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Development of Solar-Powered Fishing Boats with Leak Threat Sensor System: A Sustainable Solution for Indonesian Fishermen

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ABSTRACT

The use of ships as a means of transportation tends to have a relatively low accident rate because they are equipped with prevention and mitigation facilities, however, along with the development of demand and different types of ships, the need for electrical energy on ships becomes very fluctuating. Collaboration between PNJ PSDKU (Jakarta State Polytechnic Off-Campus Study Program) Pekalongan, Innovillage, and local fishermen from Setembok Village, Krapyak District, Pekalongan City, has produced the latest solution to optimize solar energy into electricity as a sensor leak threat system. This empowerment involves several stages, through intensive discussions, identifying critical problems faced by fishermen, and implementing Solar Power Plants (PLTS) on fishing boats as a substitute for fossil fuels as well as as a safety sensor for ship leaks. In addition, PNJ PSDKU Pekalongan is holding intensive training and workshops to increase fishermen's understanding of the benefits of PLTS and equipment operation. The workshop lasted for seven days and succeeded in improving the practical PLTS skills of fishermen and increasing optimism regarding the increase in ship leaks. The final stage of empowerment involves installing PLTS and ship leak sensors at the locations where fishing boats are installed. In conclusion, the application of this technology has a significant positive impact on improving the welfare of fishermen, environmental sustainability, and the development of independent fishermen in new, renewable energy. Recommendations for further development and wider dissemination of information provide a basis for improving sustainability and efficiency in the local fishing sector.

Keywords: Renewable Energy; Ships; Fishermen; Solar Power Plants

ABSTRAK

Penggunaan kapal sebagai alat transportasi cenderung memiliki tingkat kecelakaan yang relatif rendah karena dilengkapi dengan fasilitas pencegahan dan mitigasi, namun seiring dengan perkembangan permintaan dan jenis kapal yang berbeda-beda, kebutuhan energi listrik pada kapal menjadi sangat fluktuatif. Kerjasama antara PNJ PSDKU (Politeknik Negeri Jakarta Program Studi di Luar Kampus Utama) Pekalongan, Innovillage dan para nelayan lokal Desa Setembok,

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Kecamatan Krapyak, Kota Pekalongan, telah menghasilkan solusi terbaru untuk mengoptimalkan energi matahari menjadi listrik sebagai sistem ancaman kebocoran sensor. Pemberdayaan ini melibatkan beberapa tahapan, melalui diskusi intensif, masalah-masalah kritis yang dihadapi oleh para nelayan diidentifikasi hingga mengimplementasikan Pembangkit Listrik Tenaga Surya (PLTS) di kapal nelayan sebagai pengganti bahan bakar fosil sekaligus sebagai sensor pengaman kebocoran kapal. Selain itu, PNJ PSDKU Pekalongan mengadakan pelatihan intensif dan lokakarya untuk meningkatkan pemahaman nelayan tentang manfaat PLTS dan pengoperasian alat. Lokakarya berlangsung selama tujuh hari, yang berhasil meningkatkan keterampilan praktis PLTS para nelayan dan meningkatkan optimisme terkait peningkatan kebocoran kapal. Tahap terakhir pemberdayaan ini melibatkan pemasangan PLTS dan Sensor kebocoran kapal di lokasi-lokasi kapal nelayan yang terpasang. Secara kesimpulan, penerapan teknologi ini berdampak positif secara signifikan terhadap peningkatkan, kesejahteraan nelayan, kelestarian lingkungan serta mengembangkan nelayan mandiri dalam energi baru terbarukan. Rekomendasi untuk pengembangan lebih lanjut dan penyebaran informasi yang lebih luas memberikan dasar untuk meningkatkan keberlanjutan dan efisiensi di sektor nelayan lokal.

***Kata Kunci**: Energi Terbarukan; Kapal; Nelayan; PLTS*

INTRODUCTION

The demand for electricity in various sectors such as industry, offices, residential areas, and even for fishing vessels is rapidly increasing (Ismail et al., 2024). However, this surge in electricity demand is not accompanied by a proportional increase in electricity supply. Solar energy presents itself as an alternative means of generating electricity. Solar cells can directly convert solar radiation into electrical energy through the photovoltaic process (Daging et al., 2019). The utilization of fishing vessels equipped with solar panels as an energy source could represent a significant step towards reducing dependence on fossil fuels, decreasing carbon footprint, and introducing environmentally friendly solutions for daily fishing operations. This technology not only enhances energy efficiency but also reduces long-term operational costs. Additionally, the safety of fishermen is of paramount importance.

As the demand for various types of vessels continues to evolve, the need for electrical power aboard ships becomes increasingly diverse. Power generation aboard ships, in addition to utilizing diesel engines, can also harness solar energy as an alternative source of electrical power (Nugraha, 2020). Automatic leak detection systems on fishing vessels emerge as an impressive innovation. These systems not only minimize the risk of leaks that could harm the marine environment but also safeguard the lives of fishermen by providing rapid and effective responses to emergency situations.

With the evolving needs and various types of vessels, the demand for electrical power aboard ships becomes highly diverse. Power generation aboard ships, besides utilizing diesel engines, can also harness solar energy as an alternative source of electrical power. The emergence of automatic leak detection systems on fishing vessels represents an impressive innovation. This system not only minimizes the risk of leaks that could harm the marine environment but also secures the lives of fishermen by providing rapid and effective responses to emergency situations (Bhaskar, 2017).

As the largest archipelagic country, Indonesia's territorial waters cover 70% of its total area. With such vast maritime territory, it

should be utilized as one of the main economic resources for the Indonesian people. Based on field observations, it is known that the main problem faced by fishermen is the high operational costs of fuel needed when going to sea, while the fish catch obtained is uncertain. Additionally, energy is one of the issues faced by Indonesia and the world today, due to the imbalance between energy availability and demand. Another issue is global warming, wherein Indonesia, during the Climate Change Conference in Paris, France in 2015 (COP21) (Aisya, 2019), committed to reducing emissions together with other countries. The potential for the utilization of new and renewable energy for electricity generation on ships is highly promising (Harahap & Siahaan, 2023).

However, there are several challenges faced by small-scale fishermen. Resource limitations, such as limited equipment, can pose difficulties. The combustion of diesel fuel can produce exhaust emissions that may cause environmental pollution (Hafiz & Santosa, 2021). Moreover, diesel fuel prices can experience significant fluctuations, thereby affecting fishermen's income, and they may also encounter difficulties in obtaining fuel. Diesel fuel is sometimes hard to come by in remote areas (Syahbana et al., 2012). Additionally, external factors such as climate change leading to rough seas can potentially damage the hull of the vessel. Furthermore, limited lighting sources as they operate at night, relying solely on flashlight, are challenges that can affect the sustainability of their livelihoods.

Given this situation, our research team consisting of students and lecturers from the State Polytechnic of Jakarta's Pekalongan Campus, specifically in the Diploma 4 Manufacturing program, initiated efforts to find solutions to the issues faced by fishermen along the coast of Pekalongan. Innovillage is a sociopreneurship competition for students throughout Indonesia that is supported by PT Telkom Indonesia and Telkom University. The aim is to encourage innovation and digitalization that contribute to the welfare of society through the Sustainable Development Goals (SDGs). With the Innovillage program, we attempted to register and propose an innovative idea to modify a small boat with a size of less than 20 gross tons to install renewable energy installations, specifically solar cells, to absorb sunlight energy and convert it into electrical energy. This energy would be used for lighting and applied to a series of security sensors to detect water ingress. Subsequently, an automatic pump would activate to pump water out, thus preventing the boat from sinking.

METHOD

During the implementation period from January 29th to February 18th, 2024, our activities in Setembok Village, Krapyak District, Pekalongan City, were described in Table 1.

Table 1. Activities Schedule

Day/Date	Activities	Place
Monday/29 Jan 2024	Task mapping, and team discussions.	PSDKU PNJ Pekalongan City
Tue/Jan 30, 2024-Monday 5 Feb 2024	Observation of premises, survey of boats, checking parts of ships, determination of installation schemes.	Krapyak Port, Setembok Village, City of Pekalongan
Tuesday/6 Feb- Thursday 8 Feb 2024	Purchase of tools and materials that are still lacking.	PSDKU PNJ Pekalongan City
Thursday /8 Feb 2024-Friday /9 Feb 2024	Silvering and testing of tools and materials.	PSDKU PNJ Pekalongan City
Sat/10 Feb-Tuesday 13 Feb 2024	Solar panel support pole manufacturing	Krapyak Port, Setembok Village, City of Pekalongan
Tue/13 Feb-Thursday 15 Feb 2024	Solar Panel Installation on Fishing Boats	Krapyak Port, Setembok Village, City of Pekalongan
Friday/16 Feb-Week/18 Feb 2024	Report writing	PSDKU PNJ Pekalongan City

(Source: Analysis results, 2024)

The location targeted by researcher's has certainly been considered and analyzed beforehand, more precisely located at:

Location : Setembok Village, Krapyak
RT/RW : 003/010
District : North Pekalongan
City/District : Pekalongan

Province : Central Java
Village Head : Mr. Dhani

The Fishermen's Village located on Jln. Jlamprang Krapyak Lor, in the Krapyak village, North Pekalongan District, Pekalongan city, Central Java Province, is situated on the northern coast of Java Island, known as one of the areas rich in fishermen's life, culture, and maritime history. The daily activities of fishermen in Pekalongan begin as they prepare to sail towards the open sea in the evening after sunset prayer until dawn approaches in the morning. They use traditional boats such as small sailboats with a size of around 3 gross tons and tools such as nets commonly known as "jong" to catch fish. Navigation skills and knowledge of weather patterns, as well as suitable locations for fishing, are integral parts of their expertise. As for the planned activities that we will carry out and have been arranged in the following form.

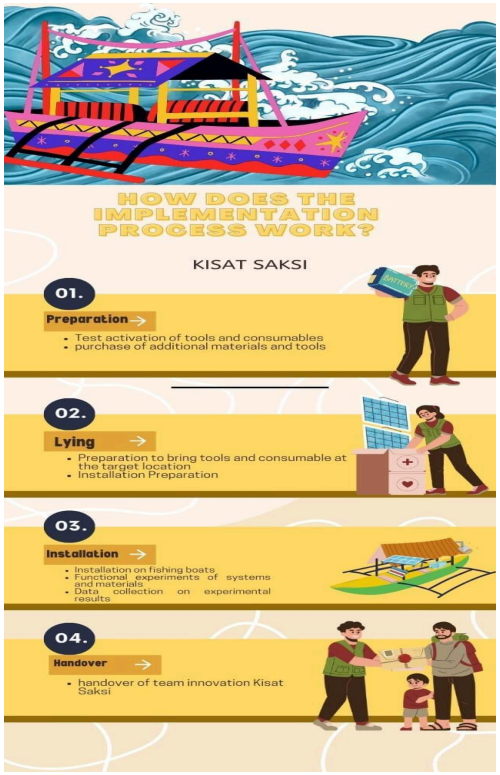

Figure 1. Activity Design
(Source: Kisat Saksi Editor, 2024)

The installation method on this ship involves several stages that will be undertaken. The stages to be conducted in this research are as follows: Identifying the problem, where the search for solutions to the issues in the background is carried out. The next stage is literature review, which involves searching for relevant theoretical references to the case or problem. Then, data collection in the field, where several data collected from the field (Table 2).

Table 2. Boats specification survey results

No.	Owner boats	Boats size	Machine	Board size	Genset (Watt)	Lamp
		(LOA)m	(HP)	(pxl)m^2		(pcs;w)
1	Handoko	14,5	40	17x17	3500	13;40
2	Wisnu	9	40	15x16	4000	6;40
3	Hamdani	7	-	13x12	-	1;10
4	Giman	6	40	12x14	3000	5;40
5	Mulya	5	40	11x13	-	7;40
6	Ade Daud	13,5	40	17x17	5000	4;40
7	Agustian	10	40	15x16	5000	5;40
8	Purnomo	5	40	11x13	-	6;40
9	Santos	6	40	12x14	4000	3;10
10	Abidin	8	40	13x14	3500	5;20
11	Rohiman	9	40	15x16	4000	4;40

(Source: Analysis results, 2024)

Information = (Length Overall = LOA) is the horizontal distance between the foremost point of the bow to the aftmost point of the stern of the ship.

(Pxlxd)m^2 = length x width x depth.

Solar Panel Electrical Load Requirement Data On Ships The solar panel electrical load requirement data (Lande, 2017) on ships include:
Solar Panel: 100 WPb.
Battery: 24V 100AH.

The method of conducting the data collection activities above is carried out through counseling and education, direct observation in the field, discussions with respondents, and filling out questionnaires by the respondents. The questionnaire provides simple alternative answers, through two options: "yes" and "no" for each question. In the implementation, this activity is also assisted by field assistants. The data obtained from the questionnaire survey are processed

using Excel application program, and the results are displayed and analyzed descriptively.

Generally, fishermen go to sea around 9:00 PM. The duration of each fishing trip is 6 hours (from midnight to 6:00 AM). When they reach the fishing grounds, it is usually nearing nighttime. The lights on the fishing net are turned on, and the nets are usually not immediately lowered until the fish gather at the net location. However, some fishermen directly lower the nets after turning on the lights. To attract fish attention, the installed lights are turned on. After waiting for a few hours and the fish start to gather at the fishing location, the nets are slowly lowered into the water, typically by rotating the roller. The observations we obtained are as follows:

1. Installation on Mr. Hamdani's ship with a size of 7GT.
2. Implementation of the correct installation scheme to avoid any potential issues.
3. Adjustment of solutions for other experienced problems.

Figure 2. Installation Scheme
(Source: Kisat Saksi Editor, 2024)

The implementation of the innovation program using solar panels for lighting on fishing boats and a leak detection system involving information sensors involves several supporting and inhibiting factors that need to be considered. Supporting factors, such as the energy efficiency of solar panels that can enhance lighting resources and electronic equipment, as well as environmental sustainability supporting eco-friendly practices, contribute positively to fishermen (Thakur et al., 2016). Operational cost reduction, ease of solar panel maintenance, and enhanced safety through a ship leak detection system are other significant supporting factors.

However, there are also inhibiting factors that need to be addressed. The initial investment cost in purchasing and installing solar panels can be a challenge, especially for fishing boats with limited budgets. Technical expertise and training to understand, install, and maintain solar panel technology and ship leak detection sensor systems are also obstacles. Harsh marine environments, resilience to adverse weather conditions, component availability, as well as regulations and certifications in specific regions are also inhibiting factors that need to be considered.

Therefore, it is important to address these obstacles to ensure the smooth implementation of the innovation program and maximize its benefits, including efforts to mitigate initial costs, enhance workforce training, and pay special attention to resilience and component availability in harsh marine environments (Kertoraharjo, 2013).

RESULTS AND DISCUSSION

The use of Solar Photovoltaic Systems (PLTS) in the fishing industry, generally, aboard a vessel, there are typically two units of diesel engines serving as electrical generators and one emergency backup generator. These engines are utilized as the primary sources of electrical power generation on the vessel (E. Kartini, 2014).

The use of lighting on board a ship is to ensure a safe working environment as well as comfort during tasks inside the vessel. A sufficient amount of electrical power in proportion is crucial for activities on the ship. Lighting in areas above deck, inside the engine room, within living quarters, or accommodations to meet specific lighting

requirements is provided by various types of lighting designed to operate safely (Kumara, 2010).

The use of electrical energy on board a ship was initially used for lighting purposes only, but later it was also utilized as navigation lights when the ship sails in adverse weather conditions and darkness. The power capacity of the lighting used can vary greatly, ranging from a few watts to kilowatts of very bright lights for illuminating the deck and searchlights for searching purposes. The amount of light that can penetrate a room or specific area can be measured with a luminance meter.

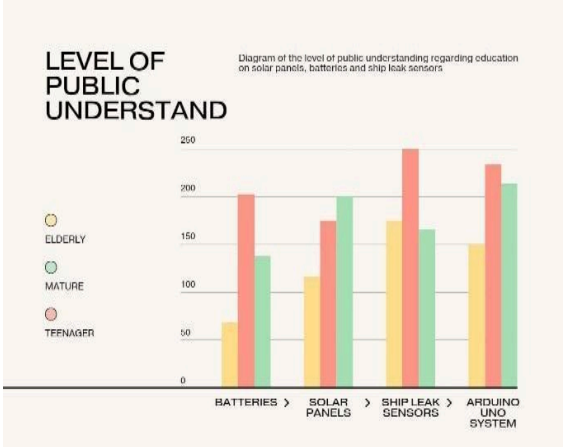

Figure 3. Graph of Fishermen's Understanding of KISAT SAKSI Technology
(Source: Author's Document, 2024)

Lighting on a ship is crucial. Without it, the operation of the power center will be disrupted. Therefore, a power supply for lighting needs to be as uninterrupted as possible. The use of lamp light for fishing in Indonesia has developed rapidly in recent years, so in areas where fishing activities take place, it is almost certain that there are lamps used for fishing. In the 1950s, the use of lamps for fishing activities was very limited and focused on specific areas. The use of electric light on an industrial scale (Sasana et al., 2022).

In Figure 3, a recapitulation in the form of a graph illustrates the results of the increase in understanding among fishermen regarding the Innovation of Fishing Boats with renewable energy solar panels equipped with leak detection sensor systems in Setembok Village, Krapyak, North Pekalongan District, Pekalongan City.

The results show a significant improvement achieved by the fishermen. Data collection was conducted through analysis of the participants' understanding during the education sessions and questions in each session. The data was processed using the activity method, which involved consulting with the Village Head, field studies, and engagement with the fishermen community; conducting education and training sessions as well as replacing the current battery system with solar panel systems; monitoring the sustainability of program implementation.

Figure 4. Built-in Innovations
(Source: Author's Document, 2024)

The outcome of this community service activity is the installation of solar panels for one unit of the boat. It is concluded that solar panels can extend the technical lifespan of batteries, thereby saving costs.

A. Solar Panel

The utilization of solar panels, also known as Solar Cells, with a capacity of 100WP on fishing boats can be explained as follows:

1) WP stands for Watt Peak.
2) The average effectiveness of sunlight in tropical countries like Indonesia is approximately 5 hours.
3) 5 hours is the standard calculation for the effectiveness of sunlight absorbed

by solar panels.

4) If using a 100 WP panel, then in one day, the solar panel generates an electrical power supply of 500 Watts. The calculation is as follows: 100 (WP) x 5 (hours) = 500 Watts.
5) The solar panel electrical system is supplied using a VRLA Narada battery or a special solar panel system battery with a capacity of 100 Ah (Ampere Hour).
6) In daily usage on fishing boats in Setembok Village, Krapyak, North Pekalongan District, the required power is 420 Watts per day.
7) Electrical energy usage on fishing boats: DC pump 60 Watts x 1 hour = 60 Watts Lighting installation: 30 Watts x 12 hours = 360 Watts
8) The specifications of the solar cell shown in Figure 4 above used in this system are as follows:
   - Name: Polycrystalline;
   - Maximum Power: 100W;
   - Weight: 7.7 Kg;
   - Dimensions: 1020 x 670 x 30 mm.

Figure 5. Solar Power System Assembly
(Source: Author's document, 2024)

As a result of testing the solar cell, the data shown in Table 3 below include the time, voltage (volt), Amperage (I), Power (Watt), and Weather Description.

Tabel 3. Test Results

Time (WIB)	Volt (V)	Ampere (I)	Power (watt)	Ket
08.00	13,7V	0,19 A	1,50W	C
09.00	14,0V	0,23 A	2,37 W	CY
10.00	14,5V	0,33 A	3,8 W	C
11.00	15,0V	0,32 A	4,4 W	PC
12.00	16,0V	0,37 A	5,38 W	C
13.00	16,5V	0,40 A	5,40 W	C
14.00	17,0V	0,45 A	6,37 W	C
15.00	18,0V	0,50 A	6,50 W	C
16.00	15,5V	0,35 A	4.31 W	PC
17.00	14,0V	0,33 A	3,8 W	PC

(Source: Analysis results, 2024)

Initials in the caption column:
CY = Cloudy
C = Clear
PC = Partly Cloudy

B. Solar Charger Controller

Solar Charge Controller (SCC) is a component of a solar power system that functions as a power regulator for both input power from solar panels and output/load current. It protects your battery from overcharging. The solar charge controller regulates the voltage and current from the solar panel to the battery.

Most 12-volt solar panels produce an output voltage of around 16 to 20 volts DC. Without regulation, excessively high charging voltage can damage the battery. Typically, a 12-volt battery requires a charging voltage of around 13 to 14.8 volts for full charge (depending on battery type). Functions and Features of Solar Charge Controller:

1. When the battery charging voltage reaches full capacity, the controller will stop supplying power to the battery to prevent overcharging. This helps prolong the battery life. In this state, some electricity supplied from the solar panel is directly distributed to the load/electrical equipment according to the power consumption of the electrical equipment.
2. When the battery voltage drops, the controller turns off the load powered by the battery. At a certain voltage level (usually around 10% of the remaining battery voltage), the controller cuts off the load current. This protects the battery and prevents damage to the battery cells. In most controller models, indicator lights illuminate with a specific color

(usually red or yellow) to indicate that the battery is being charged. In this state, when the battery is depleted (less than 10%), the controller will stop supplying power from the battery and the electrical equipment will not be able to operate. Some controller types are equipped with digital meters with a more comprehensive display to monitor various situations occurring in the solar power system.

C. Battery

Batteries are devices capable of converting chemical energy found in the active components of the battery into electrical energy through electrochemical reduction and oxidation reactions (Linden & B. Reddy, 2002). Reduction reaction involves the addition of electrons and a decrease in oxidation state, while oxidation reaction involves the release of electrons and an increase in oxidation state.

Figure 6. Leak-proof System Assembly
(Source: Kisat Saksi Team, 2024)

There are two classifications of batteries: primary batteries and secondary batteries. Primary batteries are non-rechargeable batteries that can only be used once, whereas secondary batteries are rechargeable batteries that can be used multiple times. The rechargeability of secondary batteries is based on reversible electrochemical reactions, allowing them to convert chemical energy into electrical energy during discharge and convert electrical energy into chemical energy during charging (Satriady et al., 2016).

D. Arduino dan GSM SIM900

After conducting testing and obtaining results, it can be concluded that the Automatic Water Leakage Detection and Discharge System on Arduino Uno-based Ships can be implemented directly to minimize incidents of ship sinking due to undetected hull leakage. The system is set to have 3 levels: safe, alert, and warning. In the "safe" level, the green indicator light is on. In the "alert" level, the yellow indicator light is on and the buzzer beeps.

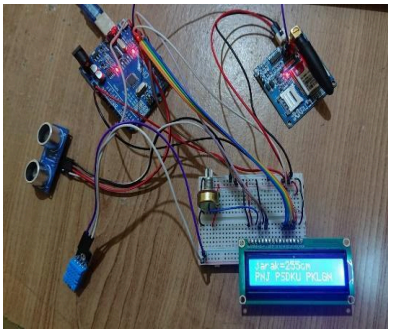

Figure 7. Leak-proof System Assembly
(Source: Kisat Saksi Team, 2024)

The GSM captures information from the sensor and sends it to the fishermen's mobile phones via SMS, then the relay and pump are activated until the water condition in the ship's hull starts to dry. This system is very effective as a warning or indication when fishermen are resting.

Table 4. Results of Sensor Detection of the Hull

Water Level	Conditions	Visual Led Indicator	Buzzer Indicator	GSM SIM 900A
1% s/d 25%	Safe	Green	Off	-
26% s/d 50%	Standby	Red	Bip	SMS
51%	Standby	Red	On	SMS

(Source: Analysis results, 2024)

Table 5. Sensor Detection Results

Water Level	Conditions	Visual Led Indicator	Buzzer	GSM SIM 900A
0-20cm	Standby	Red	BIP	SMS
55-21cm	Safe	Green	-	-
60-55CM	Safe	Green	-	-

(Source: Analysis results, 2024)

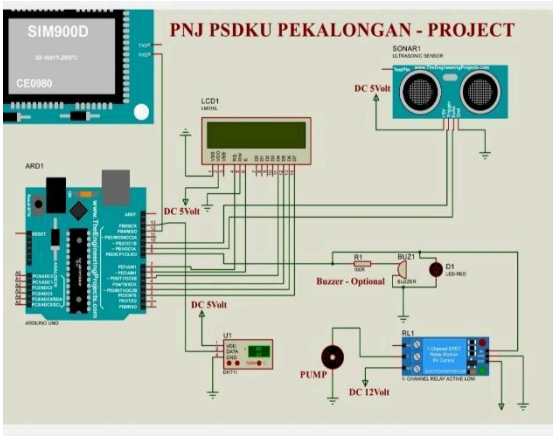

Figure 8. Arduino Assembly Scheme
(Source: Author's Document., 2024)

E. Inverter

An inverter is a circuit that converts DC voltage into AC voltage. More specifically, an inverter transfers voltage from a DC power source to an AC load. The voltage source for the inverter can be a battery, solar panel, or other DC voltage source.

CONCLUSION

Community empowerment activities through the development and implementation of PLTS to reduce the use of fossil fuels and leak safety sensors on fishing boats in Krapyak Village, Pekalongan City have had a significant positive impact. Fishermen now understand more about the great benefits, use, and installation of PLTS as an alternative energy. This allows them to make more informed decisions in the use of new and renewable energy on their ships. With the results of training and workshops, fishermen's skills in using this technology have also increased significantly both in implementation and in terms of fishermen's welfare. Apart from that, the collaborative approach between PNJ PSDKU (Jakarta State Polytechnic Off-Campus Study Program) Pekalongan, Innovillage, and fishermen has presented innovative solutions that suit the reality of the energy sector needs on local fishing boats. However, this community empowerment program has several limitations. Industrial-scale quality equipment still needs to be taken down. This condition will be an obstacle for fishermen. The duration of the program has not effectively achieved the success of technology implementation. The results achieved are only at the level of technological acceptance. Some recommendations for program sustainability are as follows:

1. PNJ PSDKU Pekalongan needs to follow up on the commitment of the local village government by forming a collaborative initiative program. Village funds can be integrated into a two-month internship program that involves students in village development programs.
2. Village governments can advocate for fishing communities regarding PLTS renewable energy, especially through collaboration with participating PLTS entrepreneurs' community service responsibility program.
3. Best practices obtained from community empowerment This program can be expanded with support from local governments. PNJ PSDKU Pekalongan needs to initiate communication of these results with the government to support the wider PLTS program.

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