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Simulation and performance analysis of reverse osmosis water desalination system operated by a high concentrated photovoltaic system

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ABSTRACT

This work examines the employment of high concentrated photovoltaic (HCPV) modules to drive reverse osmosis (RO) desalination unit in Kuwait weather. The RO systems which are operated by HCPV modules have several benefits, as low running expenses, easy running, simple setup and it is also environmentally friendly. An equivalent circuit model for single diode which is compatible with TRNSYS software is implemented to evaluate triple junction HCPV modules efficiency in Kuwait's environment considering concentration level and temperature effects. The performance of the RO unit powered by HCPV designed to provide drinking water at a constant daily load profile of 20 m^3/d to a community in a remote area in Kuwait is studied and optimized. A code consistent with available TRNSYS routines is developed to evaluate the efficiency of the RO unit in Kuwait's climate. The developed models are validated through comparison with experimental data available from literature. The efficiency of RO-HCPV unit is optimized by varying the different system parameters mainly: water salinity, water feed pressure, permeate water pressure, concentrate water pressure as well as permeate flow rate. In addition, HCPV modules slope and orientation are varied by running several simulations until the HCPV system size which satisfies the energy requirement needed is achieved. To explore the environmental effects of utilizing RO-HCPV system, the emissions of CO_2 avoided is calculated. The results show that an HCPV modules of inclination of 26° due south, which is about 0.88 of Kuwait latitude (29.5°), can attain maximum power generation. Current predictions reveal that a regular supply of 1.7 m^3/h leads to about 6,400 m^3 yearly from freshwater. Finally, the optimum HCPV modules slope which maximizes the reserved CO_2 emission corresponds to Kuwait' latitude and is equal to 2.1 ton/year.

Keywords: Solar desalination; High concentrated photovoltaic modules; Reverse osmosis; Solar radiation

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