Extraction of Wind Power at different Windy Locations in Bangladesh

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Abstract. In developing country like Bangladesh, the demand of electrical energy is very higher than the available production. Wind energy is an important source of electrical power in recent years. Its main advantage comes from the fact of being a renewable and environmental-friendly energy. Bangladesh being a tropical country does have a lot of wind flow in different seasons of the year. However, there are some windy locations in which wind energy projects could be feasible. This paper studied previously collected data on the wind resources available in Bangladesh. By analyzing this data, this work has been carried out to predict if these wind energy resources are sufficient for wind power, in the hope to determine to what extent the electrical energy produced from wind is capable of satisfying the energy demands. The wind speed data used in the analysis is the real data, which is measured in selected windy locations. The simulation analyses have been performed by using Windographer.

Keywords: Renewable energy, Wind energy, Windographer, Wind power class, Bangladesh.

1 INTRODUCTION

Now a day's worldwide energy crisis is one of the great problem. The interest in renewable energy has been revived over last few years, especially after global awareness regarding the ill effects of fossil fuel burning. The use of renewable energy technology to meet the energy demands has been steadily increasing for the past few years, however, the important drawbacks associated with renewable energy systems are their inability to guarantee reliability and their lean nature. Renewable energy sources are considered to be the better option to meet these challenges. This paper deals with an estimation of electrical energy from the previously collected wind energy data on the windy locations in Bangladesh by using windographer. Reduced magnet price has made synchronous generators with permanent magnet excitation (PMSG) an attractive alternative in the last couple of decades. Permanent magnet synchronous generators (PMSG) applied to wind energy conversion system (WECS) using variable speed operation is being used more frequently in wind turbine application. Variable speed systems have several advantages over the traditional method of operating wind turbines, such as the reduction of mechanical stress and an increase in energy capture. The amount of energy captured from a WECS depends not only of the wind at the site, but depends of the control strategy used for the WECS and also of the conversion efficiency. The software is used for analysis; Windographer is a wind data analysis program. It reads raw data files, does advanced statistical processing of the data, produces a variety of graphs for visualizing the data, and provides tools for quality control of the data. Windographer has been developed by Mistaya Engineering. It allows opening three types of raw data files: text files, NRG Systems data logger (.RWD) files, and Microsoft Excel (.xls) files. When opening one or more raw data files, Windographer creates a Windographer document and stores a copy of the data from each file in the document. Windographer never modifies the collected wind data in the original data files.

2 MOTIVATIONS

Recently, the generation of electricity using wind power has received much interest and considerable attention all over the world. Bangladesh is situated between 20.30 – 26.38 degrees North latitude and 88.04 – 92.44 degrees east. It has seven hundred Km coastal line. Analyzing the upper air data by CWET India show that wind energy resource of Bangladesh is poor in wind resource for grid connected wind parks. At present several wind resource assessment program of BPDB is ongoing in the country. From the previous studies it can be inferred that the small wind turbines can be installed in the coastal regions of the country. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind is a renewable resource because it is inexhaustible. It is a result of the sun shining unevenly on the earth. The corresponding daily and seasonal changes in temperature consistently generate wind, producing a fuel source that can never be depleted. Wind power is the world's fastest growing electricity generation technology.

3 WIND TURBINE SYSTEM

The In a wind turbine system, the kinetic energy in the wind is converted into rotational energy in a rotor of the wind turbine. The rotational energy is then transferred to a generator, either directly or through a gearbox for stepping up the rotor speed. The mechanical energy is then converted to electrical energy (variable-frequency, variable-voltage) by the generator. From the generator, the electrical energy is transmitted to a utility grid either directly or through an electrical energy conversion stage that produces constant-frequency, constant-amplitude voltage suitable for interface to the utility. Figure 3.1 demonstrates, Region I, Where the wind speed is below the cut-in speed. The power in the wind is insufficient to overcome the power losses within the turbine system. Region II, Where the wind speed is between the cut-in speed and the rated wind speed. Generally, the rated wind speed is the wind speed at which the maximum output power of the generator is reached. Region III, Where the wind speed is between the rated wind speed and the cut-out speed. The cut-out speed is the maximum wind speed at which the turbine is allowed to deliver energy. Usually, the cut-out speed is limited by engineering design and safety constraints.

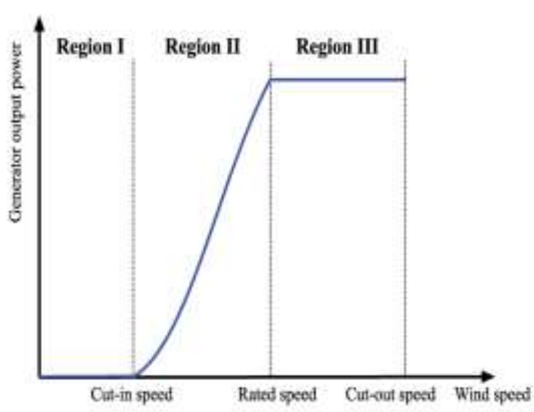

Fig. 3.1. Characteristic of a typical Wind turbine generator.

The output power of the wind turbine is given by the following equation.

$$P_m = \tfrac{1}{2} C_p(\beta, \lambda) \rho A V^3 \qquad (1)$$

Where,

Symbol	Name of the Parameter	(Unit)
C_p =	Performance coefficient	(Dimension less)
ρ =	Air density	(kg/m^3)
A =	Turbine swept area	(m^2)
V =	Wind speed,	(m/s)
B =	Blade pitch angle,	(Degree)
λ =	Tip speed ratio of the rotor blade,	(Dimension less)

Since wind turbine output is proportional to the cube of the wind speed, the wind turbine generator output fluctuates due to wind speed variations. Hence, if the power capacity of wind power generators becomes large, wind power generator output can have an influence on the power system frequency. Energy storage devices must be the good tool for smoothing the wind generator output fluctuations without the loss of any energy; however, these methods have a cost problem. The Cp is the fraction of the upstream wind power, which is captured by the rotor blades. The remaining power is discharged or wasted in the downstream wind.

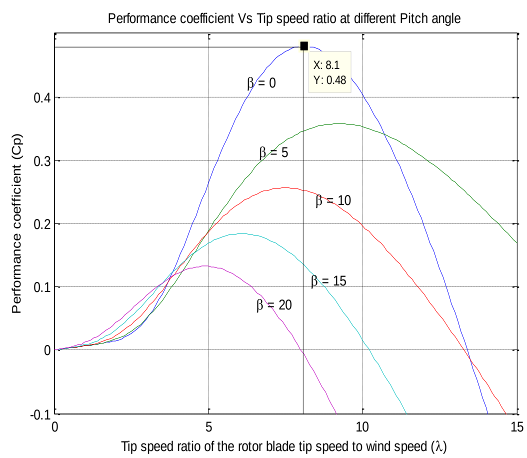

Fig. 3.2. Performance coefficient vs. Tip speed ratio at different pitch angle

From the C_p-λ characteristics, for different values of the pitch angle β, are illustrated above. The maximum value of Cp ($C_{p\ max}$ = 0.48) is achieved for β = 0 degree and for λ = 8.1. It has the maximum value of 0.59. The maximum power is extracted from the wind at that speed ratio. The theoretical maximum value of Cp is 0.59. In practical designs, the maximum achievable Cp is below 0.5 for high-speed, two-blade turbines, and between 0.2 and 0.4 for slow speed turbines with more blades. The wind turbine output mechanical torque is affected by the C_p. In order to maximize the aerodynamic efficiency, the T_e of the PMSG is controlled to match with the wind turbine T_m to have maximum possible C_{pmax}. With a power converter, adjusting the electrical power from the PMSG the T_e may be controlled, therefore the rotor speed can be controlled. The wind power class is a number indicating the mean energy content of the wind resource. Wind power classes are based on the mean wind power density at 50 meters above ground. According to the Wind Energy Resource Atlas of USA, wind power class distributions are shown below.

Table 1. Wind Power Class

Wind Power Class	Description	Power Density at 50m (W/m^2)
1	Poor	0-200
2	Marginal	200-300
3	Fair	300-400
4	Good	400-500
5	Excellent	500-600
6	Outstanding	600-800
7	Superb	800-2000

4 REAL WIND DATA ANALYSIS

The wind is never steady at any site. It is influenced by the weather system, the local land terrain, and the height above the ground surface. The wind speed varies by the minute, hour, day, season, and year. Therefore, the annual mean speed needs to be averaged over 5 or more years. However, long-term measurements are expensive, and most projects cannot wait that long. In such situations, the short term, say one year, data is compared with a nearby site having a long term data to predict the long term annual wind speed at the site under consideration. This is known as the “measure, correlate and predict (mcp)” technique. The LGED and BPDB provided us the data of January 2007 to January 2008 for three regions named Saint Martin, Cox’s Bazar, and Patenga. We have analyzed these data by the help of software named Windographer. Most of the previous wind speed data in Bangladesh available from the Bangladesh Meteorological Department at lower height. However, normal hub-heights of modern wind turbines ranges from 25 to 45m.Thus using meteorological data, designing wind energy conversion system would end in a failure and there are some previous experiences. Wind data were recorded from January 2007 to January 2008 as a daily basis and recorded by a data logger. These types of wind measurement systems provide a more accurate assessment than anemometer wind resource evaluation system of the wind resource at any location, but are more expensive. Measurement equipment is set high enough to avoid turbulence created by trees, buildings or other obstructions. The wind speed frequency distribution is processed from these data and fitted to Weibull function to predict the nature of wind. Monthly average wind speeds are measured at 30m height at different locations are summarized below.

Table 2. Monthly average speeds measured at 30m height at different

Month	Measured Wind speed in Saint Martin at 30m height	Measured Wind speed in Cox’s Bazar at 30m height	Measured Wind speed in Patenga at 30m height
January	4.48 ms^{-1}	4.09 ms^{-1}	3.95 ms^{-1}
February	4.62 ms^{-1}	4.17 ms^{-1}	4.02 ms^{-1}
March	4.54 ms^{-1}	3.96 ms^{-1}	3.73 ms^{-1}
April	4.09 ms^{-1}	3.82 ms^{-1}	3.56 ms^{-1}
May	5.37 ms^{-1}	4.79 ms^{-1}	4.23 ms^{-1}
June	6.47 ms^{-1}	5.23 ms^{-1}	4.87 ms^{-1}
July	5.86 ms^{-1}	5.32 ms^{-1}	4.98 ms^{-1}
August	5.98 ms^{-1}	4.93 ms^{-1}	4.39 ms^{-1}
September	4.77 ms^{-1}	4.42 ms^{-1}	4.11 ms^{-1}
October	4.41 ms^{-1}	4.09 ms^{-1}	3.79 ms^{-1}

November	3.83 ms^{-1}	3.81 ms^{-1}	3.63 ms^{-1}
December	4.31 ms^{-1}	3.97 ms^{-1}	3.48 ms^{-1}

5 SIMULATION RESULT ANALYSIS

Wind power is fluctuating in nature because wind speed varies as it depends upon geographical and metrological condition. As a result the power fluctuates, wind generation system will affect interconnected power system, if suitable technical device are not connected with grid. At the starting of the year i.e. in January the wind speed is low and it continues to march. From April, the speed starts to increase and during June, July and August. Wind shear profile and wind power class are demonstrated in figure 5.1 to figure 5.6 for different windy locations.

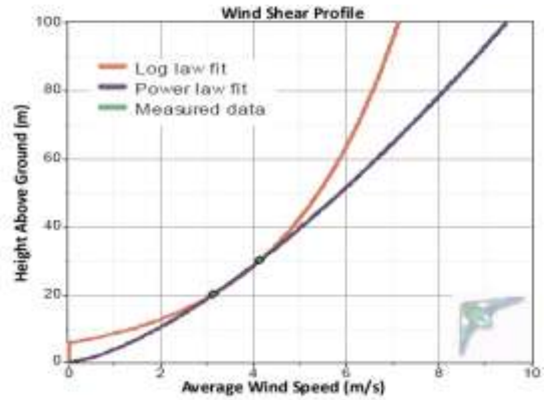

Fig. 5.1. Wind Shear Profile at Saint Martin

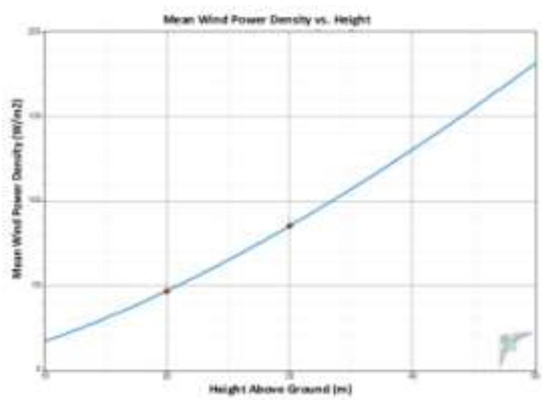

Fig. 5.2. Wind Power Class at Saint Martin

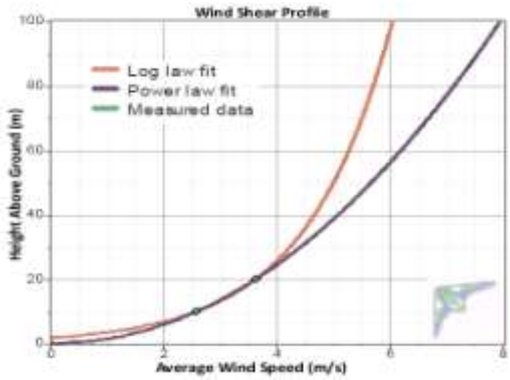

Fig. 5.3. Wind Shear Profile at Cox's Bazar

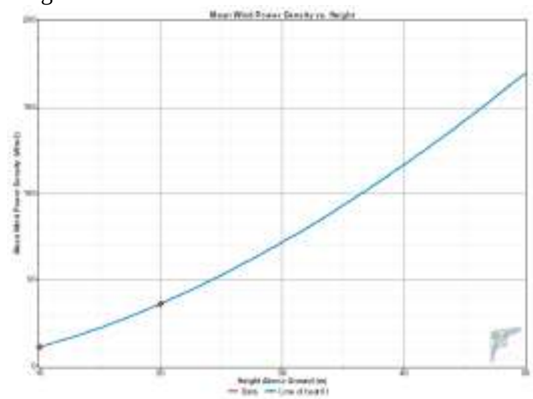

Fig. 5.4. Wind Power Class at Cox's Bazar

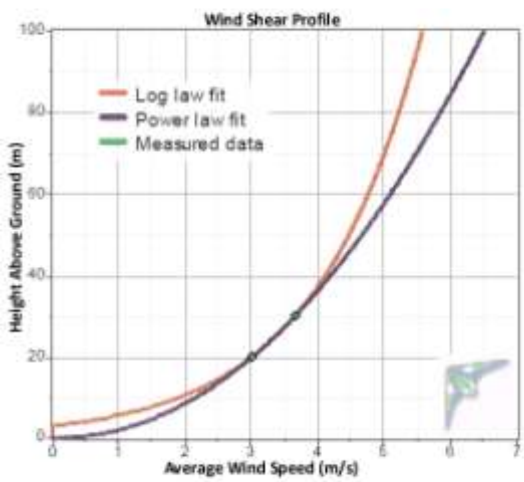

Fig. 5.5. Wind Shear Profile at Patenga

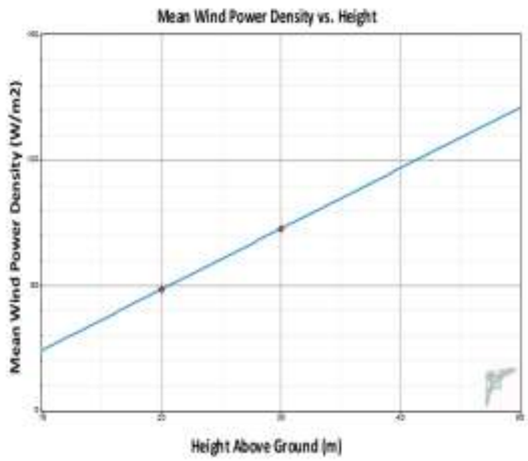

Fig. 5.6. Wind Power Class at Patenga

From the simulated graph by using windographer, obtained results are summarized below to predict if these wind energy resources are sufficient for wind power extraction or not.

Table 3. Comparison of Power Class at different locations

Location's Name	Wind Power Density(W/m^2)	Wind Power Class
St. Martin	182	Poor
Coax's Bazar	171	Poor
Patenga	142	Poor

6 CONCLUSION

The location selected for analysis has poor power class. Thus, from all the aforementioned, it can now be better understood that for the locations, the system like the one which was used for the analysis, cannot meet the energy demands of the area in a totally realistic situation from an economic point of view. The electrical energy produced from windy location selected for analysis is not capable of satisfying the energy demands effectively. It is concluded that Permanent Magnet wind generator topology could be an effective solution in small scale wind industry applications, which can be designed, analyzed and tested in few selected windy locations in Bangladesh.

References

International Energy Agency (1995). *Wind Energy Annual Report*. International Energy Agency Report by NREL.

Mukund R. Patel, (1995). *Wind and Solar Power Systems* (2nd ed.). U.S. Merchant Marine Academy, Kings Point, New York, CRC Press Boca Raton London, New York.

M. Golam Kibria Khan, Talha Rahman and M.M. Alam (2004). *Wind Energy in Bangladesh: Prospects and Utilization Initiatives*. 18-20th December, Dhaka, Bangladesh .

Gupta, A. K. (1997). *Power Generation from Renewables in India*. Ministry of Non-Conventional Energy Sources, New Delhi, India.

Windographer (2010) *Windographer Manual*. Retrieved from: http://www.mistaya.ca/windographer

K. Tan and S. Islam (2004). *Optimum Control Strategies in Energy Conversion of PMSG Wind Turbine System Without Mechanical Sensors.* IEEE Transactions on Energy Conversion, Vol. 19, No. 2, pp. 392-400.

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