Harrison, D.G., Mathew, K. and Ho, G.E. (1991) *Solar desalination.* In: Ho, G. (ed) Seminar on appropriate technology for remote communities, organised by Newman Campus, Hedland College and Remote Area Developments Group, Institute for Environmental Science, Murdoch University, 28 August, pp 63-67.

SOLAR DESALINATION

D.G. Harrison, K. Mathew and G.E. Ho

INTRODUCTION

Many inland community water sources have salinities in the range of 3000-6000 ppm, making it unsuitable for drinking water supply. Nitrate and fluoride are also often found in concentrations higher than the recommended standard. In places where surface water sources are not available or are limited, rainfall is low and groundwater salinity is high, the only possible supply of drinking water is from desalination.

Solar distillation was, until recently, the world's leading desalination technology. Its appropriateness for remote community water supply however is questionable. Reverse osmosis desalination has now superseded distillation and has been applied in the provision of drinking water worldwide.

Reverse osmosis is a pressure driven membrane separation technique which has traditionally required very high pressures. Recently, low pressure membranes have been developed which operate at much lower pressures and, though not suited to seawater desalination, are ideal for the treatment of brackish water allowing a high production rate and a lower energy demand.

The process has, however, remained a highly technical one requiring skilled supervision and ongoing maintenance. Its appropriateness for application in remote communities is therefore doubtful. Further, its energy demand, even with low pressure membranes, has made its adaptation to solar power an extremely expensive option.

The Remote Area Developments Group (RADG) of Murdoch University has been investigating the process with a view to adapting it for remote applications. The criteria for successful adaptation are seen as,

1. Simplicity
2. Low cost
3. Low maintenance
4. Robustness.

DEVELOPMENT STRATEGY

The Reverse Osmosis Hardware

The amount of water treated per membrane is restricted to about 10% as higher recovery ratios may lead to rapid membrane deterioration. Very small units, typically run from generators, may use only one or two membranes and so achieve recovery ratios of only 10 -20%. They require a much lower degree of pre and post treatment than the common larger units and brine disposal is much less of a problem. The brine is only slightly more concentrated than the feed but there is a lot of it, as 80 - 90% of the feed is rejected, but can be used for other domestic purposes.

Accordingly, for every litre of fresh water produced, up to 10 litres of feed water has to be pumped up to the system pressure. In terms of the hydraulic energy requirements the process is quite wasteful and makes adaptation to solar power a very expensive option. Also, since the system pressure and recovery ratio are determined by a throttle valve on the reject line, regular supervision and adjustment would be required to cope with the varying supply of power from the solar array.

Great savings in energy can be gained by using this still pressurised waste stream to assist in the pumping of the feedwater. The 'Powersurvivor' unit uses this arrangement and has been quite successful, although its output is restricted. No operating adjustment is necessary - or possible, and the unit looks after itself throughout the day. It operates on about one fifth of the power it would need if it did not recover the energy from the brine stream.

The RADG group has been developing a much larger unit to supply the needs of a small community based on similar principles. In the majority of cases, the salt removal efficiency does not need to be very high. Salinities of 3000 - 5000 ppm need only be reduced to 1500 ppm to meet the required NHMRC standard for drinking water. Ongoing testing of the new range of low pressure membranes will continue to determine the best combination of flux rate, removal efficiency and cost.

Solar Tracking

A Perth company, Solar Track Pty Ltd, has invented a robust and reliable solar tracker which has only two moving parts - the two bearings. The solar tracker operates purely on the weight difference between the two half-shaded copper cylinders, each partly filled with liquid Freon. When one cylinder heats up more than the other, more Freon evaporates which forces the liquid Freon below it into the other cylinder. The weight difference rotates the tracker, keeping up with the sun all the time. A patented device in the upper shade gives the tracker a kick back last thing in the evening. As the panels cool, gravity takes over and the tracker rotates back to face the east, patiently awaiting the dawn.

The typical summer production pattern of the 'Powersurvivor' coupled to the solar panel is shown in Figure 1.

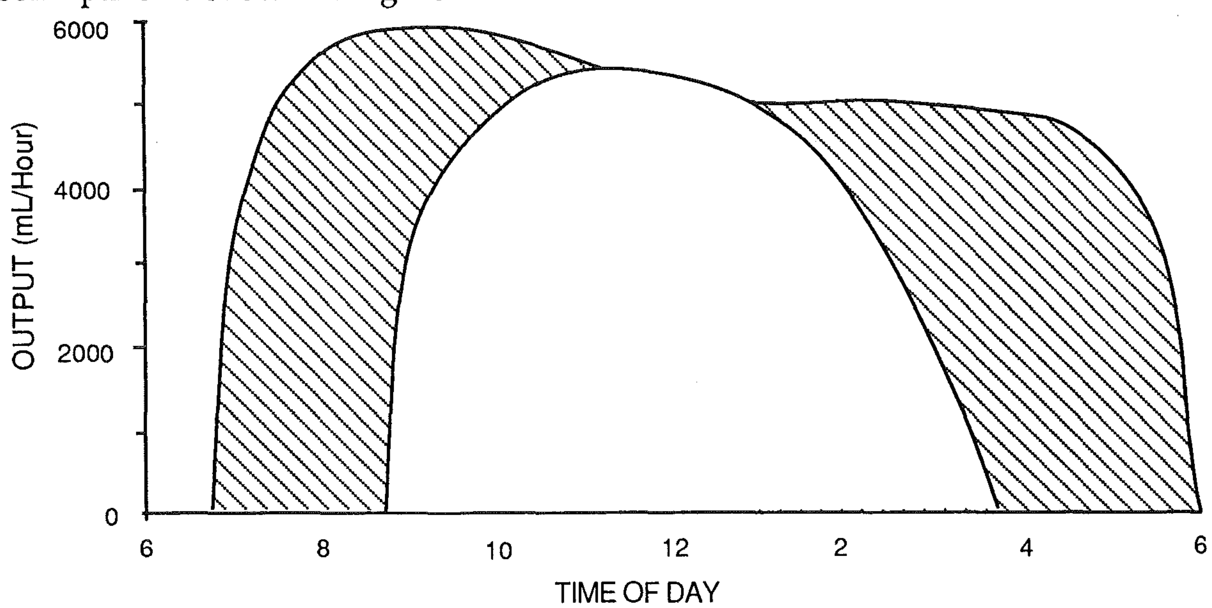

Figure 1. The hatched area represents the increased production of fresh water resulting from the use of solar tracking and pump optimisation.

Pump Optimisation

Solar panels don't produce power like a battery does. A battery provides the power at its designed voltage, say 12 V, and provides the current that the motor requires, say 4 A. The output from a solar panel is dependant on the strength of the sunshine (insolation) and power is provided in a range of Voltage/Current combinations. A Perth company, Solar Focus, produces a Pump Optimiser which keeps the voltage output up so that the output from the panel is always near its maximum.

Miscellaneous Controls

Unlike most larger scale RO plants, it is anticipated that no other control mechanisms will be required. It should be stressed that every control mechanism requires some power, is a source of failure and adds to both the capital and maintenance costs. In keeping with this philosophy, the pump is connected through the optimiser directly to the solar array and not through a battery bank. Batteries are only 70%, efficient. so 30% of the power from a solar array is lost if batteries are used. Further, since only a fixed amount of solar energy is available per day, it is considered more efficient to store that energy as water than to store it as chemical/electrical energy.

TESTING RESULTS

Tests have demonstrated the benefits of the solar tracker and the optimiser on production rates. The tracker in particular produced a significant increase in production while allowing a rapid startup in the morning. The tracker and optimiser together nearly doubled the production of fresh water. From these results, it is likely that the maximum daily duration of production (in January in Perth or October in the north of the State) will be 11 to 12 hours. The maximum production rate from the Powersurvivor is approximately 65 litres a day.

EXPECTED OUTPUT OF LARGER UNIT BEING DEVELOPED BY RADG

A computer model which takes into account energy recovery has been developed and by using low pressure membrane, a production rate of **83.7 L/h** is expected in summer bright sunshine conditions. The experiments conducted on the Powersurvivor demonstrated the extremely long duration of pumping that can be achieved using a solar tracker and solar optimiser. Summer pumping in Perth would therefore produce **1000 L/day** from just two solar panels.

CONCLUSION

Solar powered reverse osmosis has the potential to make a significant contribution to the health and wellbeing of remote communities whose water sources are not to the required drinking standard. Solar panels are maintenance free, have a life expectancy in excess of 15 years, are clean, quiet and environmentally sound. Their only failing has been their comparatively high capital cost. The use of energy recovery on the RO plant can reduce the number of panels required to one quarter of that normally required. To this end, the Remote Area Developments Group's goal is to develop the technology to produce up to 1000 L/day of fresh water from brackish water sources, from the power of only two solar panels, with the aid of,

1. energy recovery of the waste stream,
2. low pressure membranes,
3. solar trackers
4. pump optimisers
5. Australia's abundant sunshine.