Upstream Salinity Gradient Energy Harvesting

Author block: K. Hazazi, EXPEC ARC - KAUST

Abstract

Objectives/Scope: This work aims to assess the feasibility of harvesting/harnessing salinity gradient energy available in the upstream waste water streams (e.g., produced water, pond water, and boiler blowdown water).

Methods, Procedures, Process: Salinity gradient energy harvesting is a process of harnessing the released energy when two water streams with different salt concentrations are mixed together. A typical example is the water mixing that occurs at the river mouth, where rivers (fresh water) flow into the sea or ocean (salty water). The amount of salinity gradient energy that can be harvested depends on several factors, including the salt concentrations of the water streams and the efficiency of the energy harvesting technologies - such as pressure retarded osmosis (PRO) and reverse-electrodialysis (RED). For example, the ideal salinity gradient energy that can be harvested when mixing 1 m$^3$ of sea and river water streams containing only sodium chloride (NaCl) and with molar salt concentrations of 0.6 and 0.06 mol/L, respectively, is about 1.25 MJ with a potential electricity output of 0.35 kWh.

Results, Observations, Conclusions: Herein, we explore a new and promising application of the salinity gradient energy harvesting technology in the upstream oil and gas industry. Examples of upstream waste water streams existing at a wide range of salt concentrations include produced water (total dissolved solids (TDS): 50000-150000 mg/L), pond water (TDS: 1500-3000 mg/L), and boiler blowdown water (TDS: 100-500 mg/L). Such significant salt concentration differences between the aforementioned waste water streams enabled a substantial increase in the overall amount of the harvested salinity gradient energy compared to other conventional water streams with lower salinity gradients. For example, mixing 1 m$^3$ of produced water and boiler blowdown water with molar salt concentrations of 1.71 mol/L and 0.005 mol/L, respectively, would ideally generate 1.56 kWh of electricity, which is about 4 times higher than the ideal harvested energy from a typical river-sea water mixture system.

Novel/Additive Information: Salinity gradient energy harvesting is a promising technology with the potential to provide a sustainable source of renewable energy for a wide range of important applications, including wastewater treatment. Despite the fact that the technology is still in its early stages, there have been substantial technical advancements in recent years that have made it more competitive, efficient, and, most importantly, cost-effective. In addition, as research and development efforts continue to progress, we can expect to see further advancement in the performance and scalability of salinity gradient energy harvesting technology. Herein, we demonstrated, for the first time, the major advantages of adopting salinity gradient energy harvesting technology in the upstream sector and its potential for enabling or unlocking a sustainable and renewable source of energy for a wide range of upstream operations.