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Prospective analysis of wind energy for power generation by Weibull distribution method

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ABSTRACT

Clean, safe, and renewable electricity is supplied with wind power, making it one of the fastest-growing green technologies. Research on sustainable energy harvesting usingwind turbines and ways in which wind power canbe done provides information about the available methods. Wind energy is mainly used for two purposes namely irrigation (pumping) and power generation. The hope for wind power can beanalyzed in different ways. The Weibull distribution method is one of the most widely accepted methods of measuring wind power. In this paper, the prospect of wind power in India isanalyzed by means of the Weibull distribution. Details are collected from the Indian Meteorological Department located in variousparts of the country. Three different Weibulldistribution methods were used to obtain validated Weibull parameters using the most widely accepted mathematical tools.

Keywords: *Wind Data Analysis, Wind Turbine, Wind Variation*

1. INTRODUCTION

Having a limited amount of fossil fuels on Earth, such as coal, gas, and oil, is common knowledge. Electricity is increasingly being produced from renewable energy sources around the world. The process of producing solar panels uses a lot of chemicals and hazardous materials in the environment. Wind power is much cleaner and cheaper than solar power.

The overuse of natural resources such as petroleum,coal, and natural gas causes carbon dioxide andother harmful gases in the environment.

Global temperatures are rising at an alarming rate due to the release of harmful gases. Of all the available energy sources, the wind is one of the most valuable and reliable sources of energy. With population growth and development, it is estimatedthat energy demand could grow by 3% by the end of 2021. Global demand for energy is expected to growby 3% by the end of 2021 in terms of population andeconomic growth. Fuel-powered generators (PGs) generate 64.5% of the world's electricity.

Next year, it is expected that electricity bills for U.S. households will increase by 2.3%, based on data from the Energy Information Administration (EIA)quoted in the paper [4]. At current levels of human activity, coal, oil, and fossil fuels are often limited in terms of energy production [3] due to overcrowding. The earth must store up to 80% of our earth's natural resources to keep the earth's average temperature below 1.5 degrees Celsius. However, our confidence in these products is growing worldwide. Renewable energy sources must be used for socio-economic growth and development and are at the forefront of global priorities for climate change.

2. INDIVIDUAL WIND TURBINE POWER ELECTRONIC TECHNOLOGY:

The standard WTS consists of a rotor with turbine blades, a gearbox (located in direct driving systems), an electric generator, an electric converter, and a transformer to convert power from wind to electricity. A few types of wind turbine concepts exist depending on the type of generator, speed control, and aerodynamic power limits [2]. Powerful electronics play a vital role in the design of these wind turbine ideas and have distinctive energy features. From the beginning of the century, the market was dominated by the concept of DFIG withpartial power converters, but now, AG or SG with full-level converters have been introduced. Becauseof their power control, electronics converters gain popularity.

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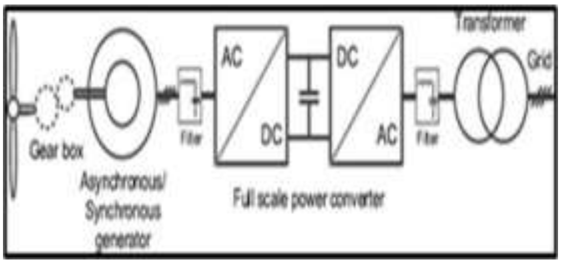

Fig.1: Wind turbine block diagram [6]

3. WIND VARIATIONS

A. Weibull Distribution

It is very important that the wind industry is able toexplain the variation in wind speed. Turbine designers need the knowledge to improve the designof their wind turbines, in order to reduce productioncosts. Turbine investors need the information to estimate their income from generating electricity. If

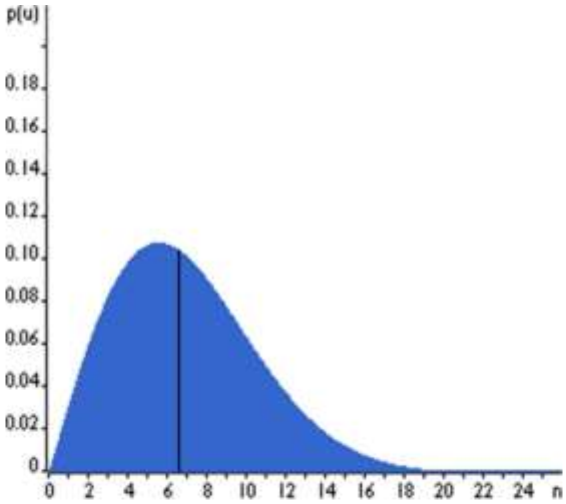

Fig 2: Weibull Distribution

we measure the wind speed throughout the year, wewill note that in many places severe storms are rare,whereas moderate winds are common.

The air variation of a typical site is often defined using the so-called Weibull distribution, as shown in figure2.[9] This particular site has an average wind speed, and the shape of the curve is determined by the shape parameter.

The area at the bottom of the curve is always 1 exactly as the probability of the wind blowing at a certain speed including zero should be 100 percent.[5]

The part of the blue area to the left of the dry black line is called the median distribution. This means that half the time will be blowing less than 6.6 meters per second, and the other half will be blowing faster than 6.6 meters per second. The distribution of wind speed statistics varies fromplace to place throughout the world, depending on the local climate, location, and location. The distribution of Weibull may therefore vary, both in terms of its size and its relative value

B. Power Density

If we multiply the power of each wind speed bythe probability of each wind speed from the Weibull graph, we calculate the wind as:

Power distribution at different wind speeds =power density

The area below the gray curve (all the way to theaxis below) gives us the amount of air energy persquare meter - airflow. The area under the blue curve tells us how muchwind energy we can technically convert into mechanical energy and the total area below the red curve tells us how much electrical energy willbe generated by a particular wind turbine on site

Typically, wind turbines are designed to start operating at wind speeds somewhere around 3 to 5feet per second. This is called cutting wind speed.[4]. The blue area on the left indicates the small amount of energy we lose because the turbine disconnects after a certain time.

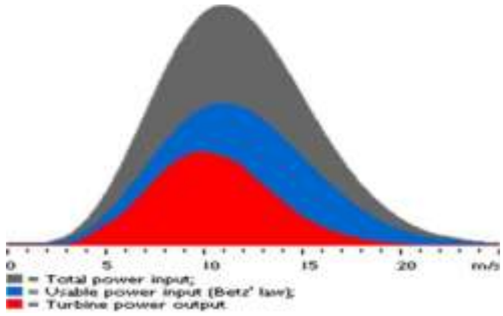

Fig.3: Power Density Curve

4. WIND DATA ANALYSIS METHODOLOGY

A. WEIBULL METHOD

The two-parameter Weibull distribution is often used to display air conditioning because it has been found to provide a good balance with measured air data. One can describe the distribution of Weibull using medium wind speedand Weibull value k. Low k values correspond to wide distribution. Optimal activity is given by thefollowing equation 1:

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

Where,

v = wind speed [m/s]

k= the Weibull shape factor [unit less]

c= the Weibull scale parameter [m/s]

The cumulative distribution function is given by thefollowing equation 2:

$$F(v)=1\text{-}\exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (2)$$

B. Power Density Method

This method is one of the most important ways todetermine k and firstly the Epf power factor feature is computerized which is defined as the ratio between a medium cubic wind speed to a medium speed cube. After calculating the powerpattern element, k and c can be determined by thefollowing Equation.

$$F(v)=1\text{-}\exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (2)$$

Where;

Γ = the gamma function

5. RESULTS

In our study, we collected monthly wind speed data from three different Indian provinces namelyTamil Nadu, Gujarat, and Rajasthan. We then use the Weibull Method and Power Density Method as our parameters to determine which state best favors wind power and which region is the smallest of the selected three.

The figure shows the variance of the curve taken from calculating wind speed in different regions. From the turn, we can see that Tamil Nadu and Gujarat are more attractive compared toRajasthan. In May, Gujarat wind energy is better

Fig. 4: Monthly Variation in wind speed

compared to Tamil Nadu, we are seeing a drop in wind speed in Gujarat after August which shows Tamil Nadu is a better wind turbine. We can also see that in December, Rajasthan, and Gujarat both show lower airspeeds compared to Tamil Nadu.

The following graph will show the wind speed calculation performed on the Weibull Method. By analogy, we can conclude that Tamil Nadu offers more favorable wind speeds than Rajasthan and Gujarat. It also indicates that the maximum wind speed is 4.75 m / s in April and the minimum wind speed is 2.75 m / s in November.

From figure 5, we can observe how k and c influence our observations indicating Gujarat and Tamil Nadu better sites for wind energy as compared to Rajasthan. Also, we can observe the variation in curves as represented in the graphs and how the shape factor varies in the data.

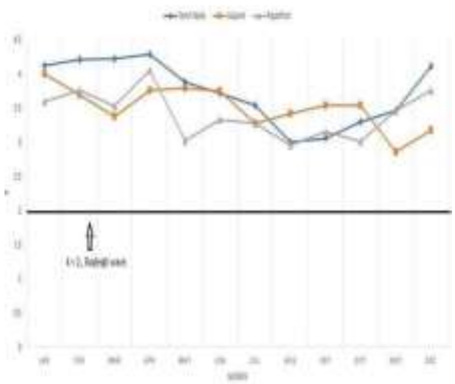

Fig.5: Shape factor (k) vs no. of months

The results show the difference in shape factor and power factor in different seasons. The monthof June, the hottest among all other months indicates that the curve line of Gujarat and Tamil Nadu meet each other. Similarly, in November, Tamil Nadu and Rajasthan show the same values of shape factor and thus stand more promising ascompared to Gujarat.

In figure 6, we notice an increase in the curve of Gujarat in the month of May and August and thena slight decrease in the oncoming of the winter season. Tamil Nadu however acts more promising in the month of December due to the favorable climatic conditions in the state

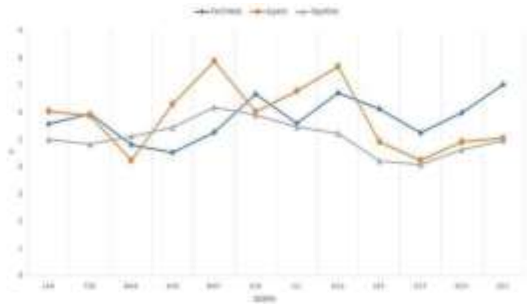

Fig.6: Scale factor (c) vs no. of months

6. CONCLUSION

This paper shows the generation of electricity through use of renewable energy sources which iswind energy. Wind power is a fast-growing greenindustry and will be a major source of renewable energy on the planet in the near future. In this paper, we have tried to study how the productionof electricity from a wind turbine occurs in a simple way. We also took the path to the equation used to calculate this wind energy and use it to ouradvantage. Since existing power sources are on the verge of extinction, this renewable energy source can emerge as a promising source of electricity if used properly.

Wind power potential in three possible wind zones has been analyzed in this analysis using thewidely used.

Weibull distribution method. Weibull parameterslike shape and scale features are calculated in different ways. The results concluded that according to Power Density Method, Gujarat is the state with high wind energy potential in India.Also. The fact that Tamil Nadu is the state with the highest

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