Energy Quarterly

News and analysis on materials solutions to energy challenges

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Inside:

Water in the desert

El Paso, Texas, is located in the desert southwest region of the United States. The Rio Grande, which separates El Paso from its neighbor, Juarez, Mexico, was a major water source in the past, but now it flows only a couple of months a year. With an average annual rainfall of less than nine inches, El Paso relies primarily on groundwater to supply potable water for a growing population, but the groundwater is becoming progressively salty.

To supplement the dwindling supply from moderately salty wells, in 2007, El Paso Water, the local water utility, opened what was then the world's largest plant to make potable water from groundwater by reverse osmosis with a production capacity of 27.5 million gallons per day. El Paso Water is now planning a facility for direct potable reuse (DPR) of treated wastewater, which is expected to be the world's largest DPR operation. Another first for El Paso is a plant under construction by the Enviro Water Minerals Company, which will extract industrial chemicals from the reverse osmosis concentrate and recover potable water that will be returned to the El Paso Water distribution system.

In 2008, the Center for Inland Desalination Systems (CIDS) was established at The University of Texas at El Paso (UTEP). I was recruited to be the Director of CIDS and immediately recruited Malynda Cappelle, a rising star in desalination research at Sandia National Laboratories, to join CIDS.

The Desal Prize competition was held last year at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in neighboring New Mexico, and the competitors had to rely completely on renewable energy to power their desalination processes. The UTEP team, headed by Cappelle, used a technology called zero discharge desalination (ZDD) for their entry. ZDD uses electrodialysis metathesis (EDM) to concentrate the salts in the stream of reverse osmosis or nanofiltration to high levels and recover gypsum as a solid byproduct. The team used photovoltaic (PV) panels to provide power and charge batteries for nighttime operation of their system. ZDD has demonstrated high recovery of fresh water (up to 98%) from the

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Top left:
Brackish Groundwater National Desalination Research Facility of the US Department of the Interior, Bureau of Reclamation in Alamogordo, New Mexico.

Top right:
The University of Texas at El Paso Desal Prize team: Thomas Davis, Malynda Cappelle, and Shane Walker. Photo by J.R. Hernandez, UTEP News Service.

Bottom left:
The Kay Bailey Hutchison Desalination Plant.

Bottom right:
Zero discharge desalination technology equipment at the Desal Prize competition.

gypsum-rich groundwater at BGNDRF, for which only about 75% recovery is expected from treatment with reverse osmosis alone.

Energy consumption is a major contributor to the cost of desalination. The demonstrations in the Desal Prize competition showed that PV is indeed useful to power desalination. An aspect of PV cells made with silicon, the most common PV cell material, is that the PV cells absorb energy from the infrared portion of solar energy, and most of that absorbed energy is converted to heat. PV cells lose 0.5% of their efficiency for converting solar energy to electrical energy for each °C of heating. We observed that energy requirements for reverse osmosis and electrodialysis are reduced when the feedwater to the desalination process is warmed, so a process is being developed to transfer the heat from the PV to the water that is to be desalted, to obtain the benefits associated with power production and desalination.

How can materials science contribute to desalination? One useful contribution is in developing membranes that require lower energy input for desalination. At the University of California, Los Angeles (UCLA), where the first energy-efficient reverse osmosis membrane was developed, Eric Hoek discovered that nanoparticles strategically placed in thin-film-composite membranes can reduce energy consumption; Hoek formed NanoH2O Inc. to manufacture those membranes. Yoram Cohen and Nancy Lin of UCLA are applying polymer brush layers on reverse osmosis membranes to delay or prevent the onset of membrane fouling and scaling.

Susan Rempe of Sandia and her colleagues have developed and tested biomimetic reverse osmosis membranes that require considerably less energy than conventional membranes, and now her team is working on bioinspired ion-exchange membranes with the expectation that their electrical resistance can be reduced in electrodialysis devices.

The next challenge will be to manufacture low-energy membranes economically on a scale where they can be used in a commercial desalination apparatus. The future of desalination in the desert is promising thanks to new materials.

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