Potential of using photovoltaic systems to power underwater fishing lights in small-scale fishing vessel in Indonesia

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ABSTRACT

The limited stock and uncertainty of fuel prices as a source of driving the main engine and generator on ships greatly affect the lives of fishermen in Indonesia. Even though there is a policy in the form of assistance from the government in the form of subsidies, fishermen still feel doubtful about being able to get such assistance. To overcome this and with the potential of solar energy in Indonesia, as well as a manifestation of appropriate technology and blue economy policies, a photovoltaic system is made that is combined with underwater lights as a fishing tool. Activities are carried out by measuring environmental conditions and the energy that comes out of the PV system and giving questionnaires to the fishermen. The results showed that the use of PV systems combined with underwater lights in fishing activities gave good results. The result of electrical energy that can be generated is 393.24 Wh/day and can meet the ship's electricity needs for 4 days. This result is also supported by the Wilcoxon test results for technical, economic, environmental, health, and safety aspects with a significance value of 0.001 ($p<0.05$).

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1. INTRODUCTION

East Nusa Tenggara is one of the provinces in Indonesia that has marine and fishery potential that cannot be underestimated. In 2020 the results of the production and production value of Capture Fisheries reached IDR 1,840,354,295.00 with a total of 123,714 tons. In addition to having enormous marine and fishery potential, East Nusa Tenggara also has enormous solar energy potential throughout the year which can support marine and fishery activities [1]. This potential can be utilized as a source of electrical energy by using a photovoltaic (PV) system by converting solar energy [2]–[7]. Utilization of this energy can help fishing activities. One of these activities is to use underwater fishing lights in fishing activities as fishing tools.

Underwater fishing lights are one form of solution to the problem of fishermen who use lights above the water's surface. The actual underwater fishing lights technology has been known by fishermen for a long time, but in its application, the technology is still underdeveloped [8]–[12]. This is because fishermen think that the technology is too difficult and if there is damage to the underwater fishing lights, fishermen will have difficulty making repairs. On the other hand, if fishermen want to buy underwater fishing lights, many face problems, such as finding a shop that sells underwater fishing lights. Apart from that, the price of underwater fishing lights is also still quite expensive. The price for one unit of manufacturer-assembled underwater fishing lights on the market ranges from IDR 1,700,000-2,000,000 per unit.

In the process of fishing activities using underwater fishing lights, there are still many fishermen who use generators as a source of electrical energy. Although the use of light emitting diode (LED) lamps that have better specifications when compared to incandescent lamps and in lighting fishing activities reduces fuel consumption by around 15-17%, this can be suppressed again by using PV systems as a good and environmentally friendly source of electrical energy. A 6–9-Watt LED lamp can produce 450 lumens, the equivalent of a 60-Watt incandescent lamp. In this case, it can be seen that the consumption of electrical energy is maximized when using LED lamps compared to incandescent lamps which convert it into heat and then light. In terms of capacity, LED lamps have a service life of about 50,000 hours [12]–[20]. The use of PV systems combined with underwater fishing lights with LED lights will of course be a form of environmentally friendly energy use. This utilization is expected to support the productivity of fishermen [1]. The low productivity of fishermen is generally caused by the lack of fishing gear and fishing aids that are still simple, so the effectiveness and efficiency of fishing gear are not optimal.

This research will create a set of underwater fishing light tools with photovoltaic systems construction as a source of electrical energy in saving the use of fossil energy and supporting the blue economy [2], [5], [21]–[24]. This research is a form of utilizing renewable energy technology in accordance with the policies of the Ministry of Marine Affairs and Fisheries in Indonesia and studies the use of this system to its effect on society, which has not been studied until now. The use of this PV system is also expected to have an economic impact on the community [25]–[32]. This study aims to determine the use of PV systems for underwater fishing lights, analyze the productivity of fishing activities, and determine the advantages and disadvantages of using PV systems as a source of electrical energy for underwater fishing lights on ships.

2. METHOD

This research is descriptive associative research. This study is used to describe an event that occurs in the field and focuses on actual problems as they were at the time the research took place and tries to describe events and events that are the center of attention without giving special treatment to these events. Then, the relationship between variables is sought, namely the extent to which variations in one variable are related to variations in other variables. The degree of relationship between these variables is expressed in one index, namely p (probability value). This value will indicate a significant mean difference between the two groups of data and produce a consistent and meaningful conclusion. This index value is then used to test hypotheses and draw conclusions about the relationship between variables or to state whether there is a relationship between variables.

The experimental design of the study used one fishing boat unit, which is the ship before and after the using PV system and underwater fishing lights. The experiment was carried out for 2 weeks. Comparison of system use is measured based on the technical, economic, environmental, health, and safety perceived of the respondents. Interview methods and questionnaires were also added to this activity to obtain more supporting data. The results of the statistical test used were paired comparative test with the Wilcoxon test. The block diagram of this study can be seen in Figure 1.

The questionnaire used in this study uses a rating scale with 4 answer ranges. This was chosen according to the main purpose of using the rating scale, namely that researchers wanted to relate the qualitative research size to various aspects of the features or products of service. In general, this measurement scale or rating scale is used to evaluate or measure the performance of a job, service, feature, and so on. Apart from that, the use of this data has advantages, such as making it easier for researchers to select data, not needing a lot of evaluation of research subjects, practical use, short time required, can be used on broad research subjects (large coverage), levels the data obtained makes it easier to analyze, the measurement scale questions are easy to understand and apply, often used for quantitative and qualitative research data collection standards.

To determine the energy output produced by the PV system, energy output measurements were carried out for 1 month (June 2022). Environmental conditions where the ship is located are also added to the measurement results. To determine the effect of environmental conditions on the energy output of the PV system, a correlation test was carried out using the spearman test as shown in Figure 2. Several measuring instruments are used in this research, such as a digital power meter, thermo-hygrometer, anemometer, scales, camera, and questionnaire. The digital power meter is used to display the current, voltage, and energy output of the system. Thermo hygrometer is used for the temperature and humidity of the environment. Anemometer is used to measure wind speed. Scales are used to calculate the weight of the fish caught by the fishermen. Cameras are used to document activities. Questionnaires were used to obtain respondents' answers to the use of tools.

Figure 1. Block diagram of statistical test for the use of PV systems and underlight fishing lights

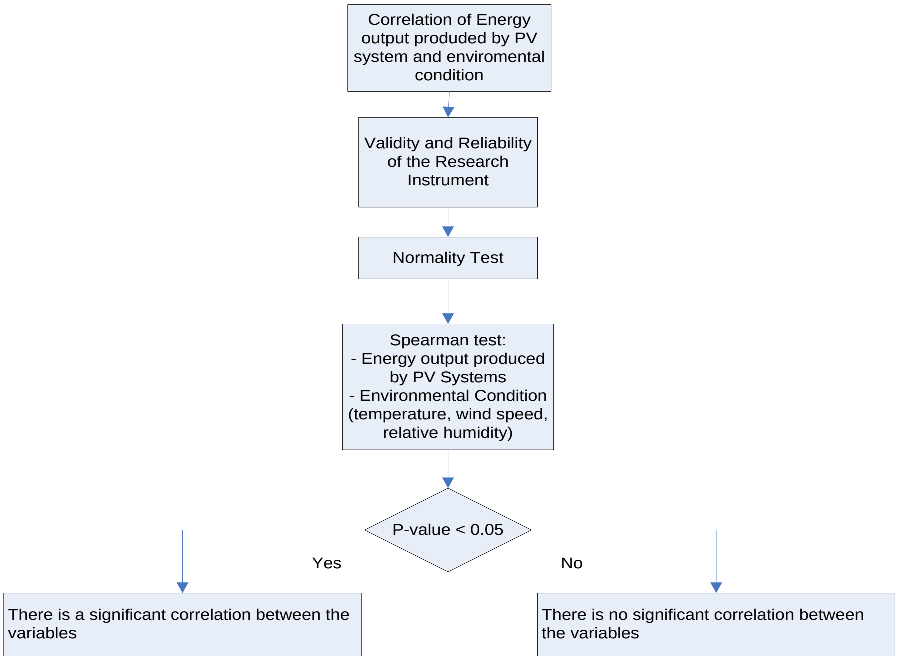

Figure 2. Block diagram of statistical test for energy output produced by PV systems and environmental condition

3. RESULTS AND DISCUSSION

3.1. Specifications of the PV system and underwater fishing lights

The results of measurements of environmental conditions (temperature, wind speed, and relative humidity) and the output of electrical energy that can be generated by the PV system around the fishing boat location as shown in Figures 3 to 5. The average temperature of the location is 27.87 °C, with a temperature range between 26.82 °C and 28.70 °C. The average wind speed of the location is 5.88 m/s, with a wind speed range between 2.62 and 8.02 m/s. The average air humidity is 74.66%, with air humidity range between 65.31% and 85.06%. The average energy that can produce by the PV system is 393.24 Wh/day, with an energy range between 184.45 and 455.6 Wh/day. From these results, it can be seen that the electrical energy produced by the PV system is influenced by environmental conditions. Based on the results of the Spearman test, the energy output of the PV system with the ambient temperature and wind speed showed a significant relationship ($p<0.05$), but not on the humidity of the air as shown in Table 1. The Spearman correlation value of -0.674 indicates that the direction of the correlation is negative, and the strength of the correlation is strong. This states that if the temperature around the placement of the solar panel increases, it will cause a decrease in the energy output of the PV system due to the lower voltage and efficiency of electricity generated by the solar panels. The Spearman correlation value of 0.419 indicates that the direction of the correlation is positive with sufficient correlation strength. It is stated that if the wind speed in the solar panel installation area increases it will increase the energy output of the PV system because it helps in the process of cooling the solar panel surface. However, these results can state that the use of PV systems for underwater fishing lights in Indonesia is very possible. Another thing that can affect it is the shadow of the trees when the boat is leaning on the beach, so it does not get full sunlight and there is dirt attached to the solar panels.

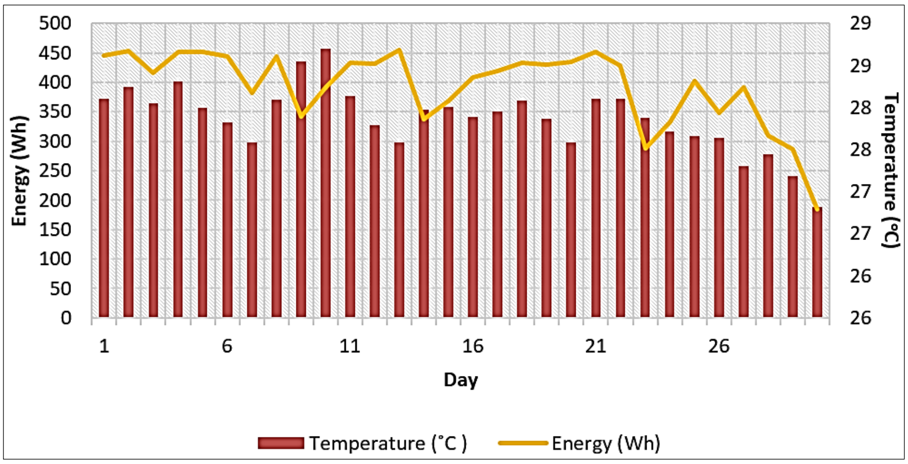

Figure 3. Electric energy of PV system and temperature at location

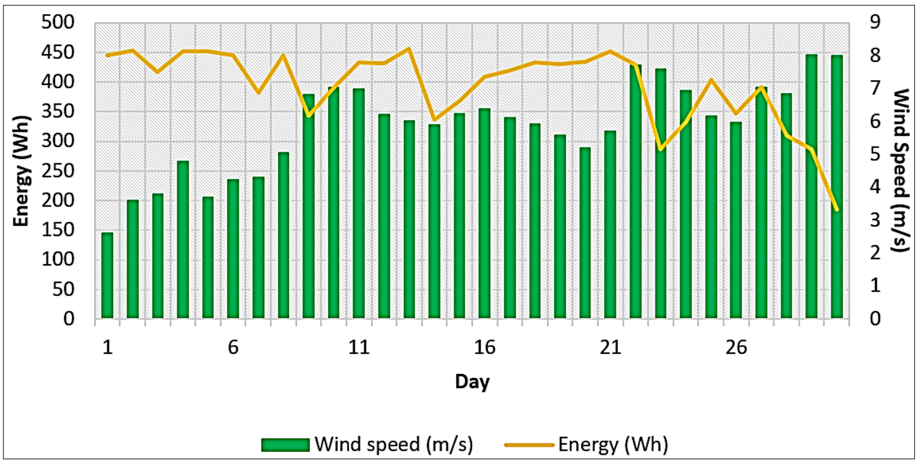

Figure 4. Electric energy of PV system and wind speed at location

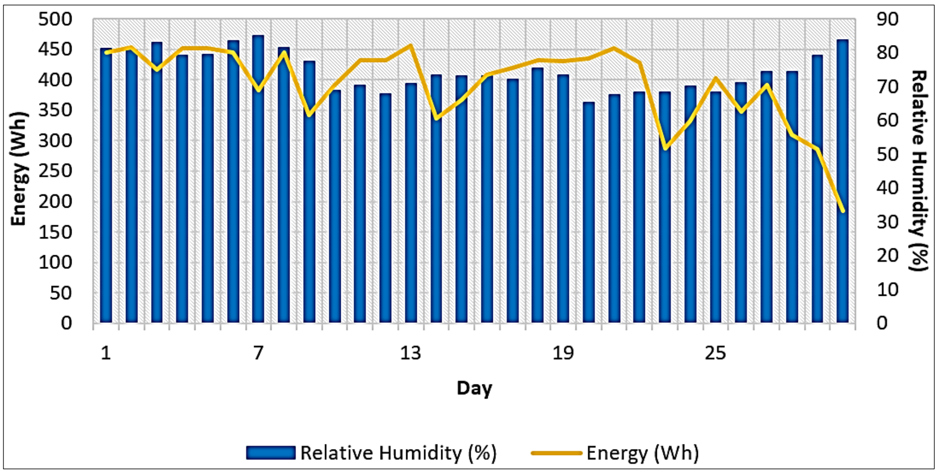

Figure 5. Electric energy of PV system and relative humidity at location

Table 1. Spearman correlation test results

		Temperature	Wind Speed	Relative Humidity
Energy output of PV system	r	-0.674	0.419	0.017
	p	<0.001	0.021	0.927
	n	30	30	30

The system specifications and the electrical load on the ship can be seen in Tables 2 and 3. The PV system uses 100 WP solar panels and 2 units of batteries 100 Ah 12 V. The selection of the specifications of the PV components of this system takes into account the conditions experienced by fishermen such as the length of time fishing and the need for uncertain loads and limited supply of fuel obtained by them in the field. This system can provide an average energy input of 393.24 Wh/day and can support load requirements for up to 4 days. Besides being used as a source of electrical energy for lighting lamps and underwater fishing lights, the battery is also used to support the ship's engine starter system. In addition to these tools, this system is also supported by the battery control unit (BCU), inverter and some additional accessories. Schematic diagrams and the system installation process can be seen in Figures 6 and 7.

Table 2. PV system specifications

Components	Quantity	Characteristics	Value
Solar panel	1	Vmpp	19 V
		Impp	5.26 A
		Voc	23 V
		Isc	5.53 A
		Efficiency	16.31%
		Type	Monocrystalline
Battery charge controller (BCR)	1	Rated voltage	12/24 V 10 A
		Rated charge/ load current	10 A
Inverter	1	Rated voltage	12 DC to AC 220 AC
		Power	500 W
Battery	2	Capacity	100 Ah
		Voltage nominal	12 V
		Type	Deep cycle
Lamp	3	Type	LED
		Rated voltage	5 Watt/220 V
Underwater fishing lights	1	Type	LED
		Rated voltage	36 Watt/220 V

Table 3. PV system load

Components	Power (Watt)	Quantity	Operation Time (h/d)	Energy (Wh/d)
Lamp	5	3	12	180
Underwater fishing lights	36	1	6	216
Total				396

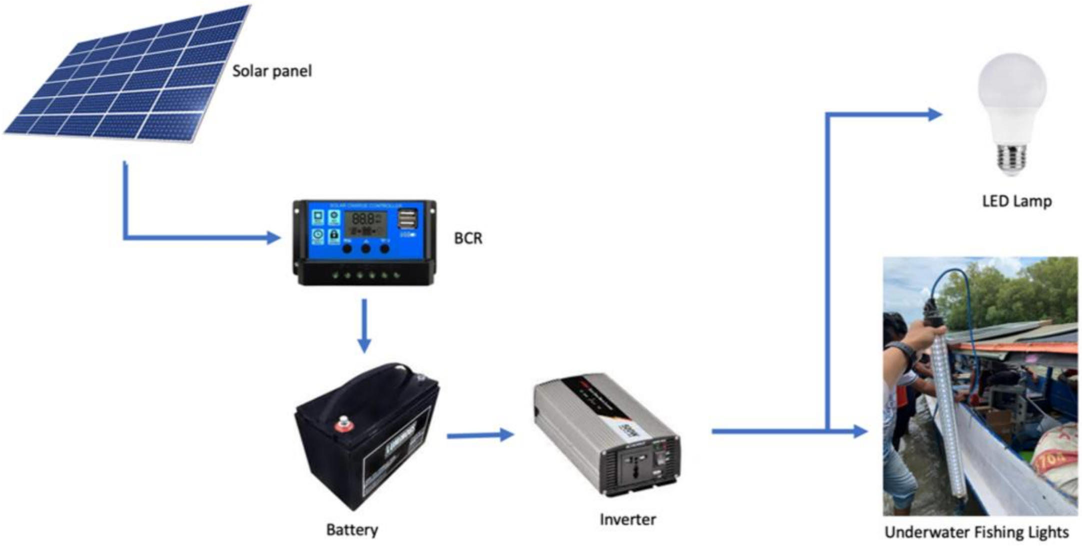

Figure 6. Schematic diagram of the system installed on small-scale fishing vessel

Figure 7. The process of installing the system on small-scale fishing vessel

3.2. Community response to the use of PV systems and underwater fishing lights on ship

Community feedback on the use of PV systems and underwater fishing lights is essential for this research. The community response is divided into several factors, such as technical, economic, environmental, health and safety. Technical aspects include the ease of use of the type of fishing gear, the energy required, comfort, and the shape of the tool. Economic aspects include the cost of using fishing gear and the catch obtained. Environmental aspects include the impact of pollution resulting from the use of tools on the aquatic ecosystem of the catchment area. Health factors include the influence of fishing gear and equipment on public health, such as respiratory problems, coughs, hearing problems, and visual impairments. The safety aspects include the level of safety of the tool during use which is measured by the respondent's feelings.

Fishing activities to determine the utilization of the system were carried out 2 times. Activities are carried out for a week in the dark moon (May 2022). This is to be able to provide better results from the use of the tool. The first activity was carried out without using a PV system and underwater fishing lights, and the respondents were asked to carry out fishing activities as usual. The second activity is carried out on the next dark moon (June 2022), which is carried out using a PV system and underwater fishing lights, and the community is asked to carry out fishing activities as usual. Each activity was then given a questionnaire and respondents were asked to answer these questions. The results of the answers to the questionnaire were then analyzed by testing the validity and reliability of the data, then continued with the normality test of the data and the Wilcoxon test. Based on the results of the analysis showed that the results of the questionnaire answers were valid and reliable. Based on the results of the analysis showed that the results of the questionnaire answers were valid and reliable. The validity value is more than 0.374 (r table) and the reliability is 0.713 with Cronbach's Alpha test. Meanwhile, in the data normality test, because the data is not normally distributed, the comparative test used is the Wilcoxon test.

The results of the Wilcoxon test analysis on the technical aspects of using PV systems and underwater fishing lights showed significant results, with a significance level of 0.000 ($p<0.05$) as shown in Table 4. So, it can be concluded that there are significant differences in technical aspects before and after using the tool. In the comparison of the technical aspects before and after treatment, there were 28 answers with the results increasing.

The results of the Wilcoxon test analysis on the economic aspects of using PV systems and underwater fishing lights showed significant results, with a significance level of 0.000 ($p<0.05$) as shown in Table 5. So, it can be concluded that there are significant differences in the economic aspects before and after using the tool. In the comparison of economic aspects before and after treatment there are 27 answers with increasing results and 1 is still the same as before.

The results of the Wilcoxon test analysis on environmental aspects of using PV systems and underwater fishing lights showed significant results, with a significance level of 0.000 ($p<0.05$) as shown in Table 6. So, it can be concluded that there are significant differences in environmental aspects before and after using the tool. In a comparison of environmental aspects before and after treatment, there are 27 answers with increasing results and 1 is still the same as before.

The results of the Wilcoxon test analysis on the health aspect of using PV systems and underwater fishing lights showed significant results, with a significance level of 0.000 ($p<0.05$) as shown in Table 7. So, it can be concluded that there are significant differences in health aspects before and after using the tool. In the comparison of health aspects before and after treatment, there were 28 answers with increasing results.

The results of the Wilcoxon test analysis on the safety aspect of using PV systems and underwater fishing lights showed significant results, with a significance level of 0.000 ($p<0.05$) as shown in Table 8. So, it can be concluded that there are significant differences in the security aspects before and after using the tool. In the comparison of safety aspects before and after treatment, there were 28 answers with increasing results.

Table 4. Wilcoxon test analysis results for technical aspect

	n	Median (minimum-maximum)	mean±sd	p
Pretest	28	7.5 (4-11)	7.71±1.512	0.001
Posttest	28	15 (12-16)	15.21±0.957	

Table 5. Wilcoxon test analysis results for economic aspect

	n	Median (minimum-maximum)	mean±sd	p
Pretest	28	2 (1-3)	1.79±0.630	0.001
Posttest	28	4 (3-4)	3.64±0.488	

Table 6. Wilcoxon test analysis results for environmental aspect

	n	Median (minimum-maximum)	mean±sd	p
Pretest	28	2 (1-4)	1.75±0.701	0.001
Posttest	28	4 (3-4)	3.64±0.488	

Table 7. Wilcoxon test analysis results for health aspect

	n	Median (minimum-maximum)	mean±sd	P
Pretest	28	6 (3-9)	5.43±1.317	0.001
Posttest	28	12 (9-12)	11.25±1.051	

Table 8. Wilcoxon test analysis results for safety aspect

	n	Median (minimum-maximum)	mean±sd	p
Pretest	28	1.5 (1-4)	1.61±0.737	0.001
Posttest	28	3.5 (3-6)	3.57±0.690	

4. CONCLUSION

The use of PV systems combined with underwater fishing lights in fishing activities in Indonesia gives good results. The results of electrical energy that can be produced as much as 393.24 Wh/day can meet the ship's electricity needs for 4 days. This result is also supported by the Wilcoxon test results for technical, economic, environmental, health and safety aspects with a significance value is 0.001 ($p<0.05$), which shows that there are differences between before and after the use of PV systems and underwater fishing lights.

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