

Functionalization of a 110 Wp Photovoltaic System for Computer Room Power Supply at SMK Muhammadiyah 2 Turi Sleman

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Abstract. Sekolah Menengah Kejuruan Muhammadiyah 2 Turi Sleman has a photovoltaic system that powers the computer room. However, since 2022, the system has not been working correctly. This paper aims to restore the photovoltaic system's functionality. The activities include checking the condition of the system's components and taking corrective actions. During the inspection, it was found that the solar module was not installed outdoors, and the battery's performance had decreased, showing a voltage of only 11.95 V. The solar module had been installed outdoors correctly. Performance tests revealed that the system can produce electrical energy, with the solar module generating an average open circuit voltage of 23.32 V in sunny weather. The battery repair resulted in an average voltage of 12.23 V. The photovoltaic system now functions as a power supply for the computer room.

1 Introduction

Sekolah Menengah Kejuruan (Vocational School) Muhammadiyah 2 in Turi, Sleman (referred to as Mitra) is a highly regarded educational institution, evidenced by its "A" accreditation rating. Mitra boasts comprehensive facilities, including a spacious yard, well-equipped classrooms, a laboratory, a library, a hall, and sports amenities. The clean, beautiful, and ample environment makes the school conducive to the teaching and learning process.

Mitra is dedicated to continually enhancing existing facilities and infrastructure to boost the quality of education. Mitra excels in providing school infrastructure, focusing on renewable energy, notably solar power. The photovoltaic technology at Mitra supports an electricity backup system for the computer lab and a lighting system for the school terrace. Utilizing solar energy as an electrical power source is a well-chosen strategy for the school. Solar energy, abundant and clean, can meet global energy demands [1]. It is widely available, with Indonesia's vast potential in renewable energy, especially solar. According to the Directorate General of EBTKE, Indonesia receives an average solar insolation of 4.8 kWh/m²/day [3]. Electricity demand in Indonesia is projected to reach about 120 GW by 2025 [4]. The National Energy Policy, outlined in Presidential Decree No. 79/2014, mandates

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that by 2025, new and renewable energy should make up 23% of the primary energy mix [5]. This energy mix provides a strong impetus for Indonesia to develop solar energy further as a critical energy source in the future.

In 2020, Mitra received assistance from the Ministry of National Education to install a photovoltaic (PV) system. The provided equipment included a PV system package consisting of solar modules with a maximum power of 110 Wp. This system was intended to supply power to the computer room during outages of the Perusahaan Listrik Negara (PLN) network. However, since early 2022, Mitra had encountered issues with the PV system, preventing it from generating electrical energy and causing disruptions in the computer room when the PLN network is down. The technicians at Mitra lack expertise in photovoltaic technology, rendering them unable to resolve the issue.

Photovoltaic systems convert electromagnetic energy from the sun directly into direct current (DC) electrical energy [6]. In the computer room, this DC power is converted to alternating current (AC) power using an inverter. Photovoltaic systems are favored for their reliable technology [7] and modular design [8]. Typically, solar modules are guaranteed to last over 20 years [9]. However, the system's reliability heavily depends on proper design, component selection, installation, and maintenance. The main components of a photovoltaic system include solar modules, controllers, batteries, inverters, and lights [6]. Neglecting maintenance can spread damage to other components, resulting in higher repair costs. Solar modules and batteries are among the most expensive parts of a PV system [10, 11]. Therefore, to address the issues at Mitra, it is necessary to inspect all components and installations of the photovoltaic system. This inspection can identify the source of the problem, enabling more effective solutions.

This paper aims to restore the PV system as an electrical power supply for the computer room. A functioning photovoltaic system is crucial for supporting the learning process in the computer room during PLN network outages, allowing students to continue their activities despite the absence of electricity from PLN.

2 Methodology

A PV installation with an AC power system includes vital components: a solar module, battery charge controller (BCC), battery, loads, and inverter [12]. The electric energy is generated by PV panels and stored in the batteries. The inverter converts the stored DC into AC power. When solar radiation is unavailable or insufficient (such as at night), the system relies directly on the batteries for power [13]. The PV technology installed at Mitra was a stand-alone system solely used for the computer room and not connected to the PLN network. Fig. 1 illustrates the schematic of the PV system at Mitra.

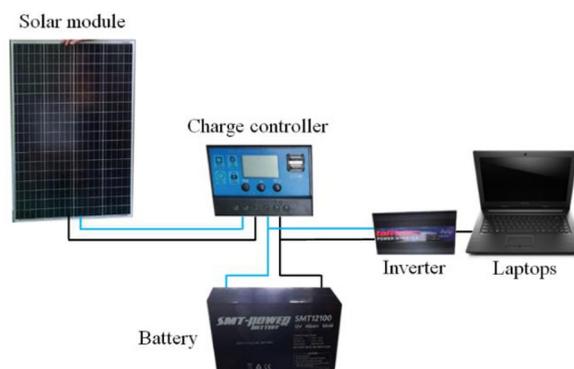


Fig. 1. Scheme of AC power PV systems.

The solution to the problems Mitra's face starts with a comprehensive inspection of all PV system components. This inspection covers physical, mechanical, and electrical aspects. The following steps outline the inspection process.

1. Solar module
 - a. Inspect the physical condition for glass cracks, solar cell damage, air leaks, and potential corrosion in the junction box.
 - b. Examine the solar panel installation for proper shading avoidance from trees and buildings, correct orientation, and stability of the supporting structures.
 - c. Check the cable and connections.
 - d. Check open circuits output voltage.
2. Battery
 - a. Check the installation location.
 - b. Physically check the battery: body swelling, dirt and corrosion on the poles.
 - c. Check cable connections and battery voltage.
3. Battery charge controller
 - a. Checking BCC installation
 - b. Check cable connections.
4. Inverter
 - a. Physically check the inverter for the possibility of fire.
 - b. Check cable connections.

The findings from the inspection were used to determine the necessary corrective actions. Following these actions, a performance test was conducted to verify that the PV system is functioning correctly. Fig. 2 illustrates the troubleshooting steps at Mitra.

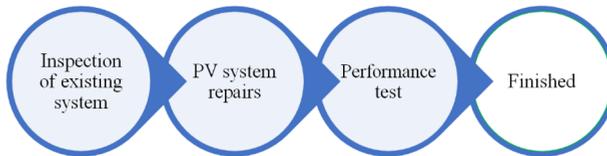


Fig. 2. Problem solving steps.

3 Results and Discussion

3.1 Field Inspection

Field inspection is a crucial step in addressing Mitra's issues. This inspection was conducted with partner technicians who are familiar with the actual condition of the PV system. The results of the PV system inspection are detailed in Table 1.

Table 1. Results of field inspection.

Components	Physical Conditions	Installation Conditions	Wiring Connections	Voltage
Solar module	Good	Solar module was placed outdoors only when in use (not common)	Good	23.32 V (good)
Battery	Good	Installed away from the floor surface (good)	Good	11.95 V (quite weak)
BCC	Good	Mounted on a panel box	Good	
Inverter	Good	Mounted on a panel box	Good	

Table 1 indicates that all PV system components' physical condition and wiring connections were in good shape. The battery, BCC, and inverter installations were also in proper condition. When the solar module was placed outdoors, it showed an open circuit voltage of 23.32 V, suggesting it was functioning well. However, the installation issue lies with the solar module. It was not installed outdoors as required but kept in the computer room. The solar module is only moved outdoors when the PV system is used, contravening the principle of solar modules designed to capture solar energy and convert it into electrical energy [13]. Although some photons from the sun can enter the room, their quantity is insufficient to generate electrical energy, leading to a low charge in the battery. The battery test results in Table 1 reveal a low voltage, indicating inadequate stored electrical energy and potential battery damage. Batteries are particularly vulnerable to damage [14]. Therefore, the primary focus for improving the PV system should address solar modules and battery issues.

3.2 Solar Module Installation

Installing solar modules outdoors necessitates a support frame and poles. The frame was constructed from galvanized angle iron, measuring 40 x 40 x 3 mm, and the poles are made of galvanized pipe with a 1.5-inch diameter. The frame is designed to accommodate the dimensions of the solar module, with a tilt angle of 20° to maximize solar exposure throughout the year [15]. The frame and solar module were secured with M8 bolts, and the solar module frame was attached to the pole using three M8 bolts.

The initial step in installing solar modules outdoors involves securely fastening the cables to the junction box poles and ensuring the cover is tightly sealed to prevent water ingress. The pole installation was carried out at a location nearest to the computer room. With Mitra's consent, the solar module pole was positioned on the school billboard, 4 meters between the module pole and the computer room. This distance poses minimal risk of electrical loss and is considered safe. The location is accessible from shading by trees and buildings, which is crucial, as shading can significantly reduce the performance of the PV system [16]. The solar modules are oriented towards the north to maximize solar energy absorption [15]. Fig. 3 shows the solar modules installed outdoors.



Fig. 3. Installation of solar module: (a) module frame, (b) solar module, (c) module cable.

3.3 Battery Repair

The battery used in the PV system is a deep cycle type. During the inspection, the battery voltage was 11.95 V, which indicates a weak battery since the operational voltage for a PV system should be above 12 V [17]. Low battery voltage can result from several factors, including the battery exceeding its typical lifespan, malfunctioning lead plates, or inadequate

electrical energy supply. In this case, the low battery voltage is primarily due to the lack of electrical energy supply, as the solar modules were not installed outdoors. This issue is clearly illustrated in Fig. 4, which shows a 0% charge condition.



Fig. 4. Existing battery conditions.

According to Fig. 4, the battery health is at 62%, indicating that the battery condition is relatively fair. The PV system can still use the battery, as it will receive electrical energy from the solar modules. An additional battery of the same type is added to ensure better battery performance. The two batteries are installed in parallel to maintain a PV system voltage of 12 V [18]. Using two batteries also increases the electrical energy storage capacity. Each battery has a capacity of 100 Ah, and the total capacity of two batteries is 200 Ah. Adding a second battery benefits the computer room, extending the duration of electrical energy availability. Fig. 5 shows the battery repair process.



Fig. 5. Installation of battery: (a) wiring repair, (b) parallel connection

3.4 Performance Test

Function tests were performed on the PV system following the installation of the solar module, battery repairs, and wiring system corrections. The test uses a 10 W AC incandescent lamp connected to the output panel box. The functional test results confirm that the PV system effectively generates electrical energy to power the lights, as illustrated in Fig. 6.



Fig. 6. Function test of PV system.

Performance tests were conducted to verify the PV system's effectiveness in generating electrical energy. The tools used for this test include a pyranometer to measure solar irradiation and a multimeter to check voltage. Voltage measurements are taken from the solar module under open circuit conditions (no load) and from the battery. The performance tests are performed between 12:30 and 14:45. The results of these tests are depicted in Fig. 7.

The solar radiation intensity was relatively high at the beginning of the performance test. However, from 13:45 onwards, the solar radiation decreased due to cloudy weather, which directly impacted the performance of the solar modules. The average open circuit voltage recorded from the start of the test until 13:45 was 23.32 V. After the appearance of clouds, this voltage decreased and fluctuated. An open circuit voltage of 23.32 V indicates that the solar module's performance is good, as it exceeds the factory nominal value of 23 V [19]. The average battery voltage during the performance test was 12.23 V, which indicates proper battery function, as it is above the nominal PV system voltage of 12 V.

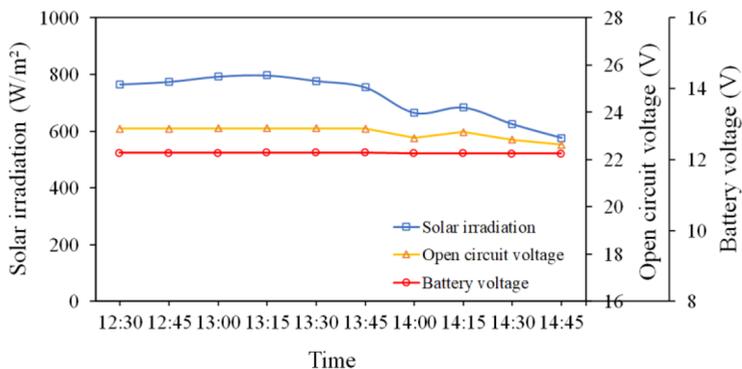


Fig. 7. Performance test results.

4 Conclusions

The community service project to restore the PV system for Mitra's computer room power supply has been completed. This activity involved inspecting the existing PV system, repairing faulty components, and conducting performance tests. The conclusions are as follows.

1. The issues with the PV system were identified in the solar module and battery. The solar module was not installed outdoors, which led to the battery being relatively weak, with a voltage of 11.95 V.

2. The solar module has now been adequately installed outdoors, facing north with a 20° tilt angle and free from shading by trees and buildings. This installation ensures that the battery receives adequate electrical energy. Additionally, the battery capacity has been increased by adding a second battery.
3. Performance tests indicate that the solar module is functioning well, with an average open circuit voltage of 23.32 V in sunny conditions. The battery is also in good condition, with an average voltage of 12.23 V during the tests.
4. The PV system in the computer room is now effectively supplying electrical power, ensuring that student learning is uninterrupted during PLN network outages. This stand-alone PV system model can be applied to other areas that require electricity when the PLN network is unavailable.

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