REVIEW ARTICLE

Wind energy potential at East Coast of Peninsular Malaysia

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ABSTRACT

The research site is located at 4°13.6′ N and 103°26.1′ E in east coast of Peninsular Malaysia. Wind data has been analyzed to determine monthly wind speed and energy potential. The monthly average wind speeds ranges from 2.00 m/s to 5.20 m/s. The yearly and northeast monsoon season mean wind speed was obtained as 2.9 m/s and 3.9 m/s, respectively. The wind power of investigated site is lowest in southwest monsoon season, while it is highest in northeast monsoon season as 84.60 W/m^2 with highest wind probability value of 0.70. In conclusion, it can be said that small wind turbines could be used to provide power at this area and particularly during the northeast monsoon season one can expect more wind energy.

Keywords: Energy Potential, Monsoon Season, Probability Value, Wind Power

1. Introduction

Renewable energy is still regarded as more expensive to use than fossil fuels. Renewable resources are often located in remote areas and it is expensive to build power lines to the cities where they are needed. The largest component of renewable generation capacity is wind power, which grew by 29% worldwide in 2008 (Purohit and Purohit, 2009). The use of renewable sources is also limited by the fact that they are not always available (Souvik and Jasvir, 2010; Muzathik et al, 2011). The production and use of renewable fuels has grown more quickly in recent years due to higher prices of oil and natural gas. The use of renewable fuels is expected to continue to grow over the next 30 years, although we will still rely on non-renewable fuels to meet most of our energy needs (Wind Power Monthly, 2009). The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet up the present day demands (Manwell et al, 2002).

Wind energy is considered one of the economic alternatives that meet the needs of modern societies by protecting the atmosphere from the adverse consequences of global warming. The Malaysia economy has witnessed active growth in the last decades, and consequently, the demand for energy has also increased (Energy Commission, 2007). The wind resources vary with the time of day, season, height above ground and type of terrain. Proper sitting in windy locations away from large obstructions enhances a wind turbine's performance.

The State of Terengganu, Malaysia is situated in the South China Sea. The demand for energy and particularly for electricity is growing rapidly, because of social and economic development of the country. Importantly, the energy use for transport and industry has almost four times increased in last 20-year period, and continues to grow, representing around 80% of the overall primary energy use in 2001. Similar patterns can be seen in other industrialized and developing nations, showing energy use for transport and industry to be a significant and increasing problem. Despite this, there has been a 10% increase in the overall annual energy

use in Malaysia since 1980. The use of fossil fuels (coal, oil and gas) accounted for 95% of the total Malaysia energy supply in 2007, which is an increase of 6.3% from the year 1995 (Ninth Malaysia Plan, 2005; Ministry of Energy, 2008).

The scope of this article is to describe the wind energy potential at the selected Kuala Terengganu site for the period 2004-2007. There are a couple of previous studies which provide substantial results regarding the wind energy potential of the country. The studies identified the wind regimes in some areas of the country and also provided estimates of wind energy potential (Lee, 1993; Sopian et al, 1995).

2. Meteorological Environment and Measurement

In this study, the wind speed data was measured at ten minutes interval by University Malaysia Terengganu Renewable Energy Research Center (UMT RERC) using 'NRG Symphonic Data Retriever' Data Acquisition System (DAS) in the selected site between the years 2004 and 2007. The collected data integrated over each hour and stored on computer using the DAS. The sensors are regularly calibrated against reference sensors maintained at the station. The UMT RERC station is located at 4°13.6′ N and 103°26.1′ E. All measurements in the wind observation station are recorded using the cup anemometer at a height of 18 m above the ground level (23 m above sea level). Figure 1 shows the location of this chosen site. Two distinct seasons are noticed in this region: north east monsoon season (November to March) and south west monsoon season (May to September) and other period (April and October).

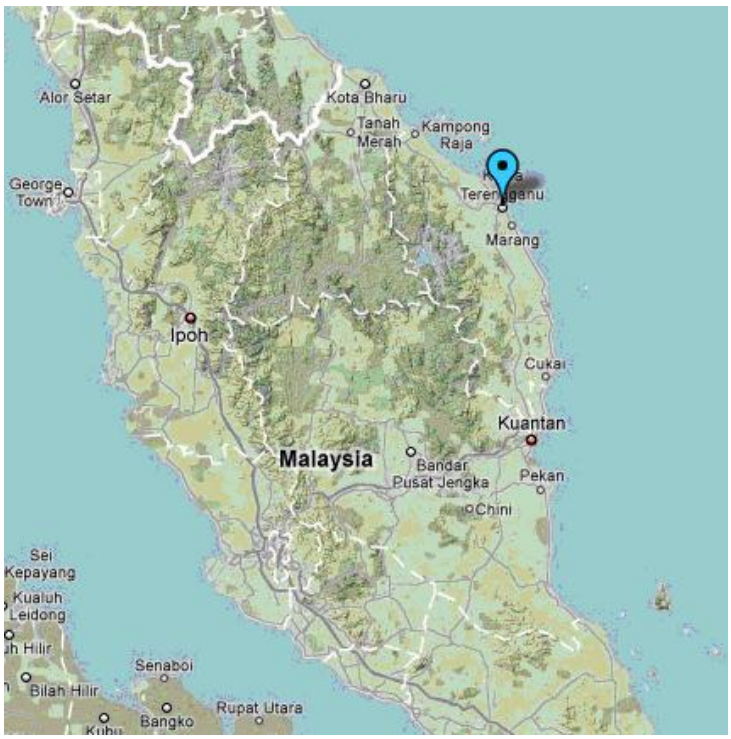

Figure 1: Location of the wind observation station

3. Wind Energy Estimation

Knowledge of the wind speed frequency distribution is a very important factor to evaluate the wind potential in the windy areas. If ever the wind speed distribution in any windy site is known, the power potential and the economic feasibility belonging to the site can be easily obtained. Wind data obtained with various observation methods has the wide ranges. Therefore, in the wind energy analysis, it is necessary to have only a few key parameters that can explain the behavior of a wide range of wind speed data. The simplest and most practical method for the procedure is to use a distribution function. The power of wind (P) can be estimated by using the following equation;

$$P = ½\ \rho\ A\ V^3 \qquad (1)$$

where ρ is mean air density, V is mean value of the wind speed and A is sweep area. The hourly wind speed values are transferred on a monthly basis for further processing.

Average wind power density of a site can be expressed based on Weibull probability density function (Hennessey, 1987; Sopian et al, 1995) as

$$P_D = \rho\ (c^{3/2})\ *\ (3/k)\ *\ \Gamma(3/k) \qquad (2)$$

where ρ is mean air density, c is a Weibull scale parameter, k is a dimensionless Weibull shape parameter and Γ is a gamma function.

4. Results and Discussion

The wind speed information is essential in order to get a clear picture about the potential wave energy induced by wind power. It is necessary to calculate the amount of wind power and time of availability. In addition, the fluctuation of the wind power is needed for designing the energy storage and load scheduling. Figure 2 shows the monthly average hourly wind speed and variations for four years of the research site. The highest monthly mean wind speed is determined as 5.20 m/s in January 2007 while the lowest mean wind speed 2.00 m/s was occurred in June 2005. Annual mean wind speed for a 4 year period is obtained as 2.90 m/s.

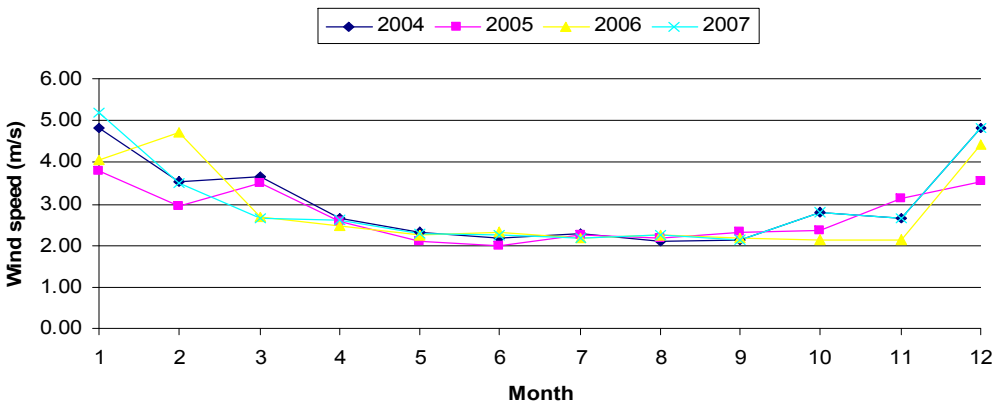

Figure 2: Monthly average wind speeds between 2004 and 2007.

In north east monsoon (November to March), the wind speeds are generally higher in late morning till midnight and lower in the early mornings. On the other hand, in south west monsoon (May to September), the trend is a bit different, wind speeds are higher in late morning till late evening and lower in night till early morning. Wind speeds undergo noticeable variations between north east monsoon and south west seasons. Figure 3 show the hourly average wind speeds on a day of June and December 2004 in the research site in Malaysia.

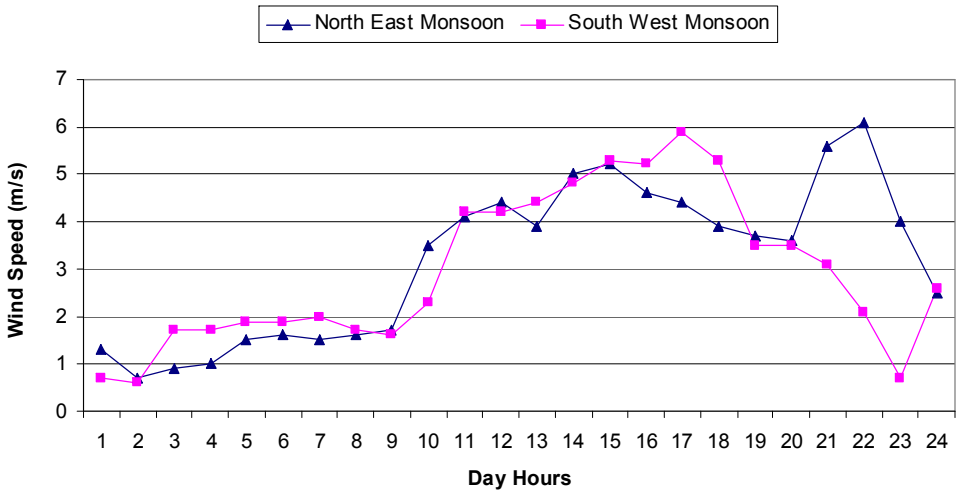

Figure 3: Hourly average wind speeds in June and December 2004.

The monthly average wind speeds and daily wind power for the period 2004-2007 are presented in Table 1 to show the monthly changes over the year and from one year to another.

Table 1: Monthly average wind speeds and monthly average daily wind power for the period 2004 -2007

Year	2004	2005	2006	2007
Month	Wind Speed (m/s)	Wind Speed (m/s)	Wind Speed (m/s)	Wind Speed (m/s)
January	4.82	3.78	4.05	5.20
February	3.55	2.94	4.72	3.49
March	3.63	3.51	2.69	2.65
April	2.66	2.58	2.45	2.62
May	2.31	2.10	2.25	2.27
June	2.19	2.01	2.33	2.25
July	2.29	2.25	2.16	2.17
August	2.10	2.16	2.24	2.24
September	2.15	2.31	2.17	2.15
October	2.80	2.36	2.13	2.80
November	2.64	3.13	2.12	2.64
December	4.81	3.52	4.43	4.81

The monthly average wind speeds (2004 - 2007) are shown in Figure 4. Wind speeds during December to March are highest as compared to other months of the year. This clearly indicates that a wind energy conversion system would produce more energy during the north east monsoon.

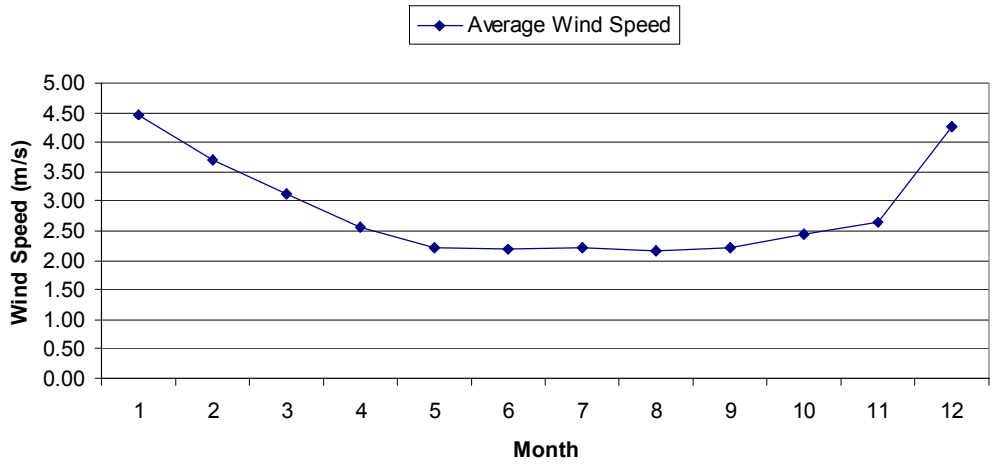

Figure 4: Monthly average wind speeds based on the average of four years data.

The frequency distribution of hourly average wind speed for a year is presented in Figure 5. The frequency is peaked in the range 1-5 m/s. This indicates that most of the wind energy at the site lies in this range. This information can be used to determine the amount of power which can be generated in a given speed band.

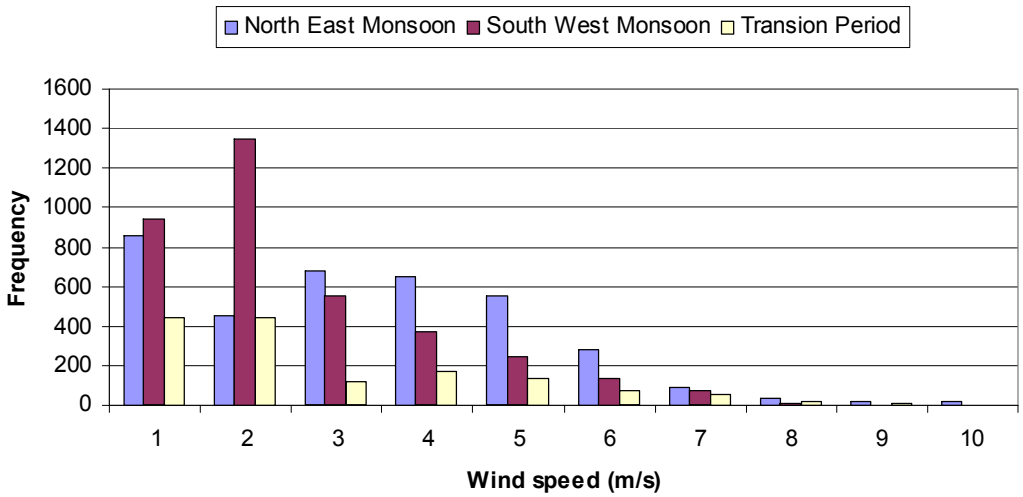

Figure 5: Frequency distribution of hourly average wind speed for year 2004

The seasonal wind characteristics in the selected site are given in Table 2, which values are calculated based on Weibull distribution. As seen from this table, the highest mean wind speed value with 3.90 m/s is determined in the north east monsoon season while the lowest value is in the south west monsoon season with 2.20 m/s. The wind power of investigated site is lowest in south west monsoon season, while it is highest in north east monsoon season as

84.60 W/m^2. The highest time factor value with 0.70 is determined in the north east monsoon season while the lowest value is in the south west monsoon season with 0.40 based on wind power production wind speed of 2.5 m/s.

Table 2: Seasonal wind characteristics in the research site

Season	V_m (m/s)	P_D (W/m^2)	Probability Value
North east monsoon	3.90	84.60	0.70
South west monsoon	2.20	15.20	0.40

5. Conclusion

The potential of renewable energy options of wind energy cannot be overlooked from the result of the present research. They can contribute considerably to the increase in supply for energy. It is interesting to note that the north east monsoon season mean wind speed was 3.9 m/s. The wind power of investigated site is lowest in south west monsoon season, while it is highest in north east monsoon season as 84.60 W/m^2. The highest wind probability value with 0.70 is determined in the north east monsoon season while the lowest value is in the south west monsoon season with 0.40. In conclusion, it can be said that small wind turbines could be used to provide power at this area research and particularly during December to March.

Acknowledgements

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