In remote and arid areas of the world the use of renewable energy sources to power desalination plants is becoming an attractive option. Here, we take a look at two examples that are proving highly successful.

RE Powers Desalination

The reliable and safe provision of water is a basic human right, but in many parts of the world this is not the case as traditional sources become exhausted. As a result desalination, a mature and reliable technology, is becoming a viable alternative, although high equipment and energy costs still prevent its wider market penetration.

In the oil rich Middle East region desalination satisfies close to 50% of the region's domestic and industrial water requirements. Here the desalination plants are typically driven by oil or its associated gas. However, there are many other arid areas of the world that have neither the economy nor the indigenous fossil fuel resources to follow a similar development. In these areas interest is growing in using renewable energy (RE) sources such as wind power, i.e. wind turbines and photovoltaics, i.e. the conversion of sunlight into electricity, to power desalination plants.

Desalination

Desalination can be divided into phase-change and single-phase processes. The most commonly used phase-change processes are Multi-Stage Flash (MSF), Multi Effect Distillation (MED) and Vapour Compression (VC). Highly developed single-phase processes are Reverse Osmosis (RO) and Electrodialysis (ED), both of which use membranes to separate impurities from water.

Desalination and RE

Although RE sources can be indirectly connected to a desalination plant through the electrical grid, the direct connection of RE to low or medium capacity desalination plants is more convenient, and in most remote regions more economically viable.

However coupling RE technologies with desalination processes is a technical challenge, with most of the problems associated with the intermitted nature of RE sources and the total system cost. To solve the matching problem, engineers tend to follow either the 'power side' management or the 'demand side' management option. In the power side option, hybrid power plants that combine more than one energy source and/or energy storage system balance the power input to the desalination. While in the demand side option, the desalination unit operates only when adequate power is available from the RE sources. The latter option can be used provided that the selected desalination technology can operate satisfactorily with regular shutdowns.

RO desalination plants powered by wind turbines is one of the most challenging options in terms of matching the power demand of the plant with the highly variable power output of the wind energy converters. However, the energy production cost of wind power is becoming competitive to utility grid electricity, and the low cost and modularity of RO technology make this combination highly suitable for low or medium capacity plants.

Photovoltaics-RO is also becoming a favoured desalination combination for small stand-alone systems. Since both technologies are highly mature and reliable these systems require minimum maintenance and are especially suited for remote areas.

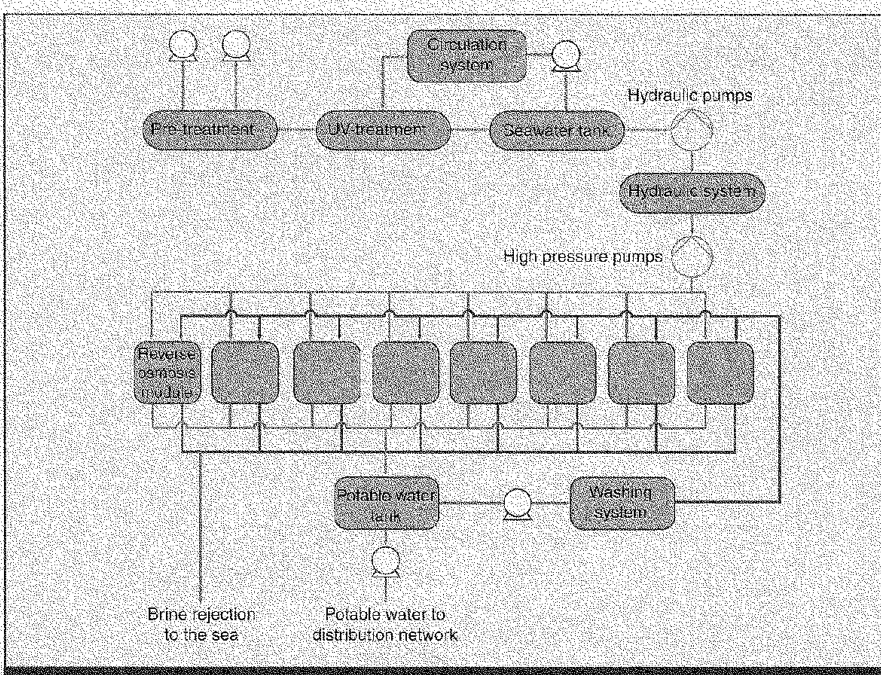

Figure 1: Configuration of the wind-powered RO desalination plant.

Wind-powered RO Plant

Current research in the field of RE powered desalination systems is focusing on the assessment of market potential, the development of demonstration plants and the improvement of the interface between RE and desalination. Sustainable water resources management policies are, however, the major instrument for boosting the development of such systems.

Research by the European Commission (EC), indicated a significant market potential for the development of RE powered desalination plants in Eastern Mediterranean countries such as Cyprus, Egypt, Israel, Lebanon and Palestine. The analysis of seasonal and spatial variations in water supply and demand indicated that water shortage problems on a national or regional level existed or were expected to appear in the near future. A similar analysis in Greece identified the Aegean Islands as the most arid regions of the country.

In 1998 a wind driven RO plant was built at Syros, an Aegean Island in Greece, and partly funded by the EC.

The wind turbine and the RO plant were installed on two different sites some 1.5 km apart. The wind turbine was erected on a hilltop to get maximum wind power and was connected via a medium voltage transmission line to the RO plant situated on the coast. Power from the wind turbine was buffered in an energy storage system that included a diesel generator, batteries and a flywheel generator. The output was fed into the RO unit and the electric grid.

The RO unit contained eight parallel modules (Figure 1), which allowed the capacity of the system to vary from 60-900 m^3/day according to available wind energy. The maximum power consumption was 200 kW.

The Syros plant is one of the largest RE powered RO units that is revealing the potential of such systems to supply entire communities.

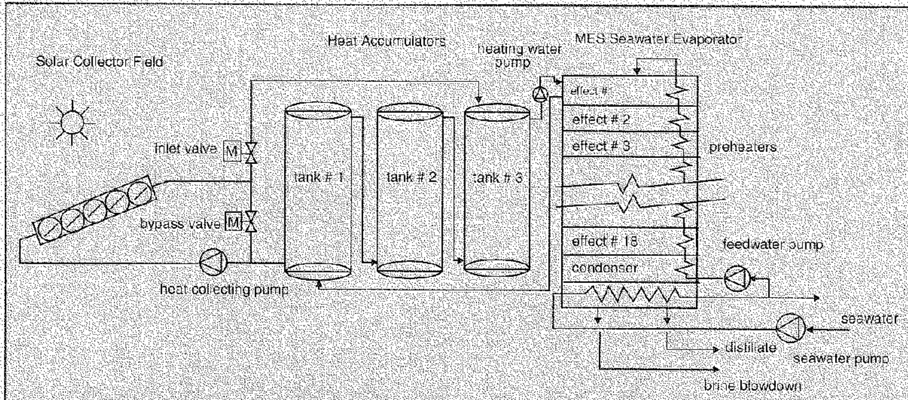

Figure 2: Schematic diagram of the solar-powered desalination plant.

Solar-powered Plant

As mentioned above the majority of desalination plants in the Middle East are powered by oil or gas, but in a number of remote areas in this region demonstration plants have been built that rely of RE sources. One such example is the Abu Dhabi solar desalination plant, which is located at Umm Al Nar Power and Desalintion Station, approximately 32 km east of Abu Dhabi city. It was designed as a demonstration unit to evaluate the technical and economic feasibility of using this type of RE technology to provide remote coastal communities with fresh water. It has been in operation for over 16 years.

The plant consists of three subsystems: a solar collector field, which functions to convert solar energy into thermal energy when solar radiation is available during the day; a heat accumulator, which stores the thermal energy from the solar collector field to provide thermal energy to the evaporator 24 hours a day; and a seawater evaporator, which is a horizontal tube, thin film multiple effect distillation unit (MED) that has a rated capacity of 120 m^3/day (Figure 2).

The monthly efficiency of the solar collector field is defined as the monthly amount of heat collected by the collector field divided by the amount of solar radiation intercepted during the month by the absorber plates of the collectors. The efficiency appears to achieve values between 43-55% No obvious indication of any deterioration in the efficiency was detected.

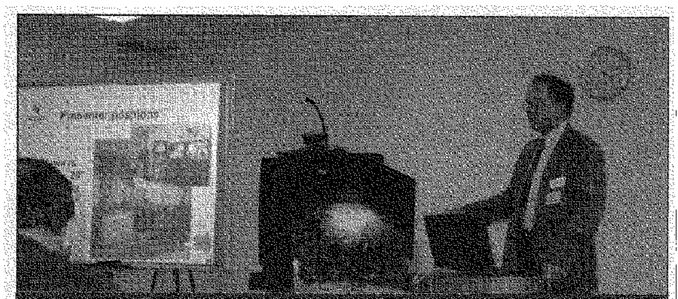

Figure 3: The Abu Dhabi solar-powered desalination plant.

The performance of the evaporator is normally measured in terms of its specific heat consumption (SHC), which indicates the amount of heat required to produce one unit mass of distillate and is usually quoted as kcal/kg. An increase in the SHC usually means that salt scale deposition on the tube bundles is taking place and an acid wash needs to be undertaken to remove it. The measured daily SHC of the evaporator indicated that the performance of the evaporator was maintained at its normal values and no scale was evident.

Based on the operating performance over 16 years of plant life the performance of the collector field and evaporator subsystems have not declined to any appreciable degree. No problems has so far been encountered with any of the tube bundles; distillate conductivity has been in the range 10- 20 mS/cm. This is an indication that a correct choice of tube and tube sheet materials was made by the manufacturer.

This desalination technology has proved its reliability and flexibility for variable load operation and is worth serious consideration as a provider of fresh water in remote communities. A pictorial view of the Abu Dhabi desalination plant is shown in Figure 3.

Acknowledgements

We would like to thank Professor Assimacopoulos, National Technical Univeristy of Athens, Greece and Ali M El-Nashar, Abu Dhabi Water & Electricity Authority, UAE, for their contribution to this article.

For more information on the Wind-powered RO plant contact: Professor D Assimacopoulos, National Technical Univeristy of Athens, Department of Chemical Engineering, Section II, Heroon Polytechniou St, 9, Zografou Campus, GR 15780, Athens, Greece. E-mail: assim@orfeas.chemeng.ntua.gr

For more information on the Abu Dhabi solar-powered plant contact: Ali M El-Nashar, Manager, Desalination Laboratory, Research Center, Abu Dhabi Water & Electricity Authority, PO Box 41375, Abu Dhabi, UAE. E-mail: elnashar@emirates.net.ae