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The Utilization of a Combination of Heatsink Material And A Water Cooler Block As An Effort To Reduce Heat From Solar Panels

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A B S T R A C T

Solar panels are an important utilization in generating renewable energy, but high temperatures can reduce energy conversion efficiency and shorten the lifetime of solar panels. This research aims to explore and evaluate the utilization of a combination of heatsink material and cooling water block as a solution to reduce the heat generated by solar panels. The research method includes the design and manufacture of a prototype consisting of solar panels mounted on a combination of heatsink material and water block. Experiments were conducted by varying the use of passive cooling and the absence of cooling on solar panels according to environmental conditions to evaluate the effectiveness of the system in reducing the temperature of solar panels. A power increase of 43.3% was achieved by comparing the system without cooling design with the passive cooling design system. The results showed that the use of a combination of heatsink material and cooling water block significantly reduced the solar panel temperature under various operational conditions. In addition, data analysis showed an increase in the energy conversion efficiency of the solar panel after the implementation of the cooling system. This research makes an important contribution to the development of more efficient and durable solar panel technology by addressing the problem of heat generation.

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INTRODUCTION

Solar panels have become one of the key solutions in supporting the transition towards renewable and sustainable energy. However, despite technological advances, issues related to the heat generated by solar panels remain a significant challenge. Increased temperature in solar panels can reduce energy conversion efficiency, increase the risk of system failure, and even shorten the lifetime of the solar panels. Therefore, efforts to address the issue of heat in solar panels have become an important research focus (A. Abdullah, Haq, Cholish, Putri, & Ramadhan, 2022).

The utilization of solar energy through solar panels has become an increasingly popular solution in supporting renewable energy needs. However, one of the main challenges faced in the use of solar panels is the increase in temperature which can reduce energy conversion efficiency and shorten the lifetime of solar panels. Therefore, this research aims to explore and evaluate the utilization of a combination of heatsink material and cooling water block as a solution to reduce the heat generated by solar panels (A. Abdullah, Putri, Iriani, Hulu, Cholish, et al., 2023).

Solar panels have become an increasingly important technology in providing environmentally friendly renewable energy sources. However, in operation, solar panels often generate excessive heat, especially when exposed to direct sunlight for long periods of time. This increase in temperature can reduce the energy conversion efficiency of solar panels and can even accelerate the degradation of solar panel components, reducing their overall lifetime and performance (S. Abdullah & Haq, 2021).

The photovoltaic effect, which transforms solar radiation into electrical energy, powers solar panels. The temperature of the solar panel and the amount of sunshine it receives have a significant impact on how efficiently solar panels create electricity in the form of voltage and current. The amount of electrical energy generated by a solar panel decreases with decreasing sunshine intensity. Furthermore, the continual exposure of the solar panel to sunlight results in a high surface temperature, which reduces the amount of electrical power generated. Starting at 25°C, every 1°C increase will result in a 0.5% decrease in the solar panel's output power (A. Abdullah, Putri, Iriani, Hulu, & Cholish, 2023).

In the face of these challenges, the use of heatsink materials and cooling water blocks has become an attractive research focus. Heatsinks, with their ability to absorb and dissipate heat efficiently, have been widely used in the electronics cooling industry. The combination with cooling water blocks, which allow heat transfer through convection and conduction heat transfer, promises to be an effective solution in lowering the temperature of solar panels (Rakino, 2019).

Thus, this study aims to explore and evaluate the utilization of a combination of heatsink material and cooling water block as a solution to reduce the heat generated by solar panels. The research method includes the design and manufacture of a prototype consisting of a solar panel attached to a combination of heatsink material and water block. Experiments were conducted by varying the use of passive cooling and the absence of cooling on the solar panel according to environmental conditions to evaluate the effectiveness of the system in reducing the temperature of the solar panel. This research will explore the potential of using a combination of heatsink material and water block cooling as an effort to reduce the heat generated by solar panels. Through a targeted approach and careful experimentation, it is expected that this research can make a significant contribution to the development of more efficient and durable solar panel technology.

LITERATURE REVIEW

The use of solar panels as a renewable energy source is growing, but the increase in temperature on solar panels can reduce their energy conversion efficiency and shorten their lifespan. Therefore, research on the utilization of a combination of heatsink materials and cooling water blocks is an interesting topic to investigate to overcome this problem. This research focuses on the utilization of a combination of heatsink materials and cooling water blocks to reduce heat from solar panels. Previous studies related to the research conducted are references to the novelty of the research conducted.

Research by Li et al. (2018), in this research, the authors investigated the use of different heatsink materials in solar panel applications to reduce the heat generated. They compared the cooling efficiency of different types of heatsinks and evaluated their impact on solar panel performance. The results provide important insights into the types of heatsink materials that are effective in overcoming heat problems in solar panels (Li et al., 2018).

Research by Zhang et al. (2019), in this research considered the use of a combination of heatsink material and cooling water circulation system as a solution to reduce the temperature of solar panels. By analyzing experimental and simulation data, the authors present promising results on the effectiveness of this approach in improving the energy conversion efficiency of solar panels while maintaining their operational temperature (Zhang et al., 2020).

Research by Rakino (2019), in this study stated that the cooling system using a combination of water with a fixed volume and heat-sink is able to reduce the surface temperature better than a system that only uses water or heat-sink alone. The output power reaches an average of 47.71% higher than the panel without cooling (Rakino, 2019).

A. Solar Panel

Solar panels are electronic devices that convert solar energy into electrical energy through the photovoltaic effect. This process occurs inside solar cells made of semiconductor materials, such as silicon. When sunlight hits the solar cell, the photons in the light cause movement of electrons in the semiconductor material. This creates an electric current that can be collected and passed through wires to electronic devices or batteries for use as electrical energy (Mayasari et al., 2022).

The basic structure of a solar panel consists of several solar cells connected in series or parallel in a module. These modules are then arranged into larger circuits to create solar panels that can produce higher electrical power. Solar cells are usually protected by a transparent glass layer on the front and a protective layer on the back to maintain operational safety and reliability (Laksana et al., 2021).

Solar cells generally consist of n-type and p-type silicon layers placed side by side. When sunlight enters, the photons cause electrons in the n-type layer to combine with holes in the p-type layer, creating an electric current that flows through an external circuit. This process is known as the photovoltaic effect (Sembiring, Mansuri, Bukit, & Sembiring, 2021).

The performance characteristics of solar panels, such as conversion efficiency, maximum current, and maximum voltage, are affected by various factors, including the semiconductor materials used, the intensity of sunlight, the ambient temperature, and the design of the solar panel itself. The efficiency of solar panels generally ranges from 15% to 22%, although there are breakthroughs and research continues to improve this efficiency (Soomar et al., 2022).

In general, solar panels have become one of the main solutions in providing clean and environmentally friendly renewable energy. They are used in a wide range of applications, from large-scale power generation to household rooftop installations. With the continued development of technology and decreasing production costs, solar panels are expected to become increasingly important in the transition towards a sustainable energy system in the future.

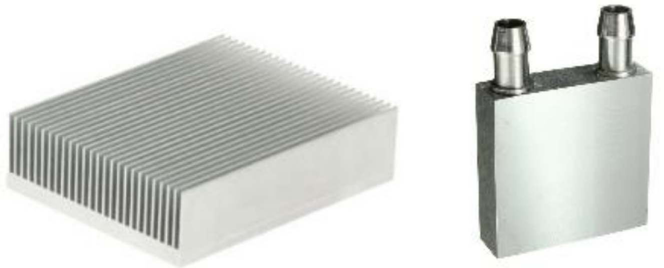
B. Heatsink and Water Cooler Block

A cooling system is a device that dissipates heat from an object into the surrounding air to maintain the optimal temperature of the object. When two parts of an object have different temperatures, the process of heat transfer occurs (Suherman, Sunarno, Hasan, & Harahap, 2019).

Heatsink material is a material specifically designed to absorb and dissipate heat from electronic devices or components that generate heat. Heatsinks are usually made of metals that have high heat conductivity, such as aluminum, copper, or aluminum-copper alloys (Arifin et al., 2020). The working principle of heatsink material is to utilize the high thermal conductivity of the metal to absorb heat from electronic devices. The absorbed heat is then conducted through the heatsink to a wider surface to be cooled by the surrounding air. Heatsink designs usually include a series of fins or small spikes that aim to expand the contact surface with the air, increasing cooling efficiency. Some heatsinks are also equipped with heat pipes to improve heat transfer efficiency (Handayani, Julian, Wahyuni, & Naufal, 2023).

Water block, also known as water cooling block or water cooler, is a device used in water cooling systems to absorb heat from electronic components and drain it into the water cooling system. Water blocks are usually made of copper or other heat-conducting materials that have a flat and smooth surface. It is placed directly over an electronic component that generates heat, such as a CPU processor or GPU in a computer. When water flows through the water block, the heat from the electronic component is transferred to the water through heat conduction. The heated water is then circulated through a water cooling system, such as a radiator or chiller, where the heat is dissipated into the air or other cooling medium. Water blocks are often used in sophisticated water cooling systems for computers, servers, or other electronic systems where high cooling performance and efficiency are required (Setyono, Kholili, & Rakhmadanu, 2020).

By utilizing a combination of heatsink and water block materials, cooling systems can be designed to efficiently absorb and remove heat from electronic components that require intensive cooling, such as solar panels. This combination can help keep operational temperatures low and improve the performance and lifespan of these electronic components.



(a) (b)

Figure 1. One type of (a) Heatsink and (b) Water Blok Cooler

METHODOLOGY

This research method is a system that focuses on Utilizing a Combination of Heatsink Material and Water Cooler Block as an Effort to Reduce Heat from Solar Panels to get maximum performance from solar panels. The research method is to use the concept of hardware and software integration, where the hardware consists of system mechanics and system electronics needs such as controllers, sensors and other electronic modules.

A. Hardware Design

Mechanical system design and electronic system design are the two main components of hardware development. The physical characteristics of the system are the emphasis of the mechanical design, while the need for various electrical modules, controllers, and sensors are included in the electronic design. The mechanical and electronic design must be well integrated with each other, because good mechanics without being supported by a good electronic system will also experience problems, and vice versa. The mechanical design of the system can be seen in Figure 2, while Figure 3 shows the block diagram for the overall hardware design.

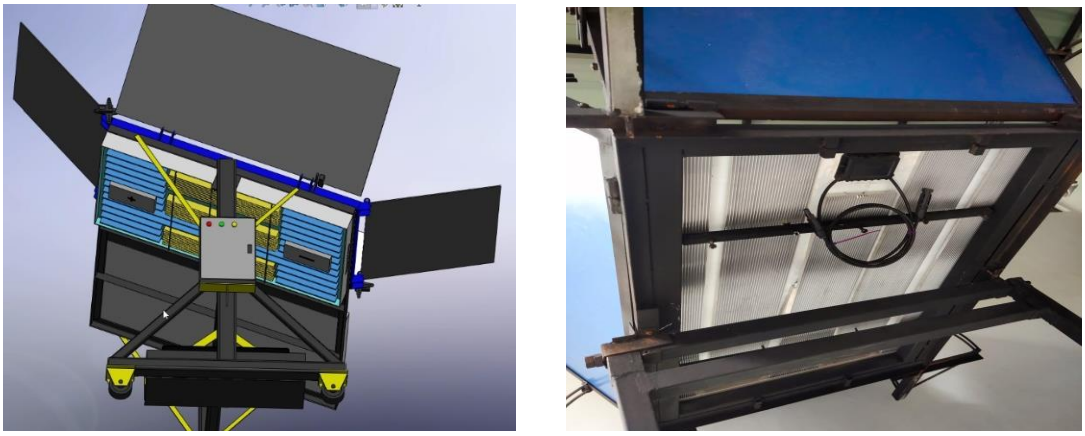


Figure 2. The Mechanical Design of System

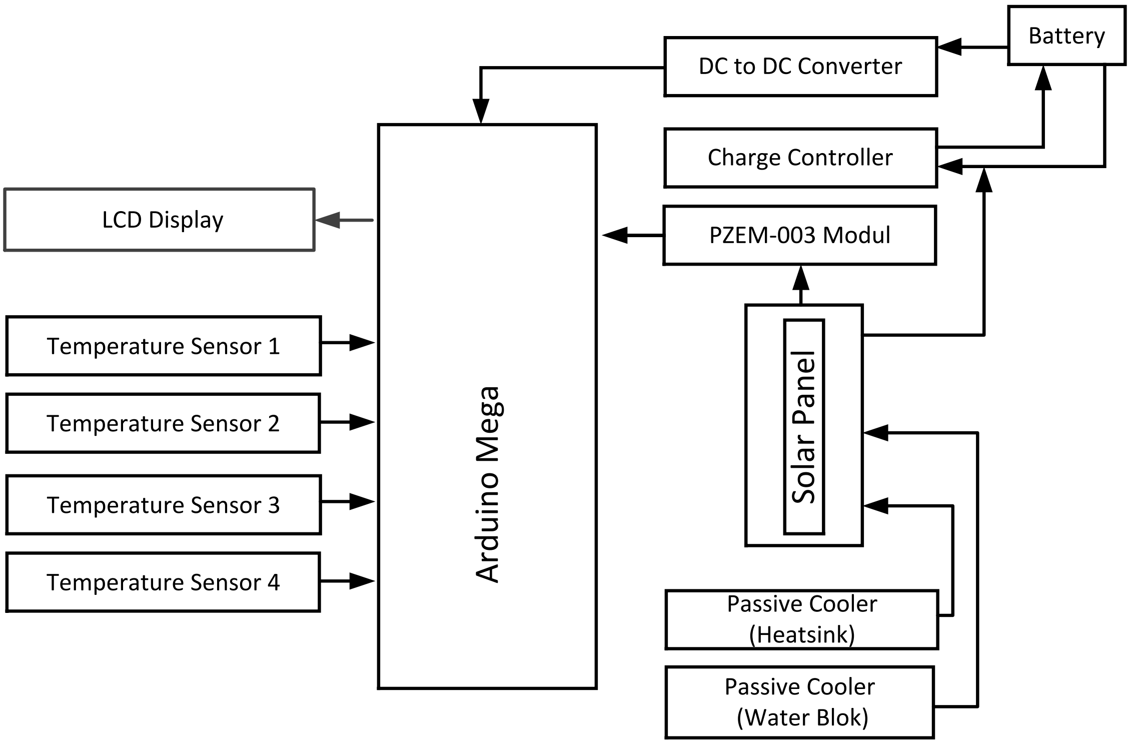


Figure 3. The Block Diagram for The Overall Hardware Design

In order to assure strength and ease of forming in accordance with the needs of the system and facilitate the placement of passive cooling materials like heatsinks and water cooler blocks, a variety of primary materials are utilized in the mechanical design, including hollow iron, plate iron, aluminum plate, and hydraulic DC motor. It is clear from the system design block diagram that the system consists of multiple essential parts. The Arduino Mega serves as the input/output processing hub for these parts. In charge of harnessing sunlight to create power is a 100 WP solar panel. The passive cooling system consists of a water cooler block and a heatsink. The solar panel's temperature can be measured between -55^{o}C and 125^{o}C using the DS18B20 temperature sensor. The solar panel's voltage and current are measured in part by the PZEM module. The monitoring results are displayed using a 20 by 4 LCD panel, which has 20 columns and 4 rows. Solar panel power is stored in deep cycle batteries. The voltage and current entering the battery are managed by the charge controller. A DC to DC converter is also included, and it helps to change the DC input voltage level into various DC output voltage levels as needed.

B. Software Design

The Arduino IDE software, which serves as the main application for controlling the system controller, including process control and monitoring, was used to program in C language for software development. Furthermore, the Blynk program serves as the interface design for the Internet of Things. The display image of this software can be seen in Figure 4 below:

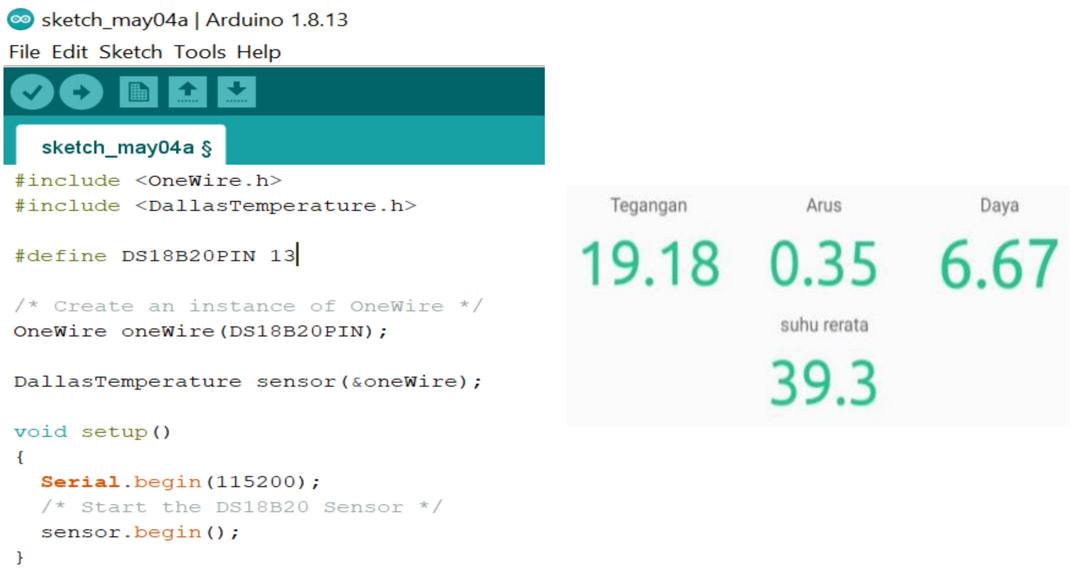


Figure 4. The Display of This Software Design

RESEARCH RESULT

The results and discussion on research Utilization of a Combination of Heatsink Material and Water Cooler Block as an Effort to Reduce Heat from Solar Panels consists of four tests, namely Testing passive cooling systems with heatsink material on solar panels, Testing passive cooling systems with water cooler blocks on solar panels, Testing passive cooling systems heatsink material + water cooler blocks on solar panels and Testing the output power of solar panels with and without passive cooling systems.

A. Testing passive cooling systems with heatsink material on solar panels

Testing passive cooling systems with heatsink materials on solar panels is intended to show the ability of heatsink materials to help reduce heat levels on solar panels. The test data can be seen in Table 1 and Figure 5.

Table 1. Testing passive cooling systems with heatsink material on solar panels

Time (Western Indonesian Time)	Solar Panel Temperature without Passive Cooler (°C)	Solar Panel Temperature with Heatsink (°C)	Temperature Difference (°C)
08:00	28,9	28,3	0,6
13:00	49,1	46,5	2,6
14:00	46,6	44,2	2,4
16:00	42,8	40,8	2
17.00	39,5	36,2	3,3

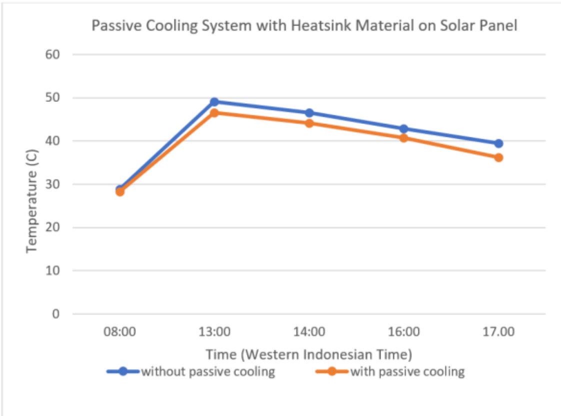


Figure 5. Graphic of Testing Passive Cooling Systems With Heatsink Material On Solar Panels

Based on Table 1 and Figure 5 above shows the work of the passive cooling system using heatsink material on solar panels, it can be seen that the cooling process has worked only that there has not been too much significant change, from the table it can be seen that the biggest temperature difference occurs at 17.00 WIB with a difference of 3.3 °C, so that design modifications using passive cooling on heatsink material can be further improved in order to get maximum results.

B. Testing passive cooling systems with water cooler blocks on solar panels

Testing the passive cooling system with water cooler block material on solar panels is intended to show the ability of heatsink material to help reduce the heat level on solar panels. The test data can be seen in Table 2 and Figure 6.

Table 2. Testing passive cooling systems with water cooler blocks on solar panels

Time (Western Indonesian Time)	Solar Panel Temperature without Passive Cooler (°C)	Solar Panel Temperature with Water Cooler Block (°C)	Temperature Difference (°C)
08:00	28,9	27,98	0,9

13:00	49,1	43,43	5,7
14:00	46,6	42,22	4,4
16:00	42,8	37,45	5,4
17.00	39,5	35,92	3,6

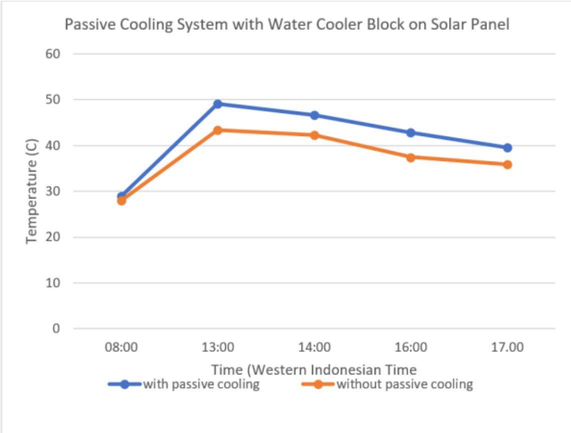


Figure 6. Graphic of Testing Passive Cooling Systems With Heatsink Material On Solar Panels

Based on Table 2 and Figure 6 above shows the work of a passive cooling system using a water cooler block on solar panels, it can be seen that the cooling process has worked, it's just that there hasn't been a significant change but it's better than the heatsink material, from the table it can be seen that the biggest temperature difference occurs at 13.00 WIB with a difference of 5.7 ^{o}C, so that the design modification of using passive cooling on the water cooler block can be further improved in order to get maximum results.

C. Testing passive cooling systems heatsink material + water cooler blocks on solar panels

Testing the passive cooling system with a combination of heatsink materials and water cooler blocks on solar panels is intended to show the ability of heatsink materials to help reduce heat levels on solar panels. The test data can be seen in Table 3 and Figure 7.

Table 3. Testing passive cooling systems heatsink material + water cooler blocks on solar panels

Time (Western Indonesian Time)	Solar Panel Temperature without Passive Cooler (^{o}C)	Solar Panel Temperature with Passive Cooler (^{o}C)	Temperature Difference (^{o}C)
08:00	28,9	27,63	1,3
13:00	49,1	41,52	7,6
14:00	46,6	39,46	7,2
16:00	42,8	36,32	6,5
17.00	39,5	33,6	5,9

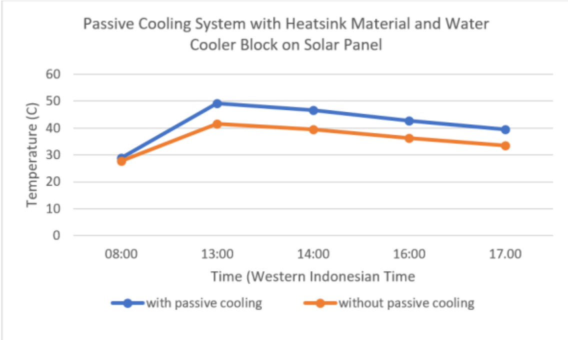


Figure 7. Graphic of Testing passive cooling systems heatsink material + water cooler blocks on solar panels

Based on Table 3 and Figure 7 above shows the work of a passive cooling system using heatsink material combined with a water cooler block on solar panels, it can be seen that the cooling process has worked better than just using heatsink material or just using a water cooler block, from the table it can be seen that the biggest temperature difference occurs at 13.00 WIB with a difference of 7.6 ^{o}C, but the design modification of the use of passive cooling used on solar panels can still be further improved in order to get maximum results.

D. Testing the output power of solar panels with and without passive cooling systems

The solar panel output power test is intended to show the effect of passive cooling in increasing the ability of solar panels to increase output power compared to the absence of passive cooling. The test data can be seen in Table 4 and Figure 8.

Table 4. Testing the output power of solar panels with and without passive cooling systems

Time	Solar Panel with Passive Cooling (heatsink + water cooler)			Solar Panel Temperature without Passive Cooler			Weather Conditions
	Voltage (Volt)	Current (Ampere)	Power (Watt)	Tegangan (Volt)	Arus (Ampere)	Daya (Watt)	
08:00	20,92	0,34	7,01	19,38	0,32	6,10	Bright
09:00	21,2	0,42	8,80	19,84	0,35	6,84	Bright
10:00	21,95	0,47	10,21	19,91	0,36	7,07	Bright
11:00	22,01	0,63	13,76	20,63	0,51	10,42	Bright
12:00	22,2	0,94	20,76	21,09	0,77	16,13	Bright
13:00	22,33	1,17	26,01	21,35	0,94	19,96	Bright
14:00	22,15	1,08	23,81	19,92	0,86	17,03	Bright
15:00	21,96	0,98	21,41	19,72	0,74	14,49	Cloudy
16:00	21,84	0,81	17,58	19,67	0,51	9,93	Cloudy
17.00	21,77	0,76	16,44	19,55	0,40	7,72	Cloudy

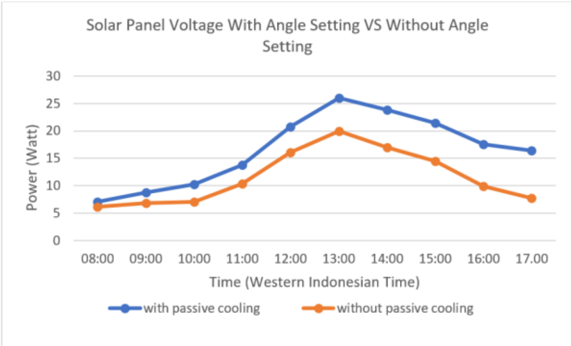


Figure 8. Graphic of Testing the output power of solar panels with and without passive cooling systems

Based on Table 4 and Figure 8 above, the results of testing the output power of solar panels with and without passive cooling systems, where without passive cooling design the total power is 115.69 W, while solar panels with passive cooling design are 165.79 W. Therefore, the difference in power can be calculated as follows:

Difference Pwr_total = Pwr_total with passive cooling design - Pwr_total without passive cooling design

= 165,79 Watt – 115,69 Watt
= 50,1 Watt

% Increase in Power = (Difference in total P cooler system / Difference in total P without cooler system) x 100
= (50,1 / 115,69) x 100
= 43,3 %
The percentage increase in panel output power is 43,3 %.

From the tests carried out showing the work of passive cooling systems using heatsink and water cooler block materials on solar panels, it can be seen that the cooling process has worked so that it directly affects the performance of the solar panel output power, so that this passive cooling concept can continue to be developed to improve the optimal work of solar panels.

DISCUSSION

Excessive temperature on solar panels greatly affects the work of solar panels, because solar panels already have specifications for their working temperature range, so a design is needed to overcome this, many methods or techniques are carried out, it's just that some methods actually become a burden in power consumption on the solar panel itself, so passive cooling can be a solution to overcome this without burdening the work of the solar panel, it just needs a good design for the placement between the heatsink and water cooler block and also needs further research on passive cooling materials that are much better than heatsinks and water cooler blocks.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this research, namely when compared to standard solar panels (without a cooling system design), solar panels with a cooling system design provide better performance to the work of solar panels, the system can work well as the utilization of a combination of heatsink material and water cooler block as an effort to reduce heat from solar panels. The use of materials with their ability to absorb and dissipate heat has worked as a solar panel cooler, the combination with water cooling blocks becomes a better passive cooling concept so that heat transfer through convection and conduction heat transfer makes an effective solution in reducing the temperature of solar panels, only the design and number of passive cooling combinations can be further improved both in quantity and in the quality of cooling materials. A power increase of 43.3% was achieved by comparing the system without cooling design with the passive cooling design system. The results show that the use of a combination of heatsink materials and cooling water blocks can help reduce the temperature of solar panels under various operational conditions. In addition, data analysis showed an increase in the energy conversion efficiency of the solar panel after the implementation of the cooling system. This research makes an important contribution to the development of more efficient and durable solar panel technology by addressing the issue of heat generation.

ADVANCED RESEARCH

A good design is needed for the placement between the heatsink and the water cooler block and there is also a need for further research on passive cooling materials that are much better than heatsinks and water cooler blocks, considering that heatsink and water cooler block materials that are sold on the market have quite expensive prices.

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