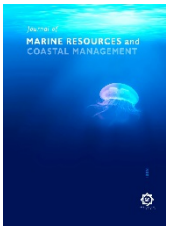
JOURNAL OF MARINE RESOURCES AND COASTAL MANAGEMENT
INDONESIAN JOURNAL OF MARINE LIFE AND UTILIZATION

e-ISSN: 2722-0966
Vol. 2 Issue 2



A study on the potential of electricity generation from wave energy in Pelabuhan Ratu, Sukabumi

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ABSTRACT

Pelabuhan Ratu is an area that has high wave energy potential and can be used as renewable energy. Wave energy harness the power of ocean waves into an electrical energy. The purpose of this research is to estimate the potential of wave energy in the month of Muharram and Rajab (Islamic/Hijriyah calendar) in the year 2018. The value of the forecasting waves in Muharram has a higher value compared to the Rajab. The estimated value of the power generated in the Muharram of 634.205 KWatt, whereas in the Rajab of 119.563 KWatt. The value is influenced to the fetch length. This wave energy potential then can be used to estimate the electrical power generated and the effect of the turbine on the application of the Oscillating Water Column (OWC) system.

Keywords: wave energy, fetch, potential of electricity, Muharram, Rajab.

INTRODUCTION

Electrical energy is a human need that can't be avoided its use, so it is very important to human activity. Daily needs also require electrical energy for the operation. The growth of the community will affect the level of electricity consumption. The government in each year would increase the supply of energy to use energy evenly in various parts of Indonesia. In June 2019, the electricity consumption of Indonesia by 18,270.13 GWh, while in June 2020 by 19,268.41 GWh. That level of consumption is increased and there is a factor pandemic to support the use of electric energy is high. The composition of the electricity consumption of the activities of the business 15.71%, Household 37.45%, Industry 41%, and Public 5.84% [1]. The government has made a strategic plan for the construction of the power station amounted to 35,000 MW to meet the needs of national electricity consumption [2]. The progress of the achievement of the installation of power plants by the year 2020 which is already a contract 343 units or the equivalent of 33,956 MW (96%), while that has not been in contact 54 units or 1,563 MW (4%) [1].

The technology of power conversion that is still used at this time is the conversion of electric power with steam power, the material of the conversion technology is coal. The installation of the conversion technology is already installed in 1997, which has been in pairs by PT PLN reach of 18.9 GW[3]. The use of such technology has long been done so that there is a serious impact to the environment. The impact of these technologies will produce carbon emissions that contained particles of Sulfur dioxide (SO_2), Nitrogen oxide (NO_2), and Carbon dioxide (CO_2). The impact has also been stated in the Decree of the Minister of the Environment No. KEP-13/MENLH/3/1995 about standard carbon emissions to the power plant [7].

Indonesia is a country that has the sea with a percentage of 70% or about 5.8 km2, the condition makes Indonesia has the potential for the development of energy from ocean waves and ocean currents. Energy is energy that can be in the update and low to the environment[4]. The potential energy of the wave that is produced in various regions of Indonesia's example to the minimum value in the region of the Malaka Bay and Makassar Bay (South) with the value of the potential 246.0294 Watt, while the maximum values in the region of the Waters of the Arafuru with a value of 125967 Watt [5].

Oscillating Water Column (OWC) is a technology of converter wave to energy, the principle working of conversion the wave energy accumulation into turbin move and then the generator have a power supply energy. The technology OWC its very convenient in within topogrraphy sloping floor and have an a high significant wave. The effect wind support the wave so high [6]. Mounting technology converters is a wave of Oscillating Water Column (OWC) has been there on the Beach Parangpucuk, Baron, Gunung Kidul. Installation of the technology was attacched in 2004 by the BPPT [7]. Generally, the higher the latitude (above 30 degrees), the better the position of OWC. Due to the directional pattern of waves, the West Coast is also the best [8]. There are installations all over the world: Scotland, India, Australia, Portugal and Japan. Unfortunately, North Carolina is not the best place to oscillate the water column on land. The best locations in the United States are in the Northwest, Oregon, and Alaska. The northeast coast of New England is also a good location, but the energy potential of the northwest is at least four times higher [9].

The condition of the area Pelabuhan ratu is an area that has the topography of the sea slope and wave conditions are high. The bathymetry in this location is very complex, consisting of the bay, the cape, the coast is steep, some gently sloping beach, and on the location about 500 m southwest, its depth reaches more than 100 m. The direction of the wind that comes from the Indian ocean has made the breeze and make a wave up the beach high [10]. The purpose of this research is to estimate the potential for wave energy in the Muharram and Rajab month on Islamic or Hijriyah calendar. The Muharram month has a high wave characteristic, and in this study compared with Rajab, the other month in Hijriyah calendar.

METHODS

Location

Sukabumi regency (Figure-1) variation has a slope of about 0-40%, on the coast in the west tend to have the topography is steep compared to the coastal area of the other. Areas that have a slope of 25-40% are mostly located in the region of Mount Gede and Mount Halimun Salak. In addition, the region Kabuptaen Sukabumi based on the slope of 15-25% to 60%, the area has a slope of 8-15% to reach 1.82 from the territory of the District Sukabumi [11].

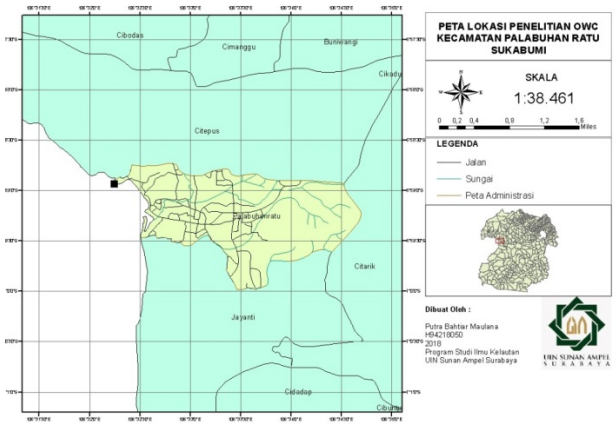

Figure-1. Location map

Data Collection and Processing

The data used secunder data wind in March until April and September until October 2018. The Data obtained from European Centre for Medium-Range Weather Forecasts (ECMWF) website, the processing data used Ocean data View (ODV). Next step of processing is a used Microsoft Excel. Processing data will be presentable can get the processing in Wind Rose Plot (WR PLOT). WR PLOT is a software used known processing data wind and dominan direction. The represntative data such a doughnut graphic, the dominant wind show the layer color and how a long the blowing wind the someplaces. Furthermore, processing data to measure the H significant and T significant.

Data Analysis

1. Fetch

Fetch is an area generating a wave of the sea that is bounded by the mainland, so that the wind that stirs the waves will reach the point of / in contact with the mainland. For the area of the fetch is an area that is exposed to the wind speed is constant, while the fetch is the distance without a hitch when the wind blows [12, 13].

$$F_{eff} = \frac{\Sigma F \cos \alpha}{\Sigma \cos \alpha} \quad (1)$$

where F_{eff} is fetch effective, F is the length of the fetch which is measured from the point of observation of the wave to the end point of fetch, and α is deviation on the side of the wind direction by using the added angle of 6^o up 42^o on both sides.

2. Convertion Wind Speed

Conversion is the result of the conversion of the measurement data of wind on the surface of the sea. The wind measurement is only on the mainland, while the wave generator is necessary wind data above the surface. The relationship of the wind the sea and the mainland, then writing the equation as follows:

$$RL = \frac{Uw}{UL} \quad (2)$$

where RL is table relationship between the wind speeds at sea and on land, Uw is wind speed in the sea (m/s), UL is the wind speed on the ground (m/s).

The chart of the relationship of wind speed according to [12] can be seen at Figure-2.

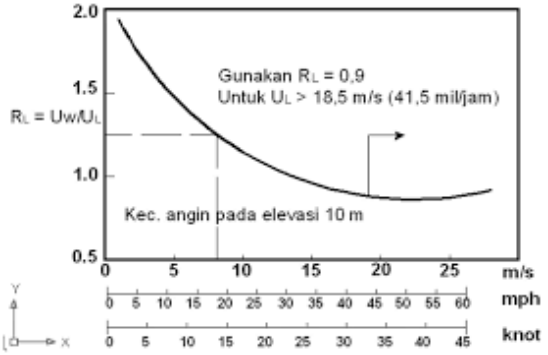

Figure-2. The chart relationships for land and sea wind

3. Wind Stress

According to [12] in the calculation of the speed of the wind is also in need of calculation factor stress of wind which can affect over the wind. The speed of the wind is converted in the stress of the wind as the following:

$$UA = 0{,}71\ U1{,}23 \quad (3)$$

where UA is factor stress of the wind (m/d).

4. Wave Hight and Period

Estimates of wave height results from the calculation of the voltage of the wind can determine the value of the wave height surface (H0) and the period (T0), then the equation is obtained as follows [12]:

$$H0 = \frac{Hs}{Ks} \text{x Kr} \quad (4)$$

$$= 5{,}112 \times 10^{-4} \text{ x UA x Fx } {}^{1}/_{2} \quad (5)$$

$$T0 = 6{,}238 \times 10^{-2} \times (UA \times F) \times {}^{1}/_{3} \quad (6)$$

5. H_{RMS} dan T_{RMS}

The value of the wave height and period after the results of the H significant and T significant, and the direction of the dominant wind is the root mean square, then the value of the equation as follows [12]:

$$H_{rms} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} H_i^2} \quad (7)$$

$$T_{rms} = \sqrt{\frac{\sum n\,(T0)\hat{}2}{\sum n}} \quad (8)$$

6. Calculation of the energy potential of the waves

Potential energy is a form of energy that is produced because of the movement of natural factors such as wind. The results of these objects have potential energy which can produce electricity. Energy potential of these may be mentioned the following formula [14]:

$$E_p = m.g\,\frac{y(x.t)}{2} \quad (9)$$

$$Ep = \frac{1}{2}\rho wgy^2 = \frac{1}{2}\rho gA^2\sin^2(kx-\omega t) \quad (10)$$

$$Ep = \frac{1}{4}\rho wgA^2\lambda \quad (11)$$

where *Ep* is potential energy (J), *m* is mass (kg), *g* is gravity (m/s^2), *y* is equations of wave (m), *A* is amplitude of the wave, λ is wavelength (m), *k* is wave constant, ω is wave frequency (rad/s), and *t* is time (s).

In conducting the data analysis, in this research using descriptive analysis approach. That the analysis of these complete with the presentation of data tables, charts and pictures. The results of the analysis of this study is seen from the results of data processing of the month of rajab and the month of muharram of the year 2018, from the data comparison is done on the month to see the potential of the wave. Sampling point location is done in the south coast region, namely Pelabuhan Ratu, Sukabumi. That the south coast region of characteristics with a wave of a strong and high, then the potential there can be made as the research potential of wave energy.

RESULTS AND DISCUSSIONS

The value of the period and the wave height obtained in the month of Muharram and Rajab 2018 on the process of forecasting. Data collection was performed on the coordinates of 106°32'00"E and 6°58'50" S. In the data retrieval is done on the Website of the ECMWF, and the subsequent processing done to find the value of the period and the wave height is in Pelabuhan Ratu.

Muharram 2018

Blowing the direction of the dominant wind which occurs in the month of Muharram 2018 in the territory of the Beach Pelabuhan Ratu, Sukabumi. The value of dominance gusts of wind (Figure-3).

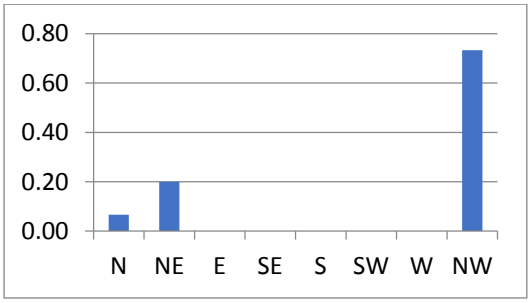

Figure-3. Graph of wind distribution frequency on Muharram 2018

The west sea into the direction of the wind is dominant which leads to the Beach area of Pelabuhan Ratu, Sukabumi. The value reached a value of 0.73 m/s. Whereas in gusts dominant can be described from the results of Windrose and fetch (Figure-4).

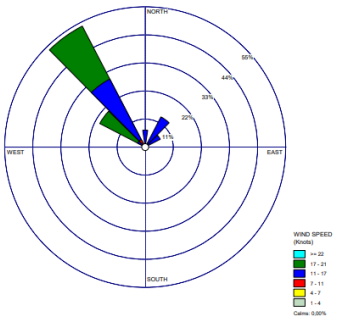

Figure-4. Windrose of Muharram 2018

Table-1. Fetch effective

a (degree)	cos a	X_1 (km)	X_1.cos a
42	0.743	541.000	402.017
36	0.809	506.000	409.354
30	0.866	462.000	400.092
24	0.914	455.000	415.643
18	0.951	1.520	1.446
12	0.978	1.320	1.291
6	0.995	0.870	0.865
0	1.000	0.460	0.460
6	0.995	0.190	0.189
12	0.978	0.029	0.028
18	0.951	0.021	0.020
24	0.914	0.019	0.017
30	0.866	0.017	0.015
36	0.809	0.150	0.121
42	0.743	0.015	0.011
Total	13.517		1631.569
		F_{eff}	120.762

Table-2. Height and period wave

No	Height and Period Wave	Value
1	Hs	3.58468528 m
2	Ts	10.0804816 s
3	Hrms	2.52442626 m
4	Trms	7.09893069 s

While the value of the fetch in the month of Muharram is 120.762 km (Table-1), while the value of the fetch average in Pelabuhan Ratu, Sukabumi is the 203.946 km. when the value of the length of the fetch will affect against gusts of wind and wave that is produced, it can be seen the high and the period of the wave (Table-2). According to [15] the length of the gusts of wind from an area towards the hinder it it will cause the characteristics of the wavelength as well.

The Calculation of the Estimated Electrical Power from the Wave Energy Potential in Muharram 2018

The calculation of the potential of the wave as the wave power plant on the Beach Pelabuhan Ratu, Sukabumi from the results of the forecasts or forecasting significant wave and the period in the Month of Muharam 2018. The use of OWC as a tool converter wave to electrical energy, is affected by the column width used. In this study, column OWC using a width of 2.5 m, the value of the width of the column is obtained from the source[16]. with the kind of sea water is 1.025 Kg/m3 and the value of gravity is 9.81 m/s2. The results of the calculation using the above equation. The results of these calculations produce the rated power of the electric wave generation by 634.205 KWatt.

Rajab 2018

Blowing of wind direction on the month of Rajab 2018 in Pelabuhan Ratu, Sukabumi in the dominance of the southwest and south. The speed of the wind that blows in the month of Rajab 2018 in Pelabuhan Ratu, Sukabumi about 0.24-0.26 m/s (Figure-5). While the results of windrose can also be described value windrose with the beam that leads to the southwest corner and the south. The value of the spread at the windrose in the month of Rajab is very diverse from different directions (Figure-6). The value of the length of the fetch in the Month of Rajab 2018 is 164.856 Km, while the average value of the fetch is 148.487 km (Table-3 & 4).

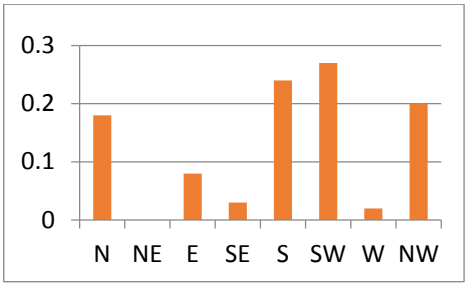

Figure-5. Graph of wind distribution frequency on Rajab 2018

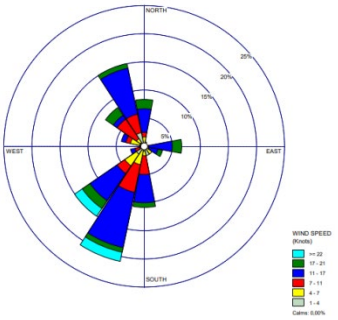

Figure-6. Windrose of Rajab 2018

The Calculation of the Estimated Electrical Power from the Energy Potential of the Waves in Rajab 2018

Based on the results of the calculation of the estimated electrical power of the generator power energy wave in the month of Rajab 2018, obtained a value of 119.563 Kwatt. Use the width of the columns on the OWC was 2.5 meters according to[16], on the use of the width of a column OWC will affect against the ingress of wave energy in the turbine and the generator, thus affecting the estimation of the electrical power generated.

Table-3. Fetch effective

a (degree)	cos a	X_1 (km)	X_1.cos a
42	0.743	27.22	20.227
36	0.809	732.00	592.188
30	0.866	575.00	497.950
24	0.914	465.00	424.778
18	0.951	343.00	326.227
12	0.978	186.00	181.927
6	0.995	96.00	95.472
0	1.000	20.80	20.800
6	0.995	18.30	18.199
12	0.978	14.50	14.183
18	0.951	13.70	13.030
24	0.914	10.50	9.592
30	0.866	9.41	8.149
36	0.809	3.55	2.872
42	0.743	2.30	1.709
Total	13.511		2,227.302
		F_{eff}	164.856

Table-4. Height and wave period

No	Height and wave period	Value
1	Hs	3.53 m
2	Ts	3.41 s
3	Hrms	2.49 m
4	Trms	2.40 s

Based on the results of the analysis, the results of power in the Month of Muharram and Rajab has a value of significant difference. That such a result, is influenced by several factors, including the weather, the force of attraction of the earth and the moon, and the wind that blows. In the Month of Muharram, told in a hadith that don't go out to sea because the waves of the month has a height to the maximum. Then the results, the data obtained from the ECMWF that wave in the Month of Muharram achieve maximum and can be used as a source of power energy wave. The value of the result of the waves of the Month of Muharram has more power compared to the Month of Rajab.

CONCLUSIONS

The analysis of of the forecasting of waves on Muharram and Rajab (Hijriyah calender) 2018 in Pelabuhan Ratu, Sukabumi show that wave height and period in the month of Muharram 2018 is high compared the value is to the Month of Rajab 2018. The month of Muharram has a value of wave height until 3.5 m/ 10 s, the potential of high wave used the electricity 634.205 KW. The Rajab month have a wave high 3.5 m/ 3.41 s, the potential for the electricity 119.563 KW.

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