Wind Energy Preliminary Potential: A Case Study on Peninsular Malaysia's East Coast

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Abstract
Wind energy is a limitless and renewable source of energy. Wind energy has been used since prehistoric times and continues to be used today. Nonetheless, wind energy has undergone a revolution in the form of electricity generation. However, wind energy is still used minimally in Malaysia to generate electricity. As a result, additional research should be conducted to optimize its use. This study aims to determine the shape of the wind speed distribution and determine the wind energy potential along the East Coast of Peninsular Malaysia in general, and specifically at Sultan Ismail College (SIC). Easy Fit and R software were used to analyse the data. The results indicated that the wind speed distribution in SIC is Weibull distributed and indicating that this location possesses wind energy potential for generating electricity. The findings show that 65.5 percent of the wind speed is greater than the wind turbine's cut in value. Following that, additional research must be conducted until all necessary information is gathered. This discovery also fulfils Malaysia's dream of wind-powered electricity generation.

Keywords: renewable energy, wind speed, distribution

1.0 Introduction

Globally, various efforts have been made to protect this world by reducing the negative impact on the environment. One of these is the use of renewable energy (Al-Salem & Al-Nassar, 2018). The use of renewable energy is also encouraged by an international organization, United Nations (UN). As a result, Malaysia, which does not want to be left behind, participates in renewable energy while positively impacting environmental conservation.

Renewable energy is energy produced by natural resources. In Malaysia, there are five types of renewable energy that have been identified. Based on the study findings, the energy potential in Malaysia is solar energy, hydropower, wave energy, biomass energy, and wind energy. These energies are synonymously used to produce electricity and, at the same time, can reduce dependence on fossil fuel energy and greenhouse gas effects.

Wind occurs through the movement of air. This movement occurs from a high pressure area to a low pressure area. High pressure areas are more exposed to sunlight, while low pressure areas are the opposite. This pressure difference causes the air to move from a high pressure area to a low pressure area. The result of this air movement produces wind. A string of these factors, the wind is one form of energy from solar energy (Daut, Razliana, Irwan, & Farhana, 2012; Murthy & Rahi, 2017). Wind energy is an alternative option nowadays and has rapidly developed in the needs of electricity generation

(Aarib, El Moudden, El Moudden, & Hmidat, 2021; Azad, Rasul, Halder, & Sutariya, 2019).

Wind technology began to undergo a significant revolution beginning in the 1970s. Among them is the production of electricity from wind energy. As well known, the oil crisis was the beginning of the history of renewable energy in general. Recognizing the importance of this, India became a pioneer country globally that has a particular ministry to protect renewable energy (Zaharim, Najid, Razali, & Sopian, 2008). The ministry was established in the early 1980s. The result can now be seen based on India's energy production generated by wind energy at a commendable level of 33000MW capacity (IRENA, 2017). Looking at this achievement, then Malaysia also participated in researching wind energy.

Renewable energy was first introduced and promoted by the Malaysian government, beginning with the 8th Malaysia Plan (Belhamadia, Mansor, & Younis, 2014; Ibrahim, Yong, Ismail, Albani, & Muzathik, 2014). India was chosen as an example, sample, and motivation for the success of wind energy generation due to its proximity to the equator. Furthermore, wind patterns are similar in countries near the equator. It receives a lot of rain and wind, which is one of its characteristics. However, wind power generation in Malaysia is still at a low level and is just getting started. A variety of factors causes this condition. One of them is the lack of comprehensive wind energy studies in Malaysia.

1.1 Problem statement

The literature review found that there is still a lack of emphasis on data form selection. Previous research findings, which primarily focus on selecting the best method for determining the predictive parameters, demonstrate this deficiency. The main thing that needs to be emphasized to get an accurate expectation is to identify the form of the data (Bagci, Arslan, & Celik, 2021). Based on previous studies' observations and findings, various findings have revealed that wind speed data is not the same for every location (Derome et al., 2018). As a result, obtaining the wind speed distribution for the study location is necessary to avoid resource waste due to errors in determining the form of wind speed data for a specific location. Inaccurate predictions of mathematical models of the locations studied will result from errors in determining the distribution.

1.2 Research objective

This research has two main goals. The first objective is to establish the appropriate distribution for the study site, Maktab Sultan Ismail (SIC), and the second is to determine the potential wind energy initialization at the site. This initial potential can then be used to determine whether a location is suitable for wind energy generation.

2.0 Literature review

Wind energy is a non -permanent energy compared to other renewable energy such as solar (Pobočíková, Sedliačková, & Michalková, 2017; Sohoni, Gupta, & Nema, 2016). Nevertheless, at the same time, this unstable element is seen as a challenge and becomes motivation and inspiration for researchers conducting studies involving wind energy (Huang, Liu, & Yang, 2018). Thus, the study of wind energy requires more focus compared to other renewable energy. This observation can be demonstrated based on wind energy industry studies (Ramlee, Fazlizan, & Mat, 2020). The selection of wind speed distribution in a location is crucial in wind forecast studies (Dokur & Kurban, 2015; Sohoni et al., 2016). (Distributions can be interpreted as a form of data. The search for data forms depends entirely on the status and condition of the data.

Based on the literature review results, the Weibull distribution becomes the distribution that is the priority of the researchers (Saberi, Fudholi, & Sopian, 2020). In addition, this distribution is a priority as it has been used for a long time. Besides that, the distribution of Weibull has also received recognition from international bodies. The recognition obtained is one of the distributions that is the benchmark for studies involving wind energy. It becomes a priority because the forecast data will provide an estimate that has a probability that is very similar to the actual data. Distributions are used to model wind conditions to become more systematic at a location.

Mathematics functions can be used to characterize wind speed data models. The function is a probability density function (pdf). A distribution cannot be used arbitrarily. It needs to be obtained by analysing the data first. It depends entirely on the data and wind speed at a location. Therefore, researchers must determine a specific distribution or type of data. This process will make stakeholders more confident in the results of the study. For example, a stakeholder such as an investor is likely to make a significant investment because the risk has been predictable (Wang, Hu, & Ma, 2016). In conclusion, the determination of the distribution is important and should not be taken lightly.

3.0 Methodology

The data used for this study involves wind speed for a year and it is in the form of a time series. It consists of 8325 data numbers (January-December 2014) and meters per second (m/s) units. The selection of the study location, Maktab Sultan Ismail (SIC), is based on the findings of previous studies. The survey shows that the proposed study involves wind energy more directed to the east coast of Peninsular Malaysia. Therefore, due to this factor, the location of the SIC in the state of Kelantan (East Coast of Peninsular Malaysia) was selected as a potential initial pilot project. In addition, SIC was also selected based on the percentage of the number of data that could be used. This selection is because as much as 95% of the data can be used for analysis purposes compared to 8760 data.

This study uses average wind speed data every 60 minutes. The data for this study were categorized as secondary data. This secondary is due to obtained through the Department of Environment, Putrajaya. Next, the data were analysed using Easy fit and R software. R software is open source that does not require a license to use it. Additionally, the program has several advantages, including the ability for anyone to add applications that they believe are necessary for their studies. Besides that, they can share their applications with others. This sharing can be done by uploading coding that has been proven successful. Then the coding will be downloaded by others in the form of packages (Susanto, 2011).

Each wind speed data obtained will go through a screening process first. This process is a mandatory process for any study. This process aims to ensure the validity and consistency of the findings of the analysis. Researchers have also decided to use the Maximum Probability Method (MLM) to find parameter values. Parameter values are required to search for the best wind speed distribution for the study location. The distribution is used to model wind speeds. Among the forms of distribution synonymous with wind speed are Weibull distribution, Gamma distribution, Normal distribution and Log Normal distribution. Once the distribution shape at the SIC is identified, the final process is to find and analyse the descriptive values. This analysis is fundamental because it can provide a collective preliminary picture of a piece of data. Additionally, be able to determine the wind energy potential of the study location.

4.0 Data analysis

The descriptive values for wind speed in SIC are shown in Table 1. Among the preliminary findings was a minimum value of 0.8 m/s. Meanwhile, in SIC, the average wind speed was 4.96 m/s. Simultaneously, the maximum wind speed for this location is 18.1 m/s. Based on this descriptive value, the first conclusion that can be drawn is that the wind speed in SIC is very suitable for use in electricity generation. This suitability is since more than half of the wind speed data collected at this location exceeds the input separator value for most wind turbines, 2.5m/s (Didane et al., 2016; Jabatan Pengairan dan Saliran Pulau Pinang, 2011; Sanusi & Zaharim, 2015). The median value at the location was used to calculate this 50% percentage estimate. The input separator value is the bare minimum required for the wind turbine to function. Furthermore, the suitability of wind power generation is demonstrated by the average wind speed (4.96 m/s), which exceeds the minimum value of the wind turbine input separator.

Table 1: Descriptive value of wind speed in SIC

Descriptive	Wind speed (unit m/s)
Minimum	0.80 m/s
First Quartile	1.60 m/s
Median	4.30 m/s
Average	4.96 m/s
Third Quartile	7.50 m/s
Maximum	18.1 m/s

Following that, the wind speed is investigated to determine the most optimal data distribution. Identifying a qualified distribution is crucial since it is used to forecast wind speed and must be done correctly. To characterize wind speed data models, mathematical functions might be applied. The probability density function, also known as the probability density function, is a mathematical function (pdf). This mathematical model was followed by comparing the results to several distinct types of synonymous distributions, typically used in wind speed investigations. The Weibull, Gamma, Normal, and Log Normal distributions are examples of such distributions (Figure 1). It was discovered that the best fit wind speed distribution in SIC is Weibull distributed (Figure 2). Moreover, findings from the goodness of fit (GOF) test support these conclusions. Kolmogorov Smirnov (KS) and Anderson Darling (AD) were the GOFs used in this investigation. The selection of the best KS and AD values is made based on the lowest values.

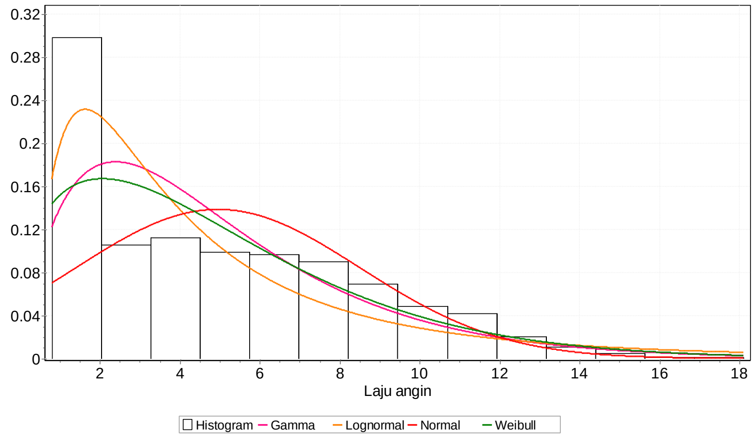

Figure 1: Wind speed distribution in SIC

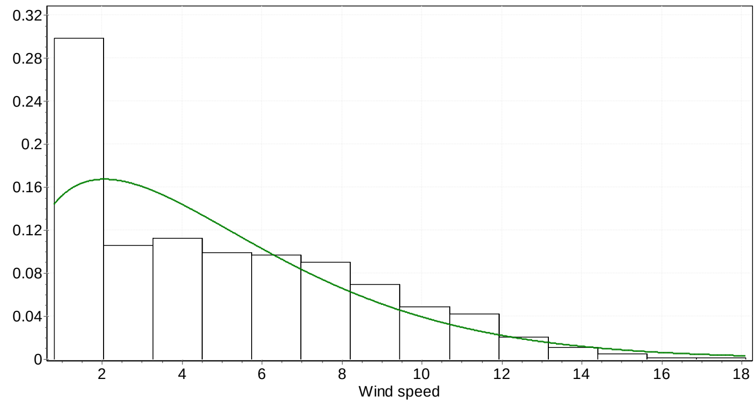

Figure 2: Best fit wind speed distribution in SIC

5.0 Discussion

To obtain more information and info on wind potential, a frequency plot for each wind speed range (m/s) is required. Figure 2 shows the frequency plot for each wind speed (m/s) starting from the minimum to the maximum value. The total frequency for this study was 8325 data. Based on the observations of Figure 2, it can be concluded that many scattered winds speed frequencies exceed 2.5 m/s. This frequency is an excellent sign of Malaysia's dream of generating electricity from wind energy for the SIC. However, the findings of Figure 2 still have weaknesses and have not been able to provide complete information related to wind speed at the study location, SIC.

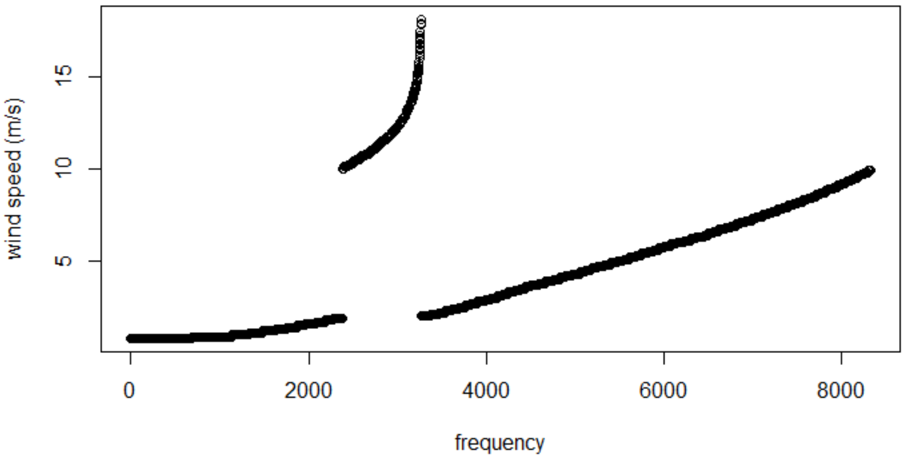

Figure 3: Wind speed frequency in SIC

Continuity from Figure 2, the percentage of wind speed exceeding the wind turbine input separator (2.5 m/s) must be specified. Furthermore, Table 2 aims to strengthen the verification of wind potential at the location by analysing the percentage of wind speed for each of the wind speeds. Based on Table 2, it is possible to conclude that up to 65.5 percent of the wind speed data is greater than 2.5 m/s. These findings demonstrate that wind speed in SIC has the potential to generate electrical energy from wind energy.

Table 2: Percentage of wind speed in SIC

Wind speed (m/s)	Observation	Percentage
0.8-2.5	2868	34.5%
2.6- 18.1	5457	65.5%

6.0 Conclusion

This research aims to determine the distribution of wind speed and the potential of wind energy in SIC. Finally, the wind speed data in SIC is in the form of Weibull distribution, and this location has the potential for wind energy generation. This potential is demonstrated by the analysis findings, which show that 65.5 percent of the wind speed at the SIC location is more significant than 2.5 m/s. The minimum value of the input separator for most wind turbines is 2.5 m/s. In the same context, it means that the wind speed in the SIC is strong enough to propel a wind turbine and generate electricity. Furthermore, this percentage can be translated into wind turbine installation, where 65.5 percent will be operational within a year. However, before any wind turbine project can be implemented, more research must gather pertinent data and information about a specific location. As an alternative, the construction of wind turbines suitable for slow wind speeds can be investigated to capitalize on a location. These wind turbines, in turn, can help Malaysia realize its dream of optimizing wind energy like other countries.

Appreciation

The authors would like to thank and appreciate Universiti Kebangsaan Malaysia (UKM) for allocating research grants under the Grad Challenge Research Project (GUP-2017-087) and the Department of Mathematics, Science & Computer Sultan Idris Shah Polytechnic in all forms of assistance given to prepare for this writing. Apart from that, many thanks also to the Department of Environment, Putrajaya, for downloading wind speed data.

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