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The scope to improve the efficiency of solar-powered reverse osmosis

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ABSTRACT

The aim of this paper is to identify and evaluate potential areas of technical improvement to solar-powered desalination systems that use reverse osmosis (RO). We compare ideal with real specific energy consumption (SEC) to pinpoint the causes of inefficiency. The ideal SEC is compared among different configurations including a batch system driven by a piston, and continuous systems with single or multiple stages with or without energy recovery in each case. For example, to desalinate 1 m^3 of freshwater from normal seawater (osmotic pressure 27 bar) will require at least 0.94 kWh of solar energy; thus in a sunny coastal location, up to 1850 m^3 of water per year per m^2 (m^3/m^2) of land covered by solar collectors could theoretically be desalinated. For brackish water (osmotic pressure 3 bar), 11570 m^3/m^2 of fresh water could theoretically be obtained under the same conditions. These ideal values are compared with practically achieved values reported in the literature. The practical energy consumption is found to be typically 40–200 times higher depending on feed water composition, system configuration and energy recovery. For state-of-the-art systems, energy losses at the various steps in the conversion process are quantified and presented with the help of Sankey diagrams. Improvements that could reduce the losses are discussed. Consequently, recommendations for areas of R&D are highlighted with particular reference to emerging technologies. It is concluded that there is considerable scope to improve the efficiency of solar-powered RO system.

Keywords: Solar power; Reverse osmosis; Photovoltaic; Rankine cycle; Specific energy consumption; Efficiency

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