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Energy Reports 8 (2022) 175–181

www.elsevier.com/locate/energy

2022 7th International Conference on Green Energy Technologies, ICGET 2022 July 28–30,
2022, Frankfurt, Germany

Improved Utilization of Solar Energy Using Estimated Optimal Tilt Factor and Trackers

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Received 19 October 2022; accepted 22 October 2022

Available online 7 November 2022

Abstract

This work contributes toward improving the utilization of solar energy. The problem with some of the existing tracking techniques for solar photovoltaic panels is that they have not been put to their best use. In this study, the objective is to optimally use tracking techniques to improve solar energy utilization. The study begins with the solar irradiance data and then proceeds with the definition and mathematical calculations related to the tilt factor. Monthly optimized tilt angles that maximize tilt factor for beam radiation are estimated through mathematical modeling. The net tilt factor is assessed to calculate the tilted global irradiance on tilted PV panels. Different solar tracking techniques like horizontal axis (continuous, daily, weekly and monthly) adjustment, vertical axis continuous adjustment and two-axis are considered to evaluate the response of the 1 kW PV array. The response is evaluated in terms of energy yield using Hybrid Optimization of Multiple Energy Resources (HOMER). The results show that the two-axis tracking system yields the best electrical energy production (2100 kWh/yr), which is 21.28% more than the yield of horizontal axis monthly adjustment (1653 kWh/yr). The extended results further show that if the horizontal axis monthly adjustments are being made using the estimated optimal angles, the energy yield increased from 1653 kWh/yr to 1792 kWh/yr, an increase of 8.40% compared to the HOMER-based calculations. The optimal angles and tilt factor calculations were performed using MATLAB. An additional advantage associated with horizontal axis monthly adjustment is that its implementation is easy, and the associated cost is less than the other tracking techniques. The results obtained can be used further to design PV-based microgrids efficiently.

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Peer-review under responsibility of the scientific committee of the 7th International Conference on Green Energy Technologies, ICGET, 2022.

Keywords: Solar irradiance; Solar collector; Solar energy; Tilt factor; Solar tracking systems

1. Introduction

In response to carbon neutrality by 2050, more than 110 countries have pledged to take necessary and immediate steps to reduce carbon emissions [1]. The new phase for the power and energy sector is to switch toward renewable

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<https://doi.org/10.1016/j.energy.2022.103992>

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