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Evaluation of Energy in Wind Turbine System Using Probability Distribution

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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 Wei bull distribution function. Finally the variation of the estimated annual energy output of the given wind turbine with the mean wind speed is presented.

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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 portrays an approach 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].

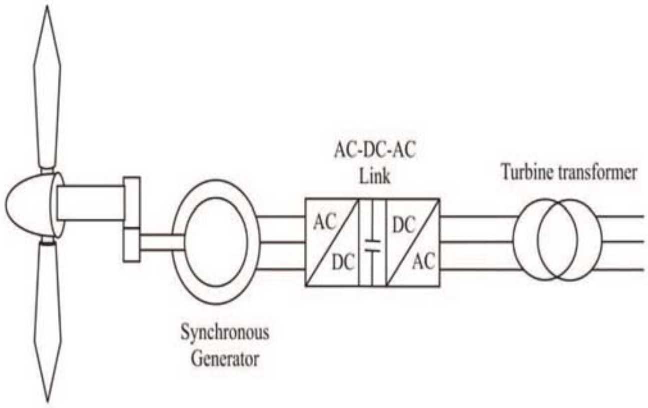

Figure 1. Typical FRC Wind Turbine Configuration

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

5. WIND SPEED DISTRIBUTION

The wind data can be well fitted into Weibull distributionfunction. The expression of Weibull distribution functionwhich 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 Weibullparameters: $a = 8.3\ ms{-}1,\ k = 1.9$ and illustrated in Figure 2.

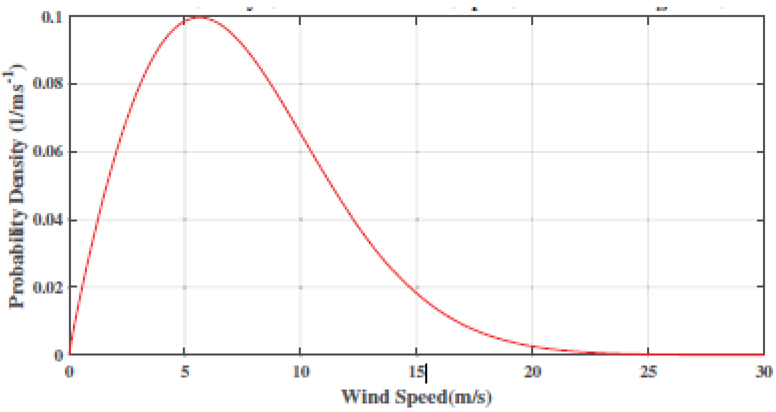

Figure 2. Weibull Probability Density Distribution of Wind Speed at 90m Aboveground

6. OPERATIONAL CHARACTERISTICS OF THE WIND TURBINE

The operation of the wind turbine is divided into fewregions, in order wind turbine to be operated to maximizethe power output while ensuring the safety of the system asillustrated in Figure 3 [8].

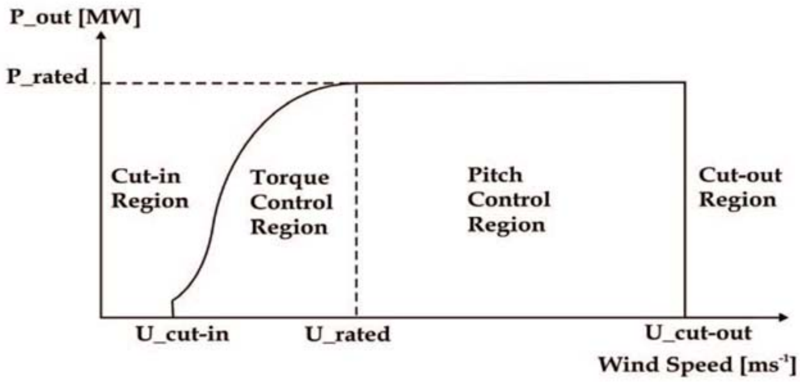

Figure 3. Operational Regions of a Wind Turbine

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

$$Pout = 1/2\rho A u 3 Cp(\lambda, \beta) \quad (1)$$

where,
ρ : 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
Cp: the power coefficient
β : pitch angle in degrees
λ : 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 generatorthrough a gear box.Then at the generator, the transmittedmechanical energy is transfered into electrical energy througha 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 theturbine is not converted into electrical power as it is, due tothe mechanical and electrical losses in the energy conversionprocess [8]. In this work, typical power characteristic of an medium scale synchronousgenerator coupled with an AC-DC-AC link shown in Figure 4 is used [12].

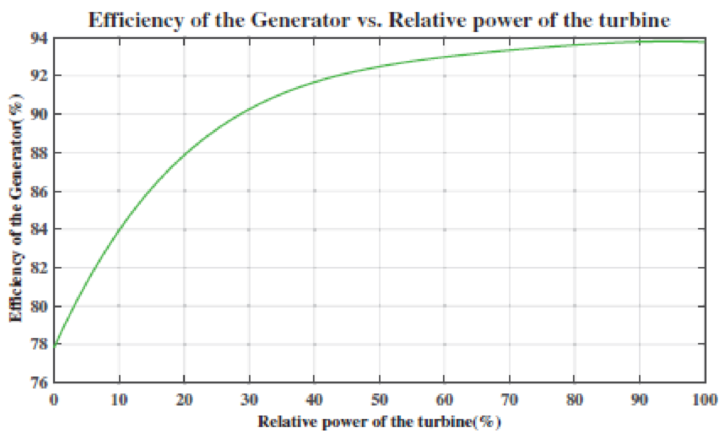

Figure 4. Variation of the Efficiency of Synchronous Generator with the Relativemechanical Power of Turbine

8. ESTIMATION OF ANNUAL ENERGY OUTPUT OF THE WIND TURBINE

By in-cooperating the Weibull distribution, the energy contributionat wind speed u to the energy output of the systemcan be expressed in (2) [12].

$$P(u) = w(u)Pelectrical \tag{2}$$

where,
$P(u)$: Predicted energy output [Wh]
$w(u)$: Probability of having a wind speed u
$Pelectrical$: The output power of the synchronousgenerator at wind speed (u)

For each set of Weibull parameters, the variation of theenergy contribution to the annual energy output is consideredwith 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 foreach set of Weibull parameters over the considered range ofmean speed, can be calculated by taking summation of theestimated energy output of the wind turbine of wind speed $u$over the range of possible wind speed $0{-}\infty$. The estimatedtotal annual energy output of the wind turbine over the rangeof mean wind speed $5 - 15\ ms{-}1$ for different shape factorsranging from $1.4 - 1.9$ is illustrated in Figure 5.

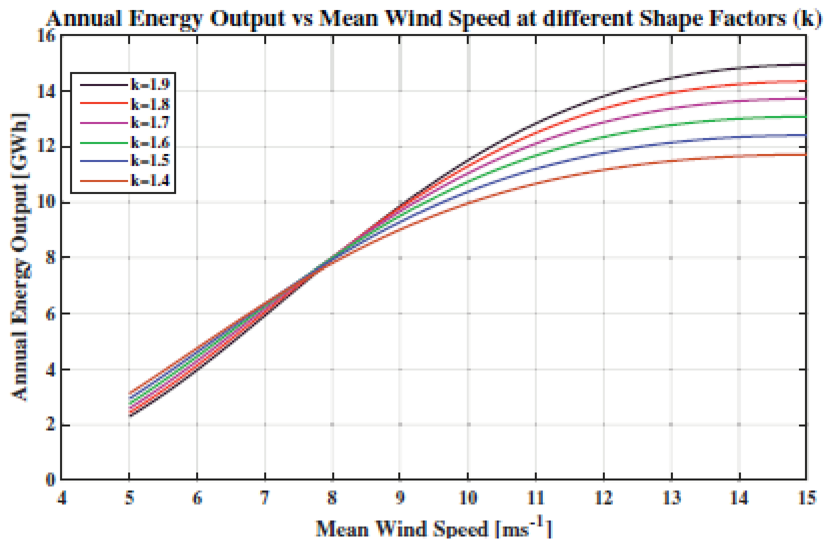

Figure 5. Variation of Estimated Total Annual Energy Output of the Wind Turbine with the Mean Wind Speed at Different Shape Factors

9. CONCLUSION

This work introduces a method of estimating the annualenergy output for a variable speed FRC wind turbine coupledwith a synchronous generator using Weibull statistical distributionof wind speed. So as to survey the monetary attainability, operational execution of a twist 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 thewind turbine system can be improved using pitch controllingabove the rated wind speed and below the cut-off wind speed.

REFERENCES

[1] Haque M. H., *et al.*, "Estimation of annual energy delivered by a variable speed wind generating system using historical wind data," in *Developments in Renewable Energy Technology (ICDRET), 2014 3rd International Conference,* pp. 1-6, 2014.
[2] Sunderland K., *et al.*, "Small wind turbines in turbulent (urban) environments: A consideration of normal and Weibull distributions for power prediction," *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 121, pp. 70-81, 2013.
[3] Olimpo A. L., *et al.*, "Wind Energy Generation Modelling and Control," in *Library of Congress Cataloguing-in-Publication Data,* 2009.

[4] Sarathkumar P., *et al.*, "Experimental Investigations on The Performance of a Solar Pond by using Encapsulated Pcm with Nanoparticles," *Materials Today: Proceedings,* vol/issue: 4(2), pp. 2314-2322, 2017.

[5] N. M. Ahmed, *et al.*, "Optimal Sizing and Economical Analysis of PV-Wind Hybrid Power System for Water Irrigation using Genetic Algorithm," *International Journal of Electrical and Computer Engineering*, vol/issue: 7(4), pp. 1797, 2017.

[6] M. A. Ebrahim, "Towards Robust Non-Fragile Control in Wind Energy Engineering," *Indonesian Journal of Electrical Engineering and Computer Science*, vol/issue: 7(1), pp. 29-42, 2017.

[7] A. Sundaram and G. P. Ramesh, "Sensor less Control of BLDC Motor using Fuzzy logic controller for Solar power Generation," *IJMSR*, vol/issue: 9(2), pp. 70-79, 2017.

[8] Celik A. N., *et al.*, "Critical evaluation of wind speed frequency distribution functions," *Journal of renewable and sustainable energy*, vol/issue: 2(1), pp. 013102, 2010.

[9] Anderson P. M. and Bose A., "Stability simulation of wind turbine systems," *IEEE transactions on power apparatus and systems*, vol. 12, pp. 3791-3795, 1983.

[10] Konara K. M. S. Y., *et al.*, "Estimation of annual energy output of a wind turbine using wind speed probability distribution," in *Electrical Energy Systems (ICEES), 2016 3rd International Conference,* pp. 117-121, 2016.

[11] Lydia M. D., *et al.*, "Analysis on Solar Panel Crack Detection Using Optimization Techniques," *Journal of Nano-& Electronic Physics*, vol/issue: 9(2), 2017.

[12] Celik A. N. and Kolhe M., "Generalized feed-forward based method for wind energy prediction," *Applied energy*, vol. 101, pp. 582-588, 2013.