Pakistan Meteorological Department

A STUDY OF WIND POWER POTENTIAL

AT

MIRKANI - CHITRAL
(NWFP)

Technical Report No. PMD-05/2009

(Preliminary report based on 24 months data)

EXECUTIVE SUMMARY

Pakistan Meteorological Department (PMD) conducted a wind power potential survey of the Northern Areas of Pakistan. Funding for this project was provided by the Ministry of Science & Technology. Under this wind data was collected at 42 sites along the Northern parts of the Country.

In this report the analysis based on twenty four (24) months wind data which has been presented along with the wind generated electric power at Mirkani-Chitral, NWFP. Wind data with ten minute average speed and direction were collected at 10 meters and 30 meters height and 50 meters values were computed from models.

At 50 meters we have the Average wind speed of 3.21 m/s during 24 months May-2007 to April-2009, the highest of **5.36 m/s** is observed in July. Seasonal Diurnal Wind variation indicates that maximum wind speed is available during the day time thought-out the whole period. Wind frequency distribution shows that during 22% of the time wind speed is above 5 m/s.

Sometimes simply wind speed averages do not give the true picture of the wind power optional of an area. For the purpose it is common to assign areas to one of the seven wind classes based on “Wind Power Density” of the area. Monthly and annual wind power density has been computed and added in the report. The total power density of Mirkani at 50 meter height is **66.30 W/m^2** according to international wind classification, this power density categorize Mirkani as a below marginal site for wind power generation.

Wind generated electric power has as also been computed on hypothetical 600KW wind turbine and its hourly, monthly and annual values has been added in this report. The total power production form a single 600KW wind turbine come out to 276,358 KWh which shows the capacity factor of 5% for Mirkani. Internationally it is accepted that if any site has a capacity factor of 25% and above than that site is suitable for installation of economically viable wind power farms. As such Mirkani and surrounding areas can be classified as non-suitable site for installing big economically viable wind farms.

1. Introduction:

Wind energy is the fastest growing renewable energy source today. A continued interest in wind energy development worldwide has produced steady improvements in technology and performance of wind power plants. New wind power projects have proven that wind energy not only is cost competitive but also offers additional benefits to the economy and the environment.

A steady supply of reasonably strong wind is necessary requirement for utilizing the power in the wind. Development of wind energy depends upon a clear understanding of wind resources. Site location, turbine performance and physical effects of turbulence and energy extraction represent a few of the issues that must be addressed by anyone interested in developing wind energy.

As such any plan to develop wind energy must begin by understanding the wind resource. Where are the best potential wind sites located? How much energy could be extracted from the wind at those sites?

1.1 **Characteristic of wind:**

The global winds are caused by pressure differential across the earth's surface. The amount of solar radiation absorbed at the earth's surface is greater at the equator than at the poles. This variation in incoming heat sets up convective cells in the lowest layer of the atmosphere. In the simplest form air rises at the equator and sinks at the poles. However the rotation of the earth complicates this simple heat transfer. A series of circulations are set up in both northern and southern hemispheres.

The areas of the globe where air is descending are zones of high pressure and where the air is ascending, low-pressure zones are formed. The pressure gradient drives the flow of air from high to low pressure, thus causing the wind. The wind is then acted on the corriolis force due to the earth's rotation. The resultant wind is turned easterly or westerly. On a smaller scale, wind is created because of temperature difference between land and sea and mountains and valleys. The local topographical features and roughness of the terrain also cause air movements.

2.0 <u>Wind Mapping Project of Pakistan Meteorological Department:</u>

As any plan to develop wind energy must begin by understanding the wind resources. Where are the best potential wind sites located? How much energy could be extracted from the wind at those sites? Will the wind turbine performance be affected by the turbulence or other wind resource characteristics?

To answer these questions and to provide wind resource database for the different potential parts of the country, Pakistan Meteorological Department prepared a phased programme. Government of Pakistan, Ministry of Science and Technology provided the necessary funding for undertaking the Phase II. Second phase covers the Northern areas of Pakistan.

2.1 Study Area:

The project area for the wind mapping Phase-II covers the Northern areas of Pakistan including Districts are Swat, Dir, Mirkani, Gilgit, Skardu, Haripur, Shangla, Buneer, Nowshara, Peshawar, Mohmad Agency, Khyber Agency and Azad Kashmir.

Forty-Two (42) stations for collecting wind data have been installed to study the wind regime as shown in Wind Mapping Sites (Phase-II) map. The list of stations is given below:

Fatehpur, Bahrain, Kalam, Khawazakhaila, Malamjabba, Tahash, Khungipayan, Dir, Tarbela, Nizampur, Warsak, Chitral City, Drosh, Mirkani, Shagore, Garam Chasma, Khagozi, Reshan, Mastuj, Kalash, Ayune, Astore, Bunji, Chillas, Gilgit, Gupis, Sost, Passu, Aliabad, Shigar, Barapayan, Sermik, Lowaramaina, Ramatkore, ShahidaSir, Danakool, Besham, Moorti Pahari, Rangla, Pedar, Shaheedgali, Dargai.

Tower is installed at Mirkani, District Chitral (NWFP). Latitude & Longitude of Mirkani are: **Latitude: 35.43º, Longitude: 71.68º, Elevation: 4151 Ft.**

2.2 Data Source:

To undertake this study 30-meter high towers are erected at the locations mentioned above. On each of these high towers two wind speed anemometers are installed at the height of 10 meters and 30 meters, respectively; wind vane for recording wind direction is installed at 30 meters height. NRG Automatic data loggers developed by NRG Systems have been installed to record data at each site. These data loggers are recording, ten-minute average wind speed at two levels, ten-minute average wind direction and 10-minute average minimum and maximum wind speed. While selecting the above-mentioned locations for wind monitoring; the main objective was to identify potentially windy areas that also possess other desirable qualities of wind energy developed site. Further following guidelines as far as possible were also kept in mind while choosing an exact location for monitoring towers.

- Towers are placed as for as possible away from the local obstruction to the wind
- Selected location should be representative of the majority of the site.

Since siting a tower near obstructions such as trees or building can adversely affect the analysis of the site's wind characteristics such as magnitude of wind resource, wind shear and turbulence levels the tower in most cases are placed as for as possible away from local obstructions to the wind. But where this rule could not be followed, the tower was placed at horizontal distance of 10 times the height of the obstruction in the prevailing wind direction as required internationally. The following parameters have been recorded during the study.

i. Wind speed ten minute average at 10 & 30 meters
ii. Maximum wind speeds during 10 minutes
iii. Minimum wind speeds during 10 minutes
iv. Wind direction ten minutes average at 30 meters

Every month a team of observers and Maintenance Engineers visits these sites to inspect the instruments and to download the data on a laptop. Finally, the data is compiled and analyzed at Renewable Energy Research Cell established at Meteorological Department Islamabad.

3.0 Methodology; Analysis & Discussion:

3.1 Wind speed variation with height:

Wind speed tends to increase with height in most locations, a phenomenon known as wind shear. The degree of wind shear depends mainly upon on two factors, atmospheric mixing and the roughness of the terrain.

Atmospheric mixing typically follows a daily cycle driven by solar heating. At the hub height of a wind turbine, this cycle often causes wind speeds to increase in the daytime and decrease at night. However, the range of variation between night and day typically diminishes as hub height increases. At a height of approximately 50 meters, it weakens or may even disappear in some cases.

Terrain roughness also affects wind shear by determining how much the wind is slowed near the ground. In areas with a high degree of roughness, such as forests or cities, near- surface wind speeds tend to be low and wind shear high, whereas the converse is true in areas of low roughness such as flat, open fields. Wind shear may be greatly reduced or eliminated where there is an abrupt change in terrain height such as a sea cliff or mountain ridge.

To save money wind measurements sometimes are taken at a lower height than the wind turbine tower. In that case, it is essential to measure wind shear at different times of day in different seasons to accurately predict the performance of a wind power plant. The shear can be measured by monitoring wind speeds at two or three heights on a tower. Since wind turbines produce much more power in stronger winds, wind turbine designers try to put turbines on the tallest possible towers. At some point, however, the increased cost of towers outweighs the benefits. With current wind turbine technology, the optimum tower height for large wind machines appears to be approximately 40 to 50 meters.

For saving money in this survey also the wind has been recorded at 10 & 30 meters and for calculating the wind speed at 50 meters the following two methods has been used in this study.

3.1.1 *Log Law:*

The turbulent mixing in the atmosphere may be considered in a similar way to molecular mixing (this is called k theory). Assuming the mixing is dominated by mechanical mixing due to shear forces a relationship of wind speed with height is derived.

$$u = \frac{u_*}{k} \ln\left(\frac{z - D}{z_o}\right)$$

Where

u_* is the friction notify

k is the von Karman constant

Z_0 is the roughness length

D is the displacement height

The von Karman constant is generally taken as 0.4. The roughness length Z_o is related to the vegetation cover of the area. The values of roughness length are given in Table-1. The displacement height D is the height above the roughness elements where the flow is free. For most vegetation it is small and is generally treated as zero. For large roughness elements like trees and building in towns it is not negligible and is the order of the average height of the elements. The **log law** may only be used for heights above D. Turbines are rarely sited in forests or towns, so D is usually taken as zero.

The wind speed at any height z can then be computed provided that the wind speed at a height Z_R is known. Thus:

$$\frac{u}{u_R} = \frac{\ln\left(z / z_o \right)}{\ln\left(z_R / z_o \right)}$$

Where

U_R is the wind speed at reference height Z_R

The reference height is usually 10m or 30m as this is the height at which mean wind data is generally collected.

3.1.2 *Power Law:*

Engineers often prefer to use a Power Law to describe the increase in wind speed with height, as it is easier to evaluate.

$$\frac{u}{u_R} = \left(\frac{z - D}{z_R} \right)^{\alpha}$$

Where:

α is the power law exponent

u_R is the wind speed at reference height z_R

The power law exponent typically varies between 0.1 and 0.32 depending upon the landscape type. A value of 1/7 is often quoted as a reasonable value for the power law exponent in countryside. The exponent can be calculated from the roughness length.

$$\alpha = \frac{\ln\left(\ln\left(z / z_o \right) / \ln\left(z_R / z_o \right) \right)}{\ln\left(z / z_R \right)} \approx \frac{1}{\ln\sqrt{\frac{z \cdot z_R}{z_o}}}$$

Where: Z is the measurement height

Z_R is the reference height

Z_0 is the roughness length

The power law exponent therefore varies with the interval between the two measurement heights. The power law should be carefully employed since it is not a physical representation of the surface layer and does not describe the flow nearest to the ground very well. Both the log law and the power law are simplified expressions of the wind profile. They are valid in flat homogeneous terrain. So they do not include the effects of topography, obstacles or changes in roughness or stability.

Table 1: Typical values of surface roughness length Z_O and power law exponent α for various types of terrain

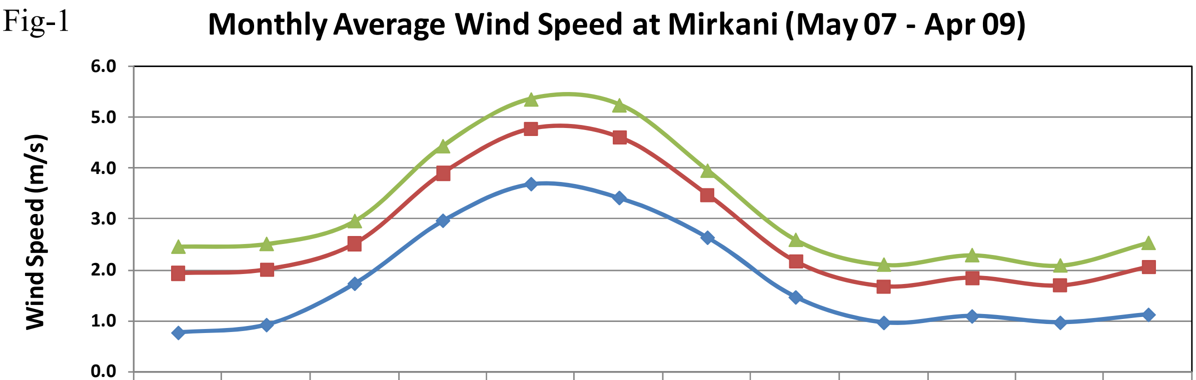
Type of terrain	$\mathbf{Z_0}$	α
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 to 2	0.32
City	1 to 4	

3.2 Average Wind Speed:

By using above mentioned methods the wind speed at 50 meters has been computed and monthly average of these wind speed at 50 meters height have been given in Fig-1 in graphical as well as tabular form.

Fig-1 shows monthly average wind speed at height of 10 meters, 30 meters and 50 meters. At 30 meters height, we have the maximum average wind speed of 4.78 m/s during July. At 50 meters we have the average wind speed of 3.21 m/s and the highest average wind speed of 5.36 m/s is observed during the month of July.

Fig-1



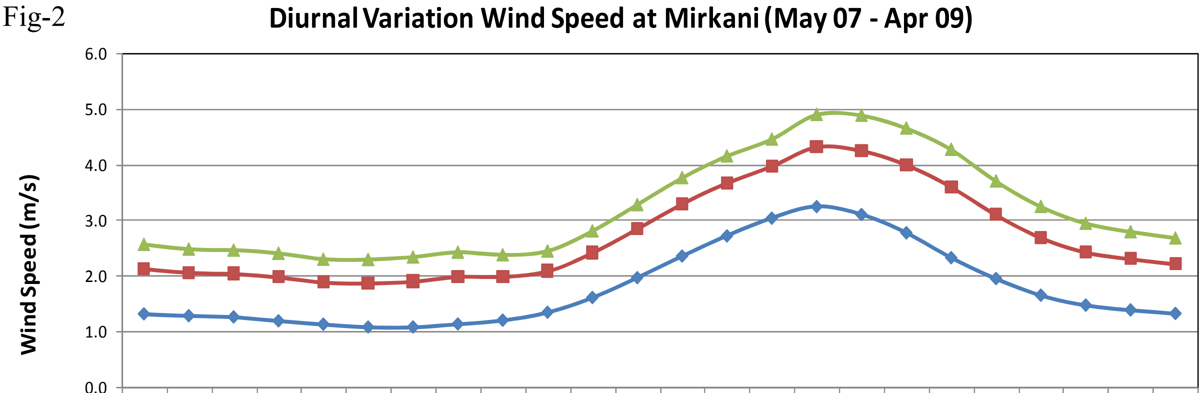
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AWS 10m	0.76	0.92	1.73	2.97	3.69	3.42	2.64	1.46	0.96	1.09	0.96	1.12
AWS 30m	1.93	2.01	2.52	3.91	4.78	4.61	3.48	2.17	1.68	1.85	1.69	2.06
AWS 50m	2.44	2.50	2.95	4.43	5.36	5.24	3.95	2.58	2.09	2.28	2.07	2.52

Months

3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Mirkani from May-07 to Apr-09 (24 months). The wind speed is generally lower during night time and after sunrise it starts picking up. At afternoon it reaches maximum, wind speeds are around 4.34 m/s and 4.90 m/s at 30 meters and 50 meters height respectively.

Fig-2

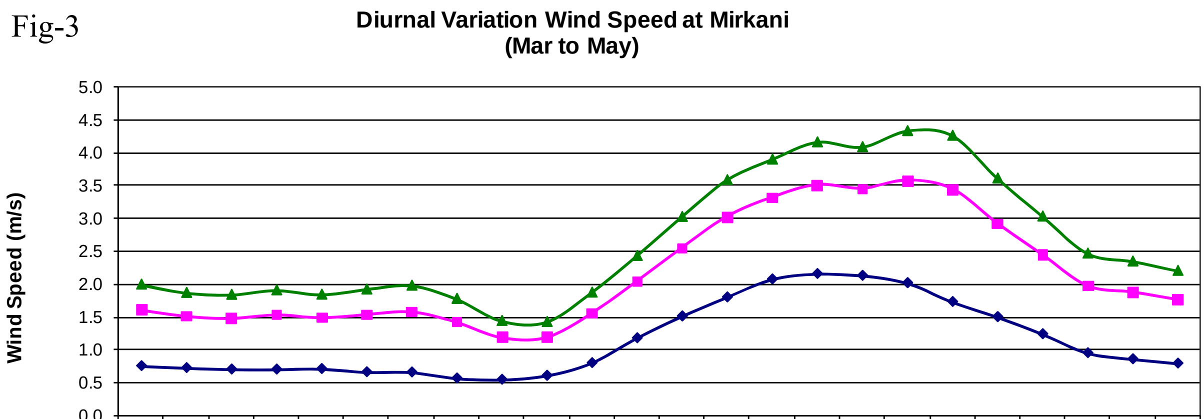


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.34	1.30	1.28	1.21	1.15	1.10	1.10	1.16	1.22	1.37	1.63	1.99	2.37	2.74	3.06	3.26	3.12	2.79	2.35	1.97	1.67	1.49	1.41	1.34
WS 30m	2.14	2.07	2.05	1.99	1.90	1.88	1.91	2.00	2.00	2.10	2.43	2.86	3.31	3.69	3.99	4.34	4.27	4.02	3.62	3.12	2.70	2.44	2.32	2.23
WS 50m	2.6	2.5	2.5	2.4	2.3	2.3	2.3	2.4	2.4	2.5	2.8	3.3	3.8	4.2	4.5	4.9	4.9	4.7	4.3	3.7	3.3	3.0	2.8	2.7

PST (Hours)

Fig-3, Fig-4, Fig-5 and Fig-6 shows the seasonal diurnal wind speed variations throughout the two year period at Mirkani respectively. The wind speed is generally higher during day time as compare to night through out the year at Mirkani.

Fig-3

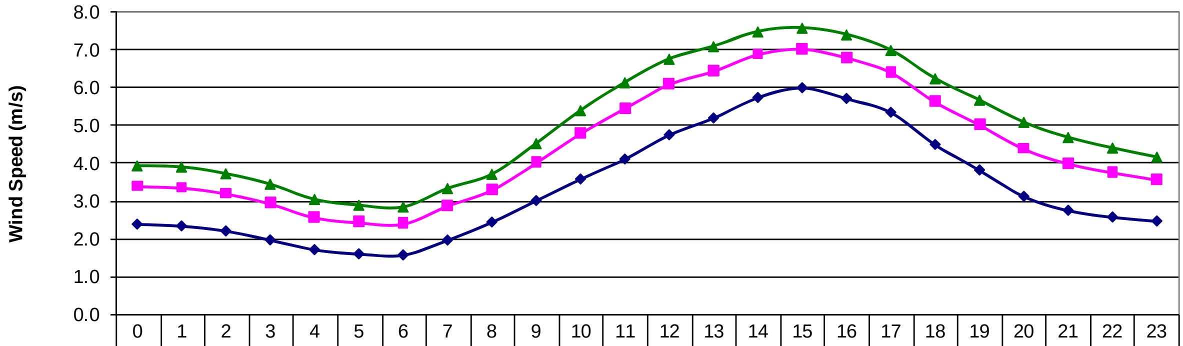


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.6	0.8	1.2	1.5	1.8	2.1	2.2	2.1	2.0	1.7	1.5	1.2	0.9	0.9	0.8
WS 30m	1.6	1.5	1.5	1.5	1.5	1.5	1.6	1.4	1.2	1.2	1.5	2.0	2.5	3.0	3.3	3.5	3.4	3.6	3.4	2.9	2.4	2.0	1.9	1.8
WS 50m	2.0	1.9	1.8	1.9	1.8	1.9	2.0	1.8	1.4	1.4	1.9	2.4	3.0	3.6	3.9	4.2	4.1	4.3	4.3	3.6	3.0	2.5	2.3	2.2

PST (Hours)

Fig-4

Diurnal Variation Wind Speed at Mirkani
(Jun to Aug)

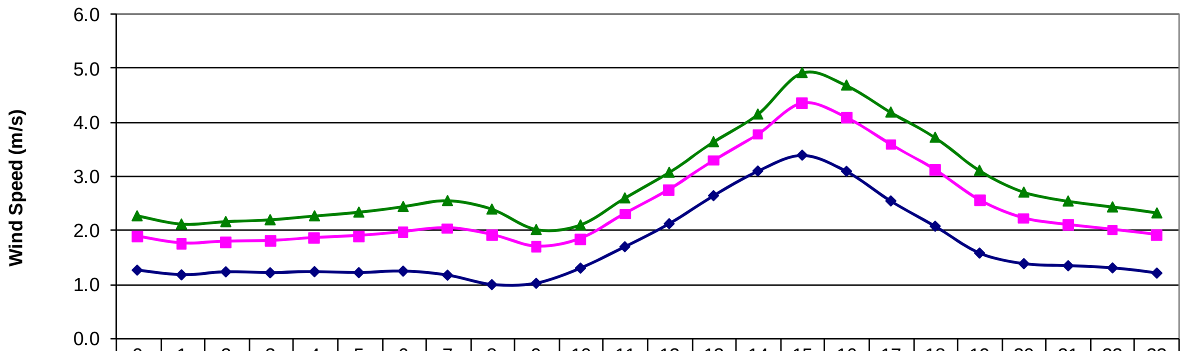


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	2.4	2.3	2.2	2.0	1.7	1.6	1.6	2.0	2.4	3.0	3.6	4.1	4.7	5.2	5.7	6.0	5.7	5.3	4.5	3.8	3.1	2.7	2.6	2.5
WS 30m	3.4	3.3	3.2	2.9	2.6	2.4	2.4	2.9	3.3	4.0	4.8	5.4	6.1	6.4	6.9	7.0	6.8	6.4	5.6	5.0	4.4	4.0	3.7	3.6
WS 50m	3.9	3.9	3.7	3.4	3.0	2.9	2.8	3.3	3.7	4.5	5.4	6.1	6.7	7.1	7.5	7.6	7.4	7.0	6.2	5.7	5.1	4.7	4.4	4.2

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Mirkani
(Sep to Nov)

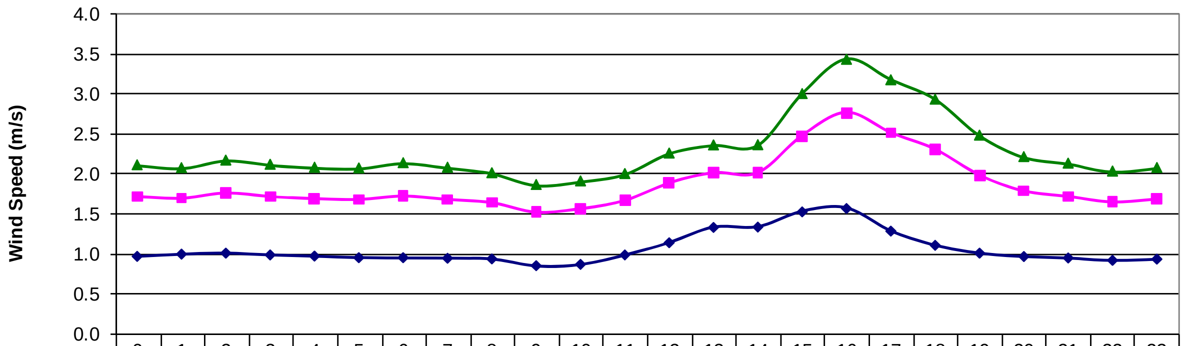


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.0	1.0	1.3	1.7	2.1	2.6	3.1	3.4	3.1	2.5	2.1	1.6	1.4	1.3	1.3	1.2
WS 30m	1.9	1.8	1.8	1.8	1.9	1.9	2.0	2.0	1.9	1.7	1.8	2.3	2.8	3.3	3.8	4.4	4.1	3.6	3.1	2.6	2.2	2.1	2.0	1.9
WS 50m	2.3	2.1	2.2	2.2	2.3	2.3	2.4	2.5	2.4	2.0	2.1	2.6	3.1	3.6	4.2	4.9	4.7	4.2	3.7	3.1	2.7	2.5	2.4	2.3

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Mirkani
(Dec to Feb)



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.9	1.0	1.1	1.3	1.3	1.5	1.6	1.3	1.1	1.0	1.0	0.9	0.9	0.9
WS 30m	1.7	1.7	1.8	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.6	1.7	1.9	2.0	2.0	2.5	2.8	2.5	2.3	2.0	1.8	1.7	1.6	1.7
WS 50m	2.1	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.0	1.9	1.9	2.0	2.3	2.4	2.4	3.0	3.4	3.2	2.9	2.5	2.2	2.1	2.0	2.1

PST (Hours)

3.4 Wind speed Frequency Distribution:

Wind speed frequency distribution can simply be obtained by plotting the different wind speeds against their frequencies / relative frequencies. For obtaining frequency distribution the following two procedures are necessary.

3.4.1 *Binning of Data:*

The sorting of the data into narrow wind speed bands is called binning of the data. In our case a bin width of 1m/sec has been used e.g. a measured wind speed of 3.5 m/sec would be placed in 3<X<=4 m/sec bin. The central value of each bin i.e. 0.5 m/sec, 1.5 m/sec etc has been used in calculations and frequency distribution group.

3.4.2 *Relative Frequency:*

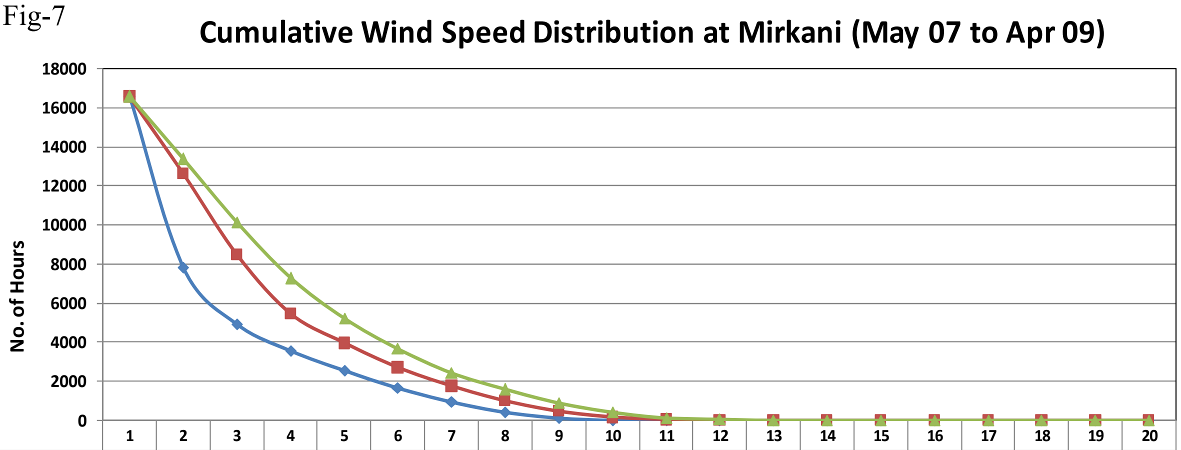
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as:

R .F = probability P (V_i) = Frequency of given wind speed / Total period

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters from May-2007 to April-2009. The analysis indicate that in a year at a height of 30 meters during 3950 hours the wind speed is equal or greater than 5 m/s whereas at 50 meters during 5222 hours the wind speed is equal or greater than 5m/s.

Fig-7



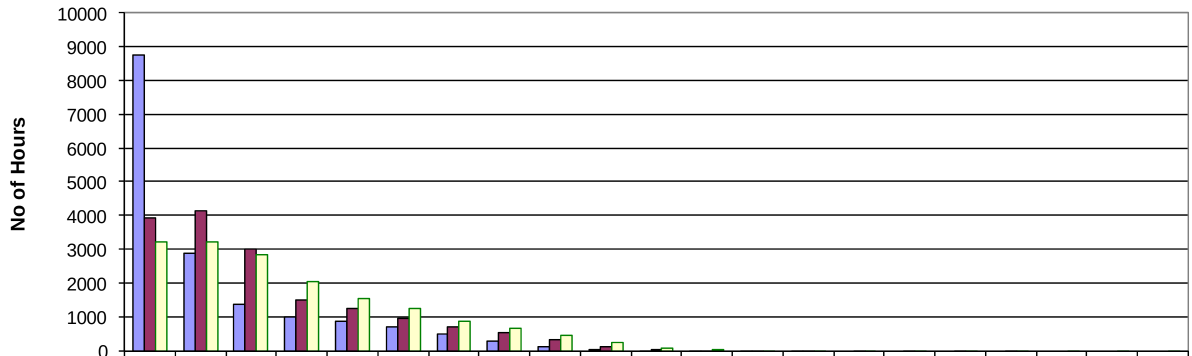
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	16571	7831	4945	3561	2547	1679	951	451	151	36	9	2	1	0	0	0	0	0	0	0
CWS 30m	16571	12630	8477	5478	3960	2717	1772	1041	492	162	46	15	7	3	1	1	0	0	0	0
CWS 50m	16571	13369	10133	7279	5222	3689	2454	1580	896	424	154	66	31	15	9	4	2	2	2	1

Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the *wind frequency distribution* at Mirkani. We can see that at 50 meters during 1533 hours wind speed is 5 m/s, 1235 hours speed is 6 m/s, 875 hours speed is 7 m/s and so on.

Fig-8 **Wind Frequency Distribution at Mirkani (May 07 - Apr 09)**

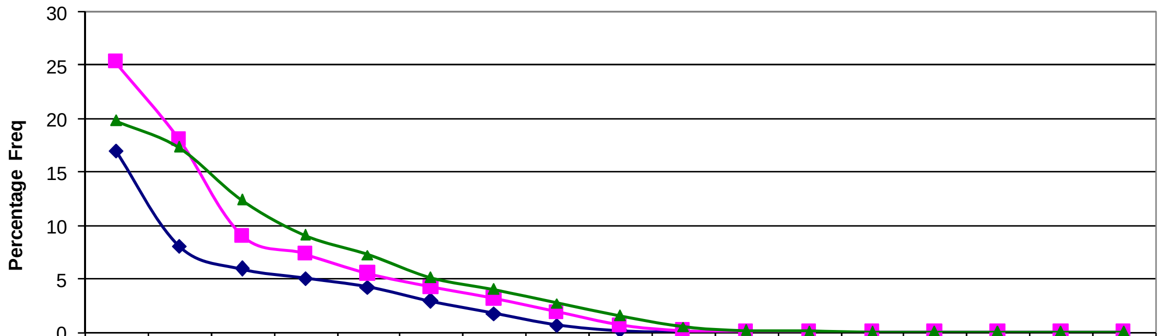


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	8740	2886	1384	1014	869	728	500	300	115	27	7	1	1	0	0	0	0	0	0	0	0
CWS 30m	3942	4152	3000	1518	1244	945	731	549	329	117	31	8	4	2	0	0	0	0	0	0	0
CWS 50m	3202	3236	2853	2058	1533	1235	875	684	472	270	88	35	16	7	5	2	0	1	1	0	1

Wind Speed (m/s)

Fig-9 gives this *frequency distribution in percentage*. At 50 meters we find that during 7.3% of time wind is 5m/s, 5.1% of the time 6m/s and 4.0% of the time it is 7m/s. whereas at 30 meters height we get 5.5% of the time wind speed 5m/s, 5.1% of the times 6m/s and 4.0% of the time 7m/s and so on.

Fig-9 **Percenatge Wind Frequency Distribution at Mirkani (May07 to Apr09)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WS 10m	17.0	8.1	5.9	5.1	4.2	2.9	1.7	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	25.3	18.1	9.0	7.4	5.5	4.3	3.2	1.9	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	19.8	17.3	12.4	9.1	7.3	5.1	4.0	2.7	1.6	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0

Wind Speed (m/s)

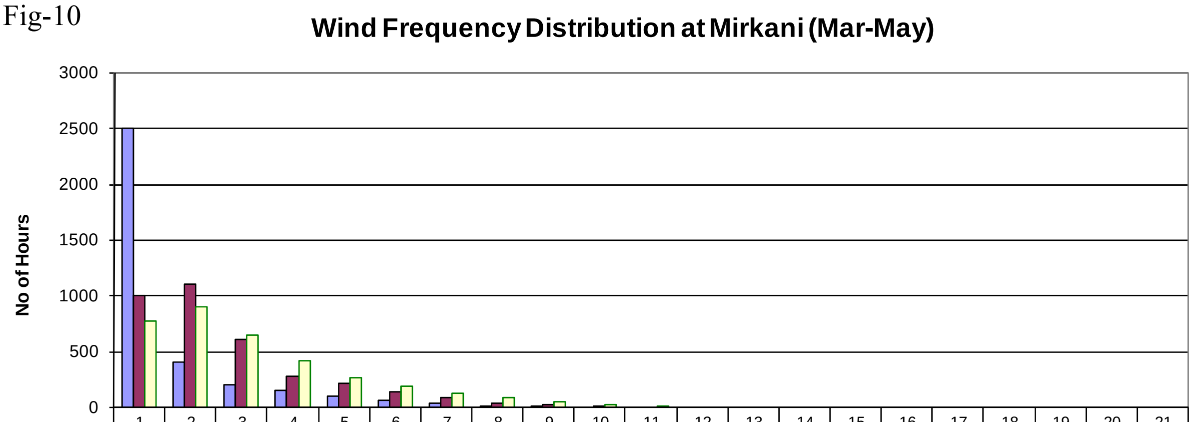
3.4.5 ***Seasonal Wind Frequency Distribution:***

Figures 10–17 gives seasonal wind frequency distribution and percentage frequency distribution.

Mar – May

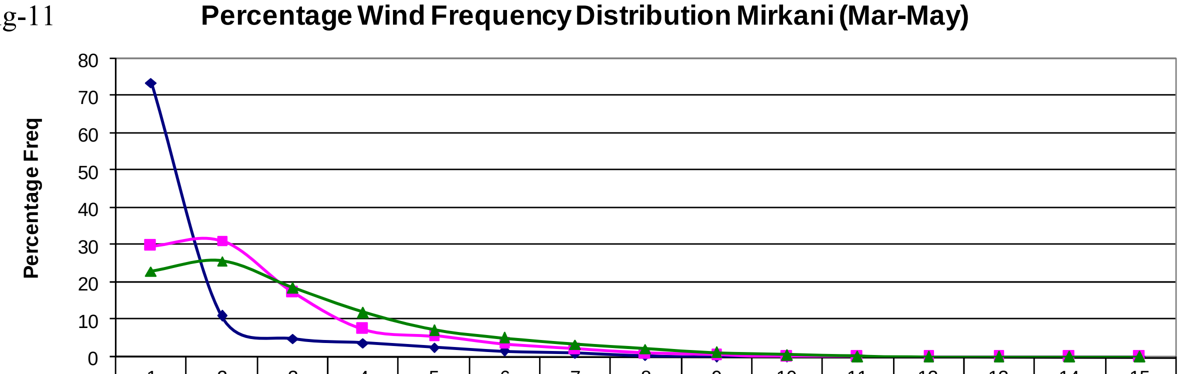
Fig-10 shows this distribution during the months of March to May. We can see that in this period at 30 meters height during 210 hours we get 5m/s, 141 hours 6m/s, 83 hours 7m/s. Similarly at 50 meters we get 263 hours 5m/s, 195 hours 6m/s, 130 hours 7m/s. Fig-11 shows percentage frequency distribution for Mar to May.

Fig-10



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2501	409	198	150	104	66	42	18	8	3	1	1	0	0	0	0	0	0	0	0	0
WS 30m	1004	1100	607	274	210	141	83	41	23	8	5	1	2	1	0	0	0	0	0	0	0
WS 50m	771	902	648	418	263	195	130	84	46	24	8	5	2	2	1	0	0	0	0	0	0

Fig-11



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	73.6	11.1	5.1	3.9	2.7	1.8	1.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	30.0	31.3	17.5	7.6	5.7	3.6	2.2	1.1	0.6	0.2	0.1	0.0	0.0	0.0	0.0
WS 50m	23.0	25.8	18.7	12.0	7.3	5.3	3.5	2.2	1.2	0.6	0.2	0.1	0.0	0.0	0.0

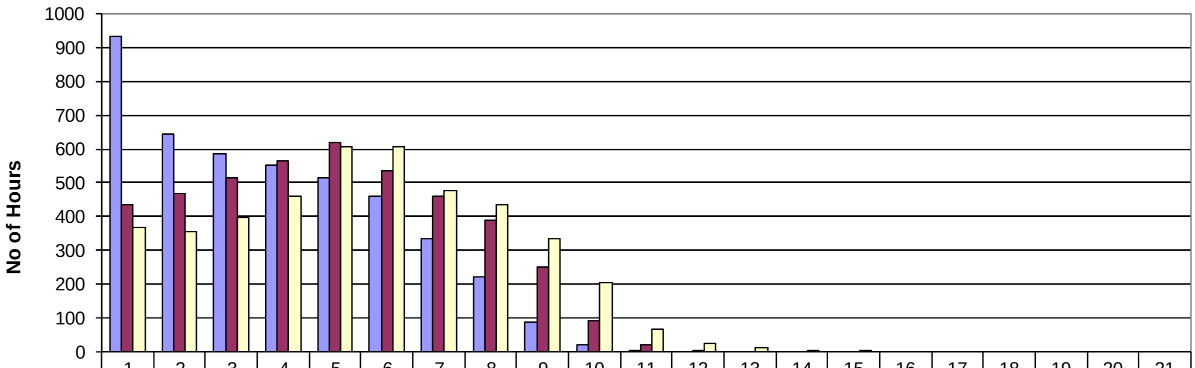
Jun – Aug

Fig-12 shows wind frequency distribution during the months of June to August. We can see that in this period at 30 meters height during 618 hours we get 5m/s, 537 hours 6m/s, 459 hours 7m/s.

Similarly at 50 meters height during 607 hours we get wind speed of 5m/s, during 607 hours 6m/s, 476 hours 7m/s, 435 hours 8m/s. Fig-13 shows this distribtution in percentage.

Fig-12

Wind Frequency Distribution at Mirkani (Jun-Aug)

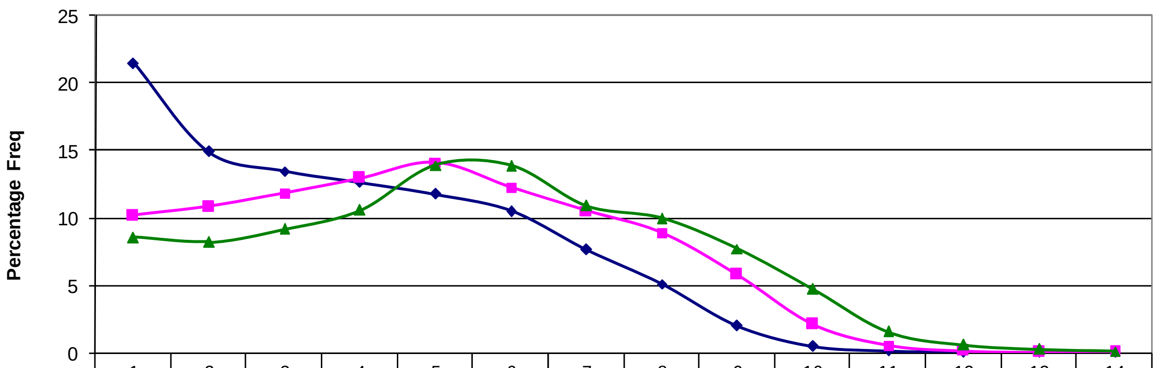


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	932	646	586	552	514	459	335	223	87	20	5	0	0	0	0	0	0	0	0	0	0
WS 30m	437	468	514	564	618	537	459	388	253	92	22	5	2	1	0	0	0	0	0	0	0
WS 50m	367	354	397	460	607	607	476	435	336	206	67	26	12	5	3	1	0	1	0	0	1

Wind Speed (m/s)

Fig-13

Percentage Wind Frequency Distribution at Mirkani (Jun-Aug)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	21.4	14.9	13.4	12.6	11.8	10.5	7.6	5.1	2.0	0.5	0.1	0.0	0.0	0.0
WS 30m	10.2	10.8	11.8	12.9	14.1	12.3	10.5	8.9	5.8	2.1	0.5	0.1	0.0	0.0
WS 50m	8.5	8.2	9.2	10.6	13.9	13.9	10.9	9.9	7.7	4.7	1.5	0.6	0.3	0.1

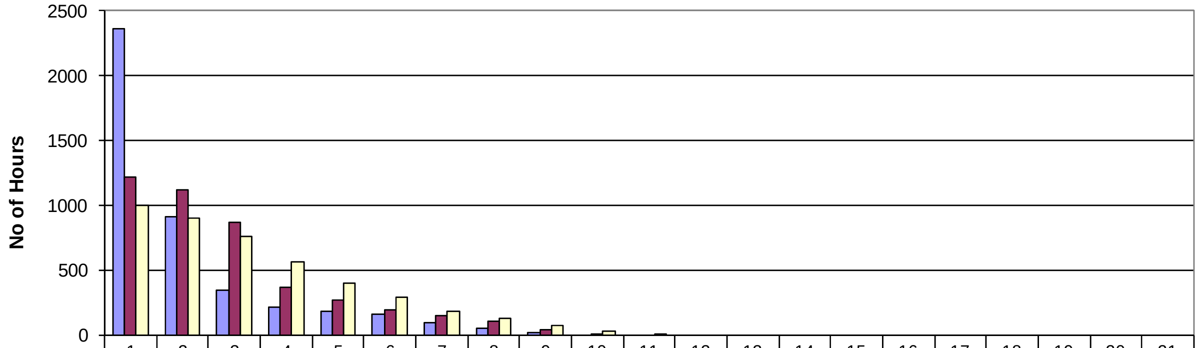
Wind Speed (m/s)

Sep – Nov

Fig-14 shows wind frequency distribution during the months of September to November. We can see that in this period at 30 meters height during 272 hours we get 5m/s, 195 hours 6m/s, 154 hours 7m/s.

Similarly at 50 meters height during 399 hours we get wind speed of 5m/s, during 289 hours 6m/s, 182 hours 7m/s, 128 hours 8m/s. Fig-15 shows distribution in percentage.

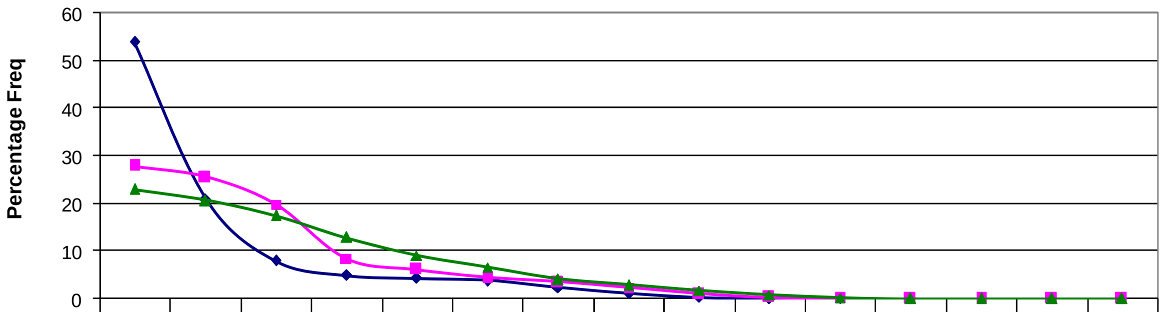
Fig-14 **Wind Frequency Distribution at Mirkani (Sep-Nov)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2354	917	350	215	188	166	104	52	18	3	1	0	0	0	0	0	0	0	0	0	0
WS 30m	1219	1119	866	371	272	195	154	104	46	17	3	2	1	0	0	0	0	0	0	0	0
WS 50m	1005	904	766	564	399	289	182	128	78	36	12	4	2	1	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-15 **Percentage Wind Frequency Distribution at Mirkani (Sep-Nov)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	53.9	21.0	8.0	4.9	4.3	3.8	2.4	1.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	27.9	25.6	19.8	8.5	6.2	4.5	3.5	2.4	1.1	0.4	0.1	0.1	0.0	0.0	0.0
WS 50m	23.0	20.7	17.5	12.9	9.1	6.6	4.2	2.9	1.8	0.8	0.3	0.1	0.0	0.0	0.0

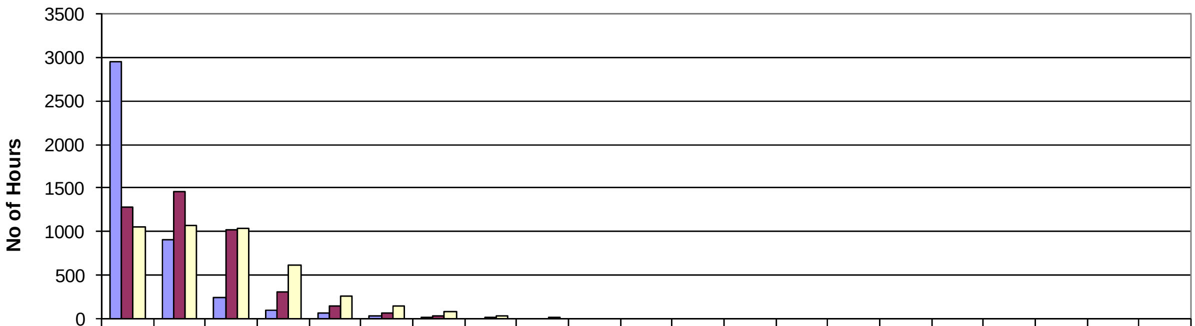
Wind Speed (m/s)

Dec – Feb

Fig-16 shows wind frequency distribution during the months of December to February. We can see that in this period at 30 meters height during 144 hours we get 5m/s, 72 hours 6m/s, 35 hours 7m/s.

Similarly at 50 meters height during 265 hours we get wind speed of 5m/s, during 144 hours 6m/s, 87 hours 7m/s, 37 hours 8m/s. Fig-17 shows distribution in percentage.

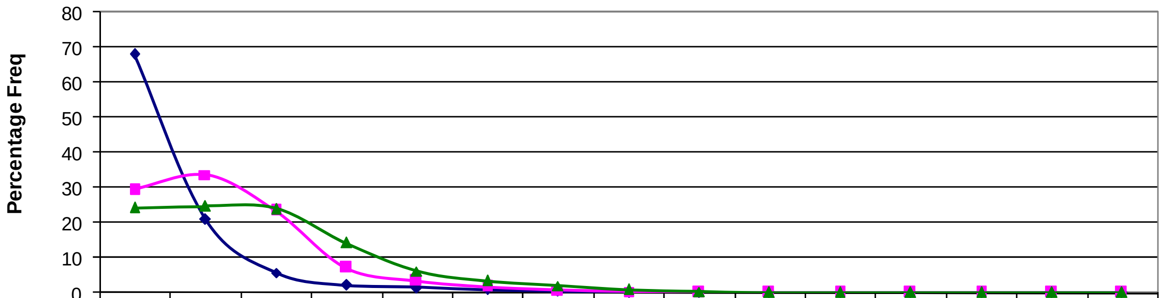
Fig-16 **Wind Frequency Distribution at Mirkani (Dec-Feb)**



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2954	915	250	98	64	37	19	7	2	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1283	1466	1013	308	144	72	35	15	7	1	0	0	0	0	0	0	0	0	0	0	0
WS 50m	1060	1076	1043	616	265	144	87	37	13	4	1	0	0	0	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-17 **Percentage Wind Frequency Distribution at Mirkani (Dec-Feb)**



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	68.0	21.0	5.8	2.3	1.5	0.9	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	29.4	33.7	23.4	7.1	3.4	1.7	0.8	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	24.3	24.7	24.0	14.2	6.1	3.3	2.0	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0

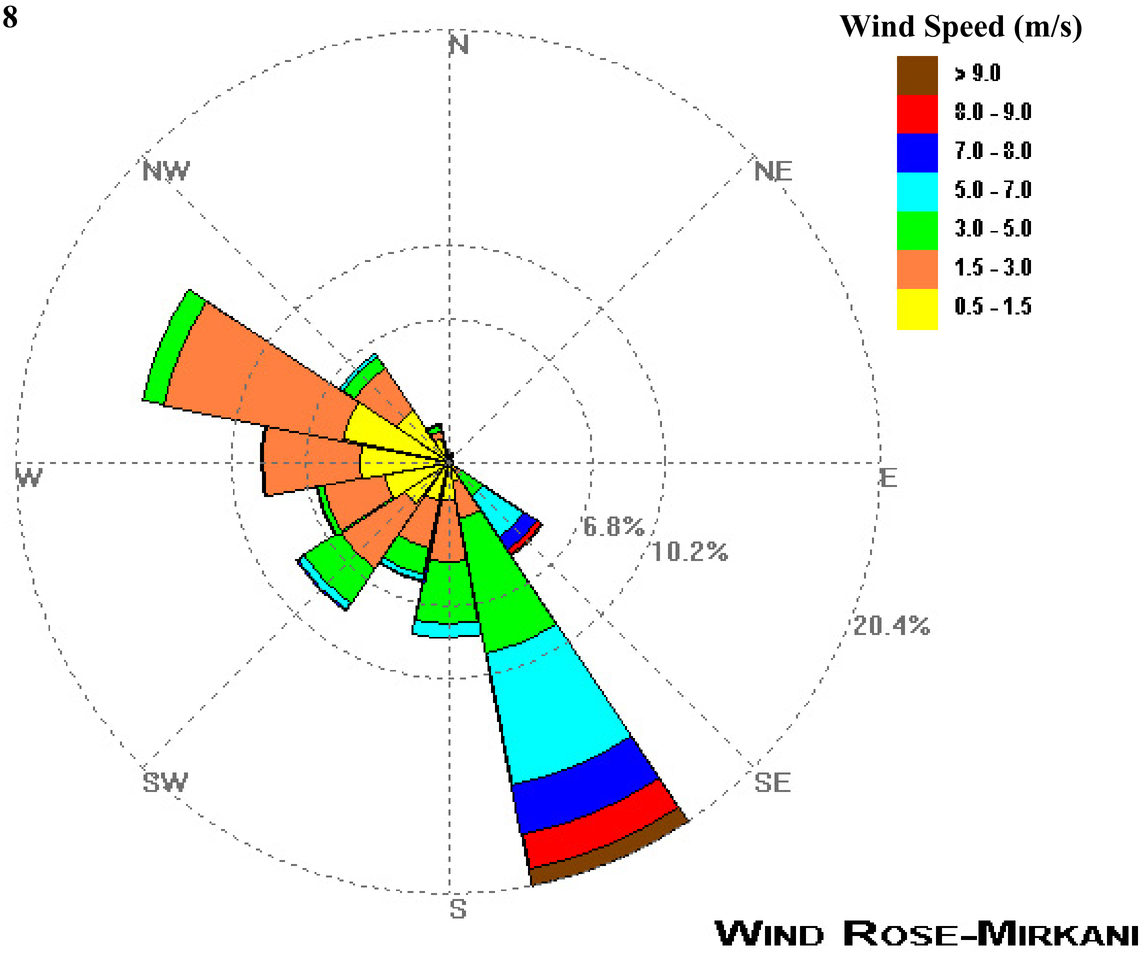
Wind Speed (m/s)

3.5 Wind Rose:

Fig-18 shows the Wind Rose based on 24 months data from May 2007 – April 2009 collected at 30 meters height. Wind Rose indicates that the wind direction is mostly between south and south east. The average wind speed is 2.77 m/s and the percentage of wind speed greater than 5 m/s is 18.5%.

Wind Rose at Mirkani (30m height during 24 months)

Fig-18



Average Wind Speed	Average Wind Direction	Wind speed greater than 5 m/s
2.77 m/s	222°	18.5%

3.6 Wind speed statistic:

3.6.1 *The statistical Mean:*

It is the average of a set of n numbers. Mathematically, we can write

$$Mean = \frac{\left[\sum_{i=1}^{n} x_i \right]}{N}$$

The Mean Wind Speed V can be calculated by the formula.

$$V = \sum_{i=1}^{n} V_i P(V_i)$$

Where Vi is the central wind speed of bin 1 and P(Vi) is the probability/relative frequency that the wind speed has in bin i.

3.6.2 *Variance:*

It is one of the several indices of variability that statistician, use to characterize the dispersion among the measures in a given set of data. Mathematically, variance is written as

$$\text{Variance} = \sigma^2 = \sum (X_i - V)^2$$

Where V is mean of data set

In case of wind speed data, we can write it, as

$$\sigma^2 = \sum V_i^2 P(Vi) - (V)^2$$

3.6.3 *Standard Deviation*

It is the square root of the variance, denoted by σ

$$\sigma^2 = (\sigma)^{1/2} = \sum \left(V_i^2 P(V_i) - (V)^2 \right)^{1/2}$$

3.7 Wind power density:

While investigating a wind power potential of an area, the average values of wind speed does not truly represent this potential because lot of information regarding frequency distribution of wind speed is suppressed in the process of averaging wind speed. As such the most important values for estimating the wind power potential of a given site is the value of the wind power density or the available theoretical instantaneous power from the wind. This available wind power in the wind is the flux of Kinetic Energy crossing the wind energy conversion system and its cross – sectional area.

Like water flowing in the river, wind contains energy that can be converted to electricity using wind turbines. The amount of electricity that wind turbines produce depends upon the amount of energy in the wind passing through the area swept by the wind turbines blades in a unit of time. This energy flow is referred to as the wind power density.

A key aspect of wind power density is its dependence on wind speed cubed. This means that the power contained in the wind increases very rapidly with wind speed; if the speed doubles, the power increases by a factor of eight. In practice, the relationship between the power output of a wind turbine and wind speed does not follow a cubic relationship. Below a certain minimum speed, the turbine does not have enough wind to operate, whereas above a certain speed its output levels off or begins to decline. In very high winds the turbine may even be shut down to prevent damage to it.

Wind power density also depends on air density. At higher attitudes, air density decreases and, as a result, so does the available power. This effect can reduce the power output of wind turbines on high mountains by as much as 40 percent compared to the power that could be produced at the same wind speeds at sea level. Air density depends inversely on temperature: colder temperatures are favorable for higher air densities and greater wind power production.

3.7.1 *Wind power classes:*

To simplify the characterization of the wind power potential, it is common to assign areas to one of seven wind classes, each representing arrange of wind power density at the special height above the ground. The standard International wind power classifications are shown in Table 2.

Table-2: International Wind Power Classification

Class	Resource Potential	30m Height		50m Height	
		Wind Speed m/s	Wind Power W/m²	Wind Speed m/s	Wind Power W/m²
1	Poor	0 – 5.1	0 – 160	0 – 5.6	0 – 200
2	Marginal	5.1 – 5.9	160 – 240	5.6 – 6.4	200 – 300
3	Moderate/Fair	5.9 – 6.5	240 – 320	6.4 – 7.0	300 – 400
4	Good	6.5 – 7.0	320 – 400	7.0 – 7.5	400 – 500
5	Excellent	7.0 – 7.4	400 – 480	7.5 – 8.0	500 – 600
6	Outstanding	7.4 – 8.2	480 – 640	8.0 – 8.8	600 – 800
7	Superb	8.2 – 11.0	640 – 1600	8.8 – 11.9	800 – 2000

By and large, the areas being developed today using large wind turbine are ranked as class 5 and above. Class 4 areas are also being considered for further development as wind turbines are adopted to run more efficiently a lower wind speeds. Class1 and class2 areas are not being deemed suitable for large machines, although a smaller wind turbine may be economical in areas where the value of the energy produced is higher

3.7.2 *Power of wind Energy:*

A parcel of Wind possesses kinetic energy

$$E = \tfrac{1}{2} mV^2$$

From this, power density is calculated as

$$P = \tfrac{e}{t} = \tfrac{1}{2} \tfrac{dm}{dt} V^2$$

Where $\frac{dm}{dt}$ is the mass of air following time.

From fluid dynamics, it can be proved that

$$\tfrac{dm}{dt} = \varphi AV$$

Volume of cylindrical cross section can be written as

$$V = \pi r^2 L \qquad \text{---------------} \quad (1)$$

Where r is radius of cylinder and L is length of it.
The wind moving with velocity V travels this distance L in time t so

$$S = L = Vt,$$

So equation L takes the form

$$V = \pi r^2 Vt$$

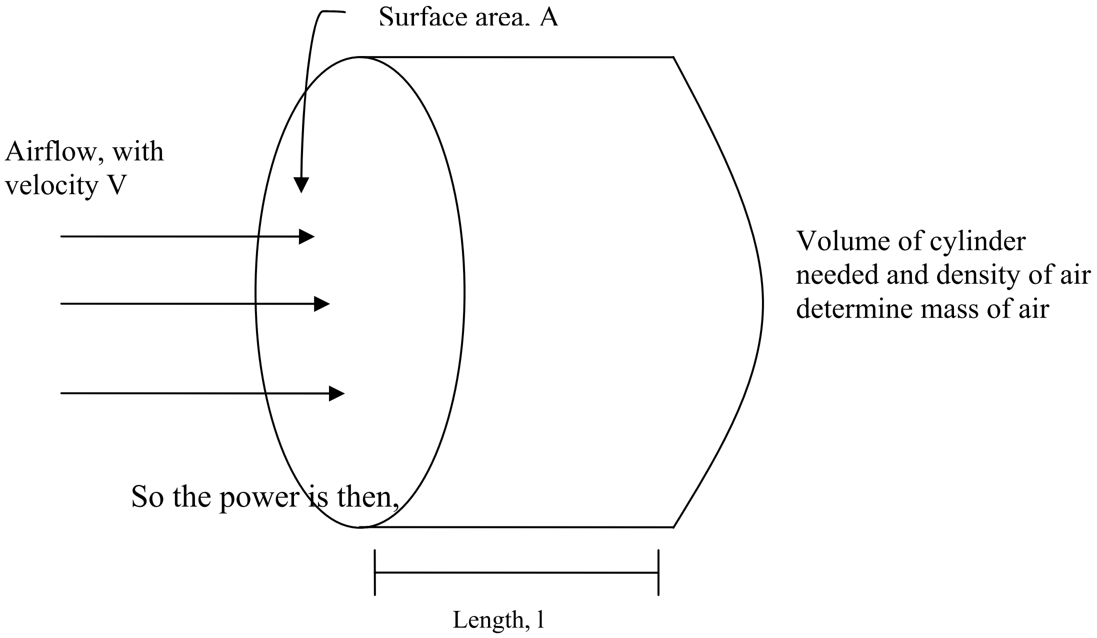
Now mass of wind can be written as

$$M = \varphi Avt$$

Differentiating

$$\tfrac{dm}{dt} = \varphi AV \tfrac{d}{dt(t)} = \varphi AV$$

Where φ is density of wind and others parameters have been defined in diagram.



So the power is then,

$$P = \tfrac{1}{2}\ {}^{dm}\!/_{dt}\ V^2 = \tfrac{1}{2}\varphi AVT/t\ V^2$$

$$= \tfrac{1}{2}\varphi AV^3$$

And power density

$$P/_A = \tfrac{1}{2}\varphi V^{3}$$

Density of wind at mean sea level is 1.225 kg/m^3

At 30° C, The area depends upon the size of the rotor. Therefore, it is clear that power density chiefly depends on wind velocity and goes up as a cube of it.

3.7.3 *Wind power calculation using Mean wind Speed:*

Wind power calculated from Mean wind speed is not true representative of wind power. In real world, the wind varies constantly. Actual wind power density at most sites can ring from 1.0 to 3 times greater then that calculated. For example, we take wind speed of 5, 7 and 8 m/sec respectively the respective power densities are 76 wat/m^2, 210 watt/m^2 and 313 watt/m^2. The average of which is 200 watt/m^2. On the other hand, the average wind speed is 6.7 m/sec and power density of average wind is 181 watt/m^2. So the power of wind calculated by mean wind speed is less than the actual power present in wind i.e. Mean wind speed is not true representative for the wind power calculations.

To overcome this drawback we find some alternative arrangement, which reduces the deficit. The Weibull distribution is the best fit of wind data to calculate wind power based on mean wind speed and variance/standard deviation.

3.7.4 *Weibull distribution:*

The Weibull distribution (named after the Swedish physicist W. Weibull, who applied it when studying material strength in tension and fatigue in the 1930s) provides a close approximation to the probability laws of many natural phenomenons. It has been used to represent wind speed distribution for application in wind loads studies for sometime. In recent years most attention has been forced on this method for wind frequency applications not only due to its greater flexible and simplicity but also because it can give a good fit to experimental data.

The Weibull distribution function, which is a two-parameter function, has been found to fit much wind data with acceptable accuracy is expressed mathematically as

$$\phi(u) = \frac{k}{c}\left(\frac{u}{c}\right)^{k-1} \exp\left(-\left(\frac{u}{c}\right)^{k}\right)$$

Where:
u is the wind speed
c is the scale parameter with units of speed
k is the shape parameter and is dimensionless

When k = 2 the distribution reduces to Rayleigh distribution and if k=1 an exponential distribution is found. These are special cased of Weibull distribution.

Solving the equation, we find that the scale factor c is closely related to the mean wind speed for the site.

$$\overline{u} = c\tau\left(1 + \frac{1}{K}\right)$$

Where* τ *is the complete gamma function

Similarly

$$\overline{u^n} = c^n\tau\left(1 + \frac{n}{k}\right)$$

And so

$$\overline{u^3} = c^3\tau\left(1 + \frac{3}{k}\right)$$

The available power density is obtained:

$$E = \frac{1}{2}\varphi c^3\tau\left(1 + \frac{3}{k}\right)$$

Where
E is the power density in watts / m^2

The shape factor k is related to the variance of the wind

$$\sigma^2 = c2\left[\left(1 + \frac{2}{k}\right) - \left(\tau\left(1 + \frac{1}{k}\right)\right)^2\right]$$

The two Weibull parameters k and c may be derived from site data.

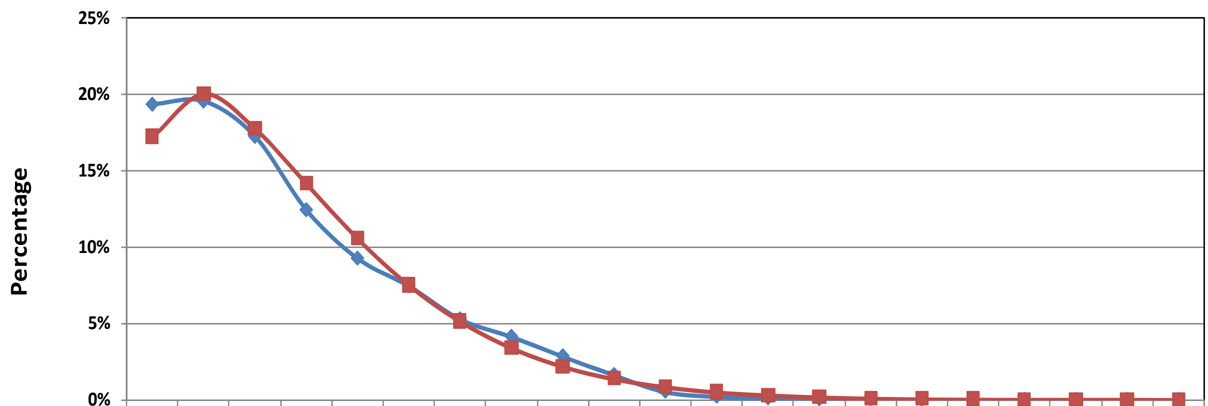
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion of wind does not contribute greatly to the overall power production.

The mathematical description of the wind frequency allows us to match with the turbine power curve. Thus a measure of the average total power capture in a year is achieved. Additionally the choice of turbine cut in and furling speed may be chosen to maximum the total energy capture.

3.7.5 *Weibull Parameters:*

Fig-19 shows the Weibull fit to the relative frequency of wind speed.

Fig-19 **Relative Frequency and Weibull Probability at Mirkani (50 m height)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R.F 50m	19.3%	19.5%	17.2%	12.4%	9.2%	7.4%	5.3%	4.1%	2.8%	1.6%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	17.2%	20.0%	17.7%	14.1%	10.6%	7.5%	5.1%	3.4%	2.2%	1.4%	0.8%	0.5%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Wind Speed (m/s)

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in **Table-3** along with other key results of analysis. If we look at the shape parameters K and scale parameter C for 50 meters height we can find that the shape parameter K varies over a wind range from the lowest of 1.27 during May to the highest of 2.14 during the month of July with a annual value of K being 1.55.

The lowest values of the scale parameter C, 2.29 is observed in November while the highest value of 6.04 is obtained in July and with an annual value of 3.57.

3.7.6 *Average Wind Speed & Standard Deviation:*

In Table-3 monthly average wind speed and standard deviation at three different heights are also given. The average wind speed values for 10 meters and 30 meters height have been obtained from the recorded data, whereas the values for the 50 meters height have been computed by using the power law as explained in the earlier section.

At 10 meters height the average wind speed is 1.82 m/s with Standard deviation of 1.56, at 30 meters this average speed is 2.70 m/s with Standard deviation of 1.83. At 50 meters the monthly average wind speed varies from the lowest of 2.07 m/s in January to highest of 5.35 m/s during July. Whereas the average wind speed is 3.21 m/s with Standard deviation of 2.10.

3.7.7 *Power Density:*

The monthly power densities for three different heights 10meters, 30meters and 50meters have also been given in Table-3. At 10 meters this power density varies between 5.04 W/m^2 in January to 3.25 W/m^2 in December with Average of 25.0 W/m^2.

At 30 meters height the power density varies from 10.20 W/m^2 in January to 9.01 W/m^2 in December and the average values is about 44.43 W/m^2.

At 50 meters height the power density of Mirkani varies between lowest 15.72 W/m^2 in November to heightest 167.97 W/m^2 in July. The average power density of the area is 66.30 W/m^2.

Table-3: Monthly Average Wind, St. Deviation and Wind Power Density at Mirkani

	10 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	0.95	0.97	1.08	0.98	**5.04**
February	1.11	1.17	1.26	0.95	**8.93**
March	0.80	0.94	0.74	0.85	**3.04**
April	1.25	1.50	1.12	0.82	**12.45**
May	1.71	1.79	1.67	0.95	**20.86**
June	2.94	2.35	3.17	1.28	**55.11**
July	3.66	2.31	4.09	1.65	**71.30**
August	3.38	2.27	3.76	1.54	**62.05**
September	2.60	2.21	2.75	1.19	**43.63**
October	1.43	1.49	1.40	0.95	**12.07**
November	0.93	0.84	0.97	1.12	**2.26**
December	1.04	0.94	1.09	1.11	**3.25**
Average	**1.82**	**1.56**	**1.92**	**1.12**	**25.00**
	30 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	1.66	1.27	1.88	1.34	**10.20**
February	2.02	1.42	2.28	1.47	**15.20**
March	1.89	1.41	2.06	1.37	**12.84**
April	2.13	1.80	2.27	1.20	**23.64**
May	2.54	2.16	2.70	1.20	**40.49**
June	3.88	2.59	4.31	1.55	**92.45**
July	4.73	2.45	5.34	2.04	**121.47**
August	4.56	2.39	5.15	2.02	**109.93**
September	3.43	2.38	3.80	1.49	**68.11**
October	2.12	1.76	2.26	1.22	**22.39**
November	1.63	1.15	1.80	1.47	**7.48**
December	1.79	1.18	2.00	1.57	**9.01**
Average	**2.70**	**1.83**	**2.99**	**1.49**	**44.43**
	50 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	2.07	1.56	2.34	1.36	**19.11**
February	2.51	1.71	2.79	1.52	**25.89**
March	2.44	1.81	2.67	1.38	**27.49**
April	2.63	2.10	2.83	1.28	**39.29**
May	3.04	2.43	3.28	1.27	**61.38**
June	4.44	2.79	5.02	1.66	**131.18**
July	5.35	2.66	6.04	2.14	**167.97**
August	5.23	2.68	5.91	2.07	**161.97**
September	3.94	2.55	4.40	1.61	**92.37**
October	2.56	2.00	2.78	1.31	**35.15**
November	2.08	1.48	2.29	1.45	**15.72**
December	2.26	1.50	2.52	1.57	**18.11**
Average	**3.21**	**2.10**	**3.57**	**1.55**	**66.30**

ESTIMATING WIND GENERATED ELECTRIC POWER OUTPUT

Appendix-I

Monthly Average Diurnal Variation of Wind Generated Electric Power Output.

Appendix-II

Hourly Wind Generated Electric Power Output

4.0 Estimating Wind Generated Electric Power Output

The average power output of wind energy conversion technologies (WECT) is a very important parameter since it determines the energy output over time thereby influencing the economic feasibility of a wind project. It is by far more useful than the rated power, which does not account for the variability of wind velocity thereby easily overestimating energy revenues. The average power of wind turbine, $\overline{P_{WT}}$, is the power produced at each wind speed multiplied by the fraction that wind speed is experienced, integrated over all possible wind speeds. In integral form this can be expressed as (Manwell et al., 2002; Borowy and Salameh, 1996):

$$\overline{P_{WT}} = \int_0^{\infty} P_{WT}(v) df(v)$$

This integral can be replaced with a summation over bins, N_B, to calculate the average wind turbine power (Manwell et al., 2002).

$$\overline{P_{WT}} = \sum_{j=1}^{N_B} \left\{ \exp\left[-\left(\frac{v_{j-1}}{c} \right)^k \right] - \exp\left[-\left(\frac{v_j}{c} \right)^k \right] \right\} P_{WT}\left(\frac{v_{j-1} + v_j}{2} \right)$$

Please note that the relative frequency, f_j/N, corresponds to the term in brackets and the power output is calculated at the midpoint between v_{j-1} and v_j .

The available power at any given wind speed *v* that is convertible by a turbine is defined by (Manwell et al., 2002 Johnson, 1985)

$$P_{WT}(v) = \frac{1}{2} \rho A C_p \eta \upsilon^3$$

Where η is the drive train efficiency (i.e. generator power/rotor power), C_p, is the machine power coefficient. In an idealized wind turbine no losses are experienced and the power coefficient, C_p, is equal to Betz' limit (i.e. $C_{p,Betz}$ = 16/27) and η = 1. Of course, in reality both the drive train efficiency and the power coefficient cannot be maximized. The extent to which the power output is limited by physical laws as well as engineering inefficiency is dependent on the specific characteristics of individual wind turbine types. This aspect will be discussed further in the analysis of the case study.

WECTs have a range of different power output performance curves, which need to be recognized when estimating the potential power output. The power output performance curves are not only defined by parameters such as the power coefficient and the drive train efficiency but also constrained by cut-in speed, furl-out speed and rated wind speed. Where the cut-in wind seed, v_c, is the minimum wind velocity to generate power from a turbine, the rated wind speed, v_R, is the wind speed at which the 'rated power' of a WETC is achieved and generally corresponds to the point at which the conversion efficiency is near its maximum and furl-out wind speed, v_F, is the wind speed at which the turbine shuts down to prevent structural damage.

To account for the above-mentioned constraints we can formulate a novel formula for the average electrical power output of a turbine, $\overline{P_{WTA}}$:

$$\overline{P_{WTA}} = \begin{cases} \sum_{j=1}^{N_B} \left\{ \exp\left[-\left(\frac{v_{j-1}}{c} \right)^k \right] - \exp\left[-\left(\frac{v_j}{c} \right)^k \right] \right\} P_{WT}\left(\frac{v_{j-1}+v_j}{2} \right) & (v_c \le v \le v_R) \\ \sum_{j=1}^{N_B} \left\{ \exp\left[-\left(\frac{v_{j-1}}{c} \right)^k \right] - \exp\left[-\left(\frac{v_j}{c} \right)^k \right] \right\} P_{WT}(v_r) & (v_R \le v \le v_F) \\ 0 & (v < v_c \text{ and } v > v_F) \end{cases}$$

The energy production of the wind turbine WE(t) over time t can thus be calculated as

$$\mathrm{WE(t)} = \overline{P_{WTA}}\,t$$

Another way of stating the energy output from a wind turbine is to look at the capacity factor for the turbine in its particular location. The capacity factor CF, is the actual energy output over a given period of time, WE(t), divided by the theoretical maximum energy output (i.e. this means that the machine is constantly running at its rated output) during the selected time-span, RO(t). This can be formulated as

$$CF = \frac{WE(t)}{RO(t)}$$

Theoretically capacity factor vary from 0 to 100%. In practice they usually range from 20 to 70% and mostly be around 20-30 percent. However, the economic feasibility of a wind turbine does not of course depend on the capacity factor of a wind turbine alone but also depends on the costs of alternative power systems. Therefore, a low capacity factor does not automatically render a wind turbine project unfeasible.

In order to maximize the energy output of a given wind regime the optimum wind speed, v_{opt}, needs to be determined. The optimum wind speed indicates at what wind velocity most energy is available in a given wind regime. It is at this particular wind speed that engineers should ensure that the power coefficient is most efficient to allow for the highest energy conversion of a turbine. The optimum wind speed can be calculated as follows (Lu et al., 2002):

$$v_{opt} = c\left(\frac{k+2}{k} \right)^{\frac{1}{2}}$$

In this regard, the power density of a turbine is a good comparative indicator to show the average power output per m^2 of wind swept area, A, at a given site. This can be defined as

$$\text{Power Density} = \frac{\overline{P_{WTA}}}{A}$$

Another important aspect of that critically determines the energy output of a turbine is elevation. In many cases the available recorded wind speed data has been measured at a lower level than the planned hub height of the wind turbine. As wind velocity increases vertically the recorded wind speed data can be adjusted using the following standard formula (Borowy and Salameh, 1996.) where v is the projected wind speed, v_i the wind speed at reference height, H the hub height of a turbine, Hi the reference height and α the power-law exponent.

$$v = v_i \left(\frac{H}{H_i} \right)^{\alpha}$$

α is often quoted to have a value of 1/7 and is seen as a reasonable power law exponent for even and unobstructed landscapes. However, where WECT development is planned either offshore or near woodlands or close to any other non flat terrains this value can differ subsequently and a more through analysis of α is necessary. Justus as well as Counnihan offer mathematical solution for 'fitting' α to these environments (Manwell et al., 2002).

4.1 **Hypothetical Wind Generated Electric Power**:

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator.

Hypothetical wind generated electric power output at Mirkani has been estimated by using the 600KW wind turbine bonus 600/44 MK IV type. The cut in wind speed of this turbine is 3m/s and cutout wind speed is 25m/s. Rotor diameter of this turbine is 44 meters and hub height has been taken as 50 meters. The monthly and annual wind generated electric power outputs at Mirkani along with the capacity factor are given in table 4.

The watt-hour (symbol W·h or Wh) is a unit of energy. It is most commonly used on household electricity meters in the form of the kilowatt-hour (kW·h or KWh), which is 1,000 watt-hours.

Table-4: Hypothetical wind generated electric energy output & Capacity Factor for a Bonus 600/44MK IV Turbine at Mirkani.

PMD Calculator (using 50M at Mirkani) from May 2007 to April 2009				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	20	7	2%	7,694
February	27	10	2%	10,127
March	29	10	3%	11,649
April	41	15	4%	16,361
May	65	23	6%	25,992
June	138	50	13%	54,639
July	177	67	17%	75,856
August	171	64	16%	72,847
September	97	36	9%	39,578
October	37	13	3%	15,133
November	17	5	1%	5,799
December	19	6	2%	7,009
Annual	**55**	**21**	**5%**	**276,358**

Wind Turbine specification	
Turbine	Bonus 600 / 44 MK IV
Power	600 KW
Cut in Wind	3 m/s
Cut out wind	25 m/s
Rotor Diameter	44 m
Hub height	50 m

Cut-in Speed:

Cut-in speed is the minimum wind speed at which the wind turbine will generate usable power. This wind speed is typically between 3 and 5 m/s for most turbines.

Cut-out Speed:

At very high wind speeds, typically between 20 and 35 m/s, most wind turbines cease power generation and shut down. The wind speed at which shut down occurs is called the cut-out speed. Having a cut-out speed is a safety feature which protects the wind turbine from damage.

Figure 20 shows the average diurnal variation of wind generated electric energy output at Mirkani (May-07 to Apr-09). The graph shows that the maximum power is produced at about 3:00 PM; of course, this is the same time when we have the maximum wind speed in 24 hours. Figure 21 and 22 shows the monthly and daily wind generated electric power output. Figure 21 depicts that at Mirkani the wind have more potential in the month of July as compared to other months. Figure 23 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20 **Mirkani: From May 2007 to Apr 2009 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output**

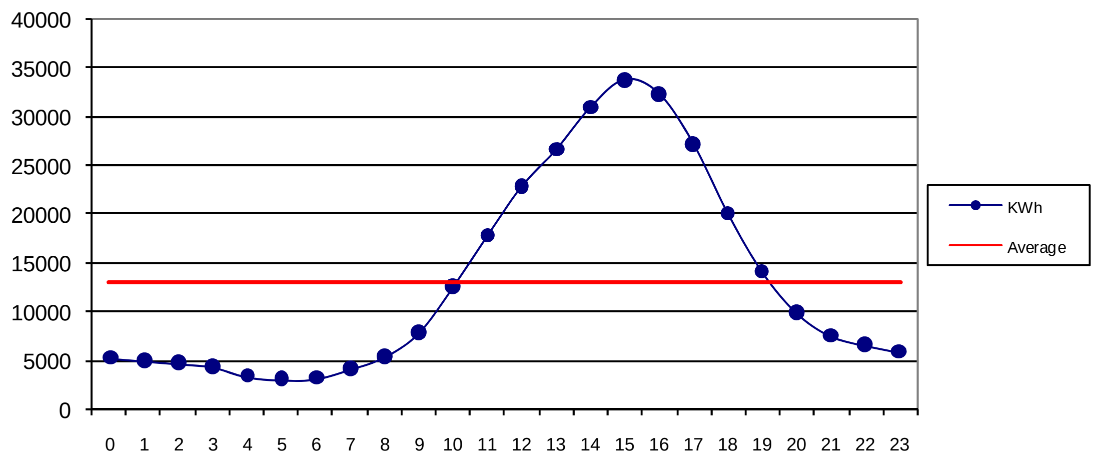


Fig 21 **Mirkani: From May 2007 to Apr 2009 Monthly Average Diurnal Varition Of Wind Generated Electric Powe Output**

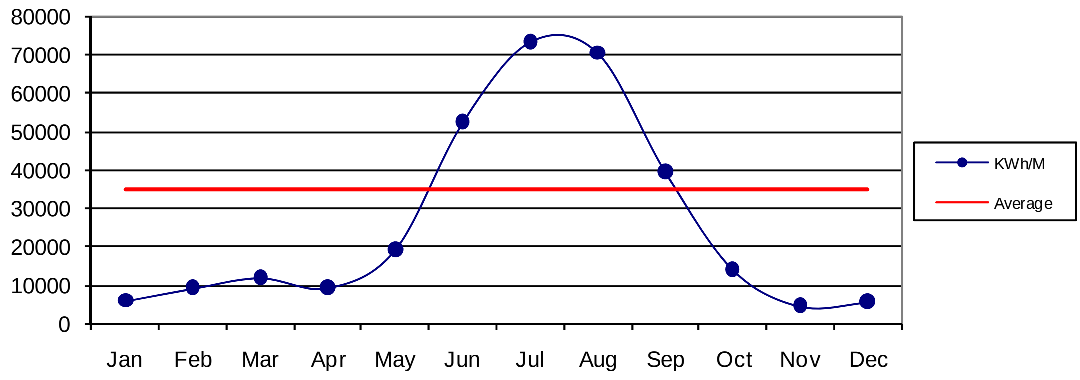


Fig 22 **Mirkani: From May 2007 to Apr 2009 Daily Wind Generated Electric Power Output**

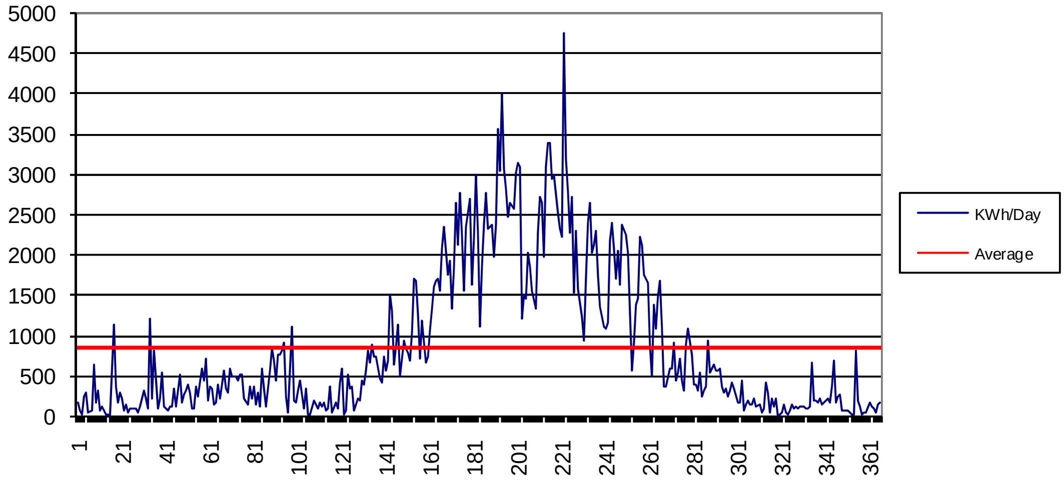


Fig 23 **Mirkani Jan: Diurnal Variation of Wind Genrated Electric Energy Output**

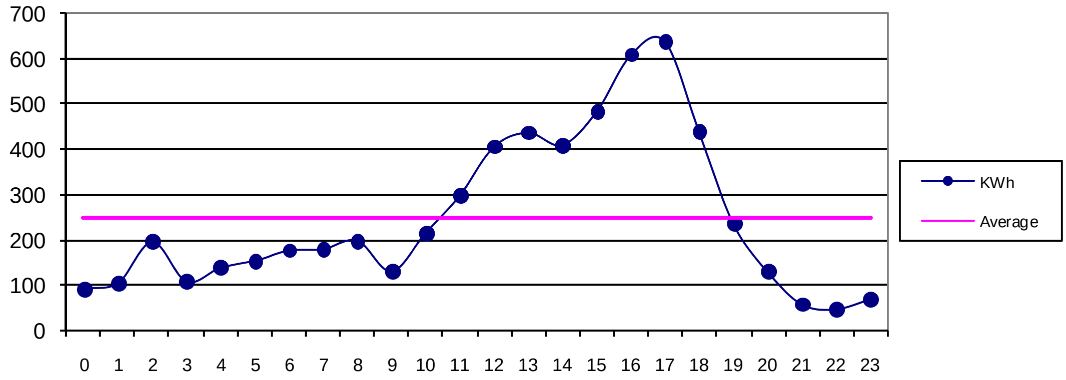
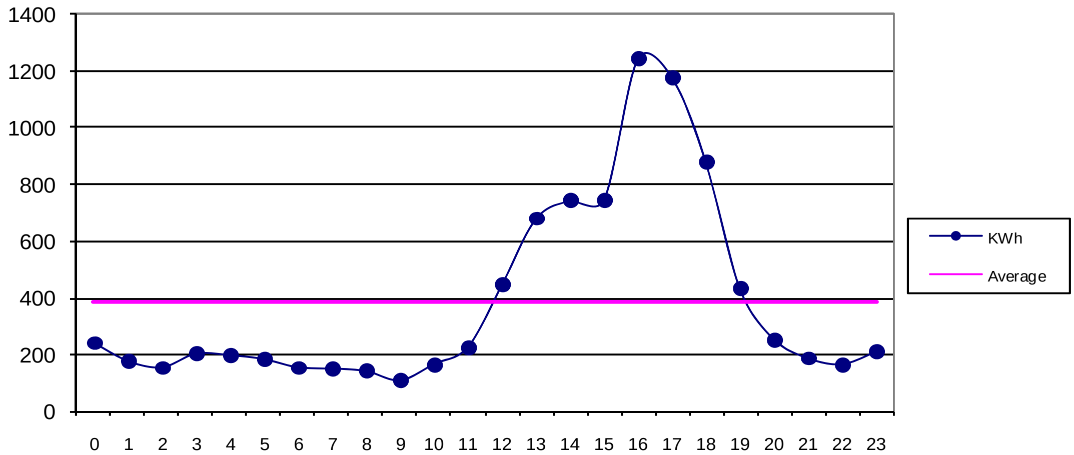
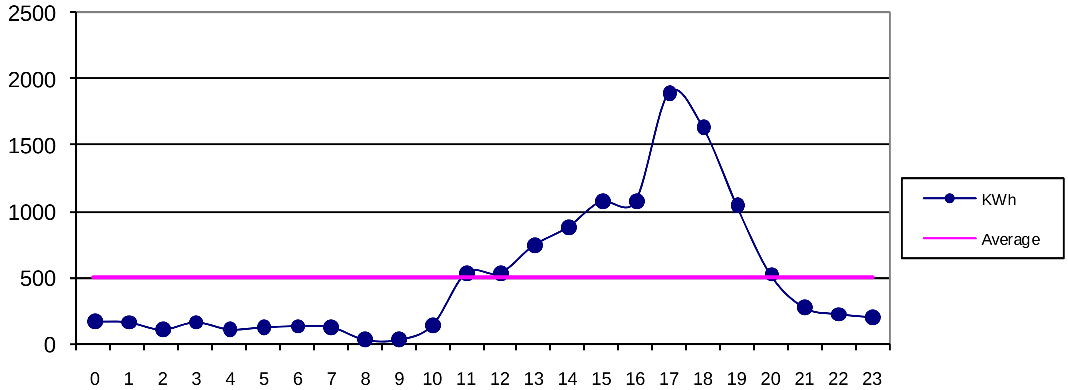


Fig 24 **Mirkani Feb: Diurnal Variation of Wind Genrated Electric Energy Output**



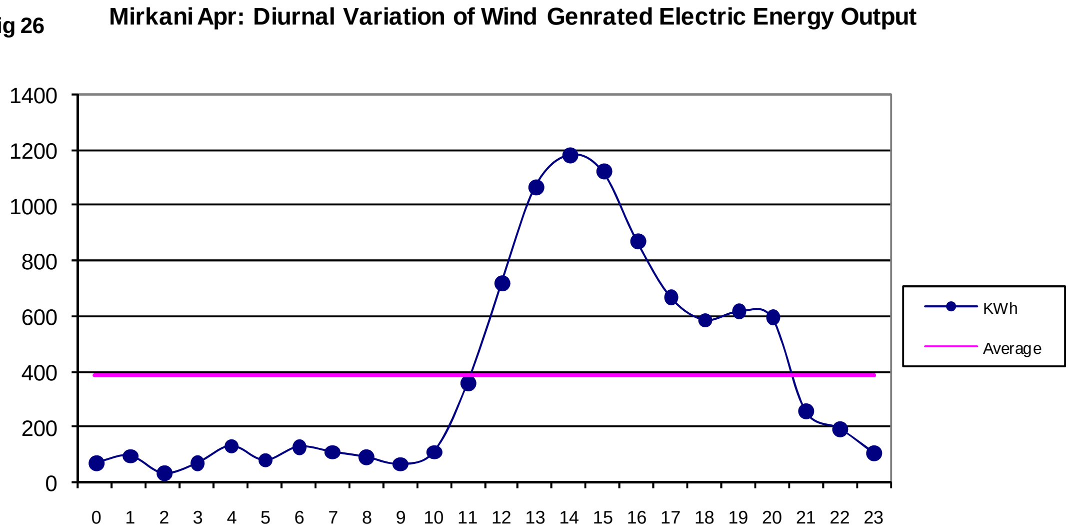
Source: Pakistan Meteorological Department

Fig 25 **Mirkani Mar: Diurnal Variation of Wind Genrated Electric Energy Output**



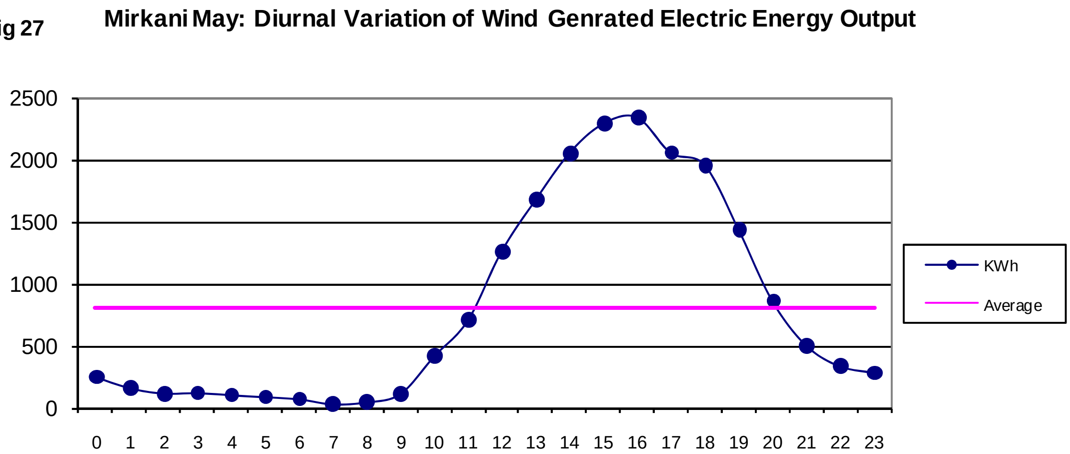
Source: Pakistan Meteorological Department

Fig 26



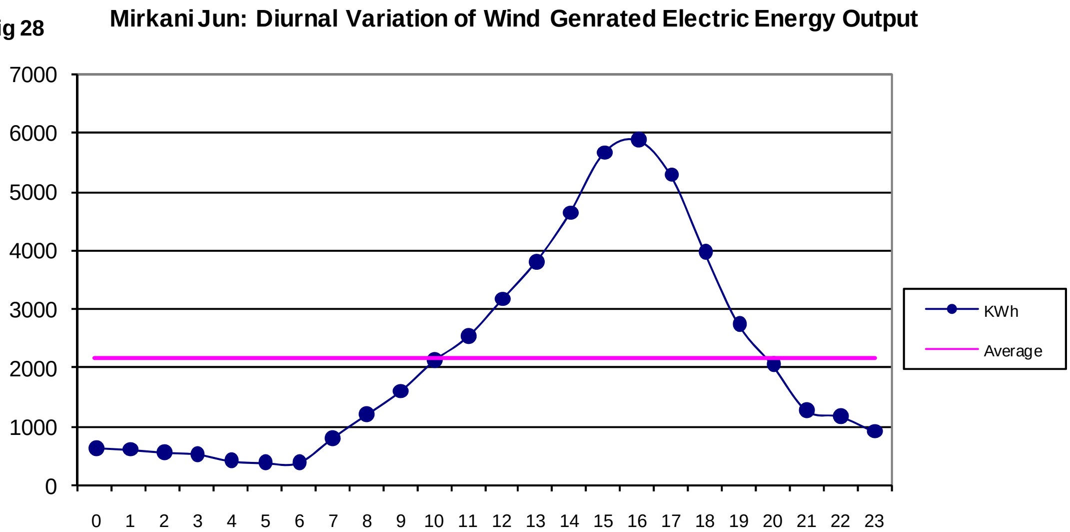
Source: Pakistan Meteorological Department

Fig 27



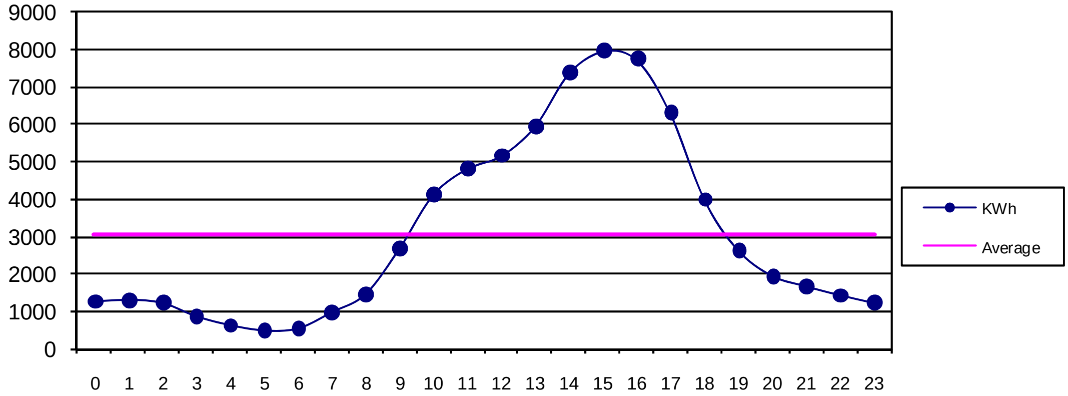
Source: Pakistan Meteorological Department

Fig 28



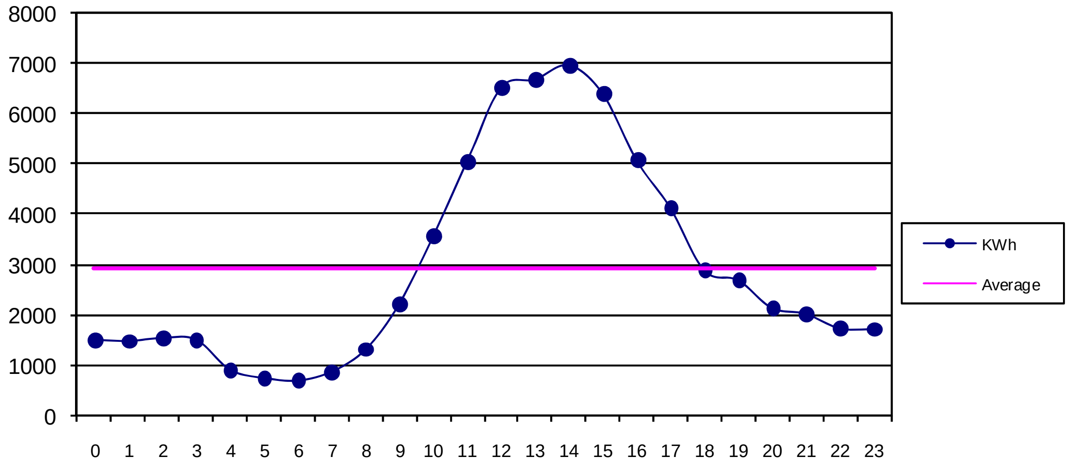
Source: Pakistan Meteorological Department

Fig 29 **Mirkani July: Diurnal Variation of Wind Genrated Electric Energy Output**



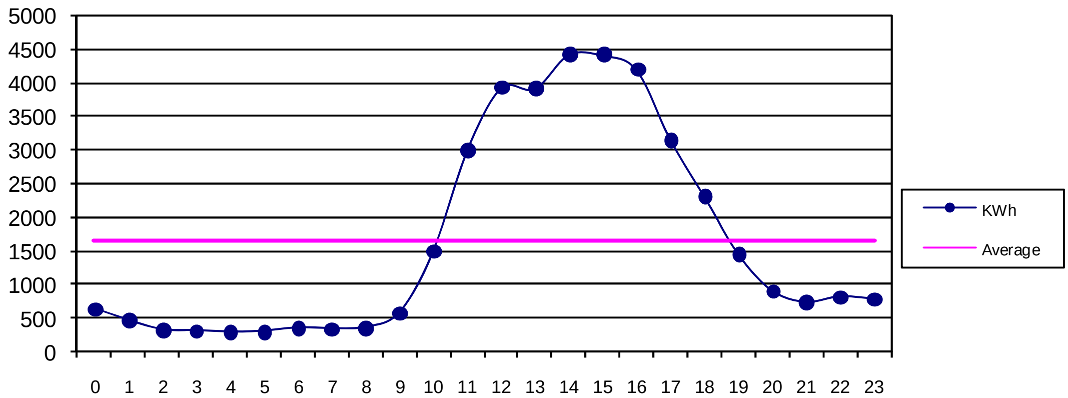
Source: Pakistan Meteorological Department

Fig 30 **Mirkani Aug: Diurnal Variation of Wind Genrated Electric Energy Output**



Source: Pakistan Meteorological Department

Fig 31 **Mirkani Sep: Diurnal Variation of Wind Genrated Electric Energy Output**



Source: Pakistan Meteorological Department

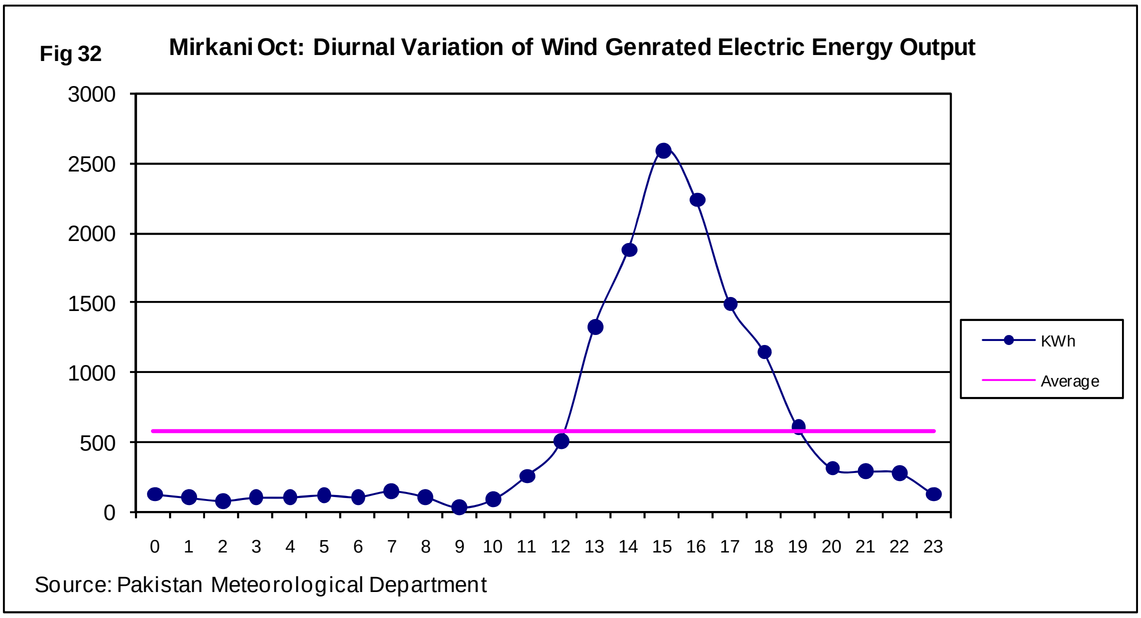


Fig 32
Mirkani Oct: Diurnal Variation of Wind Genrated Electric Energy Output
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

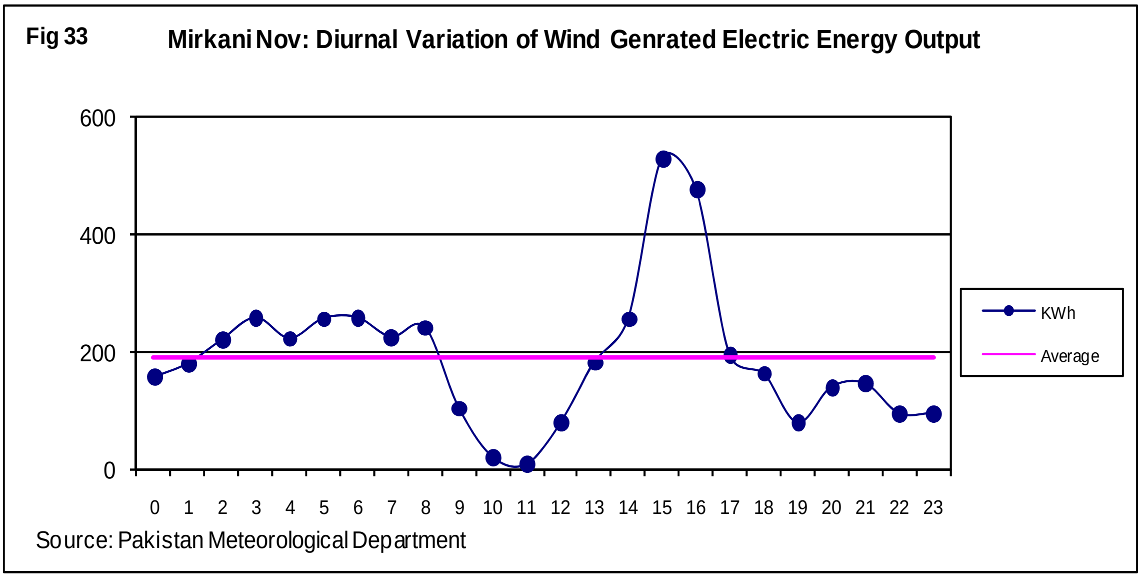


Fig 33
Mirkani Nov: Diurnal Variation of Wind Genrated Electric Energy Output
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

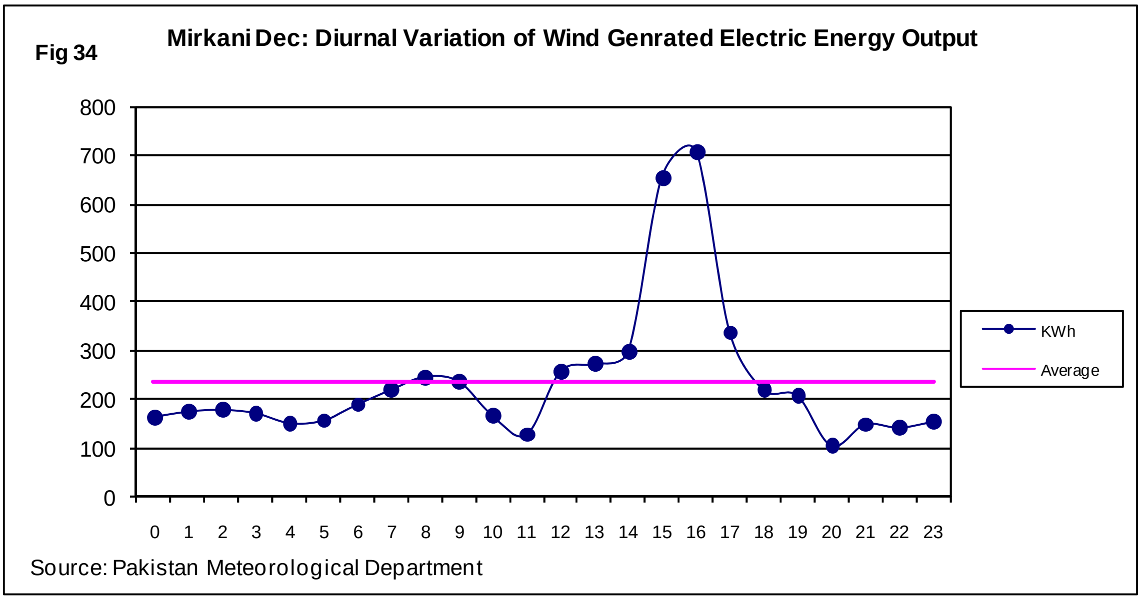
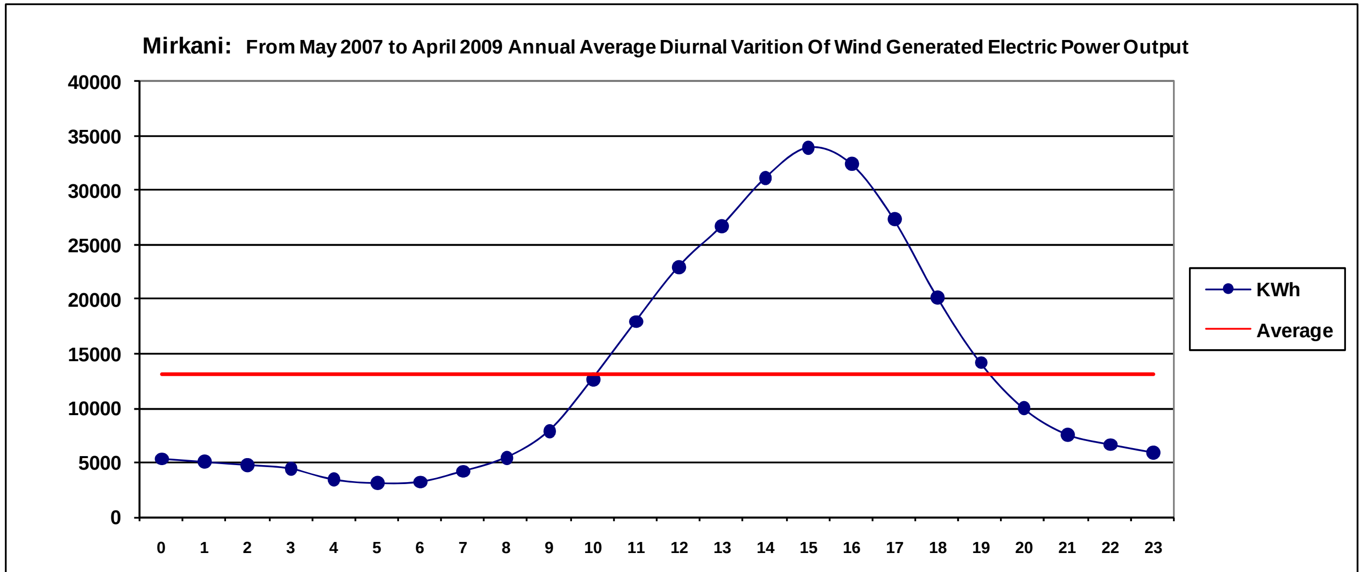


Fig 34
Mirkani Dec: Diurnal Variation of Wind Genrated Electric Energy Output
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

Appendix-I

Mirkani May 2007 to Apr 2009 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
Jan	92	105	195	108	138	154	176	179	198	130	215	298	406	436	409	483	608	638	438	235	129	57	46	68	5944
Feb	239	175	153	201	196	182	153	148	140	107	164	225	444	677	740	744	1243	1176	875	430	252	185	164	207	9221
Mar	171	166	109	165	111	127	135	130	34	32	142	539	537	747	882	1080	1075	1900	1641	1050	526	276	226	205	12003
Apr	73	99	36	72	134	83	132	113	94	69	113	361	722	1072	1186	1126	877	673	590	620	599	259	197	111	9411
May	251	161	118	121	105	88	73	31	47	113	416	706	1263	1675	2051	2288	2339	2053	1955	1437	861	504	337	286	19278
Jun	640	613	565	535	418	385	389	808	1205	1602	2125	2538	3166	3805	4631	5654	5886	5278	3968	2747	2054	1284	1177	923	52397
Jul	1247	1290	1208	849	610	468	520	955	1444	2665	4110	4799	5149	5937	7358	7956	7730	6285	3975	2616	1933	1654	1414	1207	73380
Aug	1515	1489	1550	1514	919	754	705	881	1321	2229	3580	5058	6517	6677	6959	6392	5074	4123	2886	2692	2142	2028	1736	1726	70469
Sep	643	472	332	320	297	311	359	348	368	585	1500	2989	3917	3907	4413	4402	4187	3145	2303	1447	905	739	822	789	39498
Oct	121	97	75	97	99	115	102	144	102	26	83	254	501	1328	1879	2596	2239	1493	1148	605	309	286	274	124	14097
Nov	157	181	221	259	223	257	259	226	242	105	21	9	79	183	256	530	478	195	164	79	140	146	96	96	4601
Dec	164	175	178	172	151	156	189	220	246	236	166	127	257	273	298	656	709	337	219	207	105	149	142	154	5686
KWh	5315	5022	4741	4413	3402	3081	3191	4183	5442	7901	12636	17903	22958	26716	31063	33907	32444	27296	20162	14164	9956	7568	6629	5895	**315987**
Avg	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	13166	



Source: Pakistan Meteorological Department

Mirkani Jan 2008,2009 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	1	3	2	3	3	2	5	3	1	2	1	0	10	12	13	39	51	8	3	1	2	1	5	6	179
2	3	5	7	7	9	9	8	7	17	5	3	1	0	0	1	1	2	0	0	0	0	0	0	1	86
3	0	6	0	2	6	0	1	3	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	21
4	0	0	2	5	8	20	26	10	8	5	20	15	25	27	28	27	9	8	0	0	0	0	0	0	244
5	1	1	0	1	1	5	1	0	1	0	0	0	0	1	7	53	63	83	43	30	11	4	1	0	307
6	1	1	0	0	0	1	0	2	0	0	0	2	0	4	5	2	13	3	2	1	2	3	1	3	47
7	2	2	8	5	1	0	0	2	0	0	0	2	1	1	0	21	6	5	1	1	1	0	2	8	68
8	39	57	122	40	40	2	3	18	48	30	37	31	10	4	1	11	32	34	16	29	17	7	3	6	638
9	0	0	0	0	1	0	0	0	0	0	0	2	30	40	12	21	7	1	0	35	32	0	0	0	183
10	0	0	0	0	0	0	0	34	2	2	2	15	78	72	66	22	14	11	10	1	1	3	1	0	333
11	1	2	2	4	2	1	5	2	1	0	2	1	0	3	3	7	4	25	3	2	3	3	0	0	75
12	1	1	1	0	1	1	25	2	0	0	2	1	0	6	21	16	17	6	10	4	1	1	2	1	120
13	2	2	1	1	1	3	2	1	0	0	4	2	2	0	20	4	9	22	4	2	1	1	0	0	85
14	0	0	1	0	0	0	0	0	0	0	1	2	3	3	1	3	3	3	1	0	1	1	0	0	22
30	1	0	0	0	0	0	1	0	0	1	6	1	1	2	1	1	0	1	0	0	0	0	0	0	17
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
17	0	0	1	4	28	71	73	75	96	78	98	127	153	111	79	46	40	31	20	10	1	0	0	2	1145
18	14	3	0	0	0	0	0	0	2	0	8	57	61	57	61	63	16	2	2	3	4	0	2	5	361
19	1	0	0	6	12	13	5	2	0	0	0	0	0	0	2	9	43	33	8	8	7	10	4	5	167
20	5	7	4	3	14	4	1	0	0	0	0	5	2	37	36	50	31	33	30	12	4	5	5	2	290
21	1	0	6	2	3	2	3	4	7	2	4	7	0	5	3	20	42	44	28	18	6	5	6	2	221
22	4	1	0	2	3	7	5	1	1	1	1	4	2	2	0	0	4	20	10	1	3	1	1	5	80
23	6	3	8	11	3	8	6	6	6	1	1	1	0	0	0	1	7	21	14	15	15	6	1	3	143
24	3	1	1	0	0	2	0	0	0	0	1	0	0	0	2	4	4	23	15	2	0	0	1	3	62
25	0	0	0	0	0	0	0	0	0	1	18	12	12	2	0	0	2	22	37	3	0	0	0	0	108
26	0	0	0	0	0	0	0	0	0	0	2	3	0	5	1	1	29	31	19	5	2	1	1	9	109
27	5	2	3	1	1	0	0	1	0	0	1	2	0	1	7	19	19	20	12	1	1	0	1	2	96
28	1	2	1	2	0	0	1	2	0	0	0	1	4	6	0	0	4	18	17	3	0	1	1	0	63
29	0	1	14	0	0	1	1	0	0	0	0	1	1	7	3	3	23	22	26	14	6	1	1	0	126
30	1	2	12	5	0	1	3	1	5	0	3	4	0	10	6	0	40	42	62	18	2	1	5	2	226
31	1	1	0	1	2	1	1	0	3	0	0	0	9	20	30	40	72	65	44	15	7	4	3	2	321
KWh	92	105	195	108	138	154	176	179	198	130	215	298	406	436	409	483	608	638	438	235	129	57	46	68	5944

Mirkani **Feb 2008,2009** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	3	1	2	5	5	2	4	5	6	5	2	6	6	0	0	19	52	63	9	3	8	4	3	5	218
2	2	7	3	1	4	1	1	6	2	1	1	0	1	2	0	0	1	5	10	0	1	0	0	61	107
3	106	10	0	32	20	8	0	1	0	0	0	7	44	131	226	237	176	103	56	35	2	2	1	0	1200
4	1	0	0	0	0	0	0	0	0	0	0	0	0	17	13	36	23	14	10	27	11	10	20	50	231
5	50	73	57	63	77	73	57	33	22	6	0	28	51	35	8	50	40	29	66	2	0	3	1	0	825
6	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	6	18	23	24	18	12	1	4	1	110
7	4	4	7	3	1	1	0	8	5	0	1	11	12	16	7	19	9	21	26	22	19	10	8	5	220
8	5	1	4	1	1	1	8	31	34	50	67	31	37	66	58	27	41	36	31	4	6	5	3	1	548
9	3	0	3	1	0	1	1	1	1	0	3	3	2	0	1	5	36	12	3	1	22	23	6	5	132
10	0	0	0	0	0	0	1	1	0	0	1	0	0	0	4	6	14	28	22	1	6	3	3	2	92
11	2	1	1	1	0	3	2	0	0	0	3	1	0	6	1	0	14	9	18	11	3	2	0	0	79
12	0	0	1	0	0	1	1	1	1	1	2	0	0	6	1	1	28	42	20	5	2	3	1	0	115
13	1	1	9	5	1	2	1	2	2	0	0	0	0	36	23	5	8	9	10	7	1	2	1	1	126
14	0	1	1	0	0	1	1	0	0	4	8	18	15	24	6	13	128	96	23	2	0	0	0	1	345
30	0	1	1	2	0	0	2	1	0	2	0	0	0	0	1	21	31	5	9	5	3	14	10	5	114
16	11	8	11	3	10	12	12	9	6	9	1	0	18	65	62	54	83	72	50	21	2	1	6	5	528
17	2	4	1	5	5	7	1	5	5	5	4	5	1	2	5	2	32	35	18	6	5	4	2	2	162
18	5	3	1	3	1	1	2	1	2	2	3	26	17	26	27	9	40	17	28	30	10	10	8	9	279
19	4	4	4	3	9	6	4	1	3	1	1	20	19	23	20	14	56	46	34	23	12	12	5	8	333
20	5	14	1	1	3	3	5	3	2	3	1	2	39	53	50	36	54	22	11	11	19	28	38	5	406
21	1	2	0	1	1	0	0	0	0	0	9	18	67	31	79	23	18	19	17	9	2	1	5	3	305
22	10	1	2	2	2	5	4	1	1	7	1	0	14	6	10	18	24	2	0	0	0	0	0	0	108
23	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	2	26	29	30	2	4	4	0	1	103
24	1	7	19	35	25	17	1	1	0	0	1	1	11	14	19	27	91	49	38	2	5	1	2	0	365
25	0	0	1	0	0	0	0	1	2	0	0	0	1	13	9	15	25	58	69	22	10	1	2	5	236
26	3	3	5	8	3	7	2	5	3	0	6	18	35	50	27	20	52	114	117	61	35	13	10	6	603
27	9	5	2	5	2	2	9	5	0	0	2	3	15	12	21	8	57	118	86	34	12	5	9	13	434
28	12	15	11	13	14	21	25	24	34	5	48	24	37	44	63	66	42	65	33	61	36	9	3	4	707
29	0	8	5	11	9	9	9	2	8	3	0	1	1	0	0	6	24	36	9	3	6	16	13	10	189
KWh	239	175	153	201	196	182	153	148	140	107	164	225	444	677	740	744	1243	1176	875	430	252	185	164	207	9221

Mirkani **Mar 2008,2009** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	3	32	13	15	2	10	11	4	1	0	0	0	0	14	3	2	14	91	116	17	6	11	1	2	370
2	1	5	5	5	12	5	2	9	4	2	0	2	40	21	25	21	8	42	66	37	7	12	20	5	355
3	6	6	0	33	6	15	10	9	0	0	1	0	1	59	0	0	8	7	1	0	0	0	0	0	161
4	0	0	0	0	0	0	0	0	0	0	0	1	14	34	23	31	18	17	20	4	0	1	0	0	163
5	0	0	0	0	0	1	0	0	1	0	35	229	17	11	7	9	20	16	19	16	9	3	0	0	392
6	7	1	1	1	0	0	0	0	0	0	0	0	3	0	0	0	1	21	30	14	3	4	36	98	219
7	68	40	1	4	0	1	0	0	0	0	12	30	14	6	45	165	103	20	27	21	10	1	0	1	570
8	0	1	0	1	2	1	0	3	0	2	0	1	10	20	92	71	36	36	36	9	8	5	0	1	336
9	1	0	0	2	0	1	1	1	0	0	3	1	0	4	60	32	36	56	49	22	30	1	5	1	307
10	1	1	5	7	2	5	6	9	1	0	0	40	55	67	31	36	23	93	92	58	24	12	12	11	592
11	4	3	1	3	4	10	20	8	1	4	31	28	22	23	47	3	28	94	69	59	12	7	3	6	489
12	5	4	3	8	5	4	3	8	2	0	0	2	6	7	8	0	52	143	135	52	15	14	15	9	502
13	8	11	10	8	16	11	20	7	0	0	0	1	2	3	2	25	53	152	96	58	15	3	3	2	507
14	3	9	8	10	5	8	7	11	2	0	9	0	3	0	2	20	43	105	98	51	25	5	6	6	437
30	2	1	5	10	8	12	10	14	1	1	2	30	9	1	6	36	42	89	98	80	38	19	14	2	528
16	31	12	11	3	1	5	3	3	5	0	1	2	20	7	30	49	11	179	64	44	20	12	1	1	514
17	3	16	13	5	1	6	5	1	0	0	1	0	1	1	24	2	2	23	9	13	1	32	44	20	222
18	10	8	1	2	4	3	7	3	0	2	0	0	0	14	47	2	0	22	16	1	0	0	1	0	144
19	0	0	3	1	1	5	3	1	1	1	0	0	2	5	87	109	9	54	66	11	1	2	1	1	364
20	1	1	1	3	3	3	1	5	1	17	43	4	0	0	27	50	43	20	4	1	1	0	0	0	230
21	1	0	0	0	0	0	1	0	0	0	0	25	66	51	33	38	38	54	35	9	17	6	1	0	374
22	0	0	1	4	4	4	4	5	1	1	1	0	0	0	3	2	2	15	53	37	7	0	2	2	146
23	2	4	1	1	3	1	1	5	1	0	0	0	87	65	23	20	37	32	18	3	0	1	6	1	309
24	1	1	2	12	13	9	9	7	1	0	0	0	0	1	0	10	16	10	18	24	2	0	0	1	136
25	0	0	0	0	3	5	1	5	7	0	1	2	0	0	30	52	10	86	82	130	104	75	9	2	606
26	2	1	2	0	0	0	1	0	0	0	2	111	40	7	8	37	8	2	32	52	22	8	1	3	339
27	5	1	0	0	0	0	1	0	0	0	0	0	8	20	9	10	39	14	18	1	0	0	0	0	126
28	0	0	0	0	2	2	2	5	0	0	0	0	5	171	65	26	27	77	55	60	23	29	18	5	572
29	2	1	1	8	9	0	0	2	0	1	1	14	36	83	77	102	198	130	88	37	28	6	19	3	845
30	3	5	20	15	1	0	1	1	1	0	0	3	15	43	63	116	133	110	32	74	63	1	2	1	704
31	2	4	2	3	3	2	5	6	1	0	0	12	62	9	4	3	20	91	97	55	35	5	5	19	443
KWh	171	166	109	165	111	127	135	130	34	32	142	539	537	747	882	1080	1075	1900	1641	1050	526	276	226	205	12003

Mirkani **Apr 2008,2009** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	9	11	7	2	4	5	5	6	2	0	1	2	16	1	93	123	118	44	50	59	35	27	80	56	755
2	10	1	1	0	12	4	1	0	1	13	54	77	13	20	40	86	161	113	30	13	28	40	28	19	764
3	1	3	0	6	0	0	1	1	0	0	8	92	248	210	149	51	33	7	0	0	0	1	0	1	813
4	0	0	0	0	0	0	1	0	0	1	0	5	68	149	223	170	76	87	79	30	5	4	8	0	909
5	4	7	11	31	51	12	12	3	5	8	0	0	0	24	29	15	0	2	20	15	5	2	0	0	258
6	0	0	0	0	2	0	0	2	1	1	0	0	0	0	0	0	0	0	7	15	4	4	5	2	46
7	0	1	0	0	0	6	36	53	50	21	44	120	233	185	134	79	62	20	15	31	11	14	4	1	1120
8	1	0	1	0	0	0	0	0	0	0	0	0	3	28	63	38	23	2	3	0	12	4	10	1	189
9	0	0	1	0	0	0	0	0	0	0	0	0	0	17	9	39	42	16	18	13	15	6	3	6	184
10	7	1	5	4	2	2	0	0	0	0	0	0	0	1	28	34	61	30	33	36	28	25	20	10	330
11	11	2	0	0	0	0	0	0	0	0	0	0	0	27	101	134	47	57	24	3	20	4	5	1	436
12	0	1	0	0	0	1	0	1	0	0	0	1	95	120	35	14	7	0	3	2	4	0	0	0	282
13	0	0	0	1	0	1	0	0	0	0	0	0	0	0	9	24	18	19	26	8	2	0	1	0	109
14	0	0	0	0	28	14	42	20	33	21	4	0	0	2	12	96	50	34	4	0	0	1	0	0	359
30	0	14	0	0	0	0	0	12	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	34
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	9	6	4	0	1	1	0	37
17	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9	69	31	21	37	19	10	7	1	1	207
18	19	36	2	2	1	1	1	0	0	0	0	0	0	0	0	12	22	16	16	15	0	0	0	0	145
19	1	0	0	0	0	0	0	0	0	0	0	0	10	14	2	1	2	28	27	8	1	7	2	3	108
20	1	0	0	1	1	0	1	1	0	0	0	0	0	52	1	0	0	23	29	42	8	8	0	1	169
21	3	0	2	0	0	1	2	0	0	0	0	0	4	6	13	9	16	7	10	12	19	2	9	0	116
22	2	0	0	0	0	0	0	0	0	0	0	0	0	7	104	4	26	18	3	1	1	0	1	1	169
23	2	15	1	2	0	0	0	1	0	1	0	1	0	0	0	0	6	5	1	12	8	0	2	6	63
24	2	0	0	3	3	8	2	1	0	0	0	0	1	9	1	4	0	4	2	26	19	18	1	1	104
25	0	2	1	6	13	5	6	2	0	0	1	0	0	0	1	40	6	11	11	45	210	7	2	0	369
26	0	1	2	5	3	0	1	1	0	0	0	0	4	1	4	2	6	2	4	12	7	0	0	0	55
27	0	3	0	1	4	4	0	1	0	0	0	60	22	4	33	14	0	4	0	16	4	0	2	0	172
28	0	0	1	5	6	6	11	3	1	0	0	0	0	0	0	0	1	7	12	24	12	6	0	0	94
29	0	0	0	2	1	6	8	3	0	0	0	0	0	166	92	59	12	14	40	14	14	0	0	0	430
30	0	0	1	0	1	7	3	1	0	0	1	0	2	28	2	9	34	73	78	146	117	73	10	0	586
KWh	73	99	36	72	134	83	132	113	94	69	113	361	722	1072	1186	1126	877	673	590	620	599	259	197	111	9411

Mirkani **May 2007,2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	1	2	0	0	6	1	0	0	0	0	0	0	0	0	0	4	16	3	0	0	2	0	36
2	1	0	1	2	4	5	9	2	1	0	0	0	0	0	0	0	0	4	19	26	8	2	0	1	83
3	0	4	0	5	1	1	14	3	0	0	0	0	1	0	36	121	42	43	82	68	32	57	4	5	519
4	0	1	13	40	6	2	4	0	0	1	0	0	0	11	41	35	17	45	85	5	26	0	3	2	337
5	8	2	7	0	0	1	1	0	0	0	1	0	0	11	40	28	160	61	21	23	2	8	1	0	375
6	2	1	2	1	1	1	10	0	0	0	8	4	0	0	0	0	0	1	8	6	19	1	0	0	66
7	1	0	0	0	1	4	1	1	0	0	0	0	0	1	9	52	36	60	35	3	5	9	4	6	227
8	11	0	2	0	3	0	4	1	0	0	0	0	0	21	16	61	34	17	5	24	4	4	1	1	208
9	1	0	0	0	2	0	0	2	0	0	16	82	90	71	55	54	42	18	18	2	2	1	1	0	456
10	0	0	0	0	0	0	0	0	0	0	0	0	13	43	44	31	45	43	57	51	33	20	12	5	397
11	1	0	0	0	0	0	0	0	0	0	0	20	53	65	102	114	77	22	30	14	23	14	8	21	566
12	7	13	0	1	0	0	1	0	0	0	0	0	5	36	76	141	159	121	85	35	39	32	40	30	823
13	7	5	5	0	0	0	1	0	0	2	20	28	44	43	24	179	49	82	44	76	47	2	7	3	667
14	1	0	1	1	0	2	0	0	0	0	0	18	61	89	111	166	143	74	52	87	59	13	0	1	880
30	0	5	1	5	0	0	1	1	0	0	2	30	53	53	79	17	53	53	47	64	84	141	62	3	755
16	5	4	1	0	5	7	0	2	0	0	0	8	32	53	76	77	157	166	73	39	41	2	3	2	754
17	0	2	0	0	4	4	0	0	0	0	0	0	0	0	6	47	105	98	60	68	57	16	2	1	469
18	0	0	0	0	0	0	0	0	0	0	1	40	6	0	1	0	9	89	159	73	25	9	4	0	417
19	0	0	0	0	0	0	0	0	0	0	0	5	33	78	38	51	179	140	113	47	40	18	4	0	746
20	0	0	0	0	0	0	1	0	0	0	0	17	41	54	22	41	45	81	67	58	34	63	35	4	566
21	3	3	5	1	2	2	4	3	0	0	0	0	14	5	64	53	46	65	123	163	60	25	22	36	700
22	8	9	21	14	1	12	9	7	40	77	61	47	98	179	197	88	95	76	147	226	35	10	17	36	1512
23	40	32	18	26	57	37	4	6	2	1	54	62	107	119	187	213	139	65	51	29	24	7	26	7	1312
24	2	0	1	2	1	0	0	0	0	0	1	10	39	100	169	40	115	52	18	39	22	21	16	4	653
25	8	5	10	7	12	1	0	0	3	28	191	142	94	61	86	141	45	26	0	0	0	0	1	1	864
26	3	0	3	0	0	2	1	0	0	0	0	0	57	58	86	187	195	218	270	21	13	5	8	11	1140
27	4	1	3	0	0	0	0	0	0	0	15	78	115	15	9	18	49	62	63	41	20	5	1	2	500
28	1	2	0	0	0	0	1	1	0	0	3	43	109	137	103	83	67	124	53	49	75	11	38	32	932
29	0	0	0	0	0	1	0	0	0	1	42	71	160	192	200	34	9	21	33	27	11	1	3	37	844
30	127	72	22	12	4	3	0	0	0	2	0	0	13	125	140	116	66	12	3	17	1	7	12	33	786
31	9	0	0	1	1	1	1	0	0	0	0	0	22	52	36	99	160	111	118	55	22	1	0	0	689
KWh	251	161	118	121	105	88	73	31	47	113	416	706	1263	1675	2051	2288	2339	2053	1955	1437	861	504	337	286	19278

Mirkani June 2007,2008 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	0	0	0	3	0	1	0	3	2	18	49	102	168	113	124	147	102	125	53	9	7	3	1031
2	33	12	6	1	1	3	0	0	0	1	33	59	92	110	120	260	266	208	85	112	54	20	144	95	1717
3	55	41	0	23	22	35	22	36	33	44	96	169	275	104	98	122	81	150	79	60	15	11	71	26	1670
4	6	3	8	1	0	0	0	0	0	9	13	22	111	137	123	137	206	138	104	62	28	20	110	15	1251
5	7	2	0	0	0	0	0	0	0	0	2	30	39	40	59	71	114	134	121	79	20	5	0	0	725
6	3	3	1	3	5	1	2	0	0	0	1	2	3	41	154	218	233	216	53	63	70	50	49	19	1188
7	15	5	5	8	10	2	2	2	13	60	89	30	15	53	50	43	51	78	71	59	10	3	2	6	680
8	2	3	3	5	3	1	4	0	0	0	16	20	26	30	69	121	193	90	53	42	8	10	7	28	734
9	23	0	10	2	1	9	3	1	6	18	57	77	42	59	134	129	59	172	99	73	25	31	10	23	1063
10	12	20	14	8	15	12	10	20	25	40	53	128	109	127	102	134	166	141	80	48	15	28	28	10	1344
11	5	16	49	30	8	15	10	25	36	53	96	121	77	123	188	211	129	144	130	47	42	13	23	18	1608
12	8	15	1	1	0	4	4	21	28	73	121	86	92	139	178	241	229	175	84	49	45	35	23	28	1680
13	19	30	27	8	6	12	18	36	39	59	95	89	128	96	162	185	162	159	126	100	74	52	13	2	1696
14	4	1	1	0	1	2	0	4	9	18	52	83	191	191	115	204	148	82	147	133	75	67	29	7	1565
30	21	31	32	32	41	45	49	50	65	127	110	127	150	173	44	54	73	126	243	159	141	131	5	44	2071
16	22	38	99	89	91	71	51	84	101	96	118	191	122	98	111	67	127	128	145	121	102	52	110	111	2345
17	68	68	25	13	16	24	15	25	36	50	42	67	89	83	135	245	239	165	143	85	66	30	8	9	1745
18	18	8	13	0	0	0	1	5	13	45	47	53	111	222	287	258	287	184	99	88	43	33	44	60	1918
19	55	35	8	7	7	3	3	23	31	42	27	31	23	20	107	154	147	235	150	87	53	34	34	14	1329
20	10	4	9	7	4	1	3	8	28	25	25	31	71	232	236	261	265	202	151	85	46	36	40	43	1824
21	22	35	41	14	7	8	13	31	91	143	166	166	133	145	181	186	356	381	318	135	27	13	19	26	2656
22	12	29	18	15	3	1	0	0	25	56	96	25	53	151	299	287	273	277	176	97	62	47	54	75	2131
23	29	52	43	26	13	9	26	54	82	135	129	107	127	149	236	338	344	338	293	116	55	38	15	13	2765
24	9	26	29	34	39	25	25	27	40	62	103	127	109	109	151	248	268	262	216	134	71	64	28	34	2238
25	22	7	19	12	14	10	40	171	166	22	15	20	43	102	102	89	165	169	137	65	58	45	48	23	1564
26	10	3	12	5	14	12	5	1	24	50	120	155	179	242	223	345	324	243	88	72	91	46	25	52	2339
27	27	21	18	19	13	6	14	28	43	74	144	151	163	274	240	210	325	191	217	197	204	80	22	17	2696
28	9	11	10	57	28	26	16	31	49	85	68	129	188	102	204	227	105	63	56	41	47	27	31	21	1631
29	47	35	21	40	26	19	2	42	57	67	25	50	133	264	207	229	169	113	79	119	177	121	89	62	2191
30	67	58	45	77	32	28	48	80	166	147	163	175	226	88	147	268	257	169	123	95	274	134	90	43	2999
KWh	640	613	565	535	418	385	389	808	1205	1602	2125	2538	3166	3805	4631	5654	5886	5278	3968	2747	2054	1284	1177	923	52397

Mirkani July 2007,2008 **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	48	41	47	20	13	15	9	9	9	33	80	187	181	151	268	363	242	185	83	92	71	66	37	32	2281
2	13	12	3	0	2	0	0	0	0	0	0	39	77	101	133	191	147	179	108	76	12	3	5	2	1103
3	5	3	0	8	3	3	0	1	5	12	36	57	94	163	241	242	260	305	227	59	52	32	23	13	1847
4	17	14	42	30	5	5	7	23	35	70	97	88	121	233	220	319	331	338	153	88	40	14	39	43	2372
5	10	36	39	18	13	2	19	43	61	76	104	127	204	230	261	277	193	283	307	146	112	102	50	64	2776
6	56	78	79	84	146	8	0	0	1	0	12	125	174	232	262	184	190	201	141	61	55	70	91	78	2326
7	64	258	110	38	27	30	13	30	58	105	284	172	150	223	69	160	145	119	53	34	52	89	50	44	2380
8	18	9	11	8	2	3	2	22	30	53	141	123	80	187	287	239	222	170	91	67	63	43	22	78	1970
9	133	0	113	31	15	10	0	5	1	2	1	145	143	173	236	222	235	261	147	115	89	93	86	105	2362
10	80	193	115	47	17	27	53	66	94	169	278	313	312	280	331	299	300	204	110	78	68	65	37	30	3567
11	29	45	30	18	8	6	13	28	80	166	215	217	179	273	389	421	376	188	119	87	68	44	35	9	3045
12	15	38	84	74	57	83	125	190	242	267	319	352	309	311	325	174	265	124	81	95	204	114	72	87	4006
13	55	33	42	31	26	34	20	41	49	128	241	274	300	261	389	363	239	146	104	89	59	40	25	65	3055
14	67	30	39	37	29	26	22	34	82	157	232	138	195	268	275	271	265	258	151	101	65	40	24	22	2825
30	44	23	10	12	18	12	23	37	29	101	130	135	127	132	274	338	389	280	159	76	30	14	35	32	2462
16	26	27	27	14	2	6	18	42	53	127	147	126	143	158	319	293	357	331	161	114	61	43	16	25	2635
17	28	21	25	18	8	5	17	24	50	102	111	119	157	187	319	421	283	229	146	77	85	43	66	20	2561
18	56	51	88	73	34	38	46	53	74	167	260	294	255	249	287	242	124	130	132	152	77	83	34	29	3028
19	30	23	27	23	9	15	24	63	80	144	250	306	287	261	338	300	337	202	89	104	96	40	42	47	3136
20	119	57	25	63	30	33	31	66	69	221	248	251	250	164	191	294	287	170	125	86	46	68	127	60	3079
21	9	19	40	23	14	12	16	35	46	67	147	65	31	36	29	92	220	70	71	78	14	13	41	20	1208
22	10	18	18	41	34	27	8	4	12	32	39	42	124	102	74	164	305	94	84	60	53	111	27	13	1498
23	8	8	1	1	2	0	0	1	0	0	17	69	104	159	133	119	339	165	66	55	35	52	83	41	1458
24	59	38	31	13	9	8	3	2	1	11	22	33	49	208	325	370	348	148	90	41	56	59	59	47	2028
25	27	26	23	13	8	4	8	27	20	43	93	167	182	293	160	88	143	199	123	31	39	69	39	33	1857
26	33	23	4	3	0	1	1	3	35	41	42	173	114	70	167	158	142	225	150	48	61	23	31	13	1563
27	15	33	11	0	0	0	1	0	0	0	0	0	44	96	172	223	233	186	142	77	43	34	18	5	1334
28	4	5	2	1	0	0	1	0	6	67	129	155	155	151	185	268	252	312	248	132	38	46	59	68	2283
29	81	59	61	40	21	7	2	38	67	113	139	163	129	184	160	325	280	280	156	156	92	61	69	29	2713
30	61	41	40	38	44	30	24	35	108	122	197	174	261	178	202	279	227	195	116	87	72	50	40	32	2654
31	28	28	19	33	15	18	12	33	47	68	97	172	217	222	338	256	53	108	44	55	26	28	32	20	1970
KWh	1247	1290	1208	849	610	468	520	955	1444	2665	4110	4799	5149	5937	7358	7956	7730	6285	3975	2616	1933	1654	1414	1207	73380

Mirkani **Aug 2007,2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	38	41	38	65	22	27	24	40	68	196	250	194	319	294	305	199	164	116	127	82	162	137	78	104	3090
2	91	100	124	34	27	31	26	37	50	98	196	234	351	335	365	299	213	229	57	90	56	123	89	134	3388
3	94	64	0	114	43	55	50	65	99	178	216	181	210	409	363	255	243	133	103	57	58	162	54	181	3386
4	56	49	38	26	12	45	34	52	53	148	163	222	244	281	312	312	207	245	117	47	39	76	91	74	2944
5	66	110	210	141	19	9	12	19	65	86	126	203	175	217	113	197	209	207	162	117	202	116	119	93	2994
6	80	79	70	39	8	23	30	25	39	62	181	297	255	159	204	191	129	117	121	163	140	39	33	47	2529
7	43	25	15	25	12	6	2	15	20	30	57	147	293	249	344	363	197	174	74	74	48	21	53	24	2312
8	29	25	28	15	11	4	12	40	50	95	108	161	199	168	205	253	173	172	105	199	77	39	15	41	2222
9	37	0	100	159	197	115	90	147	174	258	303	348	382	389	296	231	160	182	119	177	181	260	245	196	4745
10	102	74	66	59	46	35	41	43	68	113	213	317	383	366	254	193	203	144	108	96	66	46	87	70	3191
11	37	54	59	66	22	11	17	36	73	97	151	178	212	230	319	312	268	149	135	116	69	46	66	65	2788
12	33	67	77	46	57	25	18	39	61	114	86	129	213	216	293	141	126	188	71	69	88	79	20	26	2283
13	51	130	153	128	73	36	22	39	57	57	103	141	210	245	218	166	93	51	110	158	187	153	109	23	2712
14	36	51	74	29	20	59	49	33	35	33	52	97	186	196	146	111	73	32	21	22	67	69	6	34	1534
30	183	143	16	22	14	7	10	9	12	15	3	83	175	117	130	225	284	160	97	121	111	142	122	95	2297
16	65	46	28	12	18	8	0	0	4	8	36	144	162	203	185	107	102	135	99	71	62	41	14	32	1582
17	60	17	36	93	56	26	20	15	32	25	73	73	65	69	96	75	196	81	37	20	23	33	18	10	1248
18	20	13	11	12	2	0	1	2	5	6	20	41	42	91	214	130	89	91	61	50	12	6	17	9	947
19	1	2	1	0	0	2	4	3	20	20	65	80	132	207	255	330	209	184	85	62	11	4	22	7	1708
20	17	65	37	26	28	23	9	22	42	120	135	207	229	345	267	216	155	119	90	74	38	15	43	82	2403
21	82	50	46	29	45	39	13	37	46	63	69	152	217	216	357	217	176	224	241	115	66	52	47	42	2638
22	66	23	25	25	9	1	8	23	24	49	119	203	267	187	229	204	135	91	79	75	38	33	61	66	2039
23	33	31	14	29	16	15	12	29	63	66	129	241	261	222	198	262	146	84	53	85	57	23	19	33	2120
24	39	34	26	10	4	0	3	17	42	75	247	203	205	183	220	186	114	130	122	187	42	38	88	91	2306
25	46	33	26	25	12	13	9	15	12	23	33	89	248	281	169	254	214	80	35	44	34	31	13	13	1750
26	19	27	3	4	1	0	0	3	22	30	103	127	189	125	109	56	146	68	70	63	29	50	79	28	1352
27	11	9	6	2	2	2	0	2	1	1	27	105	168	125	118	119	80	82	70	75	44	33	29	14	1124
28	12	15	7	12	10	7	3	3	2	20	39	75	71	93	96	69	126	127	136	57	47	27	22	9	1084
29	8	9	8	4	3	3	2	2	2	18	30	42	61	89	118	255	199	104	57	37	28	51	25	17	1172
30	32	33	42	26	20	9	7	21	29	74	154	195	261	255	319	218	119	119	52	38	44	50	26	43	2187
31	28	72	168	238	110	119	176	49	50	50	92	153	133	113	141	248	125	109	73	51	17	31	26	24	2395
KWh	1515	1489	1550	1514	919	754	705	881	1321	2229	3580	5058	6517	6677	6959	6392	5074	4123	2886	2692	2142	2028	1736	1726	70469

Mirkani **Sep 2007,2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	43	21	17	29	21	8	5	22	31	46	110	218	232	170	268	389	190	87	52	35	29	19	20	17	2079
2	2	1	1	10	6	6	3	3	7	22	85	123	185	188	236	214	245	205	46	37	47	27	11	7	1718
3	2	1	0	25	7	27	32	29	45	47	80	100	132	173	207	338	307	203	176	31	23	25	23	10	2044
4	15	27	34	16	21	29	21	29	26	33	50	69	158	170	183	158	158	99	79	52	43	60	59	38	1627
5	16	17	12	15	23	25	24	21	29	47	115	145	236	123	194	126	216	181	136	78	71	44	216	258	2368
6	179	136	77	53	63	40	34	40	34	27	62	281	274	94	106	53	117	137	118	52	59	60	87	68	2250
7	79	96	77	53	47	37	25	26	31	59	90	168	140	160	302	235	126	61	87	27	14	21	26	43	2031
8	40	14	6	3	10	22	18	31	43	44	153	159	158	84	76	119	128	60	42	19	13	27	13	3	1284
9	5	0	2	1	0	0	0	2	0	0	0	8	97	86	53	66	60	66	52	12	33	9	19	4	576
10	5	0	0	1	3	10	3	0	0	0	2	49	102	158	131	114	148	81	32	19	16	12	8	11	905
11	13	9	3	6	14	10	7	7	4	9	76	101	108	115	142	227	215	190	73	25	21	3	9	0	1387
12	0	0	1	0	1	2	0	2	0	0	0	31	97	219	263	182	261	200	58	16	10	38	33	35	1450
13	24	15	8	8	11	10	1	8	3	33	58	152	228	306	190	357	177	114	117	258	83	32	11	19	2223
14	22	23	9	5	4	0	0	1	5	27	119	187	222	145	179	345	363	253	82	62	35	13	15	18	2134
30	1	9	6	2	2	6	2	1	12	36	107	174	155	209	185	273	262	122	73	48	29	9	8	19	1750
16	7	0	1	5	3	3	9	12	25	22	102	185	229	216	343	87	112	183	41	75	0	0	0	1	1663
17	0	2	0	0	0	0	0	0	0	0	7	83	177	156	81	67	102	50	91	49	4	3	12	8	892
18	8	5	6	20	5	2	4	3	2	3	14	31	64	63	125	29	3	12	7	19	25	20	9	6	485
19	2	1	2	3	0	0	0	0	0	0	0	124	179	102	75	80	137	213	228	57	62	45	31	36	1378
20	33	5	0	0	0	1	0	2	1	14	33	98	72	29	122	116	141	119	126	76	44	37	20	7	1095
21	12	16	6	1	0	1	7	5	1	13	48	131	206	168	208	100	123	49	80	67	44	69	70	58	1482
22	55	30	19	20	19	52	132	35	12	14	102	151	101	115	140	68	80	108	53	65	54	80	78	100	1684
23	70	38	40	36	28	18	15	13	18	33	46	99	130	118	56	148	13	73	110	11	2	2	0	0	1116
24	0	0	0	1	1	1	2	1	0	0	1	0	0	20	61	83	85	27	45	21	18	8	2	2	378
25	0	0	1	0	1	0	1	5	1	0	0	0	0	85	83	66	57	29	31	9	10	2	0	3	383
26	0	0	0	0	0	0	3	8	2	0	0	41	77	60	96	40	88	67	49	57	14	2	0	1	605
27	0	1	1	1	0	1	1	3	1	0	25	53	15	26	86	89	47	64	40	54	32	28	23	7	599
28	8	2	2	3	1	0	0	31	33	55	15	28	75	153	55	25	96	46	123	89	38	31	10	5	928
29	0	0	1	1	5	1	5	5	1	0	0	0	0	39	73	138	59	34	47	13	13	11	6	1	452
30	0	2	0	0	0	1	4	3	0	0	0	0	66	159	94	68	73	13	10	14	20	2	4	2	534
KWh	643	472	332	320	297	311	359	348	368	585	1500	2989	3917	3907	4413	4402	4187	3145	2303	1447	905	739	822	789	39498

Mirkani **Oct 2007,2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	2	2	1	3	5	3	4	0	0	1	11	45	97	191	152	125	21	5	9	33	15	5	728
2	3	2	0	0	3	3	7	2	2	0	0	0	0	11	51	90	73	71	50	58	16	4	2	3	448
3	0	1	0	0	0	0	2	5	5	0	0	0	33	29	32	68	67	25	24	16	3	6	5	1	323
4	0	0	0	0	1	2	2	6	5	0	0	0	38	56	96	251	162	85	66	51	13	22	22	14	893
5	3	1	1	6	1	1	2	3	1	1	15	57	83	98	207	195	77	65	100	34	44	31	40	14	1081
6	6	5	2	0	1	2	1	0	1	4	25	82	55	62	46	64	110	96	70	72	48	9	11	1	774
7	0	1	1	2	17	34	1	5	2	12	40	103	13	5	55	34	22	14	19	9	2	0	1	0	392
8	0	0	1	2	1	4	3	3	1	0	0	0	15	92	51	47	93	33	35	12	3	2	1	1	401
9	2	0	4	0	2	0	1	8	3	0	0	0	0	52	63	75	48	22	34	7	8	1	2	0	333
10	1	4	1	0	0	1	1	1	2	0	0	0	8	127	124	72	100	19	28	23	14	6	3	1	535
11	2	0	0	0	0	0	4	5	2	0	0	0	0	37	82	31	56	21	5	10	2	0	0	0	259
12	0	0	1	1	1	2	4	5	2	0	0	0	0	1	35	85	93	51	34	10	1	2	3	0	330
13	5	0	0	1	3	3	6	9	5	0	0	0	0	0	0	51	107	119	59	8	2	0	0	1	380
14	20	28	19	7	3	5	6	5	3	0	0	0	6	66	79	145	194	123	43	36	5	63	59	20	936
30	12	1	1	3	9	1	1	1	3	0	0	0	30	63	96	106	72	58	49	18	14	10	8	1	557
16	0	0	1	6	4	4	2	4	1	0	0	1	30	111	139	115	63	58	43	21	5	7	14	3	633
17	5	3	0	0	0	0	0	7	2	0	0	0	66	73	78	93	88	53	34	25	22	4	11	1	565
18	2	1	0	0	0	2	1	3	3	0	0	0	0	85	104	175	84	32	28	13	3	13	11	10	572
19	8	5	0	1	1	0	1	4	0	0	0	7	72	128	45	136	52	24	14	13	24	28	19	9	592
20	1	2	3	1	2	1	6	2	1	0	0	0	0	17	80	144	53	12	19	28	5	2	1	0	381
21	0	0	1	0	6	8	5	6	5	0	1	0	0	1	8	46	60	51	49	35	12	3	2	0	299
22	1	0	1	0	0	0	1	6	5	0	0	0	0	0	31	82	141	32	44	5	0	0	0	1	352
23	1	0	0	0	0	1	5	2	8	0	0	0	0	33	40	47	56	34	16	7	7	2	1	0	259
24	2	0	0	2	0	3	1	6	2	0	0	0	0	29	78	28	20	83	35	16	7	1	1	4	316
25	9	4	1	1	1	0	0	3	1	0	0	2	40	79	47	47	47	45	39	28	8	5	1	1	411
26	2	4	0	24	15	0	2	4	1	0	0	0	0	2	73	92	45	36	30	5	3	1	3	3	345
27	3	1	0	1	1	8	1	1	5	0	1	0	0	0	0	15	22	41	20	23	5	5	9	3	164
28	8	4	7	10	10	5	8	7	7	2	1	0	0	0	0	23	18	3	1	2	2	18	24	19	179
29	24	28	24	22	8	5	10	6	8	3	0	0	0	25	42	21	24	36	108	11	23	9	4	0	442
30	0	0	1	0	1	6	0	5	5	1	0	0	0	0	0	3	14	11	26	4	1	1	1	1	80
31	1	2	5	4	5	10	12	15	7	2	0	0	0	0	0	20	29	14	3	0	0	1	1	6	138
KWh	121	97	75	97	99	115	102	144	102	26	83	254	501	1328	1879	2596	2239	1493	1148	605	309	286	274	124	14097

Mirkani Nov 2007,2008 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	10	7	15	12	6	11	33	22	25	10	1	0	0	0	0	19	16	2	4	0	0	3	0	1	198
2	2	5	2	20	15	3	8	5	5	6	1	0	0	0	2	37	13	10	2	0	2	2	0	0	138
3	0	4	0	3	5	5	5	8	3	2	0	0	0	0	0	0	32	30	28	6	12	6	2	4	156
4	21	11	3	8	9	8	7	7	11	3	0	0	0	4	6	42	39	2	3	7	16	6	1	3	216
5	2	3	1	14	5	13	15	4	21	4	0	0	0	0	0	10	20	5	2	1	0	1	0	1	123
6	1	10	16	14	18	12	20	20	16	7	2	0	1	0	0	2	0	1	1	0	0	0	0	0	142
7	0	1	1	1	9	5	15	5	10	2	0	0	4	0	0	0	1	3	0	0	0	0	0	2	59
8	4	2	8	10	8	10	7	12	9	3	0	0	1	0	0	0	0	12	1	0	2	2	0	0	91
9	2	0	4	2	0	4	1	2	2	0	0	0	0	53	155	78	40	27	11	2	8	14	3	5	411
10	3	0	0	0	1	1	0	4	6	4	0	0	27	89	39	58	50	9	3	0	0	0	0	1	294
11	0	0	0	0	3	0	0	6	3	2	0	0	0	0	12	10	9	6	3	0	0	0	0	0	54
12	0	0	0	0	0	3	2	1	2	1	0	1	15	1	14	66	6	0	1	6	26	51	28	9	233
13	4	0	0	0	0	0	0	1	1	0	0	0	0	0	0	15	80	4	8	2	2	0	1	0	119
14	0	1	7	6	1	0	4	1	3	2	3	2	27	9	8	12	16	9	41	27	48	1	0	0	228
30	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5
16	1	0	0	1	3	2	1	2	5	1	0	0	0	2	12	11	3	6	1	0	0	3	1	1	57
17	1	4	5	6	2	9	11	4	7	5	0	0	0	0	0	19	22	23	28	2	1	0	4	2	154
18	0	1	2	1	5	4	8	1	5	2	1	0	1	0	0	6	19	1	5	1	0	0	1	0	63
19	1	1	2	0	1	0	1	2	2	1	1	0	0	0	0	3	1	3	8	4	0	0	0	0	32
20	0	0	0	0	3	3	3	4	2	2	0	0	0	0	0	24	17	11	1	0	0	1	0	1	72
21	10	5	2	5	5	16	5	7	7	3	2	0	0	8	1	44	9	3	1	2	1	1	1	5	142
22	1	8	4	4	7	10	10	5	8	7	0	0	1	0	0	21	2	3	1	1	3	3	2	7	110
23	5	7	13	5	7	10	6	10	10	2	1	0	0	0	0	10	13	4	1	0	1	3	9	5	123
24	7	7	4	4	7	9	7	5	12	3	0	1	0	0	1	3	15	0	1	6	1	5	4	8	107
25	8	5	6	14	10	12	11	6	13	5	0	0	0	0	0	6	13	4	0	0	1	1	6	3	125
26	4	7	7	10	14	6	6	6	8	5	2	0	0	0	0	5	16	2	1	3	1	5	8	6	124
27	6	9	7	8	4	10	10	10	10	9	1	0	0	0	0	6	2	0	1	1	2	1	6	7	111
28	6	4	3	7	6	6	9	9	9	6	2	0	0	0	0	1	4	2	1	2	5	12	7	7	110
29	2	7	11	5	7	8	9	5	4	1	0	3	2	15	6	9	6	2	1	3	1	8	10	9	134
30	54	73	97	97	64	76	46	49	23	8	3	1	0	0	0	12	15	11	5	3	8	16	2	8	672
KWh	157	181	221	259	223	257	259	226	242	105	21	9	79	183	256	530	478	195	164	79	140	146	96	96	4601

Mirkani Dec 2007,2008 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	30	16	17	18	19	20	21	22	23	24 Hrs
1	3	3	9	6	5	1	3	1	4	4	3	1	2	0	0	17	37	38	30	16	3	7	3	0	198
2	10	8	7	13	11	9	10	11	9	9	1	1	1	0	2	2	52	6	1	0	8	3	4	8	187
3	9	14	0	8	17	10	14	14	7	6	1	0	0	0	0	25	10	5	2	2	1	4	11	7	168
4	7	7	8	13	8	20	15	21	18	18	6	0	0	0	0	27	14	7	1	2	1	1	8	16	218
5	6	5	17	17	12	13	12	8	10	8	2	1	0	1	0	8	5	1	1	2	1	1	4	6	143
6	12	7	15	14	11	20	10	18	15	10	1	0	1	0	1	14	10	5	1	2	4	12	5	9	195
7	12	5	7	5	5	12	13	7	7	1	1	0	0	0	0	1	1	38	19	20	2	24	26	20	226
8	8	4	1	1	3	4	9	52	44	12	1	0	17	2	0	10	11	0	1	0	1	1	0	0	180
9	0	0	0	0	1	0	0	0	9	0	0	3	0	0	2	25	30	33	58	86	39	34	26	18	364
10	15	15	13	10	2	1	23	11	20	7	28	69	154	97	96	72	44	17	2	0	0	0	1	1	697
11	2	0	0	0	15	3	0	0	1	0	1	1	2	8	2	20	43	18	19	12	1	15	3	1	166
12	2	8	5	0	5	2	8	5	1	0	0	0	33	5	18	30	78	19	6	2	8	5	1	0	240
13	2	0	6	0	2	1	3	6	25	14	4	0	1	75	46	18	22	15	4	5	3	5	5	5	268
14	8	3	6	2	2	9	3	7	3	2	1	0	0	0	0	19	13	1	1	0	1	1	4	2	87
30	6	5	5	6	4	6	4	6	6	2	1	0	1	0	0	19	5	1	1	2	3	0	1	2	85
16	1	0	1	5	3	2	5	8	1	7	6	0	0	0	0	19	6	1	1	11	1	0	0	3	79
17	1	0	4	3	1	2	8	5	5	10	1	0	0	0	0	4	3	1	1	0	0	1	1	3	54
18	1	2	1	4	5	2	6	4	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	30
19	0	0	1	1	1	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0	9	19	34
20	25	53	34	18	12	4	2	1	25	70	68	37	17	45	84	99	63	42	48	25	15	13	11	10	823
21	1	1	3	1	1	1	0	0	1	24	31	2	15	26	19	29	29	17	6	2	1	0	0	2	211
22	1	1	3	1	2	0	2	2	4	2	2	1	0	2	4	29	37	10	2	2	1	1	2	1	113
23	2	2	1	4	2	2	2	4	0	1	0	1	0	0	2	2	2	3	0	1	1	1	2	1	38
24	3	1	4	3	2	2	1	2	1	0	0	0	3	3	1	5	6	1	1	3	1	3	4	1	50
25	5	1	1	4	0	1	5	1	3	2	2	0	1	0	0	9	11	9	2	1	1	1	1	1	62
26	6	5	5	6	6	7	8	11	10	12	2	2	1	0	1	23	38	6	5	4	3	10	4	1	175
27	6	10	6	10	5	8	9	3	2	4	1	0	0	0	0	16	29	3	1	3	1	1	3	8	131
28	5	3	6	9	3	5	9	3	5	4	2	0	0	0	1	14	10	1	1	1	0	0	2	3	90
29	5	2	2	1	1	2	1	1	3	3	0	0	0	0	1	8	9	6	0	0	0	1	0	0	46
30	1	0	4	5	0	4	3	2	4	2	1	0	1	1	12	47	41	13	2	2	1	1	1	1	147
31	1	7	2	1	5	3	2	3	2	1	0	2	6	5	6	46	51	20	4	3	2	2	2	4	181
KWh	164	175	178	172	151	156	189	220	246	236	166	127	257	273	298	656	709	337	219	207	105	149	142	154	5686