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Feasibility analysis of medium-sized hotel's electrical energy consumption with hybrid systems

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ABSTRACT

In this study, the case of meeting a hotel's electrical energy demand with hybrid systems has been examined by using four different scenarios. The HOMER program is used for different analyses. In the first case, when the renewable energy resources are insufficient, electrical energy is purchased from grid and in the cases, in which the production is much more than the need, electricity is sold to the grid. In three other cases, the electric demand of the hotel is met by using renewable energy and the amount, which is more than the need, is sold to the grid. As a result, at the present circumstances two scenarios were determined feasible. When the grid is used only selling surplus electricity and the electricity need of the hotel are met by only renewables, battery groups and converters are needed. So, this causes an increase in investment costs. Therefore, these situations must be supported with adequate incentives, to make these systems become more eligible.

1. Introduction

Turkey is situated at the meeting point of Asia, Europe and Africa, bordering Mediterranean, Aegean and Black Sea. Turkey is a rapidly developing country. According to the statistics of the Undersecretariat of Treasury, GDP per capita reached 8578$ for 2009 and increased 146% since 2002 (Undersecretariat of Treasury, 2011). Turkish economy is the 16th and 6th largest economy in the world and Europe, respectively. Tourism is a key economic sector for Turkey. Turkey ranks ninth in terms of income from tourism with $21.3 billion and seventh in terms of number of tourists with $25.5 million visitors per year (Ministry of Culture and Tourism, 2011). There are 4569 hotels with a total capacity of 297,126 beds in Turkey. Hotels rank fifth among the commercial buildings in terms of energy consumption.

To generate constant power utilization of hybrid, renewable energy systems are required because of the fluctuation characteristics of the renewable energy sources. Although various feasibility analyses were carried out about the use of hybrid systems for meeting energy consumption of islands and remote consumers (Diaf, Diaf, & Belhamel, 2008; Himri, Boudghene, Draouic, & Himri, 2008; Nandi & Ghosh, 2010), limited work was done in the case of hotels (Bakos & Soursos, 2002; Dalton, Lockington, & Baldock, 2008, 2009a, 2009b). One of the most crucial aspects of the design of hybrid system is sizing. Different methods and control strategies have been proposed for the optimum design of hybrid energy generation systems. Various studies were published to determine optimum configuration of the hybrid energy systems (Baniasad & Ameri, 2011, 2012; Deng, Dai, Wang, & Zhai, 2011; Fux, Benz, & Guzzella, 2013). Results of these studies showed that these systems can compete with grid based energy systems. Simulation programs are the most widely used tools to design hybrid energy systems. HOMER was a commonly used program to optimize hybrid system configurations. The HOMER program was developed by the U.S. National Renewable Energy Laboratory (Lambert et al., 2006). It is used to design the micropower systems and compare power generation technologies. It models the behavior and life-cycle cost of the system and allows comparing different design options in terms of technical and economic merits.

In this paper, the HOMER program is used to analyze whether the energy need of a medium-sized hotel with a 133-bed capacity in the Mediterranean region of Turkey can be met cost effectively with hybrid systems considering four different hybrid scenarios. In the first part of this paper, the wind and solar power potential of Turkey is examined. Second, the load model of the hotel is developed. Third, the wind and solar power potential of the region is analyzed. Lastly, the HOMER program is used for different analyses with a consideration of different hybrid scenarios and economic criteria.

2. Wind and solar energy potential of Turkey

Turkey's Wind Energy Potential Atlas (WEPA) was prepared by numerical weather prediction methodology for 200 m × 200 m resolution for different heights (Akdag & Guler, 2010). According

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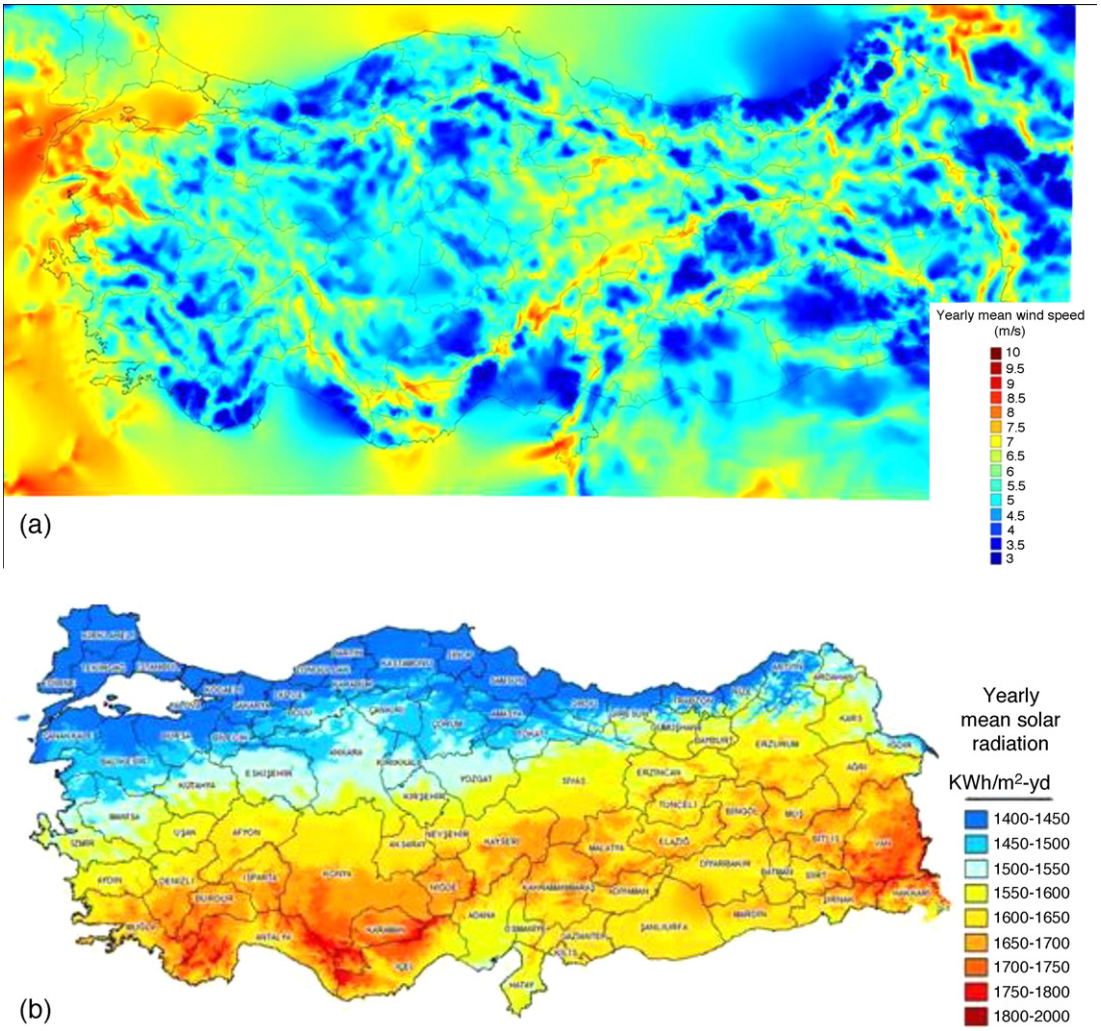

Fig. 1. Yearly mean wind speed solar radiation.

to WEPA, the wind potential of the inland regions is higher than 300 W/m^2 and the total wind potential is estimated to be 131,756 MW. Fig. 1a illustrates annual average wind speed at 50 m height (EIE, 2011a).

According to the Solar Energy Potential Atlas (SEPA) prepared by the General Directorate of Electrical Power Resources Survey and Development Administration (EIE), the average period of solar insolation time in Turkey is 7.49 h per month, with a minimum average of 3.75 h in December and a maximum average of 11.31 h in July. Turkey's monthly average level of global radiation is 4.18 kW/m^2 day with minimum average of 1.59 kW/m^2 day in December and a maximum average of 6.57 kW/m^2 day in June. Fig. 1b shows annual solar radiation levels of Turkey (EIE, 2011b). These maps indicate that there are excellent wind and solar potential. Therefore, hybrid systems can be cost effectively alternative to the grid.

3. Load modelling

The five-star hotel is located in the town of Söke in the Aegean region of Turkey (37°49′ latitude of North, 27°16′ longitude of East). The hotel has 133 rooms and a total annual energy consumption of 2,811,229 kWh. Based on our measurements, the hourly load curves of the hotel for different seasons were developed. Seasonal load profiles of the hotel were used to determine optimum hybrid energy systems. The profiles are shown in Fig. 2. As seen from the figure, the peak energy demand is around 700 kW, which was observed in the summer period. Energy consumption is generally higher in summer than in winter because of tourism activity.

4. Modelling of wind and solar resource of region

According to the WEPA prepared by the EIE, the average maximum wind speed at the height of 50 m. is 8.1 m/s and the average power density is 500 W/m^2. Wind speed of the region at the 50 m agl is shown in Fig. 3a. Considering the economic conditions of the region, the EIE states that 2523.76 MW wind power plant can be installed in this region.

In this study, wind speed measurements of the town of Söke, the province of Aydın, at 10 m height were obtained from the EIE. Weibull-shaped parameters (k) and scale parameter (c) were determined as 1.35 and 3.95 m/s. Monthly variations of hourly wind speed are given in Fig. 3b. The maximum monthly average wind speed is 5.52 m/s in July and the minimum is 2.65 m/s as observed in March. Yearly average wind speed is 3.63 m/s at 10 meters above sea level. As it is seen from the figure, the wind speed is higher in summer. Thus, energy demand is also higher in summer. In this study, the power law profile was used. The wind shear coefficient (α) for the power law profile was assumed as 0.2. The 1500 kW

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