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Creating the electric energy mix in a non-connected island

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Abstract

As the electric energy in the non-connected islands is mainly produced by oil-fueled power plants, the unit cost is extremely high due to import cost. The integration of renewable resources in the energy mix is essential for reducing the financial and environmental cost. In this work, various energy resources (renewable and fossil fuels) are evaluated using technical, environmental and economic criteria with an emphasis to biomass, pumped hydro storage and replacement of oil power plants. Finally, a synthesis is presented as a toy-model in an Aegean island that satisfies the electric energy demand including base and peak electric loads.

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Keywords: renewable energy resources; stochastic simulation; Hurst parameter; hybrid energy system

1. Introduction

Most of the Greek islands are not connected to the electricity network of the mainland. The production of electric energy relies on local oil fuel plants, which have a high cost due to the import cost of oil (compared to the import and distribution cost on the mainland and the import-free use of renewable energy resources) and also, a high environmental impact. During the last years, there has been a significant effort to replace the energy produced from oil fuel with renewable resources either partly or entirely. The continuous advances in renewable energy resources technology along with the gradual installation-cost reductions pave the way towards a wider adaptation of renewable energy resources worldwide.

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Since the late 1970s, the idea of a so called Hybrid Energy System (HES) that combines wind, solar and diesel generators, as well as battery tanks, has been developed. In recent years, the integration of other renewable resources, such as pumped hydro storage, wave energy and biomass, is also evolving. According to [1] combining HES with wave energy converters to create the energy mix of a non-connected island could lead to a much higher renewable fraction. However, so far, the combination of all renewables towards an autonomous grid is still at an early stage [1]. In this work, all six renewable resources are examined (solar, wind, marine, hydropower, biomass and geothermal) in order to create the energy mix for a non-connected island. In this respect, we note that the uncertainty that dominates the associated natural processes and the energy demand is considerable and requires the use of a stochastic approach in order to achieve effective planning of the energy system.

For our case study the selected the area for the toy-model analysis is Astypalaia, which is a Greek island, part of Dodecanese, an archipelago of twelve major islands in the south-eastern Aegean Sea (Figure 1). The island has about 1300 inhabitants and it extends in an area of 97 km^2. Astypalaia has more than 20 000 visitors per year which makes tourism the main industry.

Fig. 1. Location of Astypalaia (36◦5390N 26◦3131E).

Today the electric energy demand is satisfied by an oil-fuelled thermal station because the island is not connected to the electricity system of the mainland and there are no renewable energy sources installations in the area.

According to records from 2014 to 2015, the island's mean annual demand was 6250 MWh. The peak hourly demand was 2.2 MWh (occurred on 14/08/2015 at 21.00) and the minimum was 0.23 MWh. In Figure 2, the hourly energy demand of Astypalaia for the 2014-2015 period is shown. As expected, it exhibits high values during the summer touristic period and low values during the rest of the year.

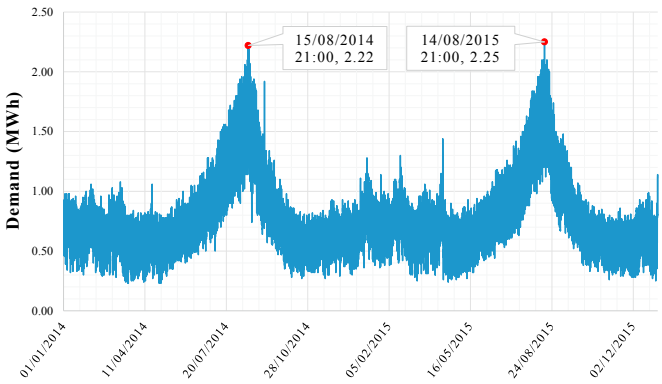

Fig. 2. Historical 2014-2015 hourly electric energy demand (MWh).

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