



## Wave Energy Potential for Development of Renewable Energy in Riau Archipelago Province

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### ABSTRACT

Energy and electricity demand in Riau Islands is increasing rapidly due to the fast-growing population, urbanization, industrial development, and economic growth. The limitations of energy and electricity in the Riau Islands caused frequent blackouts. To support the high demand for energy and electricity in the Riau Islands, renewable energy is the most suitable alternative energy solution. Renewable energy is not only playing a key role in providing energy but also providing long-term clean and sustainable energy. We investigated the wave energy potential in the Riau Islands Sea in four different consecutive monsoons (North monsoon, East monsoon, South Monsoon and West Monsoon) using ECMWF data during January 2018 to December 2018 with  $0.125^\circ \times 0.125^\circ$  and 6 hourly spatial and temporal resolutions. We extracted bathymetry data from NOAA's database ETOPO1 and forecasting wave characteristics use the SPM (Shore Protection Manual) method. The potential wave energy simulation from significant wave height ( $H_s$ ) and energy period ( $T_e$ ) was shown in spatial distribution based on different monsoon. Our studies found that the potential wave energy was higher in north monsoon with maximum spatial of wave power density  $3.240 - 3.640 \text{ kW.m}^{-1}$ . The east monsoon tended to be lower potential wave energy with dominance of wave power density at  $0 - 0.127 \text{ kW.m}^{-1}$ .

**Keywords:** wave power density, potential wave energy, ECWFM, monsoon

### ABSTRAK

Permintaan energi dan listrik di Kepulauan Riau meningkat pesat karena pertumbuhan penduduk yang cepat, urbanisasi, perkembangan industri, dan pertumbuhan ekonomi. Keterbatasan energi dan listrik di Kepulauan Riau menyebabkan seringnya terjadi pemadaman listrik. Untuk mendukung kebutuhan energi dan listrik yang tinggi di Kepulauan Riau, energi terbarukan merupakan solusi energi alternatif yang paling tepat. Energi terbarukan tidak hanya memainkan peran kunci dalam menyediakan energi tetapi juga menyediakan energi bersih dan berkelanjutan untuk jangka panjang. Kami menyelidiki potensi energi gelombang di Laut Kepulauan Riau dalam empat musim yang berbeda berturut-turut (Musim Utara, Musim Timur, Musim Selatan, dan Musim Barat) menggunakan data ECMWF selama Januari 2018 hingga Desember 2018 dengan resolusi spasial  $0,125^\circ \times 0,125^\circ$  dan resolusi temporal 6 jam. Kami mengekstrak data batimetri dari database NOAA ETOPO1 dan

peramalan karakteristik gelombang menggunakan metode SPM (Shore Protection Manual). Simulasi energi gelombang potensial dari ketinggian gelombang signifikan ( $H_s$ ) dan periode energi ( $T_e$ ) ditampilkan dalam distribusi spasial berdasarkan monsun yang berbeda. Studi kami menemukan energi gelombang potensial lebih tinggi pada musim utara dengan spasial maksimum kerapatan gelombang 3,240 - 3,640  $\text{kW.m}^{-1}$ . Musim timur cenderung memiliki energi gelombang potensial yang lebih rendah dengan dominasi densitas daya gelombang 0 - 0,127  $\text{kW.m}^{-1}$ .

**Kata kunci:** rapat daya gelombang, energi gelombang potensial, ECWFM, monsun

### Introduction

Global energy still depends on the use of fossil fuels more than 80% of the total gross primary energy used in the world community (Buchanan, 2018) and this condition gives negative impact on our environment. The increasing concern with the negative effects of fossil fuels has pushed the world to find alternative sources of clean and sustainable energy as the requirement of the electricity demand (Ilyas et al., 2014). Consequently, the exploration for a clean and sustainable energy source becomes very important and critical, but at the same time the use of fossil fuels is still difficult to suppress (Buchanan, 2018).

The world community and the environment are facing the challenge of finding alternative energy sources which are clean and environmentally friendly (Buchanan, 2018). The renewable energy sources are an attractive alternative form of energy supply because it is always available and continuous. The operation process is very important in creating a clean environment (Aderinto & Li, 2018). Although it is difficult to change the world of fossil energy dependence, the renewable energy would be the most suitable alternative as the primary energy in the future, when renewable energy is present as increasing world energy demand (T et al., 2015).

Marine energy is one of the most promising renewable energy sources (Wahyudie et al., 2017). At the scale of local communities, isolated islands or coastal communities have special needs for decarbonized energy supplies, where the transportation in supplying fossil fuels to the isolated islands is costly and ineffective. Consequently, renewable marine energy is a logical choice (Manasseh et al., 2017). Difficulties related to energy security affecting coastal communities are resolved by empowering renewable marine energy (Manasseh et al., 2017). Some countries have actively conducted studies to estimate the amount of marine energy available in their

countries to be exploited (Aderinto & Li, 2018) especially in developed countries.

Wave energy is very promising and is one of the most abundant energy sources in the world and has the highest energy density (Ilyas et al., 2014). This energy has the second-largest potential of all renewable marine energy sources to development (Thorpe, 1999; Ilyas et al., 2014; Aderinto & Li, 2018) with an estimated less than 20% which is only exploited from sources of total wave energy in the world (Salter, 1973; Mørk et al., 2010; Mustapa et al., 2017; Wahyudie et al., 2017). The development of the marine renewable energy industry, especially wave energy, also will give benefit to industry (Haces-Fernandez, Li, & Ramirez, 2018) and has been proven to be the most renewable, clean, sustainable, environmentally friendly (Ilyas et al., 2014; T et al., 2015) and is expected to increase the potential to compete with the use of current non-renewable energy sources (Mustapa et al., 2017).

Wave energy is still far behind other renewable energy resources in terms of implementation but is promising in terms of available energy and reduced carbon capability (Ilyas et al., 2014) where two percent of the world's coastal waters has a large wave power density and enough to extract wave energy (Hayward & Osman, 2011). The best wave conditions to be exploited are in medium-high latitudes and deep waters more than 40 m because in this condition wave energy can be generated reaching power densities of 60-70  $\text{kW.m}^{-1}$  (Ruud & Frank, 2014).

Riau Islands is one of the provinces in Indonesia which has high potential wave energy. It is because more than 94 percent of the province is the ocean. The composition of the wide ocean provides positive benefits for the Riau Islands to develop renewable marine energy sources including wave energy. Another strong factor is that most of the province consists of small islands. This condition of small islands in the Riau Islands is a deficiency of electricity. Renewable marine energy, including wave energy, is an

appropriate alternative to reserve electrical energy in the small islands, especially in Riau Islands. Utilization of electricity resources using renewable energy has been carried out by local governments by providing a supply of renewable energy sources using solar energy with solar panel assistance in several villages on small islands. The acceleration of the implementation of the application of renewable energy was mandatory of government regulations. Most of the application of electricity demand must be supported by environmentally friendly of renewable energy. Hence it is necessary to have the latest information related to the average wave energy density in the Riau Islands. The optimization of sea wave implementation and suitable location for ocean wave application for Wave Energy Converter (WEC) in the future would be important information for creating sustainable, environmentally friendly and clean energy. Overall, this research was a preliminary study about ocean wave energy in the of Riau Islands being able to become potential renewable energy/alternative energy in the future.

## Materials and Methods

### 2.1. Study Area

Riau Islands sea is a internal water body which has been formed from the extension of the South China Sea and Pacific Ocean and lies between Malaysia, Singapore, Sumatra and Kalimantan islands. The Riau islands sea is considered as a shallow water body with an average depth of 50 meter (extract data from NOAA). The study area location in Riau Islands sea with longitude and latitude coordinate is 103.0.0°E - 110.0.0°E and -1.0.0°S - 4.0.0°E, respectively.

### 2.2. Bathymetric data

Bathymetric data were extracted from NOAA's database ETOPO1 (Lavidas, Venugopal, & Friedrich, 2017) using the "marmap" packages by R statistics (Pante & Simon-bouhet, 2019) with large domain covers area in Riau Islands Sea (RIs) from 102 ° E to 110 ° E (Longitude) and from -1 ° N to 5 ° N (Latitude) and using by 1' to produce a regular spatial resolution of 0.025° (Lavidas, Venugopal, & Friedrich, 2017).

### 2.3. Wind Data

The purpose of this study was to determine the potential availability of renewable energy through the ocean wave in the Riau Islands during January-December 2018 period. The potential wave energy comes from the motion of sea surface wave generated by wind and is then determined by the gradient of the wind speed which induces a force. The basic principle to estimate the potential of wave energy forecast is to determine the wind speed based upon the understanding of the temporal and spatial variation of the wind force, which is converted into wave motion. Ocean wave data were collected with the hindcasting method by changing wind speed into ocean wave characteristics including wave height and wave periods data. The wind direction and speed were used as the main component to predict the characteristics of the ocean waves due to the wind parameter as one of the important factors in the formation of ocean waves (Suhana et al. 2018). For the estimate of the wave motion, we used the forecast wave parameters based on the wind speed characteristic using outputs from ECMWF (European Centre for Medium-Range Weather Forecasts) data. The European Centre, ECMWF, provides global forecasts, climate reanalysis and specific dataset (Dupré et al., 2020). For wind variability assessment in Riau Islands Sea, we used ECMWF (European Centre for Medium-range Weather Forecast) wind field based modification by (Kamranzad, 2018) during January 2018 – December 2018 with 0.125°x0.125° and 6 hourly spatial and temporal resolutions, respectively (i.e., 00 h:00, 06 h:00, 12 h:00 and 18 h:00 UTC). we compared to time series of wind speed from different Monsoon at Riau Islands in 2018. There were 4 consecutive Monsoon activities in RIs area: North Monsoon (December to February), East Monsoon (March to May), South Monsoon (June to August) and West Monsoon (September to November).

### 2.4. Wind Speed Correction and Conversion

Our ECMWF data have a NetCDF (Network Common Data Form) format. This format requires to be converted to text format using Ocean Data View (ODV) software to extract data to get wind direction and speed values. The 2018 ECMWF data used were daily data for one year which was measured on land and did not coincide with the standard 10-m reference level. To analyze and predict the wave parameters, the data had to be converted to the 10-m reference level. For the

case of winds taken in near-neutral conditions at a level near the 10-m level, the simple approximation was given below.

$$U_{10} = U_z \left( \frac{10}{z} \right)^{1/7} \quad (1)$$

$U_z$  is wind speed at height  $z$  above the surface, while  $U_{10}$  is wind speed at 10-m references level.  $Z$  is elevation of the surfaces and measured in meters. The implementation of the calculation and correction of the duration of the wind data was done, because the measurement was the result of momentary observation. Sea wave forecasting requires data on the duration of the wind blowing. During this duration, the wind speed is considered constant. Correction duration is conducted to obtain an average wind speed value and given by the following:

$$t = \frac{1609}{U_{10}} \quad (2)$$

$t$  is duration of the fastest-mile wind speed,  $U_{10}$  is a function of wind speed. The calculation of the average wind speed for one-hour duration used the following equation:

$$U_{3600} = \frac{U_{10}}{c} \quad (3)$$

$U_{3600}$  is 1-hr wind speed and  $c$  is constant. If condition  $1 < t_1 < 3600$ , then  $c$  is:

$$c = 1.277 + 0.296 \tanh\left(0.9 \log\left(\frac{45}{t}\right)\right) \quad (4)$$

Whereas if the condition  $3600 < t < 36000$ , then  $c$  is

$$c = -0.15 \log t_1 + 1.5334 \quad (5)$$

The stability correction was related to the temperature difference between land and sea level and proposes to increase the influence on the difference between land and sea. Stability correction was presented using the following equation:

$$U = R_T U_t \quad (6)$$

$R_T$  is stability coefficient and has value 1.10 because the temperature difference between land and sea level is unknown. Conversion of wind stress factors to convert data of wind direction and speed on land to the wind direction and speed on the sea used the following equation:

$$U_A = 0.71 \cdot U_W^{1.23} \quad (7)$$

$U_A$  is wind stress factor, and ( $U$ ) is the result of stability correction of wind speed. The corrected wind data were used as input to get the percentage of wind direction and speed and the wind blew every Monsoon during January 2018 - December 2018 and displayed in the form of wind roses diagram using WRPlot View software. Data of wind direction

and speed having been converted were displayed in the form of wind roses (wind rose) with blowing from mode while the percentage of the wind direction and speed is displayed in the form of a histogram.

### 1.5. The Prediction of Characteristics Ocean Waves

Ocean wave forecasting uses the SPM (Shore Protection Manual) method by (CERC, 1984). The ocean wave forecasting phase consisted of filtering of wind data, determining effective fetch length, calculation, and analysis of wave height and period. The effective fetch length was calculated using the following equation:

$$F_{eff} = \frac{\sum x_i \cos \alpha}{\sum \cos \alpha} \quad (8)$$

$F_{eff}$  is effective fetch length.  $x_i$  is length of fetch with  $5^\circ$  interval.  $\alpha$  is the angle between the directions reviewed with the fetch line. The basic principle of the empirical prediction method for ocean waves is that the interrelationship between wind direction, wind speed and fetch effective grown from the process of wave formation. The comparative analysis used the following formula:

$$\frac{gt_d}{U_A} = 68.8 \left( \frac{g F_{eff}}{U_A^2} \right)^{2/3} \leq 7.15 \times 10^4 \quad (9)$$

$t_d$  is the duration of the wind blowing.  $g$  is acceleration of gravity. If the results obtained do not match the equation, the wave which occurs is the result of perfect wave formation. Then, the calculation of wave height and period used the following equation:

$$H_{m0} = 0.2433 \times \frac{U_A^2}{g} \quad (10)$$

$$T_p = 8.134 \times \frac{U_A}{g} \quad (11)$$

$H_{m0}$  is wave height.  $T_p$  is period of the peak wave. However, if the analysis results match the above equation, the wave which occurs is the result of imperfect wave formation. The formation of imperfect waves is formed because of fetch limited and duration limited. To find the difference, it is necessary to calculate the critical duration ( $t_c$ ) with this equation by (CERC, 1984):

$$t_c = \frac{68.8 \times U_A}{g} \left( \frac{g \times F_{eff}}{U_A^2} \right)^{2/3} \quad (12)$$

The important and necessary thing to do in predicting sea waves is checking the specified duration ( $t_d$ ) and comparing with the critical duration ( $t_c$ ). If  $t_d > t_c$ ; the wave that occurs is generated by fetch limited. The

Calculation of wave height and period used this equation by (CERC, 1984):

$$H_{m0} = 0.0016 \times \frac{U_A^2}{g} \left( \frac{gF}{U_A^2} \right)^{1/2} \quad (13)$$

$$T_p = 0.2857 \times \frac{U_A}{g} \left( \frac{gF}{U_A^2} \right)^{1/3} \quad (14)$$

If  $t_d < t_c$ , the wave that occurs is the result of formation of waves by duration limited. The calculation of wave height and period used the above equation, but,  $F_{eff}$  is changed with  $F_{min}$ , it should be calculated with the following equation by (CERC, 1984):

$$F_{min} = \frac{U_A^2}{g} \left( \frac{gt_d}{68.6 U_A^2} \right)^{3/2} \quad (15)$$

## 2.6 The Wave Power Potential Characterization

In the present work, state-of-the-art numerical models have been utilized for the simulation of the main atmospheric and wave parameters, needed for the detailed monitoring of the wave energy, in conjunction with

available observations in the area of interest and a variety of statistical approaches, targeting to a high quality analysis of the obtained results (Zodiatis et al., 2014). The main issue for a wave energy study is the simulation or monitoring of the significant wave height  $H_s$  and wave energy period  $T_e$  that directly affects the wave energy potential (Kalogeri et al., 2017):

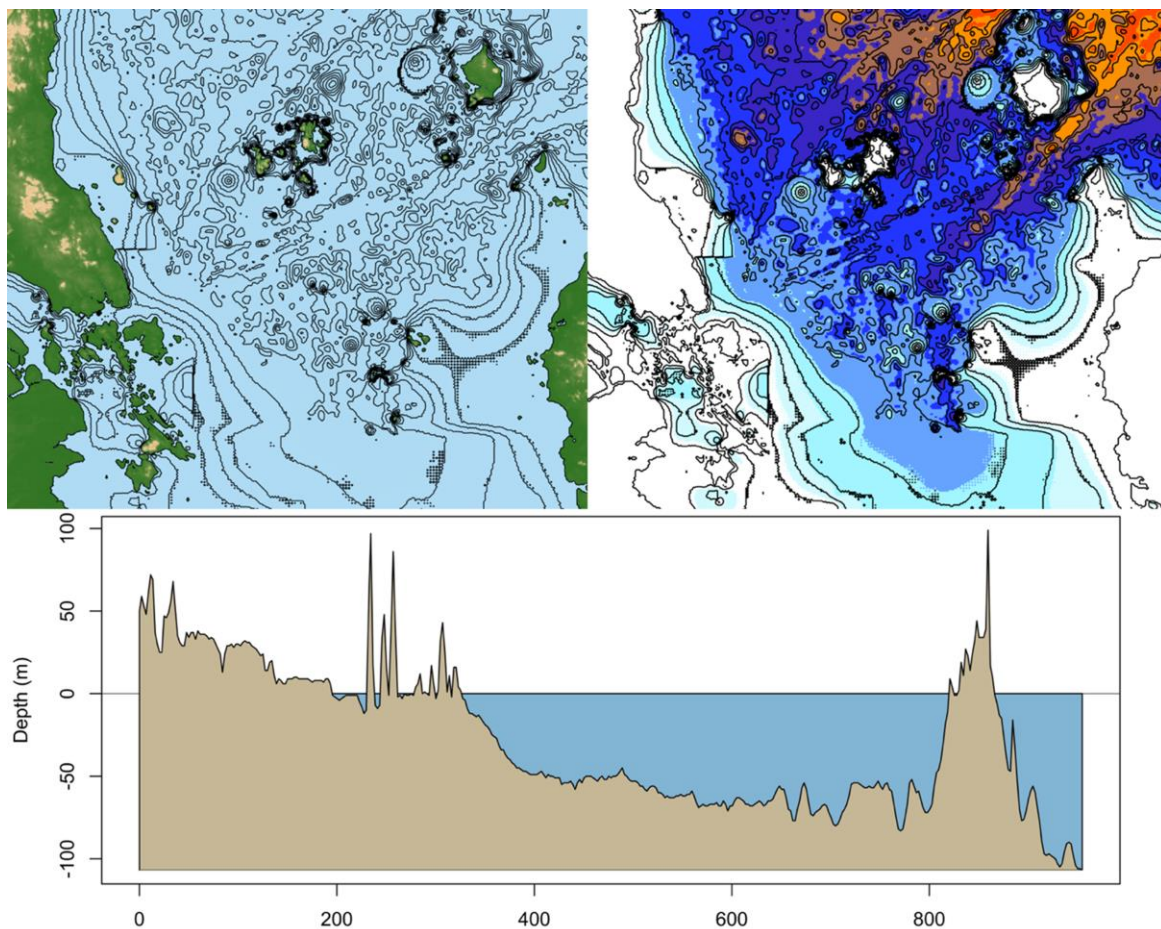
$$P = \frac{\rho_w \cdot g^2}{64 \pi} H_s^2 \cdot T_e \quad (16)$$

$\rho_w$  is the water density (an average value could be  $1025 \text{ kg.m}^{-3}$ ).  $g$  is the gravitational acceleration that is approximately  $9.8 \text{ m.s}^{-2}$ . The wave power formula is valid under the deep water assumption (Kalogeri et al., 2017).

## Result and Discussion

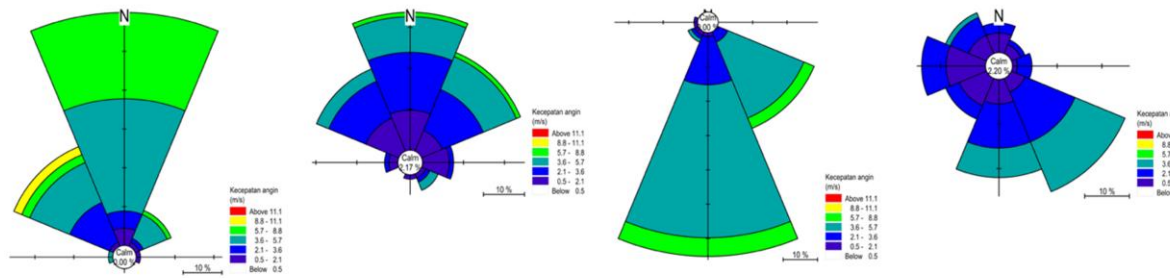
### 3.1 Bathymetry and Depth Analysis of Riau Islands Sea

The bathymetry is one of fundamental the wave height and period is formed, and its



**Figure 1.** Bathymetry and depth analysis of study region (Riau Islands Sea)





**Figure 2.** Annual distribution of wind speed and directions at four different Monsoon In Riau Island Sea. From left to the right (North Monsoon, East Monsoon, South Monsoon and West Monsoon)

influence the wavelength from the open sea to the coastal areas. The depth analysis is more important for estimate bathymetry and shoreline configuration for measuring the wave transformation, where the wave transformation used to represent the distribution of potential wave energy. Figure 1 shows that Riau Islands sea has shallow waters with an average depth of 50 meters. Of the 6 largest islands in the Riau Islands, Anambas and Natuna waters have deeper water depths up to 100 meters, while Bintan, Batam, Karimun, and Lingga Islands tend to have shallower waters. The depths in average is 30 meters. The depth analysis is shown in Figure 1, showing that the topographic shape of the Riau Islands waters is categorized as the slope category.

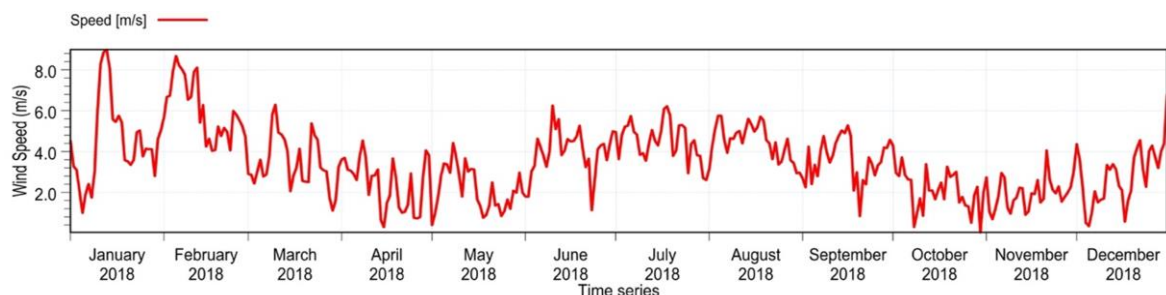
### 3.2 Annual Distribution of Wind Speed at four different Monsoon in Riau Islands Sea

The potential of wave energy comes from the motion of sea level waves generated by the wind and is determined by the wind speed gradient that induces the force. To predict the wave energy which is formed from the wave parameters the researchers used the wind speed and duration with temporal and spatial variation. The wind-generated waves can propagate over large distances and correlate with the wave energy produced. To describe the directional variability of wind and wave

densities in Riau Islands Sea, we presented the wind rose diagrams in Figure 2. As shown in Figure 2, the higher wind speed in Riau Islands Sea at North Monsoon and South Monsoon with the dominance of wind speed was  $5.7 - 8.8 \text{ m.s}^{-1}$  (North direction) and  $3.6 - 5.7 \text{ m.s}^{-1}$  (South direction) respectively.

The maximum of wind speed was  $8.8 - 11.1 \text{ m.s}^{-1}$  (Northwest direction) in north monsoon and  $5.7 - 8.8 \text{ m.s}^{-1}$  (South and Southeast direction) in south monsoon. The lowest wind speed at the West Monsoon with dominance of wind speed was  $2.1 - 3.6 \text{ m.s}^{-1}$  and maximum of wind speed was  $3.6 - 5.7 \text{ m.s}^{-1}$ . From wind rose diagram analysis, the winds are rather scattered in terms of direction in the east and west monsoon and more to be center in the north and south monsoon. The tendency of wind speed also shows that the north and south monsoon have higher wind speeds compared to the east and west monsoons. The analysis in figure 3 showed that the east and west monsoons were transitional seasons in the Riau Islands sea, the slower wind speed of the two seasons was also due to limited duration of wind blowing due to several direction bordering on main island (Eastern with Kalimantan island and Western with Sumatra Island), while the north and south monsoons the wind blows perfectly.

The Riau Islands sea is strongly influenced by seasonal wind systems. As an



**Figure 3.** One Year Analysis of Wind Speed ( $\text{m.s}^{-1}$ ) period 2018 with ECWF Model in Riau Islands

**Table 1.** Average wind characteristic Riau Island Sea at different Monsoon in 2018

Average Wind Characteristic	$U^{10}$	U (stability)	Ua	Uav3	Vav3
North Monsoon	4.5875	4.6641	4.7448	0.3438	4.2582
East Monsoon	1.6141	1.7128	1.4278	1.1180	1.1001
South Monsoon	4.6940	4.7661	4.8717	-0.3626	-4.2633
West Monsoon	1.1158	1.2027	0.9065	-0.2345	-0.8668

**Table 2.** Fetch effective length of wind in Riau Island sea

	North	Northeast	East	Southeast	South	Southwest	West	Northwest
$F_{eff}$ (km)	186.36	200.00	193.00	184.83	200.00	200.00	197.89	196.60

archipelago, the Riau Islands are included in the outer islands and have a potential category to produce alternative electrical energy sources through ocean waves. They have some islands located in the open seas area (Anambas Islands, Natuna and islands in Tambelan). These islands can provide great potential for alternative uses of marine energy, especially in wave energy conversion. The application of ocean wave energy in Riau Islands as an alternative electrical energy source is dependent on the amount of energy produced by ocean waves. The higher the waves are formed in the ocean, the higher potential energy can be produced, and the higher electricity production is through wave energy conversion (Buchanan, 2018).

### 3.3 One Year Analysis of Wind Speed and Fetch Analysis in Riau Island Sea

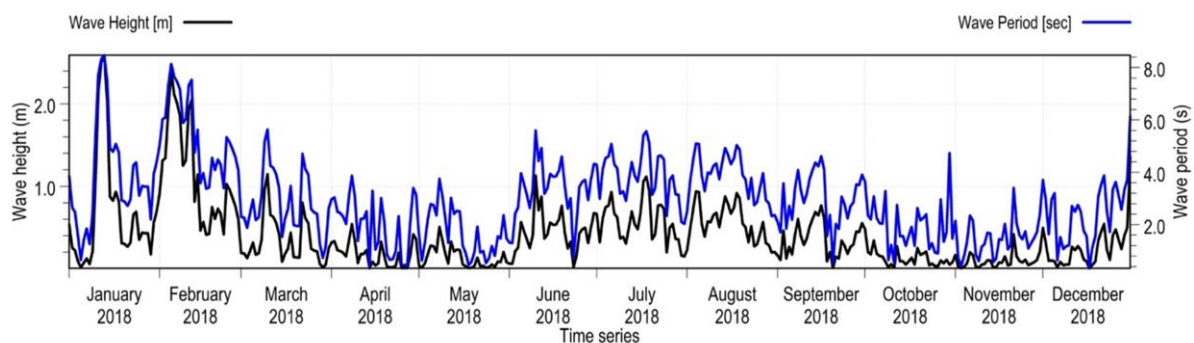
During 2018, the Riau Islands sea were affected by winds blowing from the north and south. The condition of wind speed tends to be high in January to February with the highest speed at  $9 \text{ m.s}^{-1}$  and starts to decrease from March to May with a maximum speed of  $6 \text{ m.s}^{-1}$ . The wind speeds return increase in June-August and return to decrease in September-October. In December the wind speed starts to return to increase with the highest speed at 7

$\text{m.s}^{-1}$  (Figure 3).

Despite the influence of a high seasonal wind system in the Riau Islands sea, only certain regions have the potential for ocean wave energy. From one side, it is particularly unfortunate, considering the potential of the ocean wave energy appropriate to be applied in the islands region (Sugianto et al., 2017) but the potential for the alternative electric wave energy cannot accommodate all regions in the Riau Islands areas. From the other side for most areas in Riau Islands, especially in small uninhabited islands which have not been touched by the electricity system, this alternative energy will be the main solution to existing electricity system problems in all areas in Riau Islands.

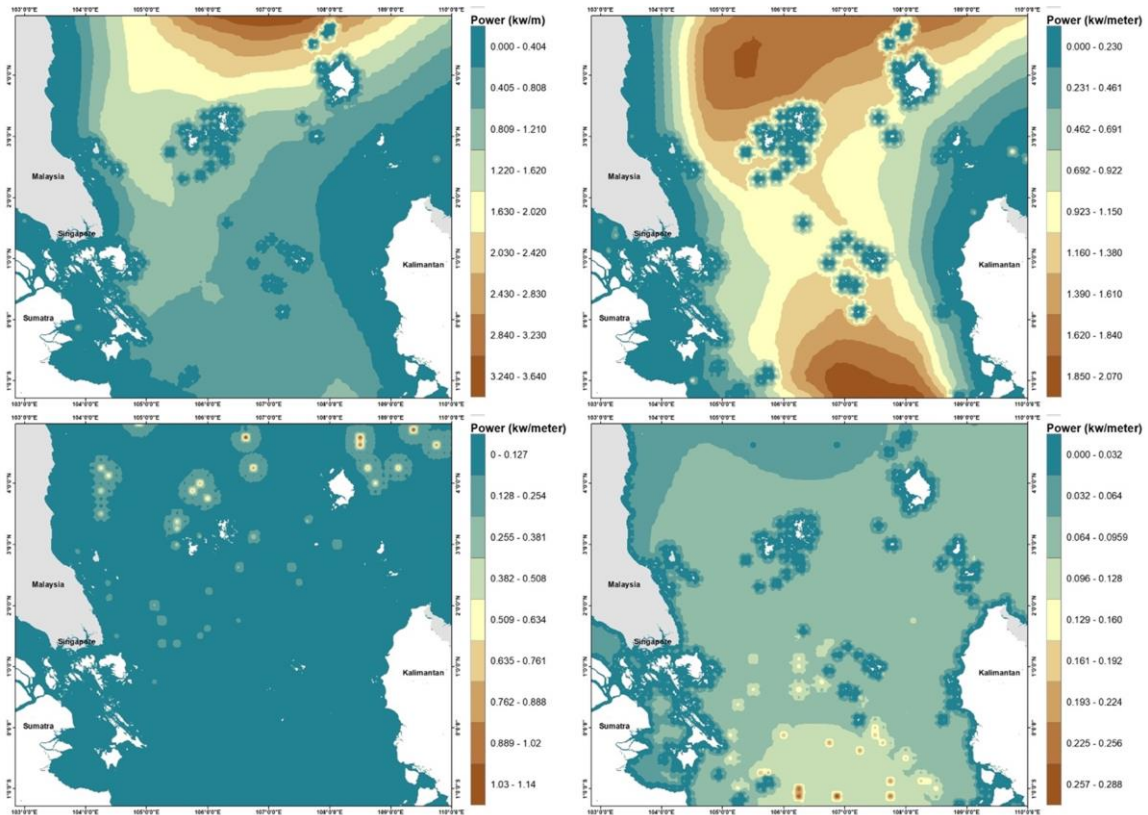
### 3.4. Annual Wave Characteristics in Riau Islands Sea

In forecasting wave heights, it is necessary to measure Fetch by analysing the distance and direction of ocean wave generation (fetch). Determination of the location of the fetch in this study was at a depth of 20 m with the assumption that the bottom waters had not affected the pattern of the wave transformation from the deep sea. The height and wave period can be predicted based on the relationship of the data of fetch length, wind

**Figure 4.** Significant wave height (black line) and wave period (blue line) time series for Riau Islands Sea in 2018

**Table 3.** Average wave characteristics  $H_{m0}$  and  $T_p$  in different monsoon

Average Wave Characteristic	$H_{m0}$	$T_p$	Information
North Monsoon	0.6000	4.0502	Dominance in perfect duration
East Monsoon	0.2342	3.5378	Dominance in limited duration
South Monsoon	0.6298	4.1560	Dominance in perfect duration
West Monsoon	0.2120	3.7081	Dominance in limited duration



**Figure 5.** Spatial Distribution of potential wave power density in different monsoon (North, South, East, West) in Riau Island

speed, and duration of wind blowing. Fetch length conditions can affect the wave transform. If the fetch is long, it will generate a higher wave. Based on the results of the analysis (Table 2), the length of the fetch in several directions reaches 200 km (northeast, south and southwest).

**3.5. Spatial distribution of Significance Wave Height**

During 2018, the direction of the dominant wave originated from the north monsoon and south monsoon with the dominance of wave height range at 0.15 - 0.76 m (north monsoon) and 0.612 - 0.814 m (south monsoon) (Figure 5). The maximum wave height in Riau sea waters in 2018 was about 1.030 - 1.150 m (north monsoon) located in Natuna Islands (Figure 5). The minimum wave height is in the

east monsoon (April-June), with a wave height of 0.076 - 0.298 m.

Overall, the characteristics of sea waves in several areas in the Riau Islands sea have the potential for ocean wave energy but have not been able to cover the entire region. In addition, the alternatives to resolve the electricity problem in Riau Island beside the implementation of ocean wave energy, the wind energy can be implemented as an alternative source of electricity for small islands (Stuart, 2006) in the Riau Islands, the consideration is that the Riau Islands are strongly influenced by the seasonal wind system conditions.

**1.6. Mean Power Density**

The distribution spatial of wave power based on the different monsoons in Riau



Islands Sea showed that the potential wave energy was higher in the north and south monsoon with the maximum spatial of the wave power density 3.240 - 3.640 kW.m<sup>-1</sup> and 1.850 - 2.070 kW.m<sup>-1</sup>, respectively. The east monsoon tended to be lower of potential wave energy with dominance of wave power density at 0 - 0.127 kW.m<sup>-1</sup>. From the spatial analysis in Figure 7, the richest potential wave energy occurs in the northern and southern parts of the Riau Islands Sea located in Anambas and Natuna Islands in the north and south monsoons respectively.

As observed in Figure 5, the richest wave energy is located at dark brown and light brown areas, where the potential of power density is greater than 1 kW.m<sup>-1</sup>. The lower potential of wave energy in the Riau Islands Sea is located at coastal area especially in western of Riau Island Sea (Bintan, Batam, Karimun) with the potential wave power density between 0 - 0.404 kW.m<sup>-1</sup> (north monsoon).

The results of the study found the characteristics of wave energy per season in the Riau Islands sea and suggested potential location mapping for implementing alternative ocean wave energy. The Anambas Islands and a group of islands in Tambelan and Natuna have the potential of ocean wave energy. the results of the study showed that the Tambelan island had the highest potential for alternative ocean wave energy. The implementation of ocean wave energy in the future in this location will considerably help the local community (Manasseh et al., 2017), almost the group of islands inhabited by the community in this region has not been entirely electrified. The utilization of wind energy during the last decade has increased significantly (Krohn et al., 2009). The average electricity capacity produced by new turbines has increased from 200 kilowatts in 1990 to 2.5 megawatts in 2010. The potential for wind energy continues to increase even up to six times. From this explanation, another solution to the lack of limited area coverage which can utilize the alternative energy potential is the conversion of wind energy. When compared with the potential of the wave energy, the wind energy is more used as the alternative energy which is long-term and sustainable for implemented in the Riau Islands.

The seasonal wind systems occur continuously throughout the year and cover the entire area of the Riau Islands which makes the conversion of the wind energy as a right solution to overcome the limitations of the area

and the suitable application as a complete alternative electric energy in the Riau Islands.

### Conclusion

The distribution spatial of the wave power based on different monsoon in Riau Island Sea shows that the potential wave energy is higher in the north and south monsoon with maximum spatial of wave power density 3.240 - 3.640 kW.m<sup>-1</sup> and 1.850 - 2.070 kW.m<sup>-1</sup>, respectively. The east monsoon tends to be lower as the potential wave energy with dominance of wave power density at 0 - 0.127 kW.m<sup>-1</sup>. Overall the characteristics of sea waves in several areas in the Riau Islands sea have the potential for the ocean wave energy but have not been able to cover the entire region.

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