

Field Pilot Testing of Electrically Conductive Reverse Osmosis (Active) Membranes for High Mineral Content Brackish Groundwater Desalination



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Challenge

The need for more reliable and drought-resilient potable water supplies will drive the interest in developing a broader portfolio of water supply sources beyond conventional fresh surface and ground waters to additionally include unconventional, impaired, and saline water sources such as municipal and industrial wastewater, brackish groundwater, and seawater. These unconventional water sources have complex geochemistry, often saturated in one or more sparingly soluble minerals and metals, and often have poor microbiological and/or organic quality. Reverse osmosis (RO) pre-treatment and membrane technologies that could reduce the cost, footprint, and operational complexity, while maintaining stable operation when facing feed waters with high fouling and scaling potential would be transformative in that they could dramatically accelerate and enable industry and end-user adoption.

Research Approach

For a period of three months of continuous operation, we plan to field test the performance of our anti-scaling electrically conducting reverse osmosis (Active) membranes against a commercial RO membrane in a high total dissolved solids (TDS) brackish water source in a plant in Sand City, CA, operated by California American Water. We plan to design and build a 10-20 gallons per minute pilot unit consisting of a train of Active membranes (Train A) parallel to an identical train of conventional brackish water RO (Passive) membranes (Train B).

The manufacturing process involves synthesizing an electrically conducting coating film on top of an already formed membrane. We have demonstrated the ability to coat microfiltration (ECMF), ultrafiltration (ECUF), nanofiltration (ECNF), reverse osmosis (ECRO) and membrane distillation membranes (ECMD). Herein ECRO membranes will be packaged in spiral-wound modules designed to function as drop-in replacements for existing RO membrane systems enabling a non-invasive retrofit business model creating minimum barrier for adoption. Customers will buy our membranes when they need to replace their old ones or build new plants

Impact

Our patented and innovative technology is electrically conducting membranes capable of actively resisting membrane fouling and scaling. Active fouling-resistance lowers energy demand, increases product water recovery (less waste generation), feed water quality adaptability minimizes pre-treatment, process complexity and footprint, and thus, significantly reduces operating and capital costs of membrane-based desalination plants. The resulting process significantly reduces the number of pre-treatment unit operations and chemicals required resulting in significant reduction in footprint, capital, and operating costs.

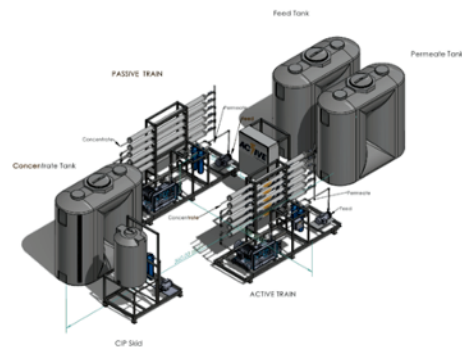


Figure 1. ECRO Process for desalinating a high mineral content unconventional water resource.

RESEARCH PARTNERS

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Accomplishments & Findings

This project operated from February to December 2025 at a produced water treatment facility in Moorpark, CA (Sand City CA's brackish GW treatment plant was not able to accommodate the pilot). The produced water had undergone "de-oiling" and had a TDS of 16-17 parts-per-thousand. This site had the added benefit of having hosted an earlier pilot of an RO system with "conventional" pretreatment in 2018.

This pilot consisted of side-by-side trains of conventional and electrically "Active" membranes operating in parallel on the same incoming water. The pilot team varied pretreatment and other operating conditions, including electrical parameters of the active membranes and compared the flux and flux decline of the conventional and active trains.

This project demonstrated that electrically "Active" membranes can effectively eliminate the need for extensive pre-treatment prior to reverse osmosis without significantly compromising water recovery rates. Not only does this eliminate the costs and logistics of chemical pretreatment, it also substantially simplifies and reduces the size of RO-based treatment systems: pre-treatment unit processes can represent more than 50% of the total treatment train size and CapEx.

The project also demonstrated that the properties of active membranes can be optimized in real-time in response to changes in incoming water quality, with changes voltage, wave form and frequency all contributing to optimizing the rejection of organic and inorganic fouling agents.

Related Accomplishments

During the project, the team tested a substantially improved formulation for the conductive coating applied to the membranes, enabling higher charging and lower resistivities. This resulted in improved fouling and scaling resistance for the same amount of electricity. The team also made substantial improvements in the manufacturing of the membranes, in part by driving the active membranes in the pilot to failure, and then diagnosing and improving the

design of the specific failure points.

Based largely on the breakthroughs the team demonstrated during this project, the Active Membranes team was selected as Semi-Finalists for BOTH Track A and Track B of the Mohamed bin Zayed-sponsored XPrize in May, 2026 - a \$119M, multi-year global effort to accelerate breakthrough seawater desalination systems that are more reliable, affordable, and sustainable.

Opportunities for Further Research

The success of this pilot project has demonstrated that produced water of this general composition (widespread throughout California's oil-producing regions) is treatable to Title 22 standards (safe for use in irrigation) at a cost that is lower than many current disposal options. The combination of water scarcity, high-value agricultural production, and wildfire risk in these areas makes the beneficial reuse of produced water an important new element in a diverse water supply strategy. The pilot team is now in negotiation to build a larger treatment facility at the location of the pilot which would treat up to 63,000 gpd.



Figure 2: Side-by-side RO trains allowed for a direct comparison of the active membrane technology versus conventional RO.