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Test reference year generation from meteorological and simulated solar radiation data

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Abstract

In this paper, a new method for generating test reference year (TRY) from the measured meteorological variables is proposed. Hourly recorded data of air temperature, relative humidity and wind velocity for two stations, Valladolid and Madrid (Spain) were selected to develop the method and a TRY was obtained. Monthly average solar radiation values were calculated taking into account the temperature and solar radiation correlations. Four different methodologies were used to evaluate hourly global solar radiation from hourly weather data of temperature and, as a consequence, four different TRYs with common data sets of temperature, relative humidity and wind velocity were generated for Valladolid and Madrid (Spain) stations. In order to evaluate the four different methodologies, TRYs data were compared with long-term measured data series using statistical estimators such as average, standard deviation, root mean square error (rmse) and mean bias error (mbe). Festa and Ratto and the TAG model, from Aguiar and Collares-Pereira, respectively, turned out to be the best methods for generating hourly solar irradiation data. The best performance was shown by the TRY0 year which was based on the solar radiation models mentioned above. The results show that the best reference year for each site varies with the season and the characteristics of the station.

Keywords: Meteorological variables; Test reference year; Models

1. Introduction

Accurate and high resolution meteorological data sets are required for performance evaluation and comparison of solar energy systems which can be carried out using multiyear hourly data or by means of a representative data year. The multiyear data series involve an expensive computational effort while the creation of a year of representative data, called test reference year permits the comparison of the performance among systems with different characteristics and installed in different places, with only one year of data.

Test reference year consists of individual months of meteorological data sets selected from different years over the available data period which is called long-term measured data series.

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Nomenclature

A_m	temperature amplitude (°C)	K_m	monthly average daily global horizontal clearness index
G_{dm}	monthly average daily solar irradiation ($J m^{-2}$)	T_{hm}	monthly average hourly air temperature (°C)
G_{0dm}	monthly average daily extraterrestrial solar irradiation ($J m^{-2}$)	T_m	monthly average air temperature (°C)

Typical Meteorological Year methodologies have been proposed by (Petrakis et al., 1998; Pissimanis et al., 1988; Argiriou et al., 1999; Festa and Ratto, 1993; Florides et al., 2001; Kalogirou, 2001; Mazzei et al., 2002; Medina, 2000). The representative data sets can be generated for several climatic variables or only for solar radiation, (Feuermann et al., 1985; Knight et al., 1991; Mosalam and Tadros, 1994). Ecevit et al. (2002) show the possibility of using daily sunshine duration to develop a Typical Meteorological Year for Ankara, Turkey.

The different TRY methodologies have been developed with selection criteria based on solar radiation or on solar radiation together with other meteorological variables. Methodologies for generating *Typical Meteorological Year* (TMY) use a modified version of Hall et al. (1978).

Methods that take into account the difference between hourly solar radiation values and long-term measured average hourly solar radiation values are proposed by Petrakis et al. (1998) and Pissimanis et al. (1988). TRY methodologies use different algorithms according to authors and typical months are selected in a way that the monthly average, standard deviation and the sequence of daily parameters of the TRY are close to the corresponding values of long-term measured data series.

Some authors propose methods known as *Short Reference Years* (Feuermann et al., 1985; Petrie and McClintock, 1978), in order to generate standard meteorological data values for a shorter time scale.

All methodologies reviewed require available solar radiation data, which is drawback because the number of solar data series is limited in some regions and countries all over the world. It would be interesting to develop a method for TRY generation based on meteorological weather data and not on solar radiation which could be estimated afterwards from temperature using different methods and models. These methods could be applied in places with long data series of air temperature, relative humidity and wind velocity.

The aim of this paper is to select, compare and validate TRYs generating methodologies implemented from long-term hourly measured meteorological data of air temperature, relative humidity and wind velocity, at two stations: Madrid and Valladolid (Spain).

The long-term measured meteorological data series used consist of hourly horizontal global radiation, air temperature, relative humidity and wind velocity values measured along a period of 14 years, from 1975 to 1998 in Madrid (Spain) and 10 years, from 1991 to 2000 in Valladolid (Spain).

The new proposed method elaborates an approximate TRY data series which is based on meteorological data of temperature, relative humidity and wind velocity. The horizontal solar radiation values are obtained from the temperature values of this approximate TRY and finally, generated solar radiation values are included in the approximate TRY and, as a consequence a TRY is completed for its validation.

In the method, solar clearness indices are evaluated from temperature values and taking into account them, the solar irradiation values are estimated by four different models. As a result, four complete TRYs have been created and validated.

The interest of the paper is based on the necessity of meteorological data series for developing and using solar energy systems in an area like the Mediterranean, where solar irradiation levels and sun light hours are significant and other energy resources are scarce. So, the results of this paper are the generation and evaluation of the first TRYs in the region, which are necessary to increase the solar energy use and to simulate the performance of solar energy systems, with low computational time and with representative measured solar radiation data.

The generation methodology, data base and the comparison of the TRYs generated are given in the following sections, where specific details can be seen at the corresponding references.

2. Methodology

The general structure of the proposed method to elaborate TRY is composed by the following steps: elaboration of an approximate TRY with meteorological data; estimation of monthly average daily horizontal global solar irradiation, from which the daily and hourly horizontal global solar irradiation values were assessed and the inclusion of solar radiation values into the approximate TRY.