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Modeling Energy Efficiency of Solar Thermal Powered Batch Reverse Osmosis

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Abstract: Modeling Energy Efficiency of Solar Thermal Powered Batch Reverse Osmosis

Batch reverse osmosis is the most energy efficient water desalination method and when powered by renewable energy, suggests promise for a cost-effective, low-carbon solution. One abundant energy source on Earth is solar energy which can be implemented using solar panels which have an established maximum efficiency of 25%, or solar thermal engines which can outperform solar photovoltaic systems by achieving higher efficiencies between 20% and 40% according to market research. Here, an approach to model and quantify the energy efficiency of a direct-drive solar thermal powered batch reverse osmosis system is presented to indicate the feasibility of pursuing this technology. One contribution of the modeling work presented is the inclusion of system dynamics since batch reverse osmosis is a transient process. The pressure needed to drive the reverse osmosis system dictates the required torque output of the solar thermal engine, affecting energy flows to the high-pressure pump and the circulation pump. The hydraulic devices consume the most energy in the batch reverse osmosis process and are therefore the most critical for energy efficiency modeling. The energy input from the sun and the efficiency of conversion by the solar thermal engine into mechanical work are also considered. Currently, from experimental work, the batch reverse osmosis process consumes about 2 kW/m^3 water produced. This process is the first thermally driven batch reverse osmosis process and could potentially be the most efficient thermally driven desalination process overall with high impact especially in regions near the equator where solar resources are prevalent.