Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

An Experimental Study on the Effect of Reflective Surface Variations on the Power Performance and Efficiency of Bifacial Solar Panel

Lastri Andini Gunawan[1], Jakariya[1*], Ahmad Deni Mulyadi[1], Doane Puri Mustika[1], Dibyo Setiawan[2], Agus Subeno[3]

[1] *Department of Energy Conversion Engineering, Politeknik Negeri Bandung, West Java, 40559, Indonesia.*
[2] *Department of Mechanical Engineering, Politeknik Negeri Bandung, West Java, 40559, Indonesia.*
[3] *Department of Mechanical Engineering, Institut Sains dan Teknologi Al-Kamal, Jakarta, 11520, Indonesia.*
* Corresponding Author. E-mail : jakariya@polban.ac.id

Article information - : Received : 13-04-2026; Revised : 23-05-2026; Accepted : 25-05-2026

Abstract

The increasing demand for clean electrical energy in Indonesia highlights the need to optimize solar power generation technologies. Bifacial photovoltaic (PV) panels offer higher energy yield by utilizing solar radiation from both front and rear sides; however, their performance is strongly influenced by reflective properties of the surface beneath the panel. This study aims to analyze the effect of reflective surface variations with different albedo values on the power output and efficiency of bifacial solar panels under tropical rainy season conditions. An experimental method was employed using three identical bifacial PV modules (545 Wp) installed above asphalt, paving block, and white-painted surfaces. The modules were installed with a tilt angle of 8°, an azimuth angle of 0° (facing north), and a height of 60 cm above the surface. Measurements of solar irradiance, voltage, and current were conducted at irradiance levels ranging from 203 to 1001 W/m^2. Data were collected three days with same conditions and parameter in November 2024 during the period time from 09:00 to 15:00. The results show that to enhance rear-side irradiance, as indicated by the increase in output power observed in this study, leading to increased output power and efficiency. The white-painted surface produced the highest performance, achieving an average power increase of approximately 9.6% and a maximum efficiency of 16.3% compared to asphalt and paving block surfaces. These findings indicate that high-albedo surfaces are an effective solution for improving bifacial solar panel performance, particularly in wet tropical climates such as Bandung, Indonesia.

Keywords: surface albedo; reflective surface; power output; efficiency; photovoltaic system.

1. Introduction

The demand for electrical energy based on clean energy sources continues to increase annually in line with population growth, as well as economic and industrial activities in Indonesia [1]. According to data from the Ministry of Energy and Mineral Resources, Indonesia has a very high potential for solar energy, with an estimated generation potential of 4.8 kWh/m^2 or equivalent to 112,000 GWp [2]. Solar Power Plants (PLTS) that apply photovoltaic (PV) technology represent one of the strategic alternatives to support Indonesia's energy transition toward clean energy sources [3], [4]. PV technology plays a crucial role in converting solar radiation into electrical energy and serves as a core component of PLTS systems. The performance of PV modules is strongly influenced by the development of solar panel technology; therefore, continuous innovation in PV technology has significant potential to enhance energy generation efficiency [5].

Recent technological developments have increasingly focused on the application of bifacial solar panels, which are considered superior to conventional monofacial panels. Bifacial solar panels are capable of absorbing solar radiation not only from the front surface but also from reflected sunlight on surrounding surfaces through the rear side of the panel [6]. In addition, bifacial panels can capture sunlight from both front and rear sides, thereby offering the potential for higher efficiency compared to monofacial panels. One of the main factors affecting performance of bifacial panels is albedo value, which represents the reflectance level of surrounding surface [7].

Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

Related research has previously been conducted under the title analysis of solar cell panel angle on output power and efficiency. This study examined the performance of solar panels under variations in tilt angles of 0°, 8°, and 16°. The results showed that tilt angle influences the performance of solar panels, where higher tilt angles generally improve energy capture under certain conditions [8].

Another study investigated the effect of solar panel capacity and tilt angle on the performance of a 12 V ff-grid PLTS system. This research analysed the influence of solar panel capacity and tilt angle on system performance in terms of panel efficiency, maximum power point tracking (MPPT) efficiency, overall system efficiency, and battery capacity stability in supplying the load. The experimental tests used monocrystalline solar panels with capacities ranging from 100 to 400 Wp, tilt angle variations from 0° to 40°, and a constant load of 400 W. Although this study also evaluated performance based on tilt angle variations, key differences lie in the absence of bifacial solar panels and the use of different panel capacities with a 12 V system configuration [9].

Other research has also discussed the performance of solar panel surfaces with temperature as the dependent variable across different types of solar cells. In this study, to determine the effect of temperature and to compare two brands of solar panels, measurements were conducted at a light intensity of 1225 and a temperature of 41.1°C. The measured parameters included voltage, current, output power, and input power for each panel. The results indicated that solar panel brand A produced a voltage of 20.3 V, while brand B produced 3.5 V. The current generated by brand A was 1.17 A, whereas brand B generated 1.68 A. The output power of brand A was 19.21 W, while brand B produced 16.94 W. Meanwhile, the input power recorded for brand A was 183 W and for brand B was 226 W. This study discussed performance differences based on panel type and brand in relation to surface temperature [10].

Based on the above discussion, this study aims to analyse the effect of variations in reflective surface types with different albedo values on the performance efficiency of bifacial solar panels under rainy season conditions, particularly in terms of power output and efficiency performance. The research was conducted by comparing three types of surfaces asphalt, paving blocks, and white-painted surfaces to examine the relationship between the albedo level of each surface and the efficiency of bifacial solar panels. The results of this study are expected to contribute scientifically to the development and optimization of bifacial solar panel technology, especially for applications in tropical environments such as the City of Bandung, West Java Province.

The novelty of this study lies in the experimental investigation of bifacial PV performance under tropical rainy season conditions with high irradiance variability, combined with a quantitative analysis of the relationship between ground surface albedo and the resulting power gain using real-field installation scenarios.

2. Experimental Methods

2.1. Research Design

This study employs an experimental research method with a quantitative approach to evaluate the effect of reflective surface variations with different albedo values on the power performance and efficiency of bifacial PV panels, as seen in Figure 1. The experiment was conducted through direct field measurements under real environmental conditions during the rainy season.

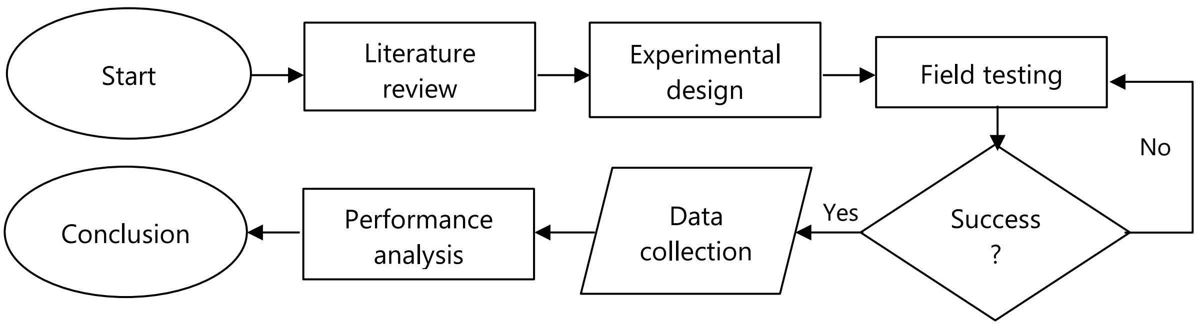

Figure 1. Flowchart research

Konversi Energi dan Manufaktur
P-ISSN : 2339-2029
E-ISSN : 2622-5565
Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

2.2. Experimental Setup

The experiment was carried out in an open outdoor area located in Bandung, Indonesia, which represents a tropical climate. Three monocrystalline bifacial PV modules with a rated capacity of 545 Wp were used in the experiment (see Figures 2 and 3). Prior to installation, all modules were inspected and tested under similar environmental conditions to ensure comparable baseline performance, considering possible manufacturing tolerances [11]. Each panel was installed above a different type of surface, namely asphalt, paving block, and white-painted surface, to represent low, medium, and high albedo conditions, respectively (Figure 4). The three surface types (asphalt, paving block, and white-painted surface) were selected to represent low, medium, and high albedo conditions, respectively [12]. The albedo values were adopted from literature, where asphalt ranges from approximately 0.05–0.20, paving block 0.25–0.70, and white-painted surfaces 0.50–0.90 [13]. However, it should be noted that the albedo of each surface was not directly measured in this study due to instrumentation limitations. The selected surface types are commonly recognized to have significantly different reflectivity characteristics and thus are assumed to provide representative variations in albedo under typical field conditions [14]. Therefore, the analysis focuses on comparative performance differences rather than absolute albedo quantification.

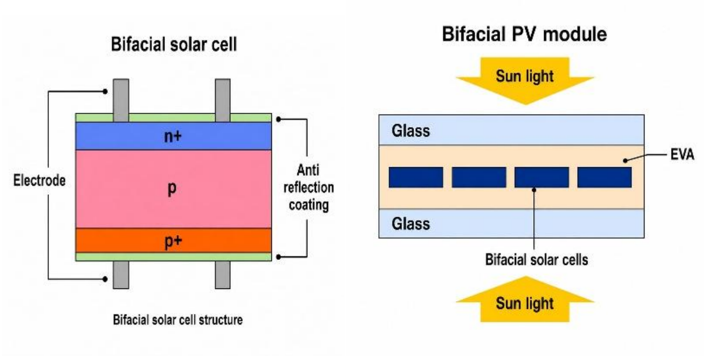

Figure 2. Bifacial solar cell structure

All PV modules were mounted at a fixed tilt angle of 8° and oriented northward (0° azimuth) to ensure uniform solar exposure. The vertical distance between the panel and ground surface was maintained at approximately 60 cm to allow sufficient rear-side irradiance reception [15].

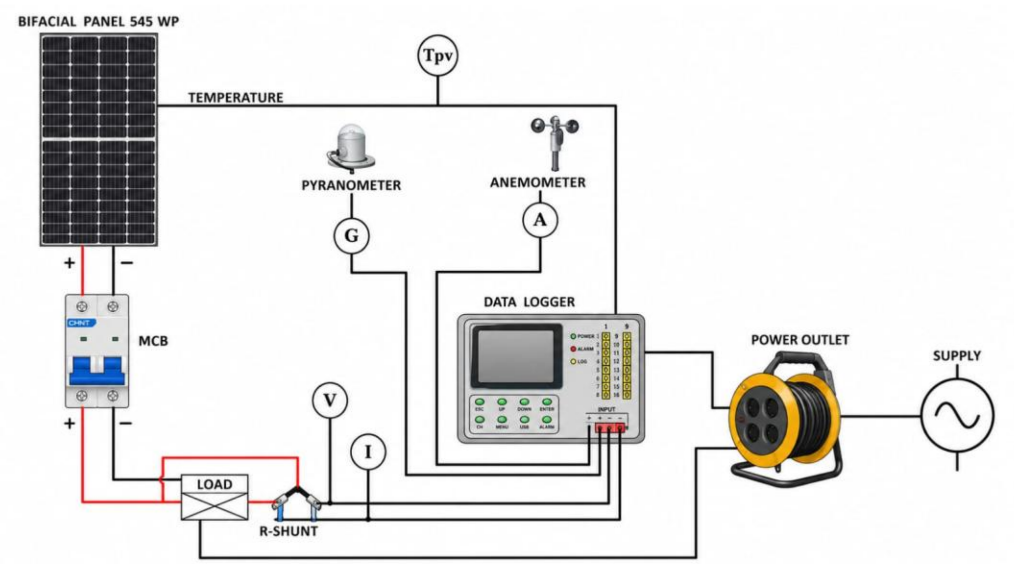

Figure 3. Block diagram system solar panel

Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

2.3. Data Collection

Measurements were conducted over a period of three days in November, coinciding with the rainy season. The selected days were chosen based on relatively comparable weather conditions to minimize extreme variability in solar irradiance. Data acquisition was performed between 09:00 and 15:00 local time, with a recording interval of 30 minutes [16]. The measured parameters included:

a. Solar irradiance (W/m²), measured using a calibrated pyranometer;
b. Output voltage (V);
c. Output current (A).

It should be noted that rear-side irradiance was not directly measured in this study due to instrumentation limitations. Instead, its contribution was indirectly evaluated based on differences in electrical output under varying reflective surface conditions [17].

All sensors were connected to a data logger for synchronized and continuous data recording. Although temperature and wind speed sensors were installed, only irradiance, voltage, and current data were used for analysis in this study [18].

2.4. Performance Evaluation

The electrical performance of each bifacial PV panel was evaluated through calculation of output power and conversion efficiency. Output power was determined using measured voltage and current values, while input power was calculated based on measured irradiance and the effective panel area [19].

The efficiency of the PV module was calculated as the ratio between output power and input solar power, expressed as a percentage. Performance comparisons were conducted at various irradiance levels ranging from 203 W/m² to 1001 W/m² to assess the influence of surface albedo under different solar conditions [20].

(a) (b) (c)

Figure 4. Testing on the variation surface (a) asphalt, (b) paving block, and (c) white paint

Performance evaluation was conducted using the following equations [8]. The input, output power and the efficiency of the solar panel were calculated using equations (1)-(3) [21].

$$Pin = G\ x\ AC \tag{1}$$

where Pin is input power, resulting from solar irradiance (W), G is solar irradiance intensity (W/m^2), and A is surface area of the solar panel (m^2).

$$Pout = V\ x\ I \tag{2}$$

where Pout is the power generated by the solar panel (W), V is the voltage of the solar panel (V), and I is the current of the solar panel (A).

Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

$$\eta Panel = \frac{Pout}{Pin\ total\ (G_{\_Front}+G_{Rear})} x\ 100\% \quad (3)$$

For bifacial PV systems, the total incident energy ideally includes both front and rear irradiance contributions; therefore, the calculated efficiency may be slightly overestimated.

2.5. Data Analysis

The collected data in Table 1 were processed and analyzed to compare the power output and efficiency of bifacial PV panels installed above different reflective surfaces [22]. The analysis focused on identifying trends and performance differences attributable to surface albedo variations. Results were presented in graphical and tabular forms to clearly illustrate the relationship between irradiance intensity, power output, efficiency, and surface reflectivity [23].

To reduce the influence of weather fluctuations during the rainy season, performance comparisons were conducted at similar irradiance levels across all surface types. This approach allows for a more consistent evaluation of the effect of surface reflectivity, independent of transient changes in weather conditions such as cloud cover.

Table 1. Measurement results of voltage and current on different surface types

Light intensity (W/m^2)	Asphalt		Paving block		White paint	
	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)
203	12.4	3.1	12.9	3.2	13.1	3.3
300	15.1	3.8	16.3	4.0	16.7	4.2
402	19.2	4.7	19.5	4.9	20.3	5.1
501	22.2	5.6	23.2	5.8	23.8	5.9
605	26.6	6.5	26.8	6.7	27.5	6.9
700	31.6	7.9	33.0	8.1	34.2	8.3
800	35.6	8.8	36.2	8.9	36.9	9.1
902	37	9.2	37.5	9.2	38.4	9.4
1001	37.1	9.1	37.3	9.2	38.5	9.4

3. Results and Discussion

This chapter presents the results of the calculations of input power (Pin), output power (Pout), and efficiency based on variations in light intensity and surface type. The data presented in Table 2 were obtained from measurements and calculations conducted during the experimental testing [24]. These results are used to analyze the effect of light intensity to ensure the reliability of results. Statistical analysis was performed by calculating the average values and standard deviations of the measured parameters over the experimental period on system performance for different surface types, that is asphalt, paving blocks, and white-painted surfaces.

Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

Table 2. Calculation results of Pin, Pout, and efficiency

Light intensity (W/m^2)	Input power (W)	Asphalt		Paving block		White paint	
		Output power (W)	Efficiency (%)	Output power (W)	Efficiency (%)	Output power (W)	Efficiency (%)
203	524.8	38.4	7.4	41.3	7.9	43.2	8.3
301	776.2	57.4	7.4	65.2	8.4	70.1	9
402	1040.4	90.2	8.7	95.6	9.2	103.5	10
501	1293.4	124.3	9.6	134.6	10.4	140.4	10.9
605	1562.7	172.9	11.1	179.6	11.5	189.8	12.2
701	1807	249.6	13.8	267.3	14.8	283.9	15.7
800	2064.4	313.3	15.2	322.2	15.6	335.8	16.3
902	2327.2	340.4	14.6	345	14.8	361	15.5
1001	2584.6	337.6	13.1	343.2	13.3	361.9	14

The results indicate that output power increases proportionally with light intensity for all surface types. Among the tested surfaces, the white-painted surface consistently produced the highest output power and efficiency across all irradiance levels. Any minor performance differences due to manufacturing variations are considered negligible compared to the observed influence of surface reflectivity. This indicates that the difference in power output is primarily influenced by the reflective properties of the surface once. Though the albedo values were not directly measured, the consistent increase in power output observed on brighter surfaces supports the expected influence of higher reflectivity. The average increase in output power for the white-painted surface compared to asphalt was approximately 9.6%.

This improvement is likely attributed to the higher albedo of the white-painted surface, which enhances diffuse reflection and increases reflected irradiance reaching the rear side of the bifacial module. Although the albedo values were not directly measured, the consistent increase in power output observed on brighter surfaces supports the expected influence of higher reflectivity. This condition enhances diffuse reflection and increases the amount of reflected irradiance reaching the rear side of the bifacial module. The additional rear-side contribution plays a significant role in improving the overall energy conversion performance.

Furthermore, the installation configuration, including a tilt angle of 8° and a module height of 60 cm, contributes to this effect by increasing the view factor between the ground surface and the rear side of panel, thereby allowing more reflected radiation to be captured.

The observed bifacial gain in this study is consistent with values reported in previous studies, which typically range between 5% and 20%, depending on surface conditions and installation parameters. These results demonstrate that surface albedo plays a significant role in enhancing bifacial PV performance under tropical conditions.

3.1. Effect of Surface Variation on Output Power

Referring to the graph of surface variation versus output power shown in Figure 5 at a light intensity of 1001 W/m^2, it can be observed that the type of surface has a significant effect on the magnitude of the generated output power. Based on the graph, the white-painted surface produced the highest output power of 361.9 W, compared to 343.2 W for the paving block surface and 337.6 W for the asphalt surface. The output power obtained from the paving block surface falls within an intermediate range, while the asphalt surface yielded the lowest output power [25]. These differences are attributed to the characteristics of each surface in reflecting and absorbing solar radiation energy. Surfaces with lighter colors, such as white-painted surfaces, exhibit higher reflectivity, resulting in more optimal light intensity received by the solar panel and consequently higher output power compared to darker surfaces.

Konversi Energi dan Manufaktur
P-ISSN : 2339-2029
E-ISSN : 2622-5565
Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
DOI: https://doi.org/10.21009/JKEM.11.2.4

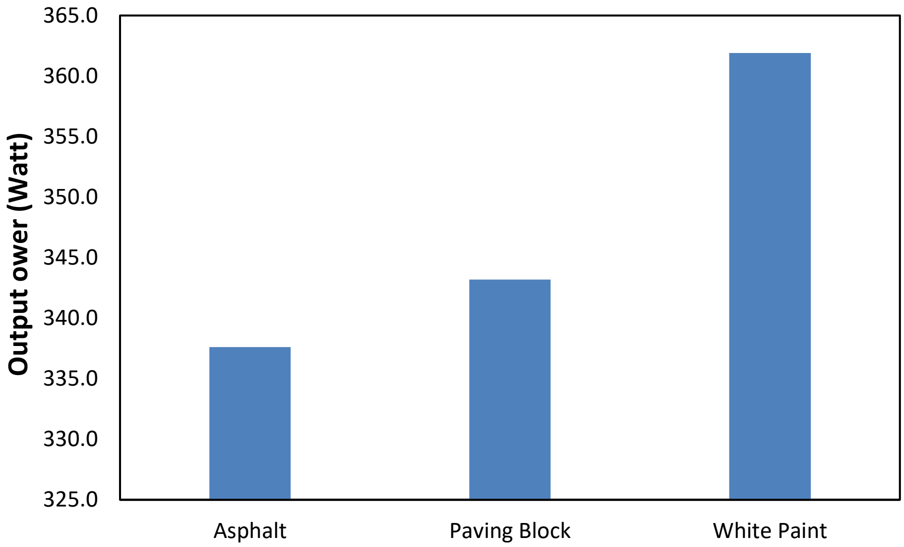

Figure 5. Effect of surface type on output power

3.2. Effect of Irradiance on Power Output

Based on the graph illustrating the relationship between light intensity and output power shown in Figure 6, a direct correlation between light intensity (W/m²) and the resulting output power (Ws) can be observed. In general, an increase in light intensity leads to an increase in output power for all surface types, such as asphalt, paving blocks, and white-painted surfaces. At low to moderate light intensity levels, the increase in output power is relatively significant; however, at higher intensities, the rate of power increase tends to slow down and approaches a maximum condition [8].

Furthermore, the graph indicates that the white-painted surface consistently produces the highest output power at each level of light intensity, followed by the paving block surface and the asphalt surface. The increase in light intensity results in a more pronounced increase in output power, particularly when using the white-painted surface. This surface exhibits a high albedo value (0.50–0.90), enabling it to reflect more light toward the rear side of the panel. This finding demonstrates that surface characteristics, especially reflectivity levels, play an important role in influencing the amount of solar radiation energy received by the panel, thereby directly affecting the magnitude of the generated output power.

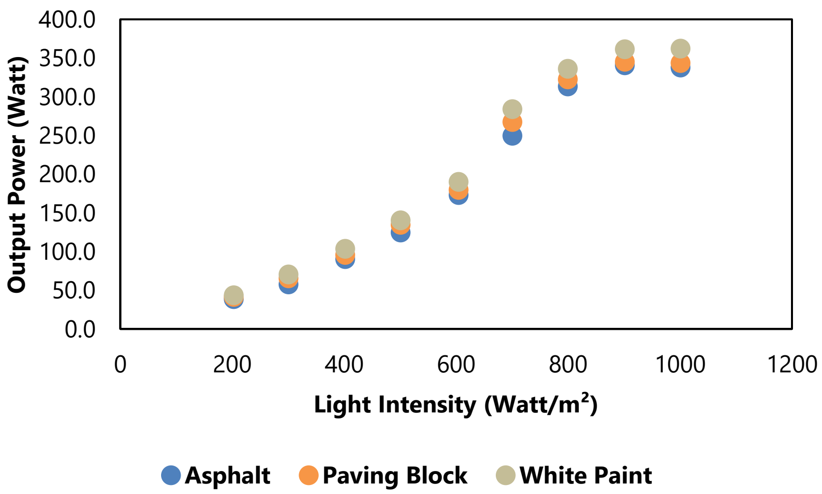

Figure 6. Effect of light intensity on output power

Konversi Energi dan Manufaktur
Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem
P-ISSN : 2339-2029
E-ISSN : 2622-5565
DOI: https://doi.org/10.21009/JKEM.11.2.4

3.3. Effect of Light Intensity on the Efficiency of Bifacial Solar Panels

The graph illustrating the relationship between light intensity and efficiency in Figure 7 shows that the efficiency of bifacial solar panels generally increases as the received light intensity increases. Within the low to moderate light intensity range (approximately 200–600 W/m^2), the efficiency gradually increases across all surface types: asphalt, paving blocks, and white-painted surfaces [25]. This trend indicates that the panels are still operating under optimal conditions in responding to increased solar radiation energy.

At higher light intensity levels (approximately 700–800 W/m^2), the panel efficiency reaches its maximum value, particularly when installed above a white-painted surface. Beyond this intensity range, the efficiency tends to decrease at light intensities of 900–1000 W/m^2. This decline suggests the presence of performance limitations, which are likely caused by an increase in the panel surface temperature due to high light intensity exposure, thereby affecting the energy conversion performance.

Moreover, the graph also demonstrates differences in efficiency based on surface type. The white-painted surface consistently yields the highest efficiency compared to paving blocks and asphalt across almost all light intensity variations. This behavior is attributed to the higher albedo value of the white-painted surface, which enables greater reflection of solar radiation toward the rear side of the bifacial panel. Therefore, it can be concluded that the combination of optimal light intensity and surface types with high reflectivity plays a crucial role in enhancing the efficiency of bifacial solar panels.

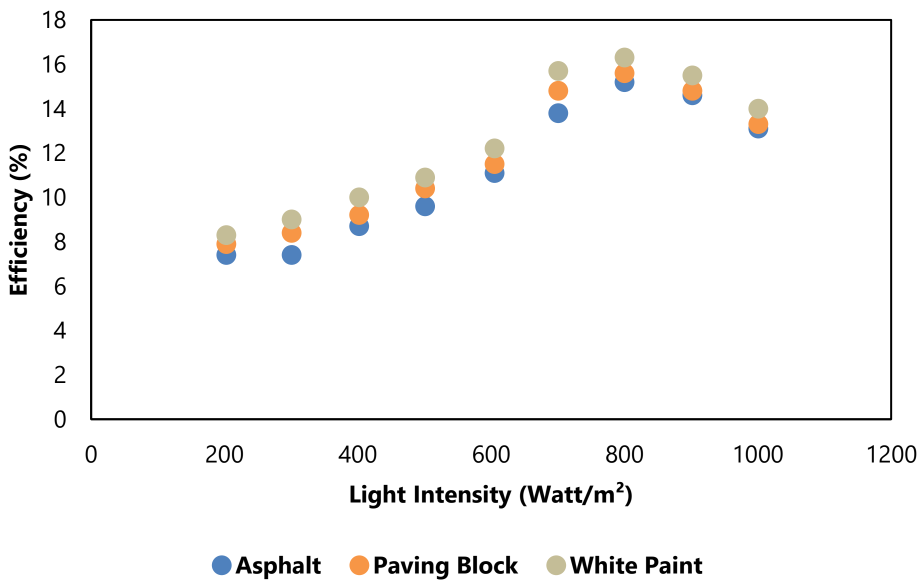

Figure 7. Effect of light intensity on efficiency

4. Conclusion

Variations in reflective surfaces (albedo) beneath bifacial solar panels have been proven to have a significant effect on panel output power and efficiency. Higher surface albedo values result in greater light reflection that can be utilized by the rear side of the panel, thereby increasing the output power.

At light intensities up to 1001 W/m^2, the white-painted surface produced the highest power output and efficiency compared to paving blocks and asphalt, with an average power increase of up to approximately 9.6% and a maximum efficiency of 16.3%. Therefore, the use of high-albedo surfaces such as white-painted surfaces is recommended as an optimal solution to enhance the performance of bifacial solar panels, particularly under tropical climate conditions such as those in the City of Bandung.

5. Acknowledgments

-

6. References

[1] Suwarti, Wahyono, and B. Prasetiyo, "Analisis pengaruh intensitas matahari, suhu permukaan & sudut pengarah terhadap kinerja panel surya," *EKSERGI: Jurnal Teknik Energi*, vol. 14, no. 3, pp. 78–85, 2018, doi: 10.32497/eksergi.v14i3.1373.

[2] A. F. Nurhasanah, Sudarti, and Yushardi, "Kajian Perubahan Iklim Terhadap Efisiensi Panel Surya," *OPTIKA: Jurnal Pendidikan Fisika*, vol. 7, no. 2, pp. 366–375, 2023, doi: 10.37478/optika.v7i2.3284.

[3] D. Hamdani, K. Subagiada, and L. Subagiyo, "Analisis kinerja solar photovoltaic system (SPS) berdasarkan tinjauan efisiensi energi dan eksergi," *Jurnal Material dan Energi Indonesia*, vol. 1, no. 2, pp. 84-92, 2011.

[4] S. Soewono and Jakariya, "Optimasi perbaikan faktor daya dengan pemasangan DC Reaktor akan mereduksi harmonisa di inverter motor pendingin air industri," *Jurnal Ilmiah Sutet*, vol. 9, no. 2, pp. 90–111, 2019, doi: 10.33322/sutet.v9i2.562.

[5] P. Siagian, H. Alam, and R. A. Frasasti, "Efektifitas konsentrator cahaya aluminium foil terhadap kenaikan intensitas cahaya dan temperatur permukaan solar cell," in *Senashtek 2024*, pp. 55–63, 2024.

[6] N. R-. Lyngskær, M. Ribaconka, M. Po, A. Thorseth, S. Thorsteinsson, C. D-. Hansen, and M. L. Jakobse, "The effect of spectral albedo in bifacial photovoltaic performance," vol. 231, pp. 921–935, 2022, doi: 10.1016/j.solener.2021.12.023.

[7] E. M. Tonita, C. E. Valdivia, A. C. J. Russell, M. M-. Szewczyk, M. I. Bertoni, and K. Hinzer "Quantifying spectral albedo effects on bifacial photovoltaic module measurements and system model predictions," *Progress in Photovoltaics: Research and Applications*, vol. 32, pp. 468–480, 2024, doi: 10.1002/pip.3789.

[8] Y. H. Anoi, A. Yani, and Yunanri, "Analisis sudut panel solar cell terhadap daya output dan efisiensi yang dihasilkan," *TURBO: Jurnal Program Studi Teknik Mesin UM Metro*, vol. 8, no. 2, pp. 177–182, 2019, doi: 10.24127/trb.v8i2.1051.

[9] R. L. Yorlanda, M. D. Alfarizi, A. Apriana, Tahdid, A. Manggala, and Zurohaina, "Pengaruh kapasitas panel surya dan sudut kemiringan terhadap kinerja sistem PLTS off grid 12 volt," *Chemical Engineering Journal Storage*, vol. 5, no. 5, pp. 729–743, 2025, doi: 10.29103/cejs.v5i05.23905.

[10] P. Harahap, "Pengaruh temperatur permukaan panel surya terhadap daya yang dihasilkan dari berbagai jenis sel surya," *RELE (Rekayasa Elektrikal dan Energi): Jurnal Teknik Elektro*, vol. 2, no. 2, pp. 73–80, 2020, doi: 10.30596/rele.v2i2.4420.

[11] E. Yusuf, Jakariya, and A. Subeno, "Planning for the development of a 40 kWp off-grid centralized solar power plant (SPP) on Insumbabi Island," *Jurnal Konversi Energi dan Manufaktur*, vol. 10, no. 2, pp. 127–139, 2025, doi: 10.21009/jkem.10.2.4.

[12] V. d'Alessandro, S. Daliento, M. Dhimish, and P. Guerriero, "Albedo reflection modeling in bifacial photovoltaic modules," *Solar*, vol 4, no. 4, pp. 660-673, 2024. doi: 10.3390/solar4040031.

[13] Y. Kotak, M. S. Gul, T. Muneer, and S. M. Ivanova, "Investigating the impact of ground albedo on the performance of PV systems," in *CIBSE Technical Symposium*, pp. 1–16, 2015.

[14] H. Kim, Y. Gao, E. Moran, A. Howle, S. McSherry, S. Cira, and A. Lenert, "High albedo daytime radiative cooling for enhanced bifacial PV performance," *Nanophotonics*, vol. 13, no. 5, pp. 621–627, 2024, doi: 10.1515/nanoph-2023-0611.

Konversi Energi dan Manufaktur

P-ISSN : 2339-2029
E-ISSN : 2622-5565

Jurnal Konversi Energi dan Manufaktur
Volume 11 Number 2 – July 2026 Page 130-139
Website : http://journal.unj.ac.id/unj/index.php/jkem DOI: https://doi.org/10.21009/JKEM.11.2.4

[15] R. A. Rahman, N. Plamonia, D. Setiawan, and R. D. D. Putra, “Development and thermal investigation of modified octadecanoic acid as energy storage material,” *Chemistry & Chemical Technology*, vol. 18, no. 4, pp. 615–622, 2024, doi: 10.23939/chcht18.04.615.

[16] Jakariya, L. Wijayantib, M. Mulyadi, D. Setiawan, H. Maksum Ardi, and Rani Anggrainy, “Studi perencanaan ulang perpipaan sistem filtrasi air skala rumah tangga,” *Jurnal Permadi: Perancangan, Manufaktur, Material dan Energi,* vol. 5, no. 3, pp. 123-131, 2023, doi: 10.52005/permadi.v5i03.120.

[17] H. L. Tan, B. H. Lim, M. H. Tan, X. Zeng, K. K-. Chong, K. H. Chua, and Y. Zhang, “Investigation of bifacial gain and albedo of bifacial photovoltaic modules that operate in a tropical site,” in *2024 8th International Conference on Green Energy and Applications (ICGEA)*, pp. 265–270, 2024, doi: 10.1109/ICGEA60749.2024.10560565.

[18] S. Saodah, B. Eliana, and J. Jakariya, “Studi pengaruh penuaan minyak trafo terhadap karakteristik dielektrik,” *JITEL (Jurnal Ilmiah Telekomunikasi, Elektronika, dan Listrik Tenaga)*, vol. 3, no. 2, pp. 83–90, 2023, doi: 10.35313/jitel.v3.i2.2023.83-90.

[19] Isdawimah, N. Nadhiroh, Muchlishah, D. Monika, A. K. Wardhany, and A. B. Kusumaningtyas, “Pemanfaatan reflektor untuk peningkatan daya luaran panel surya pada sistem off grid,” *Jurnal Poli-Teknologi*, vol. 21, no. 3, pp. 97-106, 2022, doi: 10.32722/pt.v21i3.4723.

[20] H. S. Tira, A. Natsir, and T. Putranto, “Kinerja modul surya melalui variasi solar collector dan kecepatan angin,” *Dinamika Teknik Mesin: Jurnal Keilmuan dan Terapan Teknik Mesin*, vol. 10, no. 1, pp. 25-32, 2020, doi: 10.29303/dtm.v10i1.302.

[21] S. P. Mallick, D. P. Dash, S. Mallik, R. Roshan, S. Mahata, P. Das, and S. S. Mahato, “An empirical approach towards photovoltaic parameter extraction and optimization,” *Solar Energy*, vol. 153, pp. 360–365, 2017, doi: 10.1016/j.solener.2017.05.076.

[22] Z. O. Priani, H. Batih, and S. Abduh, “Pengaruh suhu dan durasi penyinaran panel surya terhadap efisiensi energi panel surya: studi kasus PLTS institut teknologi PLN,” *Integrative Perspectives of Social and Science Journal (IPSSJ)*, vol. 2, no. 3, pp. 5201-5228, 2025.

[23] R. Pido, B. H. Rahmat, R. Wawan, and D. R. Rianto, “Pengaruh variasi aliran udara terhadap optimasi daya panel surya,” *Dinamika Teknik Mesin*, vol. 13, no. 2, pp. 189-195, 2023, doi: 10.29303/dtm.v13i2.661.

[24] R. Barokah, N. N. Suryaman, and A. Rajani, “Experimental study of bifacial solar panels with reflective surface variations in bandung, indonesia,” *REM (Rekayasa Energi Manufaktur) Jurnal*, vol. 10, no. 2, pp. 81-88, 2025, doi: 10.21070/r.e.m.v10i2.1758.

[25] M. Alam, M. S. Gul, and T. Muneer, “Performance analysis and comparison between bifacial and monofacial solar photovoltaic at various ground albedo conditions,” *Renewable Energy Focus*, vol. 44, pp. 295–316, 2023, doi: 10.1016/j.ref.2023.01.005.