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Solar-energy potential in Turkey

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Abstract

In this study, a new formula based on meteorological and geographical data was developed to determine the solar-energy potential in Turkey using artificial neural-networks (ANNs). Scaled conjugate gradient (SCG) and Levenberg–Marquardt (LM) learning algorithms and a logistic sigmoid transfer function were used in the network. Meteorological data for the last four years (2000 → 2003) from 18 cities (Bilecik, Kırşehir, Akhisar, Bingöl, Batman, Bodrum, Uzunköprü, Şile, Bartın, Yalova, Horasan, Polatlı, Malazgirt, Köyceğiz, Manavgat, Dörtyol, Karataş and Birecik) spread over Turkey were used as data in order to train the neural network. Meteorological and geographical data (latitude, longitude, altitude, month, mean sunshine duration, and mean temperature) were used in the input layer of the network. Solar radiation is the output layer. One-month test data for each city was used, and these months data were not used for training. The results show that the maximum mean absolute percentage error (MAPE) was found to be 3.448% and the R^2 value 0.9987 for Polatlı. The best approach was found for Kırşehir (MAPE = 1.2257, $R^2 = 0.9998$). The MAPE and R^2 for the testing data were 3.3477 and 0.998534, respectively. The ANN models show greater accuracy for evaluating solar-resource possibilities in regions where a network of monitoring stations has not been established in Turkey. This study confirms the ability of the ANN to predict solar-radiation values precisely.

Keywords: Solar-energy potential; City; Turkey; Artificial neural-network; Formulation

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Nomenclature

A	altitude (m)
I	solar-radiation (W/m^2 day)
L	latitude (°)
Lg	longitude (°)
M	month ($1 \rightarrow 12$)
S	mean sunshine-duration (h)
T	mean temperature (°C)
v	value normalized
v_{max}	the maximum value in all the values for related variable
v_{min}	the minimum value in all the values for related variable
v_R	the value to be normalized

1. Introduction

Due to an increase in conventional energy prices and environmental effects, such as air pollution, depletion of the ozone layer and greenhouse effects, the use of solar energy has increased, following the energy crisis in the 1970s. Solar energy is being seriously considered for satisfying part of the energy demand in Turkey, as in the world [1]. Solar-energy potential is very high in Turkey, which is located in the Mediterranean region between 36° and 42 °N latitudes and has a typical Mediterranean climate. The yearly average solar radiation is 3.6 kW h/m^{2}day, and the total yearly radiation period is ~2610 h. Solar radiation incident on a horizontal surface and sunshine duration are measured by several recording stations in Turkey [2].

Several studies [3–8] for the prediction of solar radiation in a few cities in Turkey have ensued. Our studies have predicted the solar resources in several cities in Turkey using an artificial neural-network (ANN) [9–11]. For engineers designing solar-energy systems, an accurate detailed long-term knowledge of the available global solar-radiation data in various forms, depending on the related application for efficient conversion and utilization of the solar energy is required. For this aim, Şaylan et al. [3] estimated the solar-energy gains on vertical surfaces in big cities, such as Istanbul, Ankara and Izmir for both summer and winter. Oğulata and Oğulata [4] determined the hourly global, diffuse and direct solar-radiations on a horizontal surface in Adana. For this aim, they used the measured monthly mean daily global-radiation data for estimating the global horizontal solar-radiation. Sozen et al. [9–11] performed similar studies for different stations in Turkey.

For the efficient conversion and utilization of solar energy, engineers designing solar-energy systems require an accurate detailed long-term knowledge of available global solar-radiation data in various forms, depending on the related application. This study shows the general perspective for the solar resource at