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Effect of relative humidity on solar potential

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Abstract

In this study, the effect of relative humidity on solar potential is investigated using artificial neural-networks. Two different models are used to train the neural networks. Meteorological and geographical data (latitude, longitude, altitude, month, mean sunshine-duration, and mean temperature) are used in the input layer of the network (Model 1). But, relative humidity values are added to one network in model (Model 2). In other words, the only difference between the models is relative humidity. New formulae based on meteorological and geographical data, have been developed to determine the solar energy potential in Turkey using the networks' weights for both models. Scaled conjugate gradient (SCG) and Levenberg-Marquardt (LM) learning algorithms and a logistic sigmoid transfer-function were used in the network. The best approach was obtained by the SCG algorithm with nine neurons for both models. Meteorological data for the four years, 2000–2003, for 18 cities (Artvin, Çeşme, Bozkurt, Malkara, Florya, Tosya, Kızılcahamam, Yenişehir, Edremit, Gediz, Kangal, Solhan, Ergani, Selçuk, Milas, Seydişehir, Siverek and Kilis) spread over Turkey have been used as data in order to train the neural network. Solar radiation is in output layer. One month for each city was used as test data, and these months have not been used for training. The maximum mean absolute percentage errors (MAPEs) for Tosya are 2.770394% and 2.8597% for Models 1 and 2, respectively. The minimum MAPEs for Seydişehir are 1.055205% and 1.041% with R^2 (99.9862%, 99.9842%) for Models 1 and 2, respectively, in the SCG algorithm with nine neurons. The best value of R^2 for Models 1 and 2 are for Seydişehir. The minimum

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value of R^2 for Model 1 is 99.8855% for Tosya, and the value for Model 2 is 99.9001% for Yenişehir. Results show that the humidity has only a negligible effect upon the prediction of solar potential using artificial neural-networks.

Keywords: Solar potential; Humidity; City; Turkey; Artificial neural-network; Formula

1. Introduction

Solar-energy is being considered for satisfying part of the energy demand in Turkey [1]. Solar-energy potential is very high in Turkey, which is located 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 the sunshine duration are measured by all the recording stations in Turkey [2].

Several studies have been presented [3–8] for the prediction of solar radiation in cities in Turkey. Our studies predict the solar resource 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 available global solar-radiation data is required in various forms, depending on the related application for the efficient conversion and utilization of the solar energy. For this aim, Şaylan et al. [3] studied the solar-energy gain on vertical surfaces in big cities, such as Istanbul, Ankara and Izmir of Turkey for both summer and winter. Ogulata et al. [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 using different stations in Turkey. Yang and Koike [12] investigated the estimating surface solar-radiation accounting for upper-air humidity.

For efficient conversion and utilization of solar-energy, engineers designing solar-energy systems require an accurate detailed long-term knowledge of the available global solar-radiation data. The aim of this study is to determine the effect of humidity on solar radiation in Turkey. To define the effect, two network models are used. One in which humidity is used as the input is called Model 2, the other one without humidity is Model 1. Meteorological and geographical data (latitude, longitude, altitude, month, mean sunshine-duration, and mean temperature) are used in the input layer of the network. The solar resource is in the output layer. Eighteen stations (namely in cities Artvin, Çeşme, Bozkurt, Malkara, Florya, Tosya, Kızılcahamam, Yenişehir, Edremit, Gediz, Kangal, Solhan, Ergani, Selçuk, Milas, Seydişehir, Siverek and Kilis) are selected in different regions of Turkey in which the radiation data and sunshine-duration information were collected between 2000 and 2003.

The most important theme in this study is to obtain equations based on meteorological and geographical data, for predicting the solar potential of Turkey for both models using ANN weights. Evaluating the solar resource is possible in regions