Pakistan Meteorological Department

A STUDY OF WIND POWER POTENTIAL

AT

TARBELA-NWFP

Technical Report No. PMD-03/2010

(Final report based on 36 months data)

FEBRUARY-2010

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 thirty (36) months wind data which has been presented along with the wind generated electric power at Tarbela, 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 4.20 m/s during 36 months August-2006 to Sep-2009, the highest of 5.63 m/s is observed in June. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the night time thought-out the year. Wind frequency distribution shows that during 35% of the time wind speed is 5 m/s or above.

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 *Annual Power Density* of Tarbela is 175 W/m^2 according to international wind classification, this power density categorize Tarbela 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 640,953 KWh which shows the capacity factor of 12% for Tarbela. 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 Tarbela and surrounding areas can be classified as non-suitable site for installing big economically viable wind farms but small wind turbines can be installed.

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 **Wind Mapping Project of Pakistan Meteorological Department:**

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, Chitral, Gilgit, Skardu, Haripur, Shangla, Buneer, Nowshara, Peshawar, Mohmad Agency, Khyber Agency and Azad Kashmir.

Forty-Two 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, Mirkhani, 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.

Tarbela site is situated near tarbela dam in district Haripur (NWFP). Latitude & Longitude of Tarbela is: **Latitude: 34.25º, Longitude: 72.79º, Elevation: 1289 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* 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_o 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

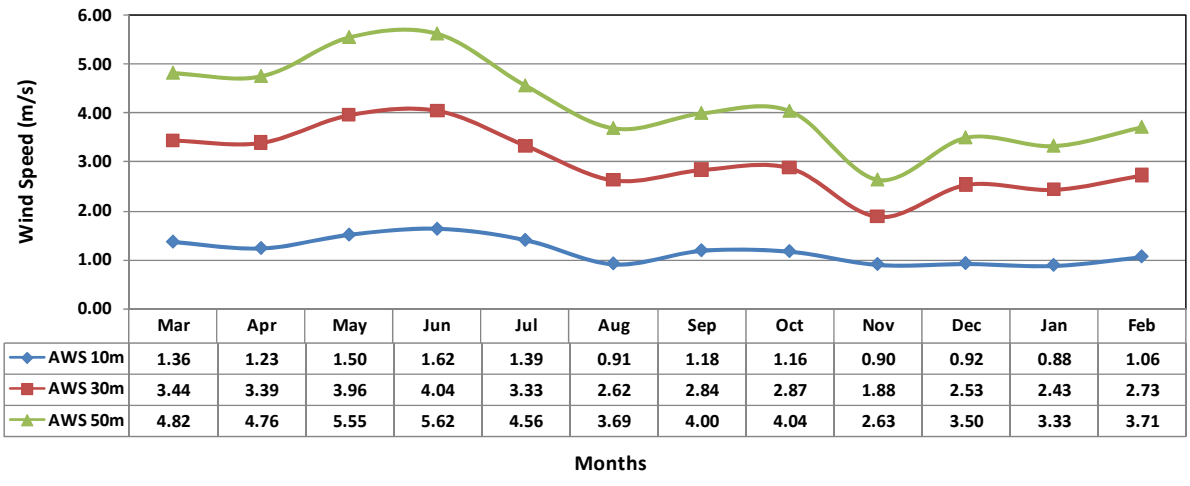
Type of terrain	**Z_0**	**α**
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	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 03 years 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 4.04 m/s during June. At 50 meters we have the average wind speed of 4.20 m/s and the highest average wind speed of 5.62 m/s is observed during the month of June.

Fig-1

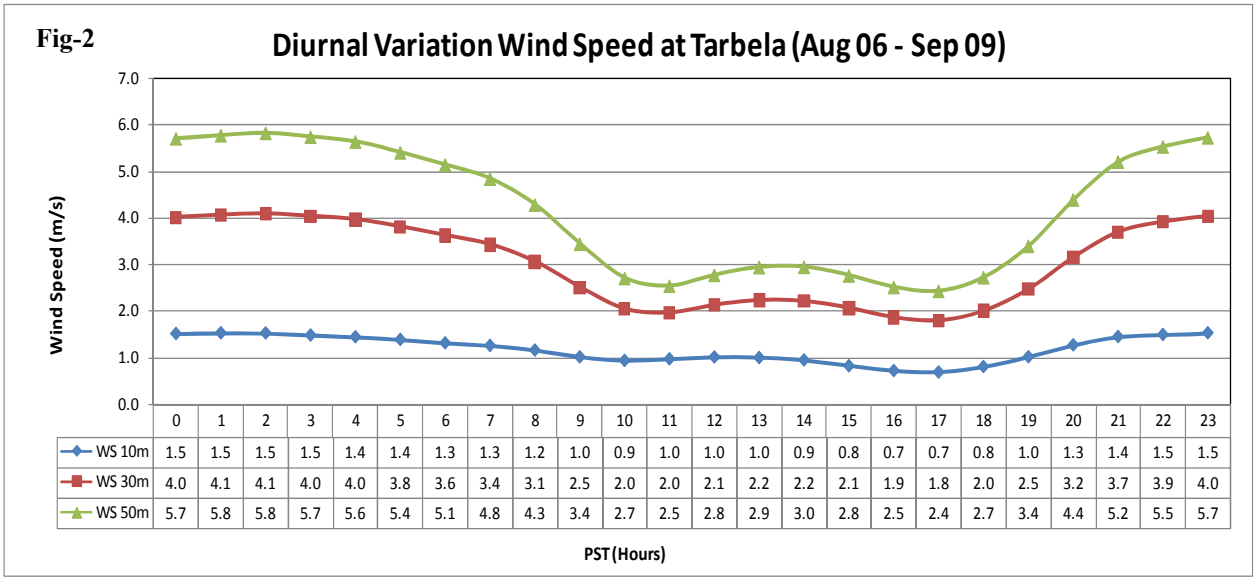


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AWS 10m	1.36	1.23	1.50	1.62	1.39	0.91	1.18	1.16	0.90	0.92	0.88	1.06
AWS 30m	3.44	3.39	3.96	4.04	3.33	2.62	2.84	2.87	1.88	2.53	2.43	2.73
AWS 50m	4.82	4.76	5.55	5.62	4.56	3.69	4.00	4.04	2.63	3.50	3.33	3.71

3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Tarbela from Aug-06 to Sep-09 (36 months). The wind speed is generally lower during day time and after sunset it starts picking up. At mid night it reaches maximum, wind speeds are around 4.1 m/s and 5.8 m/s at 30 meters and 50 meters height respectively. Figure-2 shows that the maximum wind speed during night times at 50 meters height reaches to 5.8 m/s at 2 am.

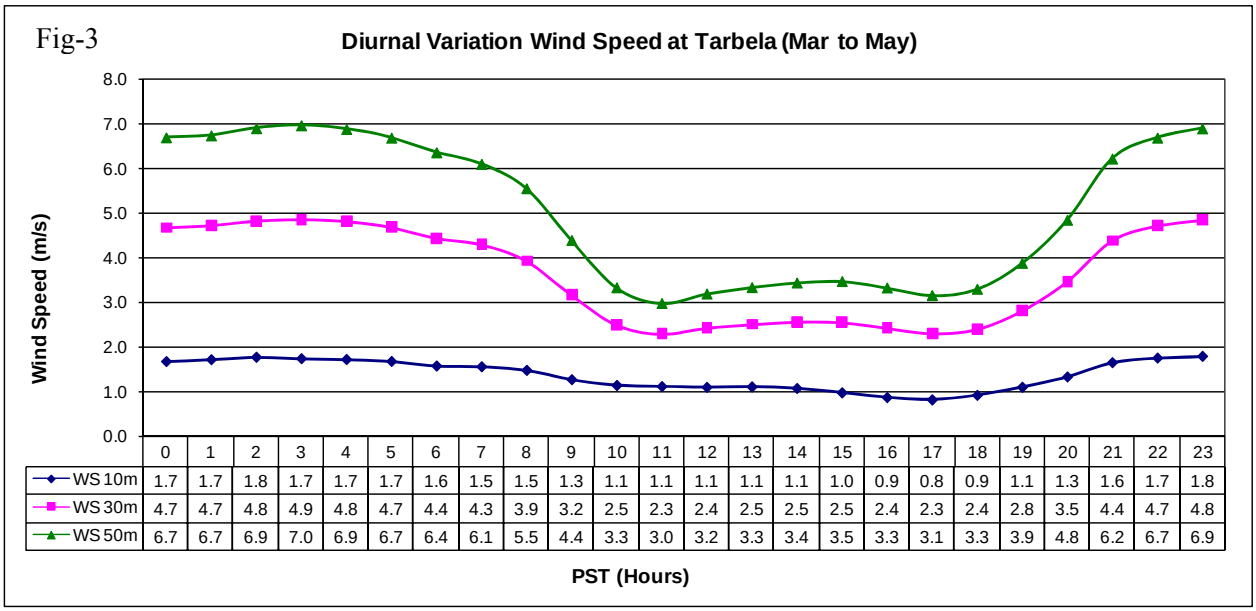
Fig-2



	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	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.0	0.9	1.0	1.0	1.0	0.9	0.8	0.7	0.7	0.8	1.0	1.3	1.4	1.5	1.5
WS 30m	4.0	4.1	4.1	4.0	4.0	3.8	3.6	3.4	3.1	2.5	2.0	2.0	2.1	2.2	2.2	2.1	1.9	1.8	2.0	2.5	3.2	3.7	3.9	4.0
WS 50m	5.7	5.8	5.8	5.7	5.6	5.4	5.1	4.8	4.3	3.4	2.7	2.5	2.8	2.9	3.0	2.8	2.5	2.4	2.7	3.4	4.4	5.2	5.5	5.7

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

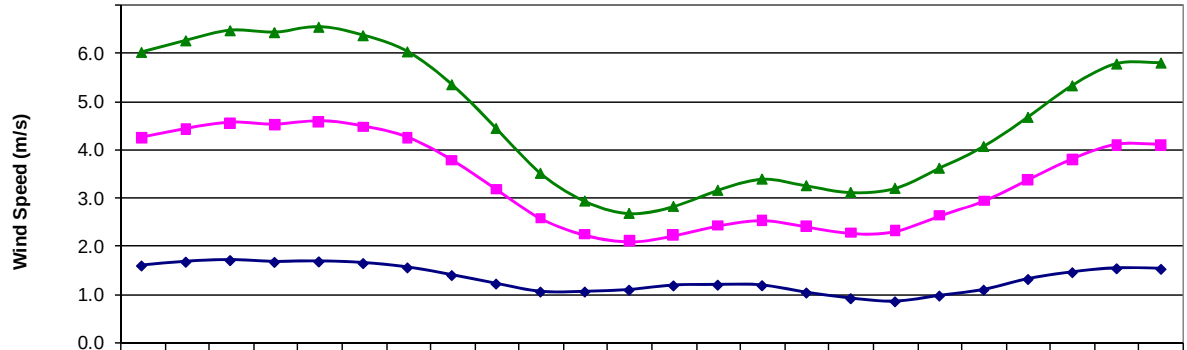
Fig-3



	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	1.7	1.7	1.8	1.7	1.7	1.7	1.6	1.5	1.5	1.3	1.1	1.1	1.1	1.1	1.1	1.0	0.9	0.8	0.9	1.1	1.3	1.6	1.7	1.8
WS 30m	4.7	4.7	4.8	4.9	4.8	4.7	4.4	4.3	3.9	3.2	2.5	2.3	2.4	2.5	2.5	2.5	2.4	2.3	2.4	2.8	3.5	4.4	4.7	4.8
WS 50m	6.7	6.7	6.9	7.0	6.9	6.7	6.4	6.1	5.5	4.4	3.3	3.0	3.2	3.3	3.4	3.5	3.3	3.1	3.3	3.9	4.8	6.2	6.7	6.9

Fig-4

Diurnal Variation Wind Speed at Tarbela (Jun to Aug)

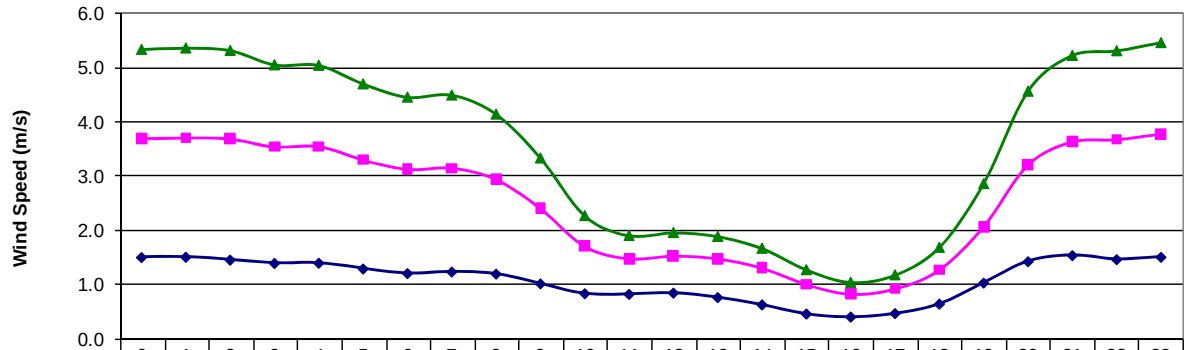


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2	1.0	1.0	1.1	1.2	1.2	1.2	1.0	0.9	0.8	1.0	1.1	1.3	1.4	1.5	1.5
WS 30m	4.3	4.4	4.6	4.5	4.6	4.5	4.3	3.8	3.2	2.6	2.2	2.1	2.2	2.4	2.5	2.4	2.3	2.3	2.6	2.9	3.4	3.8	4.1	4.1
WS 50m	6.0	6.3	6.5	6.4	6.5	6.4	6.0	5.3	4.4	3.5	2.9	2.7	2.8	3.1	3.4	3.2	3.1	3.2	3.6	4.1	4.7	5.3	5.8	5.8

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Tarbela (Sep to Nov)

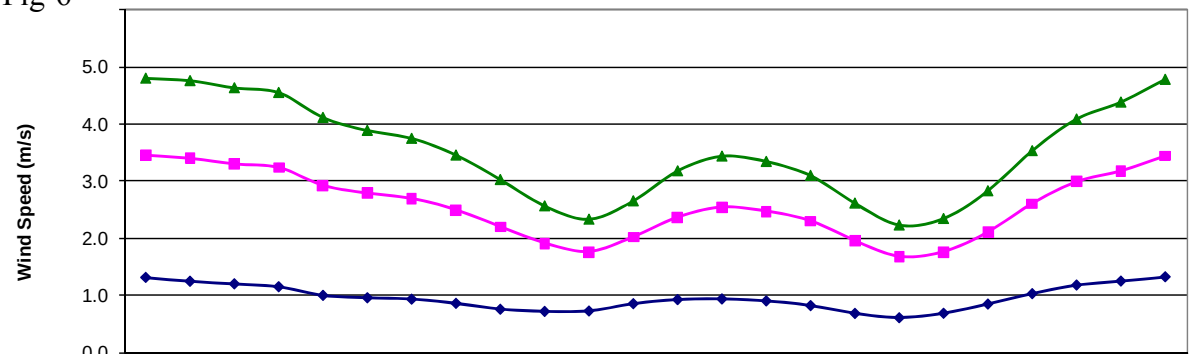


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.2	1.2	1.0	0.8	0.8	0.8	0.8	0.6	0.5	0.4	0.5	0.6	1.0	1.4	1.5	1.5	1.5
WS 30m	3.7	3.7	3.7	3.5	3.5	3.3	3.1	3.1	2.9	2.4	1.7	1.5	1.5	1.5	1.3	1.0	0.8	0.9	1.3	2.1	3.2	3.6	3.7	3.8
WS 50m	5.3	5.4	5.3	5.0	5.0	4.7	4.4	4.5	4.1	3.3	2.3	1.9	2.0	1.9	1.7	1.3	1.0	1.2	1.7	2.9	4.6	5.2	5.3	5.5

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Tarbela (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	1.3	1.2	1.2	1.1	1.0	1.0	0.9	0.9	0.8	0.7	0.7	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.7	0.8	1.0	1.2	1.2	1.3
WS 30m	3.5	3.4	3.3	3.2	2.9	2.8	2.7	2.5	2.2	1.9	1.8	2.0	2.4	2.5	2.5	2.3	2.0	1.7	1.8	2.1	2.6	3.0	3.2	3.4
WS 50m	4.8	4.7	4.6	4.5	4.1	3.9	3.7	3.5	3.0	2.6	2.3	2.7	3.2	3.4	3.3	3.1	2.6	2.2	2.3	2.8	3.5	4.1	4.4	4.8

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:*

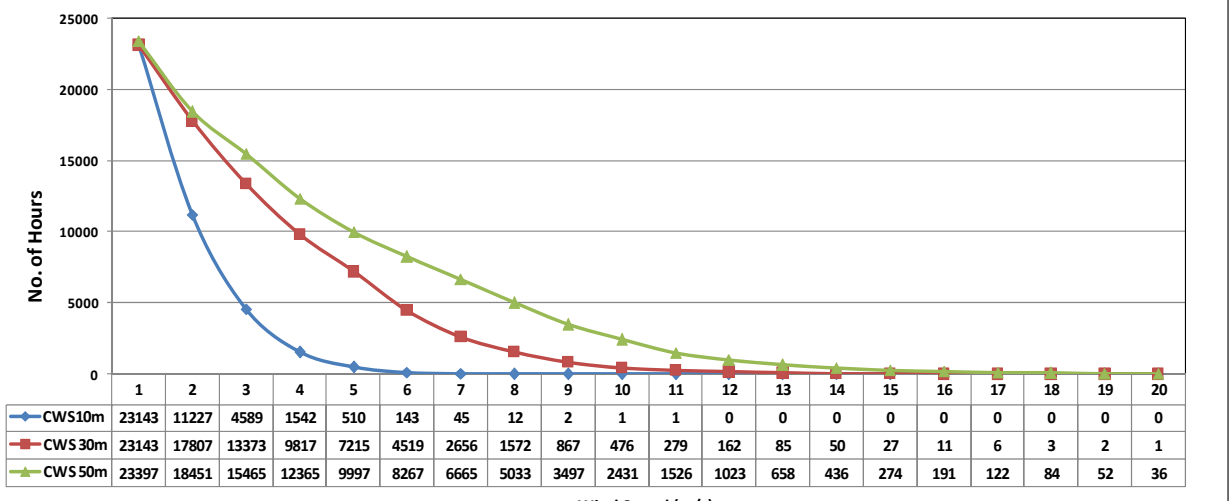
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as:

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

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Annual (Aug-06 to Sep-09) Cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters. The analysis indicate that in a year at a height of 30 meters during 7215 hours the wind speed is greater than 5 m/s whereas at 50 meters, during Annual 9997 hours the wind speed is equal or greater than 5m/s.

Fig-7

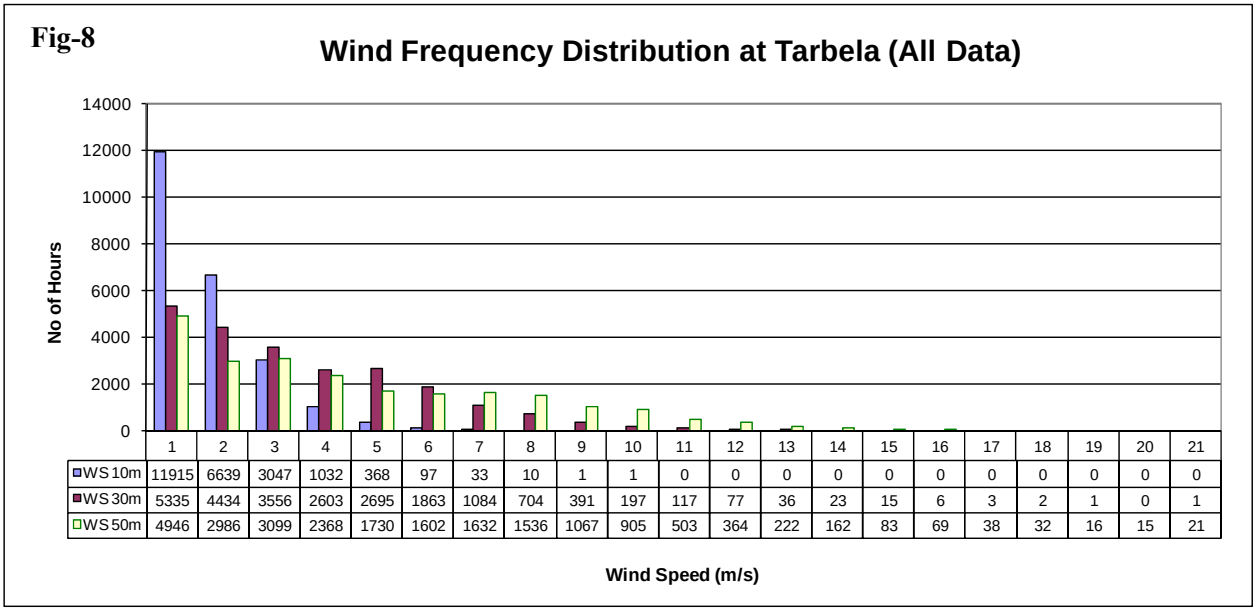


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	23143	11227	4589	1542	510	143	45	12	2	1	1	0	0	0	0	0	0	0	0	0
CWS 30m	23143	17807	13373	9817	7215	4519	2656	1572	867	476	279	162	85	50	27	11	6	3	2	1
CWS 50m	23397	18451	15465	12365	9997	8267	6665	5033	3497	2431	1526	1023	658	436	274	191	122	84	52	36

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the total wind frequency distribution at Tarbela for three years. We can see that at 50 meters during 1730 hours wind speed is 5 m/s, 1602 hours speed is 6 m/s, 1632 hours speed is 7 m/s and so on.

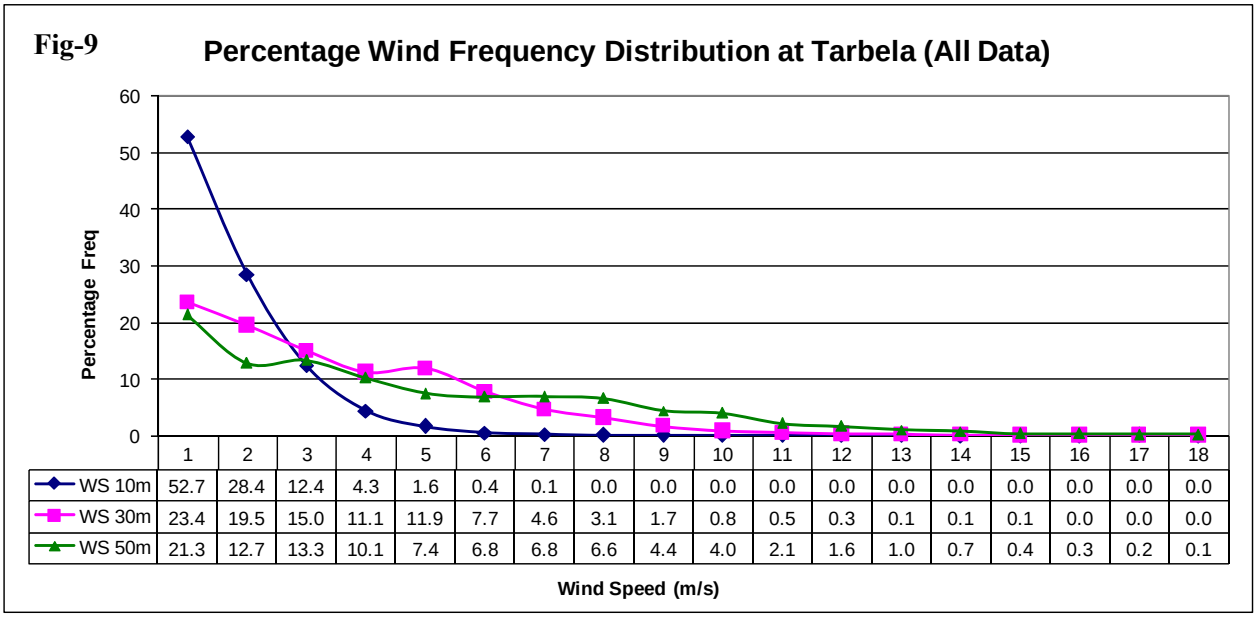
Fig-8



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	11915	6639	3047	1032	368	97	33	10	1	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	5335	4434	3556	2603	2695	1863	1084	704	391	197	117	77	36	23	15	6	3	2	1	0	1
WS 50m	4946	2986	3099	2368	1730	1602	1632	1536	1067	905	503	364	222	162	83	69	38	32	16	15	21

Fig-9 gives this frequency distribution in percentage. At 50 meters we find that during 7.4% of time wind is 5m/s, 6.8% of the time 6m/s and 6.8% of the time it is 7m/s. whereas at 30 meters height we get 11.9% of the time wind speed 5m/s, 7.7% of the times 6m/s and 4.6% of the time 7m/s.

Fig-9



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	52.7	28.4	12.4	4.3	1.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	23.4	19.5	15.0	11.1	11.9	7.7	4.6	3.1	1.7	0.8	0.5	0.3	0.1	0.1	0.1	0.0	0.0	0.0
WS 50m	21.3	12.7	13.3	10.1	7.4	6.8	6.8	6.6	4.4	4.0	2.1	1.6	1.0	0.7	0.4	0.3	0.2	0.1

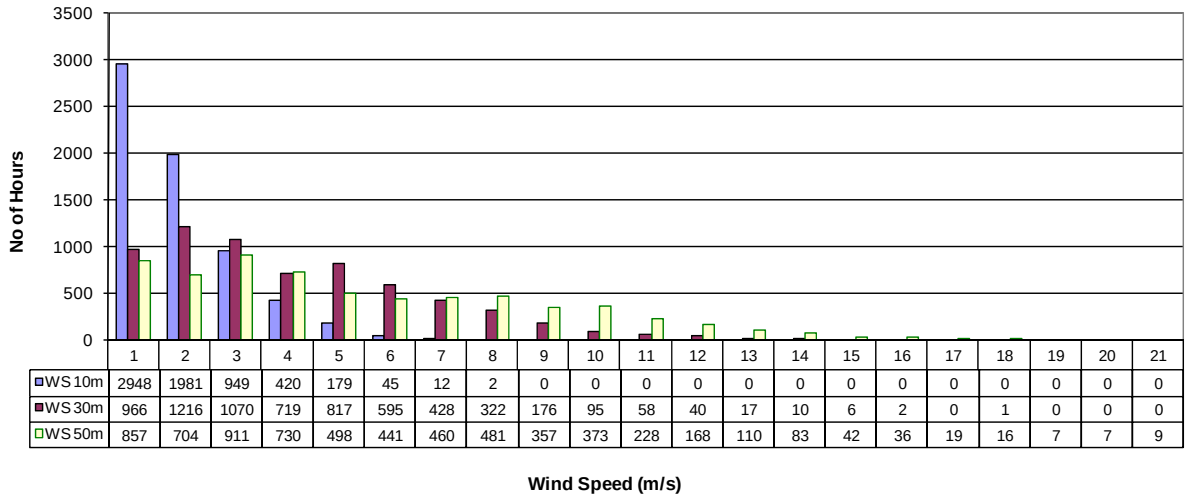
3.4.5 *Seasonal Wind Frequency Distribution:*

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

Mar – May

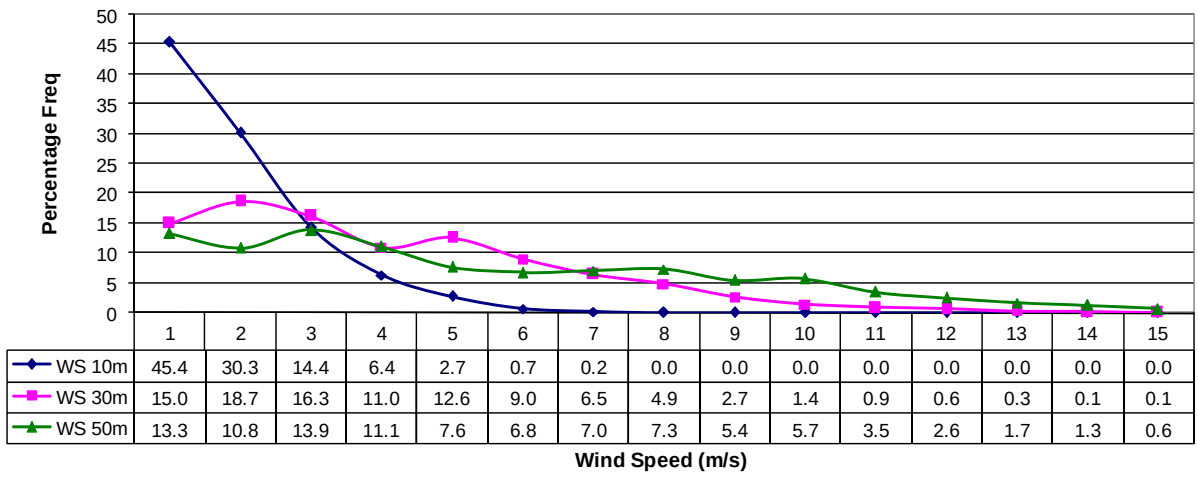
Fig-10 shows this distribution during the months of March to May. We can see that in this period at 30 meters height during 817 hours we get 5m/s, 595 hours 6m/s, 428 hours 7m/s. Similarly at 50 meters we get 498 hours 5m/s, 441 hours 6m/s, 460 hours 7m/s. Fig-11 shows percentage frequency distribution 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	2948	1981	949	420	179	45	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	966	1216	1070	719	817	595	428	322	176	95	58	40	17	10	6	2	0	1	0	0	0
WS 50m	857	704	911	730	498	441	460	481	357	373	228	168	110	83	42	36	19	16	7	7	9

Fig-11



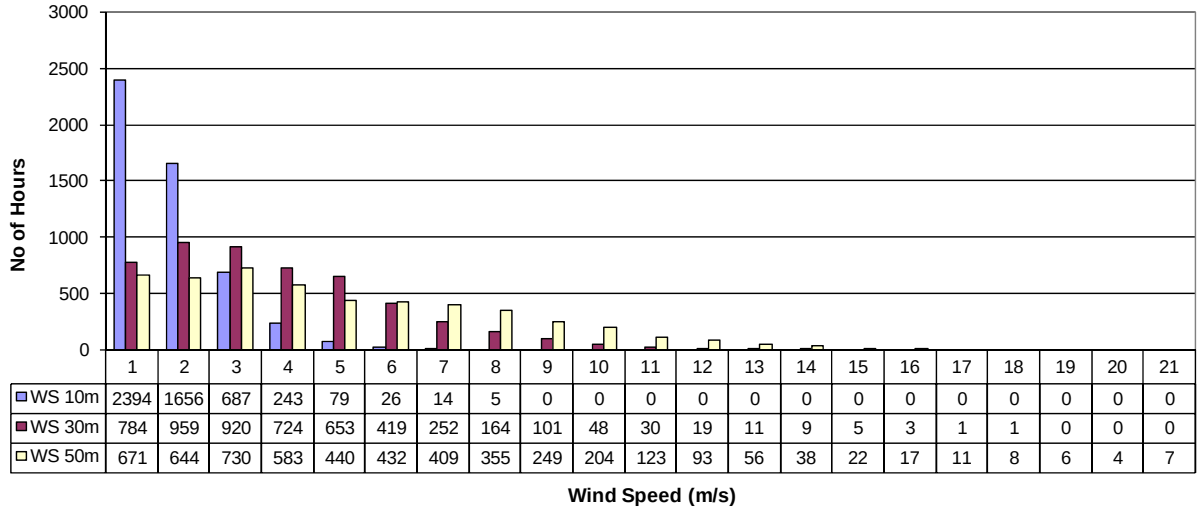
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	45.4	30.3	14.4	6.4	2.7	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	15.0	18.7	16.3	11.0	12.6	9.0	6.5	4.9	2.7	1.4	0.9	0.6	0.3	0.1	0.1
WS 50m	13.3	10.8	13.9	11.1	7.6	6.8	7.0	7.3	5.4	5.7	3.5	2.6	1.7	1.3	0.6

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 653 hours we get 5m/s, 419 hours 6m/s, 252 hours 7m/s.

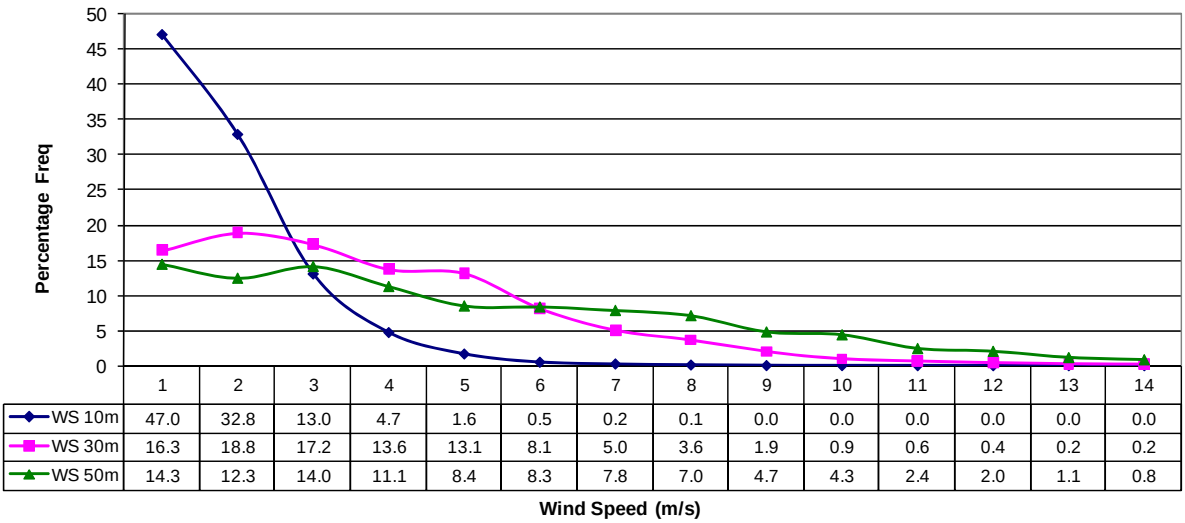
Similarly at 50 meters height during 440 hours we get wind speed of 5m/s, during 432 hours 6m/s, 409 hours 7m/s, 355 hours 8m/s. Fig-13 shows this distribtution in percentage.

Fig-12



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2394	1656	687	243	79	26	14	5	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	784	959	920	724	653	419	252	164	101	48	30	19	11	9	5	3	1	1	0	0	0
WS 50m	671	644	730	583	440	432	409	355	249	204	123	93	56	38	22	17	11	8	6	4	7

Fig-13



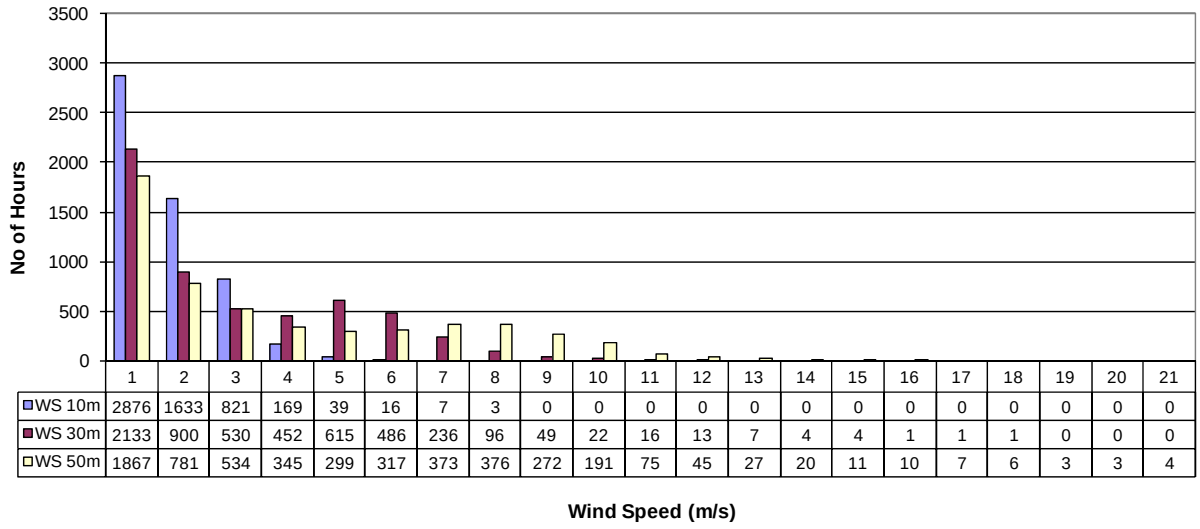
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	47.0	32.8	13.0	4.7	1.6	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	16.3	18.8	17.2	13.6	13.1	8.1	5.0	3.6	1.9	0.9	0.6	0.4	0.2	0.2
WS 50m	14.3	12.3	14.0	11.1	8.4	8.3	7.8	7.0	4.7	4.3	2.4	2.0	1.1	0.8

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 615 hours we get 5m/s, 486 hours 6m/s, 236 hours 7m/s.

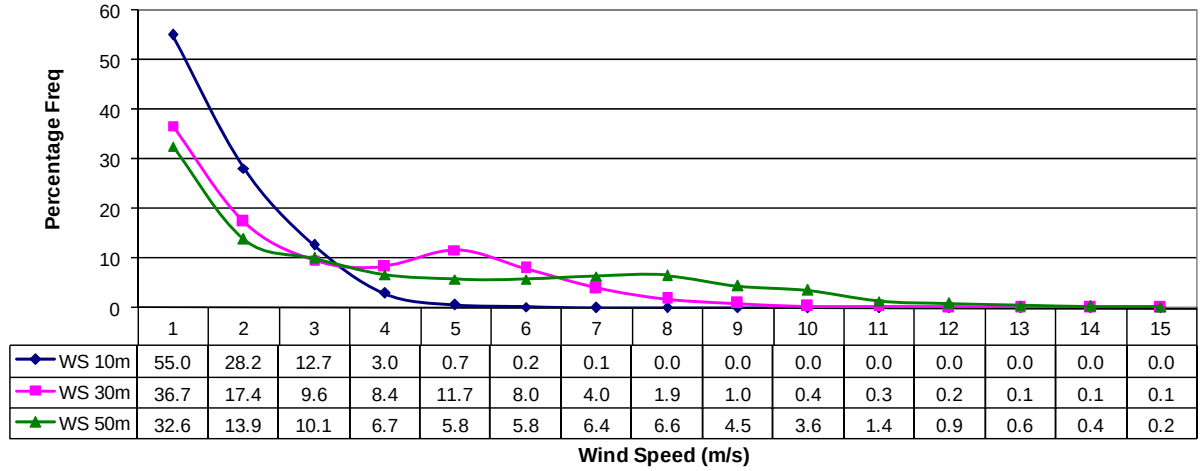
Similarly at 50 meters height during 299 hours we get wind speed of 5m/s, during 317 hours 6m/s, 373 hours 7m/s, 376 hours 8m/s. Fig-15 shows distribution in percentage.

Fig-14



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2876	1633	821	169	39	16	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	2133	900	530	452	615	486	236	96	49	22	16	13	7	4	4	1	1	1	0	0	0
WS 50m	1867	781	534	345	299	317	373	376	272	191	75	45	27	20	11	10	7	6	3	3	4

Fig-15



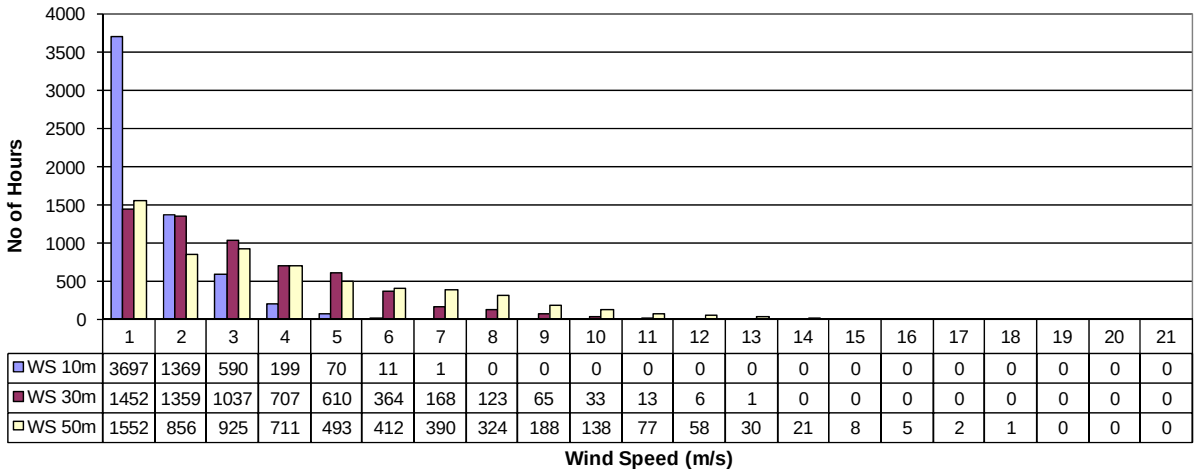
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	55.0	28.2	12.7	3.0	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	36.7	17.4	9.6	8.4	11.7	8.0	4.0	1.9	1.0	0.4	0.3	0.2	0.1	0.1	0.1
WS 50m	32.6	13.9	10.1	6.7	5.8	5.8	6.4	6.6	4.5	3.6	1.4	0.9	0.6	0.4	0.2

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 610 hours we get 5m/s, 364 hours 6m/s, 168 hours 7m/s.

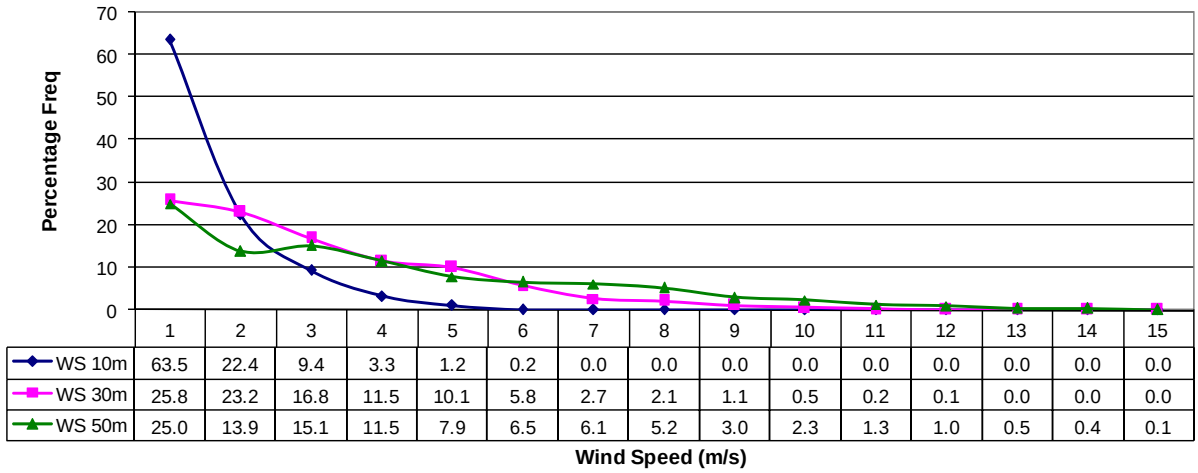
Similarly at 50 meters height during 493 hours we get wind speed of 5m/s, during 412 hours 6m/s, 390 hours 7m/s, 324 hours 8m/s. Fig-17 shows distribution in percentage.

Fig-16



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	3697	1369	590	199	70	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1452	1359	1037	707	610	364	168	123	65	33	13	6	1	0	0	0	0	0	0	0	0
WS 50m	1552	856	925	711	493	412	390	324	188	138	77	58	30	21	8	5	2	1	0	0	0

Fig-17



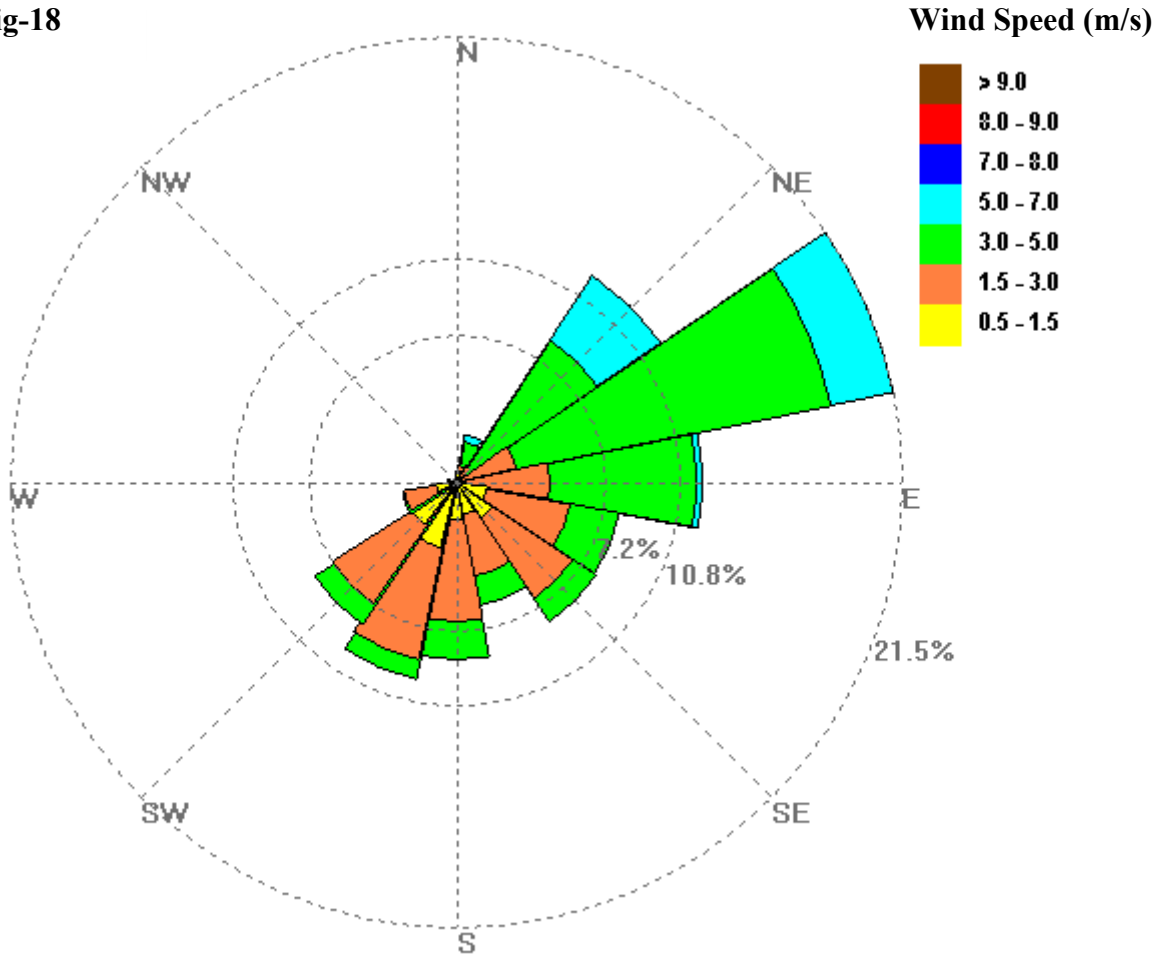
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	63.5	22.4	9.4	3.3	1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	25.8	23.2	16.8	11.5	10.1	5.8	2.7	2.1	1.1	0.5	0.2	0.1	0.0	0.0	0.0
WS 50m	25.0	13.9	15.1	11.5	7.9	6.5	6.1	5.2	3.0	2.3	1.3	1.0	0.5	0.4	0.1

3.5 **Wind Rose:**

Fig-18 shows the Wind Rose based on 36 months data from August 2006 – Sept 2009 collected at 30 meters height. Wind Rose indicates that the wind direction is mostly between east and north east. The average wind speed is 3.04 m/s and the percentage of wind speed greater than 5 m/s is 19%.

Wind Rose at Tarbela (30m height during 36 months)

Fig-18



Average Wind Speed	Wind speed greater than 5 m/s	Comments
3.04 m/s	19%	

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	---	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	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	---	7.4 – 8.2	480 – 640	8.0 – 8.8	600 – 800
7	---	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

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

Where dm/dt is the mass of air following time.

From fluid dynamics, it can be proved that

$$dm/dt = \varphi AV$$

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

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

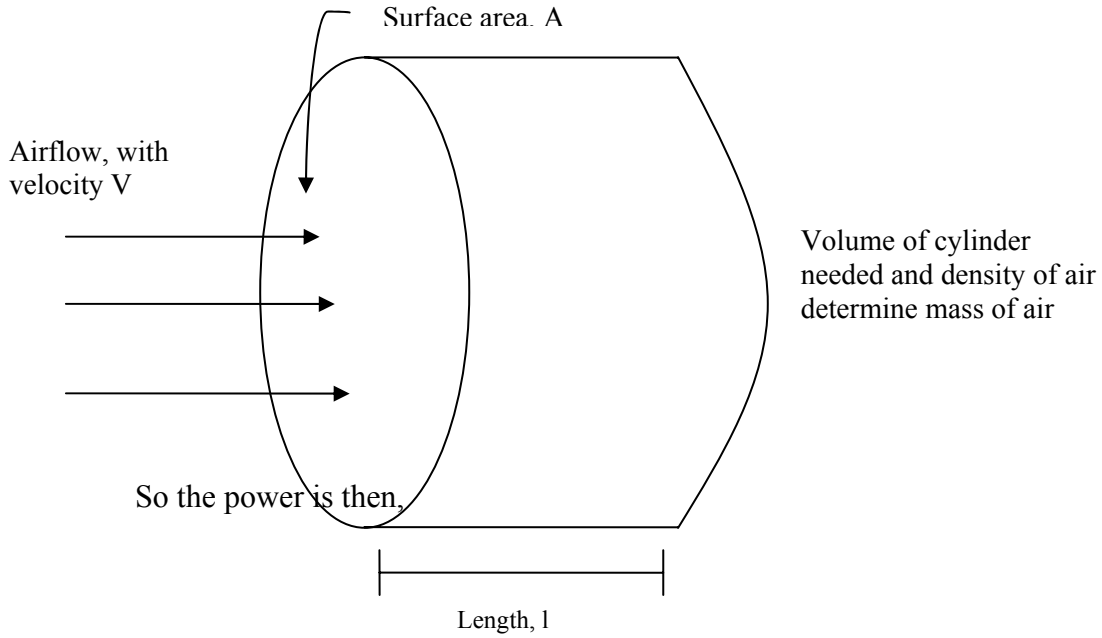
Now mass of wind can be written as

$$M = \varphi Avt$$

Differentiating

$$dm/dt = \varphi AV \, d/dt(t) = \varphi AV$$

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



$$P = \tfrac{1}{2} \frac{dm}{dt} V^2 = \tfrac{1}{2} \varphi A V T / t \; V^2$$

$$= \tfrac{1}{2} \varphi A V^3$$

And power density

$$\frac{P}{A} = \tfrac{1}{2} \varphi V^3$$

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

At 15° 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.

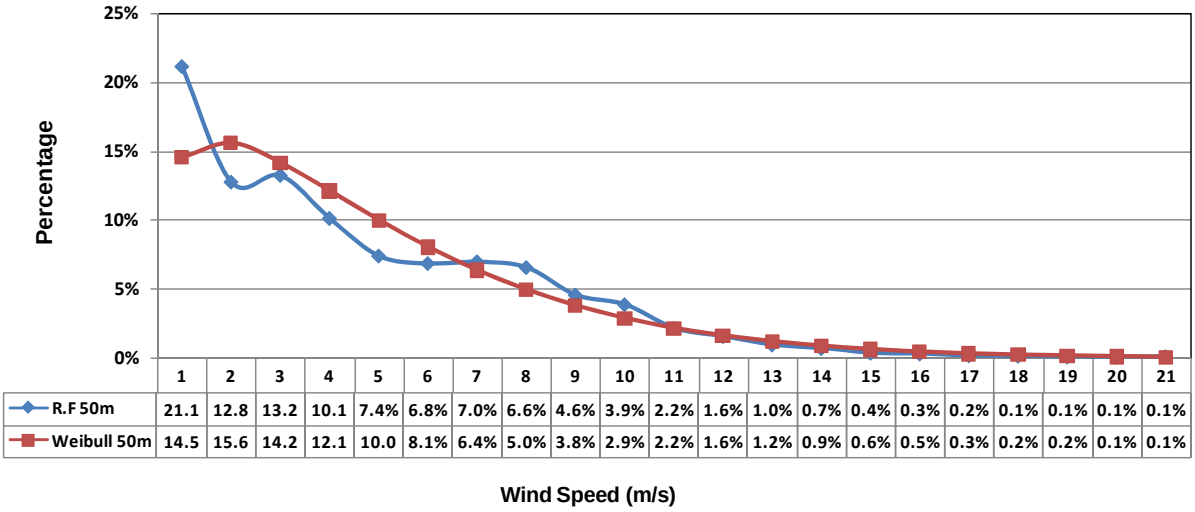
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion 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 Tarbela (50m 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	21.1	12.8	13.2	10.1	7.4%	6.8%	7.0%	6.6%	4.6%	3.9%	2.2%	1.6%	1.0%	0.7%	0.4%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%
Weibull 50m	14.5	15.6	14.2	12.1	10.0	8.1%	6.4%	5.0%	3.8%	2.9%	2.2%	1.6%	1.2%	0.9%	0.6%	0.5%	0.3%	0.2%	0.2%	0.1%	0.1%

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 0.85 during November to the highest of 1.55 during the month of June with a Annual value of K being 1.27.

The lowest values of the scale parameter **C**, 2.43 is observed in November while the highest value of 6.36 is obtained in June and with an Annual value of 4.54.

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 1.28 m/s with Standard deviation of 0.99, at 30 meters this average speed is 3.04 m/s with Standard deviation of 2.30. At 50 meters the monthly average wind speed varies from the lowest of 2.64 m/s in November to highest of 5.63 m/s during June. Whereas the average wind speed is 4.20 m/s with Standard deviation of 3.34.

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 3.23 W/m^2 in January to 2.89 W/m^2 in December with Average of 4.67 W/m^2.

At 30 meters height the power density varies from 37.98 W/m^2 in January to 39.67 W/m^2 in December and the average values is about 59.53 W/m^2.

At 50 meters height the power density of Tarbela varies from 111.75 W/m^2 in January to 117.55 W/m^2 in December. The average power density of the area is 175.29 W/m^2.

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

	10 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	1.02	0.87	1.15	1.18	**3.23**
February	1.18	0.96	1.33	1.25	**4.28**
March	1.44	1.12	1.56	1.31	**6.12**
April	1.33	1.11	1.41	1.22	**5.53**
May	1.56	1.15	1.71	1.39	**7.13**
June	1.67	1.19	1.84	1.44	**8.28**
July	1.36	1.04	1.48	1.34	**5.01**
August	1.05	0.80	1.14	1.33	**2.31**
September	1.37	0.99	1.51	1.42	**4.65**
October	1.26	0.92	1.39	1.41	**3.69**
November	1.08	0.89	1.16	1.23	**2.91**
December	1.07	0.89	1.15	1.23	**2.89**
Average	**1.28**	**0.99**	**1.40**	**1.31**	**4.67**
	30 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	2.48	1.98	2.81	1.28	**37.98**
February	2.79	2.02	3.16	1.42	**42.93**
March	3.44	2.40	3.80	1.48	**69.41**
April	3.43	2.59	3.74	1.36	**78.71**
May	3.95	2.72	4.37	1.50	**102.34**
June	4.04	2.62	4.51	1.60	**100.43**
July	3.29	2.32	3.63	1.46	**61.73**
August	2.74	2.02	3.01	1.39	**38.53**
September	2.75	2.39	2.90	1.17	**53.82**
October	2.92	2.35	3.15	1.27	**54.88**
November	1.93	2.10	1.84	0.91	**33.90**
December	2.65	2.09	2.87	1.29	**39.67**
Average	**3.04**	**2.30**	**3.32**	**1.34**	**59.53**
	50 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	3.08	2.83	3.48	1.10	**111.75**
February	3.81	2.86	4.17	1.36	**107.23**
March	4.84	3.53	5.32	1.41	**208.29**
April	4.81	3.77	5.21	1.30	**233.07**
May	5.56	3.98	6.13	1.44	**305.36**
June	5.63	3.76	6.36	1.55	**297.75**
July	4.56	3.35	5.00	1.40	**176.43**
August	3.84	3.02	4.16	1.30	**119.45**
September	3.83	3.42	4.01	1.13	**155.14**
October	4.09	3.46	4.35	1.20	**167.23**
November	2.64	3.05	2.43	0.85	**104.29**
December	3.66	3.06	3.91	1.21	**117.55**
Average	**4.20**	**3.34**	**4.54**	**1.27**	**175.29**

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 Tarbela 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 Tarbela 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 Tarbela.

PMD Calculator (using 50M at Tarbela) from Aug 2006 to Sep 2009				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	113	33	8%	37,733
February	108	37	9%	38,999
March	207	62	16%	70,123
April	224	61	15%	66,834
May	291	78	20%	87,928
June	280	80	20%	87,103
July	168	52	13%	59,081
August	114	37	9%	42,098
September	149	41	10%	45,175
October	162	46	12%	52,105
November	102	24	6%	26,733
December	119	37	9%	42,331
Annual	**161**	**48**	**12%**	**640,953**

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 Tarbela (Aug-06 to Sep-09). The graph shows that the maximum power is produced at about 2:00 AM; 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 Tarbela the wind have more potential in the month of May as compared to other months. Figure 23 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20 **Tarbela: From Aug 2006 to Sep 2009 Annual Average Diurnal Varition Of Wind Generated Electric Power Output**

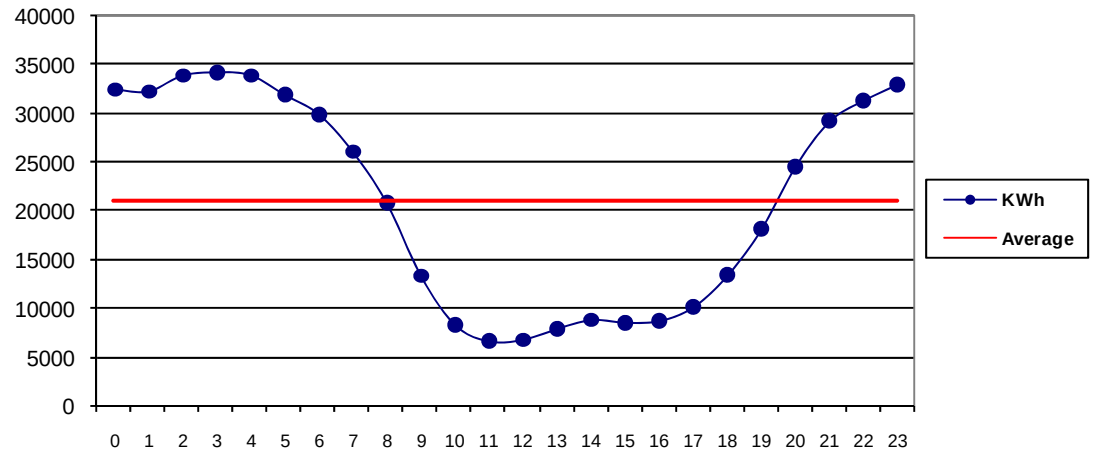


Fig 21 **Tarbela: From Aug 2006 to Sep 2009 Monthly Average Diurnal Varition Of Wind Generated Electric Power Output**

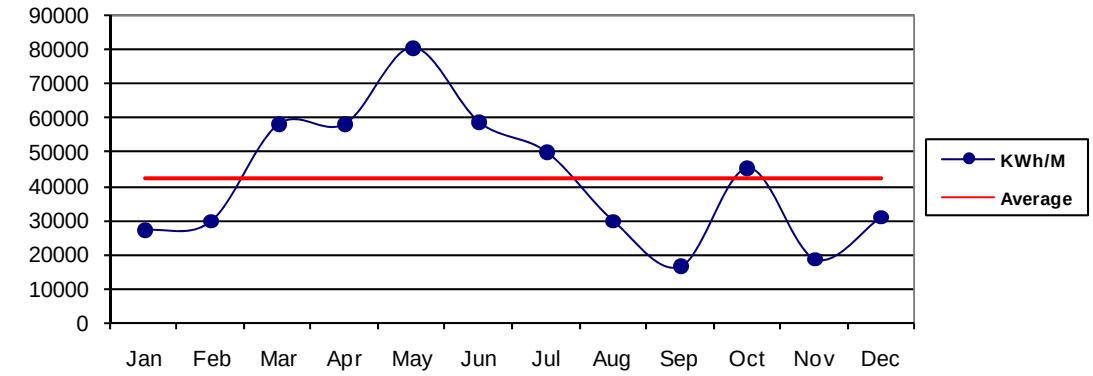


Fig 22 **Tarbela: From Aug 2006 to Sep 2009 Daily Wind Generated Electric Power Output**

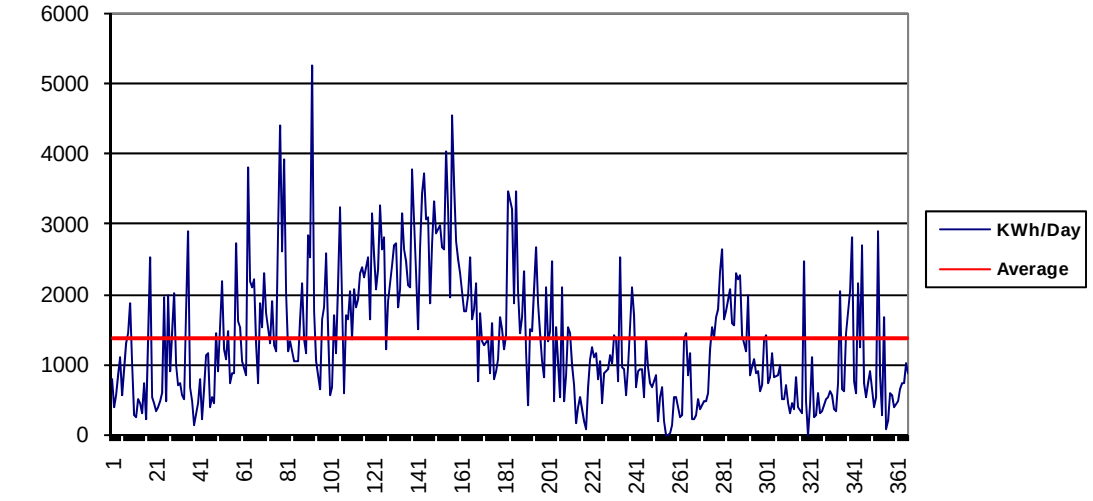


Fig 23 Tarbela Jan: Diurnal Variation of Wind Genrated Electric Energy Output

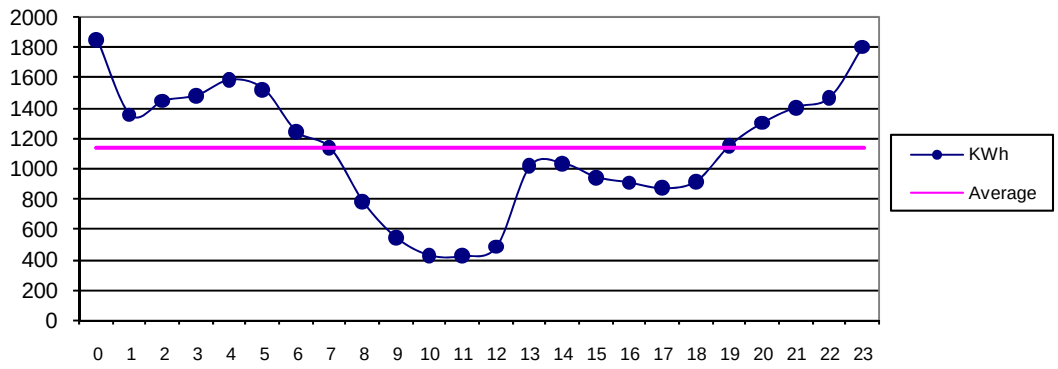
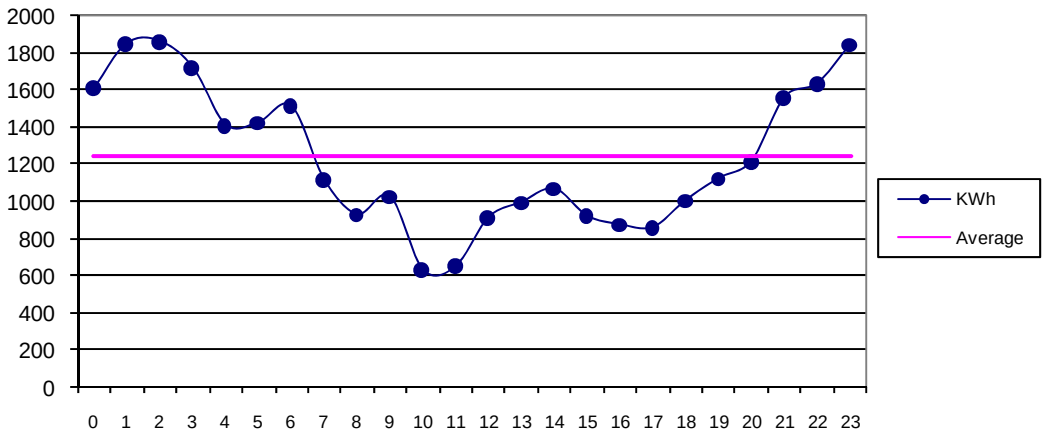
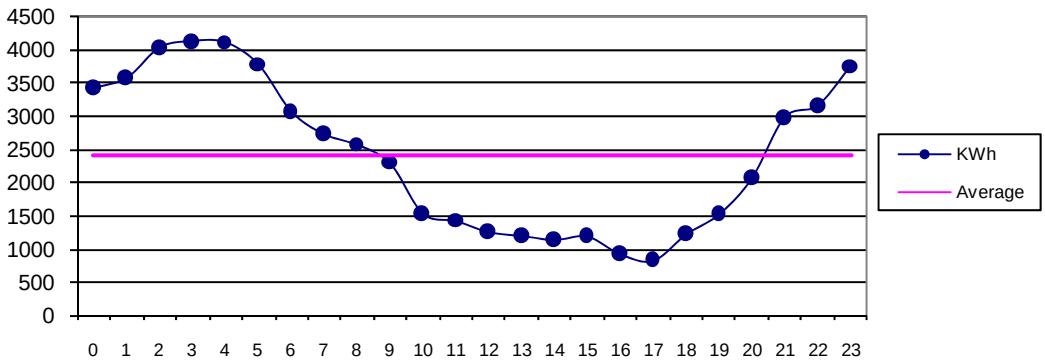


Fig 24 Tarbela Feb: Diurnal Variation of Wind Genrated Electric Energy Output



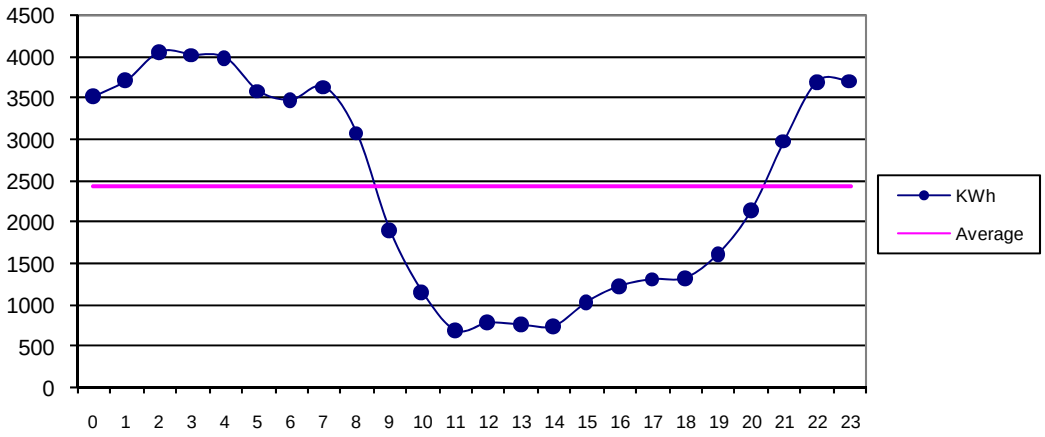
Source: Pakistan Meteorological Department

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



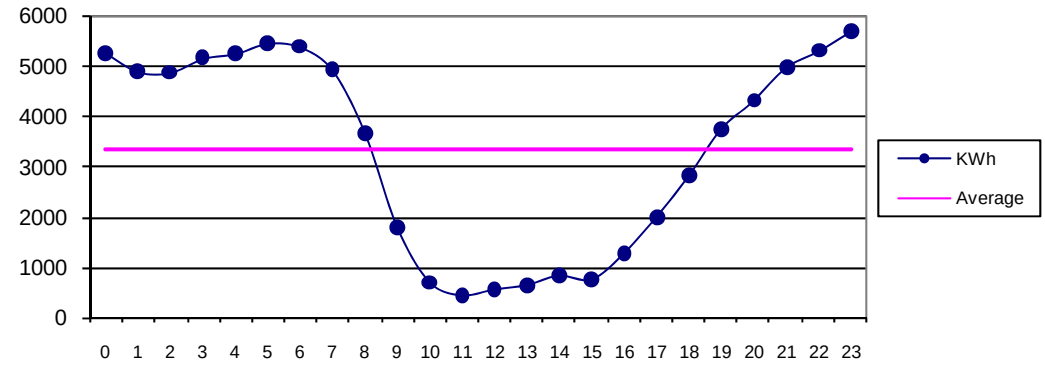
Source: Pakistan Meteorological Department

Fig 26 Tarbela Apr: Diurnal Variation of Wind Genrated Electric Energy Output



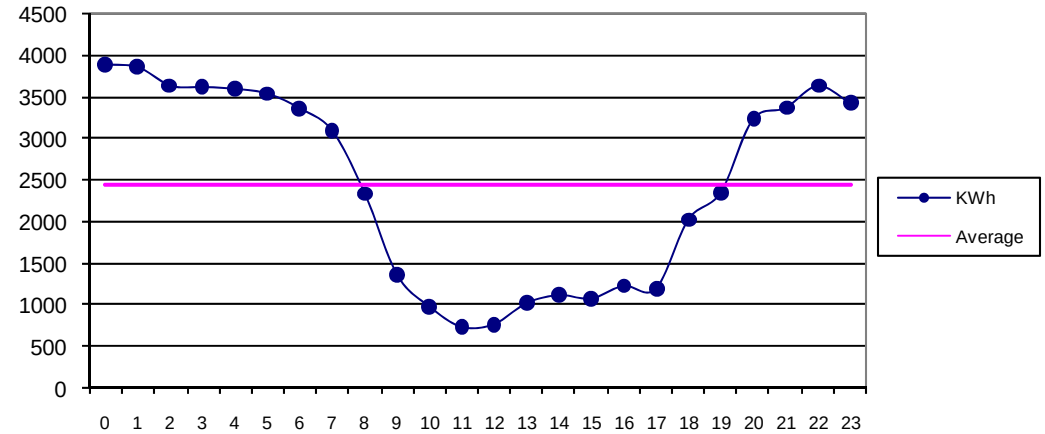
Source: Pakistan Meteorological Department

Fig 27 Tarbela May: Diurnal Variation of Wind Genrated Electric Energy Output



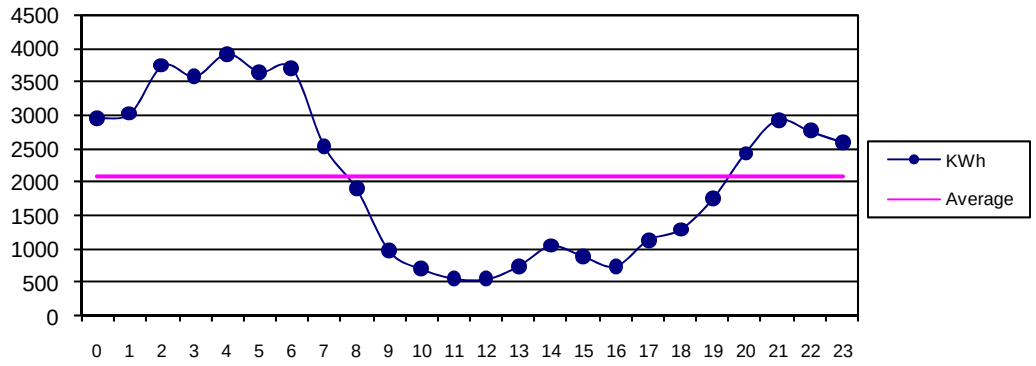
Source: Pakistan Meteorological Department

Fig 28 Tarbela Jun: Diurnal Variation of Wind Genrated Electric Energy Output



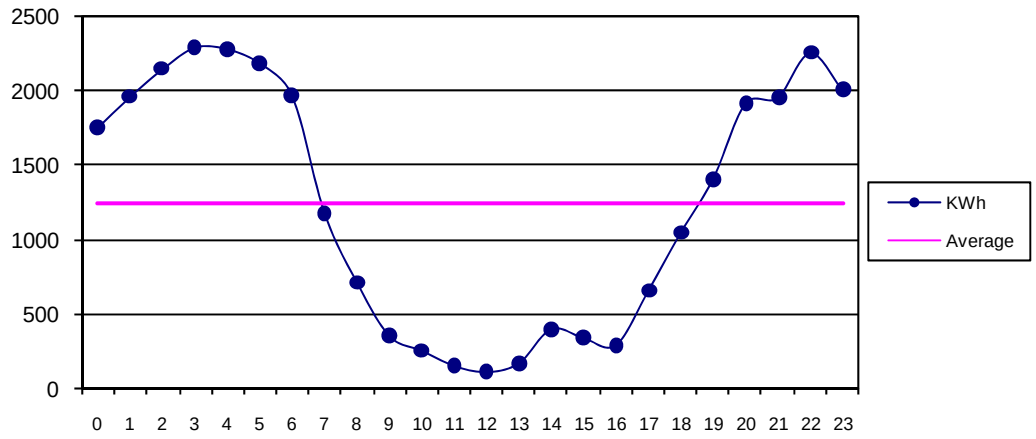
Source: Pakistan Meteorological Department

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



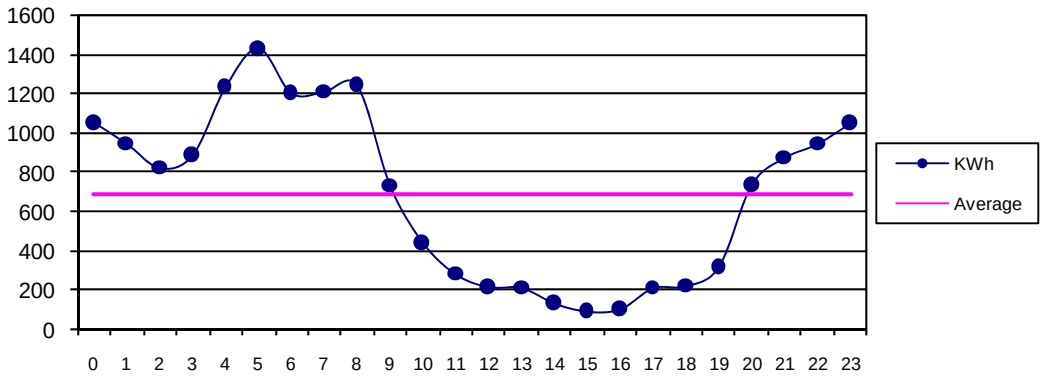
Source: Pakistan Meteorological Department

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



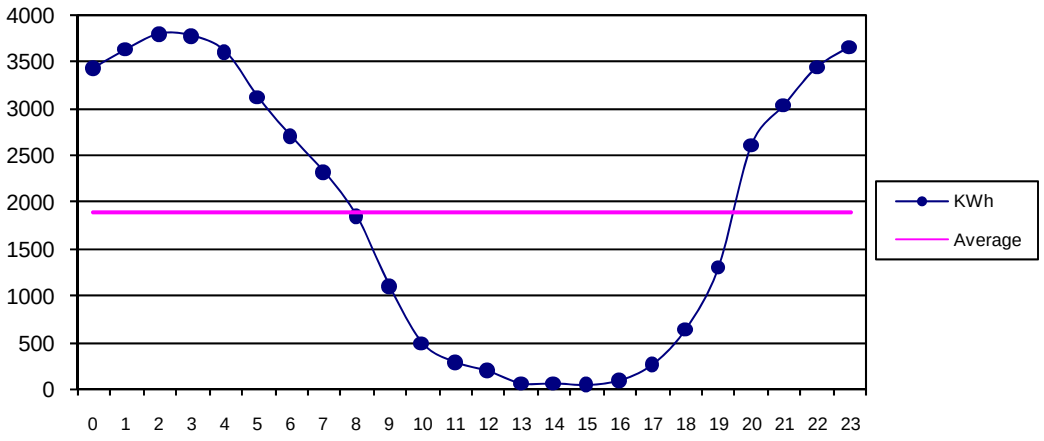
Source: Pakistan Meteorological Department

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



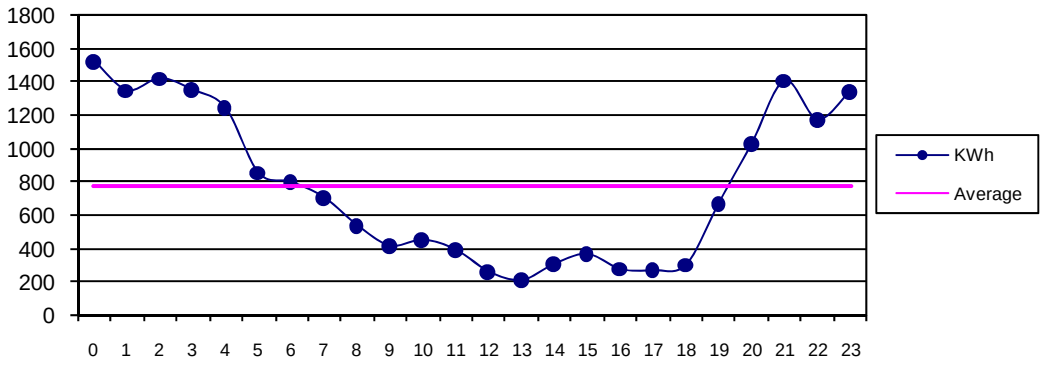
Source: Pakistan Meteorological Department

Fig 32 Tarbela Oct: Diurnal Variation of Wind Genrated Electric Energy Output



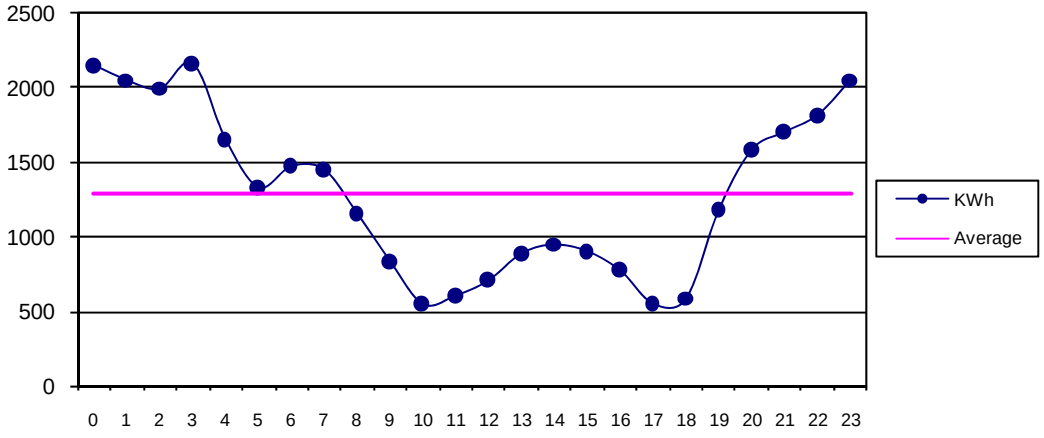
Source: Pakistan Meteorological Department

Fig 33 Tarbela Nov: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

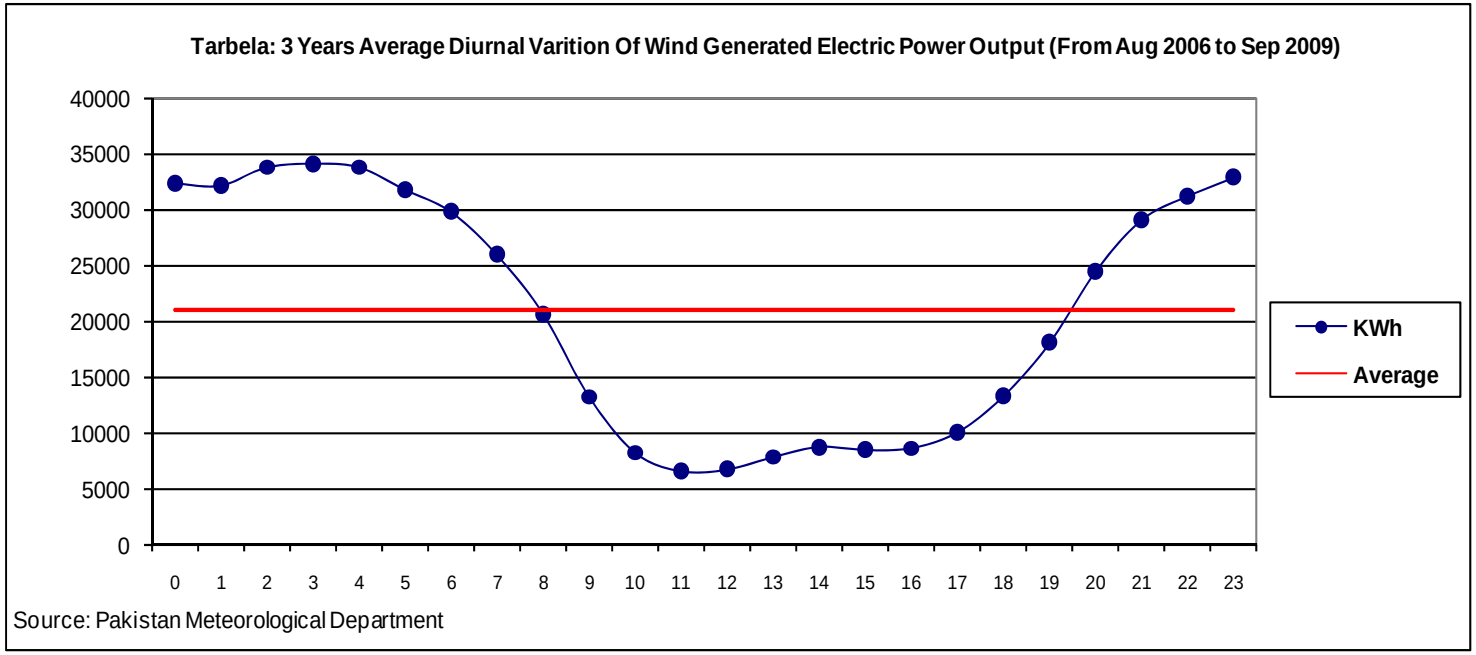
Fig 34 Tarbela Dec: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Tarbela **Aug 2006 to Sep 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	15	16	17	18	19	20	21	22	23	24 Hrs
Jan	1854	1354	1448	1483	1586	1525	1243	1137	779	543	428	423	485	1017	1035	944	908	870	917	1152	1304	1405	1468	1804	27111
Feb	1614	1851	1862	1721	1413	1427	1514	1119	933	1030	635	655	917	998	1070	924	878	864	1009	1127	1220	1561	1636	1844	29822
Mar	3433	3585	4042	4138	4118	3784	3077	2735	2575	2301	1542	1431	1263	1206	1146	1196	930	832	1228	1529	2073	2989	3167	3757	58077
Apr	3516	3712	4057	4020	3985	3585	3478	3633	3076	1913	1160	700	792	769	754	1044	1237	1316	1334	1627	2147	2983	3696	3705	58239
May	5250	4882	4869	5149	5244	5449	5377	4914	3661	1774	687	428	545	630	820	743	1261	1991	2806	3744	4307	4966	5294	5684	80475
Jun	3901	3867	3644	3629	3607	3548	3371	3100	2347	1368	983	738	773	1025	1121	1081	1234	1199	2030	2358	3240	3375	3643	3439	58622
Jul	2946	3021	3731	3568	3904	3635	3690	2527	1894	973	702	562	552	745	1047	890	744	1132	1291	1746	2421	2920	2757	2595	49994
Aug	1752	1959	2144	2287	2274	2179	1960	1174	711	354	256	155	113	171	400	341	293	657	1046	1405	1909	1950	2250	2004	29744
Sep	1053	944	821	889	1236	1432	1203	1210	1243	733	442	281	216	212	133	91	103	210	220	318	735	874	944	1049	16590
Oct	3422	3625	3788	3764	3596	3107	2689	2315	1839	1090	484	282	187	56	55	39	88	259	633	1294	2599	3027	3430	3646	45316
Nov	1526	1352	1424	1354	1244	855	801	708	542	419	455	394	264	212	310	369	279	271	304	674	1033	1409	1177	1345	18722
Dec	2152	2049	1993	2164	1651	1330	1471	1449	1155	834	545	603	706	886	946	899	772	548	579	1179	1583	1702	1816	2049	31058
KWh	32419	32201	33823	34168	33859	31857	29873	26020	20755	13330	8319	6651	6811	7927	8838	8563	8728	10150	13397	18153	24570	29162	31278	32921	**503770**
Avg	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	20990	



Tarbela **Jan 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	92	83	63	47	58	68	49	41	9	2	0	3	13	3	1	0	0	0	0	11	51	51	66	91	802
2	55	27	22	17	24	22	12	12	36	19	7	4	5	5	8	1	1	0	0	0	1	29	43	53	403
3	47	42	0	47	32	16	41	32	15	0	2	16	6	3	15	15	0	0	25	97	56	17	15	31	570
4	39	42	56	20	12	38	16	7	4	14	7	15	28	21	19	34	39	49	77	70	80	36	56	66	845
5	32	6	1	5	4	0	0	0	7	15	12	24	58	102	70	94	120	24	69	85	75	44	169	102	1119
6	119	23	0	1	9	7	9	4	8	0	0	0	2	28	130	128	36	5	48	1	5	1	0	2	566
7	0	0	7	23	98	36	35	116	42	11	7	11	41	127	67	4	125	36	55	106	54	82	50	180	1312
8	134	62	7	10	12	14	31	24	7	3	59	103	53	65	52	73	68	115	68	89	93	107	106	92	1446
9	175	0	199	248	199	174	178	71	3	12	2	3	13	85	31	15	15	54	56	57	70	85	64	64	1875
10	82	20	27	13	2	2	21	53	16	5	0	2	4	10	6	33	81	145	137	163	145	16	9	21	1011
11	37	23	11	20	22	14	0	14	36	7	3	11	10	7	14	3	4	1	0	1	13	18	2	12	285
12	9	5	3	1	6	21	6	14	6	0	0	1	8	9	7	8	1	0	0	1	0	28	59	58	251
13	31	18	41	52	32	54	16	24	31	19	20	16	6	2	2	9	12	10	5	0	15	36	32	30	513
14	49	9	18	38	46	48	36	26	16	0	1	8	1	7	11	12	10	4	2	12	22	21	27	20	443
15	16	21	24	26	31	25	16	13	6	7	7	5	22	9	3	4	2	1	0	0	10	31	30	10	322
16	26	42	33	20	8	13	16	31	41	97	66	15	29	22	6	1	7	20	15	71	77	27	15	35	732
17	10	21	29	33	22	36	7	21	2	12	3	0	1	0	4	1	0	1	0	0	3	8	3	18	234
18	29	50	15	88	130	150	89	40	51	65	76	6	31	220	258	252	245	253	95	45	83	124	68	77	2538
19	101	74	65	22	20	15	16	0	2	2	3	11	20	20	14	9	2	0	0	0	8	39	44	43	529
20	35	40	47	33	24	27	28	20	7	0	3	7	21	16	16	9	3	6	3	3	10	28	28	30	444
21	48	13	21	20	30	68	27	5	2	1	3	2	11	15	8	4	4	2	2	3	7	39	5	12	355
22	3	19	22	26	26	28	14	30	29	1	0	6	10	5	9	4	1	1	9	43	48	30	4	35	400
23	57	45	14	36	40	24	8	3	0	1	2	12	19	25	10	24	17	8	1	4	39	36	21	38	486
24	46	41	23	0	7	4	11	42	33	1	2	1	8	12	6	17	6	4	14	28	16	37	69	164	593
25	168	159	184	190	148	58	49	133	51	83	95	80	9	105	128	89	83	12	4	5	18	34	33	31	1948
26	31	50	33	15	33	29	46	20	8	1	4	9	11	8	5	21	18	39	19	2	1	19	33	16	470
27	27	56	78	81	221	238	169	123	101	24	6	16	23	20	77	57	1	24	110	172	126	92	73	76	1991
28	50	62	73	62	88	80	58	41	8	18	19	4	10	8	2	2	1	0	5	10	47	68	72	119	907
29	91	95	129	162	137	129	182	116	97	85	13	22	3	22	7	2	0	56	98	77	113	140	128	119	2024
30	122	116	141	103	38	57	17	24	45	10	2	2	10	19	17	13	3	0	0	0	6	40	91	105	983
31	92	90	60	27	25	30	38	38	60	26	3	6	3	17	30	5	2	1	1	0	12	44	50	57	717
KWh	1854	1354	1448	1483	1586	1525	1243	1137	779	543	428	423	485	1017	1035	944	908	870	917	1152	1304	1405	1468	1804	27111

Tarbela **Feb 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	52	67	77	88	62	25	40	20	3	1	0	4	6	18	11	6	2	1	1	1	19	77	87	78	747
2	61	83	56	79	36	29	7	3	22	6	6	5	10	11	6	0	5	51	22	2	8	12	11	38	571
3	45	16	0	25	34	44	130	111	4	10	2	1	1	2	3	1	1	1	10	11	5	13	15	23	508
4	20	49	45	17	14	10	5	2	86	136	89	78	52	72	128	23	24	63	112	92	164	171	124	186	1759
5	152	180	41	49	35	131	115	150	94	147	79	139	170	165	121	174	162	169	159	143	87	31	93	107	2892
6	104	104	163	165	32	1	10	9	9	1	2	2	10	8	8	6	6	5	2	6	8	2	7	13	684
7	15	6	3	4	0	0	0	3	0	4	10	25	29	43	37	13	15	71	69	95	25	0	0	4	473
8	2	7	7	0	0	4	17	8	3	4	11	3	7	6	6	4	0	1	0	0	5	13	12	25	146
9	29	0	53	26	14	1	9	20	9	0	16	45	130	18	5	4	2	4	7	6	0	1	27	39	466
10	56	77	47	18	7	7	17	12	6	1	0	10	16	18	73	135	95	45	45	40	36	23	1	4	789
11	13	28	0	5	2	2	3	1	1	20	8	6	11	13	15	11	6	3	0	0	0	4	36	30	219
12	22	11	3	0	13	38	53	145	98	94	20	35	10	7	15	8	1	4	6	1	0	16	38	21	656
13	12	28	104	40	17	43	52	10	15	2	2	22	85	90	76	66	176	159	20	1	7	32	33	35	1126
14	69	46	64	39	35	68	112	63	83	119	83	20	12	20	19	24	15	15	35	77	18	43	44	40	1165
15	21	20	29	36	39	40	36	7	0	0	1	7	8	15	13	9	6	2	6	2	6	23	37	37	401
16	47	75	90	92	49	15	16	11	2	2	2	6	18	15	11	12	6	4	3	6	24	23	17	6	553
17	18	27	22	19	1	21	13	16	0	0	2	4	31	15	15	7	3	1	0	0	46	92	51	58	461
18	57	51	69	66	44	50	33	18	26	43	36	8	46	195	185	108	97	66	6	1	11	49	82	98	1443
19	81	73	72	48	32	64	50	27	39	47	13	5	27	10	17	15	2	1	25	30	48	51	48	83	905
20	60	74	48	107	88	17	31	34	60	94	97	141	146	134	131	66	64	29	36	52	107	178	185	215	2195
21	173	133	118	44	75	93	104	69	69	2	12	3	8	12	6	10	24	21	11	11	134	49	12	28	1222
22	35	29	32	29	27	31	16	10	14	12	9	8	7	16	14	7	40	73	166	165	69	133	103	30	1074
23	48	66	58	1	7	25	46	44	20	38	17	12	1	7	24	99	89	45	143	161	164	162	126	83	1486
24	65	70	83	71	12	38	79	26	12	7	10	8	8	14	13	15	1	1	0	2	26	80	55	38	735
25	63	85	61	82	48	55	58	17	53	42	5	16	21	16	13	12	9	2	0	0	15	47	88	83	892
26	61	75	105	85	94	74	56	52	30	10	4	5	16	24	9	8	2	5	0	8	17	13	61	70	883
27	87	141	172	211	269	222	216	163	114	44	9	23	14	19	82	64	14	24	119	205	149	109	99	158	2729
28	143	157	161	164	172	140	87	51	32	64	48	6	10	11	7	11	7	0	5	6	5	78	89	157	1611
29	0	109	115	166	233	204	160	27	43	121	67	12	8	6	9	8	1	0	0	4	23	57	79	89	1541
KWh	1614	1851	1862	1721	1413	1427	1514	1119	933	1030	635	655	917	998	1070	924	878	864	1009	1127	1220	1561	1636	1844	29822

Tarbela **Mar 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	83	55	46	56	44	108	109	93	100	83	37	19	5	5	8	8	3	1	1	0	1	38	68	71	1042
2	98	100	70	49	72	33	16	36	73	37	7	8	11	11	3	4	4	0	1	8	44	74	58	44	861
3	59	74	0	246	204	223	160	183	292	350	317	237	145	148	95	71	84	62	138	220	125	138	119	107	3797
4	82	108	183	164	163	146	68	47	103	105	77	52	29	30	14	5	1	12	71	65	70	142	183	260	2182
5	268	245	306	176	177	154	68	98	113	72	30	7	22	15	12	14	8	1	1	3	18	40	60	205	2109
6	203	217	103	110	256	227	106	153	139	61	48	112	46	11	17	48	36	63	72	25	31	81	40	22	2228
7	29	54	97	110	112	56	21	10	28	47	24	10	15	13	19	22	15	3	52	127	160	144	93	57	1316
8	57	38	45	44	39	45	8	1	0	0	1	14	20	8	19	9	8	6	2	18	46	39	113	146	727
9	78	17	145	128	156	211	71	88	62	104	31	4	10	125	105	38	12	6	39	51	54	120	106	108	1867
10	83	103	99	103	80	86	112	98	121	83	37	85	74	53	38	35	14	21	12	5	24	32	61	81	1540
11	60	80	116	91	68	85	36	49	63	91	40	113	153	183	146	116	93	36	41	93	71	134	162	179	2298
12	175	158	104	67	125	141	126	72	54	86	58	44	39	20	11	33	19	22	32	45	19	88	102	93	1732
13	86	132	121	99	94	99	78	24	27	84	32	11	10	8	7	7	4	3	12	10	50	73	89	140	1303
14	114	117	131	194	198	121	55	49	68	84	29	3	7	15	13	10	10	21	75	86	59	124	137	171	1891
15	83	83	123	136	79	103	102	91	80	44	11	3	4	8	10	6	2	0	0	0	8	78	118	107	1280
16	101	92	81	161	139	173	136	23	19	17	4	4	7	4	6	9	5	1	0	5	14	45	56	102	1203
17	104	93	98	86	78	96	111	154	153	155	145	75	36	19	4	3	0	1	10	30	267	430	392	397	2935
18	312	399	453	436	455	421	334	364	135	107	200	175	99	10	43	109	122	9	66	26	40	13	33	35	4395
19	53	116	252	212	138	56	75	34	44	27	18	114	116	131	68	17	1	87	147	91	146	169	151	343	2604
20	358	252	288	224	255	200	173	152	74	165	154	172	185	180	250	260	108	67	112	69	64	53	39	56	3911
21	60	36	86	105	85	64	108	133	132	71	25	102	148	110	166	192	156	112	43	22	14	13	19	4	2006
22	4	33	62	57	50	100	113	106	103	72	49	7	4	10	8	5	6	1	1	0	29	103	168	105	1195
23	115	121	167	166	91	49	87	67	78	39	8	4	17	14	16	24	11	6	11	17	7	52	80	85	1334
24	67	74	64	55	85	97	76	50	45	25	8	5	5	4	5	4	0	28	9	21	47	98	80	92	1042
25	68	51	98	94	173	134	69	60	19	65	30	12	6	3	2	32	33	11	2	6	5	29	20	28	1052
26	25	31	60	58	93	79	113	27	35	17	22	5	12	19	4	3	33	107	83	54	72	40	27	43	1062
27	36	105	88	83	72	34	73	64	49	12	4	8	8	10	6	9	7	15	61	168	215	172	180	159	1638
28	176	194	180	219	196	181	138	208	250	89	24	8	17	17	7	7	11	0	1	19	29	62	56	72	2160
29	86	56	66	75	102	68	68	67	48	40	18	3	2	3	20	29	50	85	64	81	96	107	70	69	1373
30	69	69	48	119	57	51	62	70	60	70	51	12	4	8	10	8	3	1	0	17	54	61	77	176	1157
31	238	281	263	212	183	142	204	66	10	1	2	5	7	12	16	62	68	42	70	149	196	198	211	203	2840
KWh	3433	3585	4042	4138	4118	3784	3077	2735	2575	2301	1542	1431	1263	1206	1146	1196	930	832	1228	1529	2073	2989	3167	3757	58077

Tarbela **Apr 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	252	218	230	259	319	210	209	229	117	56	34	15	21	30	16	7	4	5	3	23	33	89	45	103	2528
2	214	260	235	223	200	154	93	206	211	174	171	192	248	254	127	211	294	335	316	316	217	208	217	176	5253
3	125	96	0	140	118	53	46	94	99	68	59	4	7	17	26	17	5	9	46	102	126	165	165	168	1757
4	64	21	30	31	29	40	65	87	102	39	6	8	7	12	34	24	41	114	91	65	65	22	21	26	1044
5	35	26	37	19	39	33	27	22	29	11	12	1	3	26	92	37	39	19	2	7	17	61	26	25	645
6	29	36	70	41	46	46	52	48	60	0	4	0	1	0	2	65	195	176	51	126	120	137	177	166	1647
7	26	30	64	45	38	75	36	24	46	145	156	160	164	149	146	99	73	31	43	53	66	55	46	51	1821
8	62	112	186	218	218	235	209	282	250	255	143	27	9	20	101	112	51	6	2	1	0	19	34	38	2592
9	34	28	272	249	152	80	115	135	35	98	44	6	12	17	8	25	20	28	2	0	3	29	49	46	1487
10	42	29	55	64	50	35	36	14	10	14	2	4	7	3	3	1	3	1	0	0	18	35	65	68	559
11	88	68	51	53	55	68	94	64	30	5	0	7	3	4	2	9	10	0	1	1	0	10	23	47	694
12	68	66	59	80	66	30	5	3	21	13	2	2	6	5	3	133	137	128	94	120	162	190	174	128	1695
13	132	155	153	74	119	124	129	45	53	22	4	3	2	2	1	1	0	2	0	3	0	11	62	69	1167
14	70	104	97	84	162	134	55	37	58	20	106	70	111	26	35	71	12	10	8	18	81	199	261	304	2131
15	183	167	167	172	164	95	134	349	291	309	230	130	127	127	64	67	109	50	14	57	46	44	72	72	3241
16	51	45	51	94	105	31	5	17	27	4	1	7	9	11	5	5	5	6	0	1	9	60	25	13	589
17	35	54	31	55	60	108	86	13	11	7	3	2	9	6	10	2	1	84	183	191	192	172	193	201	1711
18	207	217	187	147	156	110	70	67	30	38	53	22	8	7	2	2	6	2	1	3	18	64	109	112	1638
19	108	93	116	131	81	73	101	142	93	27	23	8	7	4	0	0	3	124	81	87	132	201	194	209	2038
20	126	96	73	49	67	79	99	183	215	131	13	5	5	2	1	3	7	1	1	12	13	65	65	49	1359
21	54	46	38	61	47	79	78	71	58	6	7	12	6	23	44	96	148	121	192	182	103	146	185	272	2071
22	233	272	223	86	73	109	123	97	80	31	5	2	9	14	7	11	14	3	57	16	136	50	64	109	1826
23	106	244	221	196	191	195	107	83	71	12	3	3	1	4	9	14	5	2	0	8	33	89	201	147	1945
24	114	175	203	104	133	214	180	162	100	32	4	4	4	2	9	11	3	21	120	92	136	148	156	182	2308
25	191	128	97	169	177	179	215	176	133	85	5	0	2	0	1	4	24	5	3	27	159	221	230	145	2374
26	199	178	149	130	101	92	163	196	165	104	26	1	4	2	2	9	25	21	19	23	54	104	255	226	2247
27	272	295	332	360	232	219	240	134	98	29	4	0	0	1	1	1	0	0	0	0	24	84	119	86	2530
28	84	100	119	212	279	166	52	42	78	47	9	0	1	0	2	4	0	0	1	44	50	105	130	119	1645
29	171	239	278	256	274	229	355	374	312	78	4	3	0	0	0	0	0	0	1	23	100	84	166	191	3139
30	143	119	228	217	234	292	299	236	194	55	28	2	1	1	0	1	1	11	2	24	34	115	167	154	2558
KWh	3516	3712	4057	4020	3985	3585	3478	3633	3076	1913	1160	700	792	769	754	1044	1237	1316	1334	1627	2147	2983	3696	3705	58239

Tarbela **May 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	138	102	167	180	176	242	230	236	186	91	12	1	2	1	1	1	0	0	0	0	4	75	122	108	2074
2	123	187	216	249	256	164	169	236	109	24	2	0	0	1	11	5	12	26	34	35	65	135	142	145	2348
3	90	29	0	91	143	261	204	205	276	128	30	9	1	13	62	20	113	167	118	216	236	171	321	367	3270
4	209	121	35	81	228	244	193	195	206	155	131	78	52	10	35	43	71	32	43	80	118	109	105	61	2635
5	9	88	193	201	199	228	208	160	173	66	12	18	56	51	60	91	142	145	134	81	96	135	96	170	2815
6	147	167	134	79	90	144	71	61	76	24	3	3	6	4	3	4	7	3	0	0	12	25	59	104	1224
7	135	184	222	235	268	214	204	123	45	48	3	1	6	2	2	1	2	1	3	3	18	18	62	113	1912
8	139	122	78	147	160	77	114	128	163	105	93	20	6	2	8	19	22	142	81	57	110	159	229	238	2420
9	267	136	249	172	137	101	120	134	72	16	1	1	2	9	46	83	201	163	151	146	71	68	168	189	2702
10	187	112	113	105	118	122	267	280	172	65	32	10	4	7	2	23	132	160	148	138	97	113	147	171	2725
11	160	160	190	199	164	160	168	145	108	39	16	1	2	2	45	33	18	2	3	0	17	55	61	82	1829
12	129	135	151	183	105	54	81	59	22	17	4	0	1	6	6	4	8	141	149	135	195	195	143	151	2076
13	243	201	264	167	215	293	240	207	163	53	29	13	2	3	4	1	2	3	27	169	132	203	243	265	3141
14	223	200	219	235	268	313	281	235	221	57	18	2	5	4	8	5	1	0	0	0	12	88	137	95	2628
15	72	156	184	142	154	189	201	159	111	17	3	7	23	17	7	9	4	52	101	97	148	175	219	216	2463
16	241	209	109	184	279	118	214	205	89	32	5	2	6	7	17	36	17	17	14	4	6	85	122	126	2142
17	113	154	96	160	128	119	140	71	62	52	9	4	6	7	6	5	2	47	71	96	109	138	247	267	2110
18	243	246	194	183	248	224	220	261	240	131	31	9	2	8	7	25	55	150	187	170	170	231	259	274	3769
19	246	95	60	65	106	190	183	179	72	32	2	2	2	40	61	27	6	15	36	165	184	187	140	195	2289
20	87	36	75	159	144	191	157	100	12	9	2	2	6	30	41	20	38	33	29	33	41	69	78	118	1509
21	80	70	91	181	108	121	176	152	75	30	4	4	27	100	82	34	42	51	98	225	310	250	212	143	2666
22	81	132	91	176	185	153	147	142	75	24	3	5	8	7	14	20	21	19	168	393	407	365	341	453	3429
23	472	459	366	286	233	144	132	116	110	80	46	14	1	5	2	40	20	60	83	112	213	213	237	264	3708
24	191	179	94	114	79	146	145	151	147	112	61	12	26	44	61	32	99	32	202	193	249	381	187	120	3057
25	214	286	272	244	101	61	34	11	11	26	67	168	215	139	91	59	132	42	80	114	182	246	166	143	3104
26	126	115	128	112	137	155	156	145	72	38	5	20	27	16	8	5	25	134	134	50	79	64	46	78	1876
27	107	95	57	61	110	193	131	75	76	19	5	4	12	19	43	35	33	214	225	216	219	209	249	326	2734
28	314	149	139	175	201	233	215	182	179	150	34	12	24	21	13	10	4	22	99	211	219	243	254	232	3335
29	170	192	264	257	261	251	248	184	160	52	11	3	8	4	4	3	12	62	54	74	129	160	157	135	2855
30	95	144	169	155	120	158	157	181	64	13	6	1	7	48	50	32	9	52	177	332	338	304	173	183	2969
31	198	217	249	169	122	186	175	196	114	69	8	1	1	3	20	17	10	5	159	199	120	98	172	152	2660
KWh	5250	4882	4869	5149	5244	5449	5377	4914	3661	1774	687	428	545	630	820	743	1261	1991	2806	3744	4307	4966	5294	5684	80475

Tarbela **June 07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	152	149	168	173	177	200	207	217	172	52	10	9	1	10	29	6	3	0	0	38	199	219	200	244	2636
2	304	296	313	329	244	271	114	67	77	16	4	8	9	44	25	18	12	23	210	311	352	335	380	275	4037
3	230	212	0	132	224	214	318	272	231	188	58	50	50	40	34	30	68	95	142	110	88	114	138	159	3197
4	126	86	104	150	154	156	116	150	103	112	113	71	28	29	29	19	12	7	2	4	14	73	140	174	1972
5	160	170	123	153	200	293	264	263	175	89	166	152	147	125	123	56	82	167	259	270	300	279	275	264	4555
6	270	268	223	298	247	139	177	75	137	107	36	3	5	14	51	85	51	24	111	273	320	229	149	250	3542
7	319	294	267	104	67	120	123	118	94	58	16	6	12	8	25	23	41	20	50	168	187	184	256	200	2760
8	133	151	125	107	112	96	25	80	97	84	61	36	34	104	183	139	127	91	99	74	145	171	138	83	2497
9	150	68	116	175	172	181	146	169	93	40	12	2	12	19	41	73	56	17	111	123	83	153	160	115	2290
10	116	116	119	178	240	101	83	41	52	17	6	25	22	27	29	32	11	3	52	34	46	106	154	145	1757
11	132	89	120	178	142	73	67	57	74	17	11	28	22	15	20	13	20	13	19	31	169	137	164	142	1751
12	204	207	197	97	78	105	111	63	23	17	59	41	40	31	32	26	16	9	6	12	111	156	171	177	1990
13	160	163	181	178	159	124	131	151	111	117	34	16	2	34	10	13	15	56	146	81	80	198	188	185	2533
14	198	169	77	47	84	69	74	63	22	21	13	11	43	70	76	40	52	14	6	45	158	183	78	36	1647
15	21	60	73	123	11	5	26	126	94	111	115	93	35	11	9	31	60	60	58	109	159	175	152	79	1795
16	87	38	3	26	18	35	117	131	111	106	114	119	168	172	140	145	123	80	80	50	94	80	72	51	2160
17	41	49	24	28	21	29	17	21	0	0	5	12	13	22	9	29	47	42	41	20	46	76	76	86	754
18	155	161	154	107	180	151	89	123	60	23	8	2	3	35	47	39	66	50	20	36	21	8	49	132	1718
19	74	120	77	55	38	14	30	35	5	1	1	3	8	21	15	38	165	175	174	148	115	10	3	16	1340
20	106	99	156	109	169	216	170	49	20	4	3	5	8	19	12	4	7	2	58	19	0	3	35	9	1282
21	22	28	16	29	55	36	56	88	32	40	5	5	10	26	33	32	13	3	139	131	144	83	196	141	1363
22	90	106	77	61	53	66	76	59	29	9	9	0	3	8	16	34	18	3	0	0	4	23	70	62	879
23	64	116	139	104	55	57	63	57	63	9	4	1	5	6	6	3	19	117	163	155	161	141	64	28	1600
24	58	59	8	24	51	70	112	111	74	19	11	4	13	9	17	23	16	28	23	1	17	7	13	12	783
25	60	70	67	66	64	96	111	77	59	17	0	1	8	35	39	33	13	3	0	0	0	9	23	59	910
26	58	69	72	91	57	88	95	68	126	43	54	17	13	7	12	5	5	3	13	6	9	41	78	50	1078
27	65	171	277	163	218	233	170	110	28	12	5	1	1	1	1	1	3	8	6	18	32	15	33	93	1665
28	182	100	178	178	166	146	156	151	81	6	2	3	3	6	3	15	27	27	12	6	0	1	7	40	1497
29	64	110	112	107	84	83	64	72	53	22	11	1	16	12	12	12	4	0	17	71	114	41	80	52	1214
30	99	73	77	61	69	79	61	35	54	9	35	15	39	64	41	66	80	60	11	15	74	124	101	78	1421
KWh	3901	3867	3644	3629	3607	3548	3371	3100	2347	1368	983	738	773	1025	1121	1081	1234	1199	2030	2358	3240	3375	3643	3439	58622

Tarbela **July 08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	146	178	269	266	287	225	217	17	12	5	1	1	4	6	91	197	90	136	195	196	171	209	250	284	3453
2	190	171	152	172	301	214	129	34	20	3	1	5	20	30	204	53	143	276	103	198	225	340	197	38	3218
3	60	86	0	66	69	71	63	91	77	21	27	0	6	21	102	65	6	2	14	35	244	260	243	244	1873
4	276	224	200	248	303	301	250	71	43	25	124	232	269	238	217	106	79	74	35	7	69	33	14	18	3456
5	23	58	144	116	186	321	336	223	110	57	57	39	21	17	30	22	28	22	50	20	1	11	88	70	2051
6	146	118	188	225	50	100	108	78	71	44	6	2	1	30	36	23	14	9	7	34	57	57	42	6	1455
7	70	143	229	208	127	149	180	141	65	28	11	1	2	8	12	9	14	27	4	1	6	43	119	86	1680
8	118	147	270	189	253	66	127	101	72	64	70	7	1	2	4	19	5	1	162	204	108	114	140	79	2323
9	37	0	121	145	171	100	117	89	32	9	9	3	33	49	51	74	34	5	15	2	6	57	26	14	1199
10	26	17	29	37	2	15	7	40	35	25	24	2	28	43	19	8	12	7	0	0	13	14	5	6	415
11	25	30	43	37	32	66	58	48	55	23	4	3	2	19	25	21	6	1	62	153	204	204	217	160	1498
12	109	69	28	7	37	89	50	13	9	2	6	6	5	12	30	29	14	11	114	165	217	160	102	191	1475
13	179	217	207	193	312	339	232	209	124	66	2	2	0	1	14	13	33	59	41	63	30	192	108	31	2666
14	18	52	189	292	294	216	254	125	128	43	26	4	2	5	6	11	16	20	4	31	54	57	35	5	1885
15	33	79	166	166	151	77	153	100	63	26	4	4	21	22	22	15	8	5	7	25	33	51	109	94	1435
16	63	66	210	80	74	64	166	42	75	47	11	3	20	20	13	10	6	2	0	1	5	3	27	36	1042
17	19	33	40	23	31	62	65	38	22	1	1	5	21	25	21	2	4	14	31	31	17	16	120	196	837
18	203	259	203	153	140	66	46	198	253	163	115	63	24	26	0	27	17	2	1	1	12	35	33	50	2091
19	124	124	41	55	67	75	32	0	1	1	12	7	5	2	6	43	36	43	30	92	121	136	88	185	1326
20	208	193	151	80	61	210	111	42	53	16	13	3	1	1	5	3	24	54	23	36	28	60	50	50	1475
21	41	36	50	98	190	308	306	281	221	160	106	6	3	23	4	7	16	169	105	92	164	81	6	0	2471
22	9	96	44	13	12	17	12	0	2	0	0	1	4	5	2	14	22	68	35	10	7	9	63	27	472
23	110	119	107	76	187	41	243	250	165	36	1	11	2	5	10	16	1	1	4	16	22	44	19	45	1530
24	56	32	58	61	87	31	18	9	2	0	2	2	2	2	1	1	0	0	0	6	6	45	56	65	543
25	51	69	70	95	97	84	100	94	70	58	16	3	2	2	1	1	0	53	187	186	303	313	179	66	2099
26	22	11	20	40	26	72	78	11	9	6	2	2	2	1	1	0	0	0	12	20	31	23	25	82	495
27	20	12	34	65	77	68	73	29	12	2	1	1	8	27	2	1	4	2	13	32	38	84	102	134	841
28	245	79	191	165	125	71	54	41	27	19	47	117	28	19	29	43	41	40	20	7	3	23	42	63	1538
29	51	39	1	31	57	55	55	45	18	3	0	6	5	15	40	47	27	18	1	38	188	242	226	245	1454
30	167	185	189	104	44	20	22	29	42	20	2	21	8	5	2	6	8	3	2	25	33	3	23	24	987
31	103	80	90	61	53	42	26	40	6	1	1	1	1	64	48	5	36	7	14	20	7	2	3	1	711
KWh	2946	3021	3731	3568	3904	3635	3690	2527	1894	973	702	562	552	745	1047	890	744	1132	1291	1746	2421	2920	2757	2595	49994

Tarbela **Aug 06,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	14	8	10	8	8	2	0	0	1	0	2	2	1	1	1	2	5	2	9	20	16	20	20	14	165
2	53	2	43	45	23	21	48	26	8	0	1	0	2	2	2	0	5	12	22	28	14	8	19	5	389
3	11	36	0	27	23	15	2	0	0	7	14	20	24	33	42	31	53	39	32	38	31	16	26	25	544
4	27	21	27	18	5	12	3	36	0	0	3	2	1	12	5	1	1	12	6	1	0	8	3	0	206
5	0	0	0	0	7	5	0	0	0	2	11	5	0	0	0	1	0	3	9	5	10	14	3	0	77
6	0	0	0	1	9	5	3	7	5	0	3	3	2	3	10	7	16	61	161	110	115	78	48	28	677
7	48	17	9	107	74	20	22	8	5	0	0	3	2	1	0	0	0	7	73	148	152	129	150	113	1091
8	107	125	80	70	71	60	89	64	35	17	6	0	0	0	2	6	1	26	76	31	22	101	155	100	1245
9	133	0	89	70	32	15	18	25	38	5	9	6	0	0	1	0	0	11	23	31	177	119	173	145	1119
10	156	137	72	35	136	87	55	2	0	0	0	0	0	0	1	3	13	94	75	42	54	62	83	63	1170
11	52	69	72	83	66	63	62	50	72	22	0	0	0	0	2	3	9	21	2	8	23	21	46	36	784
12	40	60	131	150	69	126	88	71	15	11	0	1	3	2	0	0	7	37	69	69	47	19	21	18	1055
13	11	28	39	42	21	36	50	9	0	0	5	2	5	1	1	5	23	28	44	11	16	31	35	18	462
14	30	120	92	137	84	84	60	28	16	4	0	3	1	23	10	4	26	12	9	25	6	33	33	42	884
15	35	49	39	41	61	59	96	47	7	2	4	5	3	0	0	2	11	40	54	29	91	55	78	114	923
16	55	52	60	156	177	238	177	45	14	9	0	4	2	3	1	4	1	4	3	2	24	27	40	37	1136
17	49	154	178	108	92	137	53	32	22	24	6	16	3	1	5	2	8	1	0	14	18	11	27	58	1017
18	74	89	69	74	80	99	83	55	45	20	6	5	1	6	0	1	1	0	8	83	152	168	179	111	1409
19	102	117	93	113	201	207	153	54	29	11	2	3	3	0	1	0	21	29	13	21	31	48	47	60	1359
20	40	40	58	68	78	76	81	44	38	19	7	2	1	1	2	5	5	18	14	13	26	50	39	46	768
21	58	57	83	96	72	92	100	80	40	31	8	1	5	20	80	38	5	112	182	258	289	285	331	191	2514
22	149	99	113	130	133	53	47	26	6	16	3	0	0	5	1	1	1	0	0	1	13	39	55	69	960
23	87	103	89	46	73	93	89	94	84	37	4	0	0	1	9	25	2	0	1	2	5	47	46	12	950
24	12	42	61	46	36	29	47	33	18	10	0	1	14	9	2	3	0	0	0	5	13	52	83	62	580
25	48	52	51	51	56	71	84	63	36	16	5	2	1	2	1	1	1	0	1	3	26	109	123	169	971
26	115	146	126	106	118	109	110	102	79	48	136	59	23	7	64	20	0	2	63	152	109	85	156	177	2111
27	42	25	40	45	136	130	143	70	50	16	5	5	8	30	145	170	69	59	51	118	107	105	80	63	1713
28	53	61	61	45	43	41	54	56	13	5	1	2	5	1	5	2	0	2	2	9	42	52	57	66	678
29	62	49	55	60	58	71	88	32	23	9	4	1	1	2	1	1	0	3	7	90	131	36	48	72	905
30	35	96	80	107	45	52	45	12	7	6	1	0	1	4	6	1	2	1	24	38	146	114	33	87	943
31	53	107	222	202	187	69	8	4	3	7	9	2	0	0	0	1	5	18	12	0	6	7	14	3	940
KWh	1752	1959	2144	2287	2274	2179	1960	1174	711	354	256	155	113	171	400	341	293	657	1046	1405	1909	1950	2250	2004	29744

Tarbela **Sep 06,07,08,09** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	16	10	22	23	40	40	18	9	3	1	1	3	4	0	0	0	0	0	1	12	28	45	105	146	529
2	123	113	21	71	140	109	82	76	69	21	4	0	0	0	3	2	0	6	0	26	135	137	90	122	1352
3	135	123	0	44	52	70	70	151	159	95	8	1	1	0	0	0	0	0	5	14	18	5	5	1	957
4	13	17	20	27	42	58	65	69	43	30	38	34	54	33	21	14	15	14	27	16	12	45	19	19	743
5	34	43	58	89	96	78	54	15	99	14	7	0	0	0	0	0	0	0	0	0	4	23	37	42	693
6	39	42	60	70	96	96	108	117	116	76	22	0	0	0	0	0	0	2	0	0	7	3	6	5	864
7	5	0	1	2	10	18	25	43	10	13	2	0	0	0	0	0	0	0	0	0	8	23	23	25	207
8	13	22	39	44	83	108	23	13	27	10	0	0	1	0	0	0	0	0	0	11	33	30	45	51	551
9	51	0	64	48	63	70	70	54	96	64	11	1	1	2	1	0	0	0	0	2	17	31	10	17	672
10	20	31	25	27	30	21	18	10	0	0	0	1	1	4	5	0	0	0	0	0	0	0	0	0	191
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	3	9	8	24
14	12	11	7	6	4	6	2	6	3	27	9	0	0	0	0	1	2	1	0	6	7	4	8	21	141
15	24	28	19	16	2	0	1	9	5	0	1	0	0	0	0	0	0	13	43	71	88	67	72	76	537
16	48	50	53	50	38	52	45	62	69	27	19	3	0	0	0	0	0	0	0	0	2	14	9	6	549
17	2	6	4	7	35	42	35	25	20	9	1	0	0	0	0	0	0	0	0	0	2	12	20	26	246
18	16	2	25	31	18	22	27	26	19	10	1	0	0	2	1	0	0	0	0	0	5	24	30	30	290
19	31	53	67	67	58	69	64	56	36	16	1	0	0	0	0	51	54	130	112	116	135	108	95	40	1359
20	32	12	31	66	58	122	84	104	131	146	139	116	82	141	94	16	28	3	2	0	0	9	18	19	1453
21	60	47	28	14	16	51	11	22	40	54	105	108	67	24	5	0	0	3	8	16	32	39	45	65	861
22	133	157	124	104	154	198	162	95	14	1	0	8	4	1	0	0	0	0	0	0	0	1	5	5	1165
23	4	15	14	8	12	10	37	24	43	5	2	0	0	0	0	0	0	0	0	0	18	17	7	6	221
24	14	14	14	9	40	14	0	20	14	13	8	0	0	0	0	0	0	0	0	1	16	16	31	10	236
25	8	19	12	5	15	21	15	44	22	13	5	0	0	0	0	0	0	0	1	5	31	29	26	25	294
26	45	13	25	13	60	69	64	32	39	30	23	0	0	0	0	0	0	3	6	10	12	22	24	23	514
27	21	0	0	0	0	0	2	2	7	6	0	0	0	2	0	0	2	35	4	3	56	65	64	103	373
28	62	40	44	36	13	13	11	38	66	20	15	3	0	1	2	4	0	0	0	0	6	21	42	51	491
29	35	20	34	10	40	23	19	56	48	16	0	0	0	0	0	0	0	0	0	1	26	58	55	47	488
30	58	57	12	1	22	53	89	32	46	16	18	2	0	1	0	0	0	0	11	6	36	22	46	61	588
KWh	1053	944	821	889	1236	1432	1203	1210	1243	733	442	281	216	212	133	91	103	210	220	318	735	874	944	1049	16590

Tarbela **Oct 06,07,08** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	62	66	87	107	121	101	33	42	76	31	5	0	0	0	2	4	0	0	5	44	97	120	105	121	1230
2	116	77	165	186	165	126	170	55	39	7	2	1	0	0	0	0	0	4	15	69	85	68	77	114	1541
3	114	139	0	155	131	141	83	75	62	48	19	1	1	1	0	0	0	3	28	63	102	64	70	88	1389
4	107	179	232	130	44	112	129	131	133	83	20	6	1	0	1	0	0	6	24	57	64	57	76	84	1677
5	83	134	97	65	78	93	115	59	46	60	4	0	1	1	1	0	0	8	27	73	161	251	188	241	1788
6	218	244	235	207	235	157	153	103	75	20	2	0	0	0	0	0	0	5	18	58	92	68	209	227	2328
7	127	142	120	199	232	247	180	143	139	70	167	192	125	17	9	5	11	26	147	120	35	49	60	70	2631
8	77	92	128	192	183	263	118	138	53	14	1	1	0	0	0	0	0	1	2	12	48	97	122	103	1644
9	114	31	162	181	164	138	232	147	91	37	7	2	1	1	1	0	0	0	4	8	61	116	159	110	1768
10	109	161	188	173	277	153	121	124	106	43	5	1	1	2	1	0	0	0	1	25	114	150	148	161	2062
11	102	75	128	120	212	177	91	39	34	36	5	0	4	2	2	0	0	1	6	52	102	114	143	152	1598
12	149	154	136	147	219	207	75	25	21	7	4	0	1	0	0	0	0	0	1	32	68	98	108	100	1553
13	156	286	296	236	220	154	46	86	44	12	11	9	4	1	3	0	0	0	0	27	135	175	181	205	2288
14	175	201	128	89	72	50	49	100	92	84	57	9	4	0	0	0	0	0	10	69	210	231	286	300	2219
15	224	246	201	146	178	201	196	173	100	77	72	18	0	0	3	15	16	12	23	38	67	65	96	104	2274
16	130	176	169	145	131	79	54	59	47	37	9	0	4	2	3	1	0	0	0	23	83	90	98	94	1434
17	69	84	108	134	83	85	103	115	56	54	13	1	2	1	1	0	0	0	2	19	89	99	93	82	1293
18	91	69	69	75	65	44	84	119	59	10	2	3	2	2	1	0	0	0	2	22	87	113	127	145	1190
19	98	86	74	30	23	55	95	111	76	56	5	2	1	1	0	0	54	172	145	201	250	184	131	125	1977
20	56	32	58	53	22	22	78	58	89	54	10	8	8	5	0	1	0	0	7	18	51	78	74	82	863
21	88	93	100	142	153	120	66	36	23	8	1	1	1	1	1	1	0	0	0	3	50	48	57	91	1084
22	84	77	44	6	31	62	59	31	59	27	7	0	1	1	4	1	0	0	0	6	65	108	112	100	887
23	124	111	110	91	53	24	37	33	44	32	5	7	1	2	3	1	0	0	1	6	47	66	64	52	914
24	63	53	43	56	22	4	28	34	50	31	13	0	8	1	0	0	0	0	1	17	43	55	47	64	631
25	64	71	81	88	81	79	72	1	1	5	0	0	0	0	1	0	0	0	0	0	26	57	45	32	705
26	9	16	81	92	24	33	21	14	25	36	16	1	4	1	2	1	0	0	140	144	179	162	181	175	1358
27	218	219	217	149	130	67	57	69	60	49	6	1	4	5	3	1	0	0	3	25	24	21	47	57	1431
28	50	67	82	47	49	19	23	29	48	11	10	16	3	2	5	5	7	16	19	26	40	46	44	65	729
29	63	51	34	57	8	4	32	37	33	4	1	0	0	0	0	0	0	0	0	7	53	99	179	161	824
30	183	125	143	177	144	56	31	67	33	34	3	1	1	1	3	0	0	1	0	10	29	24	41	70	1178
31	98	68	73	89	49	34	58	59	24	12	0	0	2	3	4	3	0	3	3	20	41	50	62	70	829
KWh	3422	3625	3788	3764	3596	3107	2689	2315	1839	1090	484	282	187	56	55	39	88	259	633	1294	2599	3027	3430	3646	45316

Tarbela **Nov 06,07,08** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	74	64	65	71	56	21	35	19	16	32	20	1	3	2	1	2	0	0	1	35	67	84	99	85	853
2	116	86	135	148	148	74	5	7	1	6	7	5	3	2	3	1	0	0	0	1	49	76	64	57	996
3	47	50	0	71	50	8	1	13	6	5	5	3	5	3	3	2	2	2	0	19	53	53	51	52	505
4	42	81	33	52	18	5	5	17	1	0	0	1	3	1	9	1	3	1	0	4	53	65	61	64	519
5	51	60	60	63	31	30	16	4	7	15	2	0	3	1	0	0	0	0	1	56	76	64	88	85	714
6	59	36	28	7	0	2	4	20	10	22	2	1	0	0	0	0	0	0	0	20	56	56	59	59	442
7	59	31	10	19	5	0	0	5	6	11	3	1	4	1	1	1	0	0	3	15	15	36	30	44	300
8	41	41	28	38	16	1	6	13	10	5	2	0	1	1	3	0	0	0	2	27	44	51	63	67	463
9	67	0	7	7	27	3	19	23	6	4	0	0	1	1	1	0	0	0	0	19	48	44	38	44	358
10	40	3	28	55	39	1	0	4	18	12	129	130	59	18	9	32	41	13	30	31	37	44	24	22	821
11	36	49	46	40	17	24	3	6	19	6	19	13	5	1	0	0	0	0	0	14	38	41	20	6	5	408
12	3	17	34	38	21	8	0	0	15	22	3	0	0	0	0	11	3	0	20	22	15	15	21	49	316
13	22	4	125	126	161	70	81	107	159	105	195	162	109	51	135	195	81	108	108	44	17	127	48	140	2480
14	160	148	128	9	24	1	1	5	1	0	5	3	5	2	0	0	0	0	0	0	0	0	0	0	493
15	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	0	1	7
16	1	39	44	37	50	44	55	33	33	44	2	3	3	1	1	1	0	0	0	0	0	3	7	19	420
17	51	41	97	148	145	145	145	128	98	33	3	0	0	3	0	0	1	1	3	1	0	9	24	18	1094
18	42	38	28	6	1	0	2	12	0	12	3	0	0	1	0	0	0	0	2	22	18	29	12	27	253
19	26	22	2	9	31	4	8	11	7	6	0	0	0	0	0	0	0	0	1	62	75	8	3	11	285
20	122	25	12	28	112	89	46	6	4	0	1	1	1	1	1	0	0	0	0	8	22	36	48	19	582
21	21	44	8	4	8	57	81	5	0	0	0	2	1	0	0	0	0	0	0	3	3	22	22	28	311
22	26	38	35	12	1	0	0	0	5	0	0	8	1	2	7	0	0	0	1	17	15	34	50	75	329
23	53	62	68	67	28	28	4	2	2	0	0	1	3	2	2	1	1	0	0	9	29	60	42	58	523
24	69	47	66	24	32	49	43	31	3	2	0	1	2	6	2	0	0	0	0	30	53	34	30	21	547
25	51	70	62	45	9	26	52	73	25	1	0	0	1	2	1	0	0	0	0	29	42	52	46	44	632
26	64	60	54	30	28	32	18	29	2	0	0	0	0	3	3	1	0	0	4	41	65	72	30	36	571
27	39	41	48	14	5	3	23	28	9	3	1	0	1	1	1	1	0	4	3	15	26	46	30	30	372
28	18	36	38	9	22	20	27	29	6	0	0	0	2	9	4	0	4	0	0	0	8	18	35	53	338
29	72	54	48	48	37	17	24	16	56	43	20	4	1	1	0	0	36	4	7	17	22	117	34	55	734
30	53	62	86	130	125	93	97	64	17	28	32	52	47	90	122	120	106	136	102	87	86	136	112	77	2058
KWh	1526	1352	1424	1354	1244	855	801	708	542	419	455	394	264	212	310	369	279	271	304	674	1033	1409	1177	1345	18722

Tarbela **Dec 06,07,08** **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	15	16	17	18	19	20	21	22	23	24 Hrs
1	78	68	53	42	41	24	13	43	34	3	13	0	7	1	2	0	0	0	0	32	37	44	57	65	659
2	79	99	79	43	12	49	7	12	6	0	6	0	4	9	9	3	1	4	1	22	52	50	42	43	634
3	67	70	0	61	61	20	33	19	21	1	9	99	25	4	37	133	103	8	50	159	190	67	103	121	1459
4	122	88	104	99	72	61	136	166	130	64	18	0	24	90	89	52	95	36	14	61	149	137	104	144	2058
5	164	236	194	132	116	164	164	173	151	143	127	113	127	122	122	95	70	24	61	77	28	33	83	79	2800
6	118	119	82	66	40	41	41	42	5	11	2	1	1	1	1	1	0	0	8	28	23	40	40	58	768
7	78	29	34	48	35	41	35	19	5	10	1	5	1	1	2	24	7	0	12	61	46	34	31	49	606
8	135	154	127	184	154	183	170	59	69	139	10	38	74	100	134	13	2	16	26	86	139	99	29	31	2170
9	27	2	32	28	41	29	1	8	6	1	1	6	20	26	15	40	70	72	65	105	173	188	157	149	1260
10	127	149	170	190	172	94	61	143	98	43	67	32	18	113	120	183	155	168	115	114	119	103	73	83	2710
11	54	46	48	50	36	21	14	15	1	0	3	4	2	2	0	0	0	0	0	30	37	58	157	172	749
12	106	36	45	46	35	40	42	20	11	0	2	23	14	3	1	0	0	1	3	20	16	14	13	42	532
13	49	33	35	52	67	39	47	101	49	10	0	0	2	9	5	10	38	5	19	22	19	22	66	51	749
14	51	62	114	71	64	63	97	112	111	52	0	1	6	6	5	1	0	0	0	0	12	19	27	33	907
15	25	17	29	52	28	3	3	11	19	15	17	3	14	10	3	2	0	0	3	28	8	22	41	38	392
16	38	33	22	95	44	25	22	0	3	2	1	0	2	2	2	1	0	11	7	23	34	61	58	49	536
17	55	53	73	102	77	43	167	153	156	169	136	120	131	137	137	129	139	121	128	163	139	133	134	93	2887
18	109	133	118	92	47	119	74	9	3	23	2	0	4	49	30	12	4	2	4	10	1	0	0	12	855
19	18	0	0	7	1	14	31	4	0	0	1	0	5	0	36	80	23	14	4	1	21	8	5	3	278
20	12	25	27	55	46	34	150	190	125	116	118	128	145	121	111	64	52	62	25	11	8	24	17	17	1683
21	14	0	0	6	3	5	2	3	0	2	1	2	10	12	2	2	2	0	0	1	0	0	0	6	76
22	27	5	6	21	6	2	1	0	0	0	1	7	13	9	13	3	1	2	2	0	0	14	38	41	212
23	25	43	105	136	92	3	6	10	42	1	0	4	1	3	5	5	0	0	0	6	19	25	30	44	608
24	74	61	56	97	63	15	1	1	1	3	3	0	1	3	1	5	1	1	9	2	19	58	56	31	560
25	25	46	19	6	10	31	15	9	6	1	0	6	13	9	24	25	4	0	0	19	46	45	19	26	404
26	34	52	57	34	13	1	23	18	12	1	0	1	1	5	7	1	1	0	0	18	48	44	44	62	477
27	51	64	69	87	49	10	2	0	0	1	0	3	19	7	6	2	1	0	13	14	36	48	69	97	647
28	71	48	62	75	50	25	19	0	10	2	0	1	12	11	9	2	1	0	9	40	55	66	66	101	733
29	105	108	49	19	47	14	3	10	28	12	3	1	2	6	4	1	1	0	0	2	29	83	105	108	739
30	137	102	87	74	73	50	42	42	27	2	1	0	5	9	8	7	0	0	1	21	47	95	88	115	1033
31	81	68	95	96	57	68	50	56	24	7	0	1	3	6	7	2	2	0	0	1	35	68	64	86	876
KWh	2152	2049	1993	2164	1651	1330	1471	1449	1155	834	545	603	706	886	946	899	772	548	579	1179	1583	1702	1816	2049	31058