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Potential of One-Axis and Two-Axis Tracking Photovoltaic Systems

A. Al Tarabsheh, I. Etier

Electrical Engineering Department, The Hashemite University, 13115 Zarqa, Jordan

Abstract

This paper explores the potential of solar energy generation in the area of The Hashemite University in Jordan (32.05_N, 36.06_E) by investigating the optimal inclination and azimuth angles of photovoltaic (PV) modules for every hour, day, month, and of the whole year. The object of this study is to maximize the annual energy production of PV systems by tracking the changes of sun's position in the sky north-to-south and east-to-west. Hourly, daily, monthly, and annually global radiation averages are simulated using the METEONORM comprehensive meteorological software and then analyzed using the MATLAB™ software. This study shows that the one-axis PV tracking system about the inclination axis increases the energy yield of 5.87% compared to the fixed surfaces (azimuth angle=0° and inclination angle=30°) , while the one-axis PV tracking system about the azimuth axis increases the energy yield of 20.12% compared to the fixed surfaces. On the other hand, the two-axis PV tracking system about both the inclination and azimuth axes increases the energy yield of 30.82% compared to the fixed surfaces.

Keywords: One- and Two-axis Tracking, METEONORM, Solar Energy

1. Introduction

In order to maximize the energy produced by photovoltaic (PV) and solar collector systems, they have to receive maximum solar irradiation by pointing them at the sun at all the times. This is done by the implementation of sun-trackers. Different configurations of sun-trackers are investigated in [1-3]. In this paper, we calculate the radiation received from the sun using the METEONORM 5.0 software (a comprehensive climatological database for solar energy applications at every location of the globe.)[4] for different azimuth $(-90^o \le \zeta \le 90^o)$ and inclination $(0^o \le \theta \le 90^o)$ angles. The integration of PV generators in buildings, presently in many industrialized countries, led to the use of a large range of different orientations and tilt angles. PV module orientations from east to west, and tilt angles from horizontal to vertical are found in practice [5].

Figure 1 shows a two-axis tracking configuration that rotates about two axes maintaining the surface of the PV module always perpendicular to the sun. Hence, it allows collecting the maximum amount of energy possible. The rotation about the azimuth axis ranges from $\zeta = -90^\circ$ (east) to $\zeta = 90^\circ$ (west) while the inclination angles range from $\theta = 0^\circ$ (horizontal) to $\theta = 90^\circ$ (vertical). In this paper, we investigate only the direct radiation meteorological data rather than the diffused radiation and explore the potential of solar energy generation in the area of the Hashemite University since on sunny days, the direct sunshine accounts for up to 90% of the total solar energy [1,6].

This work is organized as follows; Section 2 introduces the energy yield of fixed $(\zeta = 0^o, \theta = 30^o)$ PV modules which was optimized in [7] assuming the efficiency of the PV modules is 10% as a standard value. Section 3 compares between the tracking about the inclination and the azimuth axes. Section 4 shows the optimal inclination and azimuth angles and the potential of such two-axis tracking PV system.

2. Energy yield of fixed PV-modules

In this section, we start with the find outs of the researchers in [7] by fixing the inclination angle at $\theta = 30^o$ and the azimuth angle at $\zeta = 0^o$ (i.e facing the south) and then compute the energy yield of a 10% efficient PV module from 8 O'clock to 17 O'clock for over the year as shown in Figure 2. The maximum energy yield of the PV module occurs at 12 O'clock on 6th April where the radiation reaches 1100 W/m^2.

* Corresponding author. Tel.: 00962779579095
Fax: 0096253826348; E-mail: atarabsheh@hu.edu.jo

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