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Utilization of Solar Panel Technology to Save Electricity Costs in Fish Farm Irrigation

Safira Fegi Nisrina[1)*], Mohammad Alfian Mudzakir[2)], Basuki Rahmat[3)]
[1*),3)] Program Studi Teknologi Elektro Medis Program Diploma Tiga, Fakultas Kesehatan dan Keteknisian Medik, Universitas Widya Husada Semarang, Indonesia
[2)] Program Studi Teknik Elektro, Fakultas Teknik, Universitas Pawyatan Daha Kediri, Indonesia
[1)*]safira@uwhs.ac.id, [2)] mohammadalfianmudzakir@updkediri.ac.id , [3)]basuki.rahmat@uwhs.ac.id

ABSTRACT

Solar panels are a medium that can convert solar energy into electrical energy. In this research, the solar panel system in the fish pond is used as air requirements for the survival of the fish so that the air supply is sufficient. The problem is that fish farming has cloudy water due to decreasing temperatures due to lack of irrigation. This condition really requires water flow using a pump to circulate water in the fish pond. Therefore, solar panels are needed to drive the water circulation pump, where these solar panels are an alternative energy source to replace electricity from the State Electricity Company (PLN).The purpose of using a solar panel system is as alternative energy that can supply a pump motor which functions to channel water from the well to the pond to keep it flowing. This is used as alternative electrical energy to replace energy sources originating from the State Electricity Company (PLN) and to reduce operational costs of electrical energy. The method used is to assemble and install 2 units of 100WP solar panels, then testing is carried out to measure the panel output power from 06.00 to 17.00. The average result of measuring solar panel power every 30 minutes is 24.48Watts per day, this condition was when the test was carried out when the weather was less sunny. However, this can still change to get maximum power depending on weather conditions, especially when the sun is hot.

Keywords: Solar Panel; Electricity; Water pump; Energy; Economical Cost

1. INTRODUCTION

Water management is very important in the process of fish farming, the volume of water will affect the development of fish health. The availability of water greatly affects the sustainability of managing fish livestock, this must also be supported by the location and season, ponds with higher elevations than irrigation require irrigation methods that are able to channel water from the bottom to the pond (Safira Fegi Nisrina, n.d.). The problem is that fish farming requires irrigation using a water pump and energy costs for daily operations, which in this case requires high enough electricity costs to affect income.

Bandarjo fish farm, located in Ungaran City, Semarang Regency, is a fish farm whose air color is too thick or murky due to the temperature dropping due to water holes. In this situation, irrigation is really needed using a pump to circulate the air in the pond. Therefore, solar panels are needed to drive the air circulation pump, where these solar panels are an alternative energy source to replace electricity from National Electricity Company (PLN) (Wasono et al., 2024).

Solar panels are a core renewable energy power generation device, which has the main function of converting sunlight into electrical energy. In accordance with the energy law which has the main objective of suppressing the production of carbon waste into the air, so solar panels are one of the options when the regulation of the law has taken effect and is now starting to be implemented in stages. Solar energy is an energy source that is unlimited and will never run out of availability and this energy can also be utilized as an alternative energy that will be converted into electrical energy, using solar panels . Solar energy as an alternative source of electrical energy can be utilized by people who need electrical energy, but are constrained by the unavailability of electrical energy (Arifin et al., 2022). Solar panels that will be used in this study are suitable to be applied in Indonesia, because Indonesia is located in the equatorial region and has a tropical climate (Sartono et al., 2021).

So in this research, the author applies solar power as an alternative energy to replace electricity from National Electricity Company (PLN) with the main objective of reducing the cost of electrical energy as the operation and use of equipment, and the use of management of an MPPT (maximum power point traking) tool with the main purpose of

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absorbing the maximum possible power and feeding the battery or load, in accordance with the location in Indonesia with a tropical climate and a fairly long solar heat time can support the use of solar panels more efficiently .

2. LITERATURE REVIEW

Utilizing solar panel technology in fish farm irrigation can significantly reduce electricity costs and promote sustainability. Solar panels can be employed to power various irrigation systems, such as aerators for fishery fields (Muramulla et al., 2022), water pumps for irrigation farming (Calise et al., 2023), and ring irrigation systems for crop growth (Nasution et al., 2022). These systems not only reduce electricity expenses but also contribute to environmental conservation by utilizing renewable energy sources (Al-Rawashdeh, 2023). Agrivoltaic systems, which combine agriculture with solar power production, have shown promising results in enhancing land use efficiency and increasing solar panel efficiency (Shepard et al., 2022). By integrating solar panels into irrigation systems, farmers can optimize energy consumption and improve overall efficiency (Okomba, 2023; Y. E. Prasetyo et al., 2023; Putrawan et al., 2021). Moreover, the use of solar energy in irrigation can help meet crop water requirements during peak demand periods, aligning with sustainable agricultural practices (Golmohamadi, 2022). Efforts to enhance the efficiency of solar power generation in agricultural applications, such as automatic drip irrigation systems (Iskandar et al., 2023), and the integration of solar energy with smart farming practices (Ayundyahrini et al., 2023), demonstrate the potential for significant energy savings and improved crop yields. Additionally, advancements in solar panel cooling technologies have led to increased energy conversion efficiency, further enhancing the viability of solar-powered irrigation systems (Bhat et al., 2022). The research GAP is the integration of solar panel technology in fish farm irrigation not only reduces electricity costs but also promotes sustainable agricultural practices. By harnessing solar energy for irrigation purposes, farmers can achieve cost savings, increase efficiency, and contribute to environmental conservation.

3. METHOD

In this research, research methods were carried out, namely direct observation and measurement trials on solar panel power, literature studies of journals, scientific papers, case studies from various sources.

1. Observations
   Identifying the needs and problems that exist in Bandarjo, West Ungaran related to the fields of energy and technology in fish farming processing. The data obtained after observation is the need for air, pumps, electrical energy, land area, operational activities in fish farming.
2. Design
   Design in Community Service activities includes the creation of a solar panel system.
3. Installation
   InstallationCarry out installation and electrical installation of solar panels for fish pond irrigation.
4. Testing
   Testing is carried out by measuring the electrical power of solar panels every 30 minutes from 06.00 to 17.00

Tools and Materials

This research was conducted in Bandarjo, West Ungaran, Central Java. The tools and materials needed for the design include:

a. MPPT in this test system is used to absorb the maximum power generated by solar panels, because changes in sun power illumination levels change every time, it is expected that the MPPT system can work dynamically in finding the maximum power point (Swatara Loegimin et al., 2020)
b. Solar Panel Solar Panel The device used to absorb solar radiation in research with silicon type with plicrystalline silicon type (Triyanto et al., 2023). Capacity in use is 100 WP by adjusting the usage load, namely a 22 Watt DC motor.
c. The battery used is an 18650 ion battery with a value of 3S 1P, which means arranged in series 3 times and in parallel 18 times, the battery dimensions per cell are 2800mah, the type of battery used is lithium ion with good power usage and long life.

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d. BMS (Battery Management System) To manage voltage balancing on each sell in lithium ion batteries (Said et al., 2022).
e. The water pump used uses a 12V voltage with a power rating of 22 Watts at maximum speed, in the application only 6 Watts of power is used to adjust the speed of the flowing water. The water pumps used in this research are 2 pumps that function to drain water with the aim of draining water from the well to the pool, then 1 pump is only as a backup for when the maximum power works.
f. Arduino Uno The arduino circuit is the control center of the system (Primaini et al., 2022)Arduino will receive input from solar panels, this Arduino serves to regulate the temperature
g. The temperature sensor, connected to the Arduino board and the temperature detected by the sensor will be displayed on the LCD screen or serial monitor.

Solar Panel System Design

Based on the background described, a series of block diagrams can be drawn up in Figure 1 as a sequence of work steps of the equipment.

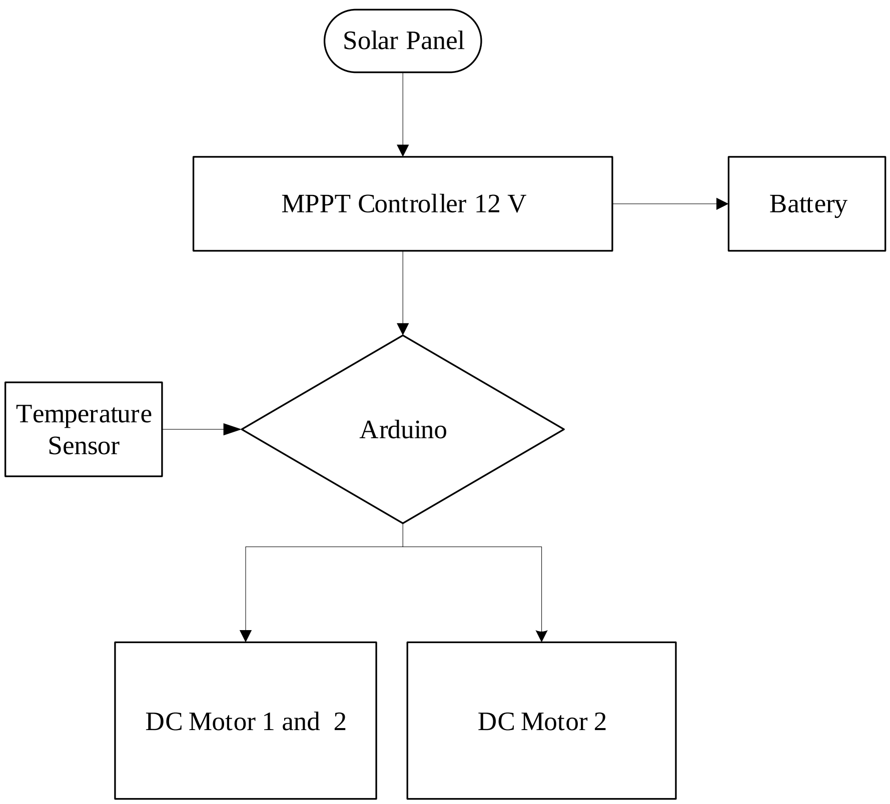

Fig.1. Block Diagram of Solar Panel System

Solar panels work based on the size of the intensity of sunlight that hits the solar panel, so that the terminal of the solar panel captures electrons converted into electrical potential energy At the output of the solar panel is a direct current (DC) whose output voltage depends on the number of solar cells installed and how much sunlight intensity can be absorbed by the solar panel (Saleh Al Amin et al., 2022).

This solar panel produces electrical energy that can be used directly to a DC voltage source with a smaller current and voltage, so that the energy obtained can be used as when it is a nighttime condition when the solar panel does not get sunlight supply (Sundaru et al., 2019). The electrical energy generated by the solar panel will produce the maximum power captured and measured on the MPPT or commonly referred to as the solar charger controller (Ahmed et al., 2021; Sadikun, 2021) , serves to regulate the output voltage of the solar panel and the current entering the battery

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automatically, then also functions as a voltage and current breaker from the solar panel to the battery. (Sundaru et al., 2019).

Furthermore, the electrical energy generated from solar panels is connected to a device, namely as a storage medium, in this case using a battery, the battery in the solar battery system is used as a component that stores direct current (DC) energy during the day, then will supply to the electrical load at night or when the weather is cloudy (not sunny) (Gunoto & Sofyan, 2020).

Solar panels that work to capture heat from sunlight as an input to the temperature sensor because during the daytime sun, the peak electrons are exposed (Haldianto et al., 2023). In this case there will be two conditions, the first situation is when the temperature is below the limit, the Arduino will set the relay 1 so that the load on pumps 1 and 2 connected parallel will turn on. The second situation is when the temperature sensor gives input to Arduino uno with High logic, so that Arduino uno regulates the ignition of relay 2 to turn on pump 3.

Arduino Uno System Design

Based on the solar panel system blog diagram that has been outlined above, the following is an explanation of the Arduino uno system design

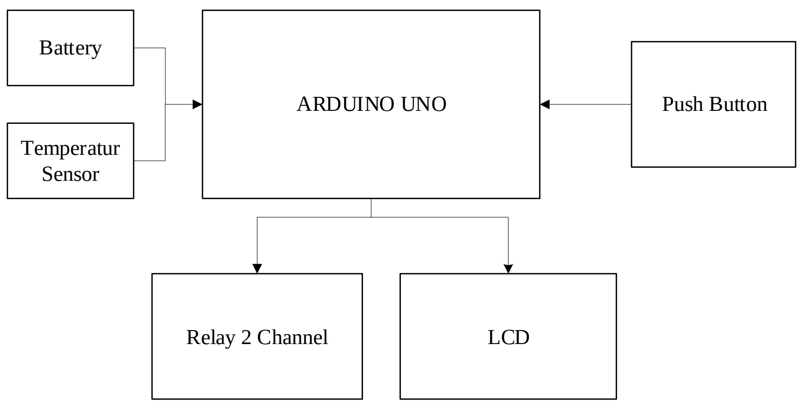

Fig. 2. Arduino System Block Diagram

The battery becomes the main supply in the solar panel system component that stores direct current (DC) energy during the day, and the temperature sensor functions to read the temperature on the solar panel to the maximum limit that has been determined based on the temperature specifications, namely the maximum limit of 65 °. (W. Y. Prasetyo & Nurpulaela, 2022). Furthermore, it is connected to the Arduino uno then, in a state of temperature below the limit, the arduiono will set the relay 1 so that the load on pumps 1 and 2 connected parallel will turn on. while in the state of the temperature sensor gives input to the Arduino uno logic High, so that the arduino uno sets the relay 2 to turn on pump 3 and the temperature detected by the sensor will be displayed on the LCD screen.

Realization of Manufacture Utilization of Solar Panel Technology

Solar panel manufacturing includes the following steps:

1. Assembling All Solar Panel Devices
2. Assembling the Arduino system
3. Setting the Output and Input Voltage Parameters of the MPPT
4. Measuring Working Voltage
5. Analyzing Power per half hour

Testing Hardware

Tool testing includes:

1. Battery Voltage Testing (Charging and Discharging)

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Battery Voltage Testing is done by measuring the voltage before installation and after installation of the resulting battery, whether it is in accordance with the expected specifications.

2. Testing the Measurement Points on each Module
   Testing the Measurement Points on each is done so that they can work as needed.
3. Temperature Control Testing
   Testing at this point is primarily to turn on the load triggers on the water pump
4. Arduino uno system testing
   Testing on this system serves to instruct the temperature sensor to work
5. Overall System Testing
   Testing the entire system is done to check the reliability of the tool before use.
6. Analyzing Power
   At this stage, power monitoring on solar panels is carried out every hour of the day.
7. Power Calculation
   Then the calculation of the electricity that will be paid by assuming one month, we can find out the savings in electricity usage by not using solar panels.

Power Calculation Formula

Determining Power from Measurements Based on Sunlight Intensity

a. Calculation of Peak Watts (WP) from Solar Measurements

$$\text{P average} = \frac{\text{W1+W2+W3+}\cdots\text{.........W23}}{23} \quad (1)$$

b. Calculation of Peak Watts (WP) from Solar Measurements per Month

$$\text{P out total per month (kWh)} = \text{P average x hours x 30 days x 2 panels} \quad (2)$$

c. Calculation of Economic Costs Generated from Solar Metering in a Month

$$\text{Saving} = \text{Pout total (kWh)x Rp. 1.444,7 per kWh} \quad (3)$$

Determining Power from Electricity Cost per Kwh from PLN in Monthly Calculations

$$\text{Ptotal} = \text{P out (watt)x hours x 30 days} \quad (4)$$

a. Economic Cost Calculation Using Electricity Cost per KwH from PLN in Monthly Calculation

$$\text{Saving} = \text{Pout total(kWh)x Rp. 1.444,7 per kWh} \quad (5)$$

Advantages After Using Solar Panel System

$$\text{Total Cost} = \text{Previous electricity costs (PLN)} + \text{Cost of Panel System} \quad (6)$$

4. RESULT

In this discussion chapter, a test will be carried out, first testing for direct power measurement with the help of a load in the form of a battery for charging and using a 12V 22Watt dc water pump. Recording is done by measuring every 30 minutes.

Testing Results

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In this study has the aim of obtaining data on the results of pure output power by directly giving the load of the battery that has been assembled. This data is taken in accordance with the time sequence that has been determined, namely every 30 minutes, from 06.00 WIB to 17.00 WIB.

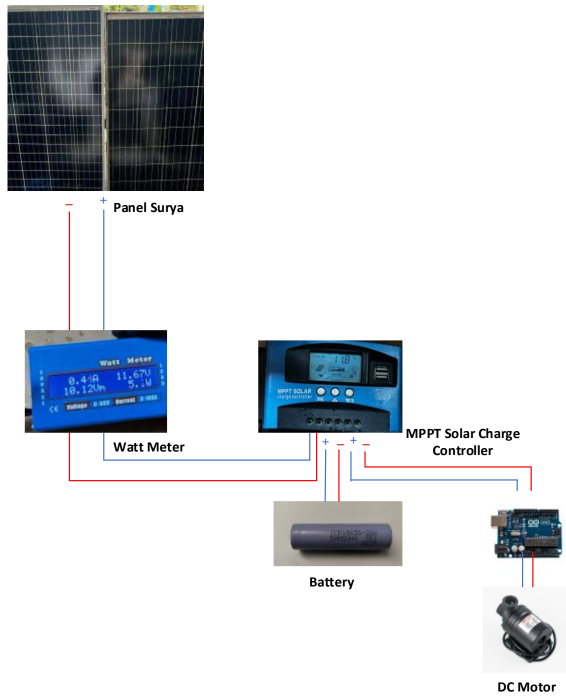

Fig. 3. Single Line Diagram of Solar Panel System

Fig. 4. Solar panel device when installed

Referring to Figure 1, there is a single line diagram of solar panel equipment that has been assembled in such a way that the output power data is proportional to time.

Table 1

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Power Measurement Testing on Solar Panels

No.	Time	Current	Voltage	Power
		A	V	Watt
1	06.00	0	11,55	0
2	06.30	0,1	11,58	1,15
3	07.00	0,31	11,7	3,62
4	07.30	0,67	11,9	7,97
5	08.00	0,66	11,45	7,55
6	08.30	1,18	11,6	13,68
7	09.00	2,17	12,07	26,19
8	09.30	3,14	12,59	39,53
9	10.00	2,61	12,56	32,78
10	10.30	3,19	12,82	40,89
11	11.00	5,23	12,25	64
12	11.30	5,3	12,3	65,19
13	12.00	5,26	12,15	63,91
14	12.30	5,23	12,35	64,59
15	13.00	3,35	11,74	39,33
16	13.30	3,27	11,67	38,16
17	14.00	3,5	11,63	40,71
18	14.30	0,42	12	5,04
19	15.00	0	10,35	0,00
20	15.30	0	11,62	0,00
21	16.00	0,44	11,67	5,13
22	16.30	0,32	11,52	3,69
23	17.00	0	10,94	0,00

In Table 1, the power measurement test on the solar panel can be seen that the power measurement results were carried out 23 times or half an hour from 06.00 to 17.00 WIB, on the measurement test carried out on that day is with the state of sunlight intensity that is not bright, so the average power produced is not optimal. This test includes Current (A), Voltage (V) and Power (W). The maximum power observation result produced was 65.19 Watt at 11:30 WIB, and the lowest result was 0 Watt at 06.00 and 17.00 because the sun was not bright.

DISCUSSIONS

Data Calculation Analysis Economics of Solar Panels

The calculation analyzed for the first is taken from table 1 of the power measurement test on the solar panel, in this case the state of sunlight intensity on that day was not bright, so the power generated tended not to be optimal. The following is an economic calculation for solar panel systems when assumed to a monetary value of Rp.1444.7 (Nisrina & Sari, 2023).

a. Calculation of Peak Watts (WP) from Non-Bright Sun Measurements per Day

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$$\text{Pout average} = \frac{\begin{matrix}0 + 1{,}15 + 3{,}62 + 7{,}97 + 7{,}55 + 13{,}68 + 26{,}19 + 39{,}53 \\ +32{,}78 + 40{,}89 + 64 + 65{,}19 + 63{,}91 + 64{,}59 \\ +39{,}33 + 38{,}16 + 40{,}71 + 5{,}04 + 0 + 0 + 5{,}13 + 3{,}69 + 0\end{matrix}}{23}$$

$$= \frac{563{,}11}{23}$$
$$= 24{,}48 \text{ Watt}$$

b. Calculation of Peak Watts (WP) from Non-Bright Sun Measurements per Month
$$\text{P out total per month} = 24{,}48\text{watt x 11 hours x 30 days x 2 panel}$$
$$= 16.156{,}8 \text{ Watt hour}$$
$$= 16{,}1568 \text{ Kilo Watt hour (kWh)}$$

c. Calculation of Economic Costs Resulting from Measuring Unclear Sun per Month

$$\text{Saving} = 16{,}1568 \text{ kWh x } 1.444{,}7 \text{ per kWh}$$
$$\text{Saving} = \text{Rp. } 23.341{,}72$$

Economic Analysis Calculation Data on Solar Panels When Peak Power is Reached

The calculation analyzed for the second is taken from the specifications of the solar panel, namely the maximum power of the solar panel, which is the sum of the Voltage multiplied by the Current of 100.08 Watt, in this case the state of sunlight intensity is assumed to be bright, so that the maximum power is generated. The following is an economic analysis calculation for solar panel systems when assumed to a monetary value of Rp.1444.7.

a. Calculation of Peak Watts (WP) from Bright Sun Measurements Maximum Power When the Sun is Bright in per Day
$$\text{Pout average} = \frac{100{,}08 \text{ x } 23}{23}$$

$$= \frac{2.301{,}8}{23}$$
$$= 100{,}08 \text{ Watt}$$

b. Calculation of Watt Peak (WP) from Maximum Power Measurement When the Sun is Bright in per Month
$$\text{P out total per month} = 100{,}08 \text{ watt x 11 hours x 30 daysx 2 panel}$$
$$= 66.052{,}8 \text{ Watt hour}$$
$$= 66{,}0528 \text{ Kilo Watt hour (kWh)}$$

c. Economic Cost Calculation Resulting from Maximum Power Measurement When the Sun is Bright in per Month
$$\text{Saving} = 66{,}0528 \text{ kWh x } 1.444{,}7 \text{ per kWh}$$
$$\text{Saving} = \text{Rp. } 95.426{,}4$$

Economic Analysis Calculation Data Using Electricity Cost per Kwh from PLN in Monthly Calculation

The following is an economic analysis calculation of the purchase of PLN electrical energy before using a solar panel system. When converted to monetary value with the assumption per kWh of Rp.1,444.7. And using 290 Watts of Input Power .

$$\text{Ptotal} = 290 \text{ watt x 11 hours x 30 days}$$
$$= 95.700 \text{ watt hour}$$
$$= 95{,}7 \text{ kilo watt hour}$$

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Economic Cost Calculation Using Electricity Cost per KwH from PLN in Monthly Calculation

$$\text{Saving} = 95{,}7\ \text{kWh x } 1.444{,}7 \text{ per kWh}$$
$$\text{Saving} = \text{Rp. } 138.257{,}7$$

Advantages After Using Solar Panel System

In this calculation, the calculated amount of electricity usage before the installation of solar panels is taken from the PLN electricity calculation data summed up with the results of the valid solar panel system costs, namely the assumption when using the maximum power taken based on the solar panel specifications that have been listed.

$$Total\ Cost = Previous\ electricity\ costs\ (PLN) + Cost\ of\ Panel\ System$$
$$Total\ Cost = Rp. 138.257{,}7 + Rp. 95.426{,}4$$
$$= Rp. 233.684{,}1$$

By using the previous amount of savings, it is assumed that the solar panel will produce 66.05 kWh of electrical energy, then the electrical energy can be fully used by the fish farm waters, and for the price of electricity per kWh of PLN IDR 1,444.7 / kWh, then the money to make 2 units of 100WP solar panels will return to capital, so as to reduce the production costs of fish farms .

5. CONCLUSION

After the research is carried out, there is a conclusion, namely the size of the light intensity generated from solar panels affects the size of the maximum power or peak power of solar panels, so that the average electric power generated by 2 units of 100 Wp solar panels is 24.48 Watt in conditions the weather is not sunny (cloudy), then the average electric power of solar panels assuming 100.08 Watt is taken from the specifications of solar panels.In the tests that have been carried out, the peak power can be reached at 11.30 WIB of 65.19 watts and the lowest at 06.00 and 17.00 which is 0 watts, and the total cost of savings obtained is taken from the total calculation before the installation of the solar panel system (use of PLN electricity) summed up with the calculation of solar panels when using maximum power, so that when converted to monetary value obtained Rp.233.684 per month..684 per month.

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* Safira Fegi Nisrina