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Tidal Modeling Analysis for Potential Tidal Power Generating In The District West Siberut

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ABSTRACT

Numerical modelling is a combination of mathematical representation of the problem in physical form and numerical approximation of mathematical equations. Oceanographic numerical modelling is a system for studying ocean dynamic phenomena into discrete/numerical equations. Tidal power plants are renewable tidal energy. The working principle is the same as a hydroelectric power plant, where water is used to rotate a turbine and produce electrical energy. This research uses descriptive quantitative methods, data processing with MIKE 21 software which results in predicted data on tides and current speeds, and results from flow and pass modelling low tide for potential electricity generation where the highest tide in 2024 in May was 1.53m and the lowest tide in April was -0.92m. In 2025, the highest tide in March will be 2.07m and the lowest tide in April will be -0.56m. for electrical energy potential in 2024 the average is 5.7kWh, and in 2025 the average is 9.07kWh.

Keywords: Modeling, Power Plan, Tidal

1. Introduction

Electrical energy is a basic need for society and supports all aspects of life and national development, including improving living standards. Society's dependence on electrical energy increases as time passes and technology develops. On the other hand, the problem that arises is that energy sources in Indonesia have so far used the conversion of fossil energy such as petroleum, coal, and gas as the main energy source. As is known, the supply of energy originating from fossils is increasingly depleted, so that over time it decreases and cannot be renewed. To overcome the depletion of electrical energy supplies, a breakthrough is needed to utilize other energy, by developing renewable energy sources. Renewable energy sources are non-fossil energy sources that can be renewed, are environmentally friendly and can be utilised over a long period. Renewable energy has a fairly important role in efforts to provide alternative electrical energy.

Most areas in Indonesia are archipelagos united by the ocean. As a country with quite a large ocean potential, Indonesia has the potential to develop alternative energy sources originating from the sea, such as alternative energy sources from sea currents. Ocean current energy is a form of renewable energy that is continuous and environmentally friendly and will never run out, unlike fossil energy. One type of ocean current energy is in the Mentawai Islands region and from the environmental perspective, it is in dire need due to the lack of electrical energy in several areas in Mentawai, such as West Siberut District.

2. Research methodology

This type of research is research with a descriptive quantitative approach with studies including data collection, data processing and data analysis using secondary data.

3. Results and discussion

3.1. Mesh results

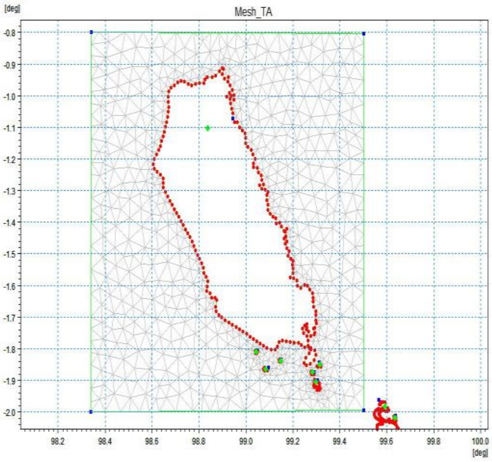

Figure 1. Mesh results

In Figure 1, the results of the mesh formed using the mesh generator in the MIKE Zero module, the mesh is useful so that during interpolation it makes it easier to provide colour gradations which produce nodes and elements automatically through the triangle code developed by Jonathan Shewchuchk. The number of nodes and elements formed was 904 and 1,474. The mesh is formed with the smallest angle of 25 degrees and mesh smoothing is carried out to produce a better mesh in the application of model simulations.

3.2. Interpolation results

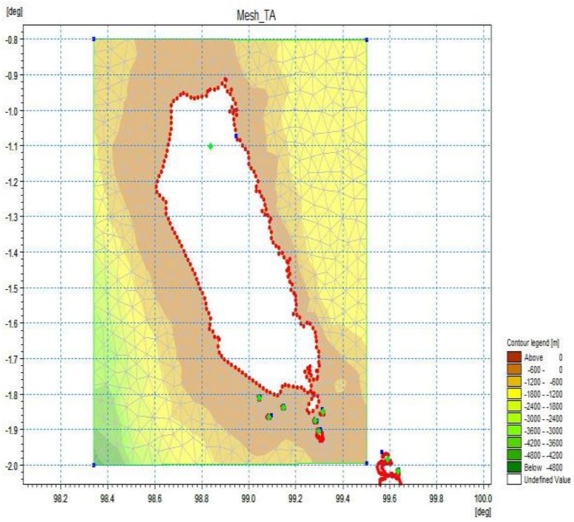

Figure 2. Interpolation results

Based on Figure 2, the results of interpolation of national bathymetric data for Siberut waters, the depth value can be seen according to the colour in the image above, the maximum depth value for Siberut waters is -4,800 meters which can be seen in the dark green, while the minimum depth value for Siberut waters is 0 - -600 meters which can be seen in brown.

Table 1. Sea depth data for Siberian waters

No	Longitude	Latitude	Depth (M)
1	98.3931	-1.1528	-4,800
2	98.3931	-1.0604	-4,600
3	98.3932	-0.9365	-4,400
4	98.3977	-0.8260	-4,200

5	98.7319	-0.9544	-4,000
6	98.8684	-0.9290	-3,600
7	98.3886	-1.2587	-3,200
8	98.3774	-1.3691	-3,000
9	98.3863	-1.4818	-2,800
10	98.3841	-1.5832	-2,400

Depth data from national bathymetric data, for the depth of the Siberian waters, is very varied, the deepest data is -4,800 m and the shallowest is -.1 m.

3.3. Tidal modelling identification results

Surface Elevation or water surface elevation is obtained by taking direct measurements at sea by observing sea-level fluctuations to obtain time series data, while in the image below the seawater surface elevation data is obtained automatically from mike21 software, the results obtained are elevation sea level, at high tide, and at low tide, for 2024.

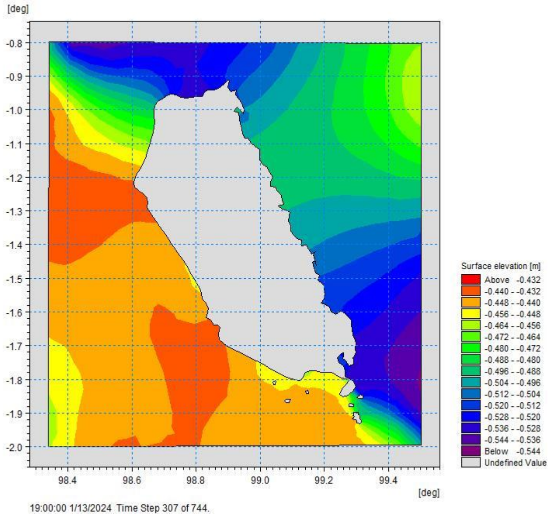

Figure 3. Sea surface elevation at low tide will be lowest in January 2024

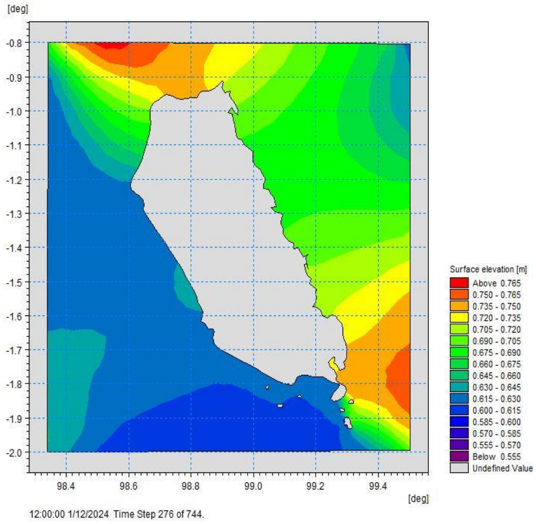

Figure 4. Sea surface elevation at the highest tide in January 2024

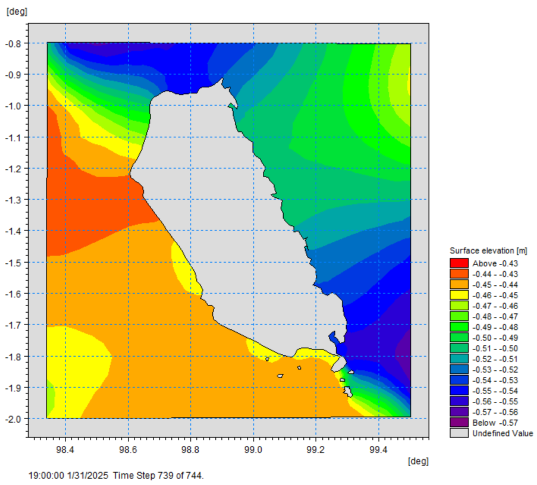

Figure 5. Sea surface elevation at low tide is lowest in January 2025

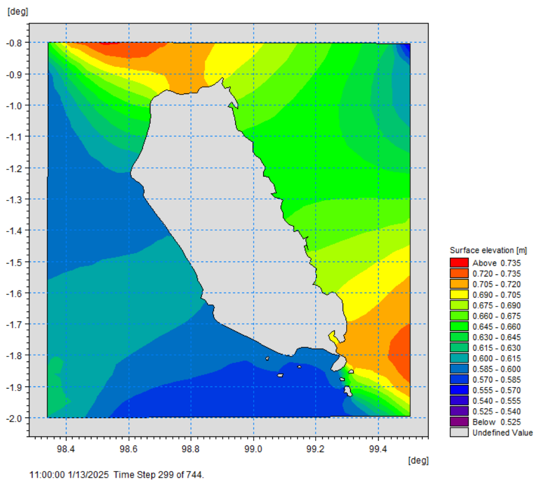

Figure 6. Sea surface elevation at highest tide in January 2025

In January 2024 there are sea surface elevation values at high tide and at low tide, the highest value in January 12/1/2024 at 12:00 at time step 276 is 0.765 m in red and for the lowest tide on 1/13 /2024 at 19:00 time step 307 is -0.544. In January 2025 there are sea surface elevation values at high tide and at low tide, the highest value in January 1/13/2025 at 11:00 at time step 299 is 0.735 m in red and for the lowest tide on 1/13 /2024 at 19:00 time step 739 is -0.57.

3.4. Result identification of current speed in 2024 and 2025

Based on Table 2, the results of identifying current speeds in West Siberian waters have different averages in 2024, the first location has an average current speed of 9.07 m/s and the second location is 38.56 m/s. And in 2025 at the first location, the current speed will be 13.44 m/s and at the second location, it will be 59.02 m/s.

Table 2. Identify ocean current speed

NO	MONTH	**2024** Location 1 (98.868421, -0.928986) (m/s)	**2024** Location 2 (98.731940, -0.954361) (m/s)	**2025** Location 1 (98.868421, -0.928986) (m/s)	**2025** Location 2 (98.731940, -0.954361) (m/s)
1	January	0.04	0.10	0.04	0.10
2	February	2.17	9.46	2.14	9.41
3	March	2.21	9.65	2.15	9.41
4	April	2.15	9.41	2.21	9.67
5	May	2.13	9.32	2.24	9.75
6	June	0.05	0.08	2.24	9.74
7	July	0.04	0.08	2.20	9.60
8	August	0.04	0.10	0.04	0.10
9	September	0.04	0.11	0.04	0.10
10	October	0.04	0.10	0.04	0.95
11	November	0.08	0.09	0.04	0.10
12	December	0.07	0.08	0.04	0.09
AMOUNT		**9.07**	**38.56**	**13.44**	**59.02**
AVERAGE		**0.76**	**3.21**	**1.12**	**4.91**

3.5. Potential electrical energy from ocean currents

Calculation of Electrical Energy Generated Without Turbine Efficiency Constant Value for 2024-2025

The results of calculating the conversion of electrical energy from the speed of ocean currents and the value of the turbine efficiency constant use the Frankeal formula as below.

$$\mathbf{P = 0.5 \times \rho \times A \times V^3}$$

$$P = 0.5 \text{ x } 1{,}025 \text{ x } 40 \text{ x } 0.04^3$$

$$= 0.00133 \text{ W} \sim 0.00000133 \text{ KW}$$

Table 3. Calculation of the electrical energy produced without the turbine efficiency constant value

NO	MONTH	2024 **Location 1 (98.868421, -0.928986)**	2024 **Location 2 (98.731940, -0.954361)**	2025 **Location 1 (98.868421, -0.928986)**	2025 **Location 2 (98.731940, -0.954361)**
1	January	0.00	0.02	0.7	0.0
2	February	0.21	17.35	0.2	17.1

3	March	0.22	18.41	0.2	17.1
4	April	0.20	17.07	0.2	18.5
5	May	0.20	16.60	0.2	19.0
6	June	0.00	0.00	0.2	18.9
7	July	0.00	0.00	0.2	18.1
8	August	0.00	0.00	0.0	0.0
9	September	0.00	0.00	0.0	0.0
10	October	0.00	0.00	0.0	0.0
11	November	0.00	0.00	0.0	0.0
12	December	0.00	0.00	0.0	0.0
AMOUNT		**0.83**	**69.46**	**2.0**	**108.8**
MIN		**0.00**	**0.00**	**0.7**	**0.0**
AVERAGE		**0.07**	**5.79**	**0.2**	**9.1**
MAX		**0.22**	**18.41**	**0.2**	**19.0**

Based on calculations of the conversion of ocean current speed into electrical energy in the waters of West Siberian, the average for each year is different, in 2024 the average at the first location is 0.07 kWh, and at the second location, it is 5.79 kWh. In 2025 at the first location, it will be 0.2 kWh, and at the second location, it will be 9.1 kWh.

Calculation of Electrical Energy Generated using Turbine Efficiency Constant Values for 2024-2025

The results of the calculation of the electrical energy produced using the turbine efficiency constant value in 2024-2025 use the Frankeal formula as below.

$$\mathbf{P = 0.5 \times \rho \times A \times V^3 \times \eta}$$

$$P = 0.5 \times 1.025 \times 40 \times 0.04^3 \times 0.35$$

$$= 0.000466949W \sim 4.66949E\text{-}07KW$$

Table 4. Calculation of the electrical energy produced uses the turbine efficiency value

NO	MONTH	2024 Location 1 (98.868421, -0.928986)	2024 Location 2 (98.731940, -0.954361)	2025 Location 1 (98.868421, -0.928986)	2025 Location 2 (98.731940, -0.954361)
1	January	2.13	0.01	0.2	0.0
2	February	2.26	6.07	0.1	6.0
3	March	2.09	6.45	0.1	6.0
4	April	2.03	5.98	0.1	6.5
5	May	0.00	5.81	0.1	6,7
6	June	0.00	0.00	0.1	6.6
7	July	0.00	0.00	0.1	6.4
8	August	0.00	0.00	0.0	0.0
9	September	0.00	0.00	0.0	0.0
10	October	0.00	0.00	0.0	0.0
11	November	0.00	0.00	0.0	0.0
12	December	8.51	0.00	0.0	0.0
AMOUNT		**17.01**	**24.31**	**0.7**	**38.1**

MIN	**0.00**	**0.01**	**0.2**	**0.0**
AVERAGE	**1.42**	**2.03**	**0.1**	**3,2**
MAX	**2.09**	**6.45**	**0.1**	**6,7**

Based on calculations of the conversion of ocean current speed into electrical energy using turbine efficiency values in West Siberian waters, the average is different each year, in 2024 the average at the first location is 1.42 kWh, and at the second location is 2.03 kWh. In 2025 at the first location, it will be 0.1 kWh, and at the second location, it will be 3.2 kWh.

4. Conclusions

In 2024 and 2025 the tidal height values are different the maximum tidal height in 2024 at the first location in May is 1.53 m on 5/27/2024 at 1:00 AM and the low tide in April is -0.92 m on 4/9/2024 at 5:00 AM, at the second location the high tide value in November was 1.13 m on 11/16/2024 at 12:00 PM and low tide in April was -0.56 at date 4/9/2024 at 6:00 AM. The maximum tide height in 2025 at the first location in March is 2.07 m on 3/3/2025 at 3:00 AM and the low tide in April is -0.91m on 2/4/2025 at 7:00 AM, and at the second location in November at 0.8 m on 11/7/2025 at 12:00 AM, and receding in March at -0.57m on 3/30/2025 at 18:00 PM. The tidal type in 2024 and 2025 on average has a double mixed tidal type (mixed diurnal tides) where in one day there are two tides with different heights and different intervals. Potential current energy in West Siberian waters in 2024 at the first location without an efficiency value of average0.069 kWh and in the second location with an average of 5.78 kWh, while the current energy produced uses the turbine efficiency value at the first location using a Gorlov turbine with an average0.024kWh and energy at the second location with an average of 2.03 kWh, Meanwhile the potential for current energy in 2025 at the first location without turbine efficiency values with an average0.11kWh and in the second location with an average9.07 kWh, while the current energy produced uses the average turbine efficiency value at the first location0.04kWh and in the second location with an average of 3.17 kWh. The potential location for electrical energy from the speed of tidal currents in West Siberut is the second location with coordinates 98.731940, and -0.95436.

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