ASSESSMENT OF WIND ENERGY POTENTIAL AT YANCO,NEW SOUTH WALES, AUSTRALIA

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Abstract - The wind resource is a critical stage in designing a wind project, thus a deep analysis of wind data is required to assess the performance of the wind project. In this paper, the statistical data of wind speed of Yanco Agricultural institute station are used to investigate the wind energy potential. The Weibull probability distribution and cumulative distribution function have been used to show the wind frequency in this area. Also, different descriptive statistics of mean, maximum, standard deviation, median, Kurtosis, skewness are analysed during the year. Results revealed that the maximum wind speed of 12.3 m/s in February. The two Weibull parameters, the scale and shape parameter was found 3.5139 m/s and 1.452780 respectively.

Keywords - Energy, Statistical Analysis, Weibull Distribution, Wind Data

I. INTRODUCTION

Since the past decade, energy usage and the criteria of supply energy are continuing to change in Australia. Due to the rapid growth of population and economy, also the improvement of living standard, the governments are more interested in renewable energy sources as it is a good choice for sustainable energy resource. The global warming problem is one of the problems that address consuming fossil fuels that emit carbon dioxide and other harmful gases. Different regulatory plan policy is built in order to increase investment in renewable energy such as solar and wind energy. Today, wind energy is considered as one of the mature technology that promises a wide application used in order to cover the demand for energy.

Australia has one of the world-class wind resources, many of the best suitable places are located in NSW regions. Currently, there are around 11 operational wind farms. The Gullen Range wind farm is the largest wind farm in NSW which had a capacity of 172 MW, with potential to cover more than 60,000 home usage of energy. In addition, there are wind farms that had a capacity larger than 100 MW such as Capital wind farm and Boco Rock wind farm that had a capacity of 140 MW and 113 MW respectively [1].
As known Wind resource is variable from one place to another, also for the same location, there is a seasonal and daily variation. This explains the need for feasibility studies of the performance of wind energy in order to predict the potential of wind in a specific site. Therefore, an accurate assessment of wind energy resource gives the confidence to invest in wind energy accordingly to the financial feasibility of wind resources. The fundamental step in the assessment of the potential of wind energy in a specific site is to determine the wind speed probability distribution. The Weibull probability distribution has been used widely according to simplicity and overall accuracy.Ahmed[2] investigated the parameters of Weibull distribution which showed that the shape parameter is not larger than 2.3, also the monthly changing values of coefficient of variation were tiny at the whole year.Hernandez-Escobedo et al. [3] assessed the potential of wind resource in Northern Mexico. The results showed the high wind potential during the year are September and October with a value of 1000 W/m^2 of wind power density. Irwanto et al.[4] examined the wind resources at Kangar and Chuping in Malaysia using recorded daily, monthly, and yearly wind speed using Weibull distribution. The results showed that Kangar was a suitable place with a high wind speed during the period between January and April.

In this study, the feasibility of wind energy in Yanco Region, which located in NSW, Australia. The recorded hourly wind speed data from Yanco station have been statistically analysed using the Weibull probability density function. In addition to the Monthly Weibull k and c parameter and several wind characteristic parameters are examined.

II. ANALYSIS PROCEDURE

A. Study area and recoarded measurment data

The wind data measurements used in this study were obtained from the Yanco Agricultural institute station. The geographic coordinate of this station is 34.62 ° south, the Longitude is 146.43 ° East, where the elevation of this station 164 m. A Yanco is considered as a low populated village with 505 people lived there, this village is located in the south-western part of New South Wales State, Australia as shown in Figure 1. In order to evaluate the wind

potential in Yanco Region, the wind speed distribution during the measurement period of June 2018 until July 2019 should be analysed using Weibull distribution function as discussed in the following section.



Fig. 1. Yanco Location.

B. Weibull distribibition function.

This study used the two important aspects of Weibull distribution function for wind characteristic analysis. Firstly, probability distribution function PDF(v)shows the fraction of time for the wind speed which may be dominated at the specific place under study. Secondly, the integral of the probability distribution function is called a cumulative distribution function CDF(v). In the following equations both probability distribution function PDF(v) and cumulative distribution function CDF(v) calculated as [5]

$$\mathrm{PDF(v)} = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \qquad (1)$$

$$\mathrm{CDF(v)} = 1 - \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \qquad (2)$$

Where k is the shape parameter, c is the scale parameter and v is the wind speed.There are different numerical methods are used for estimation the Weibull parameter.In this study, the Maximum Likelihood method is used which is the most desirable for analysing time-series wind data. The following equations calculate the shape and scale factor respectively:

$$k = \left[\frac{\sum_{i=1}^{n} v_i^{k} \ln(v_i)}{\sum_{i=1}^{n} v_i^{k}} - \frac{\sum_{i=1}^{n} \ln(v_i)}{n}\right] (3)$$

$$c = \left(\frac{1}{n}\sum_{i=1}^{n} v_i^{k}\right) (4)$$

Where v_i isthe measured wind speed at i time step , and n is the number of observation done.

Also, there are a two important statisticalexpression are used for wind data analysis are mean wind speed ($\bar{v}$), and variance (σ)as in the following equations [6] :

$$\bar{v} = \frac{1}{n}\sum_{i=1}^{n} v_i \quad (5)$$

$$\sigma = \left[\frac{1}{n-1}\sum_{i=1}^{n}(v_i - \bar{v})^2\right]^{0.5} \quad (6)$$

III. RESULTS AND DISCUSSION.

Determination of variation of wind speed during different months along the year is very essential to check the availability of wind power. The behaviour of mean and maximum wind speed during the year give essential information about analysis wind resources in a specific site. As shown in Fig.2.a.the monthly mean wind speed at Yanco area, which the mean wind speed varies between a maximum of 14.06 km/hr in February, while the minimum mean wind speed is 7.88 km/hr in December. Also, Fig.2.b.shows that the maximum wind speed of 44.3 km/hr in February, thus this value important when install the wind energy conversion system. The monthly standard deviations and median are presented in Fig.3. which the variation of the median between the maximum in February and minimum in December. While the variation of standard deviations during months is less than the variation of the median. Also, Kurtosis, skewness are important parameters which show their monthly value in Table 1.

Table 2. shows the descriptive statistics of mean, maximum, standard deviation, median, Kurtosis, skewness. Table 3 presents the annual value of two Weibull parameters, the scale parameter and the shape parameter which are found to be 3.5139 m/s

and 1.452780 (dimensionless) respectively where the variance equals 2.2275 which is moderate-high value. The annual Weibull distribution function is shown in Fig .4, while the annual cumulative density distribution is shown in Fig .5.

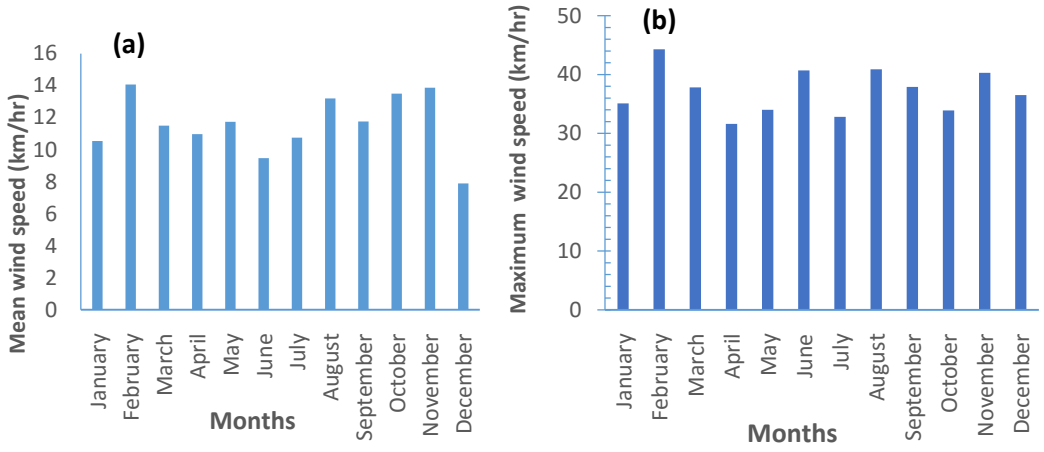


Fig. 2. a. Monthly mean wind speedb.Monthly maximumwind speed

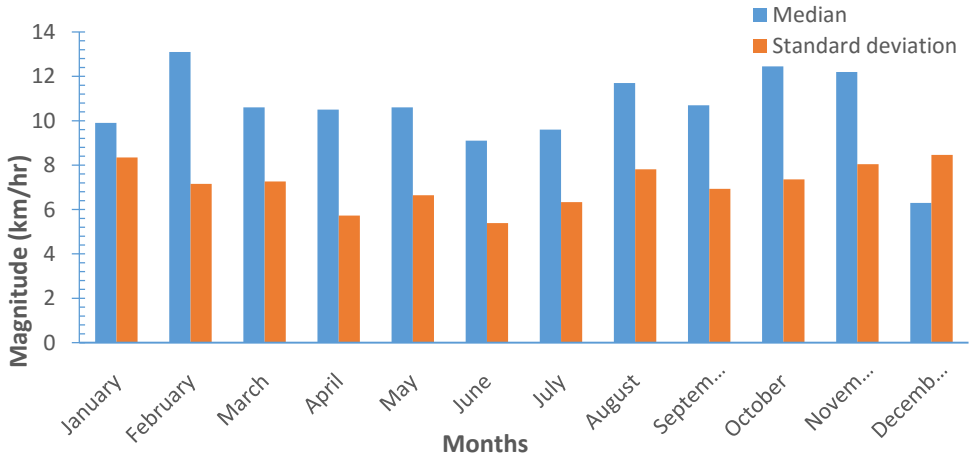


Fig. 3. Monthly Median and standard deviation of wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Skewness	0.34	0.73	0.53	0.66	0.71	0.56	0.72	0.93	0.65	0.50	0.65	0.81
Kurtosis	2.20	3.38	3.221	3.48	2.95	2.96	3.00	3.66	3.08	2.57	2.72	2.94

Table1.Skewness and Kurtosis of the measured wind speed data during one year.

Maximum wind speed (km/hr)	44.3
Mean wind speed (km/hr)	11.671
Median (km/hr)	10.7
Standard deviation (km/hr)	7.163
Skewness	0.697
Kurtosis	3.374

Table2.Descriptive statistics of the measured wind speed data during one year.

Weibull shape factor (k) (dimensionless)	1.452
Weibull scale parameter (c) (m/s)	3.513
Variance (m/s)	2.227

Table3.Weibull distribution function parameters.

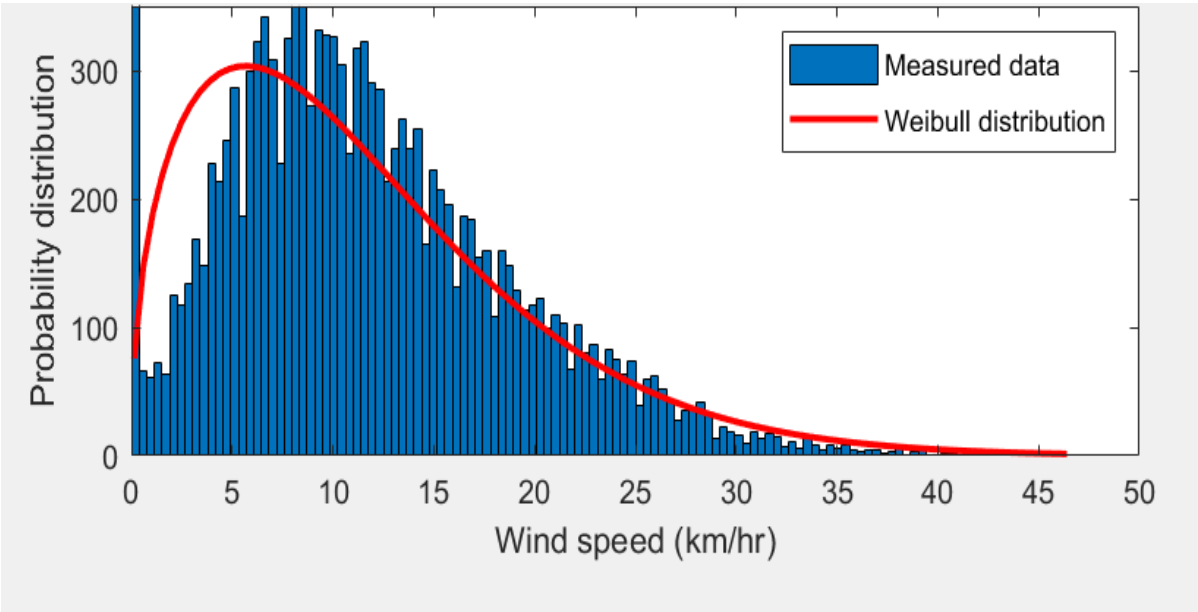


Fig. 4. Annual Weibull distribution function.

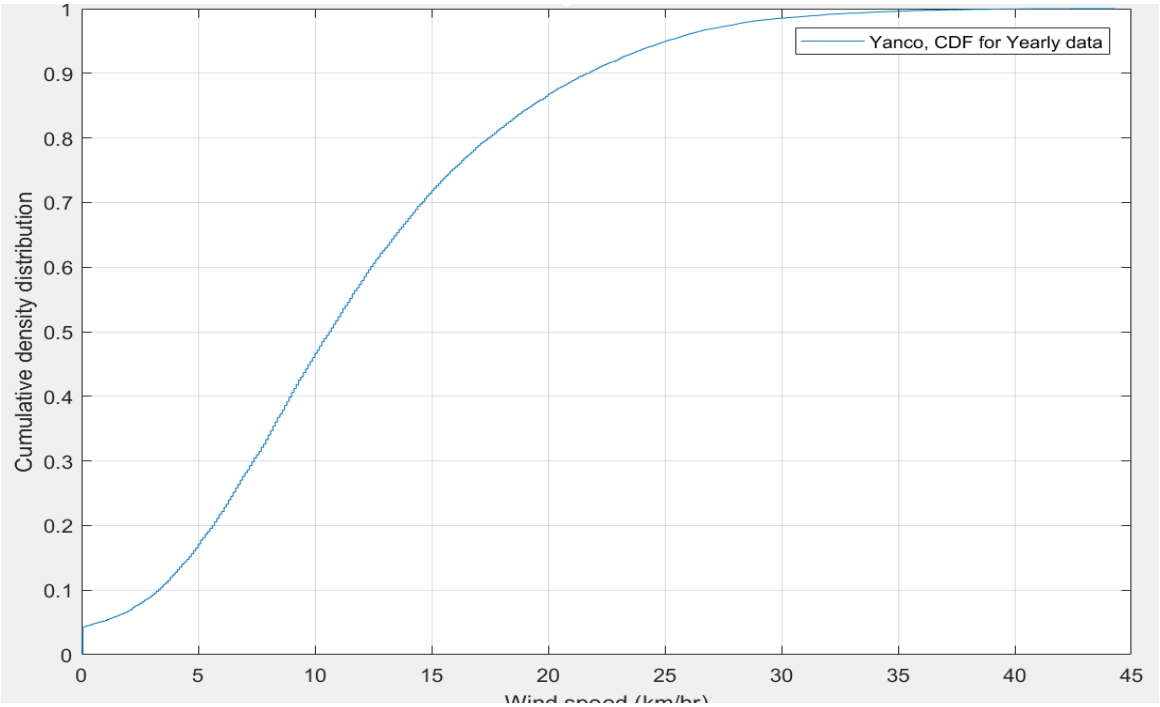


Fig. 5. Annual cumulative density distribution.

CONCLUSION

This study examined the wind characteristic in Yanco region, using Weibull distribution function. In addition, to define annual Weibull parameters. Different descriptive statistics of the measured wind speed are investigated monthly and annually.

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