International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Analysis of Wind Speed Data and Wind Energy Potential Along Selected Location in Chandwad

Pradyumna Bora[1], Lokesh Sarnot[2], Shreyas Shah[3], Mohit Shaha[4], Sagar Redasni[5]

[1]*Mechanical, SNJB COE,borapradyumna@gmail.com*
[2]*Mechanical, SNJB COE, lokesh.sarnot@rediffmail.com*
[3]*Mechanical, SNJB COE,dshah1994@gmail.com*
[4]*Mechanical, SNJB COE, shaha.mohit79@gmail.com*
[5]*Mechanical, SNJB COE, sagar.redasni@gmail.com*

Abstract—India is one of the developing countries and is majorly dependent on imported fossil fuels. Wind energy can be harnessed for various end-uses as it is renewable and environmental friendly. The main purpose of this paper is to present and to perform an investigation on wind energy potential of selected sites in Chandwad. The study consist of evaluation of mean wind speed data collected over a period of one year at two selected locations in the region of Chanwad in order to figure out the wind energy potential. The data were analyzed using the two parameter Weibull probability distribution function. With an annual wind speed of 2.92 m/s, annual energy of 552.603kWh/m² could be extracted. It is found that potential use of wind energy should be done for rural electrification in off grid and mini-grid applications.
Keywords-Mean wind speed, Wind energy potential, Weibull distribution, Chandwad

I. INTRODUCTION

The mission for reducing environmental impacts of conventional energy resources and important part to growing energy demand of global population. It has motivated to research attention in a wide range of environmental and engineering application of renewable form of energy. It is assured that wind energy, as a renewable energy source, is freely available and is abundant, inexhaustible and environmentally preferable. Due to its advantages wind energy is fastest growing renewable energy in developed and developing countries. Wind energy is widely used for generating electricity in countries like Denmark, Spain, Germany, USA, China, and India. The global cumulative installed capacity of wind power is below [1].

Table 1 Global installed wind power capacity, 2005 to 2013

Year	Capacity (MW)	Growth (MW)	Growth (%)
2005	59,062	-	-
2006	74,174	15,112	25.6
2007	93,869	19,695	26.6
2008	121,246	27,378	29.2
2009	157,909	36,664	30.3
2010	194,558	36,649	23.3

2011	237,683	42,465	21.9
2012	282,683	45,661	19.3
2013	318,510	35,828	12.7

Day-by-day energy demand increases and rapidly destroys fossil fuel reserves and environmental problem increases, it have necessitated the development of alternative energy sources like wind energy. The electricity sector in India had an installed capacity of 258.701 GW as of end January 2015 [2].The effective utilization of wind energy at atypical location requires sound knowledge of the wind characteristics and accurate wind data analysis. For example, the choice of wind turbine design must be based on the average wind velocity at a selected wind turbine installation site [3]. Prior studies have also shown that the wind flow patterns are influenced by terrains vegetation and water bodies.

Although there is no such definition of what constitutes a small wind turbine, it is generally defined as a turbine with a capacity of less than 100 kW. On comparison with utility-scale wind systems, small wind turbines generally achieve lower capacity factors and have higher capital costs, but they can meet important unmet electricity demands and can offer local economic and social benefits, particularly when used for off-grid electrification. Small wind turbines share of the total global wind power market was estimated at around 0.14% in 2010 and is expected to increase to 0.48% by the year 2020 [4].

II. METHODS

The wind data used in this study were obtained from the metrological data. The graphical co-ordinates of the metrological station where the wind speed data were captured by a anemometer are in table as shown (Table 2). There are many instruments to measure wind speed like simple anemometer, cup-anemometer etc. The guidelines and steps required to minimize these errors are outlined in manwellet. Al [5]. Following the methodologies proposed and explained in the ISO guide [6] to the expression of uncertainty in measurement, the uncertainty in the mean velocities at 95% confidence level was determined to be ±2%. Monthly wind data that collect for one year was obtained for Chandwad. The recorded wind speeds were calculated mean speed of every month. It should be noted that using monthly wind speed has some limitations such as loosing extremely low or high wind speeds within the month as well as inability to observe diurnal variations in the wind speed. However, using monthly mean wind speed, which is mostly available for most location, can be used to study the seasonal changes in wind speed and facilities wind data.

Table 2 Graphical Co-ordinates of meterological station

Station	Latitude	Longitude	Altitude
Chandwad	20.32916	74.24444	632m

Frequency distribution and site wind speed parameters

For the studies have also shown that statistical methods such as the Weibull and Rayleigh distribution models can equally used [7]. The most probably two-parameter Weibull probability distribution function[8, 9]. It is globally accepted and recommended distribution function for the wind speed data analysis. It gives the better results for measured monthly probability density distributions than other statistical function [7, 9]. By using Weibull parameter to estimate wind parameters at another height from known height [8]. Therefore, two-parameter Weibull probability density function is used. Variation in wind speed can be characterized by two parameter functions;

the probability density function and cumulative distribution. The probability density function *f*(V) indicates the probability of wind at velocity 'V' and cumulative distribution function of velocity V gives the probability that wind speed is equal to or lower than 'V' or within the range of wind speed. The Weibull probability density function is [7, 15]:

$$f(V) = \left(\frac{k}{c}\right)\left(\frac{V}{c}\right)^{k-1} e^{\left(V/c\right)^{k}} \qquad (1)$$

Where,

f(V)= Probability of given wind speed (V),
k = Dimensionless Weibull parameter,
c = Weibull scale parameter (in meter per second).

The scale factor isrelated with mean speed in given data.
The Cumulative distribution *F*(*V*) is the integral of probability density function, it is given below,

$$F(V) = 1 - \mathrm{e}^{-\left(V/c\right)^{\mathrm{k}}} \qquad (2)$$

The monthly and annual values of Weibull parameters are calculated using standard deviation method. This method is easy and useful where only the mean speed and standard deviation are available. In addition, it gives better results than graphical method and has relatively simple expressions when compared with other methods [8, 10,11]. For other method requires more detail wind data which is readily not available so it is hard to calculate and complicated .for determination weibull distribution shape and scale parameters. There is given below equation (3) and (4) [8, 12],

$$k = \left(\frac{\sigma}{\mathrm{Vm}}\right) \quad (3)$$

Scale factor can be determined by using given formula [13]

$$c = \frac{Vmk^{2.6674}}{0.184+0.816k^{2.73855}} \qquad (4)$$

The other two significant wind speeds for wind energy estimation are the most probable wind speed (V_f) and the wind speed caring maximum energy (V_E). They can be express as [7, 14],

$$V_F = c\left(\frac{k-1}{k}\right)^{1/k} \qquad (5)$$

$$V_E = \mathrm{c}\left(\frac{\mathrm{k}+2}{\mathrm{k}}\right)^{1/\mathrm{k}} \qquad (6)$$

By using this formula to find annual and monthly wind energy generation. Then further it is used for the wind turbine design for its efficiently rated wind speed.
Therefore it is required that the rated wind speed and wind speed carrying maximum energy should be closed as possible as. [15]

Extrapolation of Wind speed at different hub height

The wind speed data is collect at 3m and it is predict wind speed at different wind turbine hub height by using power law equation. It is used to adjust height of wind turbine as per requirement of power [7].

$$\left(\frac{V}{Vo}\right) = \left(\frac{h}{ho}\right)^{\alpha} \qquad (7)$$

Where,

V = wind speed at the hub height h,

Vo= wind speed at the original height ho,

α = surface roughness coefficient, it is determined

From following expression.

$$\alpha = \frac{[0.37 - 0.088 \ln(Vo)]}{1 - 0.088 \ln\left(\frac{ho}{10}\right)} \qquad (8)$$

Mean wind power density and energy density

The mean wind power density determine by using formula as given below,

$$P_D = \left(\frac{\mathrm{P}(V)}{A}\right) = \frac{1}{2}\rho \mathrm{Vm}^3 \qquad (9)$$

Where,

$P(V)$=wind power (watt),

P_D =wind power density (watt per square meter),

ρ=air density at the site (assumed to be 1.225 kg/m^3),

A = swept area of the rotor blades (in square meter).

The mean energy density (E_D) at a period of time T is the product of the mean power density and time T, and it is given below,

$$E_D = \frac{1}{2}\rho V_m{}^3 T \qquad (10)$$

III. RESULTS AND CONCLUSION

Wind speed frequency distribution

The annual probability density frequency of wind speed for Chandwad obtained usingWeibull distribution function is shown in figure1. The probability density function is used to interpret the fraction of time for which given speed of wind possibly prevails at a location. It can be observed from figure 1 that most frequent wind speed expected in Chandwad is 4.14 m/s.

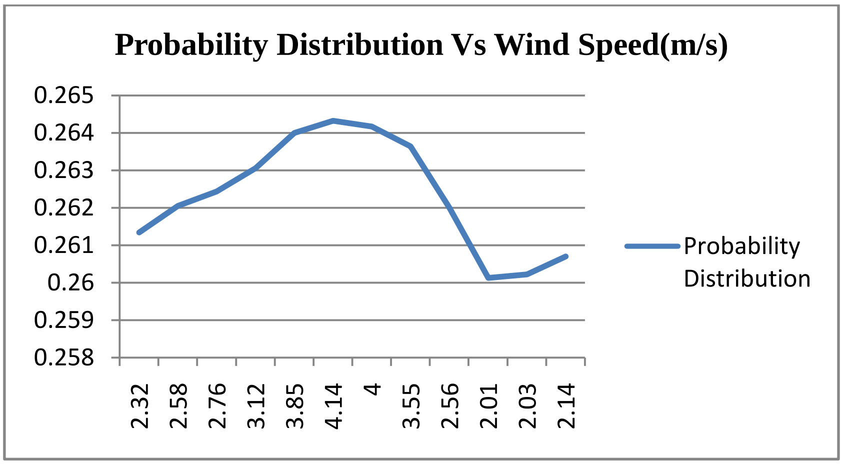

Figure 1 Probability Density Function

Table Characteristics speeds and mean power density in Chandwad at height of 10m

	V_M (m/s)	k	c (m/s)	V_F (m/s)	V_E (m/s)	P_D (W/m2)	E_D (kWh/m2)
Jan	2.32	1.67629	2.59817	1.511805	4.150775	7.64839	229.4517
Feb	2.58	1.881257	2.906627	1.942328	4.271473	10.51878	315.5633
Mar	2.76	2.024214	3.115002	2.224821	4.374071	12.87755	386.3266
Apr	3.12	2.312496	3.522174	2.757018	4.611559	18.60244	558.0732
May	3.85	2.905625	4.320827	3.736939	5.174254	34.95331	1048.599
Jun	4.14	3.144065	4.63109	4.100196	5.41613	43.46174	1303.852
Jul	4	3.02877	4.481712	3.926303	5.298406	39.2	1176
Aug	3.55	2.660585	3.996104	3.347286	4.933376	27.40256	822.0768
Sep	2.56	1.865425	2.883236	1.910181	4.260921	10.27604	308.2813
Oct	2.01	1.434498	2.214875	0.963277	4.07068	4.973868	149.216
Nov	2.03	1.450006	2.240238	0.999646	4.072993	5.123824	153.7147
Dec	2.14	1.535531	2.378052	1.197555	4.093531	6.002711	180.0813

CONCLUSION

In this study, wind energy potential and wind speed in selected location of Chandwad were investigated. The findings from the study can be summarized as followed:

1. The annual wind speed is 2.9216 m/s (3m).
2. The mean annual value of power density is 18.4201 W/m^2.
3. The mean energy density is 552.603 kWh/m^2.

REFERENCES

[1] www.thewindpower.net
[2] http://en.wikipedia.org/wiki/Electricity_sector_in_India
[3] Sunday O Oyedepo1, Muyiwa S Adaramola2 and Samuel S Paul3, Analysis of wind speed data and wind energy potential in three selected locations in south- east Nigeria, aSpringerOpen (2012)
[4] RENEWABLE ENERGY TECHNOLOGIES: COST ANALYSIS SERIES (*Volume 1: Power Sector Issue* 5/5)
[5] Manwell, JF, McGowan, JG, Rogers, AL: Wind Energy Explained: Theory, Design and Application, 2nd edn. Wiley, Wiltshire (2010)

[6] International Standards Organisation: Guide to the Expression of Uncertainty in Measurement, 1st edn. (1992)
[7] Akpinar, EK, Akpinar, S: An assessment on seasonal analysis of wind energy characteristics and wind turbine characteristics. Energy Conversion and Management 46, 1848–67 (2005)
[8] Justus, CG, Hargraves, WR, Mikhail, A, Graber, D: Methods for estimating wind speed frequency distributions. J. Appl. Meteorol. 17, 350–353 (1978)
[9] Akdag, SA, Bagiorgas, HS, Mihalakakou, G: Use of two-component Weibull mixtures in the analysis of wind speed in the Eastern Mediterranean. Applied Energy 87, 2566–2573 (2010)
[10] Jowder, FAL: Wind power analysis and site matching of wind turbine generators in Kingdom of Bahrain. Applied Energy 86, 538–545 (2009)
[11] Kwon, SD: Uncertainty analysis of wind energy potential assessment. Applied Energy 87, 856–865 (2010)
[12] Ouammi, A, Dagdougui, H, Sacile, R, Mimet, A: Monthly and seasonal assessment of wind energy characteristics at four monitored locations in Liguria region (Italy). Renew. Sustain. Energy Rev. 14, 1959–1968 (2010)
[13] Balouktsis, A, Chassapis, D, Karapantsios, TD: A nomogram method for estimating the energy produced by wind turbine generators. Solar Energy 72, 251–259 (2002)
[14] Bagiorgas, HS, Assimakopoulos, MN, Theoharopoulos, D, Matthopoulos, D, Mihalakakou, GK: Electricity generation using wind energy conversion systems in the area of Western Greece. Energy Conversion and Management 48, 1640–1655 (2007)
[15] Mathew, S, Pandey, KP, Kumar, AV: Analysis of wind regimes for energy estimation. Renew. Energy 25, 381–399 (2002)

