RECLAMATION *Managing Water in the West*

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The Knowledge Stream
Innovation Update

Reverse Osmosis Energy Savings for Seawater and Brackish Water

Equipment and process design improvements reduce RO desalination energy usage and associated costs

Bottom Line

The cost and energy needed to purify seawater thru reverse osmosis can be reduced.

Principal Investigator

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Collaborators

Reclamation's Science and Technology Program, Denver Technical Services Center, and the ADC. The majority of project funding came from the California Department of Water Resources for seawater testing and the Texas Water Development Board for brackish water testing.

What Is the Problem?

The need for additional water supplies continues to grow as population increases, droughts occur, climate change effects escalate, and other factors pressure existing water supplies. Reverse osmosis (RO) membrane technology can provide purified water from seawater and inland brackish waters, but at higher cost and energy use than using non-saline sources.

Energy use is the most expensive and environmentally taxing component of desalination operations. To reduce both costs and environmental impacts, the energy required for desalination operations must be reduced. Isobaric energy recovery devices can reduce desalination energy use and associated costs.

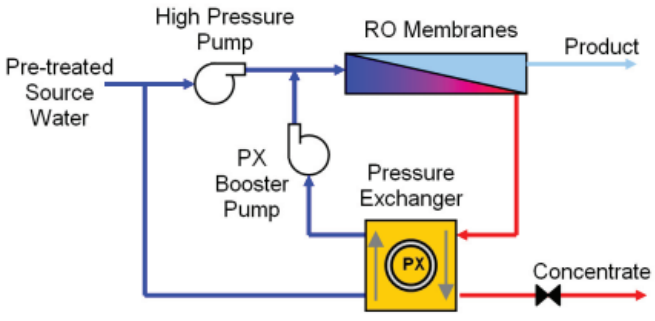
Isobaric energy recovery devices have been widely used in seawater, but optimizing the latest RO technology lowers energy use and costs. However, the industry and public are often unaware of this and may still believe that this is as cost prohibitive for most applications, as it has been in the past. In brackish water treatment, the use of isobaric energy recovery devices to reduce desalination energy use and associated costs has not been widely implemented and demonstrated to the industry.

Solution

To demonstrate how the cost and energy needed to purify seawater thru RO can be reduced, this Science and Technology Program research project provided a demonstration of the most efficient combination of the latest commercially available equipment (including a full size eight inch RO membrane, high efficiency pump, and energy recovery devices).

Seawater RO

Seawater RO using an optimized process creates an optimal cost point at 6.81 kilowatt hours per thousand gallons (kW-hr/kgal) with a 50 percent recovery and a flux of 9 gallons per square foot of membrane per day. Alternatively, an optimal energy point of 5.98 kW-hr/kgal (1.58 kW-hr/m^3) is achieved with a 42.5 percent recovery.



Seawater Water Desalination Pilot Components and Test Schematic

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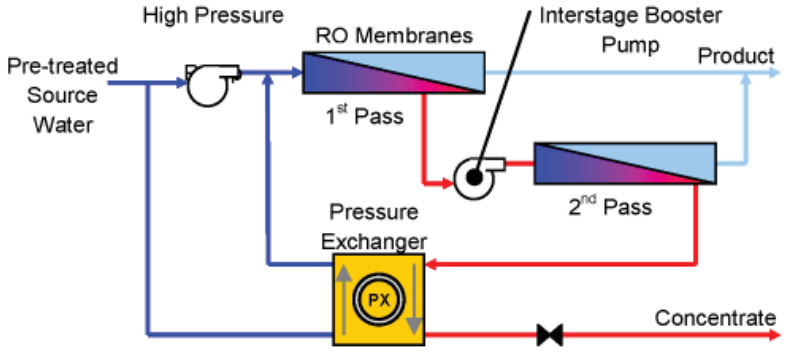
Brackish Water RO

Since brackish water RO treatment requires less energy than treating seawater, net energy usage and cost benefits attained are modest by comparison. Net benefits are most promising for water with low levels of silica due to scaling of pressure exchangers.



Brackish Water Desalination Pilot Components and Test Schematic

The innovative flow regime shown above did not produce a significant energy benefit and an increased recovery was not possible due to silica scaling. Standard process configurations with the pressure exchanger technology showed both an energy benefit over other energy recovery devices and a projected positive net decrease in cost of water produced.

Future Development Plans

There are no specific future development plans for this research. Further reduction in RO energy use will likely come from small incremental improvements driven by public research funding and competition between equipment manufacturers. The technology is approaching thermodynamic limits that cannot be improved upon.

More information

The brackish water project has two main sources for additional information:

- Report: Energy Optimization of Brackish Groundwater Reverse Osmosis Desalination from the Texas Water Development Board (TWDB).
- Conference Proceedings of the American Membrane Technology Association's 2011 Annual Conference (July 17 – 20, 2011 Miami, Florida).

The seawater project has two primary sources for additional information:

- Report: Optimizing Seawater Reverse Osmosis for Affordable Desalination from California Department of Water Resources (forthcoming summer 2012).
- Conference Proceeding of the International Desalination Association World Congress in 2009.

"Desalination technology benefits all water managers and agencies that need to use saline water sources to minimize the risk of water supply shortages. Seawater and some brackish water sources are more reliable than many freshwater sources."
Kevin Price

Where Have We Applied This Solution?

A unique collaboration of leading government agencies, municipalities, RO membrane manufacturers, consultants and others formed the Affordable Desalination Collaboration (ADC) in 2004 with the goal of reducing seawater desalination energy usage and associated costs. The ADC developed a multi-phased effort that built and operated a demonstration desalination pilot at the U.S. Navy's Seawater Desalination Test Facility in Pt. Hueneme, California. Following the pilot seawater desalination project success, the ADC reconfigured the pilot for brackish RO energy recovery and mobilized at the Kay Bailey Hutchison Desalination Plant in El Paso, Texas.