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Analysis and evaluation of various aspects of solar radiation in the Palestinian territories

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ABSTRACT

This paper aims to evaluate the different models used to analyze different aspects of solar radiation in the Palestinian territories. Calculations of the optimized tilt and surface azimuth angles on monthly, seasonal and yearly basis were conducted, with the genetic algorithm being used for this purpose. Different PV tracking methods were also evaluated, taking into account the annual energy production. The different models used to calculate hourly global solar radiation from the daily data were tested in order to facilitate the selection of the most suitable model in the context of Palestine. The calibration of coefficients for the different regression models that were used for estimating the global solar radiation based on sunshine hours was also performed during the course of this work. These coefficients were calculated using both MATLAB's fitting tool and genetic algorithm. Linear, quadratic and linear–algorithmic regression models displayed almost identical results. Each has a distinctive predominant feature, especially in the context of statistical indicators. They were calculated using both the monthly average daily data and the daily data sets. With regards to the PV panel angles' optimization, it was found that the yearly optimum tilt angle (32.8°) is adjacent to the latitude of the location (31.8°), while the surface azimuth angle is 16°. It was also found that changing the tilt angle of the PV panels quarterly (optimized on seasonally basis) increases energy yield by 3.4% when compared with fixing this tilt angle at yearly optimized value. It was also discovered that changing the surface azimuth angle is more effective during winters than summers.

1. Introduction

Nowadays, rural and urban areas utilize different types of renewable energy sources, with the photovoltaic (PV) system proving the most popular [1–4]. This technology offers clean, environmentally friendly and secure energy source [5–9]. Another important advantage of this technology is both its low maintenance and operating costs, due to its lack of moving components [10–14]. However, the total cost of PV panels and its corresponding technology is still overly expensive, especially when larger power generation is concerned [15–17]. These drawbacks resulted in many studies that try to optimize the PV systems by focusing on maximizing energy production and minimizing cost. Power generation of PV panels is location dependent, and different pre-studies should be conducted for the analysis of solar radiation data.

Palestine is blessed with high sunshine hours throughout the year. In the Palestinian territories, the yearly average daily solar radiation on horizontal surface ranges from about 5.5 kW h/m^2 to about 6 kW h/m^2, while the total annual sunshine hours exceeds 3000 h [5]. These values are relatively high, and especially advantageous in terms of solar water heating and other photovoltaic (PV) applications.

Single axis or double axis tracking systems can be used to maximize the energy production of the PV panels. The idea behind the tracker is to keep following the sun's movement across the sky. However, tracking systems are expensive, requires specialized installation and energy source to operate. Therefore, in many applications, fixed mountings or manually adjusted mountings are used. For such cases, the maximization of energy can be realized via the determination of the optimal values for both the tilt and azimuth angles of the solar panels on annual, seasonal or monthly basis.

To obtain values of the optimum tilt angles of the PV panels, the value of the solar radiation on the tilted surface from global radiation on horizontal surface needs to be calculated. Different models have been suggested and used by many authors for this purpose [10,18–21]. In these studies, the same approach was used to calculate the direct (beam) and the ground reflected solar radiation, while different approaches were used to calculate the diffuse

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