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Solar-powered seaweed powder milling: enhancing value in the blue economy

I Made Aditya Nugraha[1], I Gusti Made Ngurah Desnanjaya[2], Febi Luthfiani[1], Muhamad Amril Idrus[1]
[1]Department of Fisheries Mechanization, Marine and Fisheries Polytechnic of Kupang, Kupang, Indonesia
[2]Department of Computer System Engineering, Institute of Business and Technology Indonesia, Denpasar, Indonesia

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ABSTRACT

Design and build a seaweed powder milling machine with the blue economy concept is one form of increasing the added value of selling seaweed in Indonesia and utilizing solar energy which is so abundant in Indonesia by using photovoltaic system. This machine is expected to increase the income of seaweed cultivators, and indirectly support the blue economy policy which is one of the policies in Indonesia. Design and build this machine using several supporting components, such as solar panel, battery control unit (BCU), inverter, battery, and motor to drive the seaweed powder milling machine. Testing is carried out by measuring the voltage and current output, and adding environmental conditions. Apart from that, the economics of the machine are also analyzed. Based on the results obtained, the machine can produce electrical energy in the range of 396.95-646 Wh/day, and can operate for up to 131 minutes, with a seaweed flour output of 10-20 kg per hour. From an economic perspective, the payback period is 0.22 years, NPV of IDR 605,286,359.01, with an IRR of 449%. From this value it can be seen that economically the tool is profitable if used by seaweed cultivators.

Corresponding Author:

I Made Aditya Nugraha
Department of Fisheries Mechanization, Marine and Fisheries Polytechnic of Kupang
West Kupang, Kupang Regency, East Nusa Tenggara, 85351, Indonesia
Email: made.nugraha@kkp.go.id, imdadityanugraha@gmail.com

1. INTRODUCTION

Indonesia is one of the countries with a large seaweed producer [1], [2]. Data from the Ministry of Marine Affairs and Fisheries shows that Indonesia's seaweed production in 2021 shows that Indonesia's seaweed production reached 9.12 million tons. With this potential, in September 2022, 180.6 tonnes with a sales value of up to USD 455.7 million export volume of Indonesian seaweed can be achieved or an increase of 93% compared to the same period in 2021. The main export destination country is China. According to the Indonesian Statistics, seaweed production in Indonesia is spread across 23 provinces [3]–[10]. The top five seaweed producing provinces are South Sulawesi, East Nusa Tenggara, North Kalimantan, Central Sulawesi and West Nusa Tenggara [4], [11]–[17]. Wet seaweed production in South Sulawesi reached 1.63 million tons in 2020. Then in second place was East Nusa Tenggara with wet seaweed production of 1.03 million tons. North Kalimantan produced 441.1 thousand tons of wet seaweed, followed by Central Sulawesi with 419.9 thousand tons, and West Nusa Tenggara with 402.6 thousand tons. The Indonesian Statistics also noted that Indonesian seaweed has a large share in the world seaweed market. According to International Trade Center data, in 2018 Indonesia's seaweed exports in the form of raw materials ranked first in the world, reaching 205.76 thousand tons. The Indonesian Statistics also noted that the export value of seaweed from Indonesia to the China reached US$ 149.3 million with a volume of 148.3 thousand tons. South Korea is in second place

with a seaweed export value of US$ 9.6 million and a volume of 7.8 thousand tons. After that there is Chile with a seaweed export value of US$ 5.8 million and a volume of 3.4 thousand tons.

Meanwhile, the export value of seaweed from Indonesia to Vietnam was recorded at US$ 3.8 million with a volume of 6.1 thousand tons. Then, the value of seaweed exports to France was US$ 3.6 million with a volume of 3.3 thousand tons. In total, the export value of seaweed from Indonesia was US$ 181.4 million in 2020, down 15.7% from US$ 215.2 million in 2019. The volume of seaweed exports from Indonesia was also recorded as decreasing. In 2020, the volume was 177.9 thousand tons, down 7% from 191.2 thousand tons in 2019. Even though export performance in 2020 experienced a decline, on the other hand, Indonesia was able to rank second as the largest seaweed exporter in the world. good competitiveness. Meanwhile, according to the results of a study, Indonesian seaweed exports began to record positive performance cumulatively during the period January-October 2021. The value of seaweed exports during that period was recorded to have increased by 20.42% year-on-year. year (yoy reached US$ 177.99 million. The cumulative growth in export value was also followed by growth in export volume by 11.68% (yoy) to 159.59 thousand tons. This increase occurred due to increasing demand from Indonesia's main trading partner, China. The production results from seaweed cultivation indirectly provide a good social and economic impact for seaweed cultivating fishermen in Indonesia [15], [18]–[21].

The production output and demand for seaweed from Indonesia is very large, and to support market needs and increase the selling value of seaweed, a seaweed powder milling machine was designed with the blue economy concept. Having this equipment will indirectly help seaweed cultivators in Indonesia and be able to take advantage of the abundant solar energy in Indonesia [22]–[27]. The availability of this tool is also in line with the Blue Economy policy of the Ministry of Marine Affairs and Fisheries in Indonesia. This tool uses an electrical energy source produced from a solar power plant, then this energy is connected to a seaweed powder milling machine. The use of solar energy has been widely used in the world of maritime and fisheries, and it is hoped that this design will have a positive impact and technological development. The design of this machine can still be further developed according to existing needs and technology, such as IoT [28]–[30]. From this system you can control and know all the parameters of the tool being made. The seaweed included here is dried seaweed. The use of this tool will of course provide more income to seaweed cultivators in Indonesia considering that the selling price of seaweed flour is quite expensive on the market. The tool is designed to use a 100 Wp solar panel, and can provide enough energy to drive an electric motor to make seaweed flour.

2. METHOD

The seaweed powder milling machine that utilizes solar energy with a photovoltaic system is a form of utilizing renewable energy. This utilization is in accordance with the blue economy policy of the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia. This machine utilizes energy from the sun which is then stored in a battery, and the stored energy is used to drive an electric motor.

This seaweed powder milling machine consists of several components. These components are a 100 Wp solar panel, battery control unit (BCU), battery, and inverter. The installation of this inverter is a hybrid form of device which is designed if the energy in the battery has run out so that electrical energy can be supplied from utility grid electricity. More clearly the components of this system can be seen in Table 1, and a schematic diagram of the system can be seen in Figure 1.

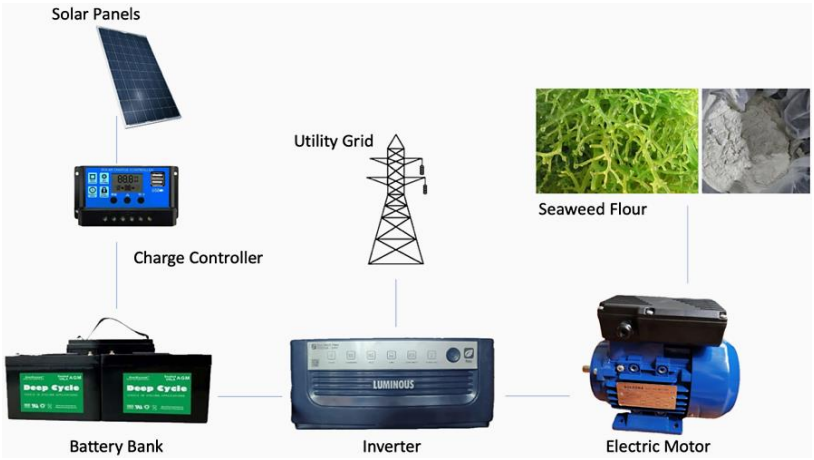

Figure 1. Schematic diagram of the system

Table 1. Components of seaweed powder milling machine

Parameters	Electrical characteristics	Specification
PV panel 100 WP	Rated maximum power	100 W
	Vmp	18.2 V
	Imp	5.5 A
	Voc	21.51 V
	Isc	5.88 A
	Nominal operating cell temperature (NOCT)	46±2 ºC
Battery	Nominal voltage	12 V
	Nominal capacity	100 Ah
Inverter	Max PV	1000 wp
	Number of batteries	2 units 12 V
	Electrical capacity	1200 w
	Frequency output	50 Hz ±2%
BCU	Load current	10 A
	End of charge voltage	13.9 V (27.8 V)
	Boost charge voltage	14.4 V (28.8 V)
	System voltage	12 V
	Self-consumption	< 4 mA
	Ambient temperature	-25 ºC to +50 ºC
Motor	Power	1.1 kW
	Voltage	220 V
	Ampere	7.3 A
	RPM	1400
	Frequency	50 Hz
	Phase	1

The process of testing this machine, the electrical energy that can be produced per day is measured. To support this data, data from measurements of environmental conditions, such as temperature and humidity is also added. In measuring electrical energy, temperature and air humidity are obtained from the results of current and voltage measurements from solar panels which are measured every 10 minutes. When measuring current and voltage using an Avometer, while measuring environmental conditions using a thermo hygrometer. Measurements were carried out for 15 days in September 2023.

Apart from carrying out technical testing, the economics of the machine made are also analyzed. The economic value of this tool is calculated by looking for the IRR, NPV, and payback period values [23], [24]. In this calculation, the interest rate from Bank Indonesia is included at 6%. This is done to find out whether the designed tool can provide economic value when used by the community.

3. RESULTS AND DISCUSSION

3.1. Technical testing of the machine

From the results of the trial of installing the equipment which was carried out for 15 days, it was found that power and electrical energy could be produced from the solar energy. In one of the measurement results carried out, the machine was able to produce 138.50 Watts of electrical power, which occurred at 12.10, with an air temperature and humidity of 37 ºC and 34%. The results of this measurement can be seen in Figures 2, 3, and 4. This measurement was carried out from 6 am to 6 pm. From these results it can also be seen that the range of electrical power that can be produced from the device is between 0.02-138.50 W (Figure 2), the air temperature range is between 27.7-45 ºC (Figure 3), and the air humidity range is between 24-62% (Figure 4).

The results of the analysis of the electrical energy that can be produced from the machine show that the electrical energy output that can be produced over several days of experiment shows different results. This difference is caused by several things, such as weather conditions (temperature and humidity) [23]. From the results of these measurements, the electrical energy that can be produced from the device is in the range of 396.95-646 Wh/day (Figure 5), the air temperature is in the average range between 28.68-30.58 ºC per day (Figure 6), and air humidity in the average range between 54.38-66.88% per day (Figure 7).

Based on the results of calculating the amount of electrical energy that can be produced by this seaweed powder milling machine, the machine can supply electrical energy for 131 minutes if used until the battery runs out. However, for longer lasting use, it is best to only use it for 105 minutes. This is to ensure that the battery is not too empty and maintains DOD at 80% so that the battery lasts longer when used. From the experimental results, the machine can carry out the process of making flour with a capacity of 10-20 kg/hour.

3.2. Economic value of the machine

This seaweed powder milling machine with a solar energy source is capable of producing 10-20 kg of seaweed flour per day. It is estimated that in one production cycle the minimum production can reach 600 kg,

with a selling price of IDR 150,000/kg, so that this process can generate income of IDR 90 million. Taking into account the current bank interest rate (6%), this machine is able to provide a payback period of 0.22 years, NPV of IDR 605,286,359.01, with an IRR of 449%. This economic value test is estimated with a tool usage period of 10 years. Clearly the economic results of this solar energy-based seaweed harvesting tool can be seen in Table 2. Based on the data in the table, it can be seen that economically this tool has economic value and can be applied to society. The existence of this tool is also in accordance with one of the Blue Economy policies of the Ministry of Marine Affairs and Fisheries, namely the Development of Sustainable Marine, Coastal, and Land Cultivation. This policy is carried out to protect important ecosystems and habitats so that they can provide ecosystem services such as carbon uptake, oxygen supply, coastal protection, and fish spawning grounds.

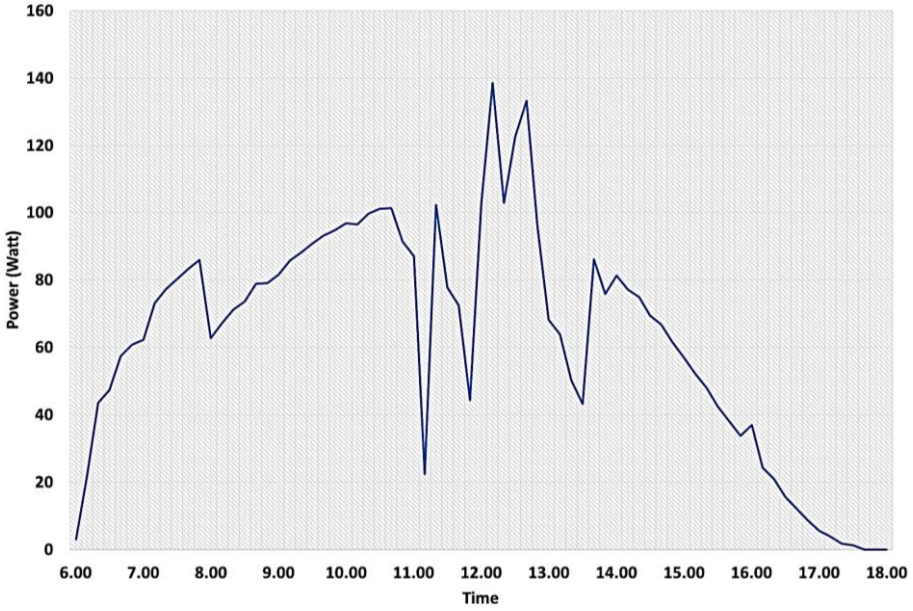

Figure 2. Results of analysis of the electrical power produced by the machine

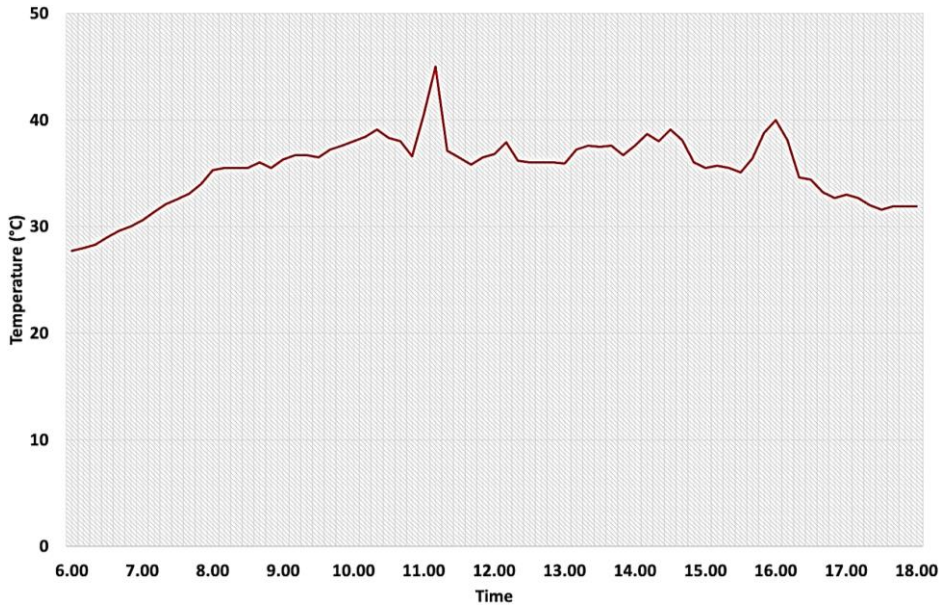

Figure 3. Air temperature measurement results

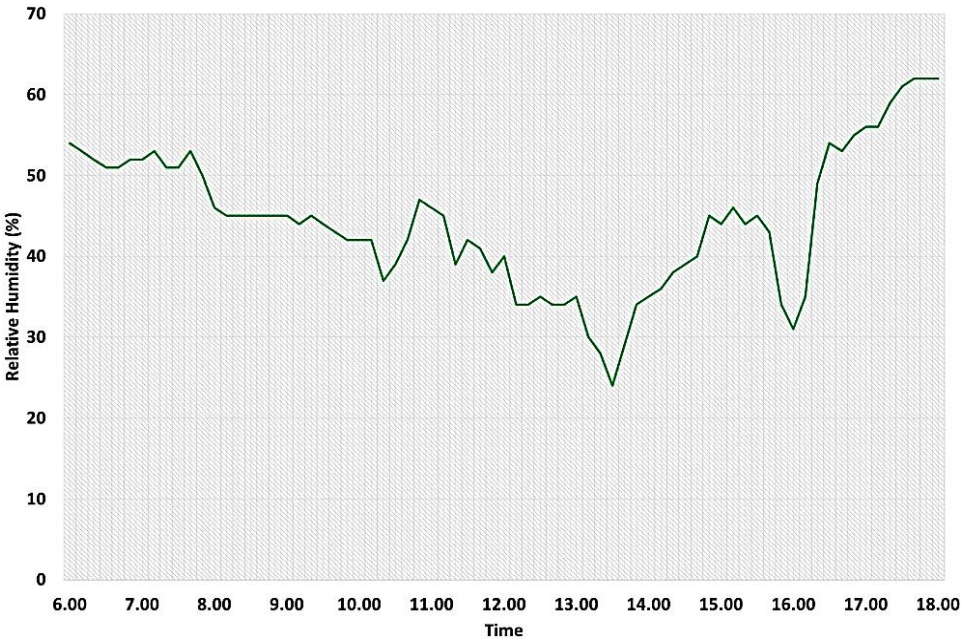

Figure 4. Relative humidity measurement results

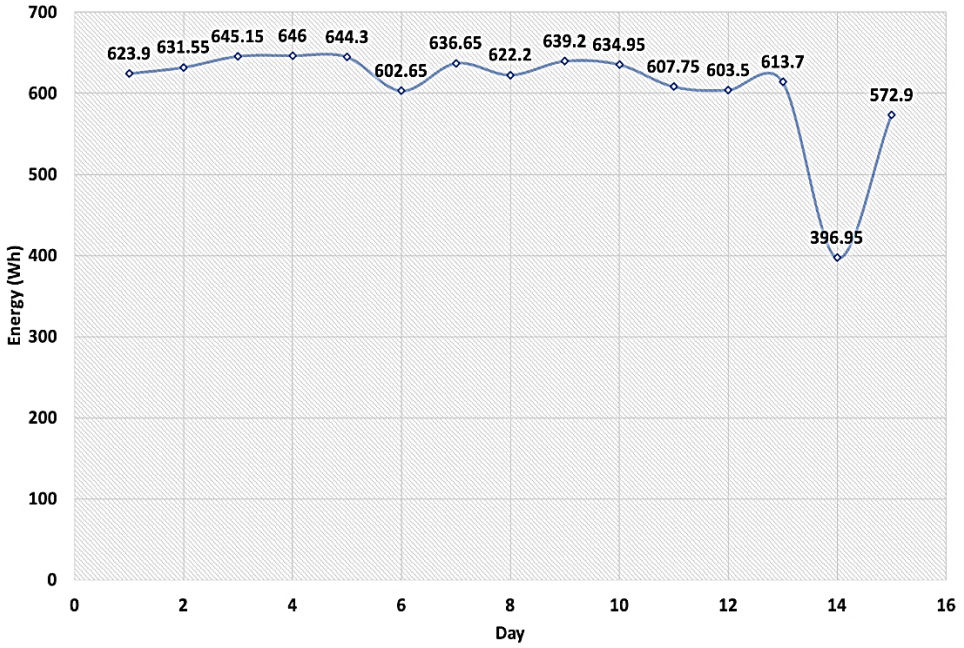

Figure 5. Results of analysis of the electrical energy produced by the machine

Table 2. Economic value of the machine

Cost and feasibility	Description
Investment Cost	IDR 20,000,000
Operational and maintenance costs/year	IDR 2,000,000
Saving-1/year	IDR 90,002,401.16
i	6%
n	10 Years
Payback period	0.22 Years
Net present value (NPV)	IDR 605,286,359.01
IRR	449%

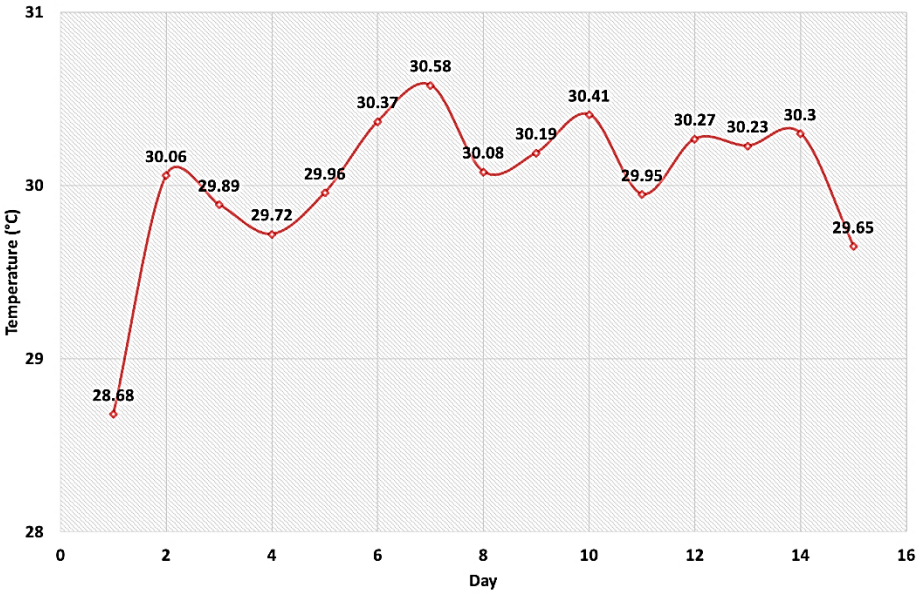

Figure 6. Results of the average air temperature per day

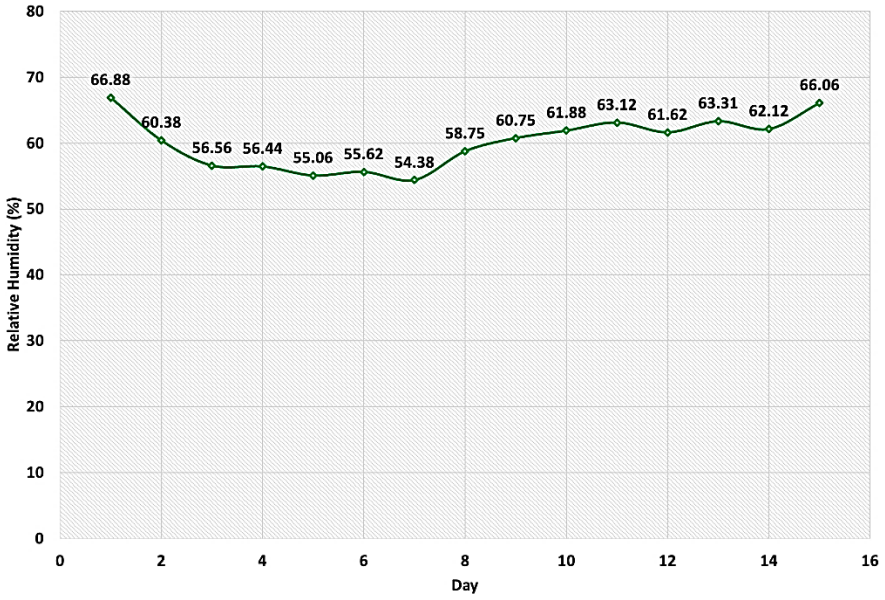

Figure 7. Results of the average relative humidity per day

4. CONCLUSION

The design of seaweed powder milling machine with the blue economy concept using solar energy sources in the form of solar power plants can run well. This machine can work well by producing 10-20 kg of seaweed flour products per hour, with a usage time of up to 131 minutes, and the energy that can be produced per day can reach 396.95-646 Wh/day. Apart from that, from an economic perspective, the tool provides a payback period of 0.22 years, NPV of IDR 605,286,359.01, with an IRR of 449%. From this value it can be seen that economically the tool is profitable if used by seaweed cultivators.

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BIOGRAPHIES OF AUTHORS

I Made Aditya Nugraha is a lecturer at the Marine and Fisheries Polytechnic of Kupang. He has been a lecturer since 2016 until now. Currently, he works at the Ministry of Marine Affairs and Fisheries Republic of Indonesia. He obtained a bachelor's degree in 2011 and a master's degree in 2013 at Udayana University, Bali in the field of Electric Power Systems and Energy Management. He also serves on the editorial board and reviewer of several journals. He is interested at research related to renewable energy, power systems, control systems, and microcontroller. He can be contacted at email: made.nugraha@kkp.go.id or imdadityanugraha@gmail.com.

I Gusti Made Ngurah Desnanjaya was born on December 20, 1988. Currently, he is a lecturer at the Institute of Business and Technology Indonesia and majoring in embedded systems, microcontrollers, control systems, internet of things, and renewable energy. He obtained a bachelor's degree in 2011, a master's degree in 2013, and a professional engineer degree in 2021 from Udayana University, Bali. He can be contacted at email: ngurah.desnanjaya@gmail.com.

Febi Luthfiani is a lecturer at the Marine and Fisheries Polytechnic of Kupang. She has been a lecturer since 2019 until now. Currently, she works at the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia. She obtained a bachelor's degree in 2015 at Padjadjaran University and a master's degree in 2018 at Bandung Institute of Technology in the field of Physics and Materials. She also served on the editorial board of the journals on Megaptera. She is interested at research related to renewable, materials, and corrosion. She can be contacted at email: febi.luthfiani@kkp.go.id.

Muhamad Amril Idrus is a lecturer at the Marine and Fisheries Polytechnic of Kupang. He has been a lecturer since 2018 until now. Currently, he works at the Ministry of Marine Affairs and Fisheries Republic of Indonesia. He obtained a bachelor's degree in 2013 at Universitas Hasanuddin Makassar in field Naval System Engineering and a master's degree in 2015 at Institut Teknologi Sepuluh Nopember Surabaya in the field of Safety and Risk Assessment. He is interested at research related to safety, risk assessment, management maintenance and marine engineering. He can be contacted at email: muhamadamrilidrus@gmail.com.