Reverse Osmosis (RO) Desalination Powered by Transient Hybrid Photovoltaic/Thermal (PV/T) Solar Systems

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I. Motivation

Reverse Osmosis (RO) is with a market share of over 60% the leading technology in desalination today [1].

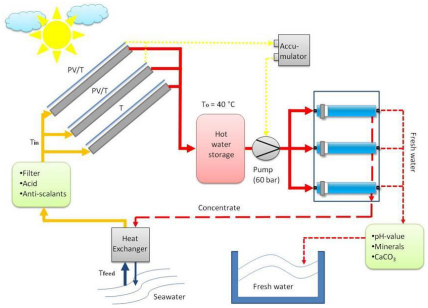

Figure 1: Sketch of a possible configuration of a PV/T-RO desalination system

Especially in the last 50 years, extensive research has been performed to further develop RO membranes, modules and plant designs. Coupling renewable energy supply with fresh water production in a very efficient and competitive way will be one major trend in the water and environmental sector in the years to come. RO plants are commonly powered by conventional energy sources, e.g. fossil fuels, at constant operating conditions. Renewable power supply often means highly transient plant operation, which is not state-of-the-art and not understood in great detail. However, consequent transient operation is not only important in renewable energy powered RO, but also in conventional RO applications where transient operation might be advantageous against scaling and fouling phenomena. Transient investigation of the boundary layer is, together with the general goal to apply PV/T hybrid collectors for RO brine preheating, one of the main foci of the present study. Both renewable power supply and control issues come up when combining RO plants with so-called hybrid Photovoltaic/Thermal (PV/T) solar collectors. Compared to Photovoltaic (PV) driven RO, two major advantages of PV/T supply of thermal and electrical energy are expected: (1st) the PV efficiency is improved due to cooling with seawater and (2nd) RO water permeability, thus freshwater output is increased due to the elevated seawater feed temperatures. In preliminary studies, potential of PV/T-powered RO plants was identified as an increase of fresh water production of about 30% in comparison to only PV-powered RO plants [2].

II. Project Idea

A lab-scale membrane plant at Technische Universität München (TUM) and a field test PV/T-RO-plant at Dead Sea and Arava Science Center (DASC) will be build up and used for systematic test series. The gained results of the field tests of the PV/T-RO-plant at DASC shall be transferred to filtration processes NF, UF, and MF. This would also enlarge the PV/T application field to contaminated surface- or beach-well-water and would open an even larger field of application for PV/T as an actual niche technology. The scientific focus of the test rig lies on the investigation of transient phenomena in the membrane boundary layer. A membrane test rig is developed including a novel membrane test cell for optical investigation of cross-flow operation at high pressures up to 80 bar. Beside,s a CFD model was implemented to numerically investigate the concentration boundary layer over the membrane, see Figure 2.

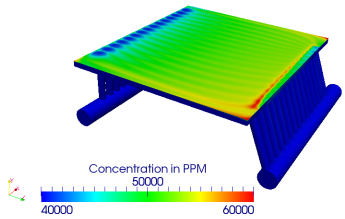

Figure 2: CFD results of 3D CFD simulation of membrane test cell

III. Work Packages and Results

In the course of the project, the following work packages shall be executed:

1. Review of state-of-the art in transient operation of membrane processes,
2. Modeling, simulation and development of control-strategies for highly transient driven membrane processes,
3. Design and realization of a lab-scale membrane test rig in Germany substantial improvement of the already existing test rig,
4. Optimization of the PV/T-RO system with a focus on RO under transient operation conditions and an optimal control strategy,
5. Planning, building and execution of the PV/T-RO field tests in Israel.

References

[1] International Desalination Association, IDA, Desalination Yearbook 2012-2013, Oxford Media Analytics Ltd., 2012

[2] Kroiss, A., Spinnler, M., Sattelmayer, T., "Analysis of Hybrid Photovoltaic/Thermal (PV/T) Solar Systems for Small Scale Reverse Osmosis Desalination Plants"; 25th European Photovoltaic Solar Energy Conference and Exhibition (PVSEC 2010), Valencia, Spain, 2010.

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