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Performance Comparison of 10Wp and 15Wp Monocrystalline Solar Panels on 12V Battery Charging

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A B S T R A C T

The increasing demand for electrical energy has encouraged the utilization of renewable energy sources, particularly solar energy through photovoltaic technology. The charging time of a 12 V battery is influenced by the power capacity of the solar panel used. This study aims to compare the charging time of a 12 V battery using 10 Wp and 15 Wp monocrystalline solar panels. The research employed a quantitative experimental method with a comparative approach. Both panels were tested under identical environmental conditions using the same charging system. Data were collected through direct measurements of output voltage, current, power, efficiency, and battery charging duration during the testing period. The results indicate that the 15 Wp monocrystalline solar panel produced higher output current and power than the 10 Wp panel, resulting in a shorter battery charging time. In contrast, the 10 Wp panel required a longer charging duration due to its lower power output. These findings demonstrate that panel capacity significantly affects charging performance. Therefore, the 15 Wp monocrystalline solar panel is recommended for small-scale 12 V battery charging applications because it provides faster charging and higher energy conversion performance

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INTRODUCTION

The continuous growth in global electricity demand, accompanied by the depletion of fossil fuel resources and increasing greenhouse gas emissions, has accelerated the transition toward renewable energy technologies. Solar energy has become one of the most promising renewable energy sources because it is abundant, environmentally friendly, and capable of generating electricity through photovoltaic (PV) technology. The integration of photovoltaic systems with battery storage has become increasingly important to ensure energy availability and improve the reliability of stand-alone power systems (Ika Putri et al., 2022).

Indonesia is located in a tropical region with relatively high solar irradiation throughout the year, making photovoltaic systems suitable for household and small-scale energy applications. Indonesia's technical solar energy potential is estimated at more than 200 GW, positioning solar power as the country's largest renewable energy resource for future development (Pambudi et al., 2023). Monocrystalline solar panels are widely utilized because they offer higher conversion efficiency and better electrical performance than many other photovoltaic technologies. Consequently, these panels are commonly employed for battery charging systems, portable power supplies, and off-grid solar applications (Julianto et al., 2022)

Battery charging performance in photovoltaic systems is influenced by several factors, including solar irradiance, operating temperature, charging controller characteristics, and solar panel capacity. In particular, the type of charge controller technology used, whether Pulse Width Modulation (PWM) or Maximum Power Point Tracking (MPPT), has been shown to strongly influence charging efficiency, with MPPT controllers typically outperforming PWM controllers under similar environmental conditions (Laguado-Serrano et al., 2019). Among these factors, the rated power of the photovoltaic module directly affects the generated current and output power, which consequently determines the battery charging duration. Previous studies have demonstrated that photovoltaic-based battery charging systems can operate effectively when appropriate charging control methods and panel specifications are employed (Ika Putri et al., 2022;Sudiharto et al., 2022)).

Several researchers have investigated photovoltaic battery charging systems. Asrori & Putra (2025) showed that the selection of solar panel type and solar charge controller significantly influences battery charging efficiency and charging time. However, these studies mainly focused on different charging technologies or different photovoltaic materials rather than comparing photovoltaic modules of the same technology with different rated capacities.

Although numerous studies have examined photovoltaic performance and battery charging systems, limited research has specifically compared the charging performance of 10 Wp and 15 Wp monocrystalline solar panels under identical environmental conditions. Most previous studies evaluated different photovoltaic technologies, charging algorithms, or battery management systems rather than investigating how differences in panel capacity affect battery charging duration. Therefore, a comprehensive comparison of charging time, output voltage, current, power, and efficiency between 10 Wp and 15 Wp monocrystalline solar panels remains necessary.

This study aims to compare the charging time of a 12 V battery using 10 Wp and 15 Wp monocrystalline solar panels under the same operating conditions. Electrical parameters including voltage, current, output power, efficiency, and charging duration were experimentally measured and analyzed. The findings are expected to provide practical guidance for selecting appropriate photovoltaic capacities for small-scale battery charging systems while contributing to the development of efficient renewable energy applications.

LITERATURE REVIEW

Solar Solar energy is a renewable energy source derived from solar radiation and is available in abundant quantities throughout the year. Through photovoltaic (PV) technology, solar radiation is directly converted into electrical energy using semiconductor materials such as silicon. The photovoltaic effect occurs when photons from sunlight strike the semiconductor material, causing electrons to move and generate direct current (DC). Unlike fossil-fuel-based energy generation, photovoltaic systems produce electricity without combustion, making them environmentally friendly and contributing to greenhouse gas emission reduction (Hasrul, 2021) The utilization of solar energy has increased significantly due to the growing demand for sustainable electricity generation and the declining availability of conventional energy resources. Indonesia possesses excellent solar energy potential because of its tropical climate and relatively high annual solar irradiation, making photovoltaic systems suitable for household electricity generation and battery charging applications.

Solar panel efficiency represents the capability of a photovoltaic module to convert incident solar radiation into usable electrical energy. Monocrystalline solar panels generally exhibit higher conversion efficiency than other photovoltaic technologies because they are manufactured from single-crystal silicon. The uniform crystal structure reduces internal resistance and facilitates electron movement, resulting in improved electrical performance. Panel efficiency is influenced by several environmental and operational parameters, including solar irradiance, operating temperature, shading conditions, installation angle, and module quality. Under optimal solar radiation, monocrystalline panels demonstrate superior conversion efficiency and more stable electrical output than polycrystalline modules (Zulhakim et al., 2025) Experimental studies using controlled climatic chambers have further confirmed that rising operating temperature reduces the open-circuit voltage and overall conversion efficiency of monocrystalline panels, with efficiency losses of approximately −0.5% for every 1 °C increase in panel temperature (Hudişteanu et al., 2024).

A solar panel, also known as a photovoltaic module, is the primary component of a photovoltaic system that converts sunlight into electrical energy through the photovoltaic effect. Monocrystalline solar panels are fabricated using the Czochralski crystal-growth process to produce single-crystal silicon ingots, which are subsequently sliced into thin wafers for solar-cell manufacturing. The highly ordered crystal structure enables higher energy conversion efficiency and longer operational lifetime than many other photovoltaic technologies (Green et al., 2020). Monocrystalline modules are widely employed in residential photovoltaic systems, portable power stations, and battery charging applications because they provide high efficiency, reliable performance, and relatively compact installation areas.

The application of photovoltaic systems offers considerable environmental, economic, and technical benefits. During operation, photovoltaic modules generate electricity without producing greenhouse gas emissions or air pollutants. Moreover, solar energy is renewable, abundant, and freely available, making photovoltaic technology an attractive alternative to fossil-fuel-based electricity generation. In addition to environmental benefits, photovoltaic systems require relatively low maintenance costs and possess long operational lifetimes. Their modular configuration also allows flexible implementation ranging from small portable charging systems to large-scale power plants (Al-ezzi, 2022). A photovoltaic power generation system generally consists of photovoltaic modules, a solar charge controller, batteries, and, where necessary, an inverter. In stand-alone photovoltaic systems, batteries serve as electrical energy storage devices to ensure continuous power availability when solar radiation is unavailable, such as during nighttime or cloudy weather. For lead-acid batteries specifically, the magnitude of the charging current has been found to affect the resulting charge–discharge energy efficiency, indicating that the charging current supplied by the photovoltaic module plays an important role in overall battery performance (Pranata et al., 2019).

Battery charging performance depends on photovoltaic output power, battery characteristics, charging controller efficiency, and environmental conditions. Higher photovoltaic output generally increases charging current and shortens battery charging duration. Therefore, selecting an appropriate photovoltaic module capacity is essential for improving charging performance and overall system efficiency (Utomo & Nugrahanto, 2023). In addition, the selection of an appropriate battery charging strategy, such as constant voltage, constant current, pulse width modulation, or maximum power point tracking (MPPT) charging, has also been reported to influence charging efficiency, battery capacity, and cycle life in off-grid photovoltaic systems (Dorel et al., 2023).

METHODOLOGY

This study employed a quantitative experimental method with a comparative research design to evaluate the charging performance of a 12 V battery using 10 Wp and 15 Wp monocrystalline solar panels. The experiment was conducted in Jasem Village, Ngoro District, Mojokerto Regency, Indonesia, where both photovoltaic modules were tested under identical environmental conditions to ensure that the observed differences were primarily caused by the panel capacity. The independent variable in this study was the rated capacity of the monocrystalline solar panel (10 Wp and 15 Wp), while the dependent variables included output voltage, output current, output power, solar panel efficiency, battery voltage, and battery charging time. To maintain the reliability of the experiment, several control variables such as battery type, solar charge controller, panel orientation, measurement interval, testing location, and weather conditions were kept constant throughout the testing process. The experimental system consisted of two monocrystalline solar panels (10 Wp and 15 Wp), a 12 V lead-acid battery, a solar charge controller (SCC), a digital wattmeter, a digital multimeter, and connecting cables. Each photovoltaic module was connected to the wattmeter, followed by the solar charge controller and the battery. The installation configuration was identical for both solar panels to ensure comparable operating conditions.

Before the experiment, all equipment was inspected to ensure proper operation. Each solar panel was installed in an open area without shading and positioned at the same orientation toward the sun. Electrical parameters, including output voltage, output current, output power, and battery voltage, were measured every 30 minutes from 09:00 to 15:00 WIB. Measurements were conducted under the same environmental conditions for both photovoltaic modules to minimize external influences on the experimental results. The collected data were analyzed using descriptive comparative analysis. The electrical performance of the 10 Wp and 15 Wp monocrystalline solar panels was compared based on battery charging time. The experimental results were presented in tables and graphs to facilitate comparison and interpretation of the charging performance of both photovoltaic modules.

RESULTS

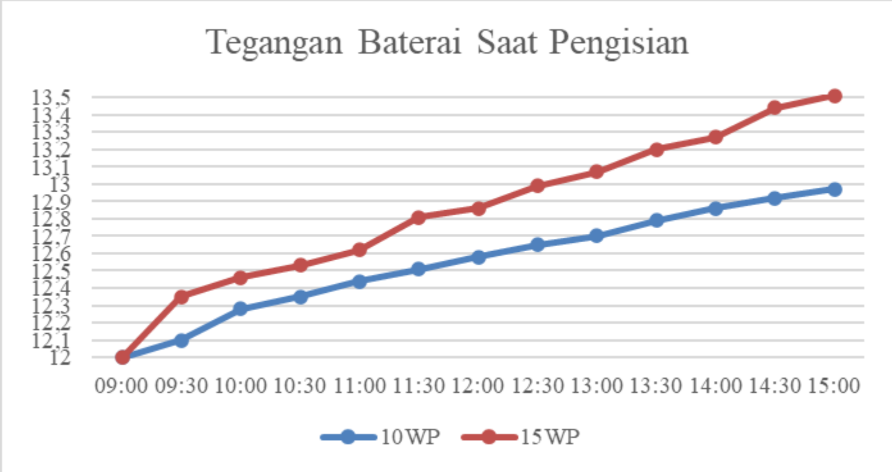
The charging performance of the 12 V battery was evaluated using two monocrystalline solar panels with different rated capacities, namely 10 Wp and 15 Wp. Both photovoltaic modules were tested under identical environmental conditions using the same battery, solar charge controller, and charging configuration. The charging process was monitored from 09:00 to 15:00 WIB, and the battery voltage was recorded at 30-minute intervals to evaluate the charging progress.

Table 1. Comparison of Battery Charging Performance

Parameter	10 Wp	15 Wp
Initial battery voltage (V)	12 V	12 V
Final battery voltage (V)	12.97	13,51
Maximum output current (A)	0.47	0.74
Maximum output power (W)	8.51	13.58
Charging performance	Slower	Faster

The experimental results indicate that both photovoltaic modules successfully charged the 12 V battery. However, the charging rate differed due to the difference in panel capacity. The battery connected to the 15 Wp monocrystalline solar panel experienced a faster increase in battery voltage during the charging process than the battery charged using the 10 Wp panel. This indicates that the higher-capacity photovoltaic module transferred electrical energy to the battery more effectively.

Figure 1.Battery Voltage Variation During the Charging Process



The faster charging performance of the 15 Wp panel is attributed to its higher output current and power. During the experiment, the maximum charging current produced by the 15 Wp module reached 0.74 A, whereas the 10 Wp panel generated a maximum current of 0.47 A. Consequently, the 15 Wp panel supplied more electrical energy to the battery within the same charging period, reducing the overall charging time. From a battery charging perspective, charging current is one of the most influential factors affecting charging duration. A higher charging current allows the battery to store energy more rapidly, provided that the charging process remains within the battery's recommended operating limits. Therefore, the higher electrical output generated by the 15 Wp photovoltaic module resulted in a shorter charging duration than the 10 Wp module.

DISCUSSION

The experimental results demonstrate that the 15 Wp monocrystalline solar panel provides better charging performance than the 10 Wp panel for a 12 V battery. Under identical operating conditions, the 15 Wp panel charged the battery more rapidly because its higher rated capacity produced greater output current and power, enabling faster energy transfer to the battery. Consequently, the battery reached the desired charging voltage in a shorter period than when charged using the 10 Wp panel. These findings are consistent with the study by Sudiharto et al., (2022), which reported that higher photovoltaic output improves the battery charging process by supplying sufficient charging current. Similarly, (Kumar et al., 2024)emphasized that selecting an appropriate photovoltaic capacity enhances charging efficiency and overall photovoltaic system performance. The present study confirms these findings through a direct comparison of 10 Wp and 15 Wp monocrystalline solar panels under identical operating conditions. This study was limited to two photovoltaic capacities and a single battery type under daytime testing conditions. Future research should investigate different battery capacities, photovoltaic ratings, and weather conditions to obtain a more comprehensive evaluation of photovoltaic battery charging performance.

CONCLUSIONS AND RECOMMENDATIONS

This study compared the charging performance of a 12 V battery using 10 Wp and 15 Wp monocrystalline solar panels under identical operating conditions. The experimental results showed that the 15 Wp monocrystalline solar panel provided faster battery charging than the 10 Wp panel because it produced higher electrical output during the charging process. Consequently, the 15 Wp panel demonstrated better charging performance and is more suitable for small-scale photovoltaic battery charging applications requiring shorter charging time. Future research should evaluate larger photovoltaic capacities, different battery types, and various weather conditions to obtain a more comprehensive understanding of battery charging performance. In addition, further studies may investigate the influence of different solar charge controller technologies and charging methods on the efficiency and charging time of photovoltaic battery systems.

FURTHER STUDY

Future research is recommended to evaluate the charging performance of 12 V batteries using photovoltaic modules with higher power capacities and different battery technologies under various environmental conditions. In addition, further studies should investigate the effects of different solar charge controller types, charging algorithms, and panel tilt angles on charging efficiency and charging time. Economic analysis and long-term performance evaluation are also recommended to determine the feasibility and reliability of photovoltaic battery charging systems for practical small-scale applications.

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