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Analysis of Reverse Osmosis Solar Desalination Plant

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Abstract: *The use of solar energy in purification process is one of the most important applications of renewable energy. Technology remains as the first cause for human development and economic growth. But its spread to be distressing slow. Electricity in spite of its unmatched technical valour, took almost century to become common place. It seems that technological valour alone is not enough to guarantee success. Some other factors are also responsible like its availability, applicability, affordability and social and economical cost for harnessing it. India is a country of so many rivers, but this water are not potable because the underground waters are frequently polluted with high levels of pathogenic bacteria.*

The World Health Organization have certain standards for drinking water quality with regard to organic, inorganic and microbial species. Its range lies in between 20-100 TDS. Drinking water should be free from pathogenic bacteria or microbes and also from toxic inorganic content like arsenic. My photovoltaic reverse osmosis desalination system consists of six stages. This report provides working of the system and analysis. Solar-driven reverse osmosis desalination can potentially break the dependence of conventional desalination on fossil fuels, reduce operational costs, and improve environmental sustainability.

Keywords: *renewable, desalination.*

1. Introduction

Among desalination technologies, reverse osmosis (RO) is rapidly overtaking thermal desalination in terms of market shares. A pressure-driven process that relies on the properties of semi-permeable membranes to separate water from a saline feed, the end result of reverse osmosis comprises the separate flows of freshwater permeate and concentrated brine. System flow rate is proportional to the difference between the applied pressure and the osmotic pressure differential between brine and dilute compartments. The amount of freshwater that can be recovered from the feed is limited by membrane fouling and scaling. The coupling of reverse osmosis desalination with solar energy is a promising field of development in the desalination sector, with the potential to

(i) improve its sustainability by minimizing or completely eliminating the dependence on fossil fuels and
(ii) Significantly reduce the operational costs of desalination plants.

Despite a steady reduction in the energy consumption of pressure-driven membrane processes in recent decades, energy consumption is still a major cost component of RO desalination plants, accounting for 40–45% of total costs.

2. Literature Summary

Andrea Ghermandi and Rami Messalem [1] in 2009 has said that photovoltaic-powered reverse osmosis is technically mature and — at unit costs as low as Rs 130-195/ m^3 — economically cost-competitive with other water supply sources for small-scale systems in remote areas. Under favourable conditions, hybrid systems with additional renewable or conventional power sources perform as good as or better than photovoltaic-powered reverse osmosis. They also suggested that in the short-term, solar RO desalination will gain shares in the market of small-scale desalination in remote areas. Concentrating solar power technologies have the highest potential in the medium-term for breakthrough developments in large-scale solar desalination.

S. Alawaji, M.S. Smiai, S Rafique and B Stafford [2] in 1995 has estimated that utilizing seasonal tilt angle variation increases the annually average permeate flow of a Photo Voltaic Reverse osmosis desalination plant in Saudi Arabia from 15 to 17 m^3/day.

S. Abdallah, M.Abu-hilal and M.S Mohsen [3] in 2005 has measured gains in electrical power output and permeate flow of 25% and 15%, respectively, when a one-axis automatic tracking system was used rather than a fixed tilt plate for a 0.1 m^3/day PV-RO testing rig in Jordan.

D.G Harrison, G.E Ho and K Mathew [4] in 1996 has determined that tracking solar arrays produced a 60% higher permeate flow than a fixed array in a small desalinator with a capacity of 0.05 m^3. The high initial investment costs required to install tracking systems. However, have so far limited their use in PV-RO desalination. Maximum Power Point Tracker (MPPT) circuits or similar trackers are mostly installed to maintain system operation at a voltage that achieves maximum power while ensuring efficiency under conditions of low irradiance.

3. Component of Reverse Osmosis Solar Desalination Plant

The various components of reverse osmosis solar desalination system are as follows.

1. Solar Panel.
2. Battery.
3. Charge Controller.
4. Reverse Osmosis Unit.

a) Pre-treatment filter
b) Membrane Unit
c) Post-treatment filter

5. Storage Tank.
6. Inverter.

3.1 Solar Panel

Solar panels are the medium to convert solar power into the electrical power. Solar panels have the ability to convert the heat of solar energy directly into the induced energy. Photo-voltaic cells are made up from the semiconductor type structures as seen in the computer technologies now days. Sun beam/rays is absorbed in the solar panel and with this panel electrons are emitted from the atoms that they are bounded in it. This release energy and activates a current. The solar panel used in my system is 20W polycrystalline PV module. Since many regions of our nation with most need for desalination have an abundance of solar energy. Many of the arid areas of the country (like Rajasthan. Gujarat) are ideally suited for solar energy harvesting.

Figure 1. 20 W Photovoltaic module

Table 1. Specifications of photovoltaic module

Maximum Power (Pmax)	20 W
Voltage at Maximum Power (Vmp)	14.4 V
Operating Temperature	-40 0C to 85 0C
Maximum System Voltage	1000 V DC
Power Tolerance	-5% to +10%
Cells	Polycrystalline silicon solar cell
Weight	Approximately 2.5 Kg
Open Circuit Voltage (Voc)	21.4 V
Short Circuit Current (Isc)	1.32 A
Length	465 mm
Height	495mm

3.2 Battery

The battery used in my system is 12 V 7AH UPS battery. The battery is high quality maintenance free lead acid battery.

Figure 2. Lead acid battery

Table 2. Specifications of battery

Overall Height	95 mm
Height up to lid	89 mm
Length	155 mm
Width	70 mm
Weight	Approximately 2 Kg

3.3 Charge Controller

An electronic component that goes between our solar panel array and our batteries in an on or off grid system is known as charge controller. Depending on various types of model, the charge controller provides both overcharge protection, so that our batteries do not receive more than the proper charge during any given day, and can also provide additional functions like automatic on and off. It also diverted the load by taking the excess energy from a full charge and a number of other uses including remote monitoring. Nowadays the most sophisticated charge controllers is MPPT, which is Maximum Power Point Tracking. Maximum Power Point-Tracker ensures maximum performance from our solar panel at all times and in all weather conditions. Maximum Power Point Tracker can yield an energy gain of up to 30% from our photovoltaic panel.

Figure 3. Charge controller

3.4 Reverse Osmosis Unit

The movement of a solvent through a semi-permeable membrane into a solution of higher solute concentration is termed as osmosis. This results in equalizing the concentrations of solute on the two sides of the membrane Whereas in the reverse osmosis process pressure is applied as the driving force to overcome the osmotic pressure of the salt solution. Reverse osmosis (RO) is the most widely used membrane desalination technology. The name of the process based from the fact that pressure is used to drive water molecules across the membrane in a direction opposite to that they would naturally move due to osmotic pressure. Because osmotic pressure must be overcome, the energy required to drive water molecules across the membrane is directly linked to the salt concentration. The energy efficiency and economics of RO have improved markedly with improvement of pre treatment steps, development of more durable polymer membranes, and implementation of energy recovery devices.

Figure 4. Reverse osmosis system

3.5 Booster Pump

As we know that positive displacement pump have higher energy efficiencies with respect to

centrifugal pump at low flow rate so nowadays it is used in reverse osmosis unit. The booster pump used in my system is of 30 W 24 V which runs on DC output.

Figure 5. Booster pump

3.6 Storage Tank

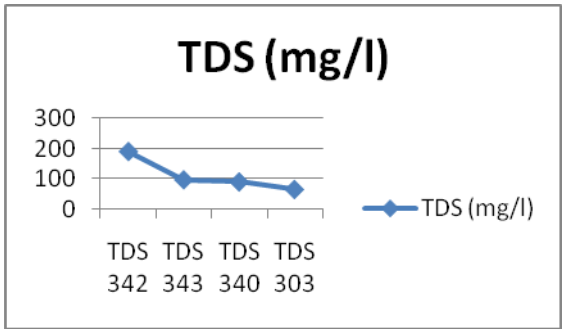
The tank used in my system for storage purpose of water is made up of steel whose capacity is of 15 litres.

Figure 6. Storage tank

4. Results

Table 3. TDS Results

Type of water	Temperature (In ^{0}C)	Feed water TDS (In mg/l)	Purified water TDS (In mg/l)	Waste water TDS (In mg/l)
Tap Water	27.6	342	191	408
Tap Water	27.6	343	97	423
Tap Water	27.6	340	90	419
Hand Pump Water	27.5	303	65	415



Graph 1. Feed water vs. purified water

5. Conclusions

- The Overall efficiency is 5.92%
- The system is able to provide purified water at the rate of 7.5 ltr/hr.
- After installation of system do not use first two batch of pure water.
- The initial cost of reverse osmosis solar desalination system is quite high.
- The system is simple and convenient to operate.
- The energy consumption of system is 7-8 KW/m^3
- Start up and shutdown of the process does not take longer time.
- Requirement of some more research to increase the efficiency of panel.

6.References

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