Optimized train configuration for mega-scale seawater RO systems with turbocharger energy recovery

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ABSTRACT

Construction of mega RO facilities (train capacity of 5,000 m$^3$/day and larger) faces many challenges including cost-effective utilization of energy recovery devices (ERDs) and high-pressure pumps. Recently, mega system owners and integrators have selected turbochargers with single train capacity exceeding 20,000 m$^3$ of daily permeate output. This study analyzes several ERD configurations in single- and two-stage arrays with a capacity of 20,000 m$^3$/day. In particular, two-stage (brine staged) configurations are extensively explored to establish the limits of specific energy consumption (SEC) reduction under realistic operating scenarios. Commercially available membrane projection software was used to develop a mathematical model of membrane array performance including the effects of feed total dissolved solids, temperature, age, and polarization. Software was developed to evaluate tens of thousands of membrane configurations along with hundreds of operating conditions to identify ERD applications and array configurations that provide the lowest SECs. A figure of merit was defined to ensure unbiased comparison of results. The findings showed that two-stage arrays provide an SEC reduction of about 3% with optimal recovery around 47% relative to single-stage arrays with the same number of membrane elements. Perhaps the most interesting finding from a practical perspective is that turbochargers in an optimized two-stage array have an SEC about the same as isobaric chambers in optimized single-stage arrays.

Keywords: SWRO; ERD; Motor assisted turbocharger; Energy consumption; Train configuration

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