Renewable Energy Options for Desalination

Using renewable energy to reduce desalination costs

Problem
Desalination by any process requires energy. The amount of energy needed depends on the amount of salt in the water—in general, the higher the salt concentrations, the more energy is needed. Other factors include source water salinity, required product water salinity, composition of the salinity in both streams, amount of desalinated water to be produced, the desalination process used, temperature of source, and the quality of the product and reject water. Renewable energy increases the sustainability of desalination processes, but research is needed to reduce overall costs and environmental impacts. Reclamation has funded several studies to investigate ways to use renewable energy for desalination.

Solutions
Solar
A variety of solar collection systems can power a variety of desalination processes.

- **Solar stills** allow sunlight to pass through a transparent material and be absorbed by a dark surface behind it. This heated dark surface helps evaporate the salty water. The vapor rises into tubes where it condenses, drains down, and is collected. Tubes rather than walls provide additional surface area for water to condense. See *Suns River Solar Still*.

- **Photovoltaic systems** can convert solar energy to electricity for an electrodialysis or reverse osmosis desalination system. See *Photovoltaic Reverse Osmosis Desalination System*.

- **Salinity gradient ponds** (also called salt gradient ponds) trap heat as the stratified water contains various levels of salt concentrations. The higher the salinity concentrations in the water, the more heat the water can store. Hot, salty water from the bottom of the solar pond heats the feed water to raise the vapor pressure. Cooler, less salty water from the surface of the solar pond cools the water vapor into distillate. See *Suns River Solar Still*.

◊ **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. See *Solar and Waste Heat Desalination by Membrane Distillation* (for further membrane distillation work, see *Desalination and Water Purification Reports #87, #96, #99, and #134*).

◊ **Multi-effect, multi-stage (MEMS)** flash distillation uses energy from the salinity gradient pond as a heat source to the MEMS systems. This small pilot system showed the potential for reducing operation, maintenance, and concentrate disposal costs in treating reverse osmosis or nanofiltration concentrate. See *Thermal Desalination Using MEMS & Salinity-Gradient Solar Pond Technology*.

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**Bottom Line**
Reclamation is exploring the use of renewable energy sources for the desalination process.

**Better, Faster, Cheaper**
We are working to reduce costs and address environmental impacts to use renewable energy to provide sustainable water supplies in the future.

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- **Solar concentrating sand beds** may further reduce the volume of concentrate from desalination processes. This study demonstrated that halophytes (salt-loving plants such as *A. nummularia*) combined with sand beds can be used in a concentrated disposal process. [Halophyte Crops and a Sand-Bed Solar Concentrator to Reduce and Recycle Industrial, Desalination, and Agricultural Brines](#)

**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.

- Renewable energy sources can be combined: a windmill to power a reverse osmosis system and solar energy to drive the system’s instrumentation. [Wind-Powered Reverse Osmosis Water Desalination for Pacific Islands and Remote Coastal Communities](#)

- A wind turbine array and intelligent control systems can reduce overall energy costs. [Wind Power and Water Desalination Technology Integration](#)

**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. [Design and Testing of a Pressure Regulation Subsystem for a Wave-Driven Desalination System](#)

**Geothermal**

- Geothermal resources provide electricity or thermal energy to power various desalination processes. Reclamation has sponsored a pilot test project in California to demonstrate the technical and economic feasibility of using geothermal energy. [Vertical Tube Evaporator Thermal Desalination Pilot Test](#)

- Photos (left to right): Nanofiltration concentrate may be recycled through the process of evapotranspiration utilizing halophyte shrubs such as *A. nummularia* halophyte shrub, Reclamation-sponsored pilot test project in California to demonstrate the technical and economic feasibility of using geothermal energy, and harnessing power for a reverse osmosis system with a windmill in Seminole, Texas.

**Collaborators**

- CalEnergy Operating Corporation
- Resolute Marine Energy
- Sephton Water Technology
- Suns River
- Texas Tech University
- University of Arizona
- University of Hawaii at Manoa
- University of Texas at El Paso