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Simulation of electricity demand in a remote island for optimal planning of a hybrid renewable energy system

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Abstract

Here we simulate the electrical energy demand in the remote island of Astypalaia. To this end we obtain information regarding the local socioeconomic conditions and energy demand needs. The available hourly demand load data are analyzed at various time scales (hourly, weekly, daily, seasonal). The cross-correlations between the electricity demand load and the mean daily temperature are computed. An exploratory data analysis including all variables is performed to find hidden relationships. Finally, the demand is simulated. The simulation time series will be used in the development of a framework for planning of a hybrid renewable energy system in Astypalaia.

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Keywords: energy demand; stochastic simulation; hybrid reneable energy system

1. Introduction

Electric load and demand forecasting involves the projection of peak demand levels and overall energy consumption patterns to support an electric utility's future system and business operations. Electricity demand's behavior is very complex due to the deregulation of energy markets. Therefore, finding an appropriate model has many hard aspects. Here we analyze and simulate the electricity demand in the Greek island of Astypalaia. The

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simulated time series will be used in the design of a hypothetical hybrid renewable energy system [1]. The required length of the synthetic time series is 100 years. Accurate forecasts will lead to substantial savings in operating and maintenance costs, increased reliability of power supply and delivery system, and sustainable decisions for future development. The energy system will make use of all potential renewable energy resources, i.e., sunlight, wind, waves and biomass and will include a pumped-storage reservoir serving multiple water uses. The analysis is based on data from the period 2014-2015 with one-hour temporal resolution. Firstly, we visualize the data in two time scales (hourly and daily) for better understanding the behavior of electricity demand and the phenomena that have direct relationship with it. Secondly, we identify the main statistical characteristics and seek for internal periodicities. If any recurrences are found, they will be taken into account in the simulation. Based on the above, synthetic time series will be generated using time series bootstrap, which reproduce the autocorrelation and the marginal characteristics of the observed data. Finally, a comparison is made between temperature data and electricity demand [2].

2. Exploratory Data Analysis

2.1 Study area

Astypalaia is a perfect example of a non-connected island where the electric energy is mainly produced by oil-fueled power plants, the unit cost of which is extremely high [3]. Astypalaia is the fourth largest and westernmost island of the Dodecanese. It is located, as shown below (Fig. 1), west of Nisyros and east of Anafi (Cyclades). It acts as a "bridge" that connects Cyclades and Dodecanese, since it administratively belongs to the Dodecanese but geographically and culturally stands between Dodecanese and Cyclades, combining elements from both island groups. The island covers an area of 97 km^2, a coastline of 110 km and has 1 334 inhabitants. Astypalaia took its name after the daughter of Phoenix and Perimidis, who was also Europe's sister. The island kept the same name for centuries [4].

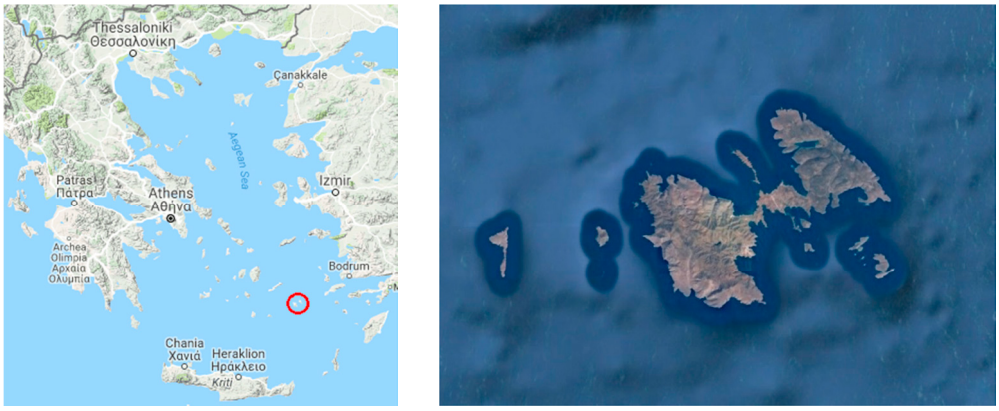

Fig. 1. Location of Astypalaia (satellite images from Status Meteo and Google Earth).

2.2 Original data

From the data analysis we obtain information about significant values. Specifically, an hourly maximum value of 2.25 MWh and an hourly minimum value of 0.23 MWh are extracted from the data, whereas we calculate an annual mean value of 6.26 GWh. In Fig. 2, we observe particularly high values during the summer, which are expected due to tourism. Also we can see the existence of annual periodicity.