

Design of a Portable PLTS as an Alternative Source of Electrical Energy and Lighting in Catfish Farming

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Abstract

Limited access to electrical energy in rural areas and catfish farming locations located far from the national electricity grid remains a major challenge, particularly for lighting needs at night. Adequate lighting is essential to support pond monitoring, security, and the continuity of aquaculture activities. This research aims to design, develop, and test a portable Solar Power Plant (PLTS) as an alternative and renewable energy source for lighting systems in catfish farming. The research method applied is Research and Development (R&D) with an experimental approach, covering system planning, energy requirement analysis, component selection, system assembly, and field performance testing. The portable PLTS system is composed of a 50 Wp solar panel, energy storage batteries, an MPPT solar charge controller, an inverter, and LED lamps as the primary electrical load. Performance testing was conducted directly at the catfish farming site to evaluate output power stability, lighting duration, and system reliability during nighttime operation. The experimental results indicate that the portable PLTS system is capable of supplying sufficient and stable electrical energy to meet lighting demands effectively. The use of LED lamps significantly improves energy efficiency and reduces overall power consumption. Furthermore, the portable design allows flexibility in installation and mobility, making it suitable for remote aquaculture locations. Overall, the developed portable PLTS system is feasible, environmentally friendly, and effective as an alternative energy solution to support sustainable catfish farming activities.

Keywords: Portable Solar Power Plant, Solar Energy, LED Lighting, Catfish Farming, Renewable Energy.

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Introduction

The demand for electrical energy in Indonesia continues to increase along with technological advancements and the growth of business sectors, including the catfish aquaculture sector. One of the fisheries activities commonly carried out by the community is catfish farming. This activity requires an electricity supply for various needs, such as lighting the pond area at night, operating water pumps for pond circulation, and running aerators to maintain dissolved oxygen levels. Adequate lighting at night also plays an important role in ensuring security, monitoring pond conditions, reducing the risk of predator attacks such as snakes, cats, and dragonfly larvae, and preventing theft. However, in rural areas or pond locations far from the national electricity grid (PLN), the availability of electricity often becomes a major constraint. Relying on fossil fuel-powered generators not only increases operational costs but also causes air pollution and noise. Therefore, an alternative energy source that is environmentally friendly, economical, and reliable is needed. Solar Power Generation (PLTS) is one solution that can be utilized. Portable PLTS systems offer advantages such as ease of mobility, flexible installation, and the ability to supply electricity without dependence on the PLN grid. This technology utilizes the abundant solar radiation available in Indonesia, which has an average solar irradiation intensity of 4–5 kWh/m² per day. By integrating portable PLTS as an alternative energy source for catfish farming, it is expected to create an independent and efficient lighting system that supports the development of sustainable aquaculture.

Literature Review

Several studies on the utilization of solar energy have been conducted in various fields. Ardiansyah and Putra (2020) designed a portable Solar Power Plant (PLTS) system for remote areas and successfully demonstrated high system efficiency.



Figure 1. Portable PLTS for Remote Areas

Hidayat and Siregar (2019) utilized solar energy as a lighting system for dragon fruit plantations, with satisfactory results that were able to meet the lighting requirements for optimal dragon fruit growth.



Figure 2. PLTS at a Dragon Fruit Plantation

Surya Ningsih and Wahyudi (2021) investigated the use of LED lamps in a Solar Power Plant (PLTS) system. The results showed that electrical energy consumption could be reduced by up to 50% compared to conventional lamps. The use of LED lighting proved to be more

Andika Syahputra, Muhammad Erpandi Dalimunthe, Pristrisal Wibowo efficient, enabling significant energy savings and improving the overall performance of the PLTS system.

Mhd. Erpandi Dalimunthe, Zulkarnain Lubis, Eddy Sutejo, and Dwi Permata Sari (2021) conducted a study entitled Analysis of Solar Cell Potential in Building I of Pembangunan Panca Budi University. This research analyzed the potential utilization of solar cells in Building I of Pembangunan Panca Budi University, with an electrical power demand of 22,106 Watts and a total energy consumption of 110,530 Wh per day. The calculation results indicated that the energy demand could be met by using 189 solar panels with a capacity of 250 Wp, arranged in a configuration of 21 panels in parallel and 9 panels in series. In addition, the study emphasized the importance of panel balancing and cable installation adjustments to ensure compatibility with the voltage requirements of the solar power system.

Khairunnisa Salsabila Purba, Amani Darma Tarigan, and Ahmad Dani (2024), in their study entitled An Application of Solar Power Plant (PLTS) as Power Supply for Radio Repeater at PT. Icon Plus Pekanbaru, examined the utilization of a solar power plant as a power supply for a radio repeater. The results showed that the use of six solar panels with a total capacity of 600 Watts, supported by two 200 Ah batteries, was able to generate 1,920 Wh of energy per day. The system achieved a Days of Autonomy value of 2.3 days, allowing the radio repeater to operate optimally without the risk of power shortages.



Figure 3. Photovoltaic Power System at PT. Icon Plus Pekanbaru

Although solar power plants (PLTS) have been widely applied in various sectors, their implementation in portable systems for catfish aquaculture is still limited. This study addresses this research gap by proposing a portable solar power plant specifically designed for lighting applications in catfish farming. The proposed system aims to reduce energy consumption in the aquaculture sector while offering an effective and efficient solution through its portable design, which allows the system to be easily relocated according to operational needs.

Research Methodology

The following are the steps carried out during the research process. The research flowchart is presented in the figure below.

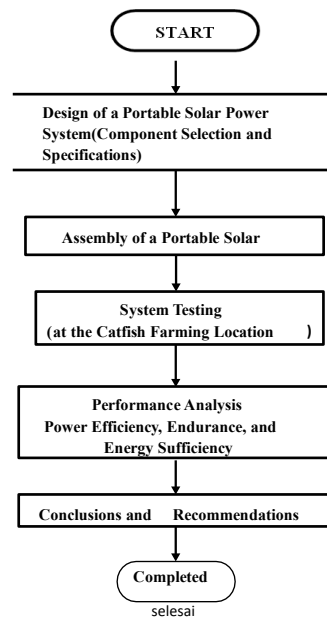


Figure 4. Flowchart Methodology

The methodology consists of the following stages:

1. Literature Study

Study the basic theory of solar power systems (PLTS), portable systems, and energy requirements for catfish aquaculture.

2. Problem and Energy Needs Identification

Identify the electrical energy requirements for pond lighting, aerators, and water pumps.

3. Portable PLTS System Design

Determine the solar panel capacity based on daily energy requirements. Calculate the battery capacity considering the Depth of Discharge (DoD). Specify the inverter according to the load demand. Develop the circuit diagram for the portable PLTS system.

4. System Assembly

Assemble the portable PLTS components according to the design specifications.

5. System Testing

Measure the PLTS output power (Wh). Test the duration of LED lighting. Observe the stability of the power supply during nighttime. Analyze the system efficiency and durability.

6. Data Analysis

Analyze the test results using a comparison method between theoretical calculations and actual field experiments.

7. Conclusion and Recommendations

Draw conclusions based on the system performance and provide recommendations for the future development of portable PLTS systems.

Results

The portable solar power system (PLTS) designed in this study serves as an alternative electrical energy source for lighting in catfish aquaculture. The system consists of a 50 Wp solar panel, an MPPT-type solar charge controller (SCC), a 12 V 5 Ah battery configured into a 24 V 10 Ah system, a 1000 W inverter, and a 15 W LED lamp as the load. All components are assembled within a portable hollow steel frame, making the system easy to transport and deploy across various pond locations. The measurements were conducted during daytime under clear weather conditions. The measured parameters included the panel voltage, panel current, and output power.

Table 1. Solar Panel Measurement Data Table

Time	Panel Voltage (V)	Panel Current (A)	Power Output (W)
11.00 AM	15,4 Volt	2,1 A	32,43 Watt
12.00 PM	19,2 Volt	2,4 A	46,08 Watt
13.00 PM	20,7 Volt	2,5 A	51,75 Watt
14.00 PM	18,4 Volt	2,2 A	40,48Watt
15.00 PM	19,1 Volt	2,3 A	43,93Watt
16.00 PM	19,8 Volt	2,4 A	47,52Watt

From Table 1, it can be observed that the maximum power output of the solar panel occurred at 13:00 PM, reaching 51.75 W. This indicates that the solar panel operates optimally when the solar radiation intensity is at its peak. The solar panel measurement results are illustrated in the figure below.

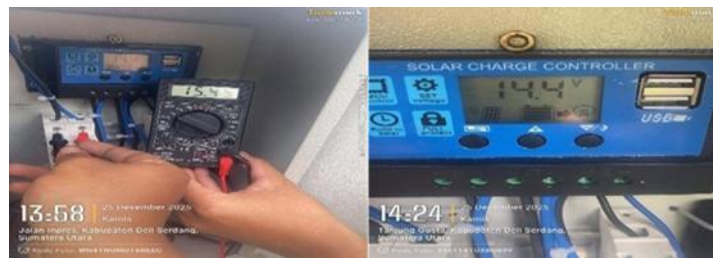


Figure 5. Battery Charging Display from the SCC

The following table presents the results of battery testing, which was conducted to evaluate charging stability and energy storage capability. Battery charging using solar panels involves photovoltaic modules that generate electrical power, regulated by a charge controller to prevent overcharging, and subsequently stored in the battery. The proper connection sequence consists of connecting the battery to the controller first, followed by the solar panel connection, and finally adjusting the panel orientation to achieve optimal solar irradiation. The charge controller plays a crucial role in managing power flow and protecting the battery from damage, thereby ensuring efficient and safe system operation.

Table 2. Battery Voltage Table During Charging

Waktu	Tegangan
11.00 AM	12,2 Volt
12.00 PM	12,8 Volt
13.00 PM	13,8 Volt
14.00 PM	14,8 Volt
15.00 PM	15,8 Volt
16.00 PM	15,9 Volt



Figure 6. Battery Charging Results Observed from the Solar Charge Controller

The test was conducted at night to evaluate the duration and stability of the lighting system.

Table 3. LED Lighting Test Data

Parameter	Nilai
LED Lamp Power	30 Watt
Inverter Output Voltage	220 V AC
Load Current	0,16 A
Water Pump Power	5 Watt
Usage Duration	±8 Hour

The results show that the LED lamps operate stably throughout the night without interruption, thereby fulfilling the lighting requirements of the catfish pond, as illustrated in the following figure.

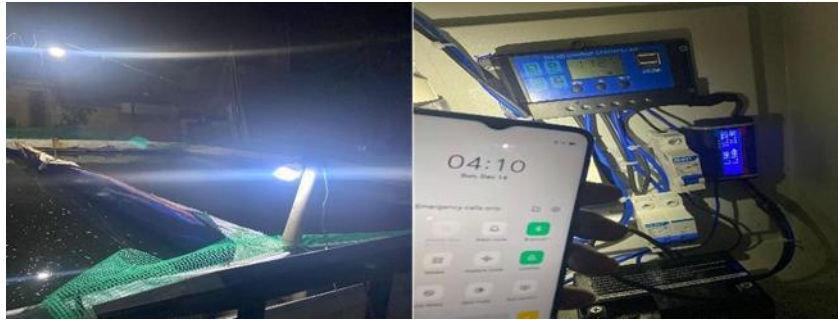


Figure 7. Results of Simultaneous Operation Testing of the Lamp and Water Pump from 20:00 to 04:00

This inverter testing was conducted to examine the operating principle of the inverter and to determine whether the battery capacity is proportional to the system design. The measurement data are presented in Table 4 below.

Table 4. Inverter Testing Data with a 570 Wh Load

Duration	Input Voltage (V)	Output Voltage (V)	Frekuensi (Hz)
0	13,3 Volt	224 Volt	50 HZ
15	12,9 Volt	227 Volt	50 HZ
60	12,5 Volt	226 Volt	50 HZ
120	12,4 Volt	225 Volt	50 HZ
180	12,4 Volt	225 Volt	50 HZ
240	12,4 Volt	225 Volt	50 HZ
300	12,4 Volt	225 Volt	50 HZ
360	12,3 Volt	225 Volt	50 HZ
420	12,2 Volt	224 Volt	50 HZ
480	12,1 Volt	225 Volt	50 HZ
570	12 Volt	224 Volt	50 HZ
625	11,9 Volt	225 Volt	50 HZ
660	11,8 Volt	224 Volt	50 HZ
Average	12,29 Volt	224,9 Volt	50 HZ

When the inverter testing duration reached 570 minutes of operation, the battery condition had decreased to approximately one-quarter of its capacity. This was indicated by the battery capacity indicator on the solar charge controller. Initially, the battery was fully charged, as shown by five bars on the indicator; after operation, only two bars remained, as illustrated in the following figure.



Figure 8. Inverter Testing

Based on the test results, the portable photovoltaic (PV) system is capable of generating approximately 200–250 Wh of daily energy, which is sufficient to operate pond lighting. The use of LED lamps has proven effective in reducing energy consumption. Furthermore, the portable design provides high flexibility and enables operation in locations that are not accessible to the national power grid (PLN).



Figure 9. System Performance Analysis Results

Conclusion

Based on the design, testing, and analysis of the portable photovoltaic (PV) system, the following conclusions can be drawn:

1. The portable PV system was successfully designed and constructed as an alternative electrical energy source for catfish aquaculture lighting.
2. A 50 Wp solar panel equipped with an MPPT system is capable of generating sufficient and stable electrical energy to meet nighttime lighting requirements.
3. The 15 W LED lamp has proven to be efficient and capable of operating for approximately ± 8 hours using energy supplied by the battery.
4. The portable PV system is suitable for use in catfish aquaculture locations that are distant from the national power grid (PLN) and is environmentally friendly.

The following recommendations are proposed for future research and system development:

1. Increasing the capacity of the solar panels and batteries to enable the system to support additional loads, such as water pumps and aerators.
2. Utilizing a pure sine wave inverter to improve the quality of the output power.
3. Conducting long-term testing to evaluate battery lifespan and overall system reliability.

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