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An experimental investigation of a solar-driven desalination system based on multi-effect membrane distillation

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ABSTRACT

We investigate the effectiveness of an integrated solar-driven system with a membrane-distillation process for freshwater production. A system is a self-powered unit that comprises a solar-photovoltaic system, solar–thermal system, and membrane-distillation system. A vacuum multi-effect membrane distillation (V-MEMD) module acts as the core of the solar desalination unit, and a heat pump is integrated to the module to improve its performance. We focus on evaluating the overall energy consumption, both thermal and electric, for the cases with and without condenser cooling. The system was tested in Riyadh over two seasons, that is, summers and winters. Upon enabling the preheat mode during June, March, and April, the maximum distillate-water production and the corresponding minimum specific electrical-energy consumption (SEEC) were achieved at approximately 31.8 L/h and 74.9 kWh/m^3, respectively, for the overall system, and the SEEC for the V-MEMD unit also reached 6.3 kWh/m^3. Furthermore, when the inlet heating (evaporator) temperature was greater than 55°C, cold-side absolute pressure was lower than 200 mbar, and preheat mode was active, then high water mass flux up to 12.2 kg/m^2 h and recovery ratio up to 36.8% could be obtained. Moreover, the gain output ratio enhanced to 4.25.

Keywords: Solar thermal desalination; Multi-effect membrane distillation; Recovery ratio; Gain output ratio (GOR); Specific electrical-energy consumption (SEEC); Specific thermal-energy consumption (STEC)

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