Enhancing the Efficiency of 100 WP Solar Panels with the Active Method of Circulating Cooling Water System

Gatot Setyono[a], Ilham Hidayad, Siswadi, Muharom, Slamet Riyadi,
Alfi Nugroho, Navik Kholili, Wahyu Nugroho, Mochammad Muchid and Dwi Khusna
Program of Mechanical Engineering, Wijaya Putra University, Raya Benowo 1-3 Rd, Surabaya, East Java, Indonesia

Keywords: Efficiency, Active Method, Cooling Water, 100WP Solar Panels.

Abstract: Cooling methods on solar panels have been widely developed today. The impact is detected that using water as a cooling medium can improve the performance of solar panels. This research has developed several data variations that will be used, including 100WP solar panels and cooling media, namely running water, and solar panel tilt angles of 18% (B-18), 22% (B-22), and 28%. (B-18), and the time range tested is between 09.00 to 15.00 (in June-July). The results showed an optimal increase in power, efficiency, Vmp, and Imp, respectively 8%, 9%, 2%, and 1.5%. It shows that the contribution of water cooling affects the performance of solar panels; this water cooling is also an effective way to increase the service life of solar panels and function as a treatment system for dust and dirt on the surface of solar panels.

1 INTRODUCTION

A modified solar panel with running water cooling is an effort to increase the electrical output power and thermal system in the solar panel module. Therefore, the optimal method is used to evaluate solar panels' power distribution and temperature from time to time (Matias et al., 2017). Solar panels convert heat energy into electrical energy on a stratified scale variation. The maximum efficiency of solar panels occurs at low temperatures. Various thermal management designs have been recommended in the last year. Water cooling is a method that is optimal for managing solar panels. Solar panels utilize the flow of water to cool cells. The cell temperature can be maintained in a certain range to prevent a decrease in the efficiency of sunlight that is too large and the environmental temperature factor. The efficiency of solar panels using cooling has increased by 52% compared to those without cooling (Wu et al., 2020). A cooling system on solar panels consists of circulating water and a slight heat exchanger. The solar panel system is applied with an active cooling process so that these conditions can lower the temperature from 760C to 700C. The results show that the conversion efficiency increased above 5.5% at 760C. The same happened to the electrical efficiency, which increased by 6.5% and the thermal efficiency by 60% at the optimal water flow rate of 2 l/min. This innovative method confirms that the heat released from the solar panels can have an impact on increasing the overall output power (Hussein et al., 2017). The cooling method in solar cells can be applied in research to obtain thermal and electrical energy from PV modules. Therefore, innovative methods are needed to analyze and predict the distribution of PV power and temperature based on usage time. In this study, second-degree polynomial modelling is used to determine the flow of PV panel strength and temperature, while linear modelling analyses the relationship between PV power and input power. The results showed that the maximum power loss, thermal power and electrical power were met at ambient temperatures during the day. Therefore, the cooling water discharge through the PV system can affect the power characteristics and the amount of electricity generated by the solar panels (Belyamin et al., 2021).

This research's basic concept is how to investigate the PV performance using circulating cooling water experimentally. The PV cooling system is designed using a 6.35mm diameter copper tube attached to the side of the solar panel via a single-absorbent plate.

[a] https://orcid.org/0000-0001-9032-1171

Setyono, G., Hidayad, I., Siswadi, ., Muharom, ., Riyadi, S., Nugroho, A., Kholili, N., Nugroho, W., Muchid, M. and Khusna, D.
Enhancing the Efficiency of 100 WP Solar Panels with the Active Method of Circulating Cooling Water System.
DOI: 10.5220/0012112600003680
In *Proceedings of the 4th International Conference on Advanced Engineering and Technology (ICATECH 2023)*, pages 157-163
ISBN: 978-989-758-663-7; ISSN: 2975-948X
Copyright © 2023 by SCITEPRESS – Science and Technology Publications, Lda. Under CC license (CC BY-NC-ND 4.0)

The results showed that the electric current and voltage increased by 2.4% and 3.5%, respectively. The same thing happened at the temperature, which decreased by 15.2%, and the electrical efficiency increased by 6% at the water flow rate of 0.0166 kg/s (Singh et al., 2021). In this study, we have investigated a PV system using water cooling, and it uses three primary parameters: maximum temperature variation, set point temperature, and water discharge. It will be applied to the entire surface of the PV mode. The temperature PV will be set to a maximum limit of 50°C with a discharge variation of 0.3 to 0.9 m3/h. The results show that the performance of the PV system is more optimal with water cooling. The optimal PV panel cooling temperature is 37°C. Cooling water is reduced by 15% to 17% when circulating at that temperature, and the PV set point temperature is very influential on the increase in energy obtained in the system (Tashtoush & Al-Oqool, 2018).

The increase in the operating temperature of the PV cell results in a decrease in efficiency and durability for a long time. Using passive and active cooling methods is one way to reduce this. The methods are passive heat sink, immersion, phase change, water flow, and airflow. The study results show that passive and active cooling media dramatically increases PV efficiency and resistance for all climatic conditions (Bhakre et al., 2021; Sato & Yamada, 2019). The research presents the performance of PV panels equipped with a cooling process by normalizing the output power, PV efficiency and performance ratio. The main objective of this research is to optimize the efficiency, performance and innovative PV cooling system. It uses a working system from air conditioning in offices, houses and apartments. The research compared two PVs with the method without and with cooling. The results showed that cooling was more optimal than without cooling. Furthermore, the ratio of work and efficiency showed an increase of 6% and 7%, respectively (Sajjad et al., 2019).

Solar panels convert heat energy from the sun into electricity. However, most of the energy is not converted to electricity, but to heat the solar panels, so that the PV surface temperature increases and impacts decreasing efficiency. Now, it has been many innovations made by researchers in order to reduce the surface heat of PV and increase its efficiency. This research uses three cooling methods: configuration, fluid medium, and phase change. This research is an essential point about the fundamental concept of PV cooling systems. The first is the selection of coolant characteristics and their use in certain areas, the second is the level of dirt accumulation and the cleaning process of the heat exchanger, which is focused on complex structures, and the third is to optimize the efficiency of cleaning and cooling solar panels. The fourth is the cooling water circulation system in tropical and subtropical climates. Researchers suggest that using the nanofluid method is more effective in sorting solar energy on a spatial and spectral scale so that the energy can be utilized optimally (Zhang et al., 2020). The decrease in solar panel efficiency is influenced by the cell surface temperature, which increases from time to time. This temperature increase is influenced by sunlight absorbed by PV, not converted into heat, resulting in a decrease in output power, performance, efficiency, and the lifetime of solar panels. The cooling method can propose an innovative option to reduce the overheating and surface temperature of PV. The results showed that the cooling method on the PV surface could increase the output power and efficiency (Dwivedi et al., 2020).

Solar panels are the most superior energy converter to other systems, such as good predictability and optimal accessibility. Although solar panels are more desirable for producing electricity on a small scale or off-grid scale, PV performance depends on several substances such as material, temperature and irradiation. Continuous irradiation conditions impact increasing the temperature so that the PV efficiency decreases. Thus, there is a need for a cooling method to improve PV performance, and there are two methods, active and passive. The active method is oriented to the utilization of water flow, while the passive method is oriented to the thermal media using a heat pipe. Therefore, the efficiency of solar panels increases depending on the sun's intensity, the module's operation and the cooling method (Maleki et al., 2020; Mohamed Fathi et al., 2020). The series of temperature reductions on the surface of the module. The cooling system installed on the PV aims to maintain a stable operating temperature and increase efficiency while extending the life of the PV (Siecker et al., 2017; Tembo et al., 2018; Zilli et al., 2018). PV performance depends on environmental factors such as operating temperature and solar radiation. The increasing environmental temperature will affect the decrease in PV efficiency, so there needs to be an optimal innovation to reduce it. Cooling media is essential when operating PV panels because of the high-temperature effect. The results show that when the operating temperature decreases, the output power produced by PV increases; this indicates that the cooling medium used on the PV surface is optimal for performance (Irwan et al., 2015; Rakhmadanu et al., 2019; Rathour et al., 2019).

Solar panels' efficiency currently only reaches about twenty per cent of the total solar energy that can be converted into electrical energy. Therefore, high-quality solar panels are needed to get a high-efficiency level. For this reason, the utilization of solar radiation can be maximized using a mechanical system oriented to the PV module. In this study, the author tries to analyze the optimal performance of PV capacity of 100 WP through water cooling media by varying the angle of tilt 180, 220, and 280. Although variation in the angle of PV tilt is a continuation of previous research, the aim is to explore the characteristics of solar panels. To produce optimal performance.

2 EXPERIMENTAL METHODS

2.1 Photovoltaic Energy Systems

Photovoltaic is a technological innovation designed to capture solar energy to convert it into electrical energy that is greater than battery energy. Although the SCC regulates the power that comes out of the PV, the SCC is to control the voltage that will enter the battery (Setyono et al., 2022). In this research, a 100WP capacity solar panel will be explored. The PV specification data used is in table 1. When testing PV, several parameters are taken, including temperature, solar radiation, voltage, and electric current.

Table 1: Characteristics of the photovoltaic used.

Parameter	Unit	Quantity
Power (Pmax)	Watt	100
Short CC (Isc)	Ampere	6.0
Voltage (Vmp)	Volt	18.2
Max. Voltage System	Volt	800
Open CV (Voc)	Volt	22.1
Current (Imp)	Ampere	5.49
Power Tolerance	%	±3
Weight	Kg	8
Dimension	mm	1005 x 665 x 30
Max. Series Fuse	Ampere	10

2.2 Water Cooling System

Cooling water will flow to the PV surface. Figure 2 shows that the temperature sensor is set at 450C. The control system will automatically turn on the submersible pump at that time. Water flows from the reservoir to the water flow sensor and the PV surface. Hot water on the surface of the PV will be channelled into a water trap with five traps, and the process serves to cool water conventionally. As a result, the water temperature will gradually decrease. The cycle will continue following the maximum working temperature of the PV.

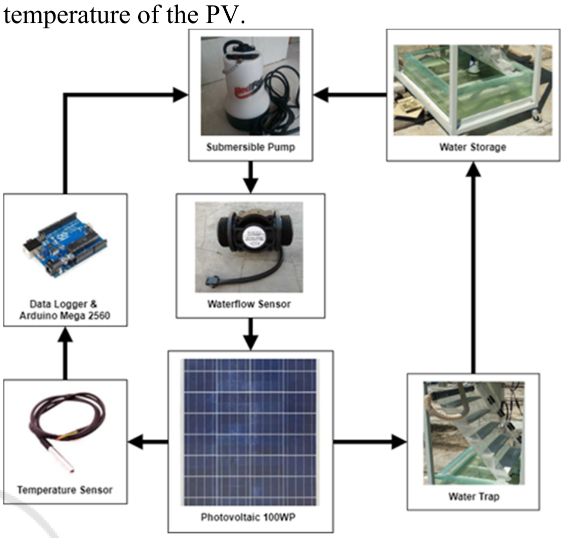

Figure 1: Water cooling system.

2.3 Performance Testing Photovoltaic

The solar panels were tested from June to July on the rooftop of the Wijaya Putra University building; the time required for data collection ranges from 08.00 to 15.00 WIB, and the parameters produced in the test are cooling water discharge, temperature, voltage, electric current and output power. The tilt angle is set in the range of 180(B-18), 220(B-22), and 280(B-28) concerning the sun's direction. Figure 2 shows a solar panel system with water cooling. The temperature sensor will identify the maximum working temperature set in the control system of 45 degrees Celsius. Then the submersible pump circulates the water up to the surface of the solar panel. The high water temperature on the PV surface will then be circulated to the water ladder. It aims to reduce the temperature conventionally, hoping that the water temperature will decrease up to the reservoir. This process will take place continuously.

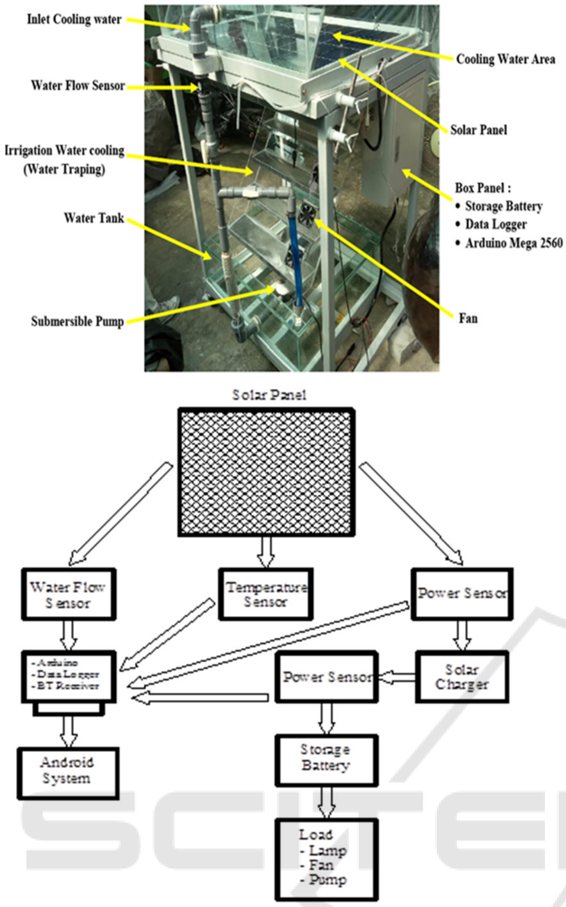

Figure 2: Performance testing photovoltaic.

3 RESULT AND DISCUSSION

The optimal cooling rate influences the increase in PV performance. Therefore, the PV cooling process must be set to the appropriate conditions. Furthermore, the optimal determination of the cooling must be under energy balance (Rakhmadanu et al., 2019; Setyono et al., 2022). The PV surface temperature setting before cooling is 45 degrees Celsius, and after the cooling process is 35 degrees Celsius. After flowing on the PV surface, the water temperature condition must reach 350C before entering the reservoir. The temperature of the water passing through the surface of the solar panel is assumed to be almost the same as the cooling temperature. Figure 3 compares the water temperature from the solar panel surface and the water temperature coming out of the reservoir; the values are 35 and 25 degrees Celsius. Observations show that with an increase in the water flow rate, the duration of time required to carry out the PV cooling process will decrease. For example, if the submersible pump is set up optimally to produce a water flow of 30 l/min, this will impact the solar panel cooling process from a temperature of 45 to 35 degrees Celsius within 5 minutes. It is concluded that the PV cooling process rate is 30 0C, and the water emission must be paused after 5 minutes. Figure 4 compares the PV temperature with various variations over the specified time. These observations show considerable fluctuations in use, and without water cooling, the graph shows that the use of cooling liquid on the surface can reduce the working temperature of solar panels by 28% (B-18), 26% (B-22), and 23% (B-28). Compared to previous research, the cooling method significantly differs from the current study.

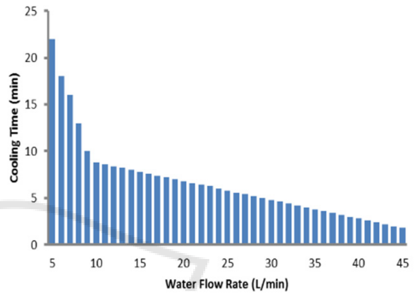

Figure 3: Function of comparison of cooling time to water flow rate.

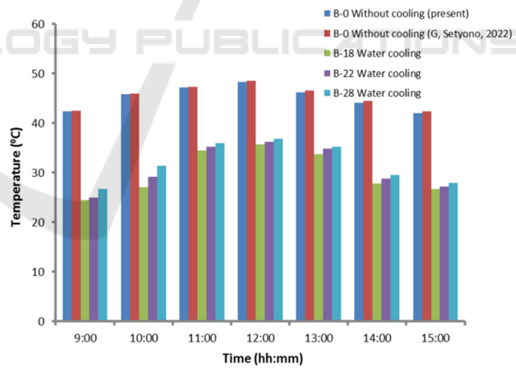

Figure 4: Temperature PV comparison function to time.

The average output power for the test time from 09.00 to 15.00 is 7% for all variations of the inclination angle. Figure 5 shows that the maximum output power generated at 12.00 is 9% because the sun's intensity increases, while the average output power for the three variations of the tilt angle B-18, B-22, and B-28 results in an 8% increase in value. That the cooling process on the solar panel surface from time to time can increase the optimal output power so that this method can be used as a reference

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

for future research. The efficiency of the resulting solar panels against the test time of 09.00 to 15.00 is 2% for all variations of the angle of inclination. For example, figure 6 shows that the maximum efficiency at 12.00 is 16% because the sun's intensity increases, while the average efficiency for the three variations in the angle of inclination B-18, B-22, and B-28 results in a 9% increase in value.

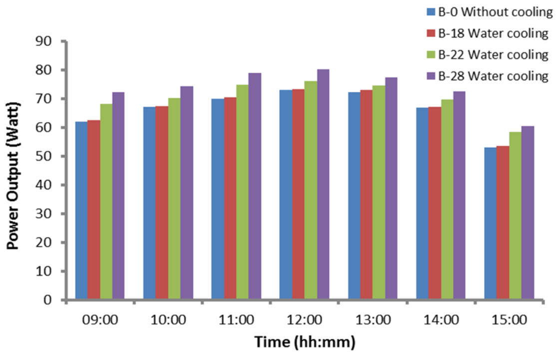

Figure 5: Power output comparison function to time.

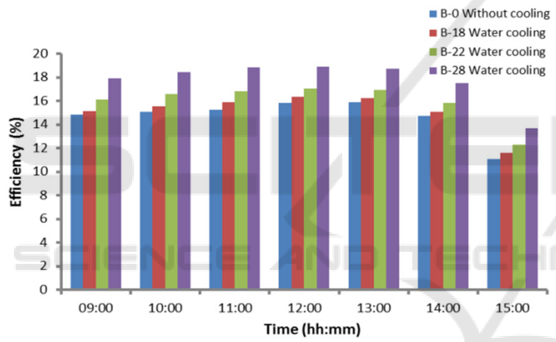

Figure 6: Efficiency comparison function against time.

The average water discharge flowing on the surface of the solar panel for the test time from 09.00 to 15.00 is 8.5% for all variations of the inclination angle. Figure 7 shows that the increase in maximum water discharge produced at 12.00 is 6% due to increasing solar intensity, while the average water discharge for the all variations of the tilt angles B-18, B-22 and B-28 increased in value by 9%. The increase in the average Vmp of solar panels against the test time of 09.00 to 15.00 is 12% for all variations of the angle of inclination. Figure 8 shows that the maximum Vmp increase was produced at 12.00 by 2% because the sun's intensity increased, while the average Vmp for the three variations of the tilt angle B-18, B-22 and B-28 resulted in a 3% increase in value. The increase in the average Imp of solar panels against the test time of 09.00 to 15.00 is 6% for all variations of the angle of inclination. Figure 9 shows that the maximum Imp increase was generated at 12.00 by 2% as the solar intensity increased, while the average Imp for the three variations of the tilt angle B-18, B-22 and B-28 resulted in a 1.5% increase in value.

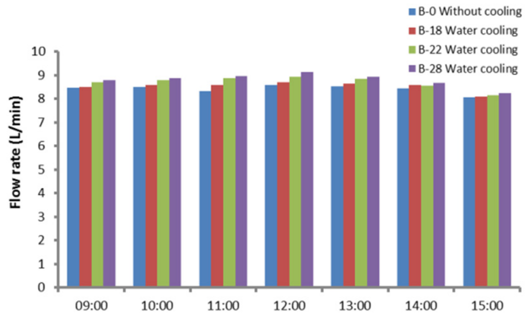

Figure 7: Flow rate of water cooling comparison function to time.

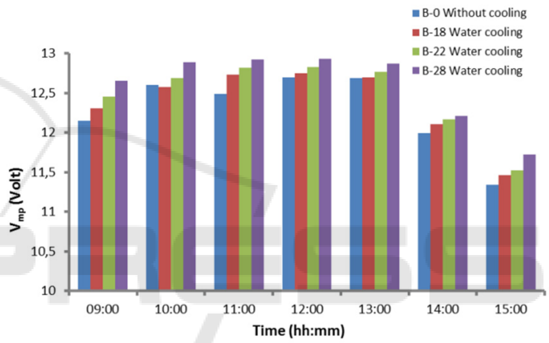

Figure 8: Comparison function of V_{mp} to time.

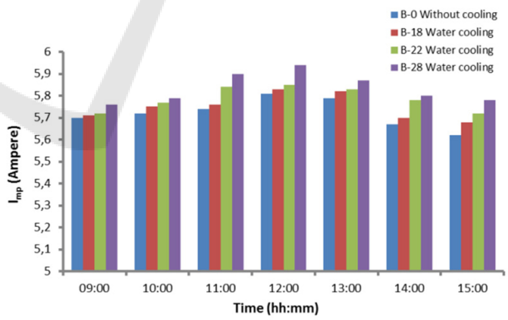

Figure 9: Comparison function of I_{mp} to time.

4 CONCLUSIONS

The cooling process on the surface of the solar panel can impact increasing the optimal output power by 8% for all variations of tilt angel B-18, B-22 and B28. Directly proportional to the output power, Vmp and Imp have increased in all tilt variations. The efficiency of solar panels has the same increase in

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

output power; this is due to the optimal cooling process in solar panels. The cooling process on the solar panel surface from time to time can increase the optimal output power so that this method can be used as a reference for future research. The effect of the cooling process not only affects the performance of the solar panel, but it can increase the service life while reducing the level of maintenance of the solar panel because the cooling process cleans the surface of the solar panel against dust and dirt.

ACKNOWLEDGEMENTS

As writers and researchers, we would like to express our gratitude for the support from the Institution of Research and Community Services, the engineering faculty, and the Mechanical Engineering Study Program Wijaya Putra University through the development of this research. We hope the community, industry, and institutions can use this research to add information on renewable energy technologies.

REFERENCES

Belyamin, B., Fulazzaky, M. A., Roestamy, M., & Subarkah, R. (2021). Influence of cooling water flow rate and temperature on the photovoltaic panel power. Energy, Ecology and Environment 2021 7:1, 7(1), 70–87. https://doi.org/10.1007/S40974-021-00223-4

Bhakre, S. S., Sawarkar, P. D., & Kalamkar, V. R. (2021). Performance evaluation of PV panel surfaces exposed to hydraulic cooling – A review. Solar Energy, 224, 1193–1209. https://doi.org/10.1016/J.SOLENER.2021.06.083

Dwivedi, P., Sudhakar, K., Soni, A., Solomin, E., & Kirpichnikova, I. (2020). Advanced cooling techniques of P.V. modules: A state of art. Case Studies in Thermal Engineering, 21, 100674. https://doi.org/10.1016/J.CSITE.2020.100674

Hussein, H. A., Numan, A. H., & Abdulrahman, R. A. (2017). Improving the Hybrid Photovoltaic/Thermal System Performance Using Water-Cooling Technique and Zn-H2O Nanofluid. International Journal of Photoenergy, 2017. https://doi.org/10.1155/2017/6919054

Irwan, Y. M., Leow, W. Z., Irwanto, M., Fareq, M., Amelia, A. R., Gomesh, N., & Safwati, I. (2015). Indoor Test Performance of PV Panel through Water Cooling Method. Energy Procedia, 79, 604–611. https://doi.org/10.1016/J.EGYPRO.2015.11.540

Maleki, A., Haghighi, A., El Haj Assad, M., Mahariq, I., & Alhuyi Nazari, M. (2020). A review on the approaches employed for cooling PV cells. Solar Energy, 209, 170–185. https://doi.org/10.1016/J.SOLENER.2020.08.083

Matias, C. A., Santos, L. M., Alves, A. J., & Calixto, W. P. (2017). Increasing photovoltaic panel power through water cooling technique. Transactions on Environment and Electrical Engineering, Vol. 2, No. 1(1). https://doi.org/10.22149/TEEE.V2I1.90

Mohamed Fathi, Abderrezek, M., & Djahli, F. (2020). Heating Behavior of Photovoltaic Panels and Front Side Water Cooling Efficiency. Applied Solar Energy 2019 55:5, 55(5), 327–339. https://doi.org/10.3103/S0003701X19050050

Rakhmadanu, Y., Setyono, G., & Arifin, A. A. (2019). Pengaruh Variasi Pendinginan Terhadap Peforma Photovoltaik Kapasitas 100 WP Ddngan Variasi Sudut Kemiringan 0°, 5° dan 10°. Prosiding Seminar Nasional Sains Dan Teknologi Terapan, 1(1), 391–396.

Rathour, R. S., Chauhan, V., Agarwal, K., Sharma, S., & Nandan, G. (2019). Cooling of solar photovoltaic cell: Using novel technique. Lecture Notes in Mechanical Engineering, 521–529. https://doi.org/10.1007/978-981-13-6416-7_48/COVER

Sajjad, U., Amer, M., Ali, H. M., Dahiya, A., & Abbas, N. (2019). Cost effective cooling of photovoltaic modules to improve efficiency. Case Studies in Thermal Engineering, 14, 100420. https://doi.org/10.1016/J.CSITE.2019.100420

Sato, D., & Yamada, N. (2019). Review of photovoltaic module cooling methods and performance evaluation of the radiative cooling method. Renewable and Sustainable Energy Reviews, 104, 151–166. https://doi.org/10.1016/J.RSER.2018.12.051

Setyono, G., Kholili, N., & Rakhmadanu, Y. (2022). The Impact of Utilization The Solar-Panels With a Cooling-Water System as a Source of Micro-Power Generation. Infotekmesin, 13(1), 87–92. https://doi.org/10.35970/INFOTEKMESIN.V13I1.1001

Siecker, J., Kusakana, K., & Numbi, B. P. (2017). A review of solar photovoltaic systems cooling technologies. Renewable and Sustainable Energy Reviews, 79, 192–203. https://doi.org/10.1016/J.RSER.2017.05.053

Singh, K., Singh, S., Kandpal, D. C., & Kumar, R. (2021). Experimental performance study of photovoltaic solar panel with and without water circulation. Materials Today: Proceedings, 46, 6822–6827. https://doi.org/10.1016/J.MATPR.2021.04.393

Tashtoush, B., & Al-Oqool, A. (2018). Factorial analysis and experimental study of water-based cooling system effect on the performance of photovoltaic module. International Journal of Environmental Science and Technology 2018 16:7, 16(7), 3645–3656. https://doi.org/10.1007/S13762-018-2044-9

Tembo, P. M., Heninger, M., Subramanian, V., Patil, M., Sidramappa, A., & Angadi, R. (2018). Experimental Investigation of Enhancing the Energy Conversion Efficiency of Solar PV Cell by Water Cooling Mechanism. IOP Conference Series: Materials Science and Engineering, 376(1), 012014. https://doi.org/10.1088/1757-899X/376/1/012014

Wu, G., Liu, Q., Wang, J., & Sun, B. (2020). Thermal analysis of water-cooled photovoltaic cell by applying computational fluid dynamics. Journal of Thermal Analysis and Calorimetry 2020 144:5, 144(5), 1741–1747. https://doi.org/10.1007/S10973-020-10283-Z

Zhang, C., Shen, C., Wei, S., Wang, Y., Lv, G., & Sun, C. (2020). A Review on Recent Development of Cooling Technologies for Photovoltaic Modules. Journal of Thermal Science 2020 29:6, 29(6), 1410–1430. https://doi.org/10.1007/S11630-020-1350-Y

Zilli, B. M., Lenz, A. M., de Souza, S. N. M., Secco, D., Nogueira, C. E. C., Junior, O. H. A., Nadaleti, W. C., Siqueira, J. A. C., & Gurgacz, F. (2018). Performance and effect of water-cooling on a microgeneration system of photovoltaic solar energy in Paraná, Brazil. Journal of Cleaner Production, 192, 477–485. https://doi.org/10.1016/J.JCLEPRO.2018.04.241

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS