INFOKUM
Volume 13, Number 06, 2025, DOI 10.58471/infokum.v13i06
ESSN 2722-4635 (Online)
https://infor.seaninstitute.org/index.php/infokum

Lithium Battery Efficiency Analysis in Solar Power Plants (PLTS) for Rice Field Irrigation Water Pumps

Deni Prabowo[1], Muhammad Erpandi Dalimunthe[2], Zuraidah Tharo[3]
Electrical Engineering Study Program, Faculty of Science And Technology, Pembangunan Panca Budi University, Jln. Jend.Gatot Subroto Km. 4,5 Medan Provinsi Sumatera Utara

Article Info
Keywords:
Lithium Battery Efficiency in Solar Power Generation

ABSTRACT
Solar Power Plant is a power generation system that uses solar energy to generate electricity. PLTS components consist of solar panels, solar charger controller, battery and inverter. Solar panels are used to convert solar energy into DC electrical energy. The solar charger controller functions to regulate the voltage value distributed to the battery. The battery is used to store electrical power and the inverter is used to convert DC current to AC. In its use, the components installed on the PLTS need to know the efficiency percentage so that the amount of electrical energy utilization that can be generated can be known. This study aims to analyze the efficiency of electrical energy generation produced by solar panels with a capacity of 250 WP and a 2000 W inverter. Tests were carried out 5 times within a 5-hour time span (10:00 WIB – 14:00 WIB) using a 350 W Water Pump load. The test results showed that the solar panels were able to produce an average power of 76.39 W, with the largest power reaching 86.55 W. The calculated solar panel efficiency was 15.13%. The battery efficiency, based on the highest power measured, reached 0.80%. The inverter's power output varied, averaging 919.6 watts, with the highest output reaching 935 watts.

Corresponding Author:
Deni Prabowo
Electrical Engineering Study Program, Faculty of Science And Technology, Pembangunan Panca Budi University, Jln. Jend.Gatot Subroto Km. 4,5 Medan Provinsi Sumatera Utara
prabowodeni03@gmail.com

INTRODUCTION

Solar radiation received by the Earth's surface is a fundamental input for many aspects, especially as a crucial parameter in the application of solar cells as power generators. The sun is a device that converts sunlight into electrical energy. Indonesia, located along the equator, receives abundant sunlight year-round, with an average solar radiation intensity of approximately 4.8 kWh/m² per day across the country. The use of solar energy for solar power plants (PLTS) is highly sought after and is being developed throughout the country, with extensive research and testing underway. This solar energy can be used to recharge batteries, thus reducing gas emissions that contribute to global warming. To realize this use of solar energy, a device is needed to systematically and monitor battery charging and usage, ensuring efficient use of the PLTS. A simple solar power plant converts sunlight into electrical energy. Sunlight is a form of energy from natural resources. This natural resource is already widely used to power communication satellites through solar cells. These solar cells can generate unlimited amounts of electrical energy directly from the sun, without any rotating parts and without the need for fuel. Therefore, solar cell systems are often described as clean and environmentally friendly. Solar cell systems used on the Earth's surface consist of solar cell panels, a charge controller circuit, and a 12- to 24-volt DC battery. A solar cell panel is a module consisting of several solar cells connected in series or parallel, depending on the size and capacity required. The battery charge controller circuit in a solar cell system is an electronic circuit that regulates the battery charging process. The controller can also regulate the battery voltage within a 12-volt range of 10%. If the voltage drops to 10.8 V, the controller will charge the battery using the solar panel as its power source. Charging occurs when there is sunlight. If the voltage drop occurs at night, the controller will cut off the power supply. After several hours of charging, the battery voltage will increase. When the battery voltage reaches 13.2 volts, the controller will stop charging. Based on a journal written by Rusman entitled The Effect of Load Variation on the Efficiency of Solar Cells with a Capacity of 50 WP and a journal written by Munnik Haryanti et al. entitled Solar Power Plants Using 50 Watt Solar Cells. In the PLTS, a battery arrangement is used that is not separated so that when charging it takes a long time, because the battery has a large capacity or exceeds the specifications of the panel used. The research uses a solar panel with a capacity of 50 WP with a charging voltage of 13.2 V, meaning the current flowing is 50 WP / 13.2 V = 3.79 A. If a battery with a capacity of 25 Ah is used, the time spent on charging is 25 Ah / 3.79 A = 6.6 hours or 6 hours 36 minutes, while the effective time of sunlight is 9 hours (07.00 WIB - 17.00 WIB) during this effective time the sun cannot shine every hour due to several factors, one of which is cloudy and rainy, so the battery cannot be fully charged in one day so that the use of large capacity batteries in the PLTS is inefficient, in this research a system will be designed that will control battery charging, and control the number of batteries used based on the load power and control the use of solar panels on the load so that the use of batteries in the PLTS can be more efficient.

METHOD

This research will utilize observation and data collection methods on solar panels and inverters over a period of time. The voltage, current, and power data obtained will be analyzed using statistical methods and other analytical techniques. The results will be used to determine the voltage and current characteristics, as well as the power efficiency of the solar panels, inverters, and batteries.

The solar power system used for data collection in this study consists of solar panels, a solar charger controller, batteries, an inverter, and a 175-watt water pump. Solar panels are the main component of a photovoltaic (PV) system, converting energy from sunlight into electricity. The electricity produced is direct current (DC). The power capacity of solar modules is measured in Watt-peak (Wp), which represents the maximum power a solar module can produce when the sunlight or solar radiation received is 1000 W/m2 and the ambient temperature is around 25°C. The power and current generated by the solar modules will fluctuate depending on the intensity of the sunlight received. The specifications of the solar panels used in this study can be seen in the table below:

Table 1. Solar Panel Specifications

Kreteria	Kapasitas
Maximum Power	250 WP
Optimum Operating Voltage	30,3V
Optimum Operating Current	8,25A
Short Circuit Voltage	36,3V
Short Circuit Current	8,75A
Ukuran Panel Surya	1645 x 995 x 50 mm

The inverter converts DC current from the solar module to AC current. The specifications of the inverter used in this study can be seen in the table below:

Table 2. Inverter Specifications

Kreteria	Kapasitas
Power Output	2000 Watt
Input Voltage DC	24 V
Output Voltage AC	220V
Frequency	50 Hz

Table 3. Battery Specifications

Kreteria	Kapasitas
Type	Aki Kering
Kapasitas	24 V
Dimensi	20 cm x 30 cm x 15cm

The power generated by the solar panels is stored in batteries and controlled by a solar charger controller based on the battery's charging voltage. To ensure the power generated by the solar panels can be used by loads such as water pumps, an inverter is used to convert DC current to AC.

RESULTS AND DISCUSSION

Solar Power Plant Current and Voltage Measurement Data

The power analysis results are obtained from the following calculation:

$$P = V.I$$

Where:
P = Power (Watts)
V = Voltage (Volts)
I = Current (Amperes)

The power analysis results for the solar panel output are as follows:

Table 4. Results of Solar Panel Output Power Analysis

Waktu (Wib)	Tegangan (V)	Arus (V)	Daya (Watt)
10	25,84	2,19	56,58
11	27,85	2,55	70,01

Waktu (Wib)	Tegangan (V)	Arus (V)	Daya (Watt)
12	29,98	2,59	86,04
13	30,16	2,87	86,55
14	30,10	2,75	82,77

Based on the results of the solar panel power calculations as in the table above, a graph of power against time can be made as in the figure below.

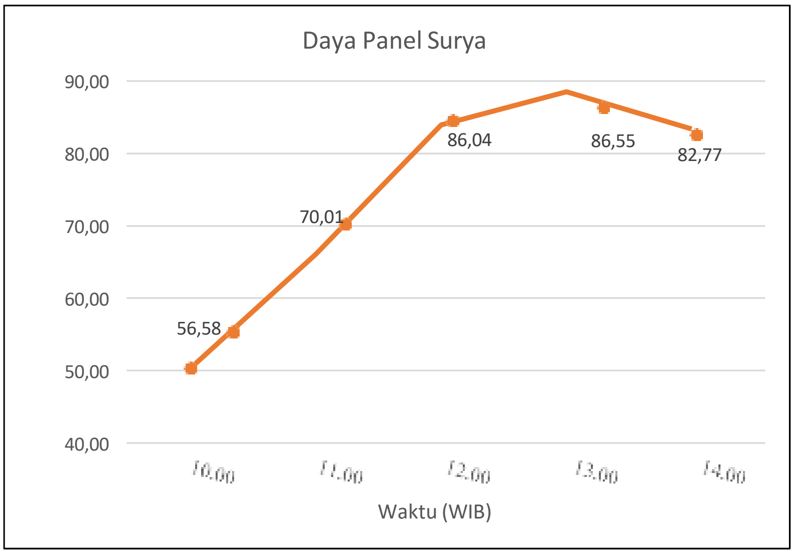

Figure 1. Hourly Solar Panel Power Graph

In the graphic above, there are 5 times of Solar Panel data collection. Each measurement is carried out by recording the power generated by the solar panel. Based on the figure, it can be seen that the solar panel output power varies with changes in voltage and current. The largest power generated is 86.55 W in the 4th measurement with a voltage of 30.16 V and a current of 2.87 A. This shows that the solar panel output power is affected by the intensity of sunlight radiation received, so that when the intensity of sunlight is higher, the power generated also increases.

Table 5. Inverter Input Power Analysis Results

Waktu (Wib)	Tegangan (V)	Arus (V)	Daya (Watt)
10	24,25	2,17	52,62
11	24,15	2,50	60,37
12	24,35	2,55	62,09
13	24,55	2,85	69,96
14	24,40	2,70	65,88

In the table above, there are 5 inverter data measurements. Each measurement is carried out by recording the inverter input power. Based on the figure, it can be seen that the inverter input power varies in each measurement. The largest power produced is 69.96 W in the 4th measurement with a voltage of 24.55 V and a current of 2.85 A. The input power of the inverter is affected by the power source used, such as solar panels or batteries. The intensity of sunlight received by the solar panels and the condition of the battery connected to the inverter can affect the input power. The input power of the inverter shows the amount of power produced by the solar panels or batteries and will be converted into alternating current (AC) which is used to operate electrical loads.

Table 6. Inverter Input Power Analysis Results

Waktu (Wib)	Tegangan (V)	Arus (V)	Daya (Watt)
10	220	4,09	899,8
11	220	4,11	904,2
12	220	4,22	928,4
13	220	4,25	935
14	220	4,23	930,6

The table above shows five inverter data collection sessions. Each measurement recorded the inverter's output power. The figure shows that the inverter's output power varied with each measurement. The highest power output was 935 W in the fourth measurement, with a voltage of 220 V and a current of 4.25 A. This inverter's output power is the result of converting DC electricity to AC, which is used to operate a water pump.

Table 7. Battery Output Power Analysis Results

Waktu (Wib)	Tegangan (V)	Arus (V)	Daya (Watt)
10	24,25	2,17	52,62
11	24,15	2,50	60,37
12	24,35	2,55	62,09
13	24,55	2,85	69,96
14	24,40	2,70	65,88

Battery Efficiency Calculation Based on the Input Voltage from the Solar Panel and the Output Voltage Entering the Inverter:

$$\text{Efficiency } (\lambda) = \frac{69.96}{86.55} \times 100\% = 0.80\%$$

Solar Power Plant Efficiency Calculation

Solar panel efficiency is calculated based on the ratio of the solar panel's output power to the input power, expressed as a percentage. The manufacturer's calculation for solar panel efficiency is as follows:

$$PIn = J \cdot A$$

$$FF = \frac{VMax \cdot IMax}{VOc \cdot ISc}$$

$$POut = VOc \cdot ISc \cdot FF$$

$$\eta = \frac{POut}{PIn} \times 100\%$$

Where:

η = Efficiency (%)

Pout = Output power (Watts)

Pin = Input power (Watts)

Given:

J = 1000W/m2 (standard solar radiation intensity)

A = Solar Panel Area = 164.5cm × 99.5 cm = 16,367.75 cm2 = 0.16367 m2
Vmax = 30.3V V
Imax = 8.25 A Voc = 36.3V
Isc = 8.75A
So the calculation results are as follows: Input power calculation (Pin):
Pin = 1000 W/m2 × 0.16367 m2 = 1636.7 W
Fill Factor (FF) calculation:

$$FF = \frac{VMax.IMax}{VOc.ISc} = \frac{30.3V\ 8.25A}{36.3V\ .8.75A} = 0.78$$

Calculation of output power (Pout):

$$POut = VOc\ .ISc\ .FF$$
$$= 36.3 \times 8.75 \times 0.78 = 247.747W$$

Calculation of Solar Panel Efficiency Based on Manufacturer:

$$\text{Efficiency } (\eta) = \frac{247.747}{1636.7W} \times 100\% = 15.13\%$$

From the calculation above, we can see the solar panel efficiency results obtained based on the manufacturer and measurements. The table shows an average power efficiency of 11.58%. The manufacturer's power efficiency is 15.13%. Low power efficiency at certain times can be influenced by several factors, such as low sunlight intensity, weather conditions, and the condition of the solar panel itself.

CONCLUSION

Based on observation data on the solar power generation system, specifically the solar panel and battery components, the following conclusions were obtained: Measurements of the solar panel voltage and current revealed an average solar panel output of 76.39 Watts, with the highest output reaching 86.55 Watts. The calculated solar panel factory efficiency was 15.13%. The battery efficiency, based on the highest power at the time of measurement, was 0.80%. Low power output at certain times can be influenced by several factors, such as low sunlight intensity and weather conditions. Measurements of the inverter power output varied, with an average of 919.6 Watts, with a maximum output reaching 935 Watts.

REFERENCE

Hagai Fernando Lumban Gaol, Zulkarnain Lubis, Muhammad Erpandi Dalimunthe, 2024 “An Analysis of the Potential of Renewable Energy Solar Panels in Ecotourism Development Planning” Jurnal Scientia Volume 13, Number 03, 2024, DOI 10.58471/scientia.v13i03 ESSN 2723-7486 (Online)

Andreansyah, Muhammad Erpandi Dalimunthe, Dicky Lesmana, 2024 “Analysis of Aquaponics Solar Panel Innovation in Building C of Pembangunan Panca Budi University” Jurnal Teknik Elektro Vol. 6, No. 1, January 2024, pp. 60-63 p-ISSN: 2686-3650 | e-ISSN: 2686-3642, DOI: 10.52005/fidelity.v6i1.201

Parlin Siagian, S.T., M.T. Hamdani, S.T., M.T. M. Erpandi Dalimunthe, S.T., M.T., M.KKK, 2022

"Solar Cell Heat Mitigation with Sunscreen" ISBN: 978-623-5488-67-7

Arif Zulfahri Siregar, Zuraidah Tharo, Dino Erivianto, "Analysis of Solar Power Generation System Design for Airport Tower Support Facilities" Journal of Information Technology and Computer Science (INTECOMS) Volume 7 Number 6, 2024 e-ISSN: 2614-1574 p-ISSN: 2621-3249

Zuraidah Tharo, Hamdani, Melly Andriana, Budhi Santri Kusuma, 2021 "Plant Power Plant Planning as a Power Supply for the Shimizu PS-128 Bit Water Pump" 2021 National Halal Seminar | Panca Budi University

Yusrizal Pahlevi Harahap, Zuraidah Tharo, Rahmaniar, 2024 "Solar Power Plant Design Study in the Electrical Engineering Laboratory of Panca Budi University" Journal of Information Technology and Computer Science (INTECOMS) Volume 7 Number 4, 2024 e-ISSN: 2614-1574 p-ISSN: 2621-3249

Zuraidah Tharo, Erwin Syahputra, 2021 "Utilization of a 500 Wp Off-Grid Solar Power Plant in Terms of Billing Cost Depreciation and Operating Hours" Seminar of Social Sciences Engineering & Humanities SCENARIO 2021 | Medan - Saturday, December 27, 2021 e-ISSN 2775-4049

Mhd Erpandi Dalimunthe, Zulkarnain Lubis, Eddy Sutejo, Dwi Permata Sari, 2023 "Analysis of Solar Cells as an Alternative Energy Source in Building I, Panca Budi Development University" Seminar of Social Sciences Engineering & Humanities SCENARIO 2023 e-ISSN: 2775-4049

Muhammad Rifaldi, Nur Rani Alham, Nurul Izzah, Muhammad Nur Ihsan, Muhammad Sugianto, 2023 "Efficiency Analysis of Solar Power Generation Systems as a New and Renewable Energy Source" Journal of Tropical Engineering Technology and Innovation RETROTEKIN Vol. 1 No. 1, July 2023, 16-24

Siti Anisah, Amani Darma Tarigan, 2023 "Design of the Atapon Grind Solar Power Plant as an Environmentally Friendly Alternative Energy Source" Journal of Information Technology and Computer Science (INTECOMS) Volume 6 Number 1, June 2023 e-ISSN: 2614-1574 p-ISSN: 2621-3249

Fadilla, Deny Ahmad, Dery Matthew, and Raihan Alfarizi. "DESIGN AND TESTING OF LI-ION AND LEAD-ACID BATTERY CHARGING AND DISCHARGING SYSTEMS WITH A PLTS (Solar Power Plant) Power Source." Journal of Electrical Installation Engineering Technology (JTRIL) 1.2 (2024): 15-21

Saini, M., Djalal, M. R., Rustang, R., Abbas, D. P. F., & Barlian, Y. H. J. J. T. M. S. (2022). Performance Analysis of Lithium Ion Battery and Ultracapacitor Installation in Solar Power Plants. vol. 20, 97-103

Ridwan, Wahyu, and Zuraidah Tharo. "Planning of an Off-Grid Solar Power Plant in the Multipurpose Building of the Sejahtera Islamic Boarding School." Journal of Electrical and System Control Engineering 8.1 (2024): 173-180

Fitri, Ameliya Tiara, and Muhammad Erpandi Dalimunthe. "Planning for the Construction of a Solar Power Plant in Vaname Shrimp Ponds in Sungai Kuruk III Village, Seruway District, Aceh Tamiang Regency." Fidelity: Journal of Electrical Engineering 6.2 (2024): 95-99

Siagian, P., Dalimunthe, M. E., Siregar, B., Fadlan, M., & Frasasti, R. A. (2022). The Cost of Islamic Boarding School Electricity Bills is Lowered by Installing Solar Cells on Grid Limiters. Jurnal Pengabdian Masyarakat Bestari (JPMB), 1(8), 895-904

S. Anisah and Amani Darma Tarigan. "ROOF-GRIND SOLAR POWER PLANT PLANNING AS AN ENVIRONMENTALLY FRIENDLY ALTERNATIVE ENERGY SOURCE

Mhd Hasbi Ramadhan, Haris Gunawan, and Dicky Lesmana. "Analysis of Solar Power System Planning for Street Lighting Supply at Campus I, Panca Budi University, Medan." INFOKUM 13.04 (2025): 918-928

Hamdani Ahmad Rangkuti, Dicky Lesmana, and Haris Gunawan. "Analysis of Power Requirements and Solar Power Plant (PV System) Components for an Electric Vehicle Charging Station at Panca Budi University, Medan." INFOKUM 13.04 (2025): 937-946