

Planning Analysis of the Utilization of Ocean Currents as a Power Plant Using Gorlov Turbines in the Botang Lomang District, South Halmahera Regency

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Electrical energy is a basic need of the community and supports aspects of national life and development, including improving living standards. Indonesia actually has the potential for new renewable energy sources in large quantities. Ocean current energy is one of the renewable energy whose existence is continuous and environmentally friendly. One of the potential energy of ocean currents is in the Botang Lomang District Area. This study aims to determine the amount of power generated from the potential of ocean currents. The minimum average speed at a depth of 10 meters is (0.21 m/s) and the maximum is (1.26 m/s). And the minimum average speed at a depth of 20 meters is (0.28 m/s) and maximum (1.67 m/s). The power obtained from the minimum and maximum ocean current speeds at a depth of 10 meters is 252 Watts to 54.654 kW. While the power obtained from the minimum and maximum sea current speeds at a depth of 20 meters is 599 Watts to 127,252 kW.

Keywords: Utilization of ocean currents, ocean current power plant, Gorlov turbine



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1. INTRODUCTION

Electrical Energy is a basic need of the community and supports all aspects of national life and development, including improving living standards. People's dependence on electrical energy is getting higher, over time and the development of technology, on the other hand the problem that arises is that energy sources in Indonesia have so far used many conversion results from fossil energy such as petroleum, coal and gas as their main energy sources. As is known, that energy sources derived from fossils are depleting their supply, so that it is getting less and less renewable. To overcome the depletion of electrical energy supplies, new breakthroughs are needed to utilize other energy, by developing renewable energy sources. Indonesia actually has the potential for new renewable energy sources in large quantities. One of them is a sea current power plant (PLTAL) using Gorlov turbines [1]. Indonesia has a lot of energy resources. As for the potentials energy, the greatest potential is in the marine sector. From the table can be concluded the theoretical potential of ocean energy is very large [2]. But only a little for its technical potential, this is due to limited technology that is insufficient to develop this ocean energy. In addition to the technological limitations that are still less developed, there is no concrete solution from the government to maximize the potential of energy source from ocean sector [3]. According to the World Energy Council (WEC) trends in Europe are beginning to switch to alternative energy using wind turbines [4], and it will be predicted by 2050 that most of Europe has already turned to alternative energy using turbine [5].

This Platform is designed using Gorlov Helical Turbine as a cold storage electric power source with a capacity of 80 tons. In addition, is built with semi submersible construction that can accommodate ship fuel supply. This Platform can be used as a solution to overcome the lack of infrastructure in the form of scarcity of cold storage in eastern Indonesia.[15]. We utilize gorlov helical turbines to utilize the energy potential of ocean currents in the target area, namely the Arafura sea which reaches 2 m/s. With the simulation method using solid works flow simulation, we get a power of 4.8 Mw. This energy output is sufficient to meet the power requirements for using 80 tons of cold storage [6]. There are generally different ways to use tidal currents in energy production, including tidal turbines, Archimedes torsion, tidal dams, floating structures, tidal kites, and finally artificially intelligent turbines. In the Persian Gulf, due to the low speed of coastal currents and its shallow depth, the use of heavy equipment is not cost-effective and practical, but the use of small equipment such as Archimedes torsional turbines is feasible. This turbine is one of the oldest machines used in the past and continues to function today. This equipment is known as small-scale power plants and is now widely used on the coasts of different parts of the world to produce clean and renewable energy. Low maintenance costs and ease of working with this equipment are other advantages. Archimedes torsional turbines are less harmful to marine ecosystems due to their construction [7].

Gorlov turbine is a cross flow turbine developed in 1995, converting kinetic energy generated by flow flow into mechanical energy / rotary motion, discovered by Professor Gorlov from Northeastern University, this type of turbine is intended for river energy, marine energy and tidal energy Lopulalan, [8] Some of the advantages of Gorlov turbines include [9], can operate in sea tidal water and river currents, can rotate at a water speed of 0.6m/s and rotate without fluctuation, rotating in one direction only[14]. A massive catches ocean current in Darrieus turbine of 0.88125 m² of overall cross section of 3.75 m² blades, with the efficiency of 23.5%, Gorlov turbine of 1.3125 m² of overall cross section of 3.75 m² blades, with the efficiency of 35%, turbine In the plane axis of 0.75 m² , from broad cross section as a whole was 3.75 m² blades, with the efficiency of more than 20%. Energy conversion of ocean currents in Lombok Strait that using scenario turbine Gorlov's has a biggest energy in the depth of 45 meters with the energy 1589,666 kWh. While for scenario Darrieus turbine produce energy of 3,741.99. And the energy that produced by turbine in the plane axis of 3,184.672 kWh in the same depth of 45 m. It is more effective and typical efficiency than the previous scenario, which is in the depth of 104m [10]

Ocean current pattern mapping is the first step to explore non-conventional energy sources of ocean currents. Information on current movement patterns can also be used for various purposes such as consideration in the construction of harbor docks, onshore and offshore structures (drilling rig and pipes to be installed on the seafloor), aquaculture and site selection most likely for development of current power generation [11]

Based on a cut-in speed of 0.5 m /s, throughout the Kemojan, Karimunjawa Island has the potential for renewable power with a layer depth of 1.5m to 3m. The highest Electrical Power potential in the West season is 565,445 Watt, and the lowest Electrical Power potential in Transition 1 season is 359.85 Watt. Based on the results of this study, it can be said that the Karimunjawa island which initially relied on PLTD for the fulfillment of its electricity powers, could have great potential to develop electricity from ocean currents, which is far more economical and environmentally friendly compared to fossil energy [12] Currently, the electrification ratio in the Maluku Islands has only reached 82.66%, even though in 2020 the government plans to increase this ratio to 100%. Most of the electricity needs are supplied through conventional electrical energy supplies. Seeing this problem, we have to look at other alternatives as a source of electricity supply for the Maluku Islands [13].

2. METHOD

The implementation of this research was carried out for approximately 3 months in Botang Lomang District, South Halmahera Regency. Botang Lomang is the name of one of the sub-districts located in South Halmahera Regency, North Maluku Province, Indonesia, and the capital of the sub-district is located in the village of Bajo. This sub-district has an area of 55.81 km² and the population in 2020 was 7,605 people.

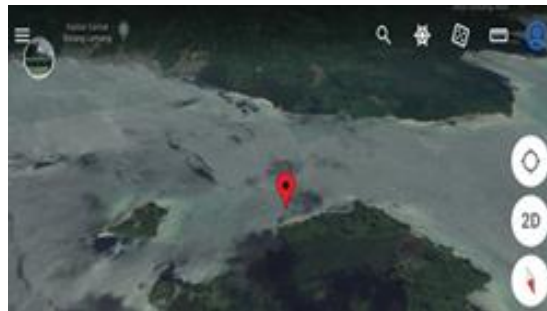


Figure 1. Research location on Google Earht

Ocean currents are the regular movement of water masses from one place to another. Most ocean currents move in a horizontal direction and only a small part move in a vertical direction. The vertical movement of seawater masses is called upwelling. Based on ocean current capture device is divided into 5 types: Horizontal Axis Turbine, Vertical Axis Turbine, Ocilating hydrofoil, Achimedes Screw, Tidal Kite

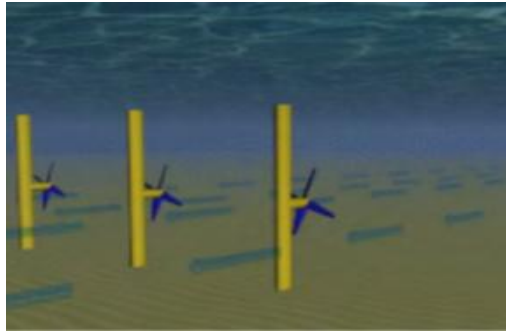


Figure 2. Turbine à axe horizontal (<http://www.emec.org.uk/marine-energy/tidal-devices/>)

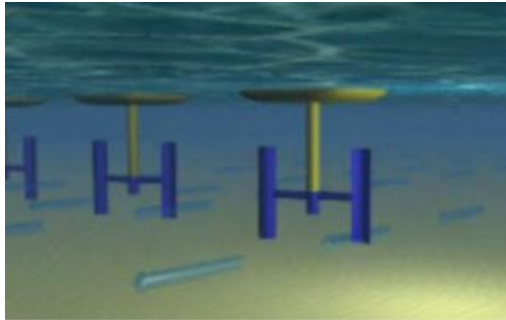


Figure 3. Vertical axis turbine (<http://www.emec.org.uk/marine-energy/tidal-devices/>)

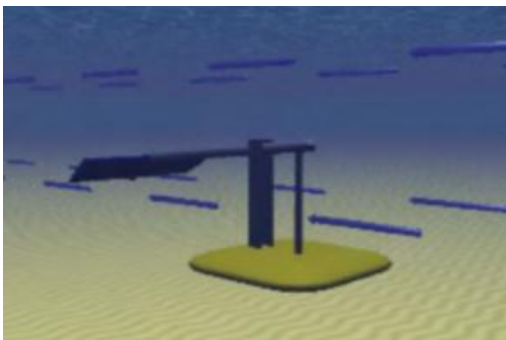


Figure 4. Oscilating hydrofoil (<http://www.emec.org.uk/marine-energy/tidal-devices/>)

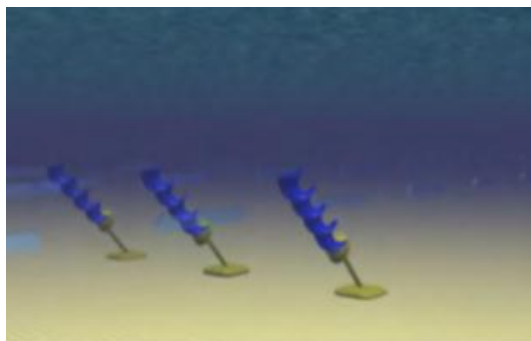


Figure 5. Archimedes Screw (<http://www.emec.org.uk/marine-energy/tidal-devices/>)

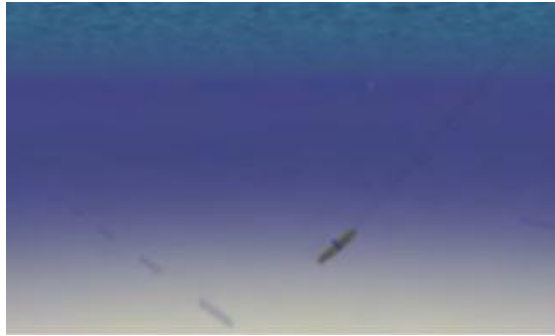


Figure 6. Tidal kite (<http://www.emec.org.uk/marine-energy/tidal-devices/>)

Ocean current power plants work like wind power plants immersed under the sea. Ocean current power plants work by utilizing turbine rotation to rotate the coils in an electric generator so that there is a change in magnetic flux that can produce electric current. Ocean current power plants have several important components, among others, the rotor functions to convert kinetic energy. There are two types of rotors (turbine leaves) commonly used, namely the type of rotor similar to a windmill or cross flow rotor and Daaricus rotor. Generators can convert motion energy into electrical energy. Rectifier inverter to overcome the ups and downs of electrical output from the generator due to the ups and downs of the turbine rotation, the electricity generated by the generator must be channeled first to the inverter rectifier system so that the voltage output and electrical frequency are the same as the electricity produced by PLN.

The tool used is a current kite used to measure the speed and direction of the current. The way it works is that the current kite is entered into the water at the same time as activating the stopwatch and left bottom by the current after arriving at a set distance the stopwatch must be stopped, then we will know the speed of the current.



Figure 7. Kite current

To find out the amount of power produced, the thing to do is to analyze the hydrodynamic force to obtain a torque calculation. Hydrodynamic force occurs due to the flow that enters the turbine blade, resulting in torque that pushes the blade so that the turbine can rotate. Hydrodynamic force is influenced by several factors including fluid properties, fluid velocity, and the area of turbine blade dimensions. The general formula used to find hydrodynamic forces is as follows (Lopulalan, Sarwito, & Koenhardono, 2016):

$$F = 0.5 \times \rho \times v^2 \times c \times h \times Cl \dots \dots \dots (1)$$

- F = Gaya (N).
- ρ = Water Mass Density (kg/m³).
- v = Current Speed (m/s).
- c = Chord Width (m).
- h = Blade Height (m).
- Cl = Coefisien Lift.

$$T = Fxr \dots \dots \dots (2)$$

- T = Torque (Nm).
- F = Gaya (N).
- r = Turbine radius (m).

After analyzing the force on the blade, it can be known the torque generated by multiplying the amount of force received by the blade with the turbine fingers. After that, the power calculation can be found with the following formula (Lopulalan, Sarwito, & Koenhardono, 2016):

$$P = T \times \text{RPM} \dots\dots\dots(3)$$

$$\text{RPM} = \omega r \times 60 \times 2\pi \dots\dots\dots(4)$$

$$\omega = vr \dots\dots\dots(5)$$

Formulated:

$$\text{RPM} = vr \times 2 \times 60 \times 2\pi \dots\dots\dots(6)$$

- P = Power (Watt).
- T = Rotor Shaft Torque.
- ω = Turbine Angular Speed;
- r = Turbine radius (m).
- RPM = Unit representing turbine rotation (Rotations Per Minute).

3. RESULTS AND DISCUSSION

Botang Lomang District is one of the areas of South Halmahera Regency, officially becoming a definitive sub-district in 2007. Botang Lomang sub-district consists of 8 villages. The land area of Botang Lomang Islands ranges from 55.8 km². Geographically, Botang Lomang District is bordered by the north bordering West Kasiruta District, the south is bordered by South Bacan District, the east is bordered by Bacan District, the west is bordered by Mandioli District

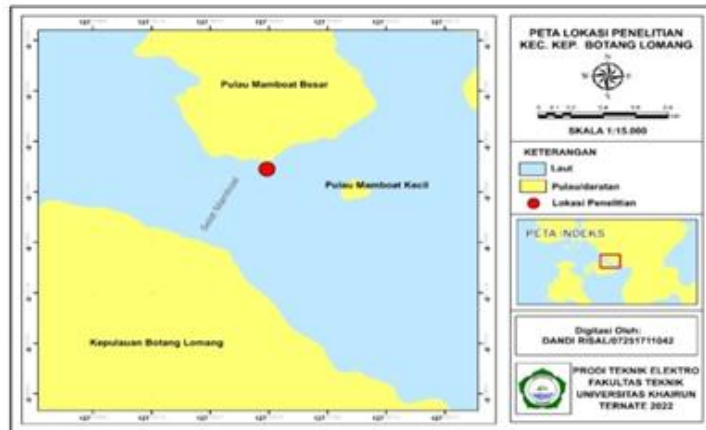


Figure 8. Map of Research Location

In a power generation system using ocean current power, turbines are one of the main equipment besides generators. The movement of the turbine is determined by ocean currents. With the value of sea current speed obtained in Botang Lomang District, it can be seen in table 2. With a maximum current speed value of 1.25 m/s, a minimum of 0.21 m/s in 10 meters of water, and a maximum current speed of 1.67 m/s of 0.28 m/s in 20 meters of water, the type of turbine chosen is the Gorlov turbine. Gorlov turbines have characteristics including having a high efficiency compared to other types of ocean current turbines with an efficient value of 35%.

Table 1. Ocean current velocity data

The	The result of a depth current velocity of 10 m		The result of a depth current velocity of 20 m		modeling
	Waktu	(m/s)	Waktu	(m/s)	
	10 : 00	0,625	10 : 00	0,555	
	11 : 00	0,357	11 : 00	0,416	
	12 : 00	0,208	12 : 00	0,384	
	13 : 00	0,238	13 : 00	0,333	
	14 : 00	0,263	14 : 00	0,312	
	15 : 00	0,625	15 : 00	0,833	
	16 : 00	1,25	16 : 00	1,666	
	17 : 00	0,714	17 : 00	0,833	
	18 : 00	0,263	18 : 00	0,454	
	19 : 00	0,384	19 : 00	0,555	
	20 : 00	0,312	20 : 00	0,277	
	21 : 00	0,25	21 : 00	0,312	
	22 : 00	0,357	22 : 00	0,416	
	23 : 00	0,384	23 : 00	0,454	
	00 : 00	0,454	00 : 00	0,625	
	01 : 00	0,454	01 : 00	0,714	
	02 : 00	0,833	02 : 00	0,454	
	03 : 00	1	03 : 00	1,25	
	04 : 00	1,25	04 : 00	1,666	
	05 : 00	0,833	05 : 00	0,714	
	06 : 00	0,208	06 : 00	0,5	
	07 : 00	0,5	07 : 00	0,416	
	08 : 00	0,714	08 : 00	0,625	
	09 : 00	0,833	09 : 00	1,25	
	Average	0,554541667		0,66725	
	Maximum	1,25		1,666	
	Minimum	0,208		0,277	

specifications of the Gorlov turbine used are as follows: Type NACA Series 4 Digit 0018

- Number of blades = 3 Count
- Turbine height = 3 Meter
- Turbine diameter = 1 Meter
- Chord blade length = 0,5 Meter

By statute:

$$\begin{aligned}
 F &= (\text{N}). \\
 \rho &= (1.025 \text{ kg/m}^3). \\
 v &= (\text{m/s}). \\
 c &= (0,5 \text{ m}). \\
 h &= (3 \text{ m}). \\
 CI &= (1,86).
 \end{aligned}$$

The calculation uses the minimum ocean current speed based on ocean current speed data, the current speed used is the average speed of the minimum ocean current depth of 10 meters, namely: 0.21 m / s. To find out the power generated from the speed of ocean currents we must calculate the hydrodynamic force first, the calculation of hydrodynamic force can be calculated using the following equation:

$$\begin{aligned}
 F &= 0,5 \times \rho \times v^2 \times c \times h \times CI. \\
 F &= (\text{N}). \\
 \rho &= (1.025 \text{ kg/m}^3). \\
 v &= (0,21 \text{ m/s}). \\
 c &= (0,5 \text{ m}). \\
 h &= (3 \text{ m}). \\
 CI &= (1,86).
 \end{aligned}$$

$$\begin{aligned}
 F &= 0,5 \times \rho \times v^2 \times c \times h \times CI. \\
 &= 0,5 \times 1025 \times 0,21^2 \times 0,5 \times 3 \times 1,86 \\
 &= 63,05 \text{ N}.
 \end{aligned}$$

After knowing the value of the hydrodynamic force, then we calculate the torque on the turbine, the torque calculation can be calculated using the following equation:

$$\begin{aligned}
 T &= F \times r \\
 T &= (\text{Nm}) \\
 F &= (63,05 \text{ N}). \\
 r &= (0,5 \text{ m}). \\
 T &= F \times r \\
 &= 63,05 \times 0,5 \\
 &= 31,52 \text{ Nm}.
 \end{aligned}$$

After knowing the torque value in the turbine, we can find out the power by doing calculations using the following equation in i :

$$\begin{aligned}
 P &= T \times \text{RPM} \\
 \text{RPM} &= \frac{\frac{v}{r^2} \times 60}{2\pi} \\
 P &= (\text{Watt}). \\
 T &= (31,52 \text{ Nm}). \\
 \omega &= \text{Kecepatan angular turbin.} \\
 r &= (0,5). \\
 \text{RPM} &= \text{Rotasi per menit (60)}. \\
 \text{RPM} &= \frac{\frac{v}{r^2} \times 60}{2\pi} \\
 \text{RPM} &= \frac{\frac{0,21}{0,5^2} \times 60}{2 \times 3,14} \\
 &= \frac{50,4}{6,28} \\
 &= 8,02 \\
 P &= T \times \text{RPM}
 \end{aligned}$$

$$= 31,52 \times 8,02 = 252 \text{ Watt}$$

The calculation uses the maximum ocean current speed based on sea current speed data, the current speed used is the average speed of the maximum sea current depth of 10 meters, namely: 1.26 m / s. To find out the power generated from the speed of ocean currents we must calculate the hydrodynamic force first, the calculation of hydrodynamic force can be calculated using the following equation:

$$F = 0,5 \times \rho \times v^2 \times c \times h \times Cl$$

$$F = (\text{N}).$$

$$\rho = (1.025 \text{ kg/m}^3).$$

$$v = (1,26 \text{ m/s}).$$

$$c = (0,5 \text{ m}).$$

$$h = (3 \text{ m}).$$

$$Cl = (1,86).$$

$$F = 0,5 \times \rho \times v^2 \times c \times h \times Cl$$

$$= 0,5 \times 1025 \times 1,26^2 \times 0,5 \times 3 \times 1,86$$

$$= 2270,06 \text{ N}$$

After knowing the value of the hydrodynamic force, then we calculate the torque on the turbine, the torque calculation can be calculated using the following equation:

$$T = F \times r$$

$$T = (\text{Nm}).$$

$$F = (2270,06 \text{ N}).$$

$$r = (0,5 \text{ m}).$$

$$T = F \times r$$

$$= 2270,06 \times 0,5$$

$$= 1135,03 \text{ Nm}$$

After knowing the torque value on the turbine, we can find out the power by doing calculations using the following equation:

$$P = T \times \text{RPM}$$

$$\text{RPM} = \frac{\frac{v}{r} \times 60}{2\pi}$$

$$P = (\text{Watt}).$$

$$T = (1135,03 \text{ Nm}).$$

$$\omega = \text{Kecepatan angular turbin.}$$

$$r = (0,5 \text{ m}).$$

$$\text{RPM} = \text{Rotasi per menit (60)}.$$

$$\text{RPM} = \frac{\frac{v}{r} \times 60}{2\pi}$$

$$= \frac{\frac{1,26}{0,5} \times 60}{2 \times 3,14}$$

$$= \frac{302,4}{6,28}$$

$$= 48,15$$

$$P = T \times \text{RPM}$$

$$= 1135,05 \times 48,15$$

$$= 54,651 \text{ kW}$$

4. CONCLUSION

From the discussion in this study, it can be concluded that the power obtained from the minimum and maximum sea current speeds at a depth of 10 meters is 252 Watts to 54.654 kW. While the power obtained from the minimum and maximum sea current speeds at a depth of 20 meters is 599 Watts to 127,252 kW. Based on the results of the study on the use of ocean currents as a power plant using Gorlov turbines in Botang Lomang District, the researchers gave the following suggestions In future researchers, it is recommended to use better equipment to measure the speed and depth of ocean currents. In the next researcher, it is expected to discuss up to the distribution system and economic calculations. To get even more power, it is still necessary to conduct in-depth research on the type of turbine that has higher efficiency so that the power produced is even greater).

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