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Analysis of solar radiation measurements at Ghardaïa area, south Algeria

Kacem Gairaa*, Saïd Benkaciali

Applied Research Unit for Renewables Energies (ARURE), BP 88 Gart Taam, Ghardaïa 47000, Algeria

Abstract

This study aims to explore the solar radiation field in southern Algerian peninsula, hourly measurements of global and diffuse radiant fluxes collected at Ghardaïa site (32.360 N, 3.810 W, 450 m above MSL), from 1 January 2005 to 31 December 2008, are employed. These data were used to further addressing radiant fluxes distribution on hourly, daily, monthly and seasonal basis that in turn are of particular important from the point of view of proper design of building energy systems as well as accurate evaluation of thermal environment within buildings. Results obtained suggest that the annual value of clearness and diffuses indexes are respectively 0.68 and 0.37, and the monthly average daily values of global solar radiant flux exhibits seasonal variability with higher values in summer (7762 Wh/m^2) and lower ones during winter (3915 Wh/m^2). Regarding diffuse radiant flux, measurements shows that the monthly average daily value is about (1173 Wh/m^2) in winter, while it is around (2829 Wh/m^2) in summer.

Keywords: Solar radiation; radiometric station; mesearements; frequency distribution

1. Introduction

The increasing global energy demands and increasing fossil fuel prices stimulate countries to downsize energy consumption and exploit renewable energy sources. In addition, environmental problems caused by mass consumption of fossil energy (e.g., global warming), are also reason for concern. In general, solar and wind energy are thought to be good alternative energy sources for overcoming these problems due to their safety and positive contribution to the global environmental state because of their lack of emissions during operation [1]. Studies on solar radiation have become an important issue for renewable energy issues stemming from oil crises and other environmental problems, thus increasing the need of reliable measurements of surface solar radiation [2]. Data are a fundamental input for solar energy applications such as photovoltaic, solar thermal systems, and passive solar

* Corresponding author. Tel.:+213-559-542-300; fax: +213-298-701-52.
E-mail address: gisol47@gmail.com.

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design. The data should be contemporary, reliable and readily available for design, optimization and performance evaluation of solar technologies for any particular geographical location. Solar energy applications require a complete knowledge and detailed analysis about the potentiality of the site so, measurements at ground level is an important feature in solar energy conversion systems. This information can be gathered from different data sources, such as ground measurements by pyranometers or reference cells or derived from satellite data, the best way for knowing the amount of solar radiation components, is to install pyranometers at many locations in the given region, and look after their day-to-day maintenance and recording. When measurements are recorded, a strict quality control is mandatory in order to build a confident database [3].

Due to its geographical position in the solar belt, Algeria is blessed with an abundance of solar energy and has the opportunity to utilize this bounty of natural energy effectively, promoting a clean environment, and developing renewable energy technologies in the region. Ghardaïa city is a dry and arid site, characterized by an exceptional sunshine, most often; it has a very important rate of insolation (75% on average) and the mean annual of global solar radiation measured on horizontal plane exceeds 20 (MJ/m2). The sunshine duration is more than 3,000 hours per year, which promotes the use of solar energy in various fields.

Global solar radiation data in north-eastern Saudi Arabia was investigated by Ahmet Aksakal et al [4, 5] from 1 January-31 December for one complete year, the highest measured daily and monthly mean solar radiation were found to be 351 and 328 (W/m^2), respectively and the highest one-minute averaged solar radiation values up to 1183 (W/m^2) were observed in summer season. Measurement of solar energy radiation in Abu Dhabi was presented by M.D Islam et al [6], who found that the highest daily one-minute average daily solar radiation was 1041 (W/m^2) While the yearly average daily energy input was 18.48 (MJ/m^2/day). José Leonaldo et al [1] focused global solar radiation measurements in Maceió,-Brazil, their results showed that the maximum values of the hourly global irradiation in dry and rainy seasons were 3.18 and 2.5 (MJ/m^2) respectively while, the peaks of hourly average solar irradiation for both periods were 2.79 (MJ/m^2). Mustafa G [7] and Oturanc et al [8] performed an analysis of daily total horizontal solar radiation measurement for 9 cities in Turkey. They compared actionograph data with pyranometer data of some stations, and developed a nonlinear model between the monthly average daily global solar radiation and the ambient temperature. They observed that the maximum value of the monthly average daily hours of bright sunshine occurred in June reaching 14.58 hours, while the minimum value was recorded during December with 9.41 hours. Statistical analysis of solar radiation measurements in Algeria was performed by F. Youcef [9] et al using beta distributions, the results of the first classification show that for each class of daily clearness index, the hourly data under consideration are modelled by only one beta distribution and when we use the second classification, linear combinations of two beta distributions are found to fit the monthly frequency distributions of the hourly solar radiation data.

The purpose of this paper is to do an analysis of solar radiation measurements and weather indexes (clearness and diffuses index), for helping designers and engineers interested in solar energy field in Ghardaïa site.

2. Solar data measurements

The measured data of solar radiation used in the present study, were collected by a radiometric station (Fig. 1), with high precision, which was installed at the roof of ARURE. This station has two parts: a fixed one consist of EKO pyranometer for the measurement of global radiant flux on horizontal plan, and a moving part, which is able to track the path of the sun from sunrise to sunset. This part is consist with EKO pyrheliometre, which is pointed at the sun disk for measuring the direct (beam) solar component, received on a normal plan, and other EKO pyranometer, for the measurement of diffuse radiant flux on horizontal plan equipped with a shadow band for hiding the radiant flux coming directly from the sun disk. All solar instantaneous components (diffuse, direct and global) are made with an interval of five minutes for each one.