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ARTICLE

Integration of Solar Energy Technology in Improving Energy Sustainability and Efficiency in the Fisheries Sector (Case Study of Rokan Hilir Regency, Riau Province)

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Abstract: Improving sustainability and energy efficiency in the fisheries sector has emerged as an essential objective in addressing current environmental and economic concerns. One promising solution is the integration of solar energy technology in the fisheries sector. The purpose of the study was to analyse the potential and benefits of incorporating solar energy technology in improving sustainability and energy efficiency in the fisheries sector. This research included quantitative and qualitative analysis of the usage of solar energy technology in numerous aspects of the fisheries sector, such as fishing vessels, aquaculture, processing facilities, and related infrastructure. Data was collected from different locations with various characteristics during field research. The study found that integrating solar energy technology can lessen reliance on fossil fuels while also saving long-term operational costs. One of the potentials that can be used to encourage the growth of Rokan Hilir Regency, particularly in the field of fisheries, is the incorporation of solar energy technology. The Rokan Hilir Regency has the potential for solar energy conversion into electrical energy that can be used for a variety of purposes. The average peak power hour (Sun Peak Hour) for a year in Bangko District is 6.84 hours, with a minimum value of 6.23 hours in December and a maximum of 7.34 hours in August. The usage of integrated solar energy technology is utilised to support the activities of the fisheries sector, including catching, cultivating, or hatching, as well as fishing product processing. Obviously, the components used in each field must be adjusted to the level of electrical energy required. Several components that are used on fishing boats to facilitate fishing activities include spotlights, LED lights, fish cool boxes, and electric starters. Lighting lamps and DC water pumps can be used in the aquaculture industry. Solar energy is also used in the Fisheries Processing sector for LED lights and electric motors in shredded fish processing machines.

Keywords: Integration, Fisheries Technology Innovations, Solar Energy, Fisheries Sector Efficiency, Rokan Hilir

1. Preliminary

Improving sustainability and energy efficiency across various sectors of the economy is a key challenge in this modern era. As the global population grows, energy demand increases, and the negative impacts of climate change become more apparent, the need to find innovative solutions to meet energy needs while reducing carbon footprints has become imperative. One area that has great potential to integrate these solutions is the fisheries sector (Hayat & Suhendra, 2021).

The innovation of solar technology integration in the fisheries sector is in line with government regulation no. 38 of 2017, which is the basis for the importance of this study. Then later, the results of the study can provide recommendations for solar technology integration innovations as a consideration for Rokan Hilir Regency government policies, especially in the fisheries sector (Kementerian Sekretariat Negara, 2017).

Fisheries are an important part of the world's economy and food resources. However, the sector also has challenges in terms of sustainable and efficient energy use. Dependence on fossil energy sources that are not only finite, but also have a negative impact on the aquatic environment and associated ecosystems, makes it necessary for the fisheries sector to look for environmentally friendly alternatives.

Solar energy technology innovation has become a major focus in the quest for sustainable solutions to energy problems. Solar energy is a renewable energy source that is abundant, renewable, and has a low environmental impact. The integration of solar energy technology in the fisheries sector has great potential to improve the sustainability of fisheries operations and the efficiency of energy use.

In this study, we will explore the innovation and potential integration of solar energy technologies in the fisheries sector. We will analyze the benefits, challenges, and opportunities of using solar energy in various aspects of fisheries, including vessel operations, aquaculture, and fishery product processing. We will also look at how these technologies can positively impact economic, environmental and social sustainability in the fisheries sector.

Through a deeper understanding of solar energy technology integration innovations in fisheries, we will be able to formulate concrete recommendations for practical applications, policies, and strategic measures to promote sustainable development and energy efficiency in this crucial sector. As such, this study aims to contribute to efforts to achieve greater sustainability and energy efficiency in the fisheries sector, given its critical role in meeting food needs and managing global marine resources.

2. Research Methods

This study used a literature review analysis approach to gather information on recent developments in the integration of solar energy technology in the fisheries sector. Data was collected from various sources, including scientific journals, and government reports. Sunlight intensity data was obtained from PVGIS and NASA SSE Satellite monitoring using PVsys software. According to (Kurniawan, 2016) the data was processed data originating from statistical mapping data and direct measurements carried out by the Meteorology, Climatology and Geophysics Agency (BMKG) of the Riau Climatology Station combined with direct measurements in areas with potential for development integration of solar panel technology in the fisheries sector. Measurements were made of solar intensity directly in the area using a pyranometer sun intensity measuring device. Furthermore, these data were analyzed to identify trends, benefits, obstacles, and opportunities related to the integration of solar energy in the fisheries sector in the areas of fishing, aquaculture, and processing of fishery products.

3. Results and Discussion

3.1. Solar Energy Potential in Rokan Hilir Regency

The most important factor that determines the amount of energy output of a PLTS system is the amount of potential radiation energy at the location it has been installed. Solar radiation energy is often given in kWh/m^2 each day. The potential for solar radiation in one location should be based on measurement data collected over an acceptable time period, of at least 3 years.

Solar radiation data were acquired from primary and secondary data sources for this research. Secondary data was derived from satellite data in the PVGIS database as well as NASA SSE Satellite Data. The database is a statistical analysis of satellite data collected over an eight-year period. Meanwhile, the primary data was received from direct measurements at the Riau Climatology Station by (BMKG), and it was combined with primary data collected by themselves.

The energy originates from three types of radiation: direct radiation, diffused radiation, and reflected radiation. Global radiation is the total of these three components. Unlike other solar power systems, which require a specific type of radiation, the PLTS system is directly tied to global radiation.

The average global radiation, or solar radiation energy, in Bangko Sub District, is shown in graphical form in Figures 1, 2, and 3 based on the PVGIS satellite database, NASA SSE Satellite, and BMKG Riau Climatology Station, respectively.

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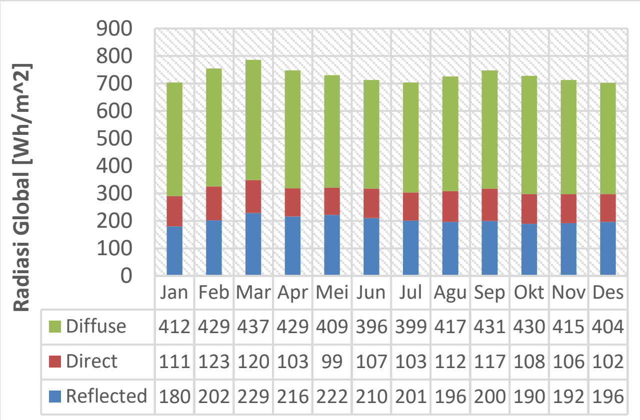

Figure 1. Solar Radiation Energy in Bangko Sub District, Rokan Hilir Regency Based on PVGIS Satellite Data

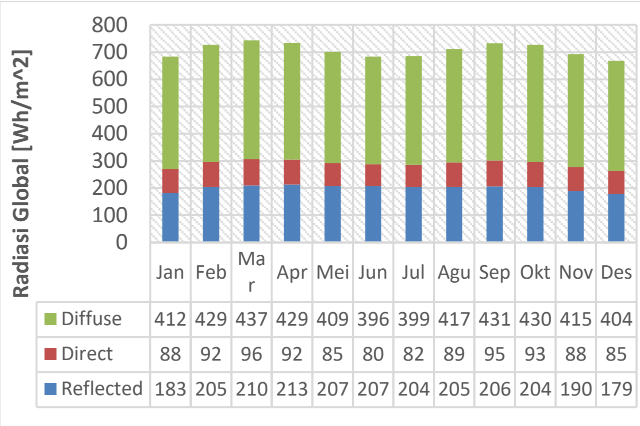

Figure 2. Solar Radiation Energy in Bangko Sub District, Rokan Hilir Regency Based on NASA SSE Satellite Data

According to Figure 1, the solar radiation energy in Bangko Sub District, Rokan Hilir Regency is 729 Wh/m^2 per day, with a maximum value of 786 Wh/m^2 (March) and a minimum value of 702 Wh/m^2 (December). The diffuse component of radiation is significant, particularly from March to October, although the direct component is relatively small all year.

Another source, displayed in Figure 2, shows that the average solar radiation energy in Bangko District, Rokan Hilir Regency, is 707 Wh/m^2 per day, with a maximum value of 743 Wh/m^2 in March and a minimum of 668 Wh/m^2 in December, based on processed data from NASA SSE Satellite Data.

According to primary data collected by the BMKG Riau Climatology measurement station from 2018 to July 2022, solar radiation energy in Bangko Sub District averaged 623.6 kWh/m^2 with a maximum of 908.2 kWh/m^2 in August 2018 and a minimum of 218.1 kWh/m^2 in February 2018.

As an equatorial country, Indonesia's solar energy potential is 4.8 kWh/m^2 in one day or 10 hours with an irradiation period from 07:00 to 17:00 if it is not disrupted by weather or radiation reaches 100%, resulting in 300 hours of solar radiation in one month. With these changes in irradiation, a potential energy production of 1440 kWh/m^2 is computed by comparing 100% variation in one month, with the maximum energy in the last 5 years occurring in August 2018, precisely 908.2 kWh/m^2.

The following table shows the variance in radiation and solar energy potential from the BMKG Riau Climatology measurement station from 2018 to July 2022:

Table 1. Radiation Variation and Solar Energy Potential

Month	Variation of Radiation Year (%)					The Potency Resulted (kWh/m²)				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Jan	28.1	36.4	37.1	29.9	37.7	403.9	523.7	534.0	431.1	543.1
Feb	15.1	39.9	38.0	45.7	41.0	218.1	574.3	546.6	658.3	590.4
March	20.7	48.9	49.6	39.4	56.9	298.5	703.6	714.8	567.2	819.2
Apr	26.6	50.8	50.4	38.2	48.1	383.7	731.4	725.1	549.5	692.2
May	42.6	50.9	51.7	40.3	57.5	613.7	733.5	744.8	580.2	828.2
Jun	42.6	42.4	20.2	51.7	56.1	613.2	610.1	291.6	744.2	807.8
Jul	46.3	58.6	55.6	51.9	52.7	667.0	844.5	800.3	747.9	758.7
Aug	63.1	51.3	58.6	40.0		908.2	739.0	843.4	575.5	
Sept	41.6	37.9	38.4	41.1		598.7	545.1	553.4	591.3	
Oct	41.7	41.2	40.1	46.9		600.5	592.9	577.6	674.7	
Nov	43.2	42.5	34.6	48.0		622.6	611.3	497.5	690.7	
Dec	39.5	22.8	42.0	34.7		569.0	328.9	604.3	499.0	
Average	37.6	43.6	43.0	42.3	50.0	541.4	628.2	619.5	609.1	720.0

Source: BMKG Riau Climatology Station, 2022 and Compiler Analysis 2022

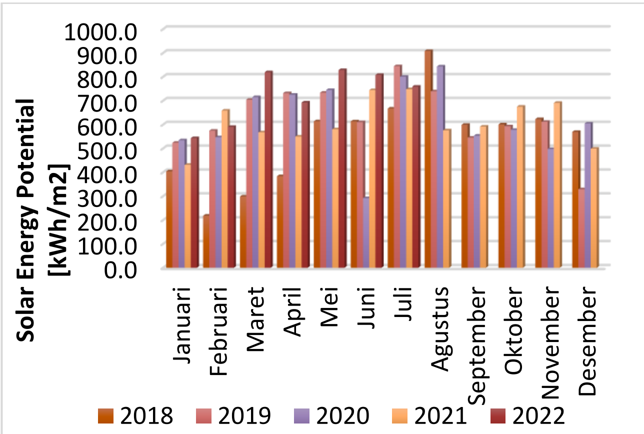

Figure 3. Solar Energy Potential Fluctuations in Bangko Sub District, Rokan Hilir Regency

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Measurement of solar radiation energy is another primary data which the measurements were carried out alone in Bangko Rokan Hilir District. Daily fluctuations in solar radiation energy are presented in Figure 4 below:

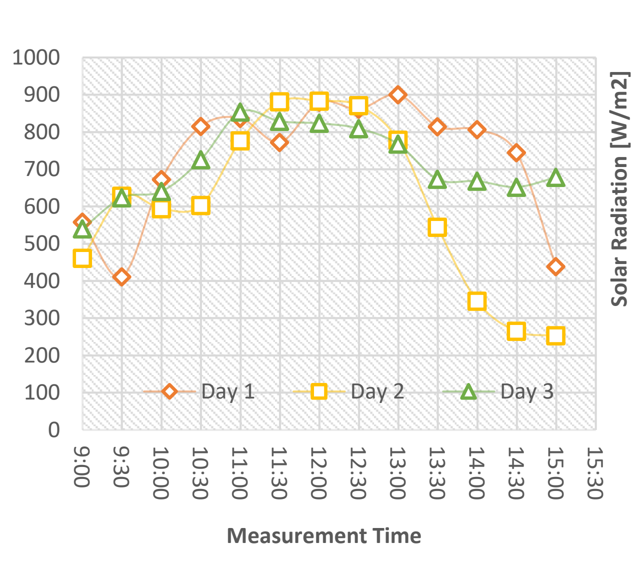

Figure 4. Daily Solar Energy Fluctuations in Bangko Sub District, Rokan Hilir Regency

The graph above shows fluctuations in solar radiation energy, which is affected by the level of brightness on that particular day. The first day's measurements reveal fluctuations at the beginning and the end of the measurement, but the trend of fluctuations in solar radiation energy appears constant around 700 - 900 Wh/m^2. In contrast to the second day, the fluctuations in the drop in solar radiation energy were the greatest from all measurements beginning at 13:00 - 15:00 based on the records at the time of measurement at that hour when dense clouds covered the intensity of sunlight.

We may conclude from the graph above that the potential energy of solar radiation is highly reliant on the weather environment in the area. Nonetheless, because Indonesia is positioned on the equator, the potential for solar radiation energy that can be utilised is enormous.

For one year, there is a large disparity between the data sources listed above, particularly satellite data and direct measurement data (primary). It is estimated in this case due to numerous considerations, including:

1) The measurement time varies.
2) Various time spans (number of years).
3) Climate change and weather are different from year to year

Different measuring methods, particularly between a specified height (as is common with PVSyst) and ground level readings (for direct measurement data).

In this study, the potential for solar energy in Bangko Sub District, Rokan Hilir Regency is defined based on an average calculation of all these sources. The average potential figure for solar energy in Bangko District, Rokan Hilir Regency is determined from these calculations, as given in Table 2 below:

Table 2. Average Solar Radiation Energy in Bangko Sub District, Rokan Hilir Regency

Month	Sun Radiation Energy [kWh/m2]			
	Self Measurement by BMKG	PVGIS	NASA	Average
(1)	(2)	(3)	(4)	(5)
Jan	4.87	7.03	6.83	6.24
Feb	5.18	7.54	7.26	6.66
Mar	6.21	7.86	7.43	7.17
Apr	6.16	7.48	7.34	6.99
May	7.00	7.30	7.01	7.10
Jun	6.13	7.13	6.83	6.70
Jul	7.64	7.03	6.85	7.17
Aug	7.67	7.25	7.11	7.34
Sept	5.72	7.48	7.32	6.84
Oct	6.11	7.28	7.27	6.89
Nov	6.06	7.13	6.93	6.71
Dec	5.00	7.02	6.68	6.23

3.2. Sun Peak Hour

In PLTS, the term Sun Peak Hour is often known as the peak hour of solar irradiation power, which is defined as the length of time the sun shines with an intensity of 1000 Wh/m^2. This quantity is needed to facilitate calculations, because the standard for testing solar panels is at radiation conditions of 1000 W/m^2.

The unit of the solar panel is Watt Peak (Wp), which signifies that the panel's output power is in conditions of 1000 W/m^2 solar radiation and a standard temperature of 25℃. A panel with a specification of 100 Wp, for example, indicates that the output power of the solar cell is 100 watts when operating under solar radiation with an intensity of 1000 W/m^2 and at a standard temperature.

On the other hand, in real-world conditions, solar radiation varies with time and rarely exceeds 1000 W/m^2 at ground level. In this situation, the exposure duration in one day must be converted as if the sun were shining with an intensity of 1000 W/m^2, which is known as Sun Peak Hour. As an example, in January, the sun shines for 12 hours with varied intensity throughout the day. If the total energy received over a

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few days is 6240 Wh/m^2, this condition is similar to 6.24 hours of sun shining with an intensity of 1000W/m^2. In this instance, the Sun Peak Hour in Bangko Sub District in January is 6.24 hours. Table 3 shows the average Sun Peak Hour for 1 year in Bangko Sub District, Rokan Hilir Regency.

Table 3. Average Sun Peak Hour in Bangko Sub District, Rokan Hilir Regency

Month	Sun Peak Hour [Hour]
(1)	(2)
Jan	6.24
Feb	6.66
Mar	7.17
Apr	6.99
May	7.10
Jun	6.70
Jul	7.17
Aug	7.34
Sept	6.84
Oct	6.89
Nov	6.71
Dec	6.23

The average peak power hour (Sun Peak Hour) in Bangko Sub District for a year is 6.84 hours with a minimum value of 6.23 in December and a maximum of 7.34 hours in August.

We may use this data to make a reference in utilising the potential of solar energy, as this study is doing to improve production in the Rokan Hilir Regency's fisheries sector, beginning with fishing, fish farming, and processing fishery products.

3.3. Integration of Solar Energy Technology in the Fisheries Sector

The planning of solar energy technology integration begins with an analysis of the characteristics and needs of electrical energy during fishing sector activities. The next stage is to compute the electricity demand for each sub-sector using these data, so that the number of solar panels and batteries required may be determined.

a. Daily Total Load
   Total Load = Load Amount x Time of Use
b. Required WP of solar panels
   WP = Total Load / Charging Time
c. The number of batteries required
   The number of batteries = Total load / (V x I)

The daily total load is the electricity load required during the activities of each sub-sector, then calculates the need for how many Watt Peak solar panels to meet the total load requirement, as well as the number of batteries adjusted to meet the total load requirement.

A. Integration of Solar Energy Technology in Fishing Boats

According to the 2021 Rokan Hilir Regency Fisheries Service Annual Report, there are 15,487 fishermen, both permanent and labour fishermen. According to these figures, the catch of fishermen has a high potential, but it has declined. According to BPS Rokan Hilir, the production of marine capture fisheries products in Rokan Hilir Regency in 2017 was 36,858.15 tonnes, whereas the production of marine capture fisheries products in Rokan Hilir Regency in 2016 was 58,377.00 tonnes.

Fluctuations in fishing efforts are caused by a variety of factors, including ever-increasing production costs, the selling price of inappropriate catches, the reduced frequency of going to sea, the weather, the catchment area, and the ability to sustain fish, which is developing slowly (Maulana et al., 2020). For example, the most expensive aspect of the fishing endeavour is the purchase of fuel and electricity. Of course, if renewable energy can be used, these expenses can be decreased.

Solar energy is one of the renewable energies that may be used for fishing boats and then utilised to support fishing activities employing boats.

Many studies have been conducted on the use of solar panels as a source of electrical energy on fishing boats, including several studies on the use of solar energy to support the electricity needs of fishing boats, such as those conducted by (Songli et al., 2020) who used solar panels to cool fish and also to provide lighting on fishing boats. Similarly, theoretical studies on the use of solar panels to satisfy the needs of fishing boats were conducted by (Purnomo, 2021). In his study, solar panels are used for drying fish and even as a boat propulsion engine, in addition to lighting aboard ships. (Sardi et al., 2020) employs solar panel technology for fishing boat lighting systems. Some of the results of the meta-analysis are shown in Table 4 below:

Table 4. Meta-Analytic Study of Research on Previous Fishing Boats

No.	Author and Title	Findings
(1)	(2)	(3)
1	(Sardi et al., 2020)	The results discovered that the solar panels used have a capacity

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No.	Author and Title	Findings
(1)	(2)	(3)
	Solar Panel Technology As A Power Generator For Lighting Systems On Fishing Boats	of 200 Wp, an average output voltage of 29.50 V, and an average output current of 3.01 A. In general, all parts function properly and can be applied to fishing boats as a power source for ship lighting.
3	(Juarni, 2021) Prototype of Cooling System (Freezer) Fish Based on Solar Energy (Photovoltaic) on Fishing Boats	A prototype of an effective fish cooling system that can be used by fishermen so that the fish they catch stay fresh on land and how the performance of the cooling system that has been made is with a cooling system with a COP of 5.17.
4	(Asri et al., 2022) Design of Hybrid Solar Panels and Generator Sets on Fishing Boats on the South Coast of Java	The solar charge controller manages to prevent overcharging and overvoltage which can reduce battery life. The battery is a component that functions to provide power to the load when the solar module cannot provide overall power to the load and stores the excess power generated by the solar module. This fishing boat is equipped with several other supporting tools such as a fishfinder, radar, and AIS.
5	(Wibawa et al., 2014) Utilization of Wind and Solar Power as a Power Generation Tool in Bagan Perahu	The battery after being charged by the solar cell for 12 hours can effectively generate electricity of 650 Watt-hours. The battery/battery after charging by Windturbine for 8.65 hours can effectively generate electricity of 44.82 Watt-hours. If we look at the socio-economic perspective with alternative energy, people are no longer dependent on fuel for lighting in their floating nets.
6	(IRHAM, 2013) Design of a Hybrid Power Plant on Fishing Vessels in the Malacca Strait	A combination of three power plants, namely PLTS, wind turbines, and generators. This hybrid system is designed using HOMER (Hybrid Optimization Model for Electric Renewable). Economic analysis is carried out using the LCCA (Life Cycle Cost Analysis) method, while the practical aspects are reviewed by comparing the size of the ship with the physical size of the renewable energy component.

No.	Author and Title	Findings
(1)	(2)	(3)
		The average intensity of sunlight is 4.86 kWh/m^2/day
7	(Sudjasta & Montreano, 2019) Utilization of Solar Energy on a 10 GT Fishing Boat as an Alternative Electrical Facility at PPI Cituis, Tangerang Regency	The design of the fishing vessel includes determining the basic dimensions, making line drawings, preparing general plans, construction designs, stability diagrams, engine power, electricity, 7tonnage and stability. The result is a maximum electricity requirement of 495 Watts, 2 units of solar panels, and 3 units of batteries/accu.
8	(Manullang et al., 2021) Potential Analysis of Solar Energy Utilization in Fishing Boats on the South Coast of Java Island as an Energy Source	The average value of the solar panel voltage obtained from 09:00 a.m. to 04.00 p.m. was 16.53 V, while on the second day, the value obtained was 16.67 V. Meanwhile in Pelabuhan Ratu on the first day, the average value the solar panel voltage obtained from 09:00 a.m. to 04.00 p.m. was 17.066 V, while on the second day, it was obtained at 16.6 V. The power generated by the solar panels for the first research location in Ujung Kulon for 2 days was 0.672 kWh on average battery charging can be done for 7 hours 15 minutes per day.

Table 5. The Need for Electrical Power on Fishing Boats

No	Item	Average Power [Watt]	Total Need [Watt]
(1)	(2)	(3)	(4)
1	Spotlight	50	100
2	LED Lamp	10	20
3	*Cool Box* Fish	232	232
4	*Electric Starter*	900	900
	Total		**1252**

From the information on the total power requirement, the following calculations can be carried out:

Total Load During Fishing Activities

Total Lighting Load = (100 Watt × 10 hours)+(20 Watt × 10 hours) = 1200 Watt Hours

Total Lighting Load = (100 Watt × 10 hours)+(20 Watt × 10 hours) = 1200 Watt Hours

Total Cool Box Fish Load = 232 Watt × 15 hours = 3480 Watt Hours

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Total Electric Starter Load = 900 Watt ×0.00556 hours = 5.004 Watt Hours

The total load above the entire power load that must be met by solar panels from all three classifications is 4685.004 Watt Hours, which can be rounded up to 4686 Watt Hours.

WP Solar Panels Required During Fishing Activities

WP=(4686 Watt Hours)/(6.84 Hours)=685.08 WP

From the calculation above the need for Watt Peak (WP) for solar panels is 685.08 WP or rounded up to 686 WP. 6.84 hours is the average value of the peak hours of irradiation for one year in Bangko Rokan Hilir Regency. It is planned that the specifications of the solar panels used are 200 WP so that the total need for solar panels is 3.43 pieces of solar panels or rounded up to 4 pieces of solar panels.

The Number of Batteries Required During Fishing Activities

It is planned that the battery to be used has a specification of 12 V 200 Ah, so the number of batteries to be used is obtained:

Number of Batteries = (4686 Watt Hours) / (12 ×200) = 1,95≈2 Pcs

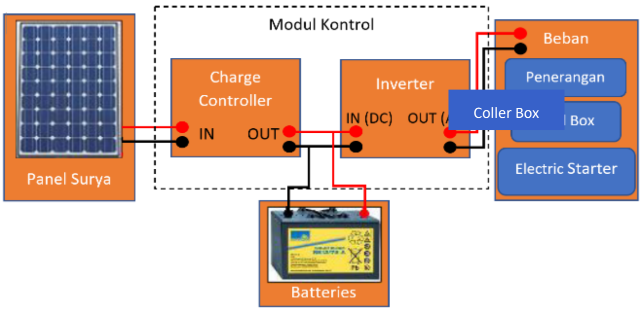

Figure 5. Installation Scheme of a Solar Power Plant on a Fishing Boat

B. Integration of Solar Energy Technology in Aquaculture

The following Table 6 summarizes research on the integration of solar energy technology in aquaculture.

Table 6. Research Meta Analysis Study on Previous Aquaculture

No	Author and Title	Findings
(1)	(2)	(3)
1	(Arohman et al., 2021) Designing a Micro-Bubble Generator (MBG) Using Electrical Energy From Solar Panels As Renewable Energy.	Renewal of the microbubble generator (MBG) tool by utilizing solar energy by applying solar panels to the design. The tool is designed to use solar cells as a tool to generate electrical power that is stored in the battery. The capacity of the battery used is 60 watts using a 50 wp solar cell. The power in the solar cell is obtained from the results of calculations and tests, which results in an efficiency of 5.89%.
2	(Rofik, Denis Abdur, Krdiman, H. Jojo Sumarjo, 2020) Design and Analysis of Microbubble Generator (MBG) Tools for NozzelVenturi Fish Pond Aeration	The input hole is a semicircular nozzel venturi with a diameter of 18 mm at the upstream and a diameter of 3 mm at the outlet, while the output hole is a cone shape with a diameter of 8 mm at the upstream and an output of 14 mm in diameter and for the process of flowing water using a semi jet pump. The results of the microbubble generator (MBG) test where the initial condition of the oxygen level was 7.7 mg/l, after the microbubble generator (MBG) was run within 1 hour the dissolved oxygen level increased to 8.8 mg/l, the lowest oxygen level produced was 8 .0 mg/l and the highest oxygen content produced was 9.0 mg/l.
3	(Dwiyaniti & Supriyono, 2020) Utilization of Solar Cells and Aquaculture as an Effort Towards Financial Independence in KAMI Schools	The community service performed intends to help schools earn money in a sustainable way for school operations by utilising solar cells and aquaculture. The strategy employed is divided into two stages: constructing physical capital in the form of fish ponds and solar cell power sources, and training and assisting instructors at our school to manage the facilities and infrastructure constructed. The results of the activity were the construction of fish ponds made of cast cement measuring 3 x 1 x 0.8 meters, two ponds for catfish and tilapia, the realization of a DC source of electricity from renewable energy, namely solar cells with a power of 300 WP for garden lighting, two pond pumps and one aquaponic pump, and the establishment of aquaponics to

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No	Author and Title	Findings
(1)	(2)	(3)
		grow pakcoy and watercress, as well as trained teachers who can manage everything well.
4	(Mawarni & Korawan, 2019) Effect of Water Fluid Discharge on Bubble Diameter Distribution in Orifice-Porous Tube Type Microbubble Generator	The performance or features of the microbubble generator were explored in this study by investigating the influence of changes in water discharge (QL) on the distribution of the generated bubbles. The flow rate employed was between 30 and 60 lpm, and the ensuing bubble diameter distribution was captured with a high-speed camera. According to the research findings, it is most likely to form bubbles with diameters ranging from 300 to 450 m.

Table 7. The Need for Electrical Power in Aquaculture

No	Item	Average Power [Watt]	Total Need [Watt]
(1)	(2)	(3)	(4)
1	Lighting Lamp	5	20
2	DC Water Pump	40	40
	Total		60

From the information on the total power requirement, the following calculations can be carried out:

Total Load During Fish Farming Activities

Total Lighting Load = (20 Watt × 10 hours) = 200 Watt Hours

Total Aeration Load with MBG = 40 Watt × 24 hours = 960 Watt Hours

From the classification of the total load above the total electrical load that must be met by the solar panel is 1160 Watt Hours.

WP Solar Panels Required During Fish Farming

WP=(1160 Watt Hours)/(6,84 Hours)=169,59 WP

According to the calculations above, the Watt Peak solar panel requires 169.59 WP, which is rounded up to 170 WP. Meanwhile, the average peak hour of irradiation in Bangko Rokan Hilir District is 6.84 hours per year. It is intended that the solar panels utilised will have a capacity of 200 WP, requiring only one piece of solar panel.

Number of Batteries Required During Fish Farming

It is planned that the battery to be used has a specification of 12 V 200 Ah, so the number of batteries to be used is obtained:

Number of Batteries = (1160 Watt Hours) / (12 ×200) = 0,48≈1 Pcs

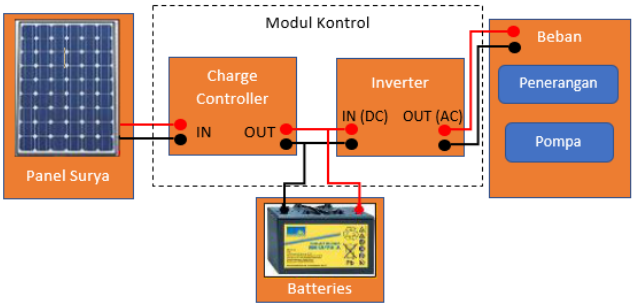

Figure 6. Solar Power Plant Installation Scheme in Aquaculture

C. Integration of Solar Energy Technology in Fish Processing

The following Table 8 shows research on the integration of solar energy technology in fish processing.

Table 8. Meta-Analytic Studies of Previous Research on Fish Processing

No	Author and Title	Findings
(1)	(2)	(3)
1	(Aswita & Zein, 2020) Solar Dryer Oven Technology as an Effort to Increase Salted Fish Production in Fishermen Communities in Gampong Deah Raya, Banda Aceh City	This study proposes a solution to increase hygienic salted fish production in the coastal area of Banda Aceh City by utilising technology in the form of a solar drier oven. Solar dryer ovens as a technology for processing salted fish can be the greatest answer in terms of decreasing spoilage and damage to fish, as well as being able to overcome excess catches that have not been sold in the market and provide more hygienic salted fish production.
2	(Utami.E.S., Priyantika.D., 2014) Application of SolcusHexa, Solar Collector Dryer 6 Angles as Optimization of Hygiene Quality of Salted Fish SME in Bandarharjo, North Semarang	The study was carried out in Bandarharjo Village, North Semarang, to improve community productivity and excellent hygiene for salted fish SMEs. This program's processes include problem identification, hearings, making solcushexa, implementation, monitoring, and evaluation. Furthermore, throughout the mentorship stage, the practise of creating tools for the community

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No	Author and Title	Findings
(1)	(2)	(3)
		and forming administrators was carried out. *Solcus Hexaini* is composed of aluminium, which is corrosion resistant, and employs sengon wood as an insulator to keep the heat created, as well as a glass lid to prevent exposure to dust or pathogenic germs during the drying process.
3	(Tjahja Mooniarsih et al., 2014) Realization of Fish Drying Using Biomass Energy and Solar Panels	The designed fish dryer utilizes heat sourced from burning biomass and solar panels which function as heat collectors. So that the drying process can take place quickly, at any time and without depending on sunlight. Controlling the drying temperature is done by opening the air duct cover on the dryer. The test results showed that within two hours, the drying process for 1 kg of wet fish decreased to 500 gr. These results indicate that the drying process using a biomass and solar power dryer is faster than the manual drying process for 4 days. The quality of machine-dried fish is better than traditional drying.
4	(Hindun et al., 2019) Utilization of Appropriate Technology Based on Solar Cells to Overcome Problems of IRT Sapeken Fishermen, Sumenep Regency	Implementation of the use of solar cell-based TTG where data is collected by being directly involved in community activities, taking product samples and recording documents and activities. Data were analyzed descriptively. An activity is considered successful if TTG is proficient in use by partners, the percentage of involvement and activity reaches ≥75%, there is an increase in the quantity and quality of products/business results, income increases, and all stages of the activity are carried out.
5	(Arinal Hamni, 2022) Manufacture of Rotary System Fish Shredder Machines for Shredded Fish Products	Fish meat shredder machines are used to boost the added value of products, hence increasing the selling price of items created from fish raw materials and making it lucrative for Tanggamus fisherman. According to the test results, the material for the fish meat shredding machine was successfully manufactured with a production capacity of up to 2 kg in 15 minutes. A 15-minute shrinking time produced little fish meat shreds with relatively uniform diameters. As a result of the testing, the meat shredding machine can create superior shredded meat in a very short period of time.

Table 9. The Need for Electrical Power in Fish Processing

No	Item	Average Power [Watt]	Total Need [Watt]
(1)	(2)	(3)	(4)
1	LED Lamp	10	50
2	Electric Motor	400	400
	Total		**450**

From the total power requirement, an analysis can be carried out as follows:

Total Load During Fish Processing Activities

Total Lighting Load = (50 Watt × 10 hours) = 500 Watt Hours

Total Load of Electric Motors = (400 Watt × 10 hours) + (400 Watt ×0,83 hours) = 4332 Watt Hours

From the classification of the total load above, the total electrical load that must be met by the solar panel is 4832 Watt Hours.

WP Solar Panels Required During Fish Processing

WP=(4832 Watt Hours)/(6,84 Hours)=706,43 WP

From the calculation above, the need for Watt Peak solar panels is 706.43 WP or rounded up to 707 WP. Meanwhile, 6.84 hours is the average peak hour of irradiation for one year in Bangko Sub District Rokan Hilir. It is planned that the specifications of the solar panels used are 200 WP so that the total need for solar panels is 3.53 or rounded up to 4 pieces of solar panels.

Number of Batteries Required During Fish Processing

It is planned that the battery to be used has a specification of 12 V 200 Ah, so the number of batteries to be used is obtained:
Number of Batteries = (4832 Watt Hours) / (12 ×200) = 2,013≈3 Pcs

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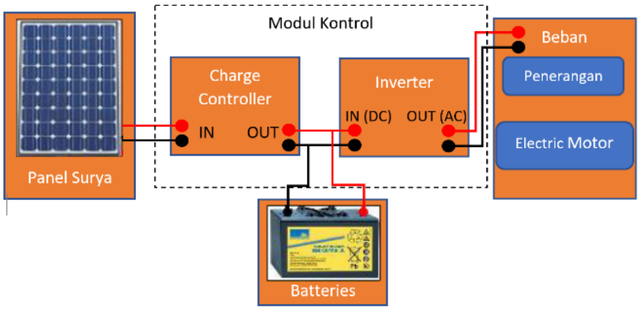

Figure 7. Solar Power Plant Installation Scheme in Processing of Fishery Products

4. Conclusion

The solar power plant is one of the potentials that can be used to encourage Rokan Hilir Regency's development, particularly in the field of fisheries. The average Sun Peak Hour for a year in Bangko Sub District is 6.84 hours, with a low of 6.23 hours in December and a high of 7.34 hours in August. The integration of solar energy technology is utilised to assist the activities of the fisheries sector, including catching, cultivating, or hatching, as well as fishing product processing. The equipment used in each area must, of course, be tailored to the needs in order to maximise the efficiency of activities in each fishery sub-sector. Several solar energy solutions are currently being employed on fishing boats for spotlights, LED lights, cooler boxes and electric starters. Lighting lamps and DC water pumps can be used in the agriculture sector. Solar energy is also used in the Fisheries Processing Sector for LED lights and electric motors in shredded fish processing machines.

Development of solar energy-based technical breakthroughs in the fisheries industry in order to optimise the fisheries sector and other sectors through a more extensive mapping of solar energy utilisation.

Suggestions for improvement of innovation fisheries for the implementation of solar energy-based innovations, it is necessary to first conduct a more detailed study for each fishery, including studies from various legal aspects, socio-economic cultural aspects and environmental aspects through a Feasibility Study.

The prototype of solar energy utilization for fishing boats, fishery product processing, and aquaculture is important as a basis for realizing the program to increase added value for fishermen and facilitate the government to cooperate with the private sector in the program.

The government, observers, and the community are expected to work together which will make Rokan Hilir Regency a developed area that is more independent from its dependence on fossil energy sources, especially in the fisheries sector, so that the energy mix target in the National Energy Policy (RUEN) and RUED-P.

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