ABSTRACT

This study explores the prospects for clean energy generation in coastal regions from salinity gradient made of seawater (SW) and its concentrates (SWC) by the CC-PRO technology of near absolute energy efficiency without energy recovery device and semi-permeable membranes such as HTI-TFC ($A = 2.49 \text{lmh/bar}$, $B = 0.39 \text{lmh}$, and $S = 564 \mu m$) of 48.3 bar maximum applied pressure and alike. This power generation process is fueled by SW as low salinity feed and SWC as high salinity feed (HSF) and the regeneration of HSF from the produced high salinity diluted feed achieved through evaporation ponds of the types extensively used by the sea salt manufacturing industry. Large-scale harvesting of clean energy from the sea could be found particularly attractive along coastlines of arid zones where climate conditions (e.g. solar radiation, temperature, wind, humidity, etc.) favor effective evaporation from reservoirs of SWC. The simulated CC-PRO process of the SW (4.2%)–SWC (25%) salinity gradient with the HTI-TFC membrane revealed maximum membrane power density of 55.6 W/m² and net electric power density after accounting for the auxiliary pumps of 39.3 W/m² at the hydraulic pressure difference of 48.3 bar under draw/permeation flow ratio of 5.0 and membrane actual/ideal flux ratio of 0.2 estimated from available forward osmosis data of the same membrane in the 1.0–3.0 NaCl salinity gradients range. HTI-TFC membrane surface area of 1,000 m² should provide 943 kWh electric energy per day enough to desalinate 377 m³/d of SW (4.2%) with 50% recovery by means of the closed circuit desalination (CCD) technology (RO: 2.5 kWh/m³). The results of this study reveal that the CC-PRO technology opens the door for large-scale commercial clean power generation from SW–SWC salinity gradients already with existing PRO membranes and improved economic feasibility when PRO membrane of higher actual/ideal flux ratio and burst pressure shall become available in the near future.

Keywords: Forward osmosis (FO); Osmotic power; Salinity gradient power; Pressure-retarded osmosis (PRO); Closed circuit PRO; Evaporation ponds; Seawater; Seawater concentrates; Clean energy generation from seawater