Wind Energy at Kuala Terengganu, Malaysia

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Abstract

Hourly wind-speed data recorded at University Malaysia Terengganu Renewable Energy Research Center (UMT RERC) using NRG Symphonie data retriever in the Kuala Terengganu between the years 2004 and 2007. 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 23 m at mean sea level (18 m above the ground level), has been analyzed to determine monthly wind speed and energy. The monthly average wind speeds for Kuala Terengganu range from 2.00 m/s to 5.20 m/s. The yearly mean wind speed for Kuala Terengganu was obtained as 2.9 m/s and north east monsoon season (November to March) mean wind speed was 3.9 m/s for the same period. 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 during the north east monsoon season.

Keywords: Wind speed, Wind power, Probability value and Monsoon season

Introduction

In the past, renewable energy has generally been more expensive to use than fossil fuels and renewable resources are often located remote areas and it is expensive to build power lines to the cities where they are needed. The use of renewable sources is also limited by the fact that they are not always available. The production and use of renewable fuels has grown more quickly in recent years due to higher prices for 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 [1].

Wind energy is one of the most attractive, clean, promising potential source of renewable energy options that is being vigorously pursued by a number of developed and developing countries (with average wind speeds of 5-10 m/s) in an effort to reduce their dependence on fossil-based non-renewable fuels [2]. Wind energy gained importance after the rapid increase in world energy production through combustion of fossil fuels that have caused heat trapping “greenhouse gases” accumulation in the troposphere. In this regard, there is now a growing concern that our human activities are going to affect the climate of earth in the future.

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. Malaysia, as a country, faces a high rate of population growth. The Malaysia economy has witnessed active growth in the last decades, and consequently, the demand for energy has also increased [3]. 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.

Since Kuala Terengganu is blessed with seasonal supply of wind and solar energy, a considerable portion of its energy needs may be supplied from these renewable sources of energy. The introduction of renewable energy options can produce significant environmental and economic and social benefits. The use of wind energy reduces the combustion of fossil fuels and the consequent CO, emission which is the principal cause of the greenhouse effect, global warming [4-7].

The State of Terengganu, Malaysia is situated at 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% on the year 1995 [8-10].

The scope of this article is to finding out 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. [11-12].

Meteorological Environment and Measurement

In this study, the wind speed data were 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 Kuala Terengganu 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).

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;

$$P = \tfrac{1}{2} \rho A V^3 \qquad (1)$$

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 [13-14] as

$$P_D = \rho (c3/2) * (3/k) * \Gamma(3/k) \quad (2)$$

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.

The probability of wind to exceed a velocity of V_x is given below by equation (3).

$$\text{Probability Value } (V > V_x) = e^{-(V_x / c)^k} \quad (3)$$

Results and Discussion

The wind speed varies not only during different seasons but at different times of the day. The knowledge of these variations is important to get an idea about the amount and time of availability of wind power. These variations are required for the design of energy storage and load scheduling with other generating systems. Figures 1 show the typical monthly average hourly wind speed for four years of Kuala Terengganu. The monthly mean wind speed variation during the period 2004–2007 at Kuala Terengganu region is given in Figure 2. 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 is occurred in June 2005. Annual mean wind speed for a 4 year period is obtained as 2.90 m/s.

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 Kuala Terengganu, Malaysia.

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

Figure 4 shows the monthly average wind speeds based on the average of 4 years (2004 - 2007) data. It is observed that the wind speeds during the north east monsoon months (December to March) are highest as compared to other months of the year. This clearly reflects that a wind energy conversion system would produce appreciably more energy during north east monsoon months as compared to the other months.

The frequency distribution/histogram of hourly average wind speed for a complete year (year 2004) is presented in Fig. 5. The frequency is highly peaked in the range 1-5 m/s. This indicates that most of the wind energy at Kuala Terengganu lies in this range. This distribution of wind speed is important in determining the percentage of time during a year, the power that could be generated from a wind machine. Moreover, this information can be used to determine the amount of power which can be generated in a given speed band. Hence it indicates the wind power potential of Kuala Terengganu for wind power applications.

The seasonal wind characteristics in Kuala Terengganu 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.

Conclusion

It is quite evident from the present study that the potential of renewable energy options of wind energy cannot be overlooked. They can contribute considerably to the increase in demand for energy. It is interesting to note that the north east monsoon season (November to March) 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. Investigations of the present study can be utilized as a tool to assess the potential of alternative energy options at Kuala Terengganu. The wind energy is fairly high during north east monsoon. Wind generation of electricity may be insufficient in south west monsoon, but if photovoltaic panels are used for hybrid generation of electric power, we may get an excellent economic advantage. The high insulation level and the sufficient wind regime at Kuala Terengganu can be exploited for hybrid power production. In conclusion, it can be said that small wind turbines could be used to provide power during the north east monsoon.

References

[1] Wind Power Monthly, 174 Hammersmith Road, London, W6 7JP, England, ISSN 109-7318, February 2009.

[2] Manwell JF, McGowan JG and Rogers AL, Wind Energy Explained: Theory, Design and Application, Chapter 1 and 2, Chichester, New York, Wiley, 2002.

[3] Department of Electricity Supply Regulation, Energy Commission, Malaysia, Performance and Statistical Information 2007. http://www.st.gov.my/images/stories/upload/st/st_files/public/Report_Performance.pdf

[4] Epstein, Paul R and Christine Rodgers. *Inside the Greenhouse: The Impacts of CO2 and Climate Change on Public Health in the Inner City.* Report from the Center for Health and the Global Environment Harvard Medical School. April 2004.

[5] R. S. Eckaus, Comparing the effects of greenhouse gas emissions on global warming. The Energy Journal, 13(1), 25-35 (1992).

[6] United Nations Framework Convention on Climate Change. Annex 1: Greenhouse Gas Inventory Database.2008.

[7] U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002. April, 2004.

[8] Economic Planning Unit, Ministry of Energy, Water and Communications, Malaysia, 2008.

[9] Ninth Malaysia Plan 2006-2010, Sustainable Energy Development, Chapter 19, pp 393-411.

[10] Faridah bte Mohd Taha, Development of Energy Labelling in Malaysia; Past, Present and Future, APEC Seminar on Cooperation on Energy Labeling, November 2003, Paper 3.

[11] Lee F.T., Wind Power Potential in West Malaysia, Energy Sources 15, 23-36, 1993.

[12] Sopian K, Hj. Othman M.Y, Wirsat A, The wind energy potential of Malaysia, Renewable Energy Vol. 6, No. 8, 1005-1016, 1995.

[13] Hennessey JP, Some aspects of wind power statistics. Applied Meteorology 16 (1977): 119-128.

[14] Justus CG, Hargraves WR, Mikhail A and Graber D, Methods of estimating wind speed frequency distribution. Applied Meteorology 17 (1978): 350-353.

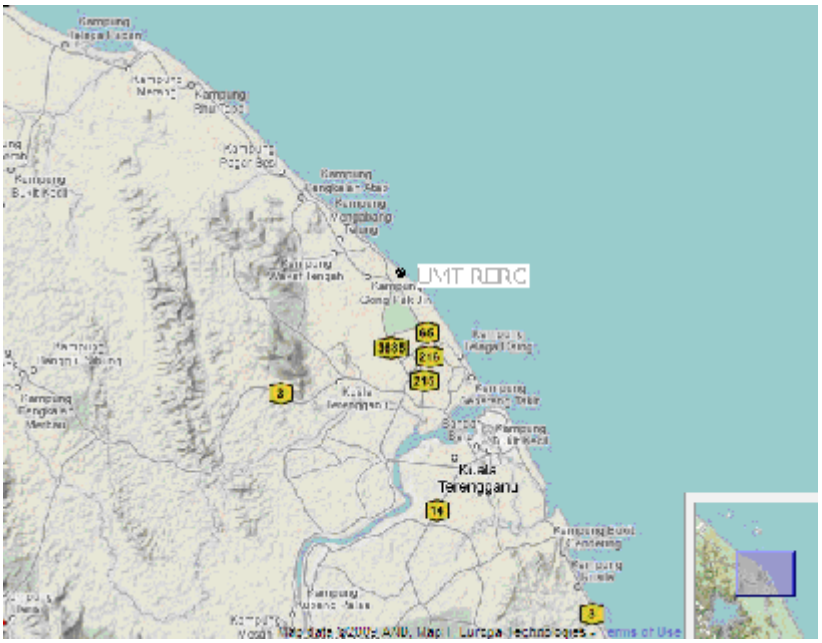

Figure 1. Location of Kuala Terengganu wind observation station

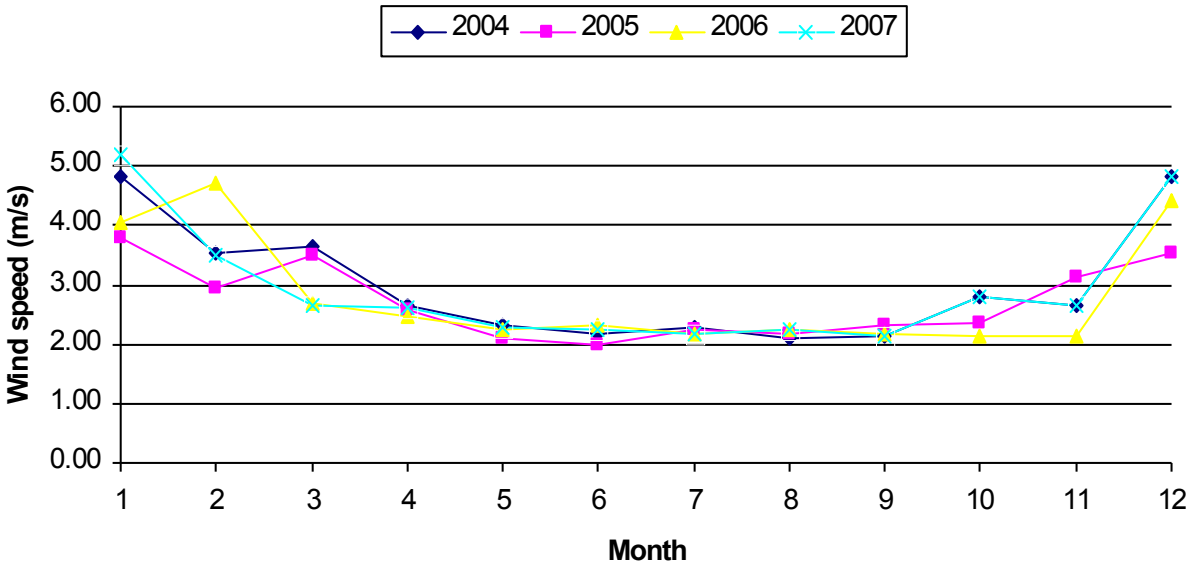

Figure 2. Monthly average wind speeds between the years 2004 and 2007 in Kuala Terengganu

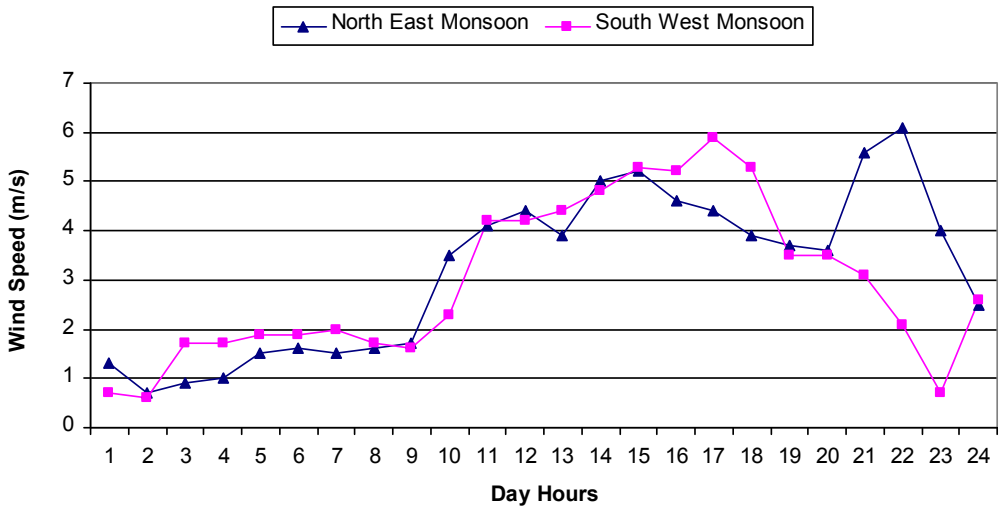

Figure 3. Hourly average wind speeds on June and December 2004 in Kuala Terengganu

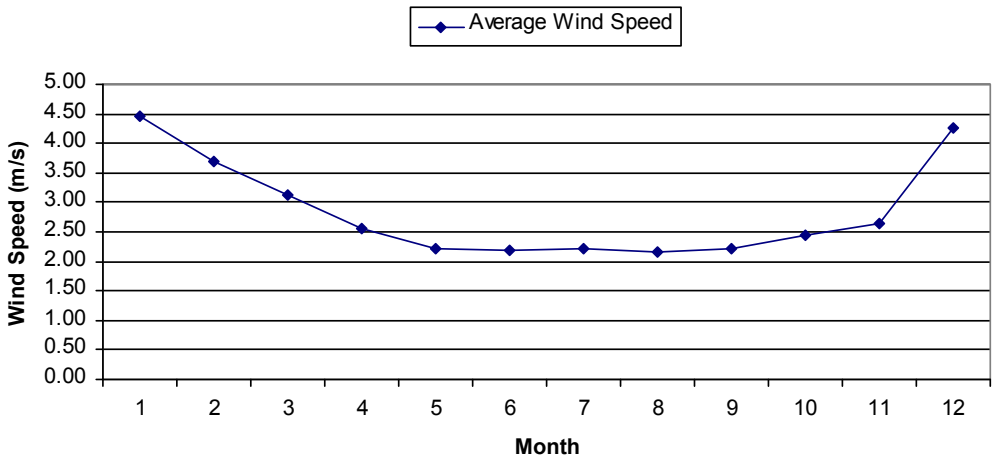

Figure 4. Monthly average wind speeds based on the average of 4 years (2004--2007) data

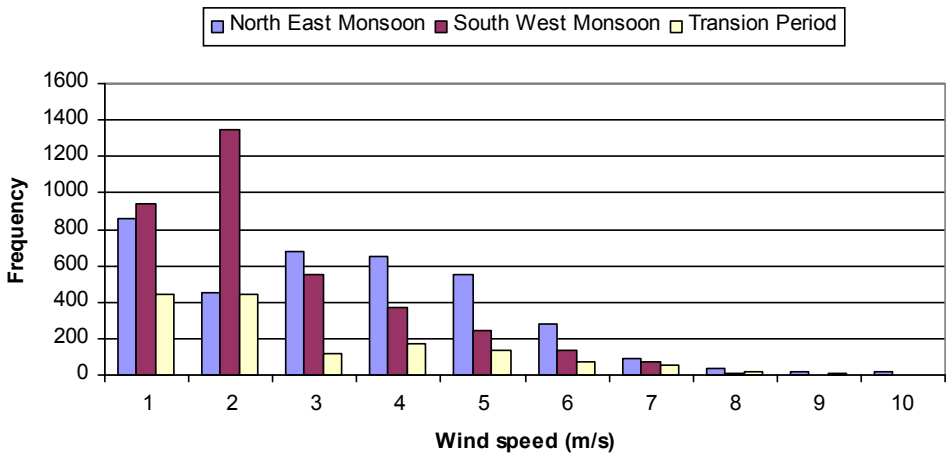

Figure 5. Frequency distribution of hourly average wind speed for year 2004

Table 1. Monthly average wind speeds and monthly average daily wind power for the period 2004/07

Year	2004		2005		2006		2007	
Month	Wind Speed (m/s)	Wind Power (Whr/m^2)	Wind Speed (m/s)	Wind Power (Whr/m^2)	Wind Speed (m/s)	Wind Power (Whr/m^2)	Wind Speed (m/s)	Wind Power (Whr/m^2)
January	4.82	1666.26	3.78	803.67	4.05	988.48	5.2	2092.25
February	3.55	665.71	2.94	378.13	4.72	1564.69	3.49	632.53
March	3.63	711.74	3.51	643.46	2.69	289.64	2.65	276.91
April	2.66	280.06	2.58	255.54	2.45	218.83	2.6	261.53
May	2.31	183.42	2.1	137.80	2.25	169.49	2.27	174.05
June	2.19	156.29	2	119.04	2.33	188.22	2.25	169.49
July	2.29	178.69	2.25	169.49	2.16	149.96	2.17	152.05
August	2.1	137.80	2.16	149.96	2.24	167.24	2.24	167.24
September	2.15	147.88	2.31	183.42	2.17	152.05	2.15	147.88
October	2.8	326.65	2.36	195.59	2.13	143.79	2.8	326.65
November	2.64	273.79	3.13	456.28	2.12	141.78	2.64	273.79
December	4.81	1655.92	3.52	648.98	4.43	1293.64	4.81	1655.92

Table 2. Seasonal wind characteristics in Kuala Terengganu

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