Wind Analysis for Reliability Evaluation of Wind Energy Conversion System

Sayali C Wardadkar (*Author*)
Department of Electrical Engineering
Rajiv Gandhi College of Engg & Research
Nagpur, India

Prof. Akshay N Deshmukh (*Author*)
Department of Electrical Engineering
Rajiv Gandhi College of Engg & Research
Nagpur, India

***Abstract*— In all the renewable energy sources, wind energy source is considered as one of the major generation alternative in power system due to its inexhaustible nature. Owing to such a major advantage of wind energy conversion system, it is very essential to find the reliability of a wind farm. Reliability evaluation of wind energy conversion system is a tedious process. It requires an appropriate wind speed recorded for a particular wind site. Hence it requires a historical wind data for a site to establish the reliability of the wind farm. In this paper an analysis of wind data is done so as to determine the reliability parameters.**

Keywords*— Wind turbine, reliability evaluation, wind speed data.

I. INTRODUCTION

The major function of the power system is to supply consumer demand within the economic limits and also with an acceptable reliability and quality. [1] The planning process doesn't consider the influence of the transmission system, but only balances generation and load system.

In the present era, a growing interest is observed in renewable energy sources. Wind energy is considered to be a very promising alternative for power generation because of its tremendous environmental, social and economic benefits. Wind power generation is depended on various factors such as wind speed, geographical condition of wind site, rated wind speed etc.

Particularly in Indian sector there is a huge gap between power supply and consumer demand. To meet this difficulty the probabilistic evaluation of reliability is carried. In this work reliability evaluation of wind power generation system is carried out to ensure the reliability of WECS. But before reliability evaluation it is very essential to analyze the wind data for a particular selected location.

A. *Reliability Indices*

Power system reliability indices can be calculated using a variety of methods. The two main approaches are analytical and simulation. [1] The most popular generation reliability index is loss of load expectation (LOLE). In reference with this expected energy not supplied (EENS) and energy index of reliability (EII) are used. Loss of load expectation (LOLE) is the time in which the load is more than generation capacity. The energy not supplied can be found out by equation 1

$$EENS = \sum_{k=1}^{n} E_k P_k \text{.....Kwh} \quad \text{..... (1)}$$

Where,
Pk – probability of capacity state Ck
n – total capacity states

Also,

EIR=EENS/energy demand…….. (2)

B. *Wind data analysis*

Various steps involved in the wind data analysis are:
1] Data collection
2] Data analysis
3] Wind speed model for a site under study
4] Wind turbine power curve
5] Evaluation of power generate

It is very important to analyse the wind site so as to become aware of energy efficient designs and construction that will save energy, cost less to operate and have less negative impact on the natural environment.

C. *Data collection*

For the evaluation process the data is obtained from

The wind data is available in hourly basis measured through anemometer installed in the selected site under study. The wind data directly obtained by the anemometer installed at the site is called as primary data. Turbine data is obtained from the turbine manufacturer. Wind site data consist of geographical information about the site such as latitude, longitude, temperature, air density, relative humidity etc.

D. *Data Analysis*

"Excel data analysis tool box" is the best for data analysis. The excel sheet data can be used to plot wind rose graph and power curve for various wind turbine generator.

Some important parameters such as average wind speed, air pressure, air density, frequency curve, speed distribution graph can be represented graphically.

E. *Wind Speed Model for Site Under Study*

In this step the wind speed model is developed by calculating the average wind speeds. With the help of this model the frequency of occurrence of wind and the probability of wind speed in the specified site can be obtained.

I. AVERAGE WIND SPEED:

The mean is given by the equation;

$$\vec{V} = \frac{1}{n}\sum_{i=1}^{w} m_i v_i \quad \text{..... (3)}$$

Where;
W – Number of different values of wind speed observed.
n – Total number of observation.

II. FREQUENCY OF OCCURRENCE:

The percent value of frequency occurrence of wind speed is given by,

$$\text{Frequency } (V_i) = \frac{\text{No.of hrs in which } V_i \text{ is occurred}}{\text{Total no.of hrs in data}} \text{ X } 100$$

F. *WTG POWER CURVE*

This is the data obtained from the turbine manufacturer companies [2]. This data consists of various specifications of turbine such as rated power output, cut-in wind speed, cut-out wind speed, swept area etc. The power curve can be determined by plotting wind speed (m/sec) on x-axis and power (KW) on y-axis.

G. *WTG Power Generation Model*

The study of power generation model depicts the total annual power generated i.e. power generated at different wind speeds throughout the year.

H. *EVALUATION OF POWER GENERATED*

The power generated can be calculated using the formula;

A detailed explanation is given in reference [3] for power generation calculation

$$P_m = C_p\left(\frac{1}{2}\rho A v^3\right)\text{.....watts.} \quad \text{..... (4)}$$

Where,

Cp – Capacity factor

ρ – Air density at wind site (kg/m^3)

A – Swept area of turbine in m^2.

v – Wind speed in m/sec.

I. *CASE STUDY*

This site is located in Locn-Rua Jose Falcao Altinho,Panjim Goa-403521. The site is above 75m from average mean sea level with a latitude 15.5ºN and longitude 73.83ºE. The data is obtained from 01/01/2010 (01:00hrs) to 31/12/2010 (23:00hrs). The average temperature recorded at the wind site is 27.11ºC.

i. *FEATURES OF WTG*

Vgo – 3.0MW (vestas).
Rating – 3000KW or 3MW
Blades – 3
Rotor Diameter – 90m
Hub Height – 65m and 80m
Cut-in wind speed – 3.5 m/s.
Cut-out wind speed – 25 m/s.
Rated wind speed – 15m/s.
Swept area – 6,362 m^2
Average wind speed = 3.00625 m/s (this can be calculated by equation 3)

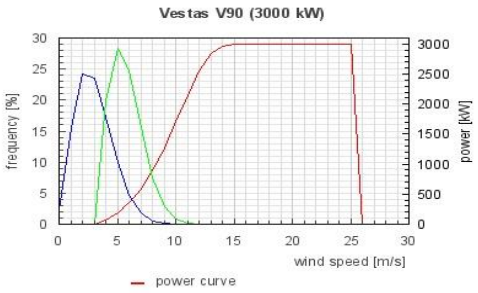

Figure 1. WTG Power Curve

Above figure shows wind turbine power curve to calculate power output from WTG at different wind speeds. From equation 4 the power generated by wind turbine can be calculated.

Using "Excel Analysis tool box" we can plot wind rose graph. A wind rose is a graphical tool used by meteorologists to give a sufficient view of how wind speed and direction are typically distributed at particular location.

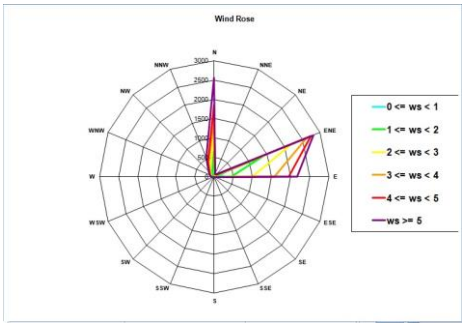

Figure 2. Wind Rose Graph

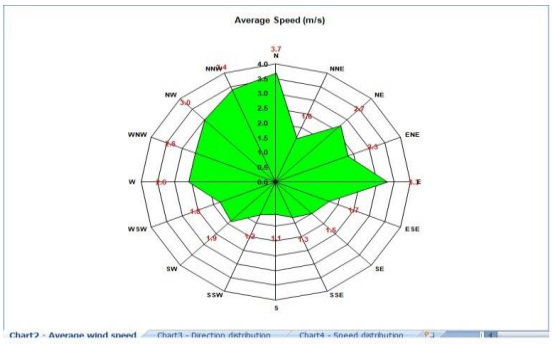

Figure 3. Average Wind Speed

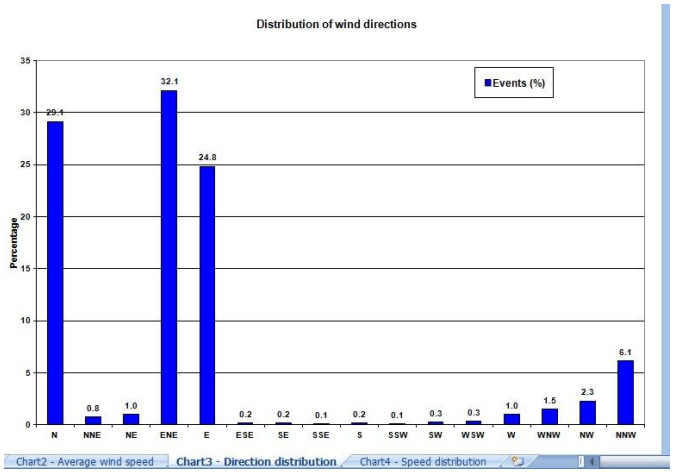

Figure 4. Direction Distribution Graph

From the same tool we can analyze direction distribution of different speeds, graphical speed distribution of different speeds from the data

Figure 5. Speed Distribution Graph

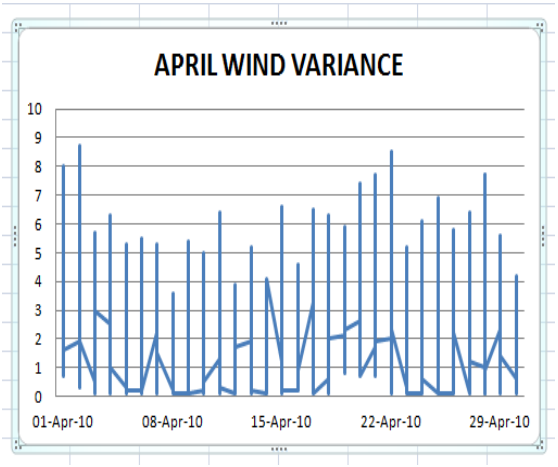

Figure 6. April wind variance at the wind site

The important work to be carried out from the wind data is to determine the cardinal directions from the wind directions which are available in degrees.

J. CONCLUSION

It is very important to achieve reliability when wind power is used to satisfy energy demand. Hence before calculating reliability indices it is first essential to analyse the wind data in detail. Hence in this paper the wind data is analyzed determines the wind rose graph, graphical speed distribution etc. From the above analysis it can be concluded that the avalaible site has a wind resource so as to erect a wind turbine on that site. Also after this work further reliability studies can be carried out for a selected geographical location.

K. REFERENCES

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