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A novel Reverse Electrodialysis application to generate power from low-grade heat

A. Tamburini[a], A. Cipollina[a], M. Bevacqua[a], L. Gurreri[a], M. Papapetrou[b], W. Van Baak[c], G. Micale[a*]

[a]*Dipartimento di Ingegneria Chimica, Gestionale, Informatica, Meccanica (DICGIM), Università di Palermo (UNIPA) – viale delle Scienze Ed.6, 90128 Palermo, Italy.*
[b] *Wirtschaft und Infrastruktur GmbH & Co Planungs-KG (WIP), Sylvensteinstr. 2, 81369, Munich, Germany*
[c] *FUJIFILM Manufacturing Europe BV, Oudenstaart 1, P.O. Box 90156, 5000LJ, Tilburg, The Netherlands*
[*]*e-mail: giorgiod.maria.micale@unipa.it*

Abstract

The efficient use of low-grade heat sources has always been an object of interest as it holds the keys to increase the overall energetic efficiency of production cycles and can provide a low-cost and widely available new source of energy.

A novel idea for the conversion of low-temperature heat into electricity is based on the generation of electricity from salinity gradients using a Reverse Electrodialysis (RED) device in a closed-loop system. In this concept a limited amount of artificial saline solutions can be used as the working fluids in a closed-loop. The solutions exiting from the RED unit are then regenerated, in order to restore the original salinity gradient, by means of a separation step, which uses low-temperature heat (40-100°C) as its energy source.

The big advantage of such technology is to efficiently convert a low-grade energy source into electric power guaranteeing: (i) continuous operations for non-intermittent supply of energy; (ii) flexible operations, according to the heat availability and/or energy demand; (iii) modularity of the plant; (iv) possibility of acting as an energy buffering systems, in which energy can be stored in the form of saline solutions.

Moreover, the use of a closed loop will address and solve the main constraints still limiting the large development of RED technology, i.e.: (i) fouling in membrane systems; (ii) uncontrollable salinity gradient allowing the operation under optimal conditions; (iii) impossibility of using any kind of solute or solvent.

The extremely wide range of possible salts, solvents and operating conditions to be adopted for optimising the overall system, opens room for a number of R&D paths oriented to the development of both the RED technology and regenerative processes, with a huge potential in the application of relevant outcomes into the field of desalination technologies. With this respect the "*RED Heat-to-Power*" research project, focusing on the development of this technology, has been recently funded by the European Commission within the Horizon 2020 framework programme.

A theoretical analysis of potentials of this technology is illustrated in the present work.

This indicates that, adopting a heat source at 90°C and a very efficient evaporative regeneration strategy, a total energetic efficiency of 12.8% can be achieved, with an exergetic efficiency (actual efficiency divided by theoretical Carnot efficiency) over 67%. Under different conditions, i.e. adopting an heat source at 60°C and adopting solutions of thermolytic salts for a low-T regeneration strategy, calculations provide a total energetic efficiency of 5.1% corresponding to an exergetic efficiency of over 42%.

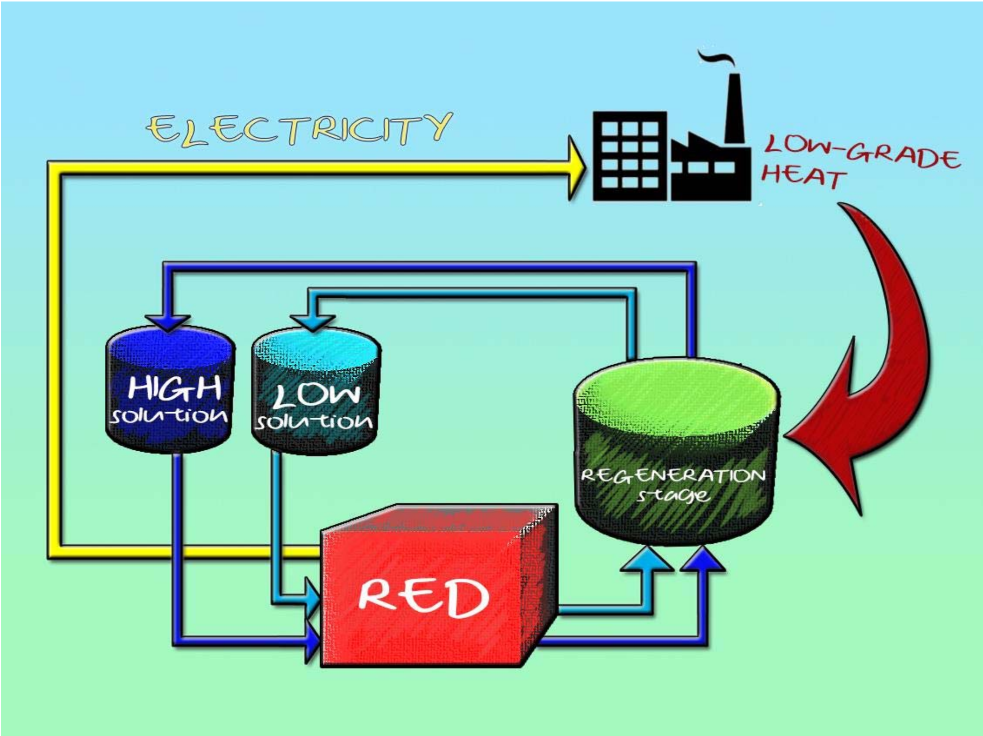

Fig.1 Graphical scheme of the RED closed loop process