

Design, simulation and economical analysis of a stand alone reverse osmosis desalination unit with energy recovery powered by a hybrid (wind-PV) energy system

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The water shortage in Mediterranean islands is a significant problem. However, the renewable energy sources are usually high.

This paper presents a simplified method for designing a stand alone, hybrid (wind-PV) reverse osmosis desalination system, with energy recovery, by utilizing spreadsheet software.

The aim of the design was to cover the daily and monthly water needs, to obtain several layers of back-up (batteries, water tank and hybrid energy system), and as close as possible to a maintenance free system.

The system design starts with the determination of the maximum water needs of a population of 60 inhabitants, of a village in Chania-Crete, which was determined to be 200 l/day person. Given the water needs, the size of RO unit is determined to be 12 m³/day. Once the size of RO unit is determined, the power and energy needs are calculated. At this stage the local solar and wind resources processing are performed. By determining the solar radiation and air temperature, the size of the PV system which will cover all the energy needs of the RO unit is determined to be 30 kW_p. According to the local wind potential, the energy produced by wind turbines of different power is calculated.

In order to determine the final PV and wind turbine hybrid system size, a technical and economical analysis is performed to evaluate the energy production cost from both the PV and wind turbines. The analysis proved that a hybrid system with two wind turbines of 4 kW and 40% of the above mentioned PV power (12.5 kW_p) is the most cost effective.

The energy recovery from reverse osmosis systems has been a major factor in the cost reduction of the desalinated seawater, for that reason a pressure exchanger using the hydraulic energy of the brine is added to the system. The power savings realized by reducing the size of the high pressure pump by about 50%, and as a result a reduction in the water production cost, (5.2 €/m³) which was calculated from the economical analysis.

In order to evaluate the system performance, a daily and monthly simulation was performed. The simulation showed that the hybrid system, the batteries and the water tank of 30 m³ could cover completely the energy needs of the RO unit and the water needs of the population.