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EVALUASI GENERATOR TENAGA SURYA PORTABEL UNTUK DUKUNGAN LISTRIK KAPAL NELAYAN TRADISIONAL

A GENERATOR SOLAR PORTABLE EVALUATION FOR THE TRADITIONAL FISHING BOAT ELECTRIC SUPPORT

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Abstrak
Model dan performansi dari sebuah sistem pembangkit listrik tenaga surya *portable* dipresentasikan *paper* ini. sistem ini di desain sebagai generator surya *portable* untuk kebutuhan listrik nelayan. Tujuan pekerjaan ini adalah menilai performansi sistem generator surya *portable* dengan berbagai cuaca lingkungan. Garis besar *outline paper* ini adalah proses desain, fabrikasi dan pengujian dalam 3 kondisi. Komponen utama penyusun yang digunakan dalam sistem ini adalah modul PV, box, baterai, *Solar Charge Control*, Inverter dan komponen pendukung lainnya. tiga kondisi cuaca pada eksperimen ini adalah kondisi hujan terang tidak menentu, terang, dan hujan lebat saat pengujian. Penilaian meliputi parameter lingkungan, daya dan efisiensi dari eksperimen kinerja generator surya *portable*. Hasil dari penilaian ini adalah kondisi cuaca sangat mempengaruhi parameter lingkungan seperti radiasi energi surya dan suhu lingkungan untuk pendinginan natural. Daya luaran maksimal dan efisiensi dari sistem generator panel surya ini adalah 60,05 watt dan 13% secara berturut-turut. Sistem ini didesain mengikuti kebutuhan beban nelayan dan digunakan untuk kebutuhan operasi nelayan. Desain dari sistem ini adalah desain *portable* agar mempermudah aktivitas nelayan.
Kata Kunci: Cuaca, Efisiensi, Energi Surya, Generator Surya *Portabel*.

Abstract
This paper presents the model and performance of a portable solar power generation system designed specifically for the electricity needs of fishermen. The objective of this study is to evaluate the performance of the portable solar generator under various environmental conditions. The outline of this paper includes the design process, fabrication, and testing conducted under three different weather conditions. The main components of the system consist of photovoltaic (PV) modules, enclosures, batteries, solar charge controllers, inverters, and other supporting components. The three weather conditions examined during testing are uncertain bright rain, clear bright conditions, and heavy rain. The assessment focuses on environmental parameters, power output, and the efficiency of the portable solar generator. The results indicate that weather conditions significantly impact environmental factors such as solar

radiation and ambient temperature, which are essential for effective natural cooling of module. The maximum output power of this solar panel generator system is 60,05 watts, with an efficiency of 13%. This system is designed to meet the operational needs of fishermen, with a portable design that facilitates their activities.

Keywords: *Weather, Efficiency, Solar Energy, Portable Solar Generators.*

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INTRODUCTION

Indonesia is an archipelagic country, with more ocean than land—approximately 70% of its area is covered by water. As a nation rich in marine resources, Indonesia's fisheries sector plays a vital role in providing employment for coastal communities. Many people living in these coastal areas work as fishermen[1]. Fishing vessels are essential for these fishermen, serving as their primary means of transportation during fishing activities. The operation of these boats is a daily task for many[2]. However, to meet their energy needs while at sea, fishermen often rely on generators. Currently, fossil fuels, particularly BBM (Bahan Bakar Minyak), are the main source of fuel for these operations[3]. In Addition, also facing political and environmental challenges related to the limitations of fossil fuel exploration. As a result, there is a growing need to transition towards more environmentally friendly energy sources. One potential solution to this issue is the increasing demand for electricity[4].

In recent years, energy consumption has risen significantly, leading to increased energy costs and negative environmental impacts. As a result, the development of environmentally friendly power generation systems has gained momentum alongside technological advancements[5]. Various clean energy sources, such as wind, solar, and geothermal power, have garnered substantial attention. Among these, solar energy stands out as an abundant resource. Improvements in technical efficiency, maintenance, and network integration have established solar panel systems as leaders in the push for increased green energy use. The implementation of green energy power generation systems in both residential and industrial applications is a promising solution for achieving a sustainable energy future[6]. Solar energy can meet electricity demand at affordable costs, making it a viable alternative to fossil fuels, which are harmful to our planet[7]. Photovoltaic (PV) systems are advanced and reliable technologies that convert solar energy directly into electricity[8]. These systems are commercially available in several types of semiconductor technologies, including monocrystalline and polycrystalline silicon. PV technology offers significant benefits for both residential and industrial use due to its competitive pricing and advantages[9]. Consequently, the use of PV is suitable in assisting the operation of fishermen in terms of ship electricity needs.

The use of diesel generators on ships is a common method for meeting electricity needs. Typically, these generators operate at only 40% to 90% of their capacity, resulting in a disconnect between the energy produced and the emissions generated[10]. With the existence of IMO regulations aimed at controlling emissions, there is an opportunity for fishing vessels to adopt photovoltaic power systems to fulfill their electricity requirements during operations[11]. The concept of solar power generators has been around since the 19th century, and significant innovations have been made to improve their performance[12,13]. Solar power generators are often used in combination with direct equipment. For instance, portable off-grid solar generators, when paired with distillation systems, can provide clean water[14]. Additionally, these portable solar generators are employed in irrigation systems, enhanced with IoT technology to enable mobility and facilitate irrigation monitoring in agriculture[15]. Moreover, solar generators serve as an emergency solution for electricity needs during rescue and survival efforts[16]. Despite various scientific studies, there has been little focus on developing solar generators specifically for traditional fishing boats. Most existing applications are limited to photovoltaic-battery-LED lamp systems used merely as fishing aids to enhance catch rates. Given this context, solar-powered systems are highly recommended for fishing boats due to their environmental benefits and zero emissions[17]. Research has also been conducted to create platforms that promote the use of solar energy in fishing[18]. However, the development of portable solar generators on fishing boats has not been investigated and manufactured.

On the other hand, temperature has a significant impact on the performance of photovoltaic (PV) modules. Previous studies have indicated that an increase in PV surface temperature can lead to a decline in overall system efficiency[19]. This finding is supported by another study which reported that high temperatures can reduce PV efficiency by approximately 0.4–0.5% for every 1°C rise in ambient temperature[20]. Ambient environmental temperature also influences the surface temperature of PV modules, thereby directly affecting their performance[21]. Although several studies have addressed the effects of temperature on PV systems, there is still a lack of research specifically examining the relevance of local weather conditions and ambient temperature fluctuations on PV performance, particularly in coastal or tropical environments.

The use of portable solar generators on fishing boats can serve as an environmentally friendly solution while reducing operational costs for fishermen. Traditional fishing boats in Indonesia typically require minimal electricity for lighting and portable navigation. Consequently, this study outlines the development and evaluation of portable solar generators designed for use by traditional fishermen. It aims to provide new insights into equipment that can assist traditional fishing boats in their operations in Indonesia. Considering that fishing activities by fishermen experience fluctuating weather and unpredictable weather conditions, further studies are needed to determine the differences in weather on portable solar generators. This approach addresses a gap in prior research, which has largely focused on performance under constant or optimal sunlight conditions

RESEARCH METHOD

System Fabrication

Before manufacturing the tool, a design phase is conducted to select the necessary components. This design process considers the load requirements and the duration for which the load will be in operation. On fishing boats, some of the electrical devices used include LED lights, electronic entertainment devices, and mobile phone charger plugs. These electronic devices are typically used at night. After identifying the load, the selection of components such as batteries, photovoltaic (PV) modules, solar charge controllers (SCC), inverters, and other supporting components follows. The system schematic for the portable solar generator can be seen in Figure 1. The portable solar generator system is systematically designed and constructed according to the initial design specifications. The model is shown in Figure 2. Any differences in placement are due to the mismatch between the size of the SCC, the designed socket, and the one actually used. However, this does not affect the performance of the portable solar generator. The schematic of the portable solar generator system process begins with the absorption of solar energy by photovoltaics. A DC MCB is then used to protect against excessive current. The electrical energy is then received and controlled by the SCC. A wattmeter is used to measure the current and voltage entering the SCC. The current from the SCC is then stored in a parallel battery. The electrical energy to be used is passed to an inverter to convert DC current to AC. An AC MCB is used to protect the load current from exceeding the standard. The circuit schematic for the portable solar generator is displayed in Figure 3. In terms of operation, it's important to follow the procedures carefully. This includes monitoring the DC miniature circuit breaker (MCB) rated for 200V and 63A on both the panel and the battery. For AC loads, one must pay attention to the AC MCB. The system uses a deep cycle battery with a capacity of 7 Ah and 12 V. It also includes a solar charge controller with a capacity of 10A and an inverter capable of delivering 12V at 300W. Furthermore, ensuring proper battery capacity is essential for the efficient functioning of the system.

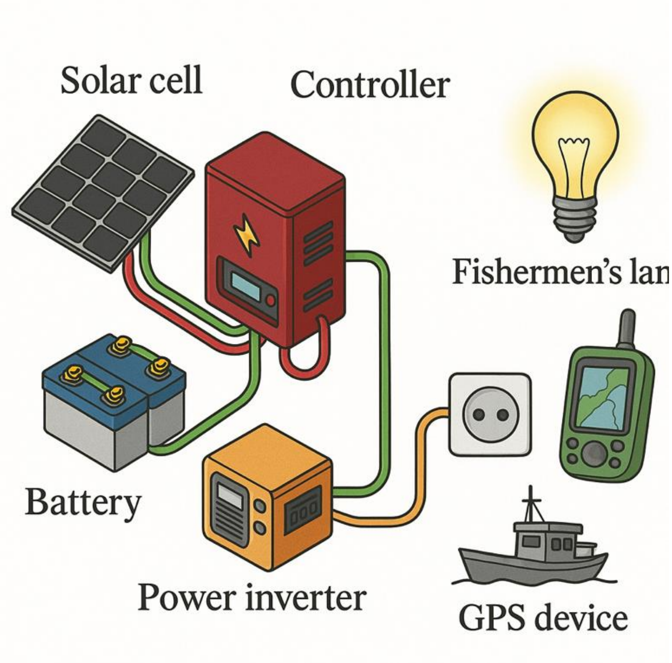

Figure 1. Portable solar generator system schematic illustration

Figure 2. Model a) Design and b) Fabrication results of portable solar generator

This study utilized polycrystalline solar panel with dimensions of 770 x 540 mm, capable of producing a maximum output of 50 W during operation. This type of module was selected due to its excellent performance in converting sunlight into electricity, along with its affordability, making it widely available in the market. The solar panel used in this research was manufactured by Visero Indonesia. The table included provides a comprehensive description of the requirements for manufacturing the module, including various factors that influence its performance.

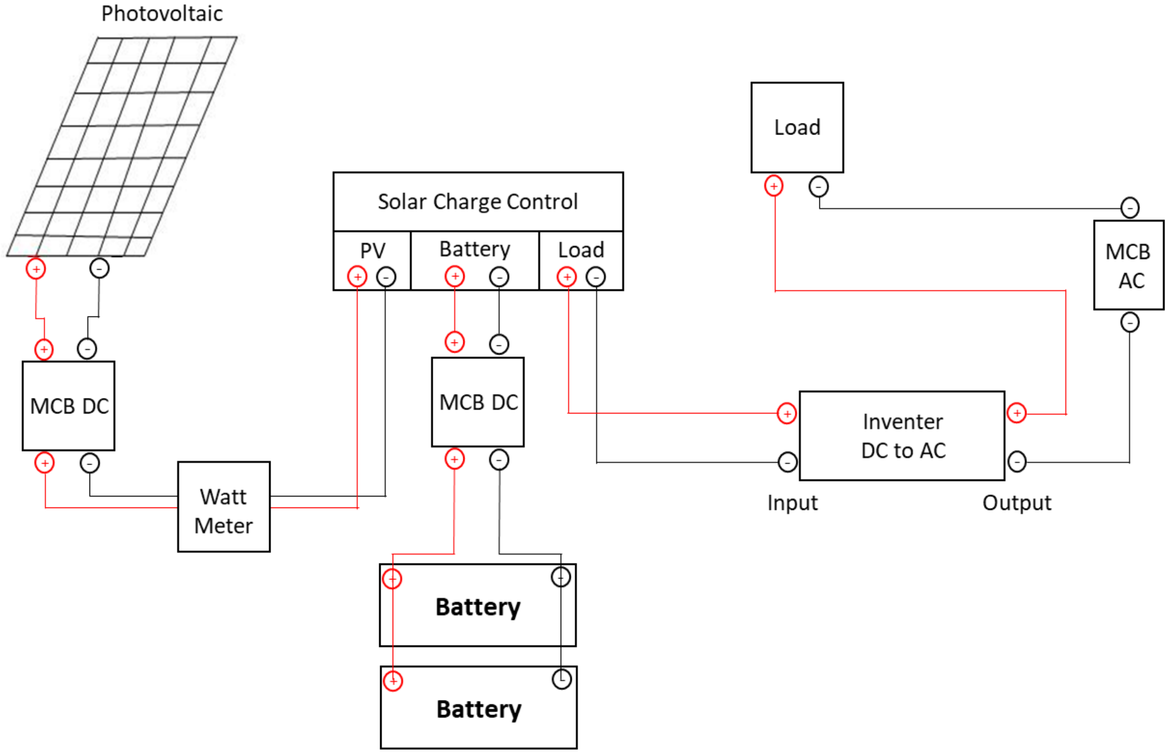

Figure 3 Overall process schematic of a portable solar generator system

Table 1. Specifications of PV modules used in portable solar generators (https://visero.co.id/product/poly-visero-50w)

Parameter	Value	Unit
Rated Maximum Power (P_{max})	50	WP
Voltage at Maximum (V_{mp})	17,6	V
Current at Maximum (I_{mp})	2,86	A
Open Circuit Voltage (V_{OC})	21	V
Short Circuit Voltage (I_{SC})	3,2	A
Maximum System Voltage	1000	V

Prototype Experiment

The measurement setup was constructed and tested under real-world conditions to evaluate the performance of the portable solar generator system across various scenarios. The evaluation was conducted under three specific conditions: bright conditions, bright and cloudy conditions, and cloudy conditions. These variations were selected to assess the solar panel's ability to capture sunlight and the generator's output. Additionally, these weather conditions are representative of those typically found in Dumai City, Indonesia. The experiment took place over three days, with the choice of days based on weather forecasts to anticipate expected conditions. Testing was conducted from 07:00 to 17:00, which aligns with the hours of available sunlight in the region.

System Measurement

Experimental setup using manual measuring instruments to determine the parameters of the portable solar generator. Measurement of solar energy radiation using solar power meter data logging B35A TES-1333. Then, for environmental temperature measurement, use a hygrometer HTC-1. At the same time, the temperature on the PV module is measured using a thermogun (Benetech, GM320). Voltage measurement from the PV module using a multitester (Fluke, 101) measured at the module's positive and negative poles. Measure the current generated on the PV module that enters the portable solar generator using a DC wattmeter with a capacity of 60V 100A. Measurement of these parameters is carried out simultaneously for 30 minutes. Measurements are recorded on a note sheet for later analysis of the results.

Data Analysis

The performance of the portable solar panel generator system, which uses photovoltaic (PV) modules, can be analyzed through thermodynamic studies[22] that consider both power input and power output. To do this effectively, it is essential to measure solar energy radiation, as this serves as the primary input power. Additionally, several equations must be calculated to determine various parameters. The maximum power entering the portable solar generator can be calculated using Equation 1[23].

$$P_{max} = V_{max} \cdot I_{max} \quad (1)$$

The maximum output power P_{out} of solar cells is measured in watts (W), while the maximum voltage is represented as V_{max} (Volts) and the maximum current as I_{max} (Amperes). The efficiency of solar cells, denoted as η, is the ratio of the output power to the solar intensity. This efficiency can be calculated using Equation 2[23,24].

$$\eta = \frac{P_{max}}{G \times A} \, x \, 100\% \quad (2)$$

The efficiency of solar cells (η) is defined as a percentage and is calculated using the maximum output power P_{max} in watts, the intensity of solar radiation (G) in watts per square meter (W/m²), and the surface area of the solar cells (A) in square meters (m²). All the data collected will be processed and summarized in a table that presents the average results.

RESULT AND DISCUSSION

This study was conducted over a period of four days in December. The measurements will later be categorized into three weather conditions observed in cities in Indonesia. Condition 1 refers to a bright and cloudy day, Condition 2 to a clear day, and Condition 3 to a bright day with intermittent heavy rain. The results of the measurements are presented in a graph showing data collected every 30 minutes.

Environment Conditions

Solar radiation is influenced by the weather conditions in the environment where solar modules are installed. The performance of solar energy systems is particularly sensitive to climate variations, making meteorological data essential for assessing how different weather conditions affect solar radiation output. Figure 4 illustrates the radiation levels in the study area under three distinct weather conditions. On average, solar energy radiation was measured at 0,53 kW/m² in condition 1, 0,67 kW/m² in condition 2, and 0,34 kW/m² in condition 3. The unpredictable nature of weather contributes to fluctuations in solar energy radiation[25]. Variations in weather characteristics lead to changes in temperature, which can significantly reduce solar energy production. Additionally, the air quality is influenced by temperature changes associated with different weather conditions[26]. Moreover, the presence of clouds can obstruct solar radiation, further diminishing solar energy values[27]. Consequently, differences in weather conditions directly impact solar radiation levels.

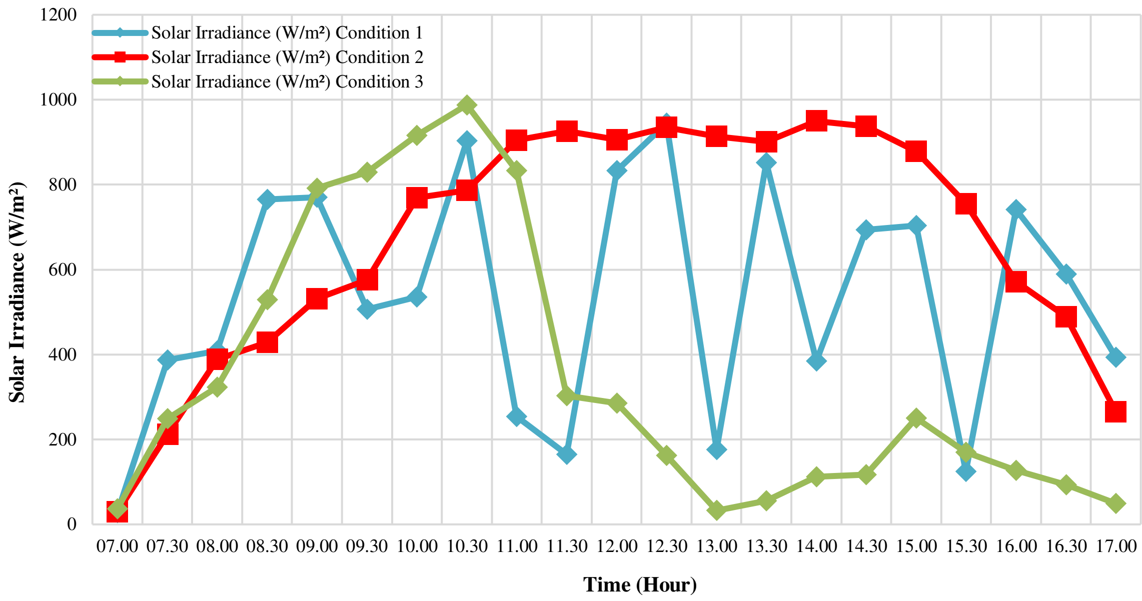

Figure 4. Radiation conditions in experimental environments with various conditions

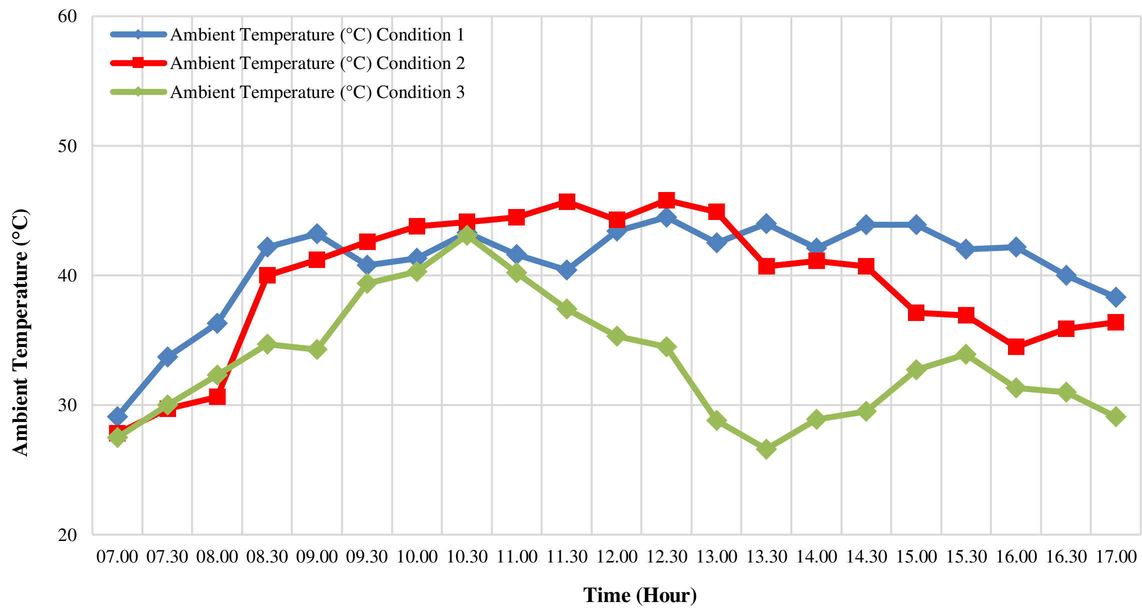

Figure 5. Experimental environmental temperature conditions with various conditions

Weather conditions not only affect solar radiation but also influence environmental temperature, which in turn impacts other parameters. Figure 5 illustrates how variations in weather can alter environmental temperature patterns. The average environmental temperatures for each condition are as follows: condition 1 at 40,89 °C, condition 2 at 39,44 °C, and condition 3 at 33,37 °C. Ambient temperature is logically affected by environmental changes, such as rain or cloud cover, which can block sunlight. Therefore, temperature is a crucial factor in the cooling process of other parameters and must be taken into account[28]. The ambient temperature and solar radiation observed during the measurements were influenced by climatic conditions characterized by cloud cover. Solar radiation intensity and ambient temperature under clear sky conditions tend to reach optimal values. However, limited studies have addressed the correlation between ambient temperature and solar radiation[20,29]. In fact, for portable solar generators, these parameters significantly affect performance and are closely related to environmental conditions, particularly the surrounding temperature. Ambient temperature can be influenced by weather clarity and cloud cover[4].

Solar Panel Surface Condition

Figure 6 illustrates the impact of different weather conditions on the surface temperature of the PV module in a portable solar generator system. The average surface temperatures for the various conditions are as follows: condition 1 at 43,95 °C, condition 2 at 44,80 °C, and condition 3 at 35,50 °C. Weather conditions significantly influence the module's surface temperature, primarily by raising environmental temperatures. This increase triggers thermal convection in the surrounding air, which plays a crucial role in the natural cooling of the PV surface. The effect of ambient air varies based on the specific experimental environment[30,31]. Additionally, the surface temperature directly affects the performance of the PV module in the portable solar generator system[32].

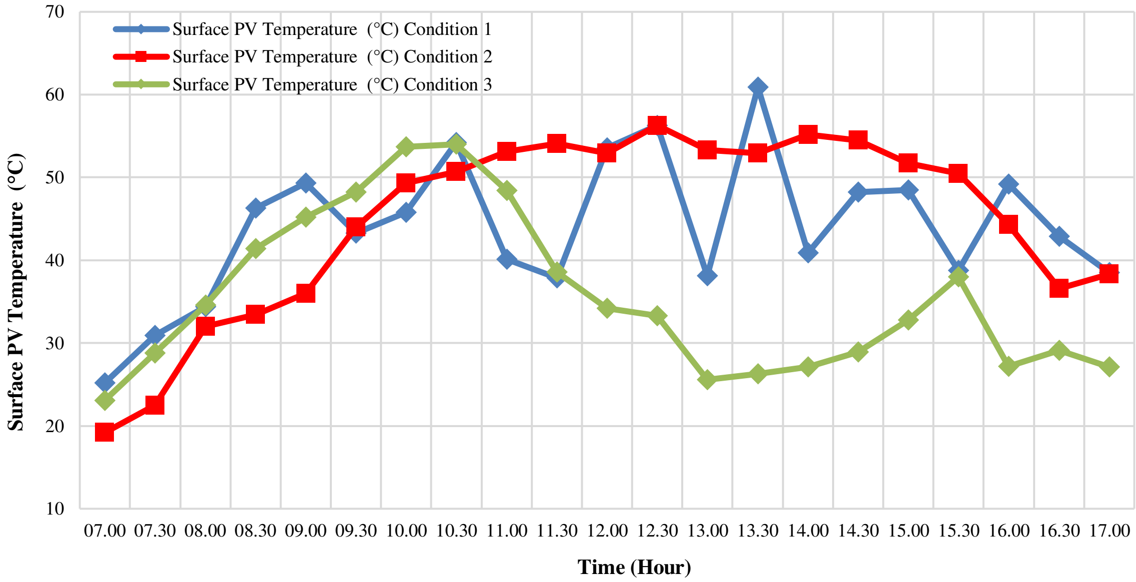

Figure 6. Surface PV module temperature in experiments with various conditions

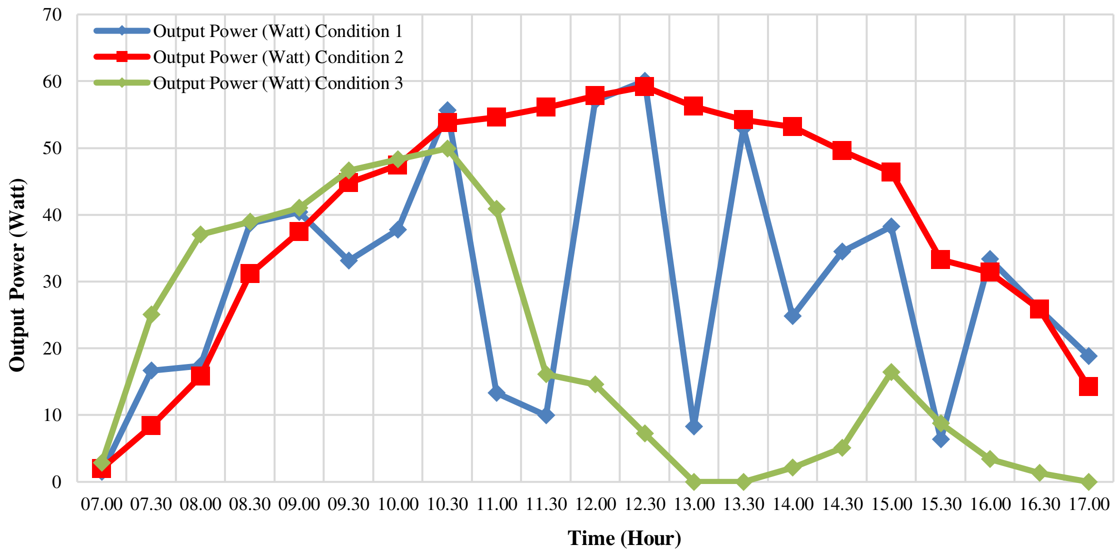

Figure 7. Output energy in experiments with various conditions from portable solar generators

Output Power Generated

Variations in weather conditions can lead to suboptimal power output from portable solar generators. Figure 7 illustrates the output power measured during experiments conducted under different weather conditions. The average power outputs for Condition 1, Condition 2, and Condition 3 were 29,74 watts, 39,64 watts, and 19,31 watts, respectively. An analysis of weather variation and PV output has been conducted, showing that changes in hourly conditions significantly affect the efficiency of the portable solar generator. The findings indicate that rainy or cloudy weather conditions can considerably reduce the output of the photovoltaic system. This study aligns with the work of Ghazi et al.[29], which investigated the impact of weather conditions on PV efficiency in the United Kingdom. Additionally, different weather conditions influence the amount of solar radiation received in the environment, which in turn can decrease the potential power generated[33,34]. Rainfall can significantly inhibit the solar radiation that reaches the photovoltaic (PV) module[35]. While weather conditions can cause reduced PV performance from any factor[36].

Evaluation of PV module efficiency and performance of Portable Solar Generator

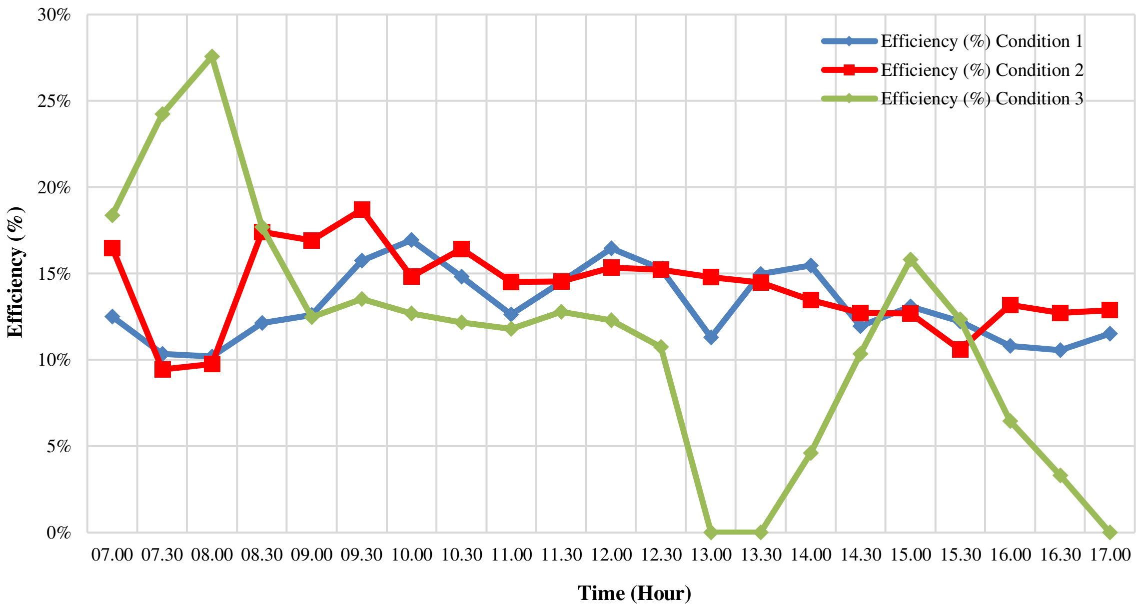

Figure 8. Efficiency of portable solar generators under various conditions

Table 2. Daily parameters on portable solar generators

Parameter	Value	Unit
Solar Irradiance	5,15	kWh/m^2.hari
Ambient Temperature	37,90	°C
Surface PV Temperature	41,42	°C
Average Power output	29,56	Watt
Efficiency	13	%

The efficiency of portable solar generators is influenced by weather conditions, making it essential to conduct specific investigations under various climatic circumstances. Figure 8 illustrates the efficiency levels at different times from 07:00 to 17:00 across several weather conditions in the experimental environment. The average efficiency results for the portable solar generators under conditions 1, 2, and 3 are 13%, 14%, and 11%, respectively. Notably, condition 3, which featured rainy weather in the middle of the experiment, experienced a smaller decrease in efficiency compared to the other conditions. This reduction in efficiency is primarily attributed to the lower solar radiation received[29]. While the presence of particles in the air may have some effect, it is not significant when it comes to the performance of photovoltaic (PV) systems. Additionally, variations in temperature on the surface of the PV modules do not substantially affect the overall performance of the portable solar generator system[37]. However, it is worth noting that the surface temperature of the solar panels can inversely affect energy conversion efficiency[38], which raises concerns regarding the conversion of energy into electricity.

The efficiency and performance results of portable solar generators under various conditions are presented in Table 2. This study indicates that the portable solar generator tested in three different environmental conditions, with data collected at 30-minute intervals, received an average radiation input of 5,15 kWh/m² per day, along with an ambient temperature of 37.90 °C. This average environmental condition serves as a benchmark for evaluating the performance of portable solar generators. As a result, the average surface temperature of the photovoltaic (PV) module reached 41,42 °C, which significantly impacts the performance and efficiency of these generators[39]. This temperature difference arises from the variation between the outer and inner surfaces of the PV module, caused by thermal mixing within the module[40]. The study concluded that the portable solar generator achieved an average efficiency of 13%, with an average output power of 29,56 watts and a maximum power output of 60.05 watts. These findings illustrate how climate influences performance, demonstrating varying efficiencies based on the natural cooling effects of the environment[41,42]. The average efficiency obtained under three different weather conditions was 13%. In contrast, a previous study by Naphon and Wiriyasart[5] reported an efficiency range of 10–12% for a prototype tested under controlled, clear-sky conditions. This comparison highlights the novelty of the present prototype, which demonstrates improved efficiency across three varying weather conditions. Unlike earlier studies that primarily focused on ideal or static environments, this research offers new insights into the performance of solar generators under real and dynamic atmospheric conditions. Further investigation into these weather conditions is essential for modifying and enhancing the performance of portable solar generators.

CONCLUSION

This study presents a comprehensive performance evaluation of a portable solar generator system deployed on traditional fishing vessels under various weather conditions. The performance assessment was conducted in coastal areas under direct sunlight, capturing a range of weather scenarios. These weather variations were treated as representations of fluctuating real-world conditions that affect the operational performance of the portable solar generator. The evaluation included power output and efficiency measurements, as well as key environmental parameters. The results indicate that each weather condition had a distinct impact on the generator's performance. Weather fluctuations significantly influenced both efficiency and power output, which were directly correlated with the variations in solar radiation received by the photovoltaic (PV) system. The experiment yielded an average efficiency of 13% across the three tested conditions, with a maximum power output of 60,05 watts. This work also contributes to the understanding of solar energy potential in Indonesia and its conversion into usable electrical power. Further analysis of weather-related factors is recommended to enhance the depth and accuracy of performance data. The proposed system demonstrates adaptability to maritime environments with fluctuating weather conditions, making it suitable for broader implementation. Future research should focus on the environmental effects of marine weather conditions to better understand the performance and economic feasibility of portable solar generator systems for traditional fishermen

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