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Technical-economic prospect for photovoltaic on fixed lift net in Indonesia

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ABSTRACT

The limited fossil energy and uncertain prices have an indirect effect on fishing activities using a fixed lift net. Therefore, energy diversification is carried out by utilizing solar energy with photovoltaics on the fixed lift net. This energy is very abundant and available throughout the year, except during the rainy season. This study uses observation, interviews, and questionnaires given to fishermen and tries to compare the utilization of photovoltaic (PV) systems with generators using different types of lamps, such as LED, CFL, incandescent lamps, and halogen lamps. The use of PV systems in fixed lift nets from a technical and economic perspective allows it to be utilized in the long term. Based on the technical aspects, the PV system can produce 471.59 Wh per day. This technical result will be more profitable if the lamp used is a light emitting diode (LED) lamp. Meanwhile, from economic aspect, the use of electrical energy from a PV system is more profitable because it provides a lower operational value than a generator, and provides good net present value (NPV) and internal rate of return (IRR) values. This utilization is also supported by the good response from fishermen towards the energy produced and the ease of operation and maintenance of the PV system.

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1. INTRODUCTION

In 2019, marine and fishery commodities for marine areas in Indonesia contributed 7,164,302 tons and IDR 204 trillion [1]. One of the contributors to this result comes from fixed lift nets in waters in Indonesia. Based on data in 2020 the number of fixed lift nets reached 24,532. Fishermen widely use fixed lift nets as fishing gear that uses light in coastal areas to catch fish because it has several advantages. These advantages are easy to do, affordable investment by the community, is a smallholder fishery that has been used by the community in coastal areas and around small islands for generations, catches are always available even though the numbers are small, absorbs a lot of labor, and the technology is very simple [2]–[6].

The results of observations in several locations show that the use of lights in the fixed lift net has a relationship with the catch [2], [5]–[7]. In the past, the use of lights as fishing aids was only limited to traditional fisheries located on the coast. However, along with the development of traditional fishing activities into an industry, the use of lights as a tool has expanded widely to assist fishing with fishing nets, trawling, fixed lift

nets, and others. Fish interest in light is influenced by several factors, such as the color of the lamp, light intensity, exposure time, water conditions, and fish conditions. The results of observations in Awur Bay Shore in Jepara, strong lighting, and the use of 4, 6, and 8 lamp units did not show significant differences in the catch. The total catch weight obtained on fixed lift nets is influenced by the number of lamps, where with each additional number of lamps there is an increase in the catch, but there is no significant difference between 4 and 5 lamp units. Based on the catch, it shows that the composition of the dominant catch for each number of lights is not the same. The use of 2 lamp units resulted in the dominant catch being shrimp, 3 lamp units resulted in the dominant catch being anchovies, 4 lamp units resulted in the dominant catch being sardines, and 5 lamp units resulting in the dominant catch being ribbon fish. The fishing process is also not only limited to the tools and the catch but also to the mechanism of attracting fish by light or things related to the behavior of fish to light, and how long it takes to pull the net. The results showed that each type of fish responded differently to the given light. Anchovies respond quickly to light, so lifting the net 4-5 times a night is possible. This is because anchovies are more prone to high-light illumination. The fixed lift nets in the Makassar Strait show that there is interest in fish around fishing gear using various types of lights, such as compact fluorescent lamp (CFL), incandescent, and mercury. The lamps used have a total power of 500 W. The results show that the use of CFL gives different results from incandescent lamps, but the same with mercury lamps. The fish's interest in the color of the lights also plays a role. This can be seen in the process of catching fish in the waters of Manado, where from the observations, fish are more attracted to white lights than green, blue, and red colors.

In Indonesia, the use of fixed lift nets with a lamp is very helpful for the fisherman. However, the lamps used are usually mercury, fluorescent, or incandescent lamps assisted by an electric generator as a source of electrical energy [8]–[10]. This is done because it is still considered simple by the fishermen [11]–[17]. For this reason, it is necessary to improve technology on the fixed lift nets considering that nowadays the use of fossil energy has begun to be limited by the government and the amount has also begun to be limited [18], [19]. The prices are erratic and the stock at the gas stations is sometimes difficult to find, so it is necessary to use other technologies [8], [20]–[25]. Based on the results of a survey related to the issue of rising fuel prices for fishermen, shows that they are not sure if the fishermen's subsidy will arrive and fulfill the quota of fishermen. In addition, the lack of fuel supply in some areas is also a problem for fishermen. Therefore, small fishermen hope that the government can ensure that subsidies are targeted and sufficient for all fishermen. The technology that makes it possible to replace onboard generators as a source of electrical energy is the PV system [1], [12]–[14], [26], [27]. This system converts solar energy and converts it into electrical energy through solar panels [28]–[35]. The potential of solar energy is so good in Indonesia that it is possible to use this energy as a substitute for generators on fixed lift nets as a source of electrical energy [23], [36]–[41].

Based on these problems and under the policies of the government of Indonesia through blue economy, a fixed lift net will be made using a PV system with the use of light emitting diode (LED) lights [1], [42]–[44]. The utilization of LED lamps has better specifications than incandescent lamps and can reduce energy consumption by 15-17%. A 6-9 Watt LED lamp can produce 450 lumens, the equivalent of a 60 Watt incandescent lamp [45]–[48]. So that the use of PV systems and LED lights on fixed lift nets can be a form of environmentally friendly energy use. The use of PV systems in the marine and fisheries world has been carried out for several decades. The results of previous studies on small-scale fishing boats in East Nusa Tenggara showed an increase in the economy, environment, and health of fishermen, so results like this can also occur in the use of fixed lift nets. This system is studied technically and economically to provide an overview of the use of the technology.

2. METHOD

The research was conducted in January-December 2022 and was carried out around the waters of East Nusa Tenggara. To support this research, the method of observation, interviews, and questionnaires were given to the respondents to obtain results and data according to what was happening in the field. Several supporting tools were used in this research, such as a multimeter, anemometer, and thermohydrometer. The materials used to support this research can be seen in Table 1. These materials are then assembled on fixed lift nets and tested for use for one month. System testing and schematic activities can be seen in Figure 1. From this figure it can be seen that two energy sources are used, namely the photovoltaic (PV) system and generator, then these two energy sources are compared for their utilization on a fixed lift net with the use of several types of lamps.

The economic analysis of the use of PV systems and generators is an indicator of project profitability and project recovery. To determine the profitability of the system installation, payback period (PP), net present value (NPV), and internal rate of return (IRR) methods are used [1]. The calculation can be seen below. The discount rate (r) is usually 4.25% in Indonesia and is based on government regulations regarding the purchase of electricity by the State Electricity Company from solar PV, amounting to US$ 25 cents/kWh. This paper does not discuss the types of fish and the number of fish caught by fishermen. This paper focuses on the technical and economic use of PV systems compared to generators as a source of electrical energy in fixed lift nets.

The utilization of the PV system in the fixed lift net is also analyzed by collecting answers from the respondents. 15 Respondents were selected using a purposive sampling method based on the people who carry out fishing activities using fishing aids with lighting whose energy comes from the PV system. 15 respondents were asked for their opinion regarding the use of the system with questions about the utilization of electrical energy and the ease of operation and maintenance. These questions include understanding the PV system, installing the PV system, maintaining the PV system, utilizing the PV system from an economic and environmental perspective. The results were analyzed using a frequency descriptive test method with an average of the respondents' answers to each question.

$$PP = Investment\ or\ capital\ cost/\ saving\ cost\ per\ year \quad (1)$$

$$NPV = Income\ cash\ flow - Outcome\ cash\ flow \quad (2)$$

$$IRR = \sum_{t-1}^{t} \frac{C_t}{(1+r)^t} - C_o \quad (3)$$

Table 1. The materials used in this research

Item	Specification	Quantity
Solar panel	100 Wp	1
Battery	100 Ah	2
BCU	10 A	1
Inverter	1000 VA	1
LED lamp	18 Watt/220VAC/White	5
CFL	23 Watt/220VAC/White	5
Incandescent lamps	100 Watt/220VAC/White	5
Halogen lamp	72 Watt/220VAC/White	5
Generator	3000 VA	1

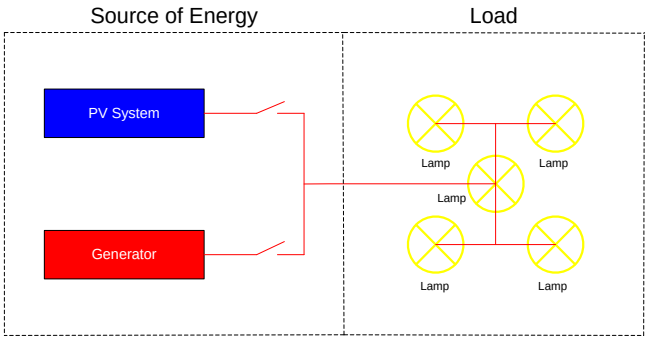

Figure 1. The electrical schematic on the fixed lift net

3. RESULTS AND DISCUSSION

3.1. Electrical energy from PV system and generator

Measurement of environmental conditions was carried out at the position of the fixed lift net installation in East Nusa Tenggara from January 2022 until December 2022. This location consists of several fixed lift nets that have been used by traditional fishermen. In support of the research carried out, measurements of environmental conditions around the fixed lift nets were carried out, which consisted of temperature, wind speed, and air humidity. This environmental condition needs to be taken into account because it will determine the energy output produced by solar panels. The environmental conditions can be seen in Table 2. The highest temperature reaches 28.09 ˚C, wind speed reaches 4.41 m/s, and air humidity reaches 87.11%. Based on the analysis results, the PV system can produce the highest energy of 657.05 Wh and the smallest of 82.45 Wh, with an average of 471.59 Wh/day shown in Table 2. The energy produced can meet the needs of LED lamps, CFL, incandescent lamps, and halogen lamps installed in the fixed lift net. The energy output of solar panels is affected by weather conditions, causing the system's electrical energy output to vary depending on each time.

The utilization of electrical energy produced by each source provides different percentages of loading for all loads. The installed electrical load comes from each of the 5 lamps LED lamps, CFLs, incandescent lamps, and halogen lamps as shown in Table 3. These lamps were chosen because they have the same lumen

value, which is 8000 lumens. From these electrical loads, it was found that using lamps for 3 hours for LED lamps requires 270 Wh, CFL lamps require 345 Wh, incandescent lamps require 1500 Wh, and halogen lamps require 1080 Wh. In the utilization of the PV system, the percentage of loading for the use of LED lamps is 61.42%, CFLs are 78.48%, incandescent lamps are 341.21%, and halogen lamps are 245.67%. Meanwhile, with the use of a 3000 VA generator, the percentage of loading for the use of LED lamps is 3%, CFL is 3.83%, the incandescent lamp is 16.67%, and halogen lamps are 12%. The results of the percentage loading on these two types of generating systems can be seen in Figure 2.

Based on the results in Figure 2, it can be seen that the use of LED lamps provides the smallest energy utilization compared to the use of CFLs, incandescent lamps, and halogen lamps. Even though the use of a generator can meet the needs of the electrical load on the fixed lift net with the use of LED lamps, CFLs, incandescent lamps, and halogen lamps, the percentage of loading on the generator is too small and below the load limit for the generator to operate. The limit value of the percentage of loading on the generator is expected to work no less than 30% and is effective at 60-86%. If this is done continuously, it will indirectly have an economic impact, on safety, and the lifetime of the generator. The combination of the use of PV systems and LED lights for fixed lift nets can be used for 7.11 days with a battery DOD of 80%.

The use of this system is also analyzed with the results of the respondents' answers. 15 respondents were asked for their opinion regarding the use of equipment in terms of utilization of electrical energy and ease of operation and maintenance, with answers of 5 and 5.33 as shown in Figure 3. The results of this respondent's answer indicate that the utilization of this equipment is in accordance with the respondent.

Table 2. Environmental conditions and electrical energy of the PV system

Month	Wind speed (m/s)	Temperature (°C)	Humidity (%)	Energy (Wh)
1	3.37	26.44	87.11	437.53
2	2.50	26.69	84.88	451.65
3	1.64	27.08	80.16	499.25
4	2.36	27.50	74.87	517.25
5	2.71	27.27	73.46	438.13
6	4.41	25.25	75.34	393.24
7	3.36	25.55	70.87	439.61
8	3.26	27.16	64.43	514.80
9	2.29	28.09	70.38	546.18
10	1.92	27.83	77.05	524.45
11	1.44	24.96	67.61	502.15
12	2.93	23.67	69.36	395.30
Average	2.68	26.46	74.63	471.63

Table 3. Energy consumption of lamps in fixed lift net

Appliance	Quantity	Load (W)	Lumens	Use hours per day (h/d)	Energy (Wh)
LED Lamp	5	18	8000	3	270
CFL	5	23	8000	3	345
Incandescent Lamp	5	100	8000	3	1500
Halogen Lamp	5	72	8000	3	1080

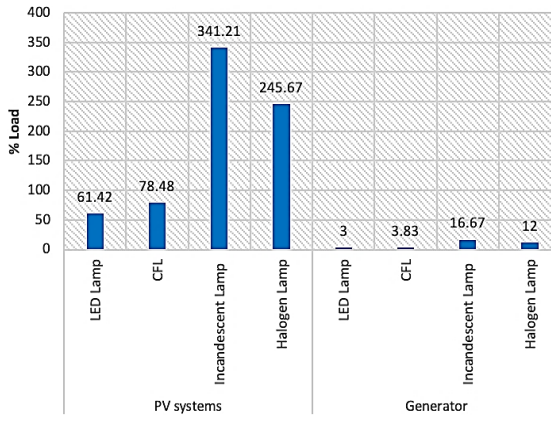

Figure 2. The results of the percentage loading of generating systems

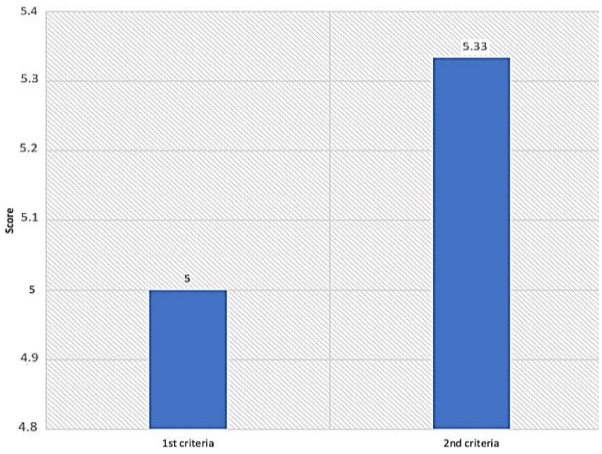

Figure 3. Respondents' opinion on the use of the PV system in the fixed lift net

3.2. Economic impact installation of PV system and generator

The economic value of using a PV system on a fixed lift net shows good economic value (Table 4). This result is supported by the NPV value of IDR 6,817,859.91 and an IRR of 6%. When compared to the use of generators on a fixed lift net, the use of PV systems is more profitable because the operational costs for generators are IDR 56,995,000 (fuel purchases and engine maintenance) per year. This value is higher than the operational costs of using a PV system, which is only IDR 70,000 per year.

Table 4. Energy cost calculation and feasibility of solar PV

Economic aspect	Description
Investment cost	IDR 7,000,000
Operational and Maintenance cost/ year	IDR 70,000
Saving-1/ year	IDR 606,221.89
I	4.25%
n	25 years
Payback Period	11,55 years
NPV	IDR 6,817,859.91
IRR	6%

4. CONCLUSION

Utilization of the PV system on a fixed lift net technically and economically gives better results than using a generator. Technically, using a PV system can produce 471.59 Wh per day, while using a generator the energy utilization is still less effective and efficient because the loading percentage is too low (less than 30%). This technical result will be more profitable if the lamp used is an LED lamp. Meanwhile, economically the use of electrical energy from PV systems is more profitable because it provides lower operational values than generators, and also provides good NPV and IRR values. The utilization of the PV system in this fixed lift also indirectly supports the blue economy policy set by the Indonesian government in the utilization of renewable energy and maintaining marine sustainability due to pollution from the use of fossil materials.

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