Renewable Energy and Desalination

Introduction

The cost of water desalination depends on a variety of factors, including source water access and quality, desalination process, concentrate disposal method, and distance to the point of use.

To help reduce desalination costs, Reclamation is promoting renewable energy sources for the desalination process. Renewable energy sources may operate individually or in a hybrid configuration to fit your water desalination needs: from small to large scale processes, coastal to rural regions, and thermal to electrical-driven processes.

Solar

Solar thermal energy may be used directly or indirectly to drive various desalination processes. A variety of solar collection systems can power a variety of desalination processes.

Figure 1: Solar Still

Direct systems absorb solar radiation and distill water in one unit. Reclamation provided funding for the study of a solar still (Figure 1) that uses solar power in two ways. The first is similar to a traditional solar still. Solar radiation passes through the transparent material and is absorbed by the dark surface. The heated dark surface facilitates the evaporation of the salty water. The vapor rises to the transparent material where it condenses and drains down the inner walls and is collected. The second feature enhances production with the use of tubing on the back wall to circulate cold water to generate additional surface area for water to condense.

Solar ponds trap heat due to the salinity gradient of the stratified water. Reclamation sponsored several projects with the University of Texas, El Paso to research the use of thermal energy from solar ponds for use in membrane distillation and in a separate study, multi-effect, multi-stage (MEMS) flash distillation. In membrane distillation, hot brine from the bottom of the solar pond was used to heat the feed water to elevate its vapor pressure. Cool water from the surface of the solar pond was used to cool the water vapor into distillate. Membrane distillation operates best at very low pressures, allowing for less expensive piping materials and fewer problems with leaks and pump failures, thus lowering capital and operational costs. In MEMS flash distillation, energy from the solar pond provides a heat source to the MEMS systems, thus using the concentrate from the MEMS system to recharge the solar pond. Although this was a small pilot system, the potential for its use in treating reverse osmosis or nanofiltration concentrate poses a strong economic value in reducing operation, maintenance, and concentrate disposal costs.

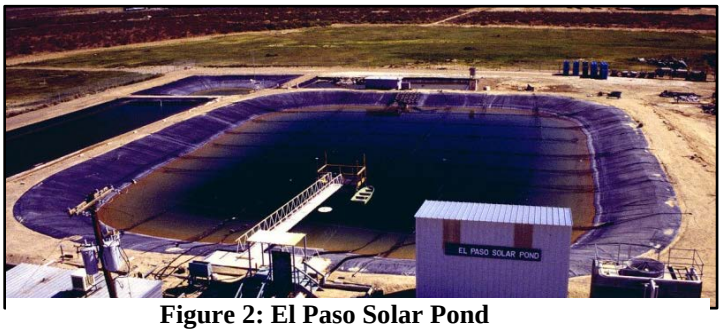

Figure 2: El Paso Solar Pond

Concentrate disposal costs may also be lowered by using solar concentrating sand beds. A Reclamation funded study done by the University of Arizona, Tucson, and Texas A&M University demonstrated that halophytes combined with sand beds are a viable source of concentrate disposal. Halophyte (salt-loving) shrubs such as *A. nummularia* and salt-tolerant grasses (Figure 3) can recycle concentrates evapotranspiration. Solar concentrating sand beds may then be used to further reduce the volume of concentrate.

Figure 3: *A. nummularia* halophyte shrub

Solar radiation may also be converted to electricity through a photovoltaic system. A photovoltaic system may combine with an electrodialysis or reverse osmosis desalination system. Reclamation worked with the Navajo Water Development and Maintenance Department to install a photovoltaic-powered electrodialysis reversal desalting system at Spence Valley, near Gallup, New Mexico. Maintenance of the unit was minimal and power consumed was considered low for a system of its size proving to be a cost-effective and reliable solution for treating brackish water. Reclamation also sponsored a study done by ITN Energy Systems, Inc. demonstrating successful use of a photovoltaic reverse osmosis desalination system in Mesquite, Nevada.

Wind

Wind turbines supply both mechanical and electrical energy sources. Mechanical power may be supplied to either mechanical vapor compression or reverse osmosis desalination processes. Electrical power may be used for the desalination processes, including electrodialysis. The availability of wind in coastal areas presents an ideal location for wind turbines. The coastal city of Perth, Australia used a wind farm to power a seawater reverse osmosis plant that requires 24 MW of electricity. Reclamation sponsored a project to develop a simple, cost-effective desalination system for Pacific Islands and other remote coastal communities. A system was tested on Coconut Island, Oahu, Hawaii demonstrating the ability to combine renewable energy sources: a windmill was used to power a reverse osmosis system and solar energy was used to drive the instrumentation for the system. It was estimated that a pilot plant with a freshwater production of 1,285,000 gallons per year would cost $5.40 per 1000 gallons. Another project sponsored by Reclamation presented the need for renewable energy sources in smaller cities where revenue streams are limited. The inland city of Seminole, Texas is within the High Plains region and has a high wind resource availability to harness power for a reverse osmosis system. Experiments conducted indicated that an optimized application of a wind turbine array and intelligent control systems can reduce overall energy costs.

Figure 4: Seminole, TX

Geothermal

Geothermal resources provide electricity or thermal energy to power various desalination processes. Thermal energy from geothermal reservoirs may power multistage flash evaporation, thermal vapor compression, or multi-effect distillation while electrical energy powers reverse osmosis, electrodialysis, or mechanical vapor compression. Reclamation has sponsored a pilot test project in California to demonstrate the technical and economic feasibility of using geothermal energy.

Wave

Ocean waves are becoming a more popular source of renewable energy in areas such as the northwestern U.S. coastal regions. Ocean wave technologies vary in location from nearshore to far offshore. Mechanisms applied to convert wave power to energy are also diverse. As wind blows over the surface of the ocean, waves are formed and energy may be extracted using wave power devices. Reclamation has recently funded a project with Resolute Marine Energy to design, build, and test a pressure and flow rate regulation system in conjunction with a seawater reverse osmosis system powered by wave energy.

Figure 5: Geothermal energy

DWPR Reports

Report Title	Performing Agency	Date	Report #	Topic discussed
Solar and Waste Heat Desalination by Membrane Distillation	University of Texas at El Paso; El Paso, TX	Apr-04	81	Thermal Energy from Solar Ponds
Thermal Desalination Using MEMS & Salinity-Gradient Solar Pond Technology	University of Texas at El Paso; El Paso, TX	Aug-02	80	Thermal Energy from Solar Ponds
Halophyte Crops and a Sand-Bed Solar Concentrator to Reduce and Recycle Industrial, Desalination and Agricultural Brines	University of Arizona; Tucson AZ; Texas A&M University; El Paso TX	Dec-98	35	Solar Facilitated Concentrate Management
Photovoltaic Reverse Osmosis Desalination System	ITN Energy Systems, Inc.; Littleton, CO	May-04	104	Renewable Energy - Photovoltaic
Wind-Powered Reverse Osmosis Water Desalination for Pacific Islands and Remote Coastal Communities	University of Hawaii at Manoa; Honolulu HI	Apr-09	128	Renewable Energy - Wind
Wind Power and Water Desalination Technology Integration	Texas Tech University; Lubbock TX	Jul-09	146	Renewable Energy - Wind