ANALYSIS OF WIND ENERGY AT BUET

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Abstract The possibility of harnessing wind energy on a large scale in Bangladesh have been assessed based on the wind data obtained from the Meteorological Department of Bangladesh, so far. Besides some other organizations are doing their works for this purpose. In this paper the variation of wind speed in BUET Campus for the month of August, 2001 will be described and possible wind energy from this location also be studied though the wind speeds are very poor in this location. Continuous wind speeds are measured in the location of BUET Campus for the month of August.2001 by means of a data logger. The stored data are downloaded to a PC through an RS-232 interface cable. Then the collected wind data are processed and analyzed by Weibull Distribution Probability Function. It is observed that the wind speeds are very poor in this location, as the mean speeds are 1.5m/s and during the data collection period the highest wind speed was in the class of 4-5 m/s its frequency was very less. It is so poor compared to that of Coastal region that; it is not advisable to set up a WECS for power in this location. However the objective of this paper is to focus on the wind energy pattern in the BUET Campus.

Keywords: Wind Shear,Lull period

INTRODUCTION

Revering Bangladesh is utilizing wind energy in the sailboats from ancient time. Electricity generation or water pumping system from wind turbine has not started yet. In order to exploit modern wind turbine technology, wind energy database of the desired location is needed. Meteorological department is measuring wind speed at different locations of the country at low height for weather forecasting purpose, which is not sufficient for harnessing wind power.

Recently another project "Wind Energy Resource Mapping (WERM) for Bangladesh based on some specified locations and installation of appropriate Wind-Driven Systems (WDS)" to be done by BUET has been approved by the Department of Environment under "Sustainable Rural Energy" program to assess wind energy potential of Bangladesh. In recent years the demand of energy has increased drastically because of the advance of the industrialization .So besides the limited natural sources of energy, renewable energy has been very important part in the recent years for sustainable development of the country. . So for extraction of wind energy from any site we need a lot of wind speed data collection particularly for that site. Hence a wind speed data measurements, its frequency, and duration etc should be recorded in a systematic way must be carried out. This is essential for studying the effectiveness of several types of WECS For the fulfillment of this purpose, a wind monitoring plant was set-up at BUET Campus location This plant was set-up with a modern electronic digital apparatus. With the rotation of a cup type anemometer, the wind speed data are directly transferred to a PC by RS-232 interface cable as percentage of total block period.

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IMPORTANCE OF WIND DATA

The velocity of wind at which it blows neither repeats it varying pattern, nor any two places on the earth have the identical values. That is why any wind energy project started without analyzing carefully its varying characteristics, must end in a failure. Already some examples of failure are in existence in Bangladesh although wind energy utilities are in their early stages of application. This is because of the fact that, only the average values of wind speed (for a certain interval of time, such as daily, weekly, monthly or yearly average) were considered for those cases. Knowing only the average wind speed for a certain frequency, it is never possible to select a Wind Energy Conversion System (WECS). These values are important to select the type of Wind turbine that matches properly with available wind energy at the location. It will also provide information to determine the read amount of energy either to operate an electricity generator or a water pump.

Therefore, it is of utmost importance that enormous wind speed data (for 5 to 10 years) should be recorded and analyzed, to get the characteristics values of the Weibull distribution function.

DATA PROCESSING FOR WEIBULL DISTRIBUTION

Continuous wind speeds are measured at BUET Campus, Dhaka by means of a Data-logger set as daily basis. There are 13 statistical blocks in the data-logger All the data from the 13 blocks representing their velocity classes and corresponding frequencies are given in the following table:

Table1-1: Velocity frequency table of wind speeds at BUET Campus, Dhaka.

Velocity classes	0-1	(1-2)	(2-3)	(3-4)	(4-5)	Total
Days	m/s	m/s	m/s	m/s	m/s	(mins)
21-8-2001	800.64	612	27.36			1440
22-8-2001	673.92	725.76	40.32			1440
23-8-2001	600.48	732.96	106.56	1.44		1441.44
24-8--2001	879.84	541.44	18.72			1440
25-8-2001	918.72	499.68	18.72	4.32		1441.44
26-8-2001	1062.72	364.32	14.4			1441.44
27-8-2001	1028.16	360	50.4	1.44		1440
28-8-2001	1224	211.68	4.32			1440
29-8-2001	957.6	426.24	54.72	2.88		1441.44
30-8-2001	285.12	874.08	247.68	33.12	1.44	1441.44
31-8-2001	675.36	724.32	37.44	1.44		1438.56
1/9/01	779.04	610.56	50.4			1440
2/9/01	655.2	707.04	79.2			1441.44
						18727.2
Total	10540.8	7390.08	750.24	44.64	1.44	18727.2

This above frequency distribution is furthered processed for Weibull Distribution to have the shape/form factor (k) and scale factor(C). There are many distributions to analyze any raw data. But for the wind regime Weibull Distribution fits very closely as it is flexible in nature .

Table2:Data processing for Weibull Distribution from raw data.

Velocity classes	Average velocity	Frequency	Relative	Cumulative	Power(P)	Energy per area
m/s	m/s	mins	Frequency	Frequency	$P/A=1/2*density*v^3$	$E/A=0.625*v^3*f$
v		f	q	Cq	watt/m^2	Wh/m^2
(0-1)	0.5	285.12	0.198	285.12	0.078	0.371
(1-2)	1.5	874.08	0.607	1159.20	2.109	30.729
(2-3)	2.5	247.68	0.172	1406.88	9.766	40.313
(3-4)	3.5	33.12	0.023	1440.00	26.797	14.792
(4-5)	4.5	1.44	0.001	1441.44	56.953	1.367

Mathematical representation of wind regime

After setting the raw data in the tabular form, the data can easily be processed by MS EXCEL or AlWIN software. The frequency distribution, the velocity duration determination of energy concentration availability of wind power, Weibull parameters, wind regime cut-in speed, rated speed, furling speed and other characteristics can be determined to select an appropriate turbine for that site.

Weibull distribution

To calculate the energy capture from a given wind turbine at a given site and to estimate other useful figures, such as the proportion of time the wind speed lies in a certain range, we need to identify a suitable probability distribution for the wind speed. It has been stated earlier that, the frequency distribution of wind speeds at most sites can be well represented by the two parameter Weibull probability density function. The probability of wind speed having a value is given by

$$f(v) = (k/C)(v/C)^{k-1}\exp[-(v/C)^k]$$

Where, k is known as the shape parameter and C the scale parameter. The following figure shows the probability distribution of the frequency and the relative frequency, which is representative of one block of wind speed data (30-8-2001), that is wind speed of one day.

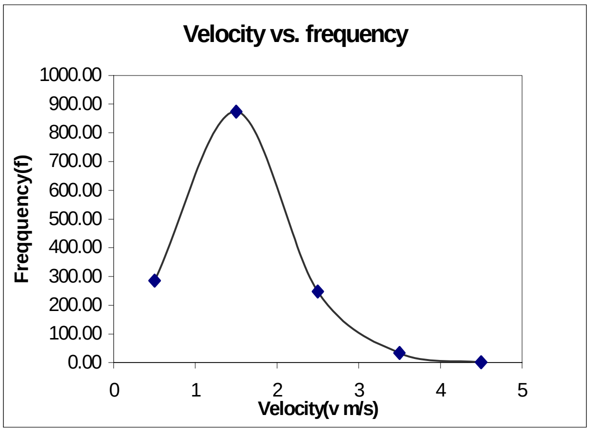


Figure: Frequency Distribution Of Velocity

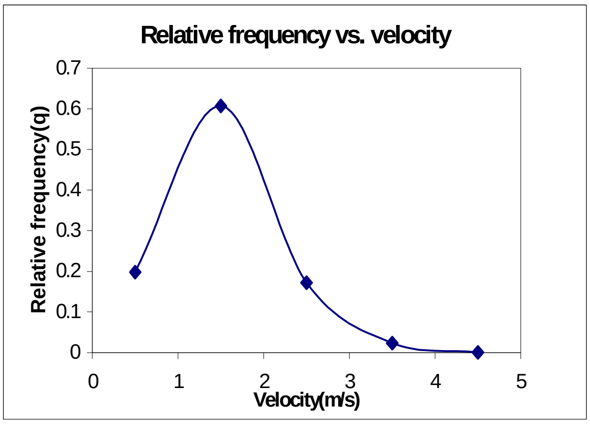


Figure: Relative Frequency Of Wind Speed.

The cumulative probability distribution is obtained by integration of the function between zero and some value, V. It indicates the time fraction or probability that the wind speed v is smaller than or equal to given wind speed V. This gives the probability of

$$F(v) = F(v \le V) = 1-\exp[-(v/C)^k]$$

The cumulative function of the observed data can be well represented by the following figure:

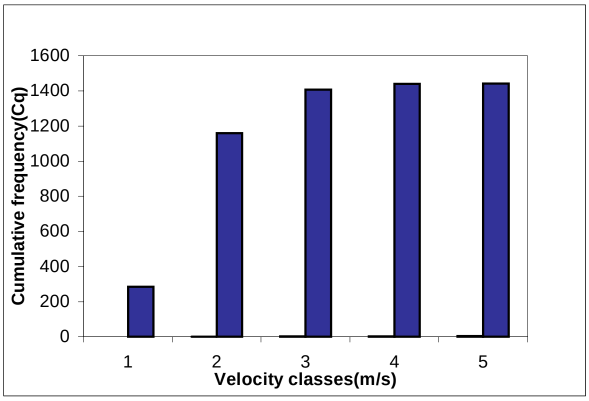


Figure: Cumulative distribution of observed data.

Another distribution function, which is known as velocity duration curve, is represented as:

$$S(v) = \exp[-(v/C)\ k]$$

The velocity duration, S (v) is the period of time during which the wind speed is available greater than that specific wind speed. The velocity duration curves for the observed data are shown below:

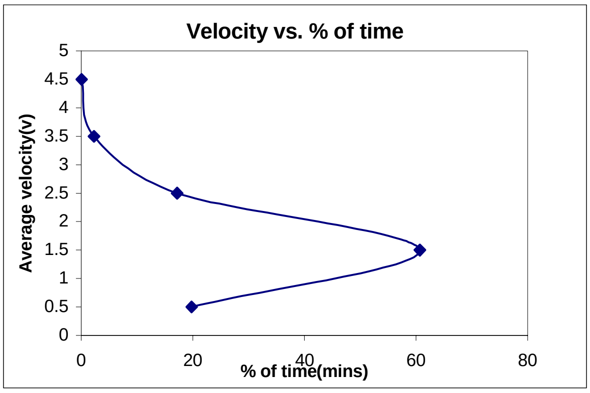


Figure: Observed velocity duration curve.

The shape of the duration curve follows a negative exponential function. The more horizontal shape means longer duration of that specific period. The steeper the shape duration curve indicates the more irregular wind speeds. From this time duration curve the cut-in speed (v_c), rated speed (v_r) and furling speed (v_f) can easily be determined.

Comparison of f (v) between observed & calculated

Weibull Density Function,

$$f(v) = (k/C)(v/C)^{k-1}\exp[-(v/C)^k]$$

The relative comparison between observed and calculated frequency is shown here in tabular form can be represented as follows:

Table 3: Comparison between observed & calculated frequency.

v	f(v)(obs)	f(v)(cal)
0.5	0.198	0.169
1.5	0.607	0.483
2.5	0.172	0.295
3.5	0.023	0.058
4.5	0.001	0.003

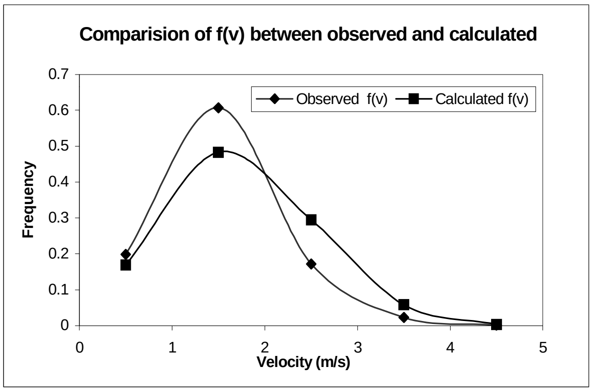


Figure: Weibull density function f (v)

Estimation of Weibull Parameters

The Weibull distribution shows its usefulness when the wind data of one reference station are being used to predict the wind regime in the surrounding of that station. The idea is that only monthly or annual average speeds are sufficient to predict the complete frequency distribution of the year or month. But as we stated earlier that the wind speeds distribution could be well matched with the Weibull distribution, so our case is to analyze with the Weibull distribution function.

From the following table we will show how to calculate the Weibull parameters.

Rel. freq,q	Vel,v	Lnq	Ln(-Lnq)	Lnv
0.198	0.5	-1.61949	0.48211	-0.69315
0.607	1.5	-0.49923	-0.6947	0.405465
0.172	2.5	-1.76026	0.565462	0.916291
0.023	3.5	-3.77226	1.327675	1.252763
0.001	4.5	-6.90776	1.932645	1.504077

Taking the logarithm of the value of (-lnQ) it can be plotted against ln (v), where Q is the relative frequency and v is the average wind speed. Then the result should be approximately a straight line with k as the gradient and the intercept at –kln(C). Linear regression can be used to find the straight line fit to the data. The figure below shows the result of such an analysis showing that the Weibull distribution is a reasonable fit to the data.

Calculation for determining k & C

From the figure we find the equation of the straight line is

$$y = 2.3843x - 1.6484$$

From this equation we find the gradient, i e k =2.3843. The next step is to calculating the value of C by using the following equation

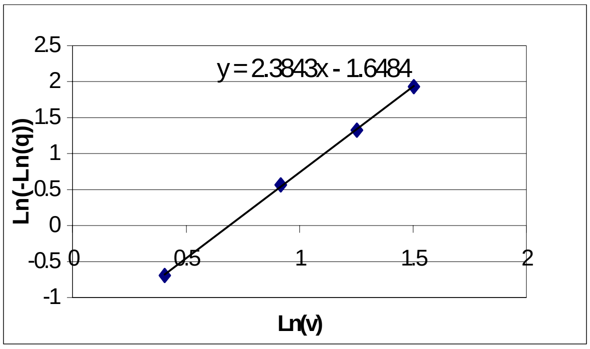
$$b = -k \ln C$$

Where, $b =$ the intercept of the line $=1.6484$

$$\therefore \ln C = (-b/k)$$

$$\therefore C = e^{(-b/k)}$$

Although widely used, linear regression applied to logarithm and double logarithms of the dependent and



independent variables will not provide the best choice of parameter k and C. A more rigorous approach to parameter estimation uses maximum likelihood techniques. These are recommended if it is important to have great accuracy.

Daily Variation Of Mean Speed

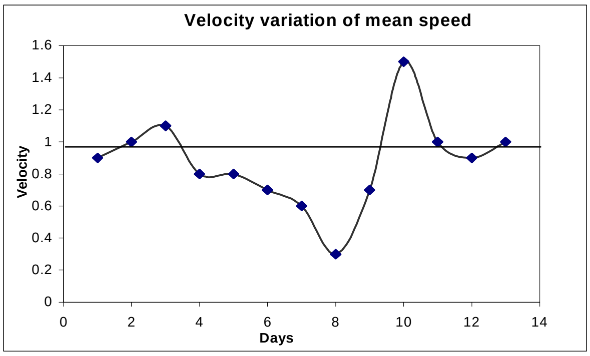
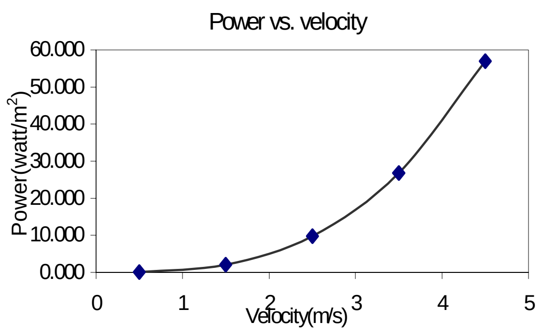


Figure: Daily variation of mean wind speed



Daily mean wind speed shows the variation of speed in different days, that in our case the 13 days variation in the month of August' 2001. In our case the highest speed profile is 1.5 m/s for the month of August' 2001.

Mean Diurnal Pattern

The diurnal pattern shows the average daily profile of wind speed.

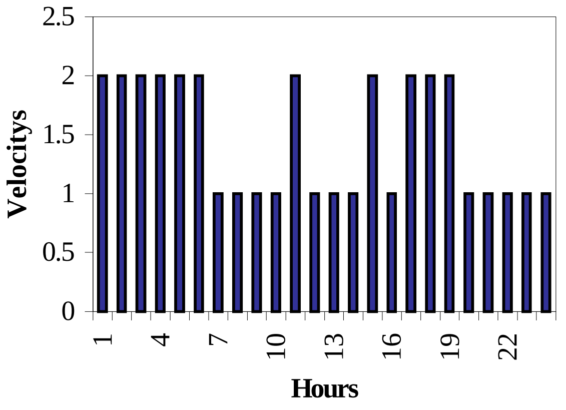


Figure: Hourly profile of wind speed.

Lull Period

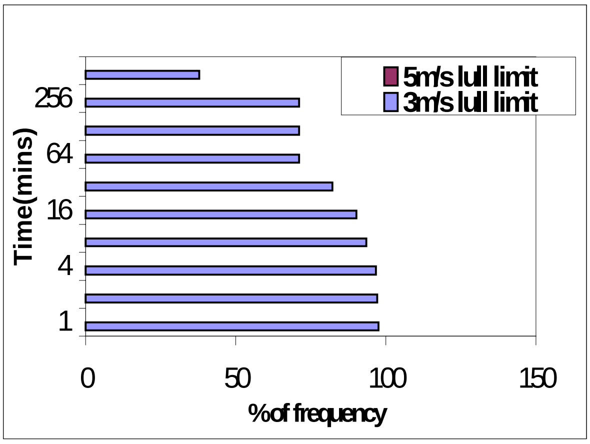


Figure: Lull duration in minutes.

. It needs a forecast for low-wind periods during which the wind power plant provides only insufficient power or no power at all. The lull period is the non-available times during which the turbine or windmill will not be on operating condition. This is very low velocity classes. It is normally fall under cut-in speed or the speed that is not sufficient to produce the output of the turbine. It is generally called the unproductive time of wind speed. The lull period is shown graphically.

DISCUSSION

In this paper the main objective was to focus on the wind energy pattern in the BUET Campus by using modern digital equipment. And this was done only with the 13 days wind speed data. But we all know that, it is necessary to collect at least five to ten years data for any particular site for the proper assessment of wind energy in that location. Another thing is important is that site selection. It is one of the most vital parts of wind monitoring study. There should be great open space surrounding the site; otherwise the wind flow will be affected by local obstacles,. Moreover, the height on which the wind anemometer is to place should be great enough to get the wind freely from all directions. From this point of view the BUET Campus location is not in such conditions. But provisions has been made to work on this wind energy assessment for a long period Since the data logger has only thirteen memory blocks, it can store only for thirteen days. But the data logger can be configured as weekly or monthly basis data storing devices. A total graphical presentation has been shown here for the data analysis. As the wind speeds did not reach at or above 5m/s; so it would not possible to include the 5 m/s lull limit in the lull duration period diagram

CONCLUSION

It has been analyze only with 13 days of wind speed data. So we cannot actually find out the actual pattern of wind at this site. Actually it requires five to ten years of data to predict the wind characteristics for any site.

- The average speed was 1.5 m/s for the month of August, 2001.
- From the daily variation of mean speed it has been noted that the speed was between 0.4 to 1.5 m/s.
- At this very low velocity level the theoretical power calculated is too poor. For the average speed of 1.5 m/s the theoretical power would be 2.109 watt/m^2.

So before the long period data analysis it is not wise to take decisions of extracting the energy from the wind resources here.

REFFERANCES

Wind Turbine Warehouse.com. J.P. Sayler. Associates. Consultants. Ltd.

E. H. Lysen. " Introduction to wind energy" .

Hussain Muhtasham " Solar and Wind Energy Potential for Bangladesh" . Center for Policy Research, University of Dhaka.

Danish wind turbine manufacturers associations. Internet address: www.WINDPOWER.org

Roy Chandra Rupesh " Evaluation of wind energy pattern for Chandona-Gazipur, Dhaka."