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Bifacial Gain Assessment of Bifacial PV Panels: A Long Term Field Study

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Abstract:

In recent years, bifacial photovoltaic technology has gained increasing attention in the solar energy industry due to its potential for higher energy generation compared to traditional monofacial PV panels. Bifacial PV modules can capture light from both the front and rear surfaces, allowing them to harness more of the available solar irradiance and potentially increase overall system efficiency. However, accurately assessing the bifacial gain, or the additional energy generated by the rear side of the module, remains a challenge for system designers and researchers. This research paper presents a practical approach to evaluating the bifacial gain of PV panels under real-world conditions of one-year field study. Yearly solar irradiance and ambient temperature is logged at Hyderabad from September 2023 to August 2024. For the monofacial panel, the front irradiance is calculated. For the bifacial panel, both the front and rear irradiance are evaluated. The total irradiance for the bifacial panel is then calculated based on the front and rear irradiance measurements. Finally, the bifacial gain is calculated by comparing the bifacial yield with the monofacial energy yield. This study observed bifacial gains of up to 19.24%.

Keywords: Bifacial solar panels, bifacial gain, albedo, energy yield, real-world testing

Introduction

The global energy landscape is undergoing a transformative shift, driven by the urgent need for sustainable and clean energy sources. Solar photovoltaic technology has emerged as a leading contender in this transition, offering a promising pathway towards decarbonizing electricity generation [1]. Traditional monofacial solar panels, which absorb sunlight only from their front surface, have been the mainstay of the PV industry for decades [2]. However, recent advancements in PV technology have led to the development of bifacial solar panels, capable of capturing light from both their front and rear surfaces. This innovative design unlocks the potential for significantly increased energy yields compared to their monofacial counterparts, making bifacial technology a compelling prospect for maximizing solar energy harvesting [3]. The monofacial and bifacial technology comparison is shown in Fig. 1.

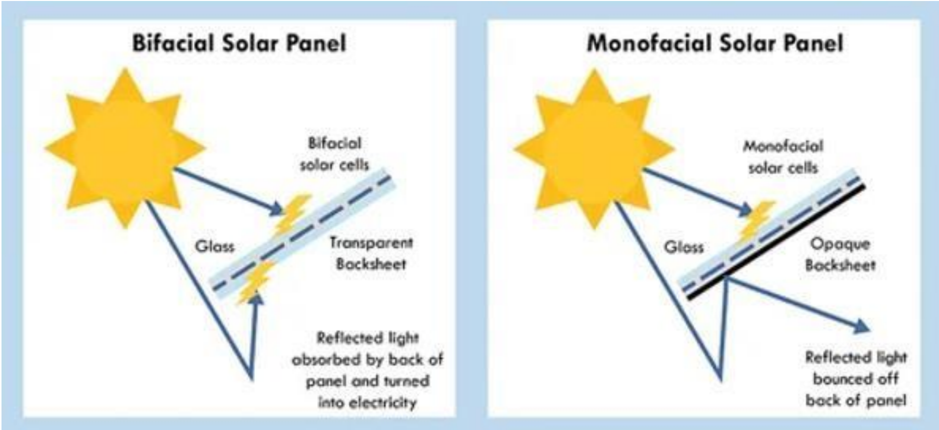

Fig. 1 Technology Comparison

Bifacial PV modules leverage the albedo effect, which refers to the reflection of sunlight from the ground or surrounding surfaces onto the rear side of the panel. This additional light capture contributes to the overall energy generation of the module, resulting in a performance boost known as bifacial gain [4][5]. The magnitude of this gain depends on several factors, including the reflectivity of the surrounding environment (albedo), the height of the panel above the ground, the mounting configuration, and the specific design of the bifacial module itself. Higher albedo values, typically associated with lighter-colored surfaces like snow, sand, or white roofs, lead to greater rear-side irradiance and thus higher bifacial gain. Similarly, elevating the panels allows for more light reflection onto the rear surface, further enhancing energy capture [6][7].

The potential for increased energy production offered by bifacial technology has spurred significant interest from researchers, manufacturers, and project developers alike. Numerous studies have investigated the performance characteristics of bifacial PV modules under various conditions, demonstrating the potential for substantial energy yield improvements compared to monofacial systems [8][9]. However, accurately quantifying and predicting bifacial gain remains a complex undertaking. The interplay of environmental factors, module properties, and system design parameters necessitates a comprehensive approach to evaluating the true potential of bifacial technology. The comparison of monofacial and bifacial technologies are presented in Fig. 1

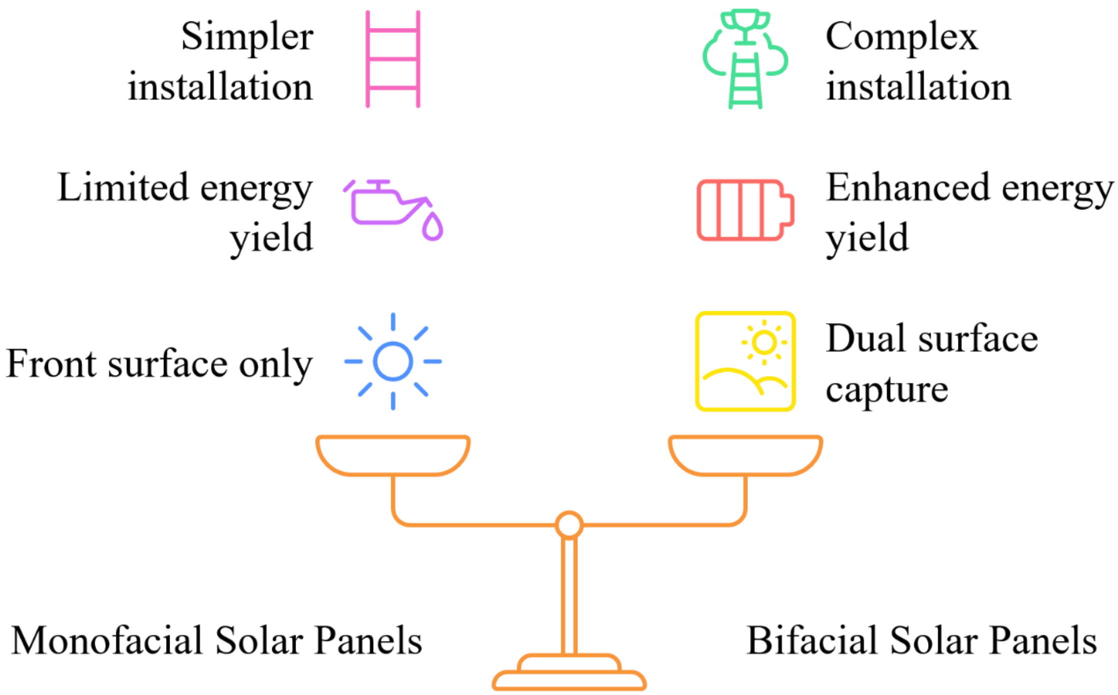

Fig. 1 Comparison of Monofacial and Bifacial Solar Panel Technologies

While theoretical models and simulations provide valuable insights into the behavior of bifacial PV systems, real-world testing and analysis are crucial for validating these models and understanding the practical implications of deploying bifacial technology in different environments. Field studies conducted under diverse climatic conditions and installation scenarios provide essential data for optimizing system design and maximizing energy output. This research paper focuses on a practical approach to assessing bifacial gain, employing real- world testing of monofacial and bifacial PV panels in both rooftop and ground installations [10][11].

The primary objective of this study is to evaluate the bifacial gain of PV panels under realistic operating conditions. By comparing the performance of bifacial modules to that of conventional monofacial modules, we aim to quantify the additional energy generation achievable through bifacial technology. This practical assessment will provide valuable insights for system designers, project developers, and policymakers seeking to optimize the deployment of bifacial PV systems and maximize the return on investment in solar energy projects. This research paper presents a practical approach to evaluating the bifacial gain of PV panels under real-world conditions of one-year field study. Yearly solar irradiance and ambient temperature is logged at Hyderabad from September 2023 to August 2024. For the monofacial panel, the front irradiance is calculated. For the bifacial panel, both the front and rear irradiance are evaluated. The total irradiance for the bifacial panel is then calculated based on the front and rear irradiance measurements. Finally, the bifacial gain is calculated by comparing the bifacial yield with the monofacial energy yield. This study observed bifacial gains of up to 20%.

Bifacial Gain Assessment Methodology

This study employs a practical, experimental approach to assess the bifacial gain of photovoltaic panels. The methodology involves comparing the performance of monofacial and bifacial PV panels by considering yearly real time conditions at Hyderabad. For this yearly solar irradiance and ambient temperature is logged at Hyderabad from September 2023 to August 2024. The logged is implemented on a 3 kW solar system and the energy yield (Y) is calculated for both monofacial and bifacial solar panels. The bifacial gain (BG) is calculated using the following equation.

$$Bifacial\ Gain\ (BG)\ \% = \left(\frac{Y_{Bifacial}}{Y_{Monofacial}} - 1\right) \times 100 \qquad (1)$$

Results and Discussions:

This one-year field study, conducted in Hyderabad from September 2023 to August 2024, yielded valuable data on the performance of monofacial and bifacial PV panels. The collected data includes yearly solar irradiance and ambient temperature measurements. For the monofacial panel, only front irradiance was measured as shown in Fig. 3, while for the bifacial panel, both front and rear irradiance were recorded as shown in Fig. 4. The total irradiance for the bifacial panel was calculated as the sum of the front and rear irradiance measurements.

Fig. 3 Monofacial Solar Irradiance Measurement (Front)

(a) Front (b) Rear

Fig. 4 Bifacial Solar Irradiance Measurement

The bifacial gain was then determined by comparing the energy yield of the bifacial panel to that of the monofacial panel. The logged is implemented on a 3 kW solar system and the energy yield (Y) is calculated for both monofacial and bifacial solar panels. The monofacial (front side) solar irradiance and bifacial (front & rear side) solar irradiance is presented in Fig. 5 and Fig. 6 respectively.

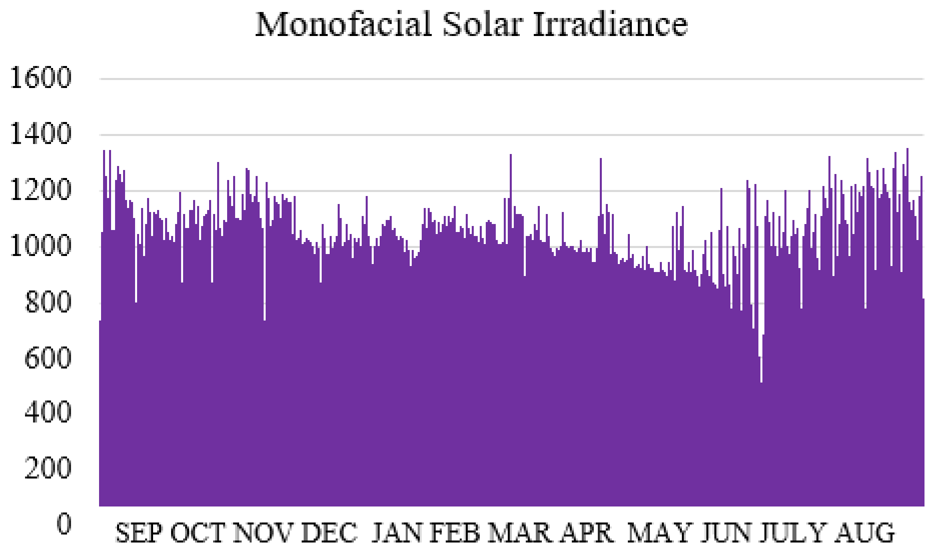

Fig. 5 Monofacial Solar Irradiance

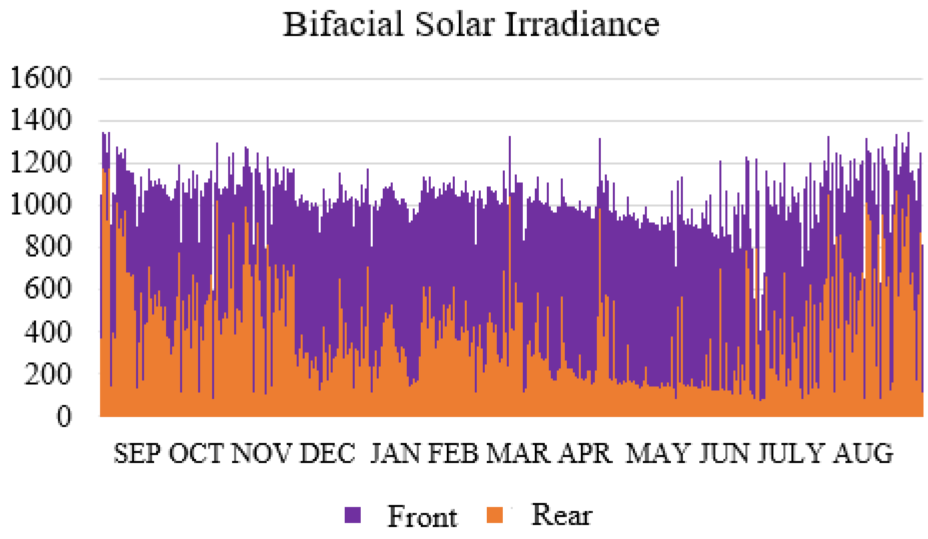

Fig. 6 Bifacial Solar Irradiance

The yearly average power of Monofacial is 3222.37 W and for Bifacial the yearly average power is 3842.59 W as show in Fig. 7. The study observed bifacial gains of up to 19.24%.

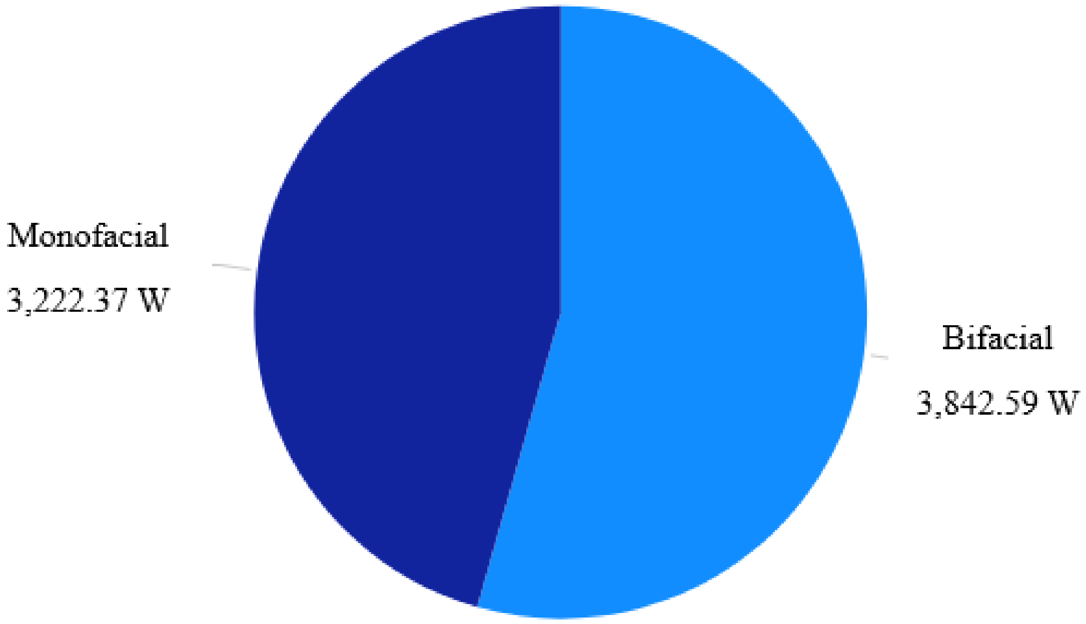

Fig. 7 Yearly Average Power

The observed bifacial gains of up to 19.24% in this study are consistent with findings reported in other real-world studies of bifacial PV systems. These results highlight the potential of bifacial technology to significantly enhance energy generation compared to conventional monofacial panels.

Conclusion:

This research investigated the performance of bifacial PV panels under real-world conditions through a one-year field study in Hyderabad. By comparing the energy yield of bifacial panels to that of conventional monofacial panels, the study quantified the bifacial gain. The study observed bifacial gains of up to 19.24%. These findings provide valuable insights for optimizing the design and deployment of bifacial PV systems. The observed bifacial gains of up to 19.24% in this study are consistent with findings reported in other real-world studies of bifacial PV systems. These results highlight the potential of bifacial technology to significantly enhance energy generation compared to conventional monofacial panels.

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