EO15

Wind Mapping in Malaysia Using Inverse Distance Weighted Method

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1. Introduction

Renewable energy is a hottest, but not a new topic in the energy fields. Especially renewable resources based on wind. Using wind energy to work out a machine is not a new technology in human history. Today, wind is the fastest growing renewable energy resources in the world [1]. Wind data is the essential study element for wind researcher in either in meteorological field or renewable. Indeed, a reliable wind data also one of the aspects studies before wind system been built. However, Malaysia, there is lack of reliable and accurate wind data which present on spatial [2].

Beside, build a wind system is very costly [3]. Studies on various aspects before building the wind system are needed to reduce the cost wasted. Study of wind resources is one of the important and primary aspects for locate the suitable sites to build wind system. A picture can describe thousand words, the wind speed, if described in an image (spatial mapping) can be more easily been understand. Spatial wind mapping present the wind energy data in a compact and full of information ways.

In this research, there are two objectives need to be achieved. First, study the variation of wind speed with height. The wind speed at 100m heights is interpolated by using the power law wind profile. This power law profile is widely used by the wind energy researchers to interpolate the wind speed variation with height [2,4]. Then, interpolate wind speed in spatial mapping for Malaysia. Spatial wind mapping are interpolated by the approach of Inverse Distance Weighted (IDW) method.

2. Methodology

2.1. Study area

Measured wind data were obtained from Malaysian Meteorological Department (MMD). The selected study areas are Mersing, Kuala Terengganu, Pulau Langkawi, Sandakan, Kudat, Kota Kinabalu, Bintulu, Kuching and Tawau, showed in Fig. 1.

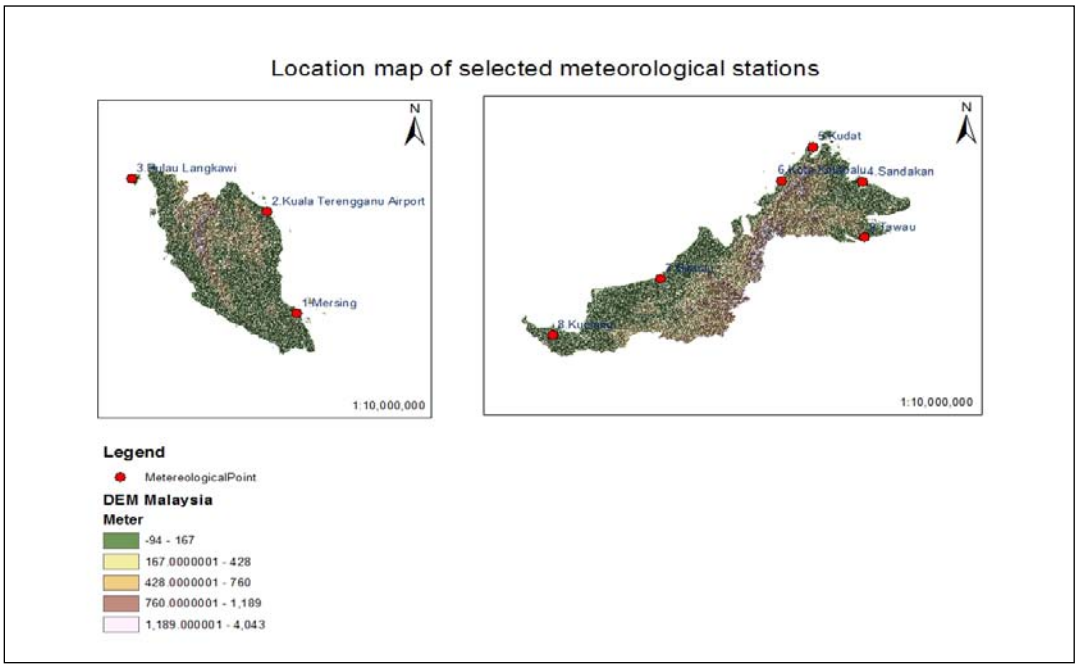

Fig. 1. Location map of selected meteorological stations

2.2. Wind speed variation with height

The measured wind data are base on the 10m height. However, the wind speeds at different heights can be interpolated to assess the availability of wind resources. Vertical wind speed profile for each station was interpolated by the power law equation [5-7]:

$$v = v_0\left(\frac{z}{z_0}\right)^{\alpha} \tag{1}$$

where v is wind speed estimated at desired height, z; v_0 is wind speed measured at the reference height, $z_{0;}$ α is the ground surface friction coefficient and calculated by the Counihan equation [4]. In this study, the vertical wind speed was interpolated at 100m of hub heights.

2.3. Inverse distance weighted (IDW) interpolation of wind speed

In this study, World Geodetic System projection was used to project the map of Malaysia based on Geographic Information System. Further, IDW method was used to calculate the unknown wind speed values for the surrounding [8-9]. The expression of IDW:

$$z_u = \frac{\sum_{i=1}^{s} z_i d_{iu}^{-k}}{\sum_{i=1}^{s} d_{iu}^{-k}} \tag{2}$$

where, z_u-unknown value of estimated at u, z_i-attribute value at control point i, d_{iu}-distance between point i and u, s-number of control point used in estimation and k-a factor.

3. Results and discussion

3.1. Wind speed trend and variation with height

Monthly mean wind speeds at study areas for 2009 are given in Table 1. The results show that, Mersing and Kudat having the high mean wind speed than other stations. The results revealed that, the monthly mean wind speed for 100m at Mersing and Kudat showed higher than 3 m/s for whole along the year.

Table 1: Monthly mean wind speed at 10m and 100m heights for 2009

Location	Hub Height (m)	Wind speed (m/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bintulu	10	1.99	1.75	1.81	1.75	1.65	1.78	1.66	1.82	1.72	1.79	1.74	1.72
	100	2.69	2.37	2.44	2.37	2.22	2.41	2.25	2.46	2.32	2.42	2.36	2.32
Kota Kinabalu	10	1.89	1.81	1.92	2.02	2.09	2.33	2.43	2.52	2.60	2.48	2.10	1.88
	100	2.37	2.26	2.41	2.53	2.62	2.91	3.04	3.16	3.25	3.11	2.63	2.35
Kuala Terengganu	10	2.49	1.86	1.84	1.66	1.73	1.79	1.79	1.87	1.57	1.59	1.96	2.65
	100	4.51	3.37	3.33	3.00	3.13	3.24	3.23	3.39	2.83	2.88	3.53	4.79
Kuching	10	2.14	1.86	1.64	1.69	1.65	1.61	1.84	1.74	1.71	1.77	1.72	1.69
	100	3.87	3.37	2.95	3.05	2.98	2.91	3.32	3.14	3.09	3.20	3.11	3.05
Kudat	10	2.61	2.44	2.05	2.56	2.18	2.17	2.53	2.99	3.19	2.77	2.05	2.93
	100	4.03	3.76	3.16	3.94	3.36	3.34	3.90	4.61	4.92	4.28	3.16	4.52
Mersing	10	4.76	3.47	2.40	2.47	2.41	2.62	2.66	2.68	2.55	2.38	2.72	3.51
	100	6.89	5.02	3.47	3.57	3.49	3.78	3.84	3.87	3.68	3.44	3.94	5.07
Pulau Langkawi	10	3.10	2.17	1.77	1.76	1.44	1.63	1.72	2.26	1.85	1.65	1.80	2.90
	100	4.19	2.94	2.40	2.37	1.95	2.21	2.33	3.06	2.51	2.23	2.44	3.92
Sandakan	10	2.83	2.70	2.41	2.19	2.11	2.16	2.02	2.24	2.16	2.24	2.06	2.97
	100	3.83	3.65	3.26	2.96	2.85	2.91	2.73	3.03	2.92	3.03	2.79	4.01
Tawau	10	1.51	1.44	1.56	1.67	1.73	1.88	1.81	1.92	1.88	1.76	1.53	1.79
	100	2.46	2.35	2.56	2.72	2.82	3.06	2.96	3.14	3.07	2.87	2.51	2.92

Meanwhile, mean wind speeds vary between 3.44 to 6.88 m/s and 3.15 to 4.92 m/s at 100m height at Mersing and Kudat respectively. However, the results revel that Kuala Terengganu, Kuching and Sandakan also have wind energy potential at 100m height, the mean wind speeds vary between 2.83 to 4.79 m/s, 2.91 to 3.87 m/s and 2.72 to 4.01 m/s, respectively.

3.2. IDW interpolation of wind speed

Spatial wind mapping provide a visual determination of the potentially high wind resources. In this map, the areas which have low wind speed or high wind speed were indicated by the colour, red to green (Fig. 2), respectively. IDW method wind speed map of Malaysia is shows decreasing by the increase of distance for the selected study stations.

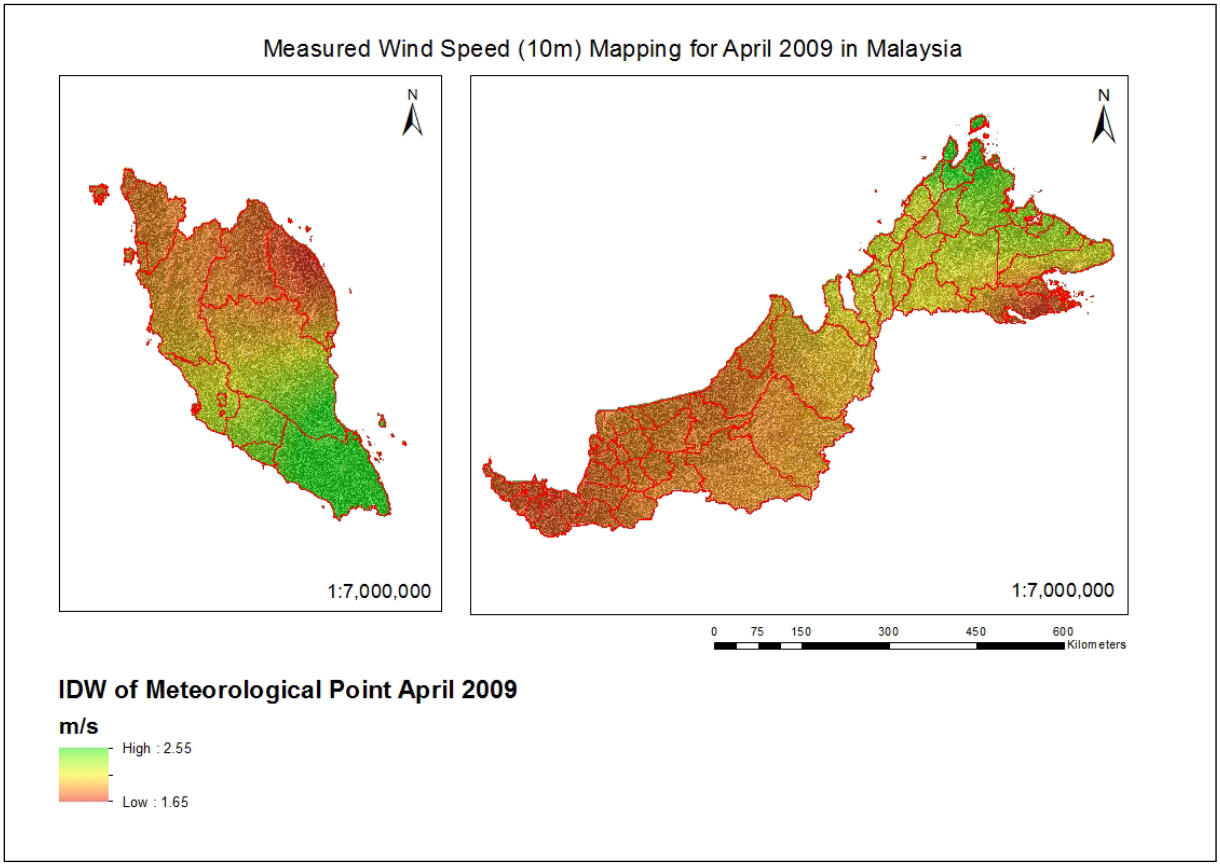

Fig. 2. Measured wind speed mapping at 10m of Malaysia in April 2009 by IDW

Over the year 2009, most of the high wind speeds were in the south of Peninsular Malaysia. It is clearly been distinguished that, in January 2009 the state of Johor showed the highest wind speed distribution (Fig. 3), the range of wind speed in 2.36 – 6.88 m/s. Then, in September 2009 (Fig. 4), the highest wind speeds were found at the tip of Borneo, the range of wind speed in 2.32 – 4.92 m/s.

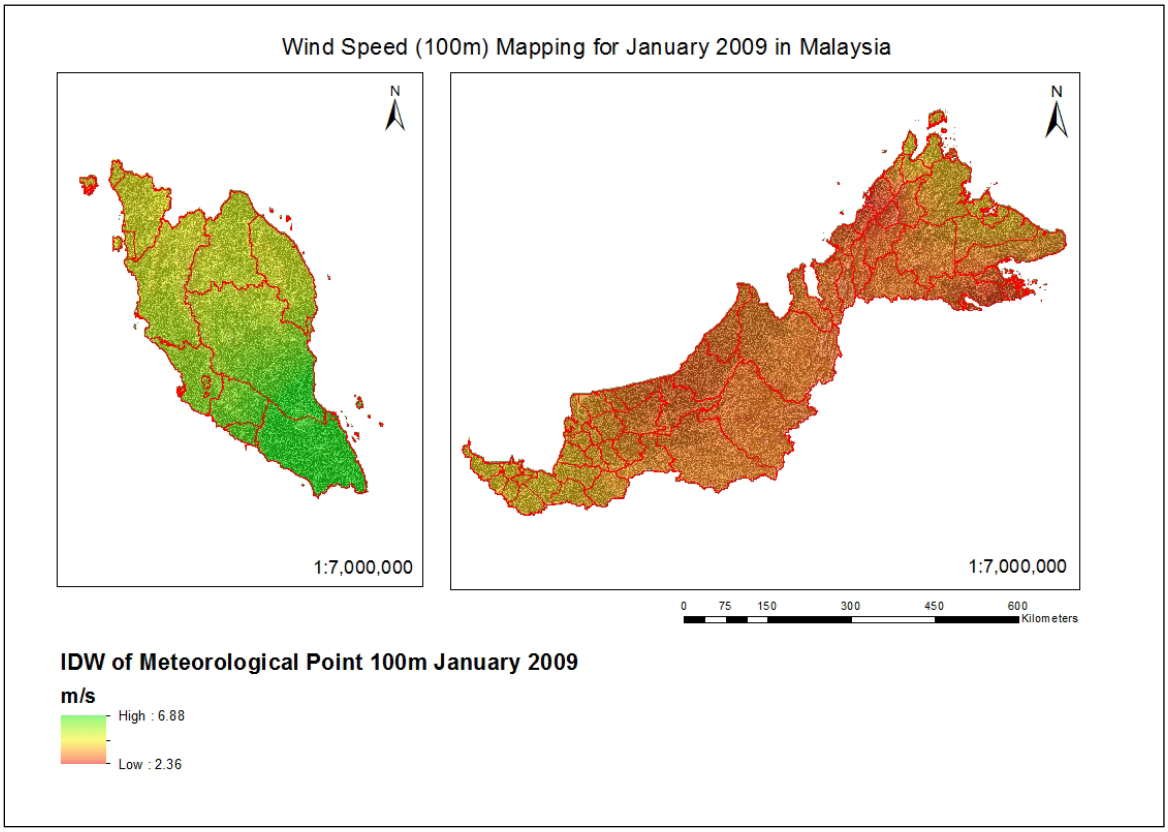

Fig. 3. Wind speed (100m) mapping of Malaysia January 2009 by IDW

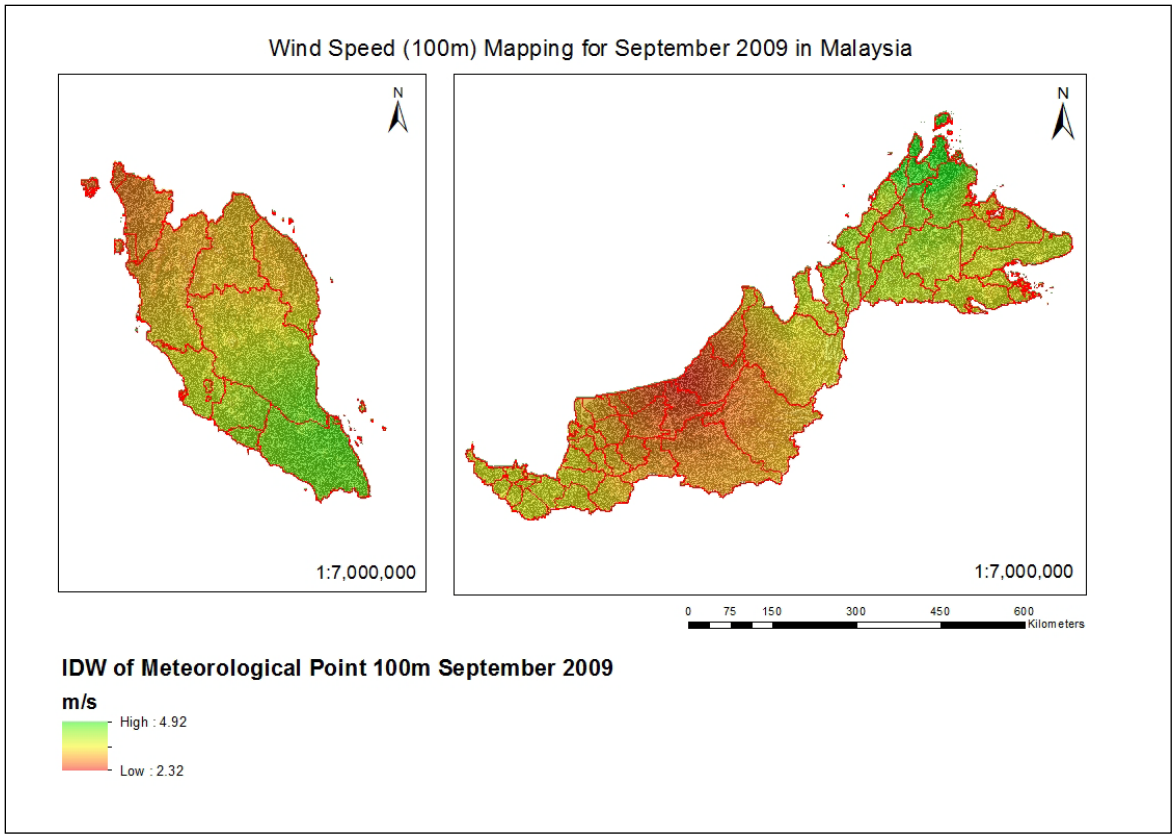

Fig. 4. Wind speed (100m) mapping of Malaysia September 2009 by IDW

4. Conclusion

Renewable energy is a hottest topic in the energy fields. Especially renewable resources based on wind. Wind data is the essential for wind energy researcher. In Malaysia, there is lack of reliable and accurate wind data which present on spatial. The spatial wind mappings leave a visual determination tool to the decision makers. IDW spatial wind mapping had been showed distribution of wind speed of Malaysia. Mersing and Kudat potentially high of wind resources to work out a modern wind turbine which has low cut-in wind speed. The wind profile affected by the elevation of selected study areas will be studied using the GIS tools.

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