Evaluation of Energy in Wind Turbine System Using Probability Distribution

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Article Info

ABSTRACT

In this work, annual energy output of a variable speed wind turbine is analyzed using annual Weibull wind speed probability distribution function. The power coefficient variety with tip speed proportion in torque control district and pitch point variety for most extreme power yield from wind turbine are examined for distinguishing control framework parameters. The wind turbine power output and variation of power coefficient with tip speed ratio as well as pitch angle are examined / reported using annual Weibull distribution function. Finally the variation of the estimated annual energy output of the given wind turbine with the mean wind speed is presented.

Keywords:
Wei Bull Distribution Function
Wind Power Prediction
Wind Speed Probability
Distribution Function

1. INTRODUCTION

The estimation of the annual energy output of a wind turbine to be installed at a particular site is very important in the assessment of economic feasibility of wind turbine installation [1],[2]. The output power of a wind power plant depends on many parameters (e.g. available wind speed resources, operational and power characteristics of the wind turbine).

2. BACKGROUND

Wind speed circulation investigation is required for choice of wind turbine and furthermore to design its control framework. The Weibull capacity is the one that most usually utilized for wind vitality forecast despite the fact that numerous numerical capacities have been proposed for wind speed likelihood appropriation capacities [3].

3. THE PROBLEM

The renewable energy is used in recent days especially solar is widely used. The solar power generation is only in day hours but in wind has generates power in both during day and night. The wind generates high power compared to other renewable energy.
4. PROPOSED SOLUTION

This paper introduces the portrayal of assessing the yearly vitality yield for a variable speed FRC wind turbine combined with a synchronous generator utilizing Weibull factual appropriation of wind speed Experimental Investigations on The Performance of A Solar Pond by using Encapsulated Pcm with Nano particles is discussed in [4]-[6]. Additionally in this work, variety of the yearly vitality yield with the mean wind speed is considered for augmenting the wind turbine control yield [7].

![Figure 1. Typical FRC Wind Turbine Configuration](image)

Wind turbine should be operated between cut-in wind speed and rated wind speed to extract the maximum power from the wind by keeping the pitch angle and the tip speed ratio at their optimum values [8].

5. WIND SPEED DISTRIBUTION

The wind data can be well fitted into Weibull distribution function. The expression of Weibull distribution function which describes the probability of having a wind speed \( u \) during the year is expressed in (1) [9]. For the example, it is characterized with specified Weibull parameters: \( a = 8.3 \text{ ms}^{-1} \), \( k = 1.9 \) and illustrated in Figure 2.

![Figure 2. Weibull Probability Density Distribution of Wind Speed at 90m Aboveground](image)

6. OPERATIONAL CHARACTERISTICS OF THE WIND TURBINE

The operation of the wind turbine is divided into few regions, in order wind turbine to be operated to maximize the power output while ensuring the safety of the system as illustrated in Figure 3 [8].

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The output power of a wind turbine is expressed in (1) [8].

\[ P_{out} = \frac{1}{2} \rho A u^3 C_p(\lambda, \beta) \]  

where,
\( \rho \): the air density (1.25 kg/m\(^3\))
\( A \): the area swept by the rotor in m\(^2\)
\( u \): the wind speed in ms\(^{-1}\)
\( C_p \): the power coefficient
\( \beta \): pitch angle in degrees
\( \lambda \): tip speed ratio

In this work, MOD-2 wind turbine is utilized and after that the power coefficient (Cp) of MOD-2 wind turbine and the tip speed proportion of the turbine are communicated in (4) [10] and (5) separately.

7. OUTPUT CHARACTERISTICS OF THE SYNCHRONOUS GENERATOR

The shaft of the wind turbine is connected to the generator through a gear box. Then at the generator, the transmitted mechanical energy is transferred into electrical energy through a magnetic medium. Analysis on Solar Panel Crack Detection Using Optimization Techniques. Journal of Nano-& Electronic Physics is explained in [11]. Hence, the total power output from the turbine is not converted into electrical power as it is, due to the mechanical and electrical losses in the energy conversion process [8]. In this work, typical power characteristic of a medium scale synchronous generator coupled with an AC-DC-AC link shown in Figure 4 is used [12].
8. ESTIMATION OF ANNUAL ENERGY OUTPUT OF THE WIND TURBINE

By in-cooperating the Weibull distribution, the energy contribution at wind speed $u$ to the energy output of the system can be expressed in (2) [12].

$$P(u) = w(u)P_{electrical}$$  \hspace{1cm} (2)

where,

$P(u)$ : Predicted energy output [Wh]

$w(u)$ : Probability of having a wind speed $u$

$P_{electrical}$: The output power of the synchronous generator at wind speed ($u$)

For each set of Weibull parameters, the variation of the energy contribution to the annual energy output is considered with the 1.0 $ms^{-1}$ class intervals over the range of wind speed $0 - 30$ $ms^{-1}$. Then the total annual energy generation of the system for each set of Weibull parameters over the considered range of mean speed, can be calculated by taking summation of the estimated energy output of the wind turbine over the range of possible wind speed $0 - \infty$. The estimated total annual energy output of the wind turbine over the range of mean wind speed $5 - 15$ $ms^{-1}$ for different shape factors ranging from 1.4 – 1.9 is illustrated in Figure 5.

![Figure 5. Variation of Estimated Total Annual Energy Output of the Wind Turbine with the Mean Wind Speed at Different Shape Factors](image)

9. CONCLUSION

This work introduces a method of estimating the annual energy output for a variable speed FRC wind turbine coupled with a synchronous generator using Weibull statistical distribution of wind speed. So as to survey the monetary attainability, operational execution of a wind turbine to be introduced, assurance of yearly vitality yield by the framework is essential. The wind turbine control yield and variety of energy coefficient with tip speed proportion and also pitch point are analyzed. It has been observed that the power regulation of the wind turbine system can be improved using pitch controlling above the rated wind speed and below the cut-off wind speed.

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