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Solar Energy for Water desalination

Pascale Compain[a]*

Bertin Technologies, 10, Avenue Ampère, 78180 Montigny-le-Bretonneux, France

Abstract

This paper presents the different solutions to the most commonly used desalination process (RO, MSF, MED), and solar energy production technology compatible with desalination. The goal is to assess the feasibility and profitability of the substitution of fuel energy used for desalination plants with renewable energy.
A review of various technologies will define broadly features associated to each technology and range of cost that are expected. Finally, a review of various projects will detail the practical aspects of floor space and actual production costs of fresh water.

Keywords : Desalination, RO, MSF, MED, Solar energy

Nomenclature	
RO	Reverse Osmosis
MSF	Multi Stage Flash Distillation
MED	Multi Effect Distillation
PV	PhotoVoltaic
LFR	Linear Fresnel Reflector
CSP	Concentrating Solar Power

1. Introduction

It's true that freshwater scarcity is associated with large quantity of solar resource. It seems also logical and attractive to associate those two parameters for countries where grid electricity is not spread widely and with easy access to seawater or brackish water.

Solar desalination is not a new idea: it has been known for ages, antique sailors used to desalt water with simple and small sized solar stills.

It's also a fact that production of fresh water requires a large amount of energy: 1000 m3 of freshwater per day requires 10 000 tons of oil per year [1]. Though solar energy is often labelled as 'free energy', it's not so simple to evaluate feasibility and cost for solar desalination

Some technologies will not be taken in account in this paper: solar ponds, which are a direct desalination method, as well as desalination with electrodialysis (whose application is restricted to low salinity water).

* Corresponding author. . Tel.: +33 (0)442 604 634; fax: +33 (0)442 600 013.
E-mail address: pcompain@bertin.fr.

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2. Desalination technologies

Desalination is by definition a process removing minerals and salts from saline water to produce freshwater, that can be used for human use or irrigation. It's applied to seawater and brackish water with different performances criteria.

It's normally considered that salinity below 500 ppm is suitable as drinking water. Basically, a complete desalination process includes 3-4 steps with, first pumping water (from sea, estuaries or saline aquifers), pretreatment of pumped water (filtration, chemical addition) desalination process 'stricto sensu' and last, a post treatment if necessary (in some case, adding few minerals).

There are different ways to produce freshwater with desalination technologies. More common technologies are:

- Reverse Osmosis
- Multi-stage Flash Process
- Multi Effect distillation.

As shown in table 1, those technologies have been developed worldwide with MSF and RO being dominant.

Table 1. Distribution of solar technologies in existing installations [2]

An example of a column heading	Total desalination plants (seawater + brackish water as feed in)	Desalination plants with seawater as feed in
Multi Stage Flash Process	43,5%	66,3%
Reverse osmosis	43,5%	22,4%
Multi effect distillation	~ 10%	
	Strong increase in worldwide installations	

2.1. Reverse Osmosis

The RO technology is based on the properties of semi-permeable membranes which can separate water from a saline solution, when excess of osmotic pressure is applied on the membrane systems. Pressure is applied with a high pressure pump (approximately 70 – 90 bars). Part of the flow (35 to 50%) goes through the membrane, with a salt concentration less than 500 ppm, rest of the flow called retentate (50 to 65%), containing high concentration of salts, doesn't pass through the membrane and is directly rejected at a high pressure.

RO can be applied to different types of water: seawater as well as brackish water, with the equivalent objectives depending on the pressure applied to the membrane

Reverse osmosis has known a great development over the last twenty years due to its easy and rather low cost technology and great improvement on membrane quality.

Key features of the RO process are the following:

- Low energy consumption
- Easy and ready to use : immediate stop and start
- Needs important pre-treatment : pre-filtration and chemical (anti-scalant) to avoid fouling on the membrane
- Outlet salt concentration around 500 ppm

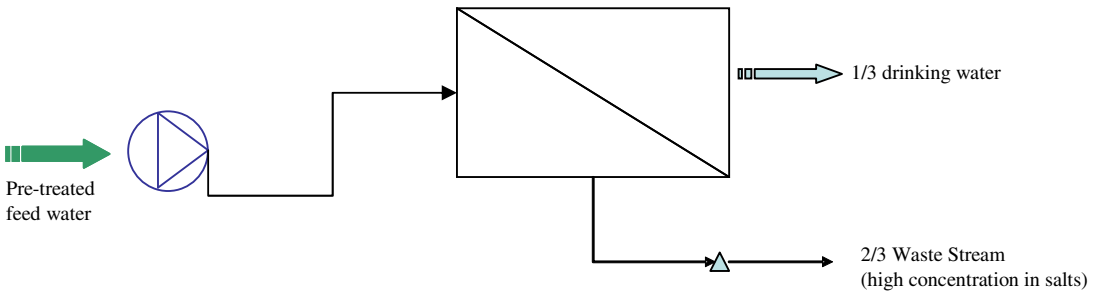

Fig. 1. Schematic of membrane RO systems

RO capacity has increased in the last 30 years to reach approximately 45 – 50 % of the desalinated total capacity.