**Long-term assessment of Energy Recovery from Salinity Gradients**

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**Highlights**

* Salinity Gradient Energy from desalination and wastewater treatment plant streams
* Mathematical modelling tool for evaluation of different scenarios.
* RED Technology for energy recovery and biomedical applications.

**1. Introduction**

Salinity Gradient Energy (SGE) is considered one of the most attractive renewable energy sources since it is completely clean and sustainable with no toxic gas emissions [1]. The main technology to harvest the SG energy is Reverse Electrodialysis (RED), which has emerged as a promising membrane-based technology for renewable energy generation by mixing two solutions of different salinity. The state of the art and technical challenges for a wider implementation of the technology have been excellently reviewed in a recent work [1]. Besides, the proximity of two streams with different salinity is important for its final implementation; apart from the well-known mixing between sea and river waters different scenarios have been analyzed such as, the mixing of desalination streams, brine with brackish water, seawater and WWTP streams, respectively. More recently the downscaling of the RED technology has addressed the development of new lab-on-a-chip (LOC) biomedical devices, e.g. medical implants powered by RED technology [2] concluding that RED technology offers great opportunities for new, long-lasting and safer biomedical devices.

In this sense, the development of robust model tools for the study of SG power generation and RED performance under diverse scenarios and different operational and system conditions is still essential for the optimization of this technology. Thus, we aim to contribute to the wider implementation of the SGP-RED technology by advancing comprehensive models supported by the experimental evidence. For this purpose, in this work we have evaluated, theoretical and experimentally, the performance of a SGP-RED laboratory plant for the long-run applied to the energy recovery from desalination wastes and we have defined the maintenance protocol.

**2. Methods**

The experiments were performed using a RED stack composed of 20 cation and anion exchange membrane pairs with membrane areas per cell of 200 cm2 and polyethersulfone spacers, both supplied by Fumatech®. The electrode rinse solution (ERS) was constantly flowed in a closed loop. The schematic setup is shown in Figure 1. Experiments were performed by using an electronic load device (Chroma Systems Solutions 63103A, USA) [3]. The stack was continuously fed with stream solutions coming from desalination plants. To perform the modelling of the process, the software Aspen Custom Model V9 (AspenTech) was used based on the equations that describe the phenomena occurring inside the cell, establishing the following assumptions: (i) co-current flow distribution, (ii) purely sodium chloride aqueous solutions and (iii) evaluation of the parameters at the average conditions between inlet and outlet [3].

Inlet

HC

ERS

Electronic load

LC

Outlet

RED Stack

**Figure 1.** Experimental setup. HC: high concentration solution; LC: low concentration solution.

**3. Results and discussion**

First, we performed the analysis of the energy recovery by mixing two solutions of different characteristics. Figure 2.a displays the gross power (W/m2) achieved under different scenarios and the experimental results against current (A), showing that predicted curves are in concordance with lab scale results. The deviation between simulated and experimental results over time was lower than 10%. In view of the simulated data for the experimental assessment we worked with 2 industrial streams, S1 and S2, with a concentration of NaCl of 0.94 M and 0.04 M respectively, together with other ions and we tested the stability of the plant with time. Figure 2.b) depicts the results obtained over one month of continuous operation. Gross Power remained constant for this period when a simple maintenance protocol was applied.

a

b

**Figure 2.** a) Power performance resulting from the combination of different scenarios; b) Long-run testing of RED stack fed with water streams from desalination plants.

**4. Conclusions**

A stable performance of the SGP-RED technology working with rejections of desalination plants has been proved in continuous operation with a simple maintenance protocol. The good agreement between the experimental results and simulated data with the mathematical model validated the design tool that can be expanded to down-scale operations using miniaturized devices.

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