POTENTIAL OF APPLICATION OF PV SYSTEM FOR BWRO DESALINATION IN GAZA

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ABSTRACT

This paper will discuss supply of potable water to the consumers living in remote rural areas and suffer from water shortage. This will be carried out by installing small scale reverse osmosis (RO) units powered by a stand alone photovoltaic (PV) system. Feasibility of small PV-RO systems (1-5 m^3/d) is being investigated as well. The RO plant, the energy supply and the system operation strategy are described considering concerned socio-economic aspects.

Keywords: photovoltaic energy, reverse osmosis, small scale desalination, renewable energy, stand-alone system

INTRODUCTION

In many countries, e.g. in the Mediterranean region and in the Middle East, the supply with clean drinking water is a problem of high priority. Especially the population in rural areas in arid countries is in many cases not connected to a central water supply and has to rely on scarce resources. Additional problems concerning fresh water supply exist in almost coastal areas of the Gaza Strip as a consequence of seawater intrusion into the groundwater. On the other hand the coastal aquifer has large reserves of brackish ground water.

Fortunately the climatic conditions in Gaza as a semi-arid region are very favorable for the exploitation of solar energy, where the daily average solar insolation is as high as 222 W/m^2. This implies the high potential of utilization of solar energy.

There are several technologies which allow the utilization of solar energy for desalination. These are solar stills, high efficient distillation techniques combined with solar collectors and membrane techniques as reverse osmosis or electrodialysis powered by photovoltaic or wind energy. As solar stills have a low specific water production per collector area and high water costs, the reverse osmosis supplied by photovoltaic (PV-RO) is a promising solution for small-scale desalination (European Commission 1998). As a policy the utilization of this resource should be enhanced since it is an environment friend resource.

Additionally, as fossil driven small-scale desalination plants are relatively expensive to operate in remote areas; solar energy can be economical in many cases for stand-alone operation.

Thus, the energy supply of the RO plant is realized with a stand alone photovoltaic system. Such a system is a suitable solution if a small electric load far away from the electric grid has to be supplied. This will be the situation in regions where a supply with relatively small quantities of good quality drinking water is of special interest (e.g. drinking water for small communities).

BACKGROUND

Brackish water desalination is a vital option especially for people in the middle area of Gaza Strip. This area is characterized by poor quality water (salinity is more than 2000 ppm). Desalination can ease the problem. However, energy is a major cost for desalination. Indeed energy accounts for 30-50% of the treatment (desalination) cost. Thus the treatment cost can be reduced, which means some relief to the consumer and increases their affordability to pay for the desalinated water.

The photo-voltaic systems application has merged over the last ten years and their use is limited to isolated and /or remote areas. This is due to the high capital cost and the fact electricity cost from such systems is about $ 0.35/kW.hr, this more than three times as the price of electricity from the grid. However in many remote are other factors should be considered when comparing the economics. Particularly, such remote communities are characterized by:

1. Non-easy access to fuel resources.
2. No access to central grid
3. Very low demand.
4. Low population.

Indeed, these are ideal situations for considering the PV as an electricity source. Also some locations in the Gaza Strip have been equipped with PV systems as lightening Gaza main coastal street, water pumping and landfills.

Solar Radiation Level

Gaza Strip has a relatively high solar insolation. In both areas the daily average on horizontal surface is about 222 W/m^2, [Manes et al., 1982]. This varies during the day and through out the year. Figure 1 illustrates the variation in the monthly daily average in total insolation on horizontal surface and the insolation at the optimum angle of tilt for each month.

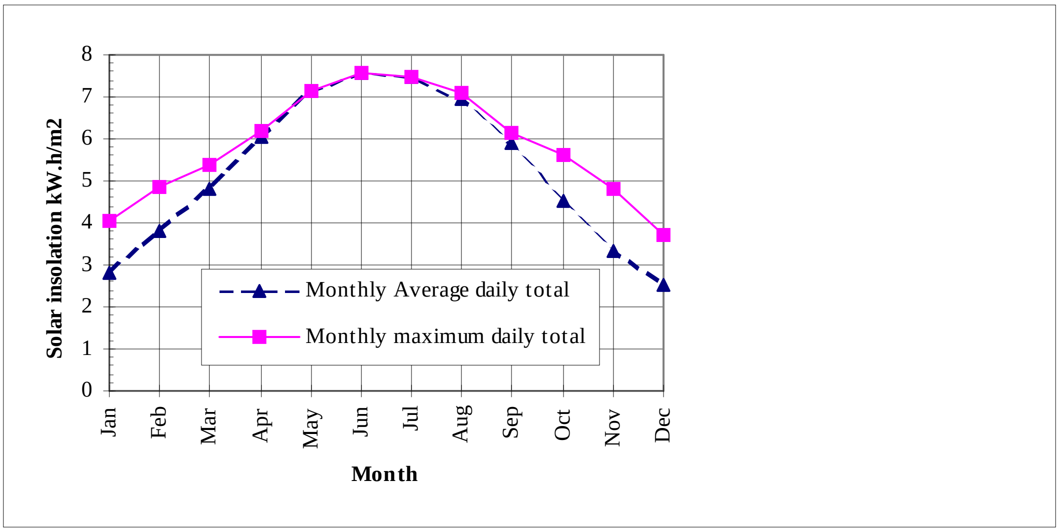

Fig. 1 Annual variation in solar insolation in Bet Degan, [Manes et al, 1982]

CLIMATIC CONDITIONS

Both of the Gaza Strip and the West Bank show are categorized as tropical regions with a relatively hot summer and mild winter. However two areas show some difference between them with respect to the temperature and the relative humidity, Fig. 2 and Fig. 3. These are important factors when design for human comfort, through active and/or passive processes, is considered.

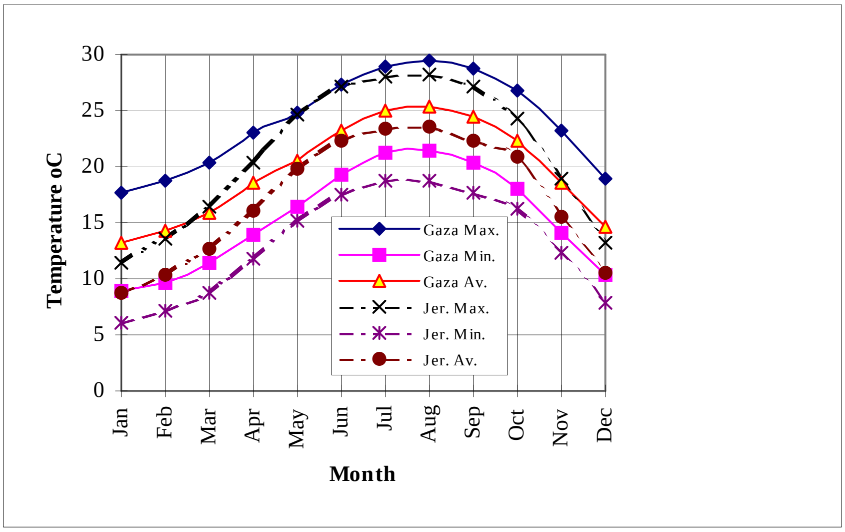

Fig. 2 Annual monthly average variation in dry bulb temperature in both Gaza and Jerusalem, [Ministry of Transport, 1980]

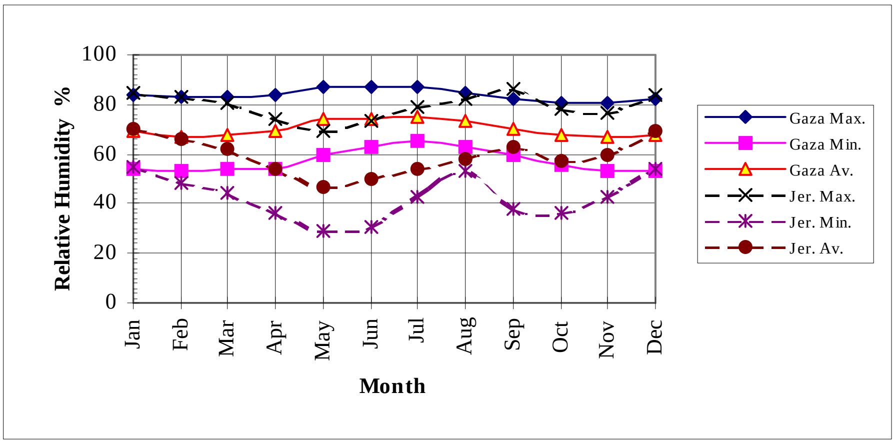

Fig. 3 Annual monthly average variation in relative humidity in both Gaza and Jerusalem, [Ministry of Transport, 1980]

TECHNICAL DESCRIPTION

A proposed small scale PV-RO system (Fig. 4) for brackish water desalination is composed of two main components as follows:

1) Power supply system comprises PV array, a diesel generator, a battery bank and an inverter. The RO unit is powered by a photovoltaic (PV) array, which is backed up by a diesel generator and batteries in order to enhance power supply reliability and improve the overall economics of the system.

2) Reverse osmosis desalination plant

The reverse osmosis desalination plant consists of:

- Shallow groundwater well as source of brackish water
- Pre-treatment unit including cartridge filter and chemical dosing system
- High pressure pump, DC and variable flow rate
- Low fouling membranes assembly
- Post-treatment unit for disinfection the product water
- Storage tank and a very simple distribution system
- An automatic control system for the operations controlling the integration between the power supply systems as well as the operation of the RO unit.

Power capacity and PV system design

We recommend installing small scale BWRO units containerized in different capacities range from 1 to 5 m^3/d to satisfy drinking water in limited quantities but not as domestic water. Other main design parameters are considered as follows:

Capacity of RO plant: max. 480 l/h, (depending on the feed pressure)

Salinity of feed water (TDS): 4200 ppm

Salinity of product water (TDS):	120 ppm
Feed pressure:	max.: 220 psi
Specific energy consumption:	1.4 kwh/m3, low for a small system
Variable flow DC SS pump:	Grunfos or equivalent
RO membrane assembly:	low fouling membrane elements

PV generator with 48 Volt, 104 Ampere-hour battery via charge controller, 9 panels with power at 600 W and an inverter with peak efficiency 96 %

Recovery is less than 20 %. Water recovery for PV-RO system is directly dependant on the insolation and power produced.

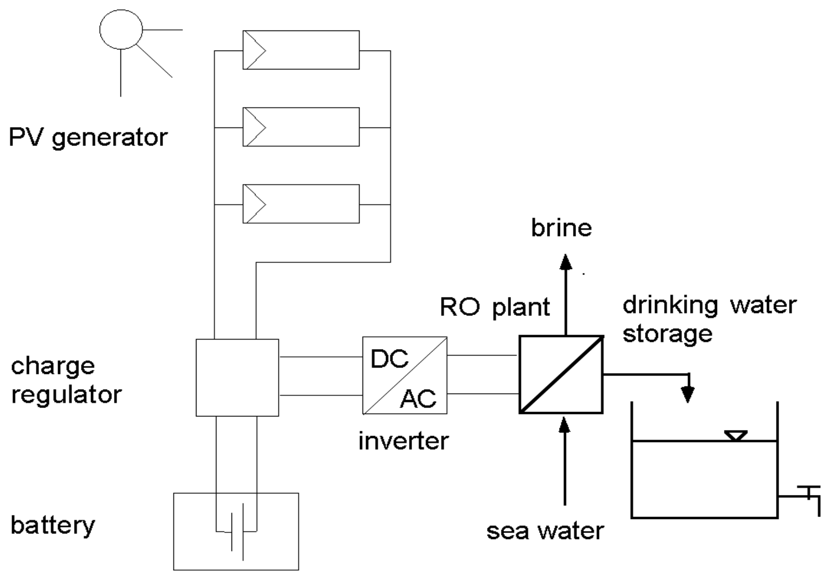

Fig. 4 Flow diagram of a PV-BWRO plant

SYSTEM RELIABILITY

The water needs shall be met with high reliability in the summer months and with lower reliability in the winter months. (Rainfall could compensate possibly deficits in the water supply in winter).

Solar radiation data of the site have been taken as basic criteria for system design. The daily average value of solar insolation on a horizontal surface at the site is 222 W/m^2.

The energy supply system is to be designed to cover a daily water demand of at least

800 l/d. The reliability of the water supply should be higher than 96 %. The daily water consumption assumed to be 800 l/d all over the year. Because of the low costs of the tank its volume might be quite large (5m^3 $\geq$6 times the daily water consumption).

This strategy has a specific electrical consumption (energy required to produce 1 m^3 drinking water) of 1.4 kW h m^{-3}, a recovery ratio of about 20 % (relation between drinking water product flow and brackish water input flow) and a drinking water cost of US$ 6-7 per m^3.

The inverter should allow a start of the motor pump without problems. The battery performance also agrees with an hourly discharge rate of approx. 65 Ah at nominal operating conditions. Duration of RO plant operation can exceed 10 hours in the summer months, resulting in daily productions beyond 1200 l.

BENEFITS

Economic

The brackish water system will result in a significant reduction in water cost based mainly on the reduction in energy cost.

Environmental

This project avoids the combustion of any sort of fuel which gives many kinds of emissions which are harmful to livings and environment.

Social

Desalination of brackish water by PV-RO system in remote areas is such a social, health and economic relief to the people of Gaza who has a very low income.

CONCLUSION

Several studies concerning suitable technical matches between renewable energies and desalination processes propose the combination of PV and RO technologies as very promising among the existing ones. In particular, this combination appears to be very suitable in Gaza for remote (coastal) sites lacking of electric grids where water scarcity is a big problem and, at the same time, the solar energy potential is high.

In such areas where fresh water has to be transferred by long piping systems to guarantee water supply, such systems have appeared to be more economical than the alternative of transporting water.

Although for small systems specific energy consumption values (i.e. kWh/m^3) are rather high compared to standard medium size (RO) systems, the investment costs of such systems are reasonable in comparison to other conventional desalination techniques.

Further research activities associated with other prototype plants should focus on optimizing such systems with the aims of reducing water production costs.

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