Development of an equivalent circuit model for reverse electrodialysis cell stack (REDCS)

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Reverse electrodialysis is a direct way to convert salinity-gradient energy to electricity using ion exchange membranes (IEMs). In this study, an equivalent circuit model is constructed for optimizing power efficiency of reverse electrodialysis cell stacks (REDCS). Input parameters are resistances of membranes and electrodes, structure of flow channels, stack number, and salt concentration. The electrical potential across a membrane is calculated from Nernest equation and also used as an input parameter. Output such as power density, short-circuit current, and open-circuit voltage can be estimated by the model. The internal resistance, which is most affected by fresh water concentration, is the critical parameter influencing the REDCS efficiency. There are parasitic currents that degrade power output: firstly, unwanted transport of ions due to imperfect membrane selectivity, secondly, ionic short current through the manifold of inlet and outlet. Those effects evaluated by the model coincide with experimental measurements for REDCSs with varying stack numbers. The power density has reached as high as 2.41 W/m^2 in 120-pair-stack REDCS optimized by this model.