A Hybrid Optical Technology for Concentrate Management

Water and energy are intertwined with demand driven by population growth and economic expansion. Water-stressed regions are exploring more nontraditional water sources and energy intensive technologies such as reverse osmosis (RO) to secure and augment their freshwater supply. As RO effectively rejects most of the dissolved species and recovers approximately 50 to 80% of water depending on water source, it also generates a relatively large concentrate waste stream. Management of concentrate streams in inland applications is the key technology hurdle to overcome as it often requires the integration of one or more unit operations. Common management strategies (surface water discharge, deep well injection, evaporation ponds, land applications, thermal evaporation, etc.) are timely, costly, and can be energy intensive. Thus, there is an unmet need and multiple incentives for process intensification in inland desalination applications to augment limited freshwater supplies and reduce energy consumption.

We propose an intensified solar-energy capture desalination system that integrates membrane distillation (MD) with a hybrid concentrated solar power (CSP)/photovoltaic (PV) collector to realize self-sustained desalination of concentrate streams in inland and off-grid applications (Fig. 1). The overlap of water scarcity in high-solar potential regions such as Arizona, California, Colorado, New Mexico, and Texas presents an ideal opportunity for a technology to successfully augment water supplies – an increasingly precious commodity – by converting highly saline concentrate streams produced during inland desalination to beneficial use. Furthermore, direct utilization of solar heat from CSP and electricity from PV for water purification enables higher energy productivity, and thus lower levelized cost of water and energy.

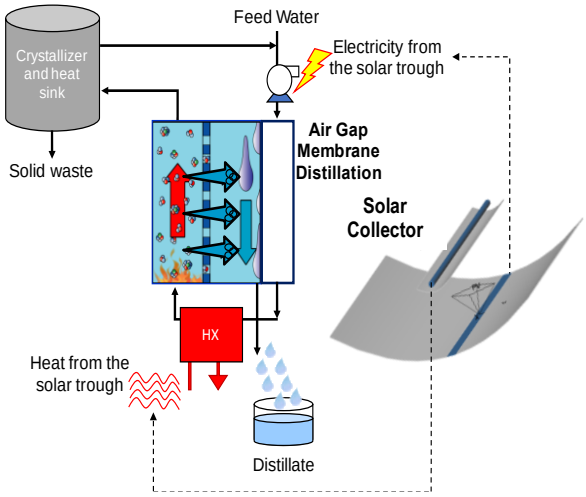

Figure 1. Hybrid CSP/PV solar collector coupled with MD. The hybrid solar collector generates heat and electricity for the air-gap MD system.

The primary goal of this project is to realize increased solar energy and water utilization in desalination processes through a hybrid MD-CSP/PV collector. At the end of the project, this system will be ready for prototyping in an operational environment (TRL 7). This will be achieved through collecting experimental data from our engineering-scale hybrid MD-CSP/PV collector in a real off-grid application (i.e., no energy inputs from the grid). We will utilize real RO concentrate from our RO system located at the Water and Energy Sustainable Technology Center (WEST) at the University of Arizona (UA). The RO concentrate is the most restrictive source water to evaluate our technology in inland desalination scenarios as it contains both high levels of inorganics (similar to a classic brackish water source) and organics (due to the wastewater source). Experimental data and previously established baseline experimental and system-level models will be used to conduct techno-economic and life cycle assessments and evaluate system economics and environmental impacts. Successful engineering of the proposed system for water reuse applications is proof that the system can be used for treatment of high-salinity waste streams from other chemical and commodity process streams (i.e., inland brackish water desalination, oil and gas process waters, or cooling tower blowdown water). This project meets several of RAPID's institutional goals, including intensified processes with reduction in capital cost, improvement in energy efficiency, and lowering waste production.

Proposed Start/ Duration: 9/1/2020 – 18 month duration