Solar Desalination

Saly T. Panicker , K.L. Thalor and P.K. Tewari
Desalination Division, BARC

1. Introduction

Membrane-based desalination technologies such as Reverse Osmosis (RO), need considerable amounts of energy in the form of electricity, to achieve separation of pure water from saline water (Fig.1). The greenhouse effect of carbon dioxide in the atmosphere, caused by burning of fossil fuel for power production leading to climate change, is of concern all over the world. Power production utilizing environment friendly renewable energy sources, is the alternate solution in such situations (Markus Forstmeier)[1]. Also, they are essential for remote locations, where electricity is either scarcely available or not at all. It is reported that, there are thousands of Indian villages which cannot be connected to the grid power network, due to their remoteness.

Fig.1: Principle of Water Desalination

The most widely used renewable energy source is the sun. The source of solar energy is inexhaustible and it is free. No harmful gases such as nitrogen oxide, mercury, carbon dioxide, or sulphur dioxide are emitted (Dirk Herold) [2]. In addition, there are various financial incentives that are offered by the government for the production of solar power (reliancenergy)[3].

The solar energy reaches the earth's surface, at a rate of around 3.9 X 10^{26} W (Nuclear Fusion)[4]. Besides powering the natural systems on earth, it can be converted into electrical energy through photo-voltaic (PV) cells. The photons in the sunlight hit the PV cells, made up of a semi-conducting material such as silicon and excite the electrons (Gil Knier)[5]. The energized electrons flow to produce a direct electric current (DC). This current can be directly used or be converted to AC with the help of an inverter. Solar PV-powered desalination systems are more suited for small community level plants, considering the techno-economic viability. RO is a pressure driven process, where pure water

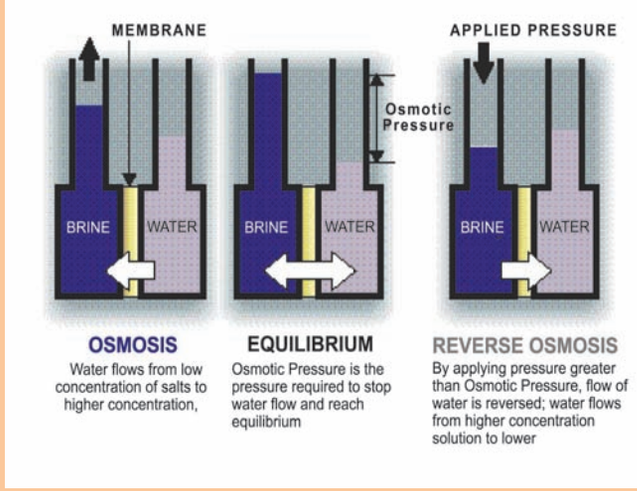

Fig. 2: Osmosis and Reverse Osmosis- Schematic Representation

from salty water is continuously drawn through a semi-permeable membrane (Fig. 2). The pressure requirement varies with the amount of dissolved salts. The normally reported brackishness in the ground water is in the range of 1000 – 3000 ppm and the desired limit of Total Dissolved Salts (TDS) in drinking water is 500 ppm as per World Health Organization (WHO) and IS-10500.

2. R&D in BARC on Solar Desalination

The Desalination Division, BARC is engaged in developmental work on desalination systems, based on solar heat and light. Solar energy-based small and community level RO units are developed, for producing safe drinking water from salty ground water.

2.1. Small RO Unit

In the RO unit (Fig. 3), the feed water is passed through the membrane with the help of a DC pump directly connected to the PV panels, without any batteries. The unit can be normally operated for 9 to 10 hrs on sunny days, which can cater to the drinking and cooking requirement of 3-4 families (at an average rate of 5 L/person/day). This unit contains a cartridge pre-filter and a spirally wound RO membrane element. The typical performance data of the unit is given in Table 1.

Fig. 3: Small Solar RO Unit at Trombay

No significant variation in the rate of power production from the PV panels has been observed during the effective operation period. Thus, the pump is able to maintain its duty, keeping the rate of drinking water production constant.

Table 1: Typical Performance Data of the Small Solar RO Unit

Capacity (m^3/day)	0.1
Feed Salinity (ppm)	1000 – 2500
Pressure (kPa)	400 – 500
Power Input (w)	10 -15
Product Salinity (ppm)	100 - 200

2.2. Community Level RO Plant

Water conservation becomes an issue when the natural recharge rate of the source is slow as in the case of groundwater. For this reason, a significant fraction of the reject flow is recycled back, so that fresh feed as well as discharge volumes can be minimized. The energy also can be recovered if water is redirected back through the membrane instead of being discharged. To enhance the RO membrane life, the RO feed water is to be physically and chemically conditioned. All the suspended / colloidal and biological matter is to be filtered out and measures are to be taken for preventing precipitation of the sparingly soluble salts on the membrane surface.

This solar RO plant consists of PV panels, inverter, charge regulator and battery storage at the power side and UV for disinfection, pre-filters, chemicals dosing systems, pumps and RO modules at the desalination side. The schematic of the plant is shown in Fig. 4.

The technical specifications are given in Table 2.

Table 2: Technical Details of the Community Level RO plant

Capacity (m^3/day)	2
Feed Salinity (ppm)	2000 – 2500
Product Recovery (%)	70 - 80
Pressure (kPa)	1.1 x 10^3 – 1.2 x 10^3
Power Requirement (kw)	1.6 - 1.8
Product Salinity (ppm)	200 - 250

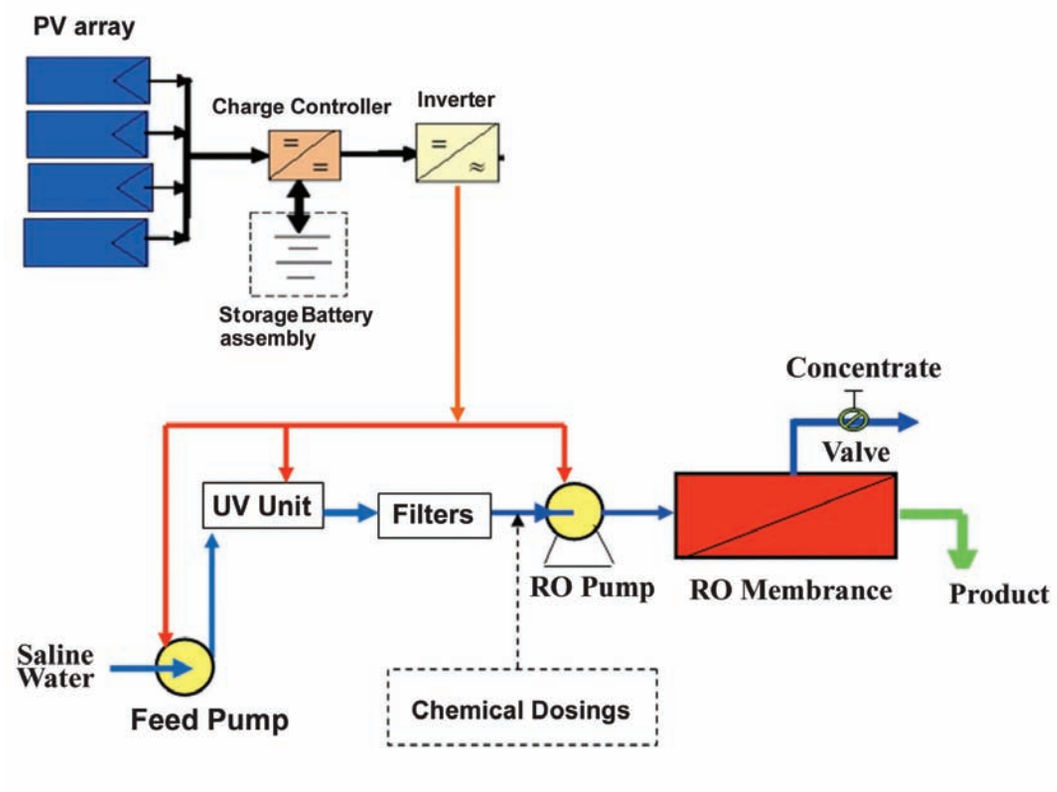

Fig. 4: Schematic of Solar Energy-Driven RO Plant

Fig. 5: Community Level RO Plant along with PV Panels at Trombay

Fig. 5 shows the community size RO plant along with the solar PV panels undergoing performance evaluation at Trombay.

3. Conclusion

Integrating desalination units with renewable energy sources is important for addressing the issues related to adverse impacts of climate change. Also, for remote areas, where scarcity of power and water co-exist, the one and only solution to produce safe drinking water is to go in for renewable energy sources. With improvement in PV efficiencies and the subsidies available, cost of PV systems is expected to come down, making the solar PV based desalination systems more cost-effective.

4. References

1. Markus Forstmeier, Wilhelm Feichter, Oliver Mayer. "Photovoltaic powered water purification — challenges and opportunities", *Desalination*, Volume 221, Issue 1-3, (2008) :23-28.
2. Dirk Herold and Apostolos Neskakis. "A small PV-driven reverse osmosis desalination plant on the island of Gran Canaria", *Desalination*, Volume 137, Issue 1-3, (2001) : 285-292.
3. http://www.authorstream.com/presentation/reliancenergy-224952-solar-power-incentives-india-developers-business-finance-ppt-powerpoint.
4. www.cartage.org.lb/en//NuclearFusion/NuclearFusion.htm.
5. Gil Knier. " How do Photovoltaics Work?", www. Science@NASA.