# EVALUATION OF WIND TURBINE POTENTIALITY AT WINDY SITES IN MALAYSIA

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## ABSTRACT

Wind speed data in Malaysia has been used, which was recorded hourly from years 1995 to 2002 at three meteorological stations, Mersing, Cameron Highland (Peninsular Malaysia) and Pulau Labuan (Sabah state). The wind speed distribution and wind power were evaluated to provide spatial mean information of wind energy potential. The behaviour of five models of wind turbine was examined. The three selected sites were found to be a potential wind turbine location based on their site effectiveness, rated overall efficiency of wind turbine, capacity factor and energy output. The three sites in three different areas namely, coastal, highland or mountain and island have been selected to evaluate five different wind turbine with cut-in wind speed between 2 m/s and 3m/s, and rated power between 300KW and 750KW. The results shows that, the 300KW have the higher values of output energy. $E_s$, Capacity factor $C_F$ and rated overall efficiency $\eta_r$. have a better values with small capacity power machine in Mersing. It is also found that there was no big difference between site effectiveness values.

## INTRODUCTION

The wind regime in Malaysia have some periodic directions due to the wind flow to the country from south west monsoon and the north east monsoon and also the effect of sea and land breeze on the coastal regions. Generally the wind speed in Malaysia is light, however the study of wind analysis are important and necessary to estimate and evaluate the potentiality of available power conversion. The finding will assist the decision of installing the wind turbine in Malaysia, due to increasing the energy consumption and the availability of the low wind speed turbine in the world marketing. The analysis of wind data was done for seven stations located in the east coast and central parts of Peninsular Malaysia and in Sabah. The assessment of wind power viability of wind WECS needed for long-term data of wind speed measurements in Malaysia at deferent locations provide important and suitable information's. On duration the year the wind speed in

Malaysia is not very vary from season to season, however, the season from the end of November to the middle of March the available wind power should be higher related with the higher wind speed in this season. Generally the wind speed on most stations is less than 3m/s, except three stations Mersing, Cameron Hiland and Pulau Labuan, where wind speed more than or equal 3m/s, the chose should be only for these tree stations for analysis and estimate the available and output wind power and also the evaluation potentiality of deferent wind turbine in the three deferent sites and the other stations was neglected.

The evaluation of wind turbine potentiality was examined for three locations at three different sites, coastal, height or mountain and island areas, using five different wind turbines with cut-in wind speed between 2m/s and 3m/s, with vary capacity wind power from 300KW to 750KW. The behaviour of these five models of wind turbine was examined and the three selected sites were found to be a potential wind turbine location based on their, site effectiveness, rated overall efficiency of wind turbines, and capacity factor and energy output.

TABLE 1. sites data distribution

| | Latitude ASL. m | Wind speed at hub height m/s | Temperature $C^0$ | Weibull shape parameter K | Weibull scale parameter C |
|---|---|---|---|---|---|
| Mersing | 43 | 3.31 | 27 | 1.93 | 3.73 |
| Pulau Labuan | 29.3 | 3.02 | 28 | 1.88 | 3.38 |
| Camero highland | 1545 | 3.08 | 18 | 1.67 | 3.45 |

TABLE 2. Technical data for five models of wind turbine

| | $P_r$ KW | $V_{ci}$ m/s | $V_{co}$ m/s | $V_r$ m/s | D m | Hh m |
|---|---|---|---|---|---|---|
| Nordex N43 | 600 | 3.0 | 25 | 13.5 | 43.0 | 50 |
| Bonus 300KW | 300 | 3.0 | 25 | 15.0 | 33.4 | 50 |
| Enercon E 30 | 300 | 2.5 | 30 | 12.0 | 30.0 | 50 |
| Lagerway LW50/750 | 750 | 3.0 | 25 | 12.0 | 51.5 | 50 |
| Nordex N40/6.44E2 | 600 | 2.0 | 25 | 15.0 | 43.5 | 50 |

## RESULTS AND ANALYSIS

Tables 3,4 and 5 present the results of the machine of the WECS models with the site wind distribution. The available wind power is very small, however, a correct siting should be assumed, so that, the wind machine matches the local maximum effectiveness. With an average wind speed of 3.31 m/s at hub height in Mersing the 300KW machine will generate between 138247-192086KWh/ year, the 600KW machine generate between 190950-195426 KWh/year and the 750KW machine about 182602 KWh/year. And for other station see Table 4 and 5. Three fundamental types of wind turbine characteristics namely the capacity factor $C_F$, the rated overall efficiency of wind turbine $\eta_r$ and site effectiveness $\varepsilon$ has been carried out. For Mersing, the site effectiveness of thee types wind turbine, 300KW, 600KW and 750KW equal 0.947, 0.797 and 0.777 respectively, and for the other two stations see Table 4 and Table 5. The wind turbine efficiency for the 300KW wind turbine located between 0.100 – 0.420, for 600KW between 0.209 –0.281 and for 750KW about 0.356. The annual energy output from a wind turbine is based on the capacity factor for the turbine in its particular location. Capacity factors may theoretically vary from 0 to 100 per cent, but in practice it will usually range from 20 to 70 per cent, and mostly be around 25-30 per cent. In this study the capacity factor for all machine and all sites is very low, related with the low annual energy out put from turbines. The estimation of the output energy flux from turbine have to combine of the Weibull distribution with the power curve. This is what was done using the power density calculator in [http://www.windpower.org/tour/wres/pow/index.htm.].

TABLE 3. Input and output wind energy and coefficients of all models at Mersing

| | $P/A$ w/m$^2$ | $V_{maxE}$ m/s | $V_{Hh}$ m/s | $P$ w/m$^2$ | $E_S$ Kwh/m$^2$/yr | E Kwh/year | $c_F$ % | $\varepsilon$ | $\eta_r$ |
|---|---|---|---|---|---|---|---|---|---|
| Nordex N43 (600 KW) | 42 | 5.4 | 3.31 | 15 | 131.49 | 190950 | 2.66 | 0.80 | 0.21 |
| Bonus (300 KW) | 42 | 5.4 | 3.31 | 18 | 157.788 | 138247 | 5.26 | 0.80 | 0.10 |
| Enercon E 30 (300 KW) | 42 | 5.4 | 3.31 | 31 | 271.746 | 192086 | 7.30 | 0.95 | 0.42 |
| Lagerway LW 50/(750 KW) | 42 | 5.4 | 3.31 | 10 | 87.66 | 182602 | 2.78 | 0.79 | 0.36 |
| Nordex N40/6.44E2 (600 KW) | 42 | 5.4 | 3.31 | 15 | 131.49 | 195426 | 3.71 | 0.73 | 0.28 |

TABLE 4. Input and output wind energy and coefficients of all models at Pulau Labuan

| | $P/A$ w/m$^2$ | $V_{maxE}$ m/s | $V_{Hh}$ m/s | $P$ w/m$^2$ | $E_S$ Kwh/m$^2$/yr | E Kwh/year | $c_F$ % | $\varepsilon$ | $\eta_r$ |
|---|---|---|---|---|---|---|---|---|---|
| Nordex N43 (600 KW) | 33 | 5.0 | 3.02 | 11 | 96.426 | 140030 | 2.66 | 0.80 | 0.21 |
| Bonus (300 KW) | 33 | 5.0 | 3.02 | 14 | 122.724 | 107520 | 4.09 | 0.80 | 0.10 |
| Enercon E 30 (300 KW) | 33 | 5.0 | 3.02 | 22 | 192.852 | 136319 | 5.18 | 0.78 | 0.42 |
| Lagerway LW 50/(750 KW) | 33 | 5.0 | 3.02 | 8 | 70.128 | 146082 | 2.22 | 0.79 | 0.36 |
| Nordex N40/6.44E2 (600 KW) | 33 | 5.0 | 3.02 | 11 | 96.426 | 143305 | 2.73 | 0.74 | 0.28 |

TABLE 5. Input and output wind energy and coefficients of all models at Cameron Highland

| | $P/A$ w/m$^2$ | $V_{maxE}$ m/s | $V_{Hh}$ m/s | $P$ w/m$^2$ | $E_S$ Kwh/m$^2$/yr | E Kwh/year | $C_F$ | $\varepsilon$ | $\eta_r$ |
|---|---|---|---|---|---|---|---|---|---|
| Nordex N43 (600 KW) | 34 | 5.5 | 3.08 | 12 | 105.192 | 152760 | 2.904 | 0.768 | 0.21 |
| Bonus (300 KW) | 34 | 5.5 | 3.08 | 15 | 131.49 | 115206 | 4.381 | 0.768 | 0.10 |
| Enercon E 30 (300 KW) | 34 | 5.5 | 3.08 | 25 | 219.15 | 154908 | 5.890 | 0.774 | 0.42 |
| Lagerway LW 50/(750 KW) | 34 | 5.5 | 3.08 | 9 | 78.894 | 164342 | 2.500 | 0.766 | 0.36 |
| Nordex N40/6.44E2 (600 KW) | 34 | 5.5 | 3.08 | 12 | 105.192 | 156333 | 2.972 | 0.724 | 0.28 |

## CONCLUSION

The three selected sites have high values of site effectiveness, but Mersing is the most suitable sites for installation of wind machine, because there are many reasons such as the higher annual mean wind speed, the available wind power and higher values of output energy. Besides that the economical reason such as, the costs of roads and foundations which depend on soil conditions is also help in the suitability of Mersing. Another variable factor is the distance to the nearest ordinary road.

A machine with a large 750 kW generator may generate less electricity per meter cubic per year and is not suitable to be used in these wind regions if it is located in a low wind area, than, say a 300KW machine. The design of wind turbine should be made specially for the site, or, at least the turbine should be chosen carefully among many. Small wind turbine with power capacity about 300KW and cut-in wind speed between 2m/s and 2.5m/s, can be used in Mersing site.

## NOTATION

$C_F$ capacity factor %
$E$ output energy *Kwh/year*
$E_o$ output energy *Kwh/m$^2$/year*
D rotor diameter of wind turbine *m*
Hh hub height of wind turbine *m*
$P$ power output *w/m$^2$*
$P/A$ power input by swept area *w/m$^2$*
$P_r$ rated power of wind turbine *Kw*
$V_{ci}$ cut-in wind speed of wind turbine *m/s*
$V_{co}$ cut- off wind speed of wind turbine *m/s*
$V_{Hh}$ wind speed at hub height *m/s*
$V_{maeE}$ wind speed at maximum output energy *m/s*
$V_r$ rated wind speed of wind turbine *m/s*
$\varepsilon$ site effectiveness
$\eta_r$ rated value of overall efficiency

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