INNOVATIVE JOURNAL
OF INTELLIGENT CONTROL AND OPTIMIZATION FOR ELECTRICAL SYSTEM
Vol. 2 (2025) No. 1
Publisher by AITEKS : Aliansi ahlI TEKnologi dan Sains
https://ijcioes.org/index.php/ijcioes

Utilization of Solar Power Plants (PLTS) To Operate DC Pumps 250 Watts For Irrigation of Rice Fields in Nagari Batu Taba

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***Abstract*— Indonesia has a very abundant source of renewable energy, namely solar energy. This energy can be converted into electricity using photovoltaic (PV) technology in a system called Solar Power Plants (PLTS). The use of solar power plants in rice field irrigation systems is an environmentally friendly solution that has the potential to increase efficiency in the agricultural sector. The purpose of making this tool is to evaluate the performance of a 250 watt DC pump operated with energy from a 600Wp monocrystalline solar panel, as well as to control the system and use the battery as a storage of electrical energy generated by the solar panels. The test is carried out by measuring the intensity of sunlight, current and voltage from solar panels, as well as current and voltage in the battery. The data obtained were analyzed to determine the reliability and efficiency of the system in meeting irrigation needs for rice fields. The results obtained show that the solar panels can meet the needs without experiencing voltage drops, and the system is able to operate the DC pump stably during the day. With this optimal performance, the system can fill an 800-liter tank in 4.6 hours. The application of this system to rice field irrigation can be an alternative for farmers who are far from conventional electricity access and reduce their expenses.**

***Keywords*— Renewable Energy, Solar Panels, Irrigation, Monocrystalline, DC Pump.**

Manuscript received 31 Oct. 2024; revised 29 Feb. 2025; accepted 20 Mar. 2025. Date of publication 30 Jun. 2025.

I. INTRODUCTION

New Renewable Energy (NRE) or New Sustainable Power is an environmentally friendly energy source and does not damage the ecosystem, in contrast to fossil energy which tends to pollute the environment. Examples of renewable energy include energy from sunlight, wind, water, biofuels, geothermal, biomass, and seawater tides [1]. The intensity of solar radiation is affected by the rotation of the earth, weather, cloud quality, and the change of seasons from hot to cloudy, as well as the position of latitude. In Indonesia, sunlight radiation lasts about 5 hours per day [7]. One type of power plant that uses sunlight to produce energy is called solar power plants (PLTS). On residents' rice fields, sunlight, one of the abundant renewable energy sources in nature, is often used to generate electricity as a substitute for electricity from the National Grid, especially in areas far from residential areas. For those looking to create sustainable electrical energy, these solar panels offer an environmentally friendly replacement. These solar panels are an eco-friendly way for an environmentally friendly replacement for those who want to provide sustainable electric power

A. Solar Panels

Solar panels are devices that function to convert solar energy into electrical energy. This tool is made of semiconductor materials, especially silicon, which are coated with special additives. When sunlight hits the surface of the solar panel, the electrons will detach from the silicon atoms and move to form an electric current, so that electrical energy can be generated. The working principle of photovoltaic cells is highly dependent on the amount of sunlight received. Solar panels generate an electric current that can be used to charge the battery. The main component of solar panels is photovoltaic cells, which generate electricity based on light intensity. When the intensity of light decreases, for example when the weather is cloudy or rainy, the electric current produced will also decrease [9]. This test uses solar panels with a monocrystalline type. Solar panels with monocrystaline type have better efficiency compared to polycrystaline solar panels with a difference of 2%. The average efficiency of monocrystalline solar panels is 14%, while polycrystalline panels are 12%. From the test, it can be concluded that monocrystaline type solar panels are the best type to be applied [2].

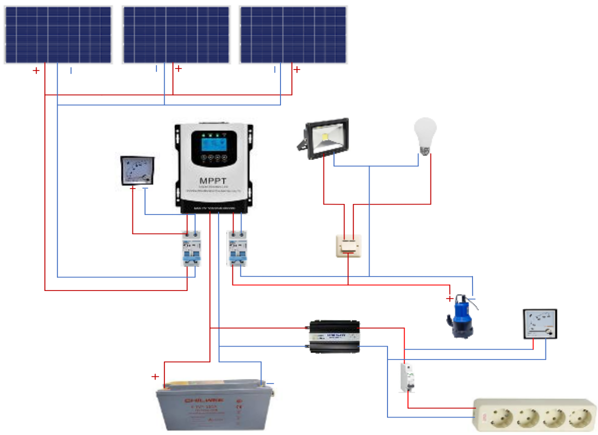

FIGURE 1. Solar Panel Installation Along with other Supporting Components

B. Controler

Controler Maximum Power Point Tracking (MPPT) is a method used on charge controllers in wind power generation systems and solar power systems to optimize the power voltage generated from the source. MPPT converts the higher DC voltage of the solar panel into a lower voltage suitable for battery charging. This device also stabilizes the output voltage from the solar panel so that it can be efficiently channeled to the battery, as well as adjusting the voltage based on the condition of the battery. The actual power output produced can vary depending on weather, temperature, and other factors [3].

C. Battery

A Battery is a device that stores energy that can be converted into electrical power using an electric cell. Batteries generate electricity through chemical reactions. Batteries operate as a type of electrical cell that allows for the reversal of highly efficient electrochemical reactions [4].

D. Inverter

An inverter is an electronic device that can convert DC (Direct Current) voltage into AC (Alternating Current) voltage. The source for the inverter can come from the battery [6]. In inverter components, there are parts that use controllers such as PWM and SPWM.

E. Water Pump

SPATS is a pumping system for water or fluids that uses a direct current (DC) motor to drive the pump. The pump functions to move fluid from a low pressure or position to a higher pressure or position. Based on the installation location and water depth, pumps are divided into two types: surface mounted pumps and deep well pumps. Surface pumps are capable of sucking water at a depth of 10 to 20 feet, while submersible pumps designed specifically for solar panels (PV) have an overall efficiency of between 30-70% [8].

II. METHOD

A. Research Stages

1. The first step in this flowchart is to identify the daily load needs and calculate the load needs to be used.
2. The next step is to select components based on calculations that have been carried out to ensure that all components meet the specifications during the trial.
3. The assembly of the solar frame aims so that during the test, the three solar panels receive light with the same intensity.
4. Current and voltage testing of solar panels; If it is not legible during testing, check the cable or terminals to make sure they are installed correctly. Once the voltage and current are read, record the test result data.
5. The second test, test the water pump with the solar panel source connected to the MPPT, then take measurements on the current and voltage of the solar panel, battery and load and then record the test result data.

6. The third test, turn on the water pump using the source from the battery; measure the current and voltage on the battery and the current on the load, and record the test results.
7. The fourth test, measure the intensity of sunlight during the test, and record the data obtained.
8. Based on the data from the test, perform an analysis of the current, voltage, and light intensity (lux) of the sun

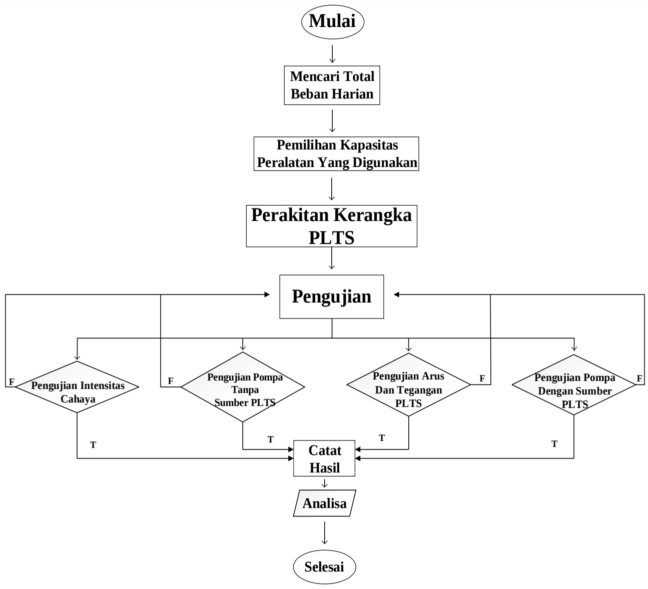

FIGURE 2. Research Flow Diagram

B. *Electrical Design on Off-Grid Solar Power Plants*

In the design of Off-Grid Solar Power Plants, several calculations are needed to carry out the design, among others.

TABLE I
Calculation of Electricity Capacity Used

No	Burden	Amount	Power (W)	Usage Time (hours)	Energy Consumption (Wh)
1	Dc Pump	1	250	5	500
2	SpotLights	2	20	11	440
3	Light Blub	2	15	11	330
			Total		1270 Wh

From table 1 above, the total daily load is 1270 Wh, so it must adjust the energy consumption needs with the solar panels to be used

1) Solar Panel/ Photovoltaic Design

In Indonesia, solar energy that can be absorbed and converted into electricity for battery charging generally lasts for about 5 hours per day. The type of solar panel used is monocrystalline because it has higher efficiency compared to polycrystalline. To calculate the need for solar panels, electrical energy consumption is divided by the optimal charging time, which is 5 hours. With an estimated electrical energy consumption of 1270 Wh, solar panels are needed as follows

$$\text{Solar Panel Capacity} = \frac{total\ dialy\ load}{5\ hours} \tag{1}$$

$$= \frac{1270\ watt/hours}{5\ hours}$$

$$= 254\ Wp$$

To get the desired power, we need to prepare a solar panel capacity of 254 Wp, but solar panels on the market are in the range of 100Wp, 200Wp to 500 Wp. We use solar panels with a capacity of 200Wp

$$\text{Number of Solar Panels} = \frac{254\ Wp}{200\ Wp}$$

= 1,27 round into 2 pieces

From the calculation above, the number of panels used is 2 pieces with a capacity of 200 Wp. In order to make the process of charging the battery faster, 3 200 Wp solar panels are used.

2) Maximum Power Point Tracking Design

From the calculation above, the number of panels used is 2 pieces with a capacity of 200 Wp. In order to make the process of charging the battery faster, 3 200 Wp solar panels are used.

$$\text{MPPT Capacity} = \frac{\textit{Solar Panel Power}}{\textit{Voltage System}} \quad (2)$$

$$= \frac{600\ Wp}{12\ Volt}$$

$$= 50 \text{ A}$$

After determining the value using the formula above, we use MPPT with a rating of 50 A.

3) Battery Capacity Design

An important part of the solar energy system is the battery. Batteries are not necessary for every solar power system, although they can help deliver electricity around the clock. When choosing a battery for a solar PV system, there are a number of factors to consider. The type of battery used in this device is Narada Valve Regulated Lead Acid Battery. The calculation of battery requirements is carried out as follows:

$$\text{Battery Capacity (Ah)} = \frac{\textit{Total Energy Requirements}}{\textit{Voltage System}} \quad (3)$$

$$\text{Battery Capacity (Ah)} = \frac{1270\ Wh}{12\ Volt} = 105 \text{ A}$$

From the calculation results, the capacity of the battery used is 126 A, assuming the use of the pump is limited to 2 hours at night and the use of lighting lights can be used for 11 hours.

C. Solar Panel Testing

In this test we use 3 solar panels with a capacity of 200Wp each with a monocrystalline type, data collection is carried out for 6 hours from 09.00 to 15.00 with a data collection time span of 30 minutes, we take data on sunlight intensity, solar panel voltage, solar panel current, battery current and load current. This measurement was carried out on July 25, 2024 with the following measurement:

Measurement of Sunlight Intensity (a) | Voltage Measurement (b) | Current Measurement (c)

FIGURE 3. Part a Sunlight Intensity Measurement, part b current and part c Solar Panel Voltage Measurement

Seen in Figure 3 is the collection of sunlight intensity data received from solar panels, measurements using a Lux meter with a factor of x 1000 as well as current and voltage data collection generated from solar panels.

III. Result And Discussion

A. 1st Day Loaded and Unloaded Solar Panel Test Data

From Figure Graph 6 above Sunlight Intensity measured with a lux meter, the highest sunlight intensity on the first day was measured at 13.30 at 933 lux. On the first day of testing, the intensity of sunlight tended to be more stable than on the second day. On the first day of measurement, the percentage of hot conditions dominated by 54% while sunny conditions by 46% allowed the solar panels to work optimally, producing electrical power close to the maximum capacity for which they were designed. The system can produce more electricity and meet the required energy needs

TABLE II
Loaded vs. Unloaded Solar Panel Test Data

No	Hour	Light Intensity (Lux)	PV Voltage	PV Current	Battery Current	Load Current (A)	Note
1	09.00	600	19,71	6,5	7		Bright
2	09.30	727	19,29	5,5	6,4		Hot
3	10.00	734	19,12	3,6	6,2		
4	10.30	788	17,82	10.1	9,5	9,1	Hot
5	11.00	781	17,51	9	8,9	9	
6	11.30	611	16,11	8.2	8,5	8,8	Bright
7	12.00	868	19,18	5,9	5,5		Hot
8	12.30	581			4,7	8,6	Bright
9	13.00	819			4,5	8,5	Hot
10	13.30	933			4,3	8	
11	14.00	602	18,68	9,2	10,1		
12	14.30	654	18,5	4,1	5,2		Bright
13	15.00	550	17,22	1,9	2,9		
Amount of % intensity of sunlight							46% (Bright) 54% (Hot)

In Figure 7, it can be seen that the voltage conditions measured with the multimeter fluctuate from time to time. The measured peak voltage of the solar panels occurred at 09.00 WIB and 09.30 WIB.

Table 2 shows that the voltage generated by the solar panels before loading remains constant at 19 volts. The voltage generated by solar panels often fluctuates, up and down, based on the amount of sunlight received during the test, which is carried out from 10.30 WIB to 11.30 WIB with a load in the form of a DC pump. The second test was conducted with a DC pump that operated continuously, but a battery supply was used to power the pump instead of a solar panel supply. At 2:00 p.m., the test was complete, the pump load was removed, and the solar panel was reinstalled in place to charge the battery.

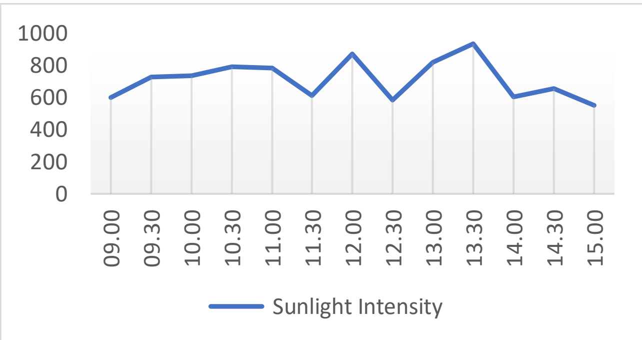

FIGURE 6. Sunlight Intensity Graph

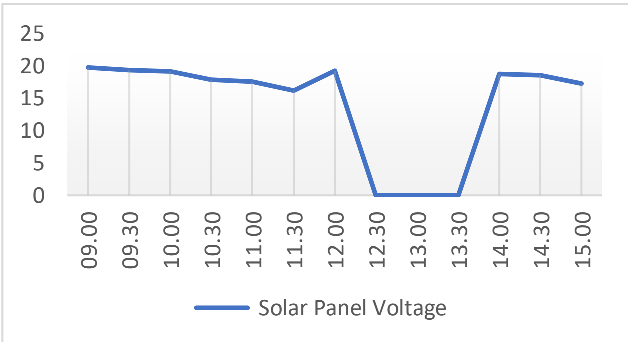

FIGURE 7. Solar Panel Voltage Chart

Based on Figure 8 The graph in blue above is the peak current of the solar panel measured from the amperage pliers at 10.30 WIB of 10.1 A, when the load is turned on, this large current is used to charge the battery with the source of the solar panel still attached. At 12.30 WIB to 13.30 WIB, the source from the solar panel is released for data capture without a source from the solar panel. At 14.00 WIB, the source from the solar panel was turned back on and a measurement of 9.2A was obtained.

From the orange graph is a graph of the battery current measured with amperage pliers, at 09.00 WIB to 10.00 WIB the battery is charged. At 10.30 a.m. to 11.30 a.m., the load of the DC pump was turned on for 1 hour, which caused the battery current to increase to 9.5A with the source form the solar panel still connected. At 12.30 WIB to 13.30 WIB, a load test was carried out on the pump without a source from the solar panel, the battery current remained stable at 4.5A, at 14.00 WIB, the load from the pump was released and the source from the solar panel was installed to charge the battery, the measurement current read on the amperage pliers after the test was carried out at 10.1 A.

It can be seen in Figure 9 above that the test was carried out 2 times using a source from solar panels and also without a source. Seen in the blue graph is the load current using the source from the solar panel, the current that flows for 1 hour towards the load remains stable at 9A. The second test seen in the Orange graph was carried out without the source of the solar panel the rated load current every 30 minutes decreased because the source for charging the battery had been dissconetion

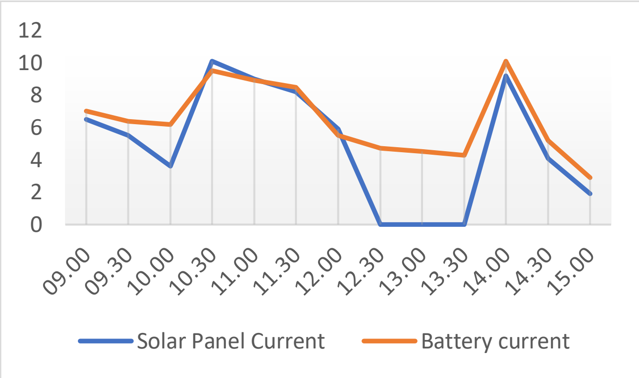

FIGURE 8. Current Generated by Solar Panels and Current in Batteries

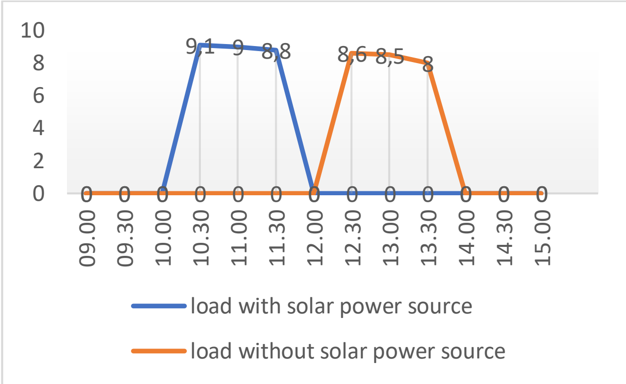

FIGURE 9. Charts With And Without Solar Panel Source

B. Calculation of Filling Tekmon Air 800 Liters

The calculation for filling a water tank with a water capacity of 800 liters fills per liter is 2.1 seconds. The calculation is as follows:

Charging Time = (60 seconds : 21 seconds/ liter) (4)

$$\text{Charging Time} = \frac{60 \text{ seconds (1minute)}}{21 \text{ seconds/liter}}$$

= 2.85 liter/minute

$$\text{Charging Time} = \frac{(800 \text{ liter})}{2.85 \text{ seconds/liter}}$$

= 280 liter/minute

$$\text{Charging Time} = \frac{(280 \text{ liter/minute})}{60 \text{ minute}} = 4{,}6 \text{ Hours}$$

So with a water capacity of 800 liters and a water speed in 1 liter of 2.1 seconds, it takes 4.6 hours to be able to fill 800 liters of water.

C. Battery Capacity Calculation

For the calculation of the battery capacity used, it cannot be 100% used because there is also a limit to each type of battery, such as in the battery used with the Narada Velve Regulated Lead Acid Battery brand. For maximum battery usage 90% and 10% losses during transmission from battery to load. With a battery capacity of 12V 100 Ah can be used as a 250 Watt DC pump suplay with the following calculations;

$$I = \frac{P}{V} \quad (5)$$

Information:

P = 250 Watts

V = 12 Volts

$$Arus = \frac{250\, Watts}{12\, Volts}$$

=20,8 Amper

$$Usage\ (hours) = \frac{Battery\ Capacity\ (Ah)}{Current\ (A)} \quad (6)$$

$$= \frac{90\ Ah}{20{,}8}$$

= 4,3 hours

So with a pump power of 250 Watts and with a usable capacity of only 90% of the battery, the battery usage time is approximately 4.3 hours. Calculation of pump load by adding 2 lighting lights with a power of 15 Watts each and spotlights 2 pieces with a power of 20 watts each. The total power usage is 320 watts with the following calculations:

$$I = \frac{P}{V} \quad (7)$$

Information:

P = 320 Watts

V = 12 Volts

$$Arus = \frac{320\, Watts}{12\, Volts}$$

=26,67 Ampere

$$Usage\ (hours) = \frac{Battery\ Capacity\ (Ah)}{Current\ (A)} \quad (8)$$

$$= \frac{90\ Ah}{26{,}67} = 3{,}7\ Hours$$

So, with a pump power and 320 Watt lighting with a usable capacity of only 90% of the battery, the battery usage time is approximately 3.7 hours.

D. Battery Charging Time Calculation

This battery is used at night and can only be used for only 90% of the total battery so as not to make the battery fast. For the calculation of the battery charging time, we take the maximum battery usage at the following calculations:

$$Ipanel = \frac{P}{V} \quad (9)$$

$$= \frac{600\ Watts}{12\ Volts}$$

= 50 Ampere

$$T = \frac{C}{I} x \frac{I}{\mu} \quad (10)$$

Information:

C = Battery Capacity (90Ah)

I = Charging Current (50 A)

μ = Efficiency 0,85

$$T = \frac{90\ Ah}{50\ A} x \frac{1}{0.85}$$

= 1,8 x 1,175 = 2,1 Charging Hours

So with the calculations that have been made, the battery charging time of 100 Ah with a maximum use of only 90% is obtained for a battery charging time of 2.1 hours

IV. CONCLUSION

1. To meet the power needs of 320 watts, we use 3 pieces of 200 Wp solar panels with the aim that the charging of the 12 Volt 100 Ah battery is faster and there is no voltage drop in the morning when the pump is turned on.
2. With a *capacity* of 800 liters of water and a water discharge per minute of 2.1 seconds, it takes 4.6 hours to fill an 800-liter water tank during the day

ACKNOWLEDGMENT

Thank you to the supervisors, labor technicians who have assisted in the research process of making tools as well as reports and journals, then thank you to the entire academic community of the Department of Electrical Engineering at the Padang State Polytechnic

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