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MODELLING AND ASSESSMENT OF WIND ENERGY RESOURCE FOR POWER DISTRIBUTION SYSTEM

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ABSTRACT

This paper presents Stochastic Modeling for investigating the performance of wind energy technology using wind speed data for the city of Maiduguri (11.850 N; 13.083 E; altitude 354 m), North-Eastern Nigeria. In this paper, Probability Density Function (PDF) used to match wind speed distribution against wind energy that are contingent on the assessment method and region of interest to enhanced the voltage profile by employing Distributed Generator system (DGs). Many studies on wind energy are based on average wind variation, however, study on elaborate voltage profile distribution of different seasonal weather conditions are lacking. Site matching or fitting presented in these studies is used to determine the best energy distribution for improving voltage profile using wind energy. Wind characteristics obtained from Nigerian Metrological Department are categorize into the three basic seasons that is cold, hot and raining seasons were assessed and evaluated after getting the wind power profile against wind speed PDF Characteristic. Using Probabilistic approach, the maximum power output was found to be 550kW, 350kW, 350kW for raining, hot and cold seasons respectively.

KEYWORDS: Renewable Energy, Probability Density Function, Distributed Generations, Wind Speed, Wind Turbine Generator.

INTRODUCTION

Energy is an important input in all sectors of any country's economy. The standard of living of a given country can be directly related to its per capita energy consumption. Energy crises are usually due to the following reasons; firstly, the population of the world has increased rapidly and secondly, standard of living of human beings has increased.[1]

Today, every country draws its energy needs from two or more sources. This could be via commercial sources (such as fossil fuels, hydroelectric power and nuclear power) or via non-commercial sources such as animal waste, solar, wood and agricultural waste.

Alternative energy is a term that refers to any source of re-usable energy intended to replace fuel sources without the undesired consequences of fossil fuels such as high carbon dioxide emissions, which is considered to be the major contributing factor of global warming according to the inter-governmental panel on climate change.[2] The renewable energy sources have proven to be of great help in reducing the amount of toxins which are by-products of the energy exploits. Increased population growth and economic development are accelerating the rate at which energy, and in particular electrical energy is being demanded.[3] All methods of electricity generation have consequences for the environment, so meeting this growth in demand, while safe guarding the environment poses a growing challenge.

Deregulation in the power market has encouraged the move towards distributed generation, where many smaller generating plants located close to a few large centrally located power stations are penetrating interconnected power systems. Nowadays, generating electricity using decentralized generators of relatively small scale is attracting a great interest from power systems energy researchers. Such kind of generation generally known as distributed generation systems (DGs).[4] The reliability of the distribution system as well as the quality of the electrical energy can be improved by placing the sources close to the consumers and the efficiency is improved by locally generating electrical and thermal energy.[5]

Wind energy is a promising source of electrical power because it is a clean and renewable resource. However, because wind speeds vary by time of day, season, and even from one year to the next, wind energy is an intermittent resource.[6] The presence of renewable energy resources at the distribution level allows for improvement of power network performance for meeting the required energy balance between supply and demand, with reduced investment in generating resources and transmission system.

This paper presents Stochastic Modelling for investigating the performance of wind energy technology using wind speed data for the city of Maiduguri. The objective of the study is to assess and model the wind energy resource using probabilistic approach.

METHODOLOGY

The most acceptable employed parameters in Weibull Probability Distribution Function (W-PDF) for wind speed estimation are Mean Wind Speed (v) and the Standard Deviations (σ). W-PDF is an important tool in estimation future wind power in different regions, since most of the statistical evaluation focuses mainly on efficiency of Wind Turbine Generators (WTGs). Wind speed data was obtained from Nigerian Metrological Department (NIMET) and is used as input to the probabilistic wind models in equations (1-2) to obtain the Probability Density Function (PDF) of the wind energy system. Equation (3) was used to obtained power output by the wind Energy technology. Analysis and evaluation was carried out using MATLAB 2012 Graphical user Interface.[7]

The Wind Energy System Model

The introduction to variability of the wind is achieved by statistical analysis of historical data of wind speed over a period of time. The data was sourced from Nigerian Meteorological Department (NIMET), Maiduguri International Airport. The wind speed is truly variable depending on the location and time. There are many probability distribution functions that describe wind speed distribution in a particular location. Raleigh and Weibull distributions are the two most widely used [8]. The Weibull distribution is adopted in this study because of its versatility and found to give a better fit with experimental data [9-10]. Parameters of Weibull function can be obtain by the following formula:

$$f(v) = \left(\frac{\alpha}{\beta}\right)\left(\frac{v}{\beta}\right)^{\alpha-1} \exp\left[-\left(\frac{v}{\beta}\right)^{\alpha}\right] \quad (1)$$

Where α and β are the Weibull shape and scale parameters that are used to determine its location and describe the dispersion of the given data. And v is the wind speed (m/s), the two parameters α and β are related to the average wind speed by

$$\bar{v} = \beta\Gamma\left(\frac{1}{\alpha} + 1\right) \quad (2)$$

Where Γ the gamma distribution function

The real power output for a wind turbine is given by equation (3)

$$P_m = ½(ρ.πR^2.V^3.C_P) \quad (3)$$

Where ρ is the air density in kg/m^3, R is the turbine radius in m, C_p is the turbine co-efficient power conversion efficiency of a wind turbine and V is the wind speed in m/s.[9]

RESULTS AND DISCUSSION

Stochastic modelling of wind power plays a vital role in formulating, planning and effecting wind turbine. These necessitate development of link between wind speed profile and wind power characteristics. Site-Matching explicated in this study for PDF development was to evaluate and assess the most favourable wind speed distribution of wind turbine generators (WTGs). Many studies on wind energy used average wind variation however, it is necessary to have elaborated skewed distribution profiling. Figure 1, 2 and 3 shows the waveform of power output by the WTGs during cold, hot and raining seasons respectively.

Case 1: Cold season (December, 2013)

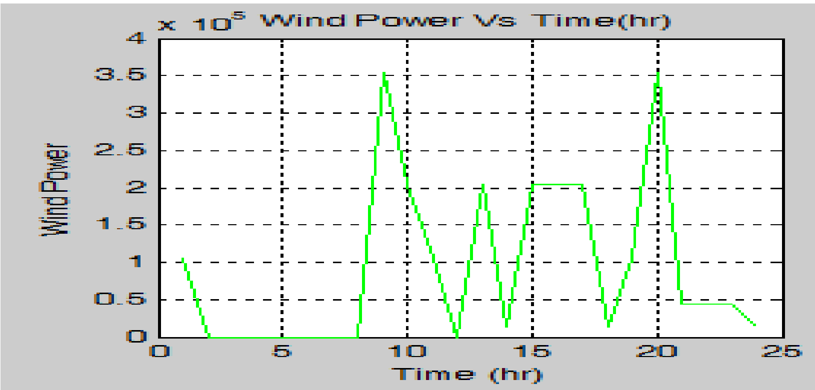

Figure 1: Waveform of Power Output by the Wind Turbine with respect to time for cold season.

Case 2: Hot Season (April 2013)

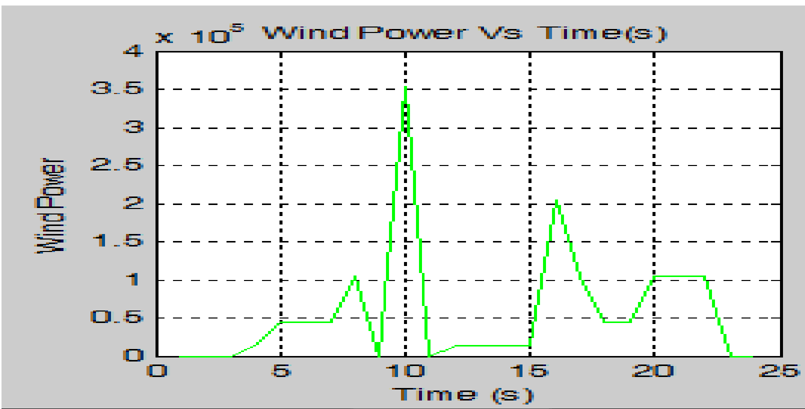

Figure 2: Waveform of Wind Power Output per unit time for hot season.

Case 3: Rainy season (August 2013).

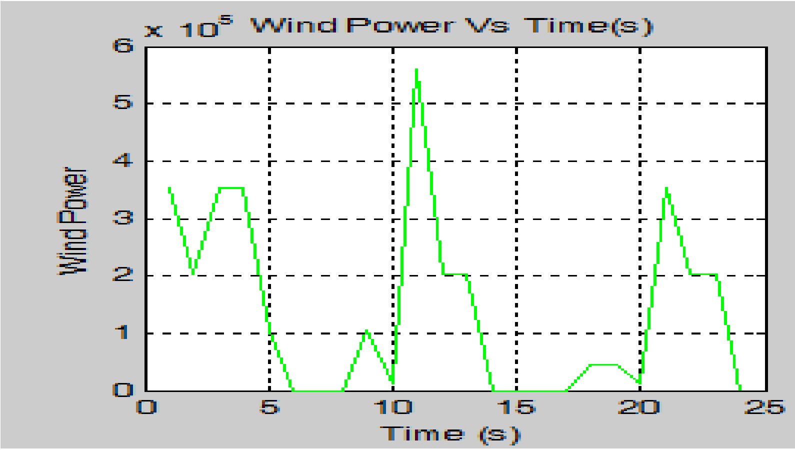

Figure 3: Waveform of Wind Power Output per unit time for the rainy season.

The maximum power output by the wind turbine for both cold and hot seasons was 350kW as captured in figure 1 and 2 respectively. Though figure 3 which illustrate the raining season the power output increases to 550kW due to high rate of wind prevailing during rainy season in the region.

Figure 4, 5 and 6 displayed the performance of the system interms of voltage profile meant for the compensated node with and without the WTG for the cold, hot and raining season respectively.

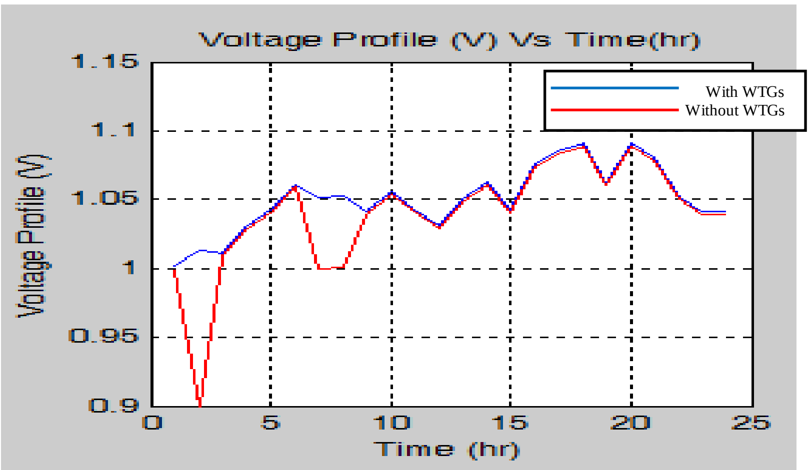

Figure 4: Voltage Profile Waveform at the Compensated Node with and without DG during the cold season.

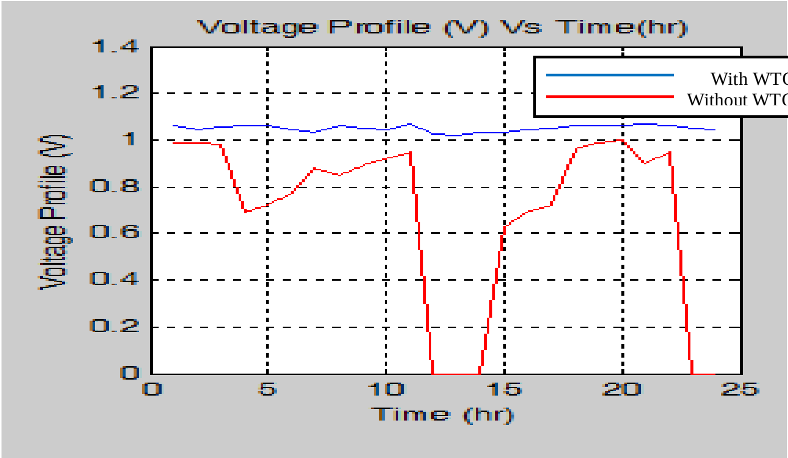

Figure 5: Voltage Profile Waveform at the Compensated Node with and without DG with respect to time during hot season.

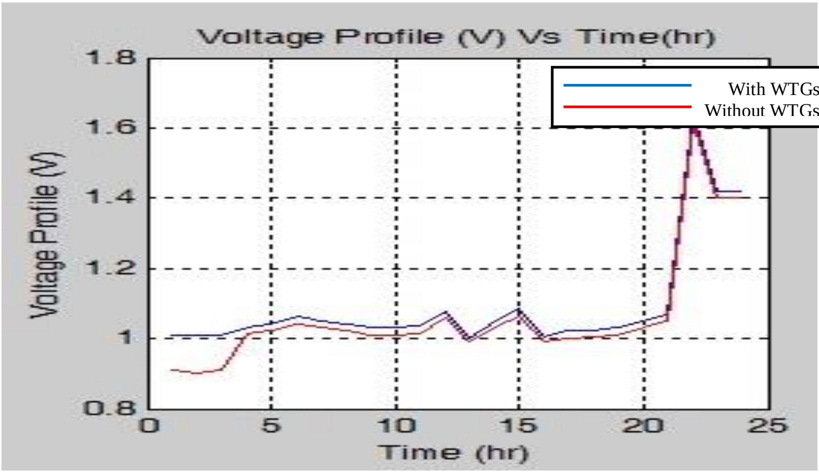

Figure 6: Voltage Profile Waveform at the Compensated Node per unit time with and without DG during rainy season.

Figure 4 shows a voltage profile waveform in p.u. of the nominal voltage for cold season of the compensated bus with and without WTG with respect to time. A voltage dip was noticed before insertion of DGs at 02hrs; with the insertion of DG, there was significant impact on the system voltage with the nominal voltage improved and maintained at above 1.0 p.u level. Figure 5 shows a voltage profile waveform in p.u of the nominal voltage during hot season of the compensated bus with and without DGs with respect to time. On two occasions, system failure was observed between the hours of 12-14hrs and 23-24hrs before insertion of the DGs. However, with placement of DGs, there is clear improvement and stabilization in voltage profile on that particular node. Similarly, figure 6 presents the voltage profile waveform in p.u for raining season with and without DGs on the network. The result shows a steady improvement in the voltage during the season under review.

CONCLUSION

This paper has presented Stochastic Modelling technique for investigating the performance of wind energy technology using wind speed data for the city of Maiduguri, the objectives of the work has been achieved which is to model the wind speed data using probabilistic approach. Summary of the findings are as follows: maximum and minimum seasonal wind speed values are 6 to 2 Nautical miles per hour respectively, and the voltage profile has relatively enhanced, thus, power flow improvement.

REFERENCES

1. Bloem, J. Distributed Generation and Renewables – Integration and Interconnection, Power Quality and Utilization Guide – LPQI Program, Issue Winter, 2006.
2. Dorin B., Cristian D., Adrian G., & Adran D. Isolated Hybrid Solar-Wind-Hydro Renewable Energy Systems. Petru Maior University of Tg. Mures Electrical engineering Department Romania, 2009.
3. Burton, T., Sharpe, D., Jenkins, N. and Bossanyi, E. Handbook of Wind Energy, ISBN 0-471-48997-2, The Atrium, Southern Gate, Chichester, England, John Wiley and Sons Ltd, 2004.
4. Aldo, V. Fundamentals of Renewable Energy Processes, a thesis project submitted to the Department of Power System Engineering, Stanford University, England, 2005.
5. Alarcon, A. and Haesen, E. “Multi-objective planning framework of stochastic and controllable distributed energy resources” IET Renewable Power Generation, 2009; 3: 227-238.
6. Microsoft ® Encarta ®. © 1993-2008 Microsoft Corporation, 2009.
7. MATLAB Software -www.mathworks.com/matlabcentral, 2012.
8. Musa, B. U. and Gwoma, Z. M. Analysis of Wind Energy Conversion Systems in North East Nigeria Using Present Value Cost Method. University of Maiduguri, Borno State of Nigeria, 2013; 2(8): 28-34.
9. S. K. Nandi, Prospect of Wind-PV-Battery hybrid power system as an alternative to grid extension in Bangladash, Energy, 2010; 35(7): 3030-3017.
10. We bull W. A. Statistical distribution of wide applicability: Journal of Applied Mechanics, 1957; 18: 293-7.
11. *http://www.go* thogle.com ‘Wind Energy Toolbox’ Beta conversion\.