of the overall process is modelled by a set of algebraic and ordinary differential equations based on mass and energy balances, thermodynamic equilibria and constitutive equations. The model is developed through a hierarchical structure, with models for the single effects, the thermo-ejector, pre-heaters, etc. and a higher-level model for the overall plant. The model is able to predict the behaviour of the unit in the presence of non-condensable gases, thus carefully simulating all the main physical phenomena happening in transient operations of the MED plant. The implemented model was coupled with a dynamic model simulating the transient behaviour of a molten-salts Concentrated Solar Power plant, simulating transitory operations of the co-generation plant for a period of one month, characterised by the real oscillatory trend of solar irradiation. Results highlights the main issues related to the operation under transitory conditions and indicate the most effective strategies for controlling and optimised solar-powered co-generation plants.

*Keywords:* Process modeling, gPROMS, Dynamic simulation, MED, TVC, CSP, Molten salts

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## Pressure drop in woven-spacer-filled channels for reverse electrodialysis: CFD prediction and experimental validation

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Reverse electrodialysis (RED) is a promising technology for electric power generation by the chemical potential difference of two salt solutions within a stack equipped by selective ion-exchange membranes (salinity gradient energy). Mechanical energy is required for pumping the feed solutions, which can reduce dramatically the net power output. Pressure drops, affecting pumping power, are influenced by stack geometry, flow rate and feeds properties. Moreover they can be identified as pressure drops distributed along the channels and those localized in the distribution/collection manifolds. Net spacers are usually adopted as mechanical support and mixing promoters, but exhibit high pressure drops compared to the empty channel. Of course, spacer features have a significant impact on the performance.

In this work computational fluid dynamics (CFD) simulations of spacer-filled channels for RED were carried out in parallel with an experimental campaign focused on the collection of data for model validation. Woven spacers 280-480 μm thick were investigated at the flow rates typical of RED channels. The construction of the computational domain was based on measurements made by optical microscopy and micrometer; also, the compression of filaments was taken into account in order to reproduce realistic geometries in the simulations. Fully developed flow conditions were assumed, thus periodic boundary conditions were adopted (unit cell approach). The computational domain was discretized by hybrid grids mainly composed by hexahedral volumes and with tetrahedral volumes near the filaments. The sensitivity analysis of the results to the discretization degree was tested preliminarily. The experimental apparatus consists of a mono-channel stack in the classical plate-and-frame geometry. Pressure drops were measured with and without the spacer, in order to quantify the effect of inlet-outlet channel and identify the distributed pressure drops due to the woven nets.

Experimental results showed that the distributed pressure drop along the spacer-filled channel

for the cases investigated is around 40% of the overall pressure loss. The significant contribution of the manifolds is due to the relatively high velocity of the fluid entering and leaving the channel in radial direction in the inlet and outlet holes. Therefore, improving the design of the manifolds is a crucial topic. A fair agreement was found between CFD results and experimental data on hydraulic loss along the channel. Therefore, CFD modelling can be used to evaluate the pressure drops within spacer-filled channels of any customised geometry, representing a powerful predicting tool which requires fewer resources in terms of equipment and time compared to the experimental investigation.

*Keywords:* Woven spacer; Pressure drop; Reverse electrodialysis; CFD

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## Operation and perspectives of the first reverse electrodialysis pilot plant fed with brackish water and brines

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Reverse electrodialysis (RED) represents nowadays one of the most affordable technologies to produce electricity from salinity gradients. A wide investigation has been performed so far on lab scale, leading to significant improvements in membranes and stack developments. Therefore, a further scale-up is now required for testing the RED technology on real environment.

This work describes the performance of the first RED prototype plant fed with real brackish water and saltworks brine. The plant has been installed at the *Ettore e Infersa* salt ponds in Marsala (TP, South of Italy) as final accomplishment of the REAPower project (www.reapower.eu). A RED unit equipped with 125 cell pairs and 44x44 $cm^2$ membrane area was tested for the first time, using brackish water (equivalent to 2 g/l NaCl solution) and saturated brine from saltworks (equivalent to 200 g/l NaCl solution) as feed streams. Electrical variables, pressure drops and streams properties were monitored during the testing period. The prototype has been operating for four months without showing substantial performance losses.

The experimental data collected in the real environment, together with the model predictions performed with a process simulator developed by the same authors, allowed to outline a detailed analysis of the future perspectives for the RED technology. Such information will be extremely useful for the planned scale-up of the pilot plant.

*Keywords:* Salinity gradient power; RED; Pilot plant; Brackish water; Brine; Ion exchange Membrane