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Status of Wind Energy in Bhopal Airport India

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Abstract: The continuous decreasing of fossil fuel sources like coal, petroleum as well as its adverse impact on the environment shifts our paradigm towards renewable energy sources like solar, wind and geothermal to fulfill the ever increasing energy demand. The future development of any country will depend on its capability of using eco-friendly energy to reduce the carbon footprint worldwide. Although the main source of energy are coal and petroleum for India but recently India has become a major player in wind energy production due to the presence of large coastal area and constant government support in terms of subsidy. Energy demand in India will become three times more in 2030 than the present scenario. This paper gives a brief idea about the wind power near the Bhopal Airport in Madhya Pradesh.

keywords: Energy Deficiency, Environmental Pollution, offshore wind power, wind energy, status of wind energy

1. INTRODUCTION

Wind data measurements over a period of ten-years are required to obtain an accurate assessment of the wind regime of an area [1]. The methodologies adopted to ultimately determine the annual energy production potential of a site must be carefully determined and documented [2]. Methodologies on wind farm design rely on data from the nearest measuring station and careful analysis of wind flow, which takes into account the topography and the roughness level of the surrounding land. Unless the data on wind speed, direction, topographical features and roughness classes are accurate calculations may result in significant errors in estimating the wind speed, which may lead to even greater errors in energy estimation especially in complex terrains [3]. In all of above cases, the first step is to estimate the mean value of the wind speed that is expected on a site and afterwards, the wind energy that a proposed wind farm would produce in an average year, is estimated.

India has a gross wind power potential of over 45195 MW, and the technical potential of 13390 MW depending upon land availability and grid penetration. India has made rapid strides in harnessing wind power. The gross generation capacity towards the end of 2008 was 8757 MW [4]. Exploration of newer sites to assess the wind energy potential is an ongoing process and many more wind monitoring stations are being installed to collect time series data on wind speed and direction. The present work is based on the time series wind data collected over a period of 10 years at two mast heights of 10 and 70 m located at 77°35'E Longitude and 23°28' N Latitudes at the height of 530 m above mean sea level near Bhopal.

Wind speed data in metre per second and the direction in degrees were obtained from the India Meteorological Department for the site. Procedures and methodology to be adopted for the assessment and determination of the wind energy are explained and also the observed wind climate for different months have been calculated.

Objectives of the study:

- Recording wind speed data including direction.
- Preparation of vector map.
- Classification of terrain features.
- Analysis of wind data and determination of observed wind climate.

2. METHODOLOGY

The topography map No.55 E/7 has been obtained from the Geological Survey of India in which the contours of the site near Bhopal are shown. This site has been chosen for the study (Fig. 1). The site under consideration covers an area of approximately 256 square kilometres in undulating topography, interspersed with water bodies, cultivated and barren land and semi urban dwellings. A satellite image of the area is shown in (Fig. 2). These areas were marked off separately in the vector map giving roughness values as defined by WAsP and given in Table 1.The map of the whole area was digitised with elevation contours at 5 m intervals.

Fig. 1. Topography map of the area

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Fig. 2. Satellite images of the area

Table 1. Roughness class and terrain surface characteristics

z_0 [m]	Terrain surface characteristics
0.50	Suburbs
0.20	many trees and/or bushes
0.10	farmland with closed appearance
0.005	bare soil (smooth)
0.000	water areas (lakes, open sea)

Mortensen *et al* have reported that it is possible to obtain accurate assessment of stable wind speed which are close to the measured values with maps of 8 x 8 sq. km and the influence of contour interval on the accuracy of wind speed prediction [5]. Prediction errors can be reduced with smaller contour intervals with a contour interval of 20 m or less. In the present study the hilly site near Bhopal covering an area of 16 x 16 sq. km. has been considered.

The topography map has been obtained from Geological Survey of India and the detailed surface features based on aerial photography conducted by the National Remote Sensing Agency were available as 2 x 2 sq. km tiles in the AutoCAD dwg format. These 6 layer map provide contours at 1 m intervals, trees, buildings, temples, tombs, electric and telegraph poles, waterways, marshy areas, roads, footpaths etc in different layers. Information relevant to WAsP, namely contours, open areas, farmlands, water bodies and urban and semi urban areas were retained by switching off the unwanted layers. Such tiles were joined together in the AutoCAD software and saved as dxf files (drawing exchange format), which could be

imported into the WAsP Map Editor. In this study, contour intervals at 5 m were retained and imported into

the WAsP Map Editor for calculating the wind energy density throughout the area. The map was transformed to the Universal Transverse Mercator (UTM) projection with the datum of WGS 1984. The area falls in Zone 43 with the central meridian of +75° E. There are 280 height contours in the map with elevation ranging from a low of 450 m to a high of 570 m. The total number of digitised points was 215000, thus giving reasonably smooth contour lines as shown in Fig. 3.

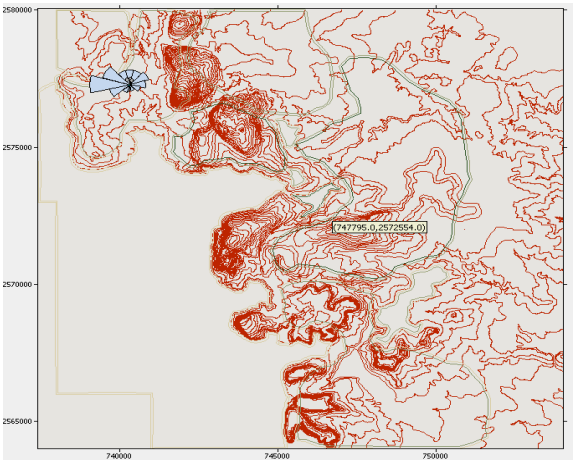

Fig. 3. Digital contour map of the area under study Bhopal air port

Table.2 obstacles at the site

Obstacle	A1 [°]	R1 [m]	A2 [°]	R2 [m]	Height [m]	Depth [m]	Porosity
1	35	99	41	92	10	10	0
2	66	117	70	112	6	10	0
3	74	72	83	78	10	15	0.75
4	217	186	295	135	15	20	0.5
5	338	159	352	115	10	20	0

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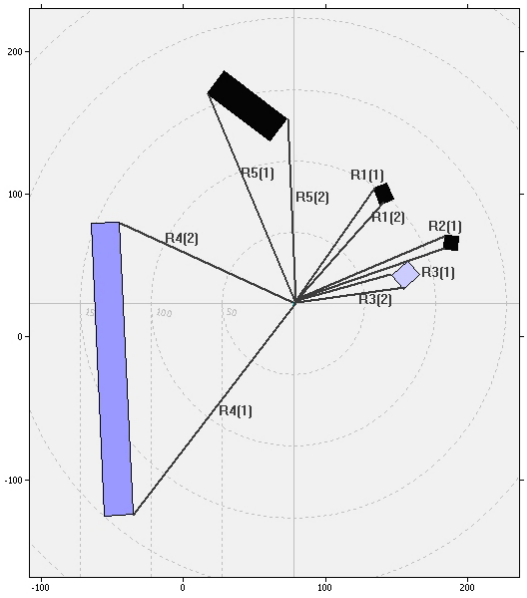

Fig.4 Location of Obstacles near Bhopal Airport

3. WIND DATA ANALYSIS

Standard meteorological wind data are regularly collected by the India Meteorological Department near airports and towns for weather prediction and civil aviation requirements. Meteorological aspects of utilization of wind for the extraction of power have been well documented [6].Wind speed data in knots and the direction in degrees were recorded from the station near airport site located at 77°35'E Longitude and 23°28' N Latitudes for a period of 10 years from 1998 to 2008 at two heights using pressure tube anemometer (Dines anemometer) at 10 m height and the other by hydrogen balloon at 70 m. The measurement site lies at an elevation of 530 m above mean sea level.

Table 3 Mean monthly wind speed and extrapolated wind speed, m/s

Month	α	10 m	50 m	60 m	70 m	120 m
Jan	0.142	3.60	4.53	4.65	4.76	5.14
Feb	0.141	3.67	4.61	4.47	4.48	5.22
March	0.140	3.70	4.64	4.768	5.51	5.94
April	0.144	5.12	6.46	6.64	6.79	7.33
May	0.139	6.71	8.40	8.62	8.81	9.49
June	0.142	6.60	8.30	8.52	8.71	9.40
July	0.142	6.15	7.74	7.95	8.13	8.77
Aug	0.140	5.72	7.17	7.36	7.53	8.12
Sep	0.139	4.85	6.07	6.23	6.37	6.86
Oct	0.139	3.65	4.50	4.61	4.71	5.07
Nov	0.142	2.97	3.74	3.84	3.93	4.24
Dec	0.140	3.00	3.76	3.86	3.95	4.25

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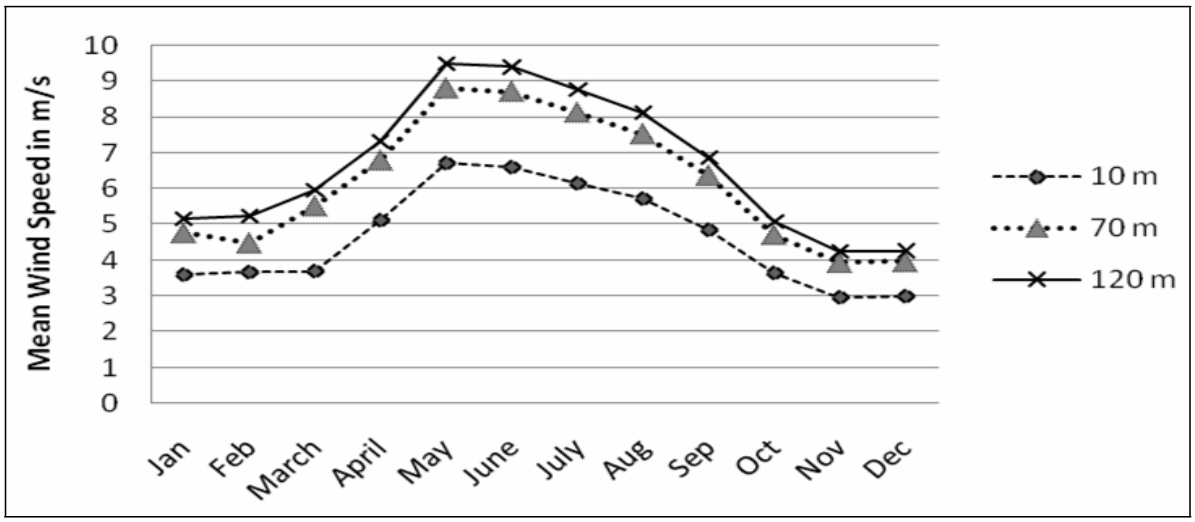

Fig. 5 Mean Monthly Wind speed from 1998-2008

Table 4 Weibull Parameter of last 10 years at 70 m height

Year	K	c, m/s	u, m/s	E, W/m^2
1998	1.35	5.2	4.78	216
1999	1.7	7	6.27	346
2000	1.67	7.2	6.43	381
2001	2.09	6.4	5.64	202
2002	1.99	7.1	6.25	288
2003	1.74	6.8	6.09	307
2004	1.35	5.1	4.7	210
2005	1.36	5.4	4.78	220
2006	1.76	5.5	4.86	154
2007	1.56	5.5	4.92	187
2008	1.78	5.6	5.01	167

k: Shape parameter, c: Scale parameter, u: Average wind speed, E: Wind power density

Table 5 Mean Monthly Wind Speed (m/s) of last ten years

Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	4.06	4.62	5.77	6.63	12.78	7.94	8.71	7.33	5.8	4.67	3.86	3.31
1999	4.12	4.07	5.13	5.86	7.11	11.01	9.59	7.62	8.24	5.34	3.99	3.27
2000	5.31	6.72	6.76	7.92	7.96	7.74	7.65	8.48	6.46	4.31	3.97	3.34
2001	4.04	4.77	5.41	5.51	7.71	8.166	8.68	7.57	5.5	4.56	4.39	3.69
2002	5.41	4.51	4.51	7.4	7.96	7.95	8.72	7.65	7.31	4.99	3.72	4.05
2003	4.89	5.05	5.29	6.74	8.41	8.22	6.89	7.93	6.215	4.32	3.69	3.8
2004	3.72	4.33	4.7	6.2	6.26	6.46	5.82	5.8	4.4	3.37	3.3	3.28
2005	4.32	4.61	4.5	5.19	8.28	8.88	6.796	6.74	6.05	4.64	3.11	3.925
2006	3.7	4.36	4.53	5.1	6.41	6.84	6.02	6.18	6.05	4.24	3.09	3.53
2007	3.76	4.61	4.7	6.2	7.62	7.24	5.46	4.77	4.26	3.37	2.9	3.8
2008	4.3	4.5	3.8	5.11	7.6	6.7	6.98	5.24	3.38	3.32	3.32	3.49

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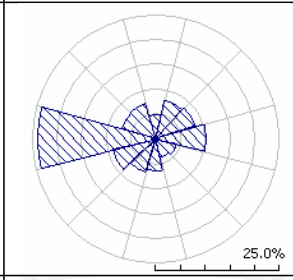
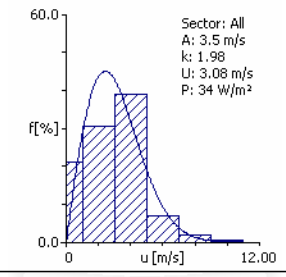
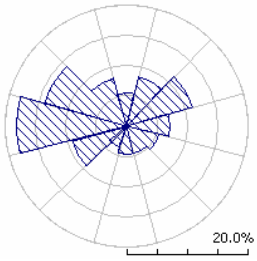
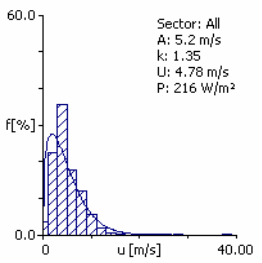
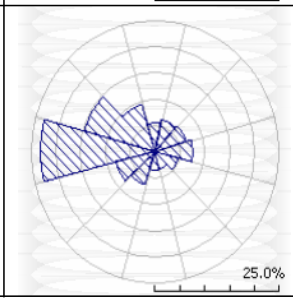
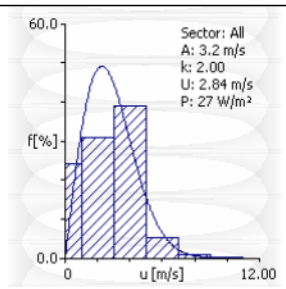
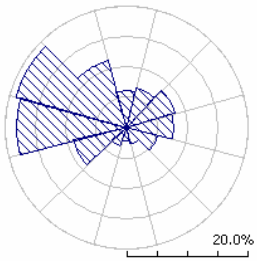
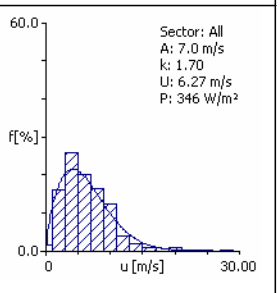
3.1. OBSERVED WIND CLIMATE

The detailed time series wind data recorded at the wind monitoring station have been analyzed and the observed wind climate determined by using WAsP. These are shown for the two hub heights of 10 and 70 m in Fig 7.

Year	Wind Direction at 10 m	Frequency Distribution at 10 m	Wind Direction at 70 m	Frequency Distribution at 70 m
1998				
1999				

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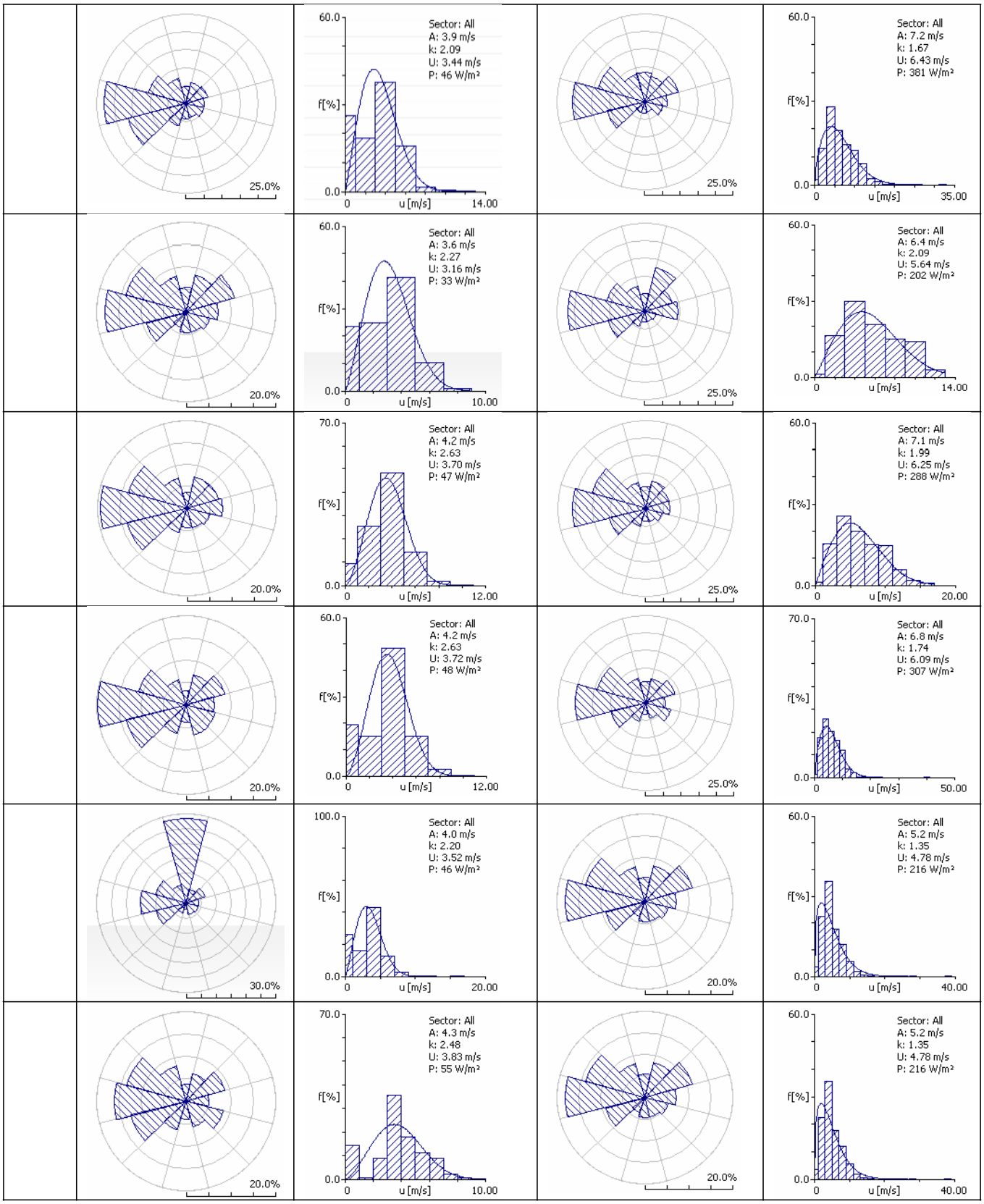

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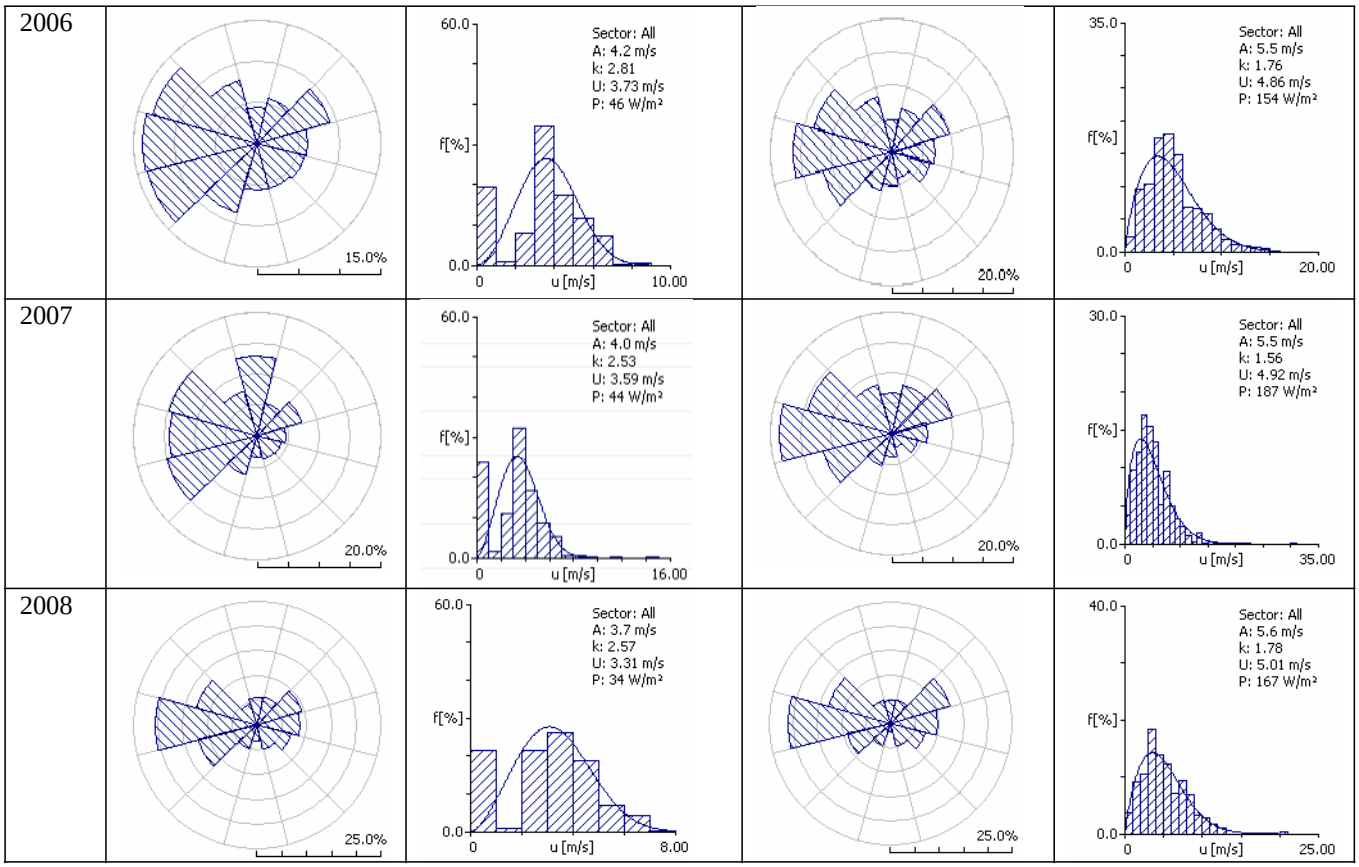

Fig.7 Observed Wind Climate of Last Ten Year

4. OBSERVATION AND CONCLUSIONS FROM THE STUDY

It is seen from the analysis of observed wind climate for the site that the site is endowed with good wind power potential with the wind power density in the range of 154-381 W/m^2 from the year 1998 through 2008. However, it is also seen that the average wind speed calculated for different years does not indicate corresponding wind power density owing to uneven wind speed distribution. It is also seen from the wind roses that wind flows predominantly
from the West-North West indicating a strong influence of the monsoon in the Indian sub- continent. Also there are many lull period in the winter month which gradually gain momentum as the climate warm up towards the approach of summer. The typical monthly variation in wind speed from January to December for a representative year average for the study period is shown in Fig 6. Exploitable wind speed is experienced only at the hub height of 50 m or more. Therefore, a wind turbine generator with a cut-in speed of 4 m and cut-out speed in the range of 20-25 m/s is recommended for the area.

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