Analysis of Desalination Plant Types Connected to Wind Generator and the Possibility of Use in the Brazilian Northeast

P. C. M. Carvalho, L. G. Coelho Junior.
DEE – Universidade Federal do Ceará
Cx. Postal 6001 / 60.455-760 / Fortaleza, CE, Brazil
Phone: +55 85 3288 9585 / Fax: +55 85 3288 9574
e-mail: carvalho@dee.ufc.br

Abstract

This paper analysis alternative projects for producing drinking water in high wind potencial and water-scarce regions in an economical, maintainable and autonomous way. Initially, problems and potentialities of the Brazilian Northeast region are identified. After that, the advantages and disadvantages of different wind energy desalination plants are mentioned.

1. Introduction

The lack of drinking water emerges on that millennium as one of the most important global problems. An example of an area affected by this problem is the Northeast Region of Brazil. In this region the mean annual rainfall precipitation is about 700 mm, but ranges from as little as 250 mm to over 1000 mm. Because of the warm weather, the annual evaporation potential is around 1700 to 2000 mm, which greatly exceeds the annual precipitation. For water policy purposes, the distribution of rainfall throughout the year is more important than the average. The main problem lies in the fact that most rainfall (some 85% or more of the precipitation) occurs within the short rainy season (January-May), and very little more falls during the rest of the year. In addition to the intra-seasonal fluctuation, rainfall is variable among years. Often sequences of years exhibit rainfall well below average, leading to the characterization of the region as the drought polygon [FUNCEME, 2002].

Desalination of seawater and brackish water is one of the alternatives for ensuring a dependably supply of drinking water. The most important desalination technologies use thermal and non-thermal processes, also called membrane processes. An example of a thermal process is the Vapour Compression (VC). The operation is based on the principles of evaporation and condensation. This method repeats the Earth's natural water cycle, and is widely used in many countries of the Arabian Peninsula, the Caribbean and the Canary Islands [Feizollahi, 2004]. In this system, the sea or brackish water is heated to its ebullition point and the applied pressure is reduced in order to maintain the water boiling. After a time, the water is transformed in vapour, then is cooled and condensed into drinking water. In non-thermal processes, like the reverse osmosis (RO), the desalination procedure is based on the application, with high pressure, of water with high salts content against selective membranes. In such case, the membranes will allow the water flowing through it, obstructing most of the salts presented in the original water [Maurel, 1990].

In the renewable energy field the Brazilian Northeast region has a great wind energy potential. This is true mainly in the State of Ceará, that is leader in the use of wind energy in Brazil.
According to the wind energy resource atlas of State of Ceará, the statistical distribution in the dry season (July – December) averaged for 5 towers, 40 – 50 m anemometer height, installed in very low roughness sites in the coastal area of Ceará shows that wind speeds lower than 4

m/s occur for an average of ca. 2 hours per month (0.27 %); for more than 90 % of the time, wind speeds are between 7 m/s and 13 m/s, which corresponds to the maximum aerodynamic efficiency of existing wind turbines. For this semester a shape factor of 5.85 is found. Considering the technological trend towards Megawatt-sized wind turbines, corresponding to hub heights of 70 m or higher, the annual potential wind energy production in Ceará is estimated at 233.7 TWh/year (to compare, the Brazilian electrical power consumption in 2002 was 290.5 TWh). The State of Ceará occupies less than 1.8% of the Brazilian territorial area [SEINFRACE, 2001].

2. Different Types of Wind Energy Structures for Water Desalination

The use of desalination systems coupled to wind plants is already known in several countries. Experiences made in Spain show the system effectiveness. However, an important step to be evaluated is which combination is better to be used in a certain area. Different technological concepts are available and the need to evaluate them is becoming necessary: the wind generator not coupled to desalination, in other words, there are two independent structures working in an united way, and the desalination working in the same wind generator structure.

In the case of wind generator technology not coupled to desalination plants, there are many projects in use. The efficiency of this project depends directly on its components. In Brazillian Northeast region, this technology could be well adapted, due to the possibility of transport of its structures without the demand of an specific infrastructure. Another important factor is the installation place versatility. The desalination plant can be installed in a strategic place and the wind generator in other; in such case, the connection between both is by electric cables (figure 1). The composition of this system is: an unit of water pre-treatment, a high pressure motor-bomb, membrane modules, an unit of energy recovery in the concentrate flow, a control unit and a wind generator.

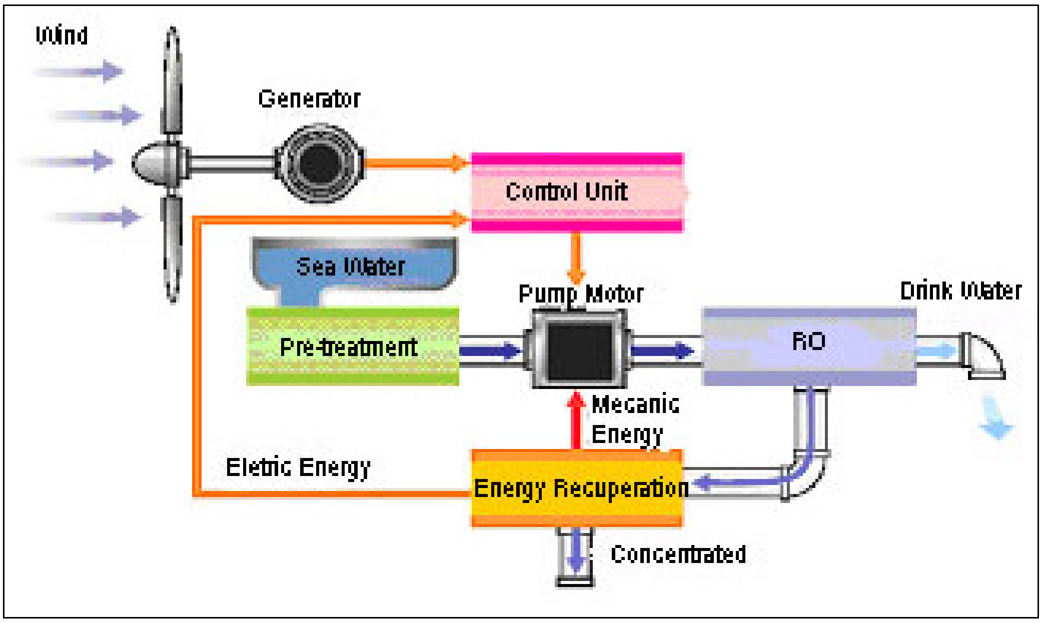
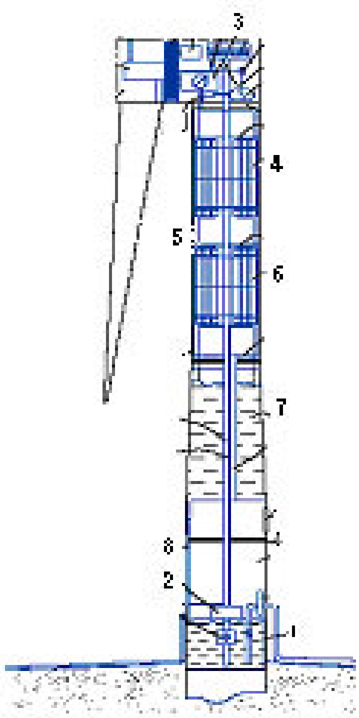


Figure 1: Basic structure of a wind powered RO plant [Carvalho, 2003]

In the case of desalination plants working in the same structure of a wind generator, the transport to the installation place can be more complicated, so the need of an adequate infrastructure.

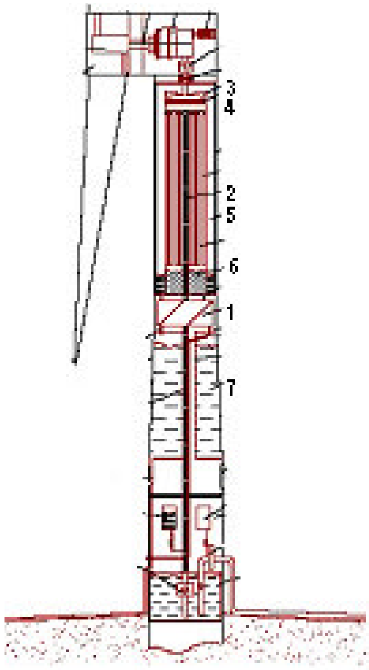


Using the process of RO (figure on the left side), the salty water enters the seawater reservoir (1) via a filter. After the water is pre-treated (2), the pump transports the sea water to the pressure pump in the nacelle, and later to the storage tank.

The rotational energy of the wind energy converter (WEC) rotor is transmitted via a gearbox to one or more pump aggregates in the nacelle of the WEC. From the tower base, the directly driven pumps (3) are supplied with the seawater to be desalinated and create a rotor speed dependent volume flow. The RO unit (4) is charged with this seawater through a valve system.

Arranged underneath the nacelle in a frame (5) rotating with the nacelle are the filtering units (4) and the reverse osmosis installation (6). As the suspension rotates with the nacelle, the connecting tubes between the pressure pumps (3), filtering unit and the RO installation can be connected tightly. Located below the reverse osmosis installation (6) is the drinking water tank (7) which serves as a reservoir.

Through the geodetic height of the water column, simultaneously pressure is created in the clean water outlet pipe (8), which in turn facilitates the bridging of greater distances. The higher concentrated saltwater is leaving the process through the waste water pipe next to the lifting pipe.



In the process of Vapour Compression (VC) (figure on the right side), the pre-treated salty water is heated via an electrical heating when the process is started and via heat exchangers (1) during normal operation transferring the heat from the outlet of the process like brain and distillate to the inlet.

This pre-heated feed water is pumped to the top of the pipe bundle (2), building the falling film evaporator of the VC. Special arrangements on top of the pipes secure the definite falling film all through the pipes, avoiding scaling at the inner surface.

From this falling film water damp is evaporating and streaming upwards driven by the compressor (3), sucking the damp through a demister (4) and pressing it to the heating shell (5) on the outside of the pipe bundle (2).

Due to the increased pressure and temperature of the steam that passed the compressor the outside of the pipes, which is still at a temperature level of the feed water, forces the steam to condensate. The condensation energy released is driving the evaporation process inside the pipes through the pipe shell. The distillate is collected at the bottom of the condensation room (6). Led through the heat exchanger (1) into the distillate tank (7).

An important point in the systems evaluation is the advantage for using desalination rejects (concentrate flow) as extra source of revenue. The concentrate, with high salt concentration, is appropriate to create fishes and shrimps (technology already used in the Northeast region). Other possibility is to reuse the concentrate from fishes captivity to produce plants adapted to the semi-arid conditions (Atriplex). Those plants are used for animal feeding in water-scarce periods with excellent results.

3. Conclusion

It is evident that desalination in the Northeast semi-arid area is necessary, however, it has to be accomplished in a maintainable way. A good form to it happens, is to use wind energy , as well to utilize the desalination rejects . There is a direct dependence of three factors in relation to the best desalination type: the installation place, the investor type and, mainly, the technology type that, in the installation period, is the best cost benefit. In this way, we can set up an ecological desalination plant , in an extra source of revenue to the beneficiary, that can be used to finance maintenance and project operation costs and, in such case, guaranteeing the complete project sustainability.

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