Analytical Study and Comparison of Selective Locations (Different Region) For Power Generation from Wind Energy in Gujarat

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ABSTRACT

In Wind energy, Wind Speed plays important roles for power generation, so the Analysis of wind speed is necessity of this study. The statistical Analysis of Wind speed in this study, using a monthly and yearly average wind speed data. The wind speed intensity of several locations in Gujarat is received by compiling data from Agricultural Universities of Anand, S.K.Nagar, Navsari, Junagadh, for the period of five years(2009-2013).The wind speed is recorded at daily and for this purpose it is extraploted at 50 meter height above the ground level by $1/7^{th}$ power law equation. Monthly and annual wind speed calculated and Analyzed with Statistical test (R^2). The results are all shown in graphical forms. The calculated shape and scale parameter of these locations with the help of Weibull distribution. Weibull Probability density function (PDF) and Weibull Cumulative density function (CDF) are also calculated.

Keywords: *wind energy, wind speed, weibull distribution,$1/7^{th}$ power law equation, Agricultural Universities*

I. INTRODUCTION

Gujarat is a important state of India for power generation from Renewable energies like Solar, Wind, Biogas, Tidal etc. The possibility of power generation from Renewable energy in Gujarat is higher than other state in India. Gujarat has a long coastal area around 1600 kms, so it is the most suitable for power generation from wind energy. There is also great wind energy potential in Saurashtra and Kutch region of Gujarat has to make of its renewable resources, such as solar, wind and biogas, not only for power generation, but also for environmental reasons. Some studies have reported that the wind speed is large at coastal area. Gujarat has a unique geographic location with the wind speed for generation of electricity locally as well as grid connected. Due to all these characteristics, Gujarat is a ideal for generating energy from the wind. In present study, daily wind speed data were measured for the year 2009 to 2013 by the different Agricultural Universities of Gujarat.The aim of the present study is to analyze wind speed data at selected locations of Anand, S.K.Nagar, Navsari and Junagadh in Gujarat due to the importance of statistical analysis of wind speed data and to predict the power density in this area.

II. STUDY AREA

Gujarat is a state in the western part of India. Geographically, Gujarat has the following coordinates: 20° 6' N to 24° 42' N (north latitude) and 68° 10'E to 74° 28'E (east longitude). The boundaries of Gujarat are surrounded by the Arabian Sea in the West. Rajasthan in the North East, Madhya Pradesh in the East and Maharashtra in the South East. It shares a common border with Pakistan on the Northern side. It has an area of 1,96,204 km^2 with a coastline of 1600 km with the longest coast line.(Govt. of Gujarat, 2014). The population of Gujarat State was 60,383,628 according to the 2011 census data. Gujarat is counted among the fastest growing Indian states in terms of economy. The following locations of four region of Gujarat are selected for the research work for solar radiation and bright sunshine hour's analysis. The detail coordinates are as follows.

Sir No.	Name of Location	Name of region	Latitude ^{0}N	Longitude ^{0}E	Elevation (m)
1	Anand	Central Gujarat	22.32	73.00	197
2	S.K.Nagar	North Gujarat	24.12	72.28	201
3	Navsari	South Gujarat	21.07	73.4	222
4	Junagadh	Saurashtra	21.31	70.36	55

The data were collected from the various agricultural Universities located at Anand, S.K.Nagar, Navsari, Junagadh for detail analysis

III. WEIBULL DISTRIBUTION

(1) Frequency Distribution of Wind Speed:

The Weibull distribution has been found to fit a wide collection of recorded wind data**.** In this paper, the Weibull method is used. The Probability density function of the Weibull distribution is given by,

$$f = (k/c) (v/c)^{k-1}exp(-(v/c)^k)\dots\dots\dots\dots\dots\dots(1)$$

Where v is the wind speed, k is a shape parameter, and c is a scale parameter determined from the data. These parameters allow the calculation of the expected monthly and annual, wind power density per unit area in a given area. The corresponding cumulative probability function of the Weibull distribution is given by:

$$f (v) = 1-exp(-(v/c)^k) \dots\dots\dots\dots..\dots\dots(2)$$

For this present work, the scale and shape parameters were estimated using standard deviation method (SDM) using Matlab software.

Determine the k and c from the following equation:

$$k= \left(\frac{\sigma}{\bar{v}}\right)^{-1.086}, \quad c = \frac{\bar{v}}{\Gamma(1+\frac{1}{k})}\dots\dots\dots\dots\dots\dots.\dots(3)$$

where k=shape parameter ,c= scale parameter(m/s),Γ( )=Gamma Function, σ=standard deviation

(2) Wind Speed Variation with Height:

Wind speed near the ground changes with height. This requires an equation that predicts the Wind speed at one height in terms of the measured speed at another.

Apply 1/7th power law,

$$v_2/v_1=(h_2/h_1)^{\alpha}\dots\dots\dots\dots\dots\dots(4)$$

Where v_2 and v_1 are the mean wind speeds at heights h_2 and h_1, respectively. The exponent α depends on such factors as atmospheric stability and surface roughness. The value of α is 0.14 (Widely applicable for well exposed sites).

IV. GRAPHICAL REPRESENTATION

From the recorded data, the graphical representation of selected locations are as under:

Fig. Period (Month) versys Power (Theoretical and Weibull Power)

NAVSARI

JUNAGADH
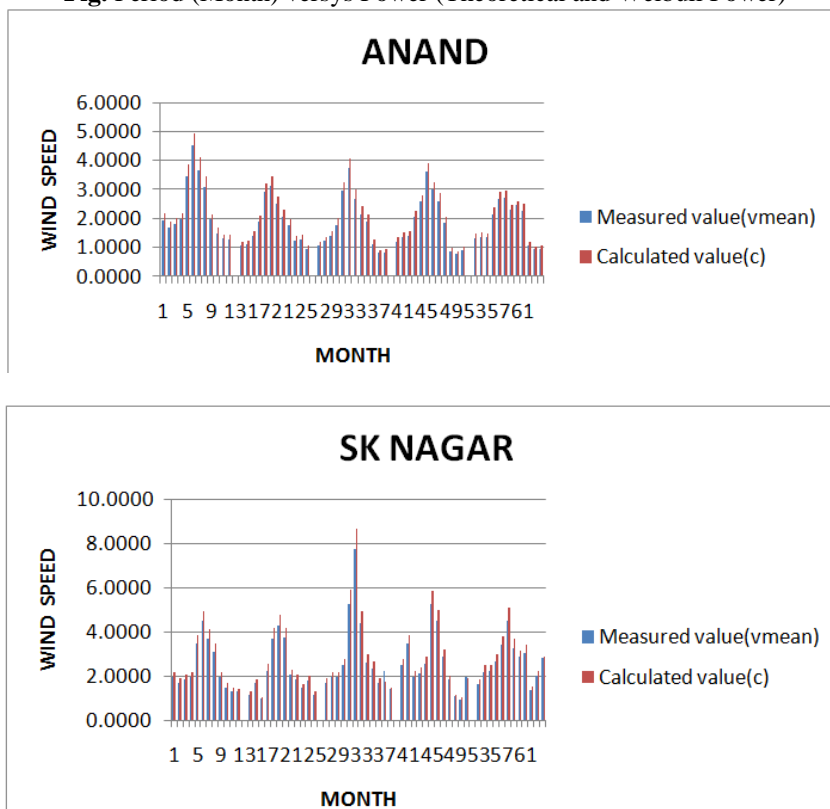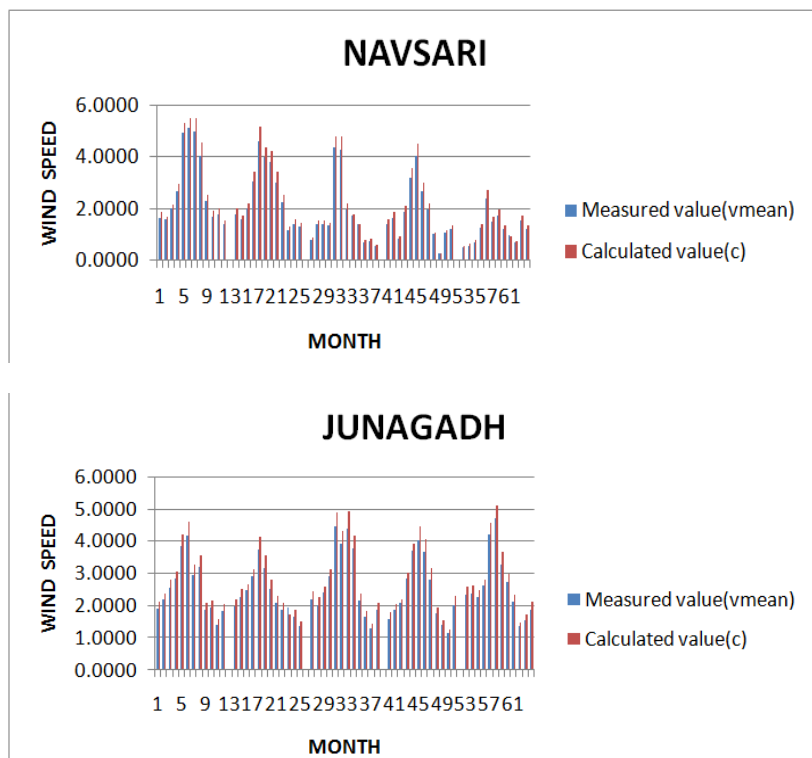
From the graphical representation the theoretical power and weibull power is nearly same, so weibull distribution is the best fit for wind energy potential.

V.   STATISTICAL PARAMETER

After Statistical Analysis (correlation coefficient R^2 test) the data of selected locations are as under:

Location	(R^2) Correlation coefficient
Anand	0.986278
SK Nagar	0.971722
Navsari	0.978006
Junagadh	0.987137

VI.   CONCLUSION

From this study, it is concluded the wind speed of these locations from statistical test (R^2),preference of these locations for new wind energy project (install new wind farms) are Junagadh (saurashtra),Anand (Central Gujarat), Navsari(South Gujarat) and S.K.Nagar (North Gujarat)respectively.
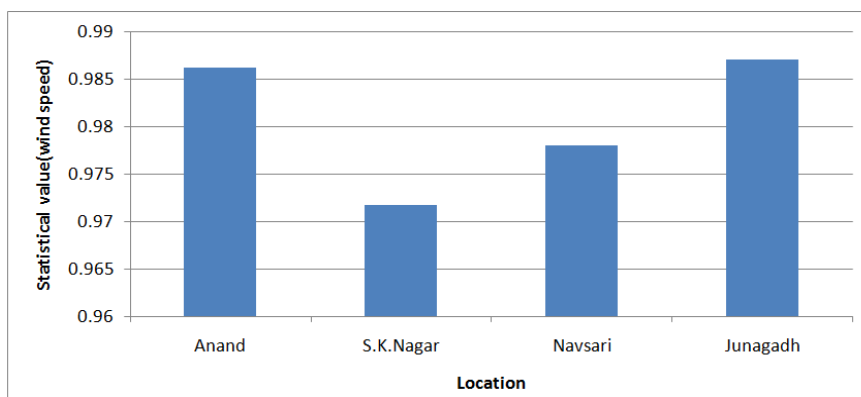
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