Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2017.20630

74 (2017) 21–34
May

Emergy, energy and exergy analysis of a solar powered low temperature desalination system

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Received 12 October 2016; Accepted 22 February 2017

ABSTRACT

A low temperature phase change desalination process was studied in which, saline water is desalinated by evaporation at near-ambient temperatures under low pressures. The low pressure is achieved naturally in the head space of water columns of a height equal to the local barometric head. We present the energy, exergy and emergy analysis of this process to evaluate the thermodynamic efficiency of its major components and to identify suitable operating conditions that minimize exergy destruction and maximize resource utilization (emergy). For energy and exergy analysis, three different heat sources such as direct solar energy (SSV), photovoltaic energy (SSPV) as well as a low grade heat source (SSL) were considered. Exergy analysis showed that the major exergy destruction occurs in the condenser where the latent heat of the water vapor is lost to the environment. The overall exergy efficiencies were 0.04%, 0.051% and 0.78%, respectively, for SSV, SSPV and SSL configurations. Exergy performance of individual process components and recommendations to further improve the exergy efficiency of the proposed process were discussed. Emergy analysis was performed on the three different configurations to assess their resource utilization efficiencies, environmental impacts and sustainability. Six different indices based on the emergy approach took into account factors such as renewable and non-renewable energy used by the process, benefit of the process to society and economics of the process. Based on the indices estimated in this study, the configuration utilizing thermal energy from SSL (such as a solar water heater) was found to be the most promising sustainable technology. Results of this study indicate that future research and development work on the barometric distillation process should focus on further refining the configuration utilizing thermal energy from other SSLs.

Keywords: Desalination; Energy; Exergy; Emergy; Resource utilization; Thermodynamics; Sustainability; Transformity

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