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Prediction of daily solar radiation intensity by day of the year in twenty-four cities of Morocco

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ABSTRACT

In this study, by using the acquired data from Meteonorm, we used two empirical models developed in literature to predict direct, diffuse and global solar radiation fluxes. Solar radiation intensity of Agadir, Al Hoceima, Beni Mellal, Casablanca, Er-Rachidia, Essaouira, Fes, Ifran, Kenitra, Larache, Marrakech, Meknes, Melilla, Nador, Ouarzazate, Oujda, Rabat, Safi, Sidi Ifni, Tangier, Taza, Midelt, Tetuan and El Aaiun cities is predicted. In order to evaluate the day by day performance of these models, a statistical analysis was performed by using several statistical indicators of mean absolute bias error, root mean square error, normal root mean square error, test statistic, standard deviation and coefficient of determination. The results obtained are acceptable and they gave a good approximation between the estimated and the measured values. The daily solar radiation intensities predicted in this study can be used in the design and estimation of the solar system performance in all Moroccan cities and in other locations of similar climate conditions.

Contents

1. Introduction

Increase of energy consumption, depletion of fossil energy sources, the petroleum crisis and its price elevation require to found a new energy source, which can to improve and save sustainable development in world. Renewable energy sources (Sun and its direct and indirect effects on the earth such as: solar radiation, wind, biomass,…) can produce marketable energy by converting natural phenomena into useful forms of energy [1,2]. Use of solar energy and its conversion is the best economical and technological solution. Several range of solar energy systems developed recently to achieve best conversion of solar energy to another useful energy.

Morocco benefits from great solar and wind energy potential, as well as from a key geographical location. Two major renewable energy sources initiatives – the Moroccan wind and solar projects– have been launched in order to reach the national target of increasing the share of renewable energy sources in the energy mix to 42% by 2020 [3].

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Nomenclature

G	Global flux received on a horizontal surface (W/m^2).
I	Direct flux received on a horizontal surface (W/m^2).
D	Diffuse flux received on a horizontal surface (W/m^2).
G_{dm}	Daily measured solar radiation (kWh/m^2/day).
G_{dp}	Daily predicted solar radiation (kWh/m^2/day).
H_0	Daily extraterrestrial solar radiation (kWh/m^2/day).
I_0	Solar constant (W/m^2).
C_t	Correction of the Earth-Sun distance (dimensionless).
θ_z	Zenith angle (degrees).
h	Solar elevation (degrees).
Γ	Turbidity factor (dimensionless).
CI	Clearness Index (dimensionless).

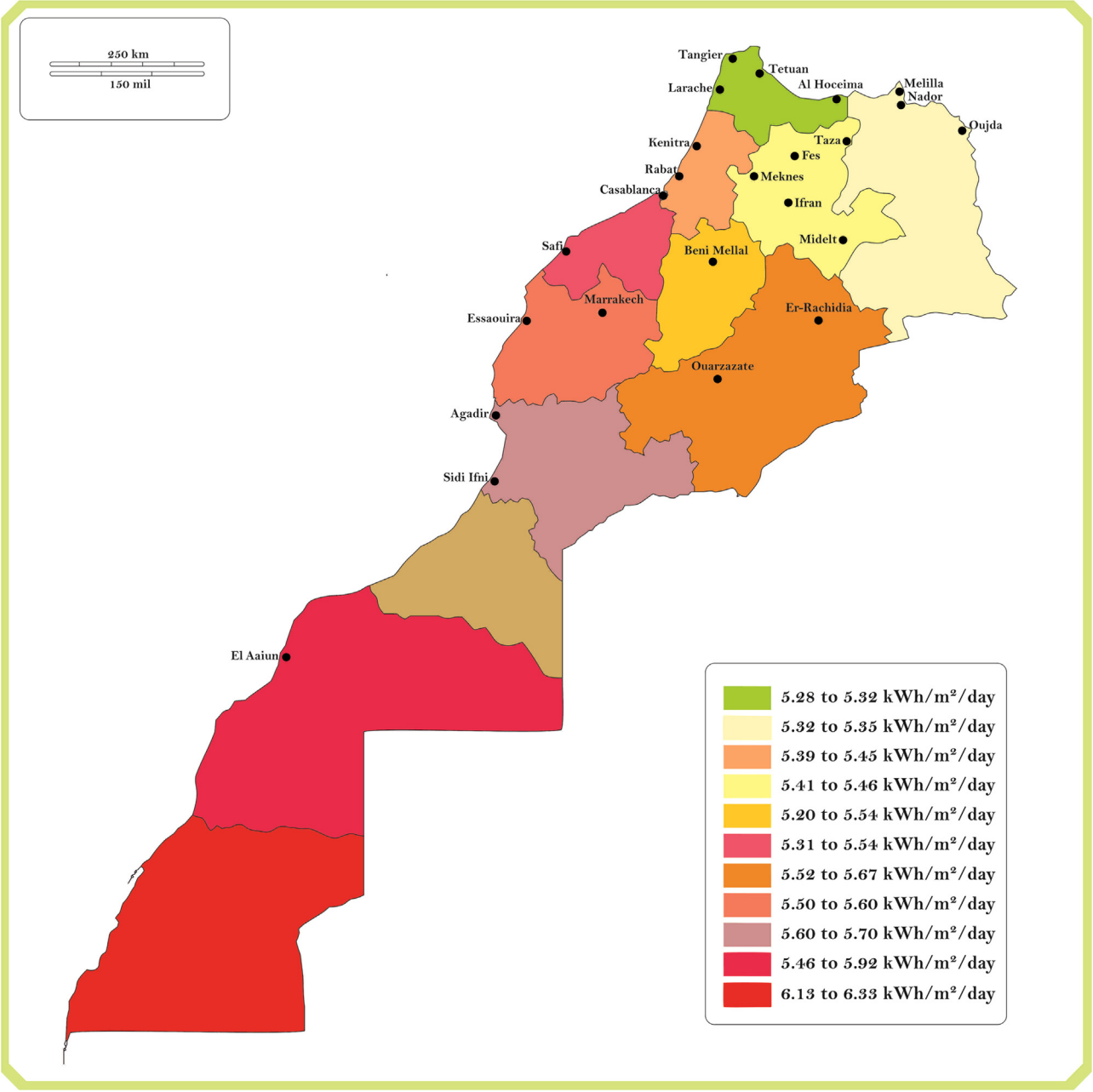

Fig. 1. Various solar radiation intensities in Morocco.

With an abundant solar resources (a potential of 2600 kWh/m^2/year) Morocco offers a wide range of investment opportunities in the sector of thermal and photovoltaic solar energy. Daily average solar radiation intensity value in Morocco (see Fig.1 that was elaborated by the author) close to 5.80 kWh/m^2/day (21 MJ/m^2/day).

In order to minimize the imported energy supply (close to 95% of its energy) as fossil fuels and to response on growing population, rising living standards and increasing power demand from cities and energy intensive industry, the Morocco have launched a great project of solar energy of an investment cost estimated at 9 billion US dollars in five sunlit position _ Ourzazate, Boujdour, Ain Bni Methar, Foum Al Oued and Sebkhat Tah [4]. Where this national ambitious and realistic project aims at establishing by 2020 a capacity of 2.000 megawatts. This production capacity represents 38% of the installed power by late