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Wind Energy Potential in Nine Coastal Sites in Malaysia

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Abstract: In this paper, the wind energy potential in Malaysia is examined by analyzing hourly wind speed data for nine coastal sites namely Bintulu, Kota Kinabalu, Kuala Terengganu, Kuching, Kudat, Mersing, Sandakan, Tawau and Pulau Langkawi. The monthly averages of wind speed and wind energy are calculated. Moreover, the wind speed distribution histogram is constructed for these sites. The results showed that the average wind speed for these sites is in the range of (1.8-2.9) m/s while the annual energy of the wind hitting a wind turbine with a 1 m^2 swept area is in the range of (15.4-25.2) kWh/m^2.annum. This paper provides a data bank for wind energy for Malaysia.

Keywords: Wind speed for Malaysia, Wind energy for Malaysia, wind power systems

Introduction

Wind is the flow of gases on a large scale. On Earth, wind consists of the bulk movement of air. However, a wind turbine is a device that converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. Based on this, a comprehensive study for the wind speed for a specific area must be done before installing wind power systems (Zhou, 2010).

Some of the researches in regards to wind power systems have been done for Malaysia. In (Khatib, 2012, Rajkumar, 2011, Seng, 2008, Haidar, 2011) the use of wind energy in hybrid renewable energy system is highlighted. However, all these researches have been done considering six zones in Malaysia namely Kudat and Kuala Terengganu, Johor Baharu, Pinang, Selangor and Sarwak while other zones in Malaysia have not been considered. Based on this, the main objective of this paper is to study the wind energy potential for new nine sites in Malaysia. This work is done based on hourly wind speed data provided by solar energy research institute (SERI), University Kebangsaan Malaysia, (UKM).

Wind energy potential in Malaysia

In this section the wind energy potential in Malaysia is examined by analyzing hourly wind speed data for nine sites in Malaysia. Figure 1 shows the selected sites located on a political map of Malaysia. Malaysia is an Asian country located in the Far East and consists of eleven states with two separated main lands.

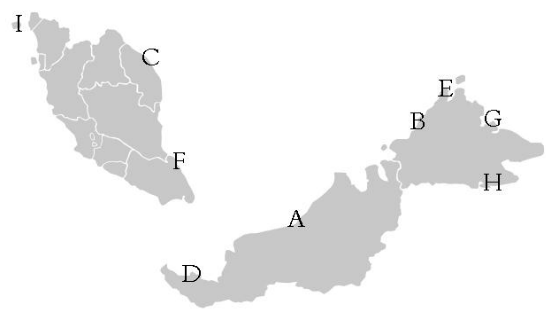

Figure 1 The selected sites in this study

Malaysia has a hot, humid tropical climate with two monsoon seasons, one between October and February and the other from April to October; the latter is characterized by thunderstorms. Temperatures and humidity are high year round, but the mountains are slightly cooler. Meanwhile wind speed is relatively low all over the year. However, Table 1 shows the selected sites in this study.

Table 1 The geographical location of the selected sites in this study

Site name	E	L	LOD	key
Bintulu	23.1	3.07	113.01	A
Kota Kinabalu	2.3	5.56	116.03	B
Kuala Terengganu	5.2	5.23	103.06	C
Kuching	21.7	1.29	110.20	D
Kudat	3.5	6.55	116.50	E
Mersing	43.6	2.27	103.50	F
Sandakan	10.3	5.54	118.04	G
Tawau	17.0	4.18	118.01	H
Pulau Langkawi	6.4	6.20	99.44	I

After analyzing the wind speed data, an estimation of wind power is done. As wind is made up of moving molecules which have mass, wind energy is in terms of its kinetic energy and it is given by,

$$Kinetic\ Energy = {}^{1}/_{2}\, M V^{2} \quad (1)$$

where M is the mass of wind molecules (Kg) and V is wind speed (m/s).

Considering that air has a known density around (1.23 Kg/m^3), the mass which hits a wind turbine with a swept area each second is given by,

$$M/_{S} = V\left(\frac{m}{s}\right) A_W (m^2) Air\ density\ \left(\frac{Kg}{m^3}\right) \quad (2)$$

where A_W is wind turbine swept area.

Substituting (4) into (3), the power (energy per second) in the wind hitting a wind turbine with a certain swept area is given by,

$$P_W = {}^{1}/_{2}\ Air\ density\ r^2 \pi V^3 \quad (3)$$

where r is wind turbine rotor radius.

The output power of wind turbine (P_T) is then calculated after defining the efficiency of the wind turbine (η_T) as follows [2]:

$$P_T = P_W \eta_T \quad (4)$$

In this research we assume that the conversion efficiency of a wind turbine is equal to 20%.

Bintulu zone

Figure 2 shows the wind speed distribution histogram for Bintulu. From the Figure, the major of the hours in the year has wind speed in the range of (1-2) m/s, while most of the remaining hours has wind speed either in the range of (0-1) m/s or (2-3) m/s. based on this a very low performance of a wind turbine located in this area is expected whereas most of the wind turbines has a cut in speed equals to 3 m/s. However, Figure 3 shows the monthly averages of wind speed for this area (the first part) and the wind energy of the wind hitting a wind turbine with a 1 m^2 swept area. From the Figure the annual energy produced by a wind turbine with a 1 m^2 swept area is 3.1 kWh (15.5 kWh/m^2 times ηT) while the annual average wind speed is 1.8 m/s

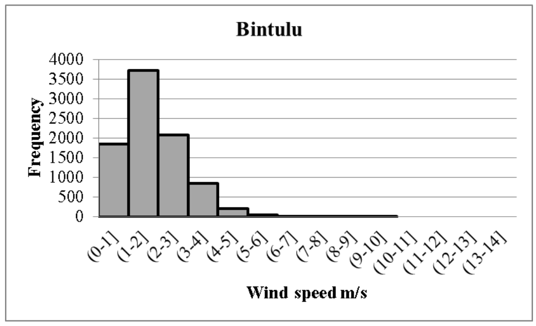

Figure 2 wind speed distribution histogram for Bintulu

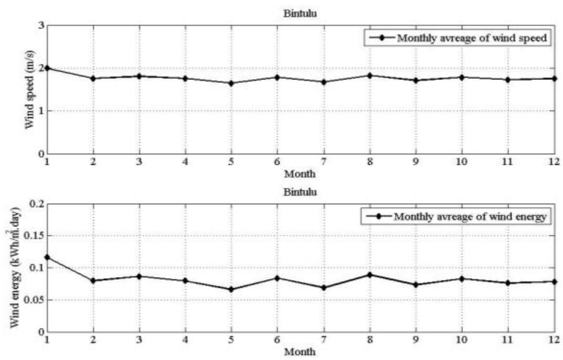

Figure 3 Bintulu wind potential profile

Kota Kinabalu zone

Figure 4 shows the wind speed distribution histogram for Kota Kinablu. The most of the hours in the year have wind speed either in the range of (1-2) m/s, or (2-3) consequently a better performance of a wind turbine located in this area is expected as compared to Bintulu zone. However, Figure 5 shows the monthly averages of wind speed and the wind energy of the wind hitting a wind turbine with a 1 m^2 swept area for this zone. From the Figure the annual energy production is 3.82 kWh (19.1 kWh/m^2 times ηT)while the annual average wind speed is 2.2 m/s. in addition, it is clear that the wind speed is higher for the months (June- October) not like Bintulu zone where the wind speed is stable all over the year.

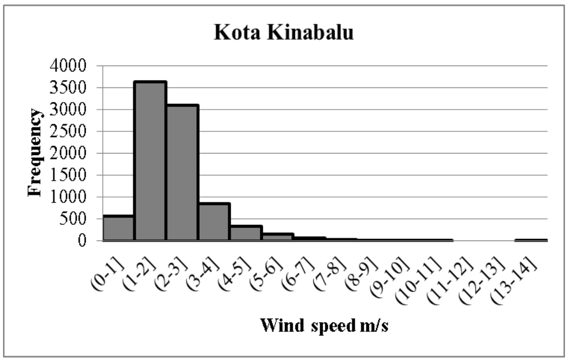

Figure 4 wind speed distribution histogram for Kota Kinabalu

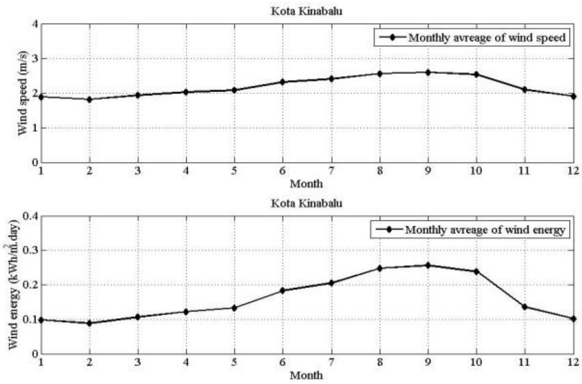

Figure 5 wind potential for Kota Kinabalu

Kuala Terengganu zone

As for this area, the major of the hours has wind speed in the range of (1-2) m/s as illustrated in Figure 6. However, Figure 7 shows that the annual average of wind speed is 1.9 m/s while the wind energy of the wind hitting a wind turbine with 1 swept area is 16.7 kWh/m^2. In addition, from the second part of Figure 7, it noticed that some overshoots in the wind speed curve occur in January and December.

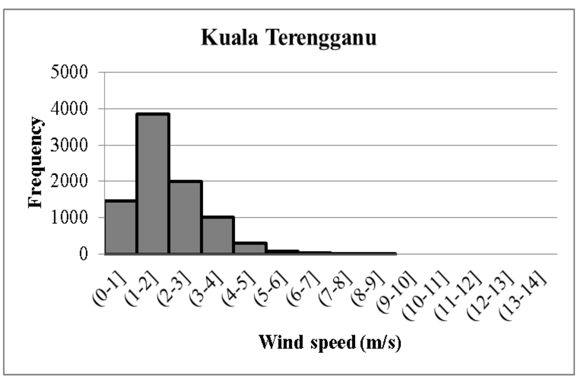

Figure 6 wind speed distribution histogram for Kuala Terengganu

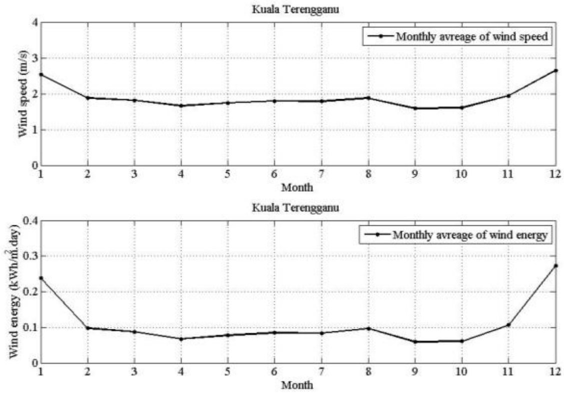

Figure 7 wind potential for Kuala Terengganu

Kuching zone

The same is in Kuching. Most of the hourly wind speed values are in the range (0-3) m/s with maximum value in the range (1-2) m/s (Figure 8). Moreover, Figure 9 shows that Kuching zone has a stable monthly wind speed all over the year with annual average equals to 1.8 m/s. However, the annual wind energy of the wind hitting a wind turbine with a 1 m^2 swept area is 15.4 kWh/m^2

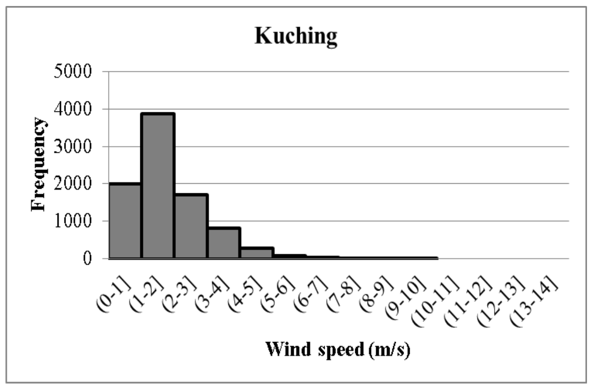

Figure 8 wind speed distribution histogram for Kuching

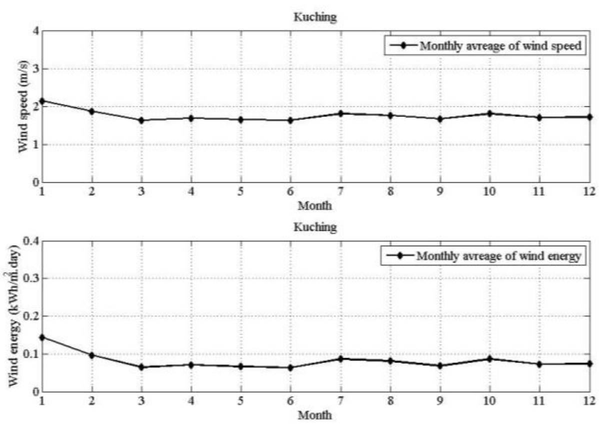

Figure 9 wind potential for Kuching

Kudat zone

The things are quite different in Kuadat, whereas the wind speed distribution histogram which illustrated in Figure 10 shows that a relative good number of hours has wind speed values higher than 3 m/s. Moreover the first part of Figure 11 shows that a relatively high monthly average of wind speed especially in the period of (august -October). According to Figure 11 the annual average of wind speed is 2.5 m/s and consequently a better performance of wind power systems is expected as compared to all above zones. However, the second part of Figure 11 shows that the annual wind energy of the wind hitting a wind turbine with a 1 m^2 swept area is 22.2 kWh/m^2

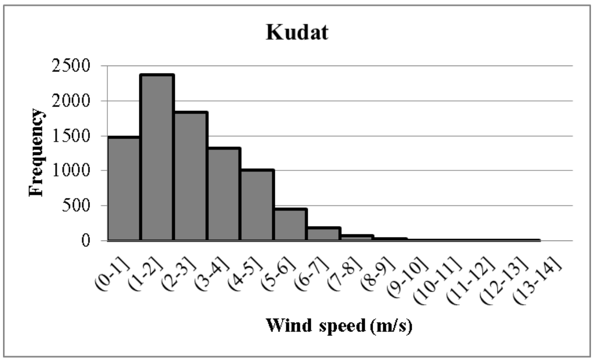

Figure 10 wind speed distribution histogram for Kudat

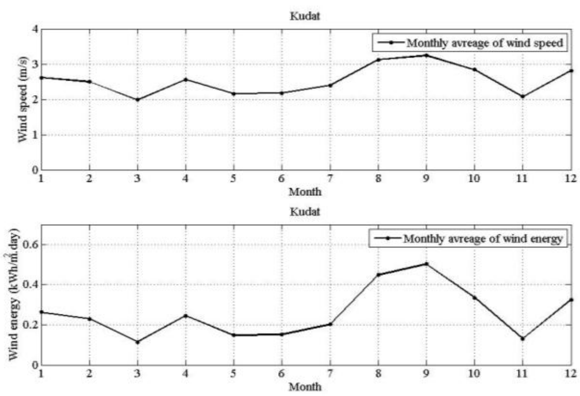

Figure 11 wind potential for Kudat

Mersing zone

In Mersing zone, the wind energy potential is close to Kudat zone whereas the major of hours have wind speed values in the range of (2-6) m/s according to Figure 12. Meanwhile Figure 13 shows that the annual wind speed is 2.9 m/s with a stable monthly average except some overshoots in the beginning of the year. Meanwhile, the second part of Figure 13 shows that the annual energy of the wind hitting a wind turbine hitting a 1 m^2 swept area is 25.2 kWh/m^2, and this is the highest value as compared to the other zones.

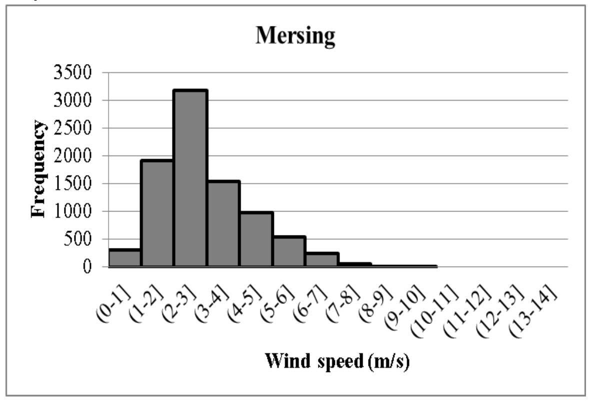

Figure 12 wind speed distribution histogram for Mersing

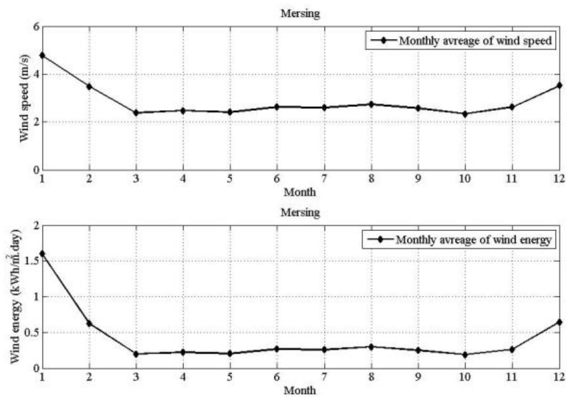

Figure 13 wind potential for Mersing

Sandakan

In this zone, the potential of wind speed is degraded as compared to Mersing and Kudat but still better than the other zones. According to Figure 14 most of the hours have wind speed in the range of (1-4) m/s. In addition Figure 15 shows the monthly wind speed which is stable over all the year with an annual average equals to 2.3 m/s. Moreover, Figure 14 shows the monthly wind energy of the wind hitting a wind turbine. According to the second part of Figure 15, the annual wind energy is 20.4 kWh/m^2

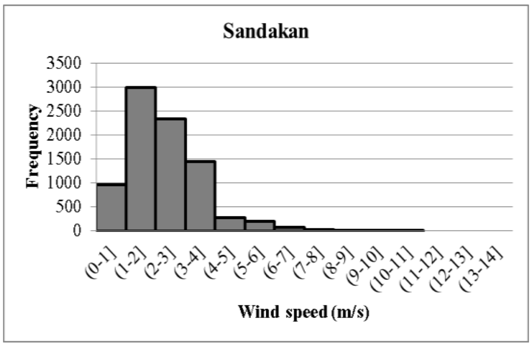

Figure 14 wind speed distribution histogram for Sandakan

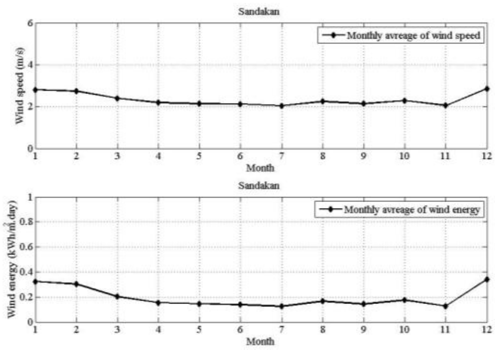

Figure 15 wind potential for Sandakan

Tawau zone

Figure 16 shows the wind speed distribution histogram for Tawau. From the Figure, the major of the hours in the year has wind speed in the range of (0-2) m/s. here also a very low performance of a wind turbine located in this area is expected. However, Figure 17 shows the monthly averages of wind speed for this area and the wind energy of the wind hitting a wind turbine with a 1 m^2 swept area. From the Figure the annual energy produced by a wind turbine with a 1 m^2 swept area is 2.98 kWh (14.9 kWh/m^2 times ηT)while the annual average wind speed is 1.9 m/s.

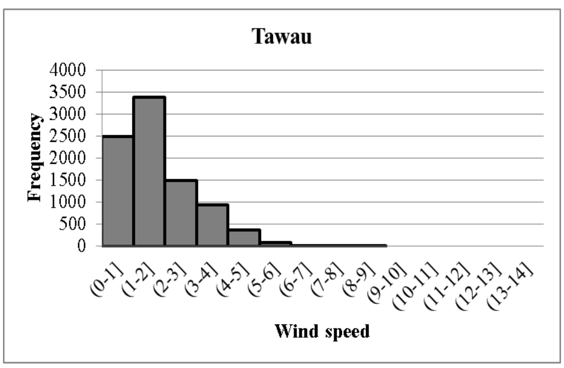

Figure 16 wind speed distribution histogram for Tawau

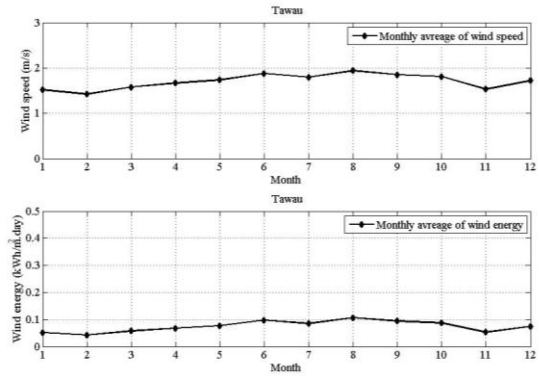

Figure 17 wind potential for Tawau

Pulau Langkawi

As for the last zone, Figure 18 shows its wind speed distribution histogram. From the Figure the major of the hours in the year have wind speed in the range of (1-3) m/s. Meanwhile Figure 19 shows that the monthly average wind speed is 2 m/s and the annual wind energy is 17.5 kWh/m^2

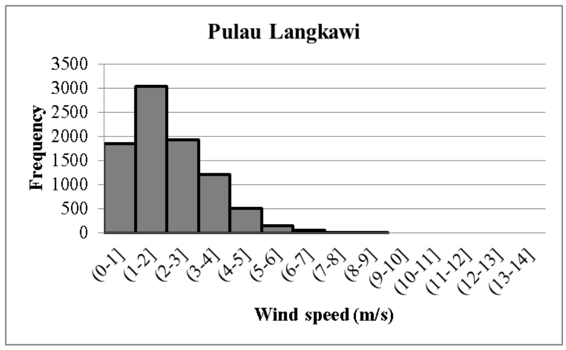

Figure 18 wind speed distribution histogram for Pulau Langkawi

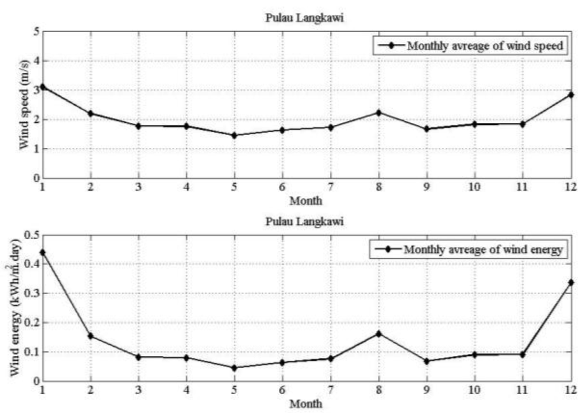

Figure 19 wind potential for Pulau Langkawi

From all the above Figures, it is clear that the wind energy potential is low and consequently the wind power system choice in Malaysia is not feasible because of the high cost of energy produced. To briefly illustrate this, suppose that a 1300 kW with a 6.8 m^2 swept area is installed at Mersing (the best zone among the studied zones). The annual production of this turbine at average wind speed equals to 5 m/s is 2400 kWh. However, it is expected that this turbine will produce only 19.72 kWh per year (ηT= 20%) in case of locating it at Mersing which means about 1 % of the rated energy.

Conclusion

In this research, the wind energy potential for Malaysia is studied. Hourly wind speed data for nine sites in Malaysia is analyzed by calculating the monthly averages of wind speed and wind energy as well as constructing the wind speed distribution histogram. These sites are Bintulu, Kota Kinabalu, Kuala Terengganu, Kuching, Kudat, Mersing, Sandakan, Tawau and Pulau Langkawi. Based on the results, the average wind speed for these sites is in the range of (1.8-2.9) m/s while the annual energy of the wind hitting a wind turbine with a 1 m^2 swept area is in the range of (15.4-25.2) kWh/m^2. This paper provides a data bank for wind energy for Malaysia.

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