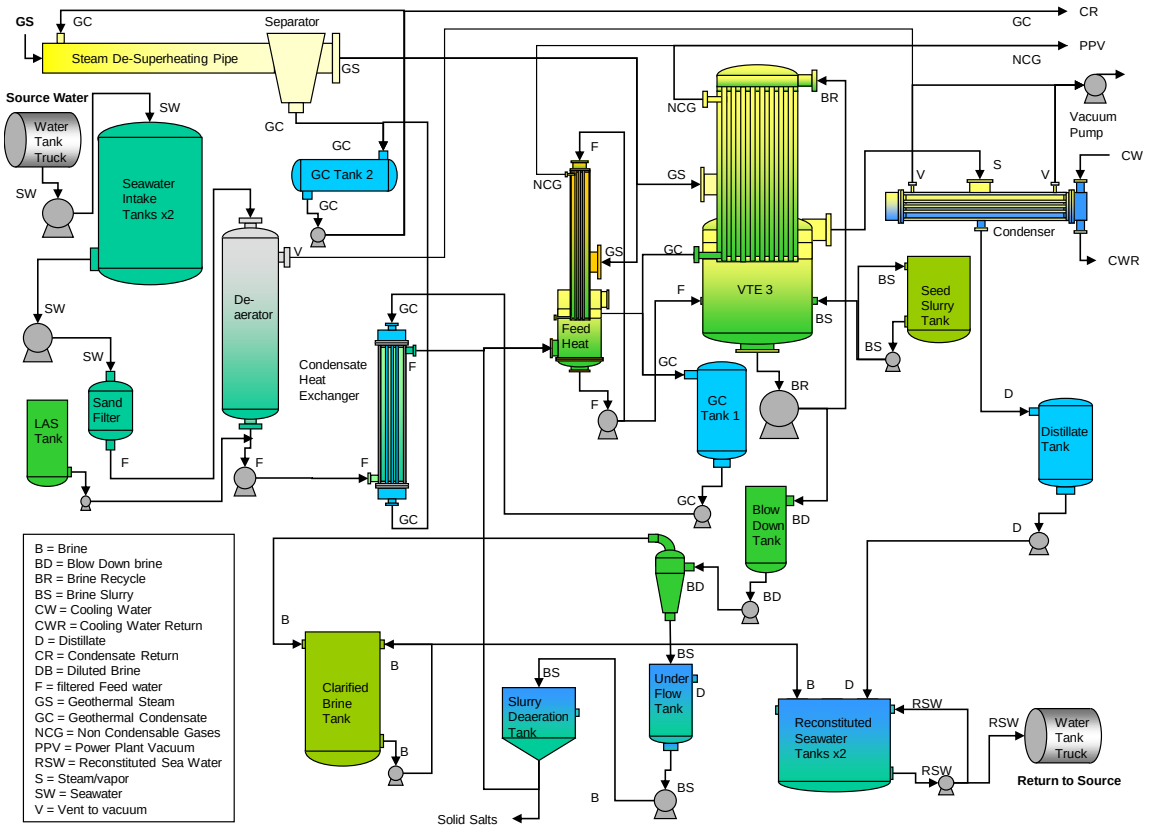


VTE Pilot Plant Schematic, Figure 2.

The VTE Pilot Plant already in place (Figure 2) has two small evaporators configured to simulate the temperatures and brine chemistry of one or two effects of a 15-effect plant. It can use up to 1,000 lbs/hr of low-pressure (25 psig) steam from the Cal Energy geothermal plant to convert up to 5,000 gallons of Salton Sea water to distilled water daily. The condensed geothermal steam is returned to the Cal Energy geothermal plant condensate pond and the non-condensable gasses are returned to the geothermal plant vacuum system. Cooling water at up to 190 gpm is drawn from and returned to the geothermal plant. Salton Sea water is brought in by tank truck, transferred to holding tanks, separated into distilled water, solids, and concentrated seawater brine by the VTE

process. The water samples are tested for chemical and physical properties. Distilled and concentrated seawater fractions are then recombined, mixed, and tested before return to the Sea.

The VTE Pilot and Demonstration Plants will only transfer heat energy from the geothermal steam to the saline water being distilled. There will be no direct contact between any geothermal materials and Salton Sea or other saline source water materials. All distilled water and concentrated brine separated from Salton Sea or other water will be returned to the source except for small samples for laboratory testing. All geothermal steam from the power plant will be returned to the geothermal plant as condensate or non-condensable gasses.



VTE Demonstration Plant Schematic, Figure 3.

The VTE Demonstration Plant (Figure 3) will operate similarly to the Pilot Plant, but at a higher capacity. It will use an evaporator rated for 50,000 gallons per day capacity, but the maximum amount of water distilled will be about 21,000 gallons per day using a maximum of 7,500 lbs/hour of low-pressure geothermal steam from the Cal Energy plant. The maximum flow of cooling water will be 190 gpm using the existing 4” tie in pipes to the power plant cooling system.

Seawater will be transported to and from the site by tank truck. A reduction in the level of the Salton Sea leaves insufficient local offshore depth to operate continuous flow fish screens previously approved by environmental agencies. Also, the remaining DWR grant funds are very limited. For these reasons, intake and return pipelines to the Salton Sea that were planned and permitted in 2009 have not constructed at this time. These pipes may be constructed in late 2014 under a new grant awarded by the State to IID and Sephton Water Technology.

Applicability to Local Needs

One research objective has been to find methods to control the water chemistry of concentrated Salton Sea brine so that it can be suitable for injection into the geothermal aquifer. This would provide a way to safely remove salts, selenium, and other contaminants from the Salton Sea while converting most of the water treated to beneficial use. It may also help maintain the geothermal aquifer. Testing toward this objective has been completed. An unintended benefit of this testing has been the development of a process that converts mixed Salton Sea brine into 99% pure sodium chloride brine which may provide an economically viable way to extract large quantities of commercially salable salt from the Salton Sea to manage salinity while fully recovering the costs.

The VTE technology has previously been tested in collaboration with the California DWR at Los Banos to maintain salinity in a salinity gradient solar pond using solar thermal energy from the pond. VTE technology may be well suited to converting Salton Sea water to supply saturated brine for use in solar energy generating salinity gradient solar ponds while recovering most of the water for potable use. This process can be driven by non-commercial geothermal steam or by solar energy collected and stored as heat in the ponds. In addition to producing solar energy, salinity gradient solar ponds installed in exposed lakebed as the Salton Sea recedes can eliminate fugitive dust, serve as a large repository for excess sea salts, and supply pure distilled water for wildlife or other beneficial uses. Planning of a joint effort with the Imperial Irrigation District to pilot test this concept on recently exposed Salton Sea lakebed is underway. This work is partly funded under a new grant awarded in 2013 by the State of California to IID and Sephton Water Technology under the Salton Sea Financial Assistance Program.

The State of California has identified a Preferred Alternative for Salton Sea restoration, but funding and political support for this alternative has not been forthcoming. VTE technology can be used to purify Salton Sea water to maintain a high water quality in habitat ponds at the Salton Sea such as those anticipated by the State plan or by local efforts without the risk of selenium buildup from contaminated local rivers and drains. This concept is also planned to be tested in cooperation with IID under the Salton Sea Financial Assistance Program.

VTE desalination is well suited to take advantage of the geothermal energy resource to benefit Imperial County. In the near future, these benefits could include millions of gallons of high quality water each day, salinity control for wildlife habitat areas, recharge of the geothermal aquifer or saturated brine supply to salinity gradient solar ponds,

support of efforts to reduce negative impacts from reduced inflows to the Salton Sea, and supporting local development of renewable energy.

Project Status

At this time (December 2013) testing is underway with the VTE Pilot Plant to control mineral scaling and to control corrosion of evaporator tube metals caused by hydrogen sulfide and ammonia in geothermal steam. The existing major equipment for the VTE Demonstration Plant has been refurbished and resealed. The expanded plant will add a larger Vertical Tube Evaporator and condenser in a 40ft by 60ft spill containment structure adjacent to the current VTE Pilot Plant. Existing support frames for the large evaporator and condenser have been fitted with a broader base and lateral extensions to secure the system in the event of earthquakes. Pipes and auxiliary equipment will connect it to the VTE Pilot Plant and the CalEnergy plant's low pressure steam pipe, cooling system, condensate pond, and non-condensable gas recovery system. The VTE Plants will be assembled from VTE desalination equipment owned by Sephton Water Technology and support equipment provided by the Bureau of Reclamation. Pipe, steel and other materials are being purchased locally.

The VTE Demonstration Plant is planned for use to convert Salton Sea water to distilled water to sustain a habitat test pond and Salton Sea salts to saturated brine for use as a solar heat absorption and storage medium in a salinity gradient solar pond under the Salton Sea Financial Assistance Program grant. The VTE Pilot Plant is planned for relocation to the salinity gradient solar pond ½ mile from its current location to use solar heat to distill Salton Sea water.

After completion of all of the tests, the VTE Demonstration Plant will be disassembled and all equipment and materials will be removed from the CalEnergy site. Data from the tests will be evaluated to provide recommended methods and estimates of the economic and environmental benefits of the geothermal driven VTE technology. Final reports will be submitted the U.S. Bureau of Reclamation and the California DWR, which will be available to other agencies or interested parties.

Permitting Status

The required Federal, State, and local permits were obtained to construct the existing VTE Pilot Plant in 2004 and 2005. The Imperial County Building Permit from 2005 (#046994) was renewed in 2008 (#051946) for upgrades to the Pilot Plant. All physical work done to date is within the scope of the permits issued in 2004, 2005, and 2008.

For the VTE Demonstration Plant, a CEQA and NEPA process has been completed by Reclamation, the California Regional Water Quality Control Board has issued a determination that an NPDES permit is not required, and the California Department of Fish and Game as been notified of procedures to prevent take of endangered species. An operating permit with the Imperial Air Pollution Control District was secured when using power from portable generators. The plant is now on utility power with no regulated air emissions.

In December 2008, encroachment permits were applied for with the Imperial County Department of Public Works and IID, and drawings were submitted to the Imperial County Planning and Building Department for the intake and return pipes to the Salton Sea. A 2005 minor amendment (allowing the VTE Pilot and Demonstration Plants) to Imperial County Conditional Use Permit #9014A-94 held by CalEnergy Operating Company has been extended extended through 31 December 2014. A new building permit application for the VTE Demonstration Plant equipment is now under submission.