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ASSESSMENT OF OCEAN RENEWABLE ENERGY RESOURCES IN TERENGGANU, MALAYSIA

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ABSTRACT

The main purpose of this paper is to exploit and discover the potential of ocean renewable energy at Terengganu coast, Malaysia. Ocean renewable energy is a new alternative to solve the massive energy consumption for now and for the future. This research is very crucial that ocean renewable energy can replace the non-renewable energy which is over excessively used and is going depleted soon. A series of data of Terengganu coast such as current data and wave height were collected and analyzed. It was then compared with the data of the following year and with the future by forecasting the data with certain organization which is Intergovernmental Panel on Climate Change (IPCC). The mean sea level that is increasing annually also has a great impact that boost the current and significant wave height. Comparison was done between five normally used ocean renewable energies to select the best that suit the current condition in Terengganu coast. It is found out that tidal turbine stands out as the option to be used because it is cost effective and the overall statistics out-performed the other technologies.

Key words: Ocean renewable energy, Terengganu coast, Malaysia

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1. INTRODUCTION

In Malaysia, the rapidly growing population and urbanization are increasing the demand of electricity usage. In year 2014, Malaysia has generated 147,480 Gigawatt hours (GWh) of electricity. 43.9% of the total generation mix is from natural gas whereas coal and oil had 43.2% and 2.8% respectively. The other percentage was shared by hydropower and other renewable energy sources. It can be said that 89.9% of electricity generated is came from the fossil fuel [3]. However, electricity generated mainly from fossil fuel is clearly not sufficient to sustain in the near future and might cause crucial environmental issue [1]. It is proven that the stock for crude oil and natural gas are predicted to last for only 41.8 years and 60.3 years respectively if the production rate continues [2]. Nevertheless Malaysia government is still working on the renewable energy such as solar photovoltaic, biogas, biomass, mini hydro and solid waste to lessen the massive needs in fossil fuel [3].

The over consumption of non-renewable energy to generate electricity in Malaysia has been a chronic issue to be concerned nowadays. In 2011, the utilization of renewable energy in Malaysia has supplied 1% of annual electricity generation and has expected to rise up to 13% of total power generation in 2030 [3]. But non-renewable energy is not permanent and can be diminished in a very soon future. We conducted this study to discover and understand the true potential of ocean renewable energy especially in Terengganu coast, Malaysia.

In 2006, Yaakob has inspected and revised Malaysia's oceanographic data and also did the study of thermal energy, tidal energy, wave energy, marine current and salinity gradient. He concluded that Malaysia has less potential and suitability compared to other Southeast Asian countries because average wave height is as low as 1m as shown in Figure 1 [4].

But it does not hinder us to exploit the ocean renewable energy as the data shown above is almost 10 years ago. Hence, we obtain the data collected from year 2013 and analyze to understand and determine the current and future wave characteristics of Terengganu coast.

In this study, there are five ocean renewable energies such as tidal barrage, wave energy, tidal current energy, Ocean Thermal Energy Conversion (OTEC) and salinity gradient. Comparisons between these approaches need to be evaluated and one of the approaches is chosen based on the several criteria such as predictability, manufacturability, installability, operability, survivability, reliability and affordability.

The objectives of this are, to do the assessment and to understand the suitability and potential of the ocean renewable energy resources concept worldwide and then focus to the coast of Terengganu, to predict or forecast the characteristics of the wave in the future and fimally to select appropriate ocean renewable energy for Terengganu coast.

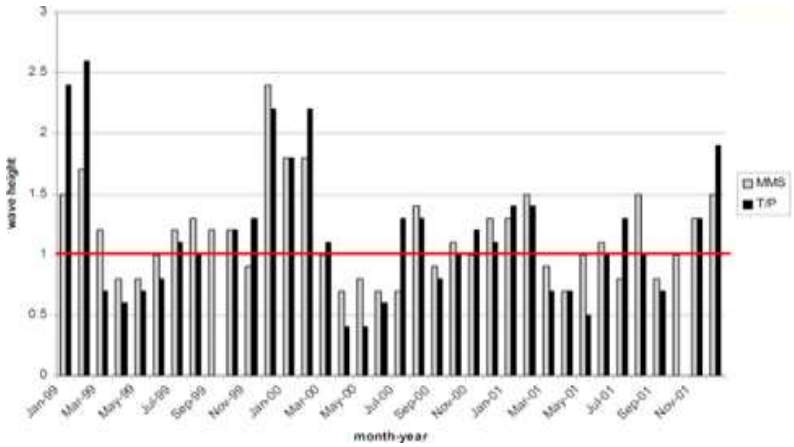

Figure 1 Ocean wave data in Malaysia

2. RESEARCH METHOD

The project started with the collection of data from Institute of Oceangraphy (INOS), Universiti Malaysia Terengganu. The data collected are current data, wave data and temperature data ranging from April to October 2013 as shown in table 1, 2 and 3.

Table 1 Sample current data

TIME & DATE	CELL 1		CELL 2		CELL 3	
	SPEED	DIR	SPEED	DIR	SPEED	DIR
21/04/2013 16:00	0.23	231.42	0.01	180	0.05	188.43
21/04/2013 16:05	0.23	231.42	0.01	180	0.05	188.43
21/04/2013 16:10	0.19	254.35	0.21	220.66	0.09	206.57
21/04/2013 16:15	0.13	42.15	0.04	45.91	0.05	188.47
21/04/2013 16:20	0.07	111.21	0.06	153.43	0.01	90

The current data is recorded every five minutes each interval throughout the data recording and the parameters recorded are speed and direction. The data was recorded until 07/10/2013 22:00 as the last data. The wave data is recorded every 20minutes each interval instead and the parameters included are Hs, H10, Hmax, Tp, Tmean, DirTp, SprTp and MainDir. . The data was recorded until 07/10/2013 22:01 as the last data.

Table 2 Sample wave data

N0	DATE & TIME	Hs	H10	Hmax	Tp	Tmean	DirTp	SprTp	Main Dir
1	21/04/2013 16:01	0.3	0.33	0.38	2.57	2.28	97.55	80.49	87.31
2	21/04/2013 16:21	0.3	0.33	0.5	2.23	2.16	351.76	80.64	211.36
3	21/04/2013 16:41	0.29	0.3	0.41	2.46	2.19	144.93	80.39	34.33
4	21/04/2013 17:01	0.29	0.31	0.45	2.62	2.2	283.69	80.6	89.03
5	21/04/2013 17:21	0.28	0.3	0.39	2.38	2.13	112.33	80.84	48.34

Where Hs- Significant wave height (m), Hmax – max probable wave height (m) [5], H10 = irregular wave height at which 10% of the waves are higher [6], Tp - peak period (s), Tmean- mean wave period (s) [7], DirTp - direction at Tp (deg), SprTp - spreading at Tp (deg), MainDir - main wave direction (deg) [7]

The temperature data is recorded every five minutes each interval similar to current data and the parameters recorded are depth and temperature. . The data was recorded until 07/10/2013 22:00 as the last data same as the current data.

Table 3 Sample temperature data

DATE TIME	DEPTH	TEMPERATURE (°C)
21/04/2013 16:00	20.3	30.31
21/04/2013 16:05	20.3	30.31
21/04/2013 16:10	20.29	30.32
21/04/2013 16:15	20.29	30.32
21/04/2013 16:20	20.31	30.31

The data collected is further analyzed by developing the graphs to see its pattern or trend using Microsoft Excel. Parameters like wave speed and wave height are used to determine which techniques and devices to be used in Terengganu coast.

For the selection of technique used it will be most probably tidal current energy as stated in expected outcome. Although the concept of extracting energy using current is similar to wind, but the tidal turbine is operating at a different environment which is in water compare to wind that has a density of 832 times higher than the air.

There are two major types of tidal turbine that can be chosen which are axial turbine also known as horizontal axis turbine and cross flow turbine as vertical axis turbine. Axial turbine utilizes at direction of flow parallel to axis of rotation whereas the cross flow turbine applies the direction of flow across the axis of rotation.

3. RESULTS AND ANALYSIS

The raw data above was recorded in every 20 minutes interval. The date started is from 21/04/2013 16:01 until 07/10/2013 22:01 which is 169 days long. The average significant wave height of each day is then tabulated into monthly form as shown in Table 4 to obtain the average significant wave height of each month.

Table 4 Monthly average significant wave height for April

Date	Average daily significant wave height,Hs (m)
21 April	0.29625
22 April	0.218667
23 April	0.242361
24 April	0.309167
25 April	0.4325
26 April	0.409722
27 April	0.344444
28 April	0.265634
29 April	0.274306
30 April	0.309722
Monthly average (m)	0.310277

It is observed that the difference in average significant wave height is relatively small as the average significant wave height from April to October is 0.385m which fits the trend of the above bar chart. Month of August has the highest significant wave height of 0.44m whereas April has the lowest of 0.31m. Overall the trend of this data is pretty steady and stable, as shown in Figure 2.

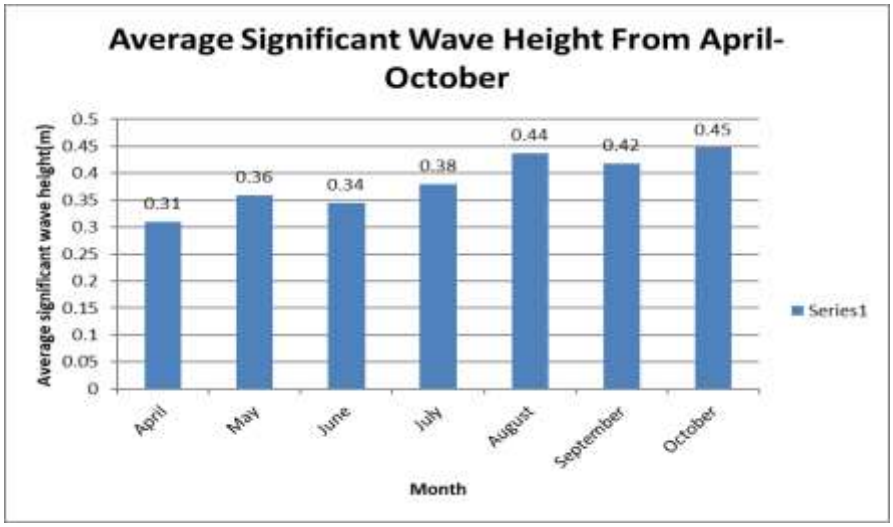

Figure 2 Average significant wave height from April to October

It was found out that June had outperformed other months in term of average current speed. The month June had reached its outmost peak compared to other months starting from buoy no 4 all the way up to buoy no 15 that ranges from average current speed of 0.17m/s to 0.25m/s, , as shown in Figure 3.

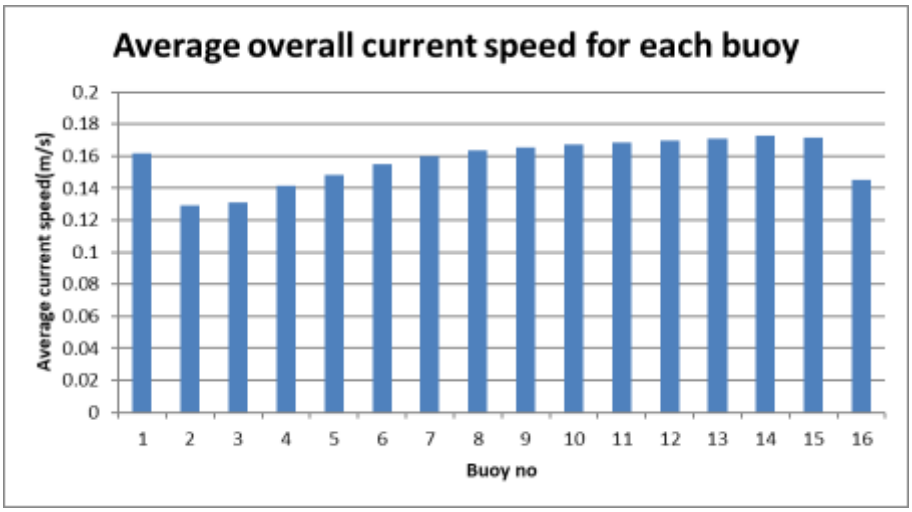

Figure 3 Average Overall Current Speed For each buoy

As seen from the chart, buoy number 14 performed the highest average current speed while buoy number 2 performed the lowest average current speed in their respective location. The highest average current speed was recorded as 0.173m/s for the span from April to October. Nevertheless, the average significant wave height of Terengganu coast is still relatively lower compared to Malacca strait which already has a fixed minimum flow of 0.5m/s and can up to 4m/s as peak flow [3].

Peninsular Malaysia is divided into West and East coast. Since west coast of Peninsular Malaysia possessed low potential of wave energy due to Sumatera protection, while Terengganu coast which located in East coast will be considered has a greater potential to exploit the usage of ocean renewable energy. Based on the result above, average current speed and average significant wave height had been chosen to assess the potential ocean renewable energy in Terengganu.

For the result for average significant wave height, the average significant wave height from April to October is 0.385m. There was a study in Kuala Terengganu that showed that it has two monsoons which are northeast and southwest monsoons. Northeast monsoon starts between November and March whereas southwest monsoon is between May and September. Both possessed different ranges of wave significant wave height. Northeast monsoon has higher significant wave height of 1-2m compared to southeast monsoon which is less than 0.8m [8]. This is due to northeast winds blowing over the South China Sea which Terengganu coast is facing with.

Since our data is from April to October 2013, it is in the range of southwest monsoon which is between May and September. It indicates that the significant wave height data will be at lower value compared to the season in northeast monsoon. It is believed that the data collected during the northeast monsoon will achieve a higher value of significant wave height based on the seasonal influence. This will possess a higher possibility in utilizing the usefulness of ocean renewable energy resources.

We can compare our significant wave height data of 2013 to a journal that show the significant wave height of Kuala Terengganu in 2014. It was shown that during the northeast monsoon in 2014, the highest significant wave height recorded was 1.48m in January 2014 whereas the average significant wave height of the southwest monsoon was approximately around 0.66m [9]. Since our data is in southwest monsoon season, our average significant wave height was only 0.385m in 2013 compared with 0.66m in 2014 which is almost double our value. It is obvious that even both the data were only one year after another, the changes in the average significant wave height is huge enough to conclude that the climate change play a huge factor in affecting such result. Besides, the maximum significant wave height observed in northeast monsoon was as high as 1.48m which is way higher than the average significant wave height during southwest monsoon. If this trend continues, the hidden potential of ocean renewable energy in Kuala Terengganu can be exploited in near future.

The mean sea level had drastically surged for the past 100 years. The Intergovernmental Panel on Climate Change (IPCC) was estimating an average of 1.7mm/year of increment from 1901-2010. Unfortunately, IPCC clarified that the actual average increment of 3.2mm/year from 1993-2010 and even shockingly 0.63m at the end of 21st century (2081-2100) [10]. According Malaysian Meteorological Department Scientific Report on climate change scenarios for Malaysia 2010-2099, it also showed some similar results that average of 1.8mm/year increment of sea level from 1961-2003 but 3.1mm/year in sea level rising from 1993-2003 [11]. The fact is that sea level rise can actually increase the significant wave height in a study of effect of sea level rise in Pearl River Estuary and their result also showed that the greater the sea level rise, the greater the increase in significant wave height [12]. A case study for East Anglia (UK) also stated that sea level will affect the change in annual maximum significant wave height which also indicates as the sea level increases, the significant wave heights increases as well [13]. Since our world mean sea level is increasing year by year, the significant wave height in Terengganu coast will be definitely become higher hence increasing its potential in harnessing the ocean renewable energy.

Moreover, an increase of mean sea level will also affect the tidal current. A 20% growth in tidal current if an estimated increased of 0.30m in sea level rises in year 2050 [14]. Since higher sea level rise causes higher tidal current, both tidal energy dissipation and tidal energy output will increase relatively with higher tidal current. It indicates that sea level rise will induce faster tidal current in running the turbine [14]. Although our best performed buoy only had 0.173m/s of average current speed from April to October, but with unstoppable increasing trend in mean sea level, this value will be rising in very soon future.

4. CONCLUSION

The data analyzed in 2013 such as average significant wave height and average current speed were relatively lower than average of other Southeast Asia country. But if we compared the result of significant wave height in 2014, it showed an unbelievably increment that were almost double the average of the data in 2013.

Speaking of mean sea level, it will affect directly to both average significant wave height and average current speed. The higher the mean sea level, the higher the significant wave height and current speed. The mean sea level is increasing uncontrollably as the average increment is not fixed every year. This indicates both the significant wave height and current speed will only increase as the time goes on.

Since Malaysia is still at an infant stage in adapting the ocean renewable energy, it is advised that we should use tidal turbine in harnessing the ocean renewable energy in Terengganu coast. One of the reasons is that it is cost effective compare to other technologies which is a good reason because not too much money need to be invested as testing purpose in exploiting the ocean renewable energy.

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