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EVALUATING WIND SPEED CHARACTERISTICS IN TANJUNG SEDILI, MALAYSIA THROUGH WEIBULL DISTRIBUTION

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ABSTRACT

Malaysia has yet to acknowledge and utilize wind energy as a potential renewable energy source in this country primarily due to its location situated near the equator and belonging in a low wind speed region. The viability in wind energy of a chosen location can be determined through a comprehensive analysis. Therefore, the aim of this study is to analyze wind characteristic at Tanjung Sedili, Johor over a three-month period to obtain preliminary results for this region, which is considered as a potential site for wind energy. The measured data will then proceed to the post-process analysis and wind frequency assessment by using Weibull distribution. The average wind speed over the three months is approximately 3.4 m/s which is higher than the cut in wind speed for conventional wind turbines but relatively low for constant power generation. Parameter estimation in Weibull distribution for June until August resulted in the shape parameters, k at 2.135, 2.06, 2.09 and for the scale parameter, c calculated at 3.7, 3.85 & 4.01. The highest probability density function is at 3 m/s for all three months. The result shows that with proper matching of wind turbines and meticulous planning to maximize energy production, Malaysia has the potential to exploit a fair amount of wind energy, contributing to the energy mix in the future.

KEYWORD

Wind energy, Malaysia, Wind frequency assessment, Weibull distribution

INTRODUCTION

Wind energy is clean and emits less to none greenhouse gases during its operation. Therefore, it has experienced significant growth over the past few decades worldwide. Despite that, wind energy has a hard time to maintain its reputation as reliable renewable energy sources in Malaysia. This is primarily due to Malaysia's geographical location near the equator, which classifies it as a low wind speed region. Besides, Malaysia has diverse topography and tropical locations that become obstacles to discover its potentiality in wind energy (Bakar, 2023). In recent years, Malaysia has accelerated efforts to reduce its dependency on fossil fuels and expedite the transition to renewable energy in order to achieve net zero emission by 2050. The most noticeable endeavour currently belongs to solar energy development whilst wind energy establishment remains inconspicuous. This occurrence may be attributed to the previous installation of wind turbines in Malaysia (Darus, 2009) which were deemed as lack of success and resulted in unreturned investment. Major obstacles in the past wind turbine installation lie not only on the wind resources but also on the lack of site assessment prior to installation. Reliable wind resource analysis is evidently a crucial factor for a successful wind turbine installation process (Rudien, 2021). Therefore, the objective of this study is to conduct wind characteristics analysis using Weibull distribution for the chosen location in Malaysia for a period of three months.

METHODOLOGY

In-situ data measuring is required for a profound understanding of the wind resources. The proper site assessment together with wind turbine selection will influence the success of the wind power project (Shoib, 2021). Highly reliant on the data from the meteorological department can introduce uncertainty due to extrapolation error and changes in topography. The selected place for the study is located at Tanjung Sedili, Johor which is about 70 km from Mersing, a place where it is considered as windier site in Malaysia (Shamshad, 2007). The wind data used in the analysis spanned three months, from June to August during the southwest monsoon period which according to Albani (2023), the winds are particularly calm and fluctuating.

The wind speed data was measured in a logging system using a cup anemometer fixed on top of the 10 m mast, with readings taken at one-minute intervals. The collected data then underwent post-processed analysis that included the determination of mean wind speed on a monthly basis and maximum wind speed in each month by using MATLAB software. MATLAB software is an exceptional tool for site assessment analysis due to its capability to process large datasets such as wind speed measurements. The wind speed data will be assessed by using Weibull distribution to determine the wind frequency distribution and the parameter will be evaluated through Root Mean Square Error (RMSE).

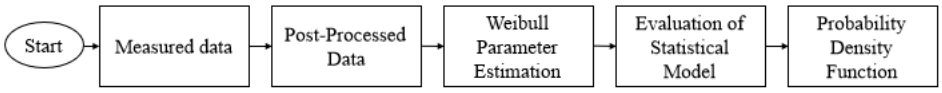

Figure 1: Flowchart of the study.

Weibull Distribution

Weibull distribution is one of the distinguished methods in assessing wind resources and widely used in wind energy studies due to its flexibility that can complement the erratic nature of wind (Nketiah, 2021). In this study, the Maximum Likelihood Method has been used for estimation of the shape parameter, k and the scale parameter, c. The probability density function can be determined as follows:

$$f(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (1)$$

where :

k : Shape parameter
c : Scale parameter (m/s)
v : wind speed (m/s)

RESULT AND DISCUSSION

The data of the wind speed analysis computed in the MATLAB software is presented in Table 1. The average wind speed for the three months is 3.4 m/s which is higher than the cut-in wind speed for conventional wind turbines that is usually around 2.5 m/s but relatively low for constant power generation. The highest wind velocity recorded was in June with a speed of 19.1 m/s, while the lowest was at 0 m/s which is a common occurrence especially in the low wind speed region such as Malaysia. The highest frequency was recorded at 3 m/s for all three months and accounted for up to 30% each month. The rest of the data that approximately amounted to 70% wind speed frequency indicates that the wind speeds fluctuate across a wide range.

The estimation on the value of the shape parameter, k in Weibull distribution also reflects on the characteristics wind speeds. The values estimated for the three months are 2.135, 2.06 and 2.09. This value can be considered as slightly low and indicating a wider distribution curve and greater wind speed variability in wind speed. Meanwhile, the scale parameters, c for all three months are 3.70, 3.85 and 4.01 m/s, respectively. These values represent the wind speeds with the highest

probability. The evaluation through RMSE suggests that the data in July has a larger difference between the measured values and those estimated by using Weibull distribution compared to the other two months.

Table 1: Wind speed parameters for June until August

Parameter	Value		
	June	July	August
Mean wind speed (m/s)	3.274	3.401	3.554
Max wind speed (m/s)	19.1	17.3	14.2
Standard Deviation	1.628	1.755	1.806
Wind speed duration at 3 m/s (hr)	276.07	223.87	278.97
Shape parameter, k	2.135	2.06	2.09
Scale parameter, c (m/s)	3.70	3.85	4.01
RMSE	0.0432	0.1622	0.0447

Based on these findings, it can be seen that Tanjung Sedili, Johor has sufficient wind speed to exploit wind energy on a small scale. The data utilized in this analysis originates from the southwest monsoon season, which generally exhibits lower wind speeds than the northeast monsoon season. Naturally, wind speeds during the northeast monsoon are supposedly higher, rendering it more feasible for energy generation.

CONCLUSION

Due to Malaysia's classification as a low wind speed region, the utilization of wind energy has not yet been fully realized. Proper site assessment evidently needs to be conducted prior to wind turbine installation to effectively exploit wind resources. The critical factor of wind turbine design for Malaysia's wind conditions is a low cut-in wind speed to match the low wind speed environment. This criterion is essential due to the lack of this feature in most conventional wind turbines, making the matching of wind turbine systems critical for application in these conditions. Therefore, findings from this study suggest that Malaysia possesses a fair amount of wind energy that can be exploited highlighting the significance of selecting appropriate wind turbine designs to maximize energy production.

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