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Research Article

Offshore Desalination Using Wave Energy

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This paper evaluates the design of an offshore desalination plant currently under preliminary development. The purpose is to test the feasibility of producing drinkable water using wave energy in out-of-sight installations, as an alternative for those locations where land use, civil engineering works, and/or environmental impact make a coast-based solution inadequate. After describing the components, a proposal for sizing them is studied, based on using buoy-measured data at the expected location and their mathematical models of the different sections of the plant. Finally, by using measured buoy data, the influence of sizing on the expected performance is studied for a specific location, and one of the designs is developed in detail.

1. Introduction

Offshore desalination plants powered by renewable energies are being proposed as an alternative for a coastal desalination facility, for those locations where the lack of suitable land makes a land-based desalination plant inadequate [1, 2]. Different techniques of desalination have been studied in previous works. Among the most developed are reverse osmosis and vapor compression desalination [3].

This paper studies a proposal to use an offshore wave platform as the sole energy source of a reverse osmosis (RO) plant to produce drinkable water, which is then transported offshore (through pipes, water tank ships, or bladders) [4].

Some economic studies have been published about the advantages of autonomous wave-powered desalination plants. These works have discussed whether the real value of the system is enhanced due to its flexibility for deployment and reduced environmental impact [5, 6]. As renewable energy is the only source of energy, a central problem would be to balance energy consumption with energy production; as energy production is variable and the electrical system is isolated from the grid, the desalination plant has to be designed with variable production in mind [7, 8]. Most of the works on wave energy conversion have focused on electricity production. Any such converter could, in principle, be coupled to an electrically-driven desalination plant, either with or without connection to the local electricity grid. Various concepts have associated wave energy converters and RO [9].

The proposal presented here is based on dividing the plant into a few sections, which would be switched on or shutdown, depending on the available energy [10, 11]. All of this requires a specific control system, which is discussed later. Wave energy converters are studied as they provide lower variability in energy production in comparison with other sources [12]. Thus, power consumption adapts to power production by connecting or disconnecting sections of the plant (following a Smart Grid approach for the microgrid in the plant) and using temporary storage of electricity for short-time balances and an increase in autonomy.

The process diagram in Figure 1 presents the main blocks of our proposal: the wave energy converters (WECs), batteries, the seawater pumps (SWPs), the seawater tank, the desalination plant, the fresh water tank, and the water transport facility (by tankers, bladders, or pipes). After the introduction, a description of the different components is given in Section 2. A control system is proposed in Section 3. Section 4 gives some guidelines for the system sizing methodology. In Section 5, a case study is presented. Section 6 depicts some results and finally, some conclusions are provided in Section 7.