WIND RESOURCE ASSESSMENT AND SITE ANALYSIS AT RAJEEV GANDHI TECHNOLOGICAL UNIVERSITY, BHOPAL, INDIA

Prashant Baredar *1, Anil kumar, R. P. Karsoliya and Hitesh Kumar Khare2

1. Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh (INDIA)
2. Technocrats Institute of Technology, Bhopal, Madhya Pradesh (INDIA)

Received July 07, 2009      Accepted April 23, 2011

ABSTRACT
This research paper is prepared as an account of work sponsored by an agency of India, All India Council of Technical Education (AICTE) under Research Promotion Scheme (RPS). The concept paper represents the potential finding of wind resource using ‘WRPLOT’ software. A Wind rose is constructed using the data collected by weather monitoring station throughout the year. Among the various energy alternatives, the wind energy source for the generation of electricity as wind energy systems stands out distinctly for their use in tropical regions. Keeping this in view a wind energy system has been evolved for University Institute of Technology, Rajeev Gandhi Technological University site (Whose wind data are known) with the available wind resource.

Key Words: Wind turbine generator, Doubly fed induction generator, Wind velocity, Dynamic simulation model, Renewal energy

INTRODUCTION
There is rising need for alternate and renewable sources of energy, especially in developing countries, whose progress and economic growth may strongly be indexed to its development. The subject of wind assimilation in the power system has been getting more consideration recently1,2. Most studies understood a low access of wind potential as proportion of wind production over peak load and treated the yield of farms as negative load3,4. With the ever increasing growth in energy consumption and rapidly depleting fossil fuel reserves, it is feared the world will soon exhaust its fossil fuel reserves. Amongst the assessed studies of the literature there are several cases in which the wind prospective of a site is particularly considered and thus influences, to a great extent.5 India is an energy deficient country and each year spends a large amount of its foreign exchange to import oil, to meet its energy requirements. At the end of 2009, worldwide capacity of wind-powered turbines was 159.2 gigawatts (GW)6. Thus the need to develop alternate energy resources has become inevitable. The oldest and most widely used renewable energy resources are solar and wind, which have shown prospects and potential for efficient utilization. In the recent past, wind energy has emerged as clean, abundant, affordable, inexhaustible and environmentally benign source of energy. It has been forecasted that by 2020, approximately 12% of the world’s electricity will be obtained from wind power source, located offshore where better wind conditions is there.7 Wind energy has the advantage that it can be utilized independently, and deployed locally in rural and remote areas. Aero turbines convert the wind energy to rotary mechanical energy.

MATERIAL AND METHODS
The quantity of power in the wind is very dependent on the speed of the wind. Because the power in the wind is relative to the cube of the
wind speed, small differences in the wind speed make a big difference in the power we can make from it. A 10% difference in speed makes about a 33% change in power. This gives rise to the main reason for wind resource potential assessment. In order to more accurately predict the potential benefits of a wind power installation, wind speeds and other characteristics of a site's wind regime must be accurately understood. Wind power is the conversion of wind energy into a useful form of energy, such as using wind generators to make electricity.

Thus a mechanical set up consisting of a step up gear and a coupling transmits the rotary mechanical energy to an electrical generator. The power obtained by wind generator depends on number of factors such as wind speed, height of the wind turbine, air density, geographical location of the wind turbine, texture of the land over which wind generator is installed, and number of other factors. Wind speed is measured by anemometers, most commonly using rotating cups or propellers. When a high measurement frequency is needed, wind can be measured by the propagation speed of ultrasound signals or by the effect of ventilation on the resistance of a heated wire.

The Wind data furnished by weather monitoring station is for the period 01.09.2008 to 18.10.2009 and collected from Meteorological Department 5 km away from Bhopal. We have taken monthly averages. The Wind data is recorded at 10 mtr height. The wind turbine tower is of 18 mtr height. As per formula, the wind velocity becomes 10% more at 18 mtr height as compared to that at 10 mtr. Therefore we have considered wind velocity 10% more at 18 mtr and the same works out to average 4.75 m/s. (To estimate the wind speed at any height, we employ the Hellmann exponent law:

\[ \frac{S}{S_0} = \left( \frac{H}{H_0} \right)^{1/7} \]  
(1)

Where \( S_0 \) is wind speed at 10 mtr, \( H \) is Wind Speed at 'x 'mtr.Here x=18m

The estimated Energy requirement at site RGTU is a load of 6000 Watts to be connected on the proposed System and total power requirement of 30 units (30kW) per day.

Generation of power from a windmill requires continuous flow of wind at a rated speed. The rotor of the turbine collects energy from the whole area swept by the rotor.

This is difficult to accomplish because wind by its very nature is not constant and does not prevail at a steady rate, but in fact fluctuates over short periods of time. The speed of wind is also dependent on height above the ground.

The accessible power in the wind per unit area at any wind speed may be calculated as:

\[ P = \frac{1}{2} \rho AV^3 \]  
(2)

Where \( \rho \) is the air density, which was assumed to be 1.225 Kg/m³ and \( V \) is monthly mean wind speed in m/sec. This available power can not be totally extracted by any wind machine. The maximum extractable power from any wind machine is limited by the Betz relation, which assigns the power coefficient \( C = 16/27 \) for the highest performance of a wind generator.

**Wind resource assessment**

Once an area has been chosen for assessment, it is necessary to collect wind speed and direction data. A complete wind resource assessment involves a dense network of anemometers (wind monitoring stations) recording continuous wind data for at least one year. Since such wind monitoring efforts are time consuming and costly, wind researchers often obtain data sets that have been previously recorded.

Several sources may be helpful in obtaining existing meteorological databases. For example, Climatological stations, and airports are likely to maintain reliable records. If possible, existing data sets should be supplemented with spot measurements. When choosing sites to examine for potential wind development, the researcher should focus on areas likely to have enhanced wind speeds.

In this paper data are obtained from the local meteorological station of each area. However, it is expected that similar or even better wind conditions would exist for wind farm projects in areas yet to be explored, particularly in the mountainous and hilly regions of North and North
Eastern India. In fact, some of the best locations identified so far in the country, such as Muppandal in Tamil Nadu, Jogimatti in Karnataka and Rammakkelmedu in Kerala, are in complex terrain.

**Data analysis by constructing Windrose using ‘WRPLOT’ software**

The next step in the wind resource assessment is to analyze the wind data set to determine patterns in the magnitude, duration and direction of the wind.

An elegant method of describing average wind speed, duration and direction on a single graph is shown in Fig. 1. It is known as wind rose. It depicts the compass bearing from which the wind comes (all 16 directions) along with average wind speed and duration in a year. The lengths of bars represent the percentage of duration. It is also possible to present same information by another wind rose shown in Fig. 2. Here, the concentric circles represent duration in 100 hr interval and the solid lines the wind speed contours. ‘WRPLOT’ View is a Windows program that generates wind rose statistics and plots for selected meteorological stations for user-specified date and time ranges. A wind rose depicts the frequency of occurrence of winds in each of the specified wind direction sectors and wind speed classes for a given location and time period.

Wind roses can sometimes be used to depict graphically the dominant transport direction of the winds for an area. Due to the influences of local terrain, possible coastal effects, the exposure of the instruments, and the temporal variability of the wind, the wind rose statistics may not always be representative of true transport for an area. Other meteorological conditions may also be important for determining the formation and transport of certain atmospheric contaminants, particularly for reactive pollutants. The results of this program should therefore be used with caution. Wind rose for a RG Tu location indicates the frequency of occurrence of wind in a particular direction and it plays a vital role in proper micrositing because, the rotor has to be positioned always to face the wind. In wind electric generator WEG, the wind direction sensor placed on the top of the nacelle, adjacent to the anemometer indicates the direction from which wind is blowing, and this signal is used by the yaw drive in the WEG to position the nacelle to face the wind.

In the above window ‘WRPLOT’ view software program Import Surface Data from Excel utility which allows us to create a SAMSON hourly surface data file from data in an Excel spreadsheet. Then ‘WRPLOT’ view software program is used to generate wind rose statistics and plots for weather monitoring stations located at University Institute of Technology Bhopal for the year 2008-2009.

**RESULTS AND DISCUSSION**

The field trial run data of wind power potential at site RG Tu Bhopal has been obtained over the year and thereafter it has been analyzed by using WRPLOT software for making wind power potential assessment analysis. After analyzing the data, the Wind Rose for a particular site has been constructed. It is a graphic tool used to give a succinct view of how wind speed and direction are typically distributed at a particular location. The directions of the rose with the longest spoke show the wind direction with the greatest frequency. The length of each “spoke” around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric circle represents a different frequency, emanating from zero at the center to increasing frequencies at the outer circles. A wind rose plot may contain additional information, in that each spoke is broken down into color-coded bands that show wind speed ranges. Wind roses typically use 16 cardinal directions, such as north (N), NNE, NE, etc., although they may be subdivided into as many as 32 directions. Fig. 3 shows the graphically displaying of the frequency distribution of occurrences of winds in each of the defined direction sectors and wind speed classes for the month Jan 2008. The resultant vector of the Wind Rose is plotted Fig. 2 above is calculated by computing the vector resultant or vector sum of the unit vectors that represent the various directions in the data.

The resultant vector of the Wind Rose plotted above in Fig. 2 is calculated by computing the vector resultant or vector sum of the unit vectors that represent the various directions in the data.
Fig. 1: Import surface data from excel

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Not Applicable
Fig. 2: Wind rose construction of site RGTU, Bhopal

Fig. 3: Wind class frequency distribution in the WRPLOT view
The resultant vector combines the frequency of winds in each direction to get an “average” wind direction. There are two things to note:

1. The calculation of the resultant vector considers only wind direction and the frequency of each wind direction, wind speed has no part in the calculation.
2. Calms are included in the calculation. This can be confusing as calms do not appear as part of the wind rose, especially if there are a lot of calms in a direction where there is little non-calm wind. A situation such as this can cause the resultant vector to point away from the predominant non-calm wind directions. Here the direction of resultant vector is 222° representing the mean resultant vector-58%.

The frequency distribution plot displaying the normalized frequency of occurrences of winds in each direction sector and each wind speed class (Fig. 3). The sub-totals for each column and row (total occurrence of wind class and wind direction respectively) are displayed; also the number of calms and total wind data are shown. Wind class of 5.7 m/s to 8.8 m/s is maximum in the whole session i.e. 31%. This Wind speed is good for small WEG system, which produce up to 40kW to 80kW power. But for a heavy WEG system such as 100 kW to 500 kW this site is not too good. 100 kW WEG system requires 11 m/s wind speed for efficient power production. We get hardly 17.2 % wind with 11 m/s wind speed in whole session. So our site is quite good for medium range electricity generation.

CONCLUSION

The hourly wind speeds at the candidate site as observed and recorded with the wind monitoring mast at two heights, namely 10 and 25 meters are adequate for the appraisal of the site for wind energy exploitation. It is also seen that the daily mean and maximum wind speeds exhibit similar trends as those of hourly wind speeds in the monsoon season. The general wind power density is generally low for the installation of modern high power wind electric generators. However, reasonable power may be derived in the monsoon months by the selection of appropriate models suitable for such low wind regimes.

ACKNOWLEDGEMENT

The authors are very much thankful to All India Council of Technical Education (AICTE) for Sponsoring under Research Promotion scheme (RPS) The authors gratefully acknowledge to the former Vice Chancellor Dr. P.B. Sharma and Director energy Centre Dr. V.K. Sethi of the Technical University of M.P. India for their kind permission and directions to conduct the experimentation and research work on integrated renewable energy system (Biomass Gasifier / gas engine gen-set) located at Green power technology center of RGTU, Madhya Pradesh India.

REFERENCES

8. Akhlaque Ahmad M., Firoz Ahmad, and Akhtar M. W., Assessment of wind power potential for coastal areas of Pakistan, *Turk...*
