PAKISTAN METEOROLOGICAL DEPARTMENT

A STUDY OF
WIND POWER POTENTIAL AT
Warsak-NWFP

Technical Report No. PMD-17/2008
(Preliminary Report based on 18 months data)
January-2009

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 *18 months* wind data has been presented along with the wind generated electric power at Warsak, NWFP. Wind data with one minute and 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 2.57 m/s during eighteen months *March-2007 to September-2008* the highest of 4.40 is observed in February. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the Day through-out the whole period. Wind frequency distribution shows that during 13% 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 average power density of Warsak at 50m is ***56.29*** w/m^2 according to international wind classification, this power density categorize Warsak 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 from a single 600KW wind turbine come out to 206,556 KWh which shows the capacity factor of 4% for Warsak. 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 Warsak and surrounding areas can be classified as no 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 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 Map-1. The list of stations is given below:

Warsak, Bahrain, Kalam, Khawazakhaila, Malamjabba, Tahash, Khungipayan, Dir, Tarbella, 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, Lempiapatian, Dargai.

Warsak is situated in district Peshawar. Latitude & Longitude of Warsak is:
Lat = 34.10°, Long = 71.39°, Elevation = 1088 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 both level, 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 far as possible away from the local obstruction to the wind
- Selected location should be representative of the majority of the site.

Since sating 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 visit site 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 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
$\mathbf{Z_o}$ 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.

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

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

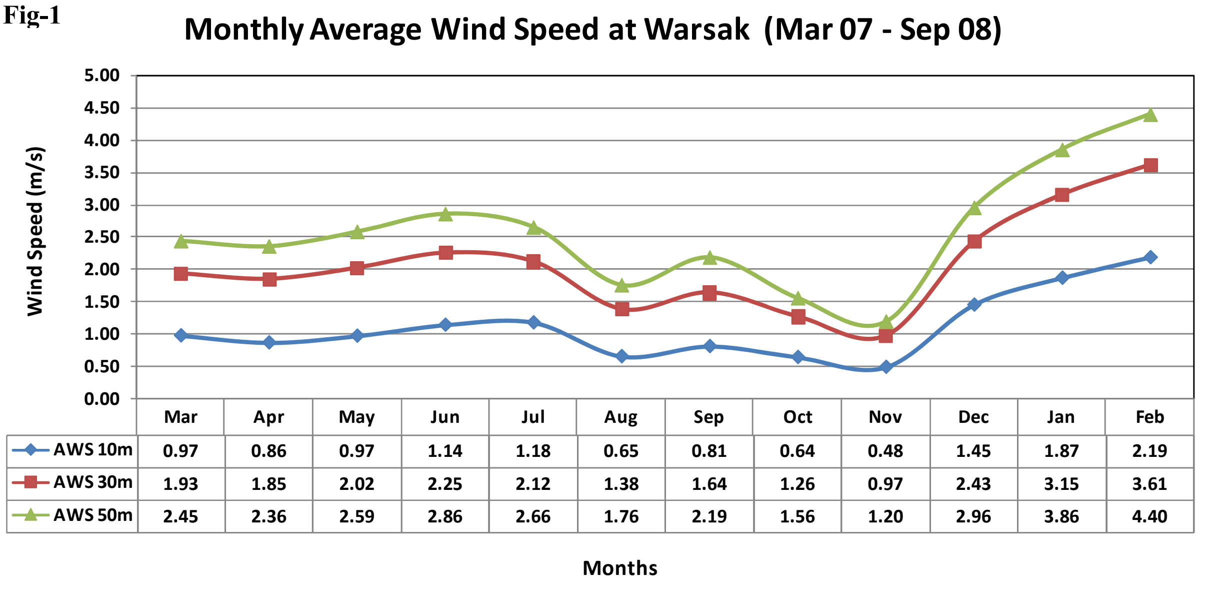
Type of terrain	Z_0	α
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 to 2	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 monthly average wind speed at height of 10 meters, 30 meters and 50 meters. At 30 meters height, we have the annual average wind speed of 2.1 m/s from Mar-07 to Sep-08 where as maximum average wind speed of 3.61 m/s at this height is during February. At 50 meters we have the annual average wind speed of 2.57 m/s from Mar-07 to Sep-08.

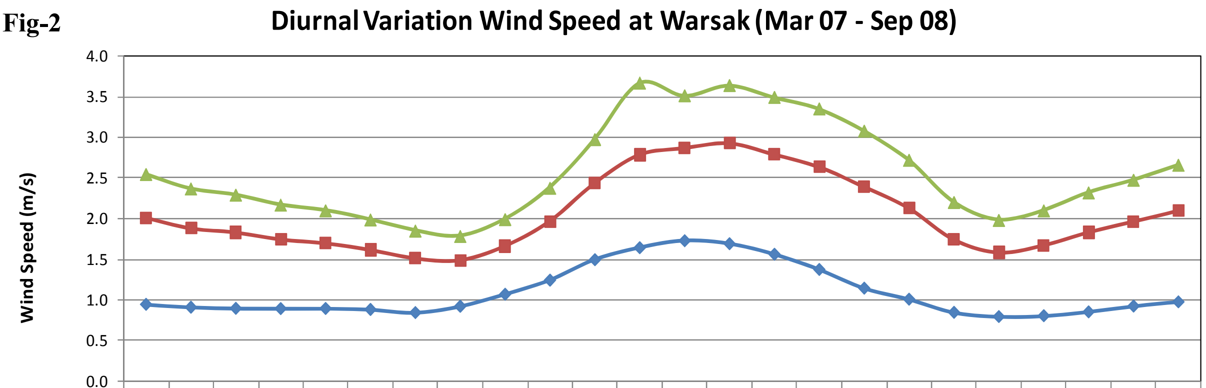
Fig-1



3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Warsak for 18months (Mar-07 to Sep-08). The wind speed is generally high during day and it starts picking up and reaches maximum around 11 a.m. which is around 2.8 m/s and 3.7 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 3.7 m/s at 11 a.m.

Fig-2

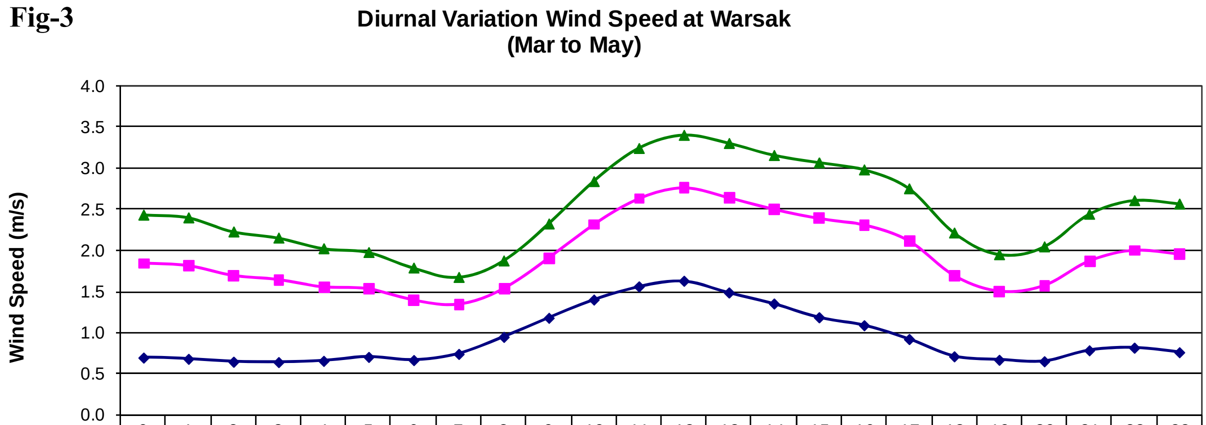


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.1	1.2	1.5	1.6	1.7	1.7	1.6	1.4	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0
WS 30m	2.0	1.9	1.8	1.7	1.7	1.6	1.5	1.5	1.7	2.0	2.4	2.8	2.9	2.9	2.8	2.6	2.4	2.1	1.7	1.6	1.7	1.8	2.0	2.1
WS 50m	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.8	2.0	2.4	3.0	3.7	3.5	3.6	3.5	3.4	3.1	2.7	2.2	2.0	2.1	2.3	2.5	2.7

PST (Hours)

Fig-3, Fig-4, Fig-5 and Fig-6 shows the *seasonal diurnal wind speed variations* at Warsak for (Mar-May), (Jun-Aug), (Sep-Nov) and (Dec-Feb) respectively.

Fig-3

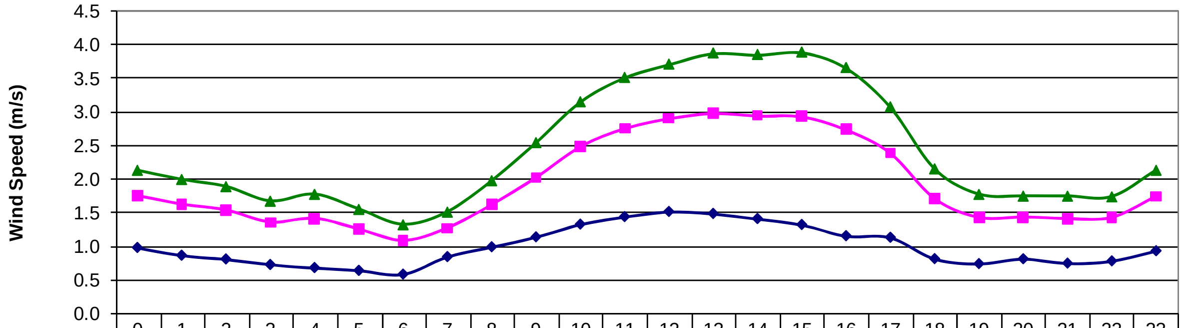


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.7	0.7	0.6	0.6	0.7	0.7	0.7	0.7	0.9	1.2	1.4	1.6	1.6	1.5	1.3	1.2	1.1	0.9	0.7	0.7	0.6	0.8	0.8	0.8
WS 30m	1.8	1.8	1.7	1.6	1.6	1.5	1.4	1.3	1.5	1.9	2.3	2.6	2.8	2.6	2.5	2.4	2.3	2.1	1.7	1.5	1.6	1.9	2.0	1.9
WS 50m	2.4	2.4	2.2	2.1	2.0	2.0	1.8	1.7	1.9	2.3	2.8	3.2	3.4	3.3	3.2	3.1	3.0	2.7	2.2	1.9	2.0	2.4	2.6	2.6

PST (Hours)

Fig-4

Diurnal Variation Wind Speed at Warsak (Jun to Aug)

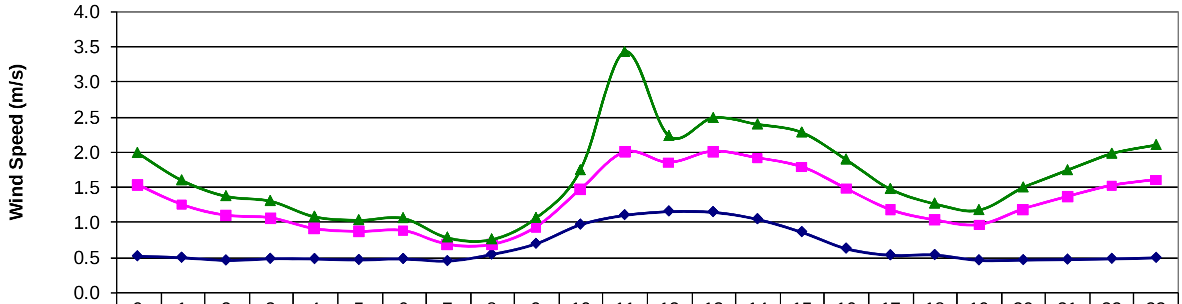


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.8	1.0	1.1	1.3	1.4	1.5	1.5	1.4	1.3	1.1	1.1	0.8	0.7	0.8	0.7	0.8	0.9
WS 30m	1.7	1.6	1.5	1.3	1.4	1.2	1.1	1.3	1.6	2.0	2.5	2.7	2.9	3.0	2.9	2.9	2.7	2.4	1.7	1.4	1.4	1.4	1.4	1.7
WS 50m	2.1	2.0	1.9	1.7	1.8	1.5	1.3	1.5	2.0	2.5	3.1	3.5	3.7	3.9	3.8	3.9	3.7	3.1	2.1	1.8	1.7	1.7	1.7	2.1

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Warsak (Sep to Nov)

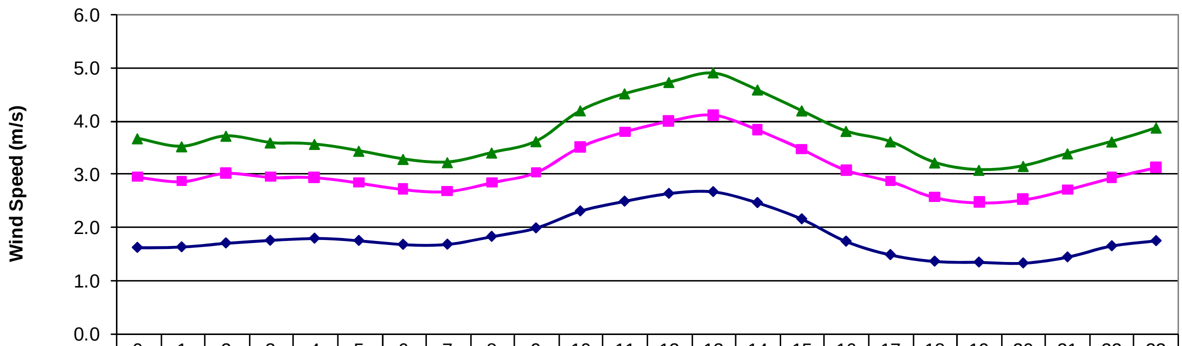


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	1.0	1.1	1.2	1.1	1.0	0.9	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
WS 30m	1.5	1.2	1.1	1.1	0.9	0.9	0.9	0.7	0.7	0.9	1.5	2.0	1.8	2.0	1.9	1.8	1.5	1.2	1.0	1.0	1.2	1.4	1.5	1.6
WS 50m	2.0	1.6	1.4	1.3	1.1	1.0	1.1	0.8	0.8	1.1	1.7	3.4	2.2	2.5	2.4	2.3	1.9	1.5	1.3	1.2	1.5	1.7	2.0	2.1

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Warsak (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	1.6	1.6	1.7	1.8	1.8	1.7	1.7	1.7	1.8	2.0	2.3	2.5	2.6	2.7	2.5	2.2	1.7	1.5	1.4	1.3	1.3	1.4	1.6	1.7
WS 30m	2.9	2.9	3.0	2.9	2.9	2.8	2.7	2.7	2.8	3.0	3.5	3.8	4.0	4.1	3.8	3.5	3.1	2.9	2.6	2.5	2.5	2.7	2.9	3.1
WS 50m	3.7	3.5	3.7	3.6	3.6	3.4	3.3	3.2	3.4	3.6	4.2	4.5	4.7	4.9	4.6	4.2	3.8	3.6	3.2	3.1	3.1	3.4	3.6	3.9

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

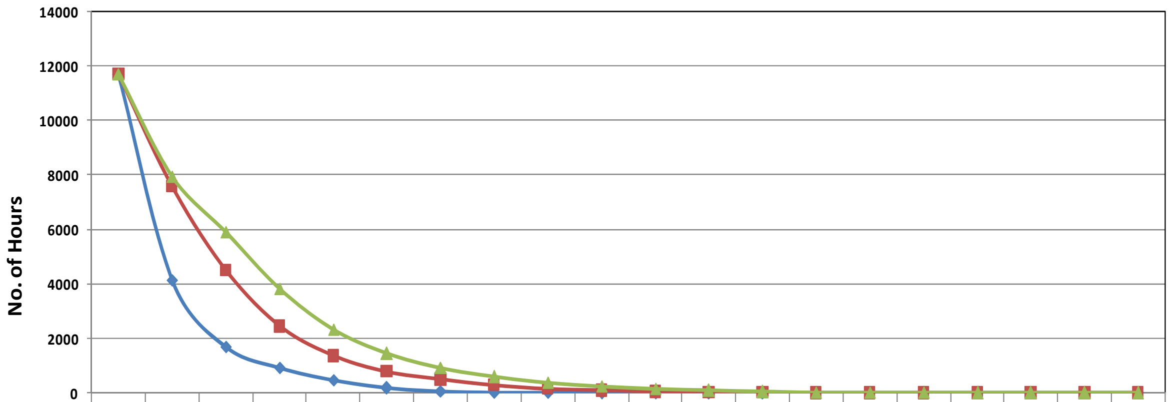
R .F = probability P (V_i) = Frequency of given wind speed / Total period

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Cumulative Wind Frequency distribution from March 2007 to September 2008 at three heights 10, 30 and 50 meters. The analysis indicate that at a height of 30 meters during 1371 hours the wind speed is greater than or equal to 5 m/s. Whereas at 50 meters, during 2351 hours the wind speed is equal or greater than 5m/s.

Fig-7

Cumulative Wind Speed Distribution at Warsak (Mar 07 to Sep 08)



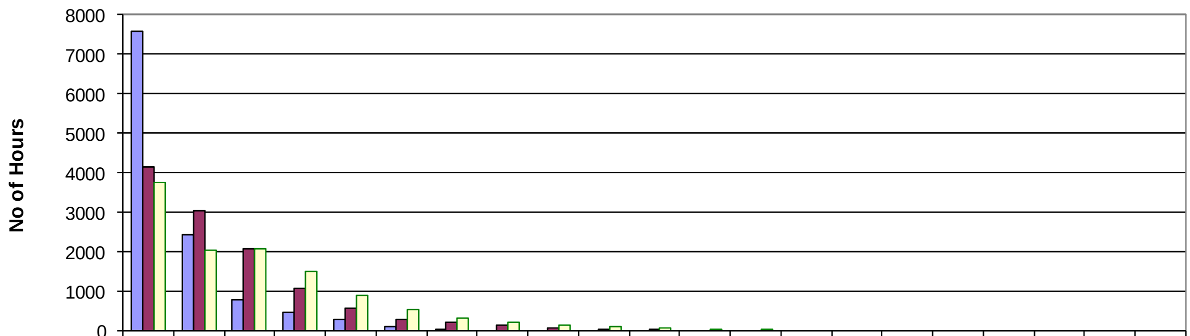
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	11700	4140	1699	930	479	187	77	32	15	5	2	1	1	0	0	0	0	0	0	0
CWS 30m	11700	7574	4522	2455	1371	787	507	308	170	94	52	30	17	12	5	2	1	1	1	0
CWS 50m	11700	7966	5916	3840	2351	1460	926	600	388	254	158	96	60	35	23	15	10	5	2	1

Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the frequency distribution. We can see that at 50 meters during 891 hours wind speed is 5 m/s, 534 hours speed is 6 m/s, 325 hours speed is 7 m/s, 212 hours speed is 8 m/s and during 134 hours the wind speed is 9m/s and so on. This indicates wind potential in this area.

Fig-8 **Wind Frequency Distribution at Warsak (Mar 07 - Sep 08)**

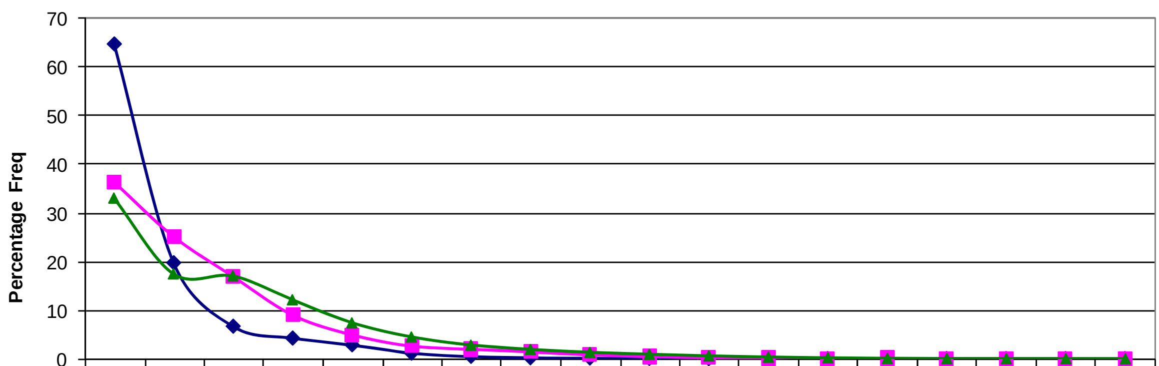


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	7560	2441	768	451	292	110	44	17	10	3	1	1	0	0	0	0	0	0	0	0	0
CWS 30m	4126	3052	2067	1085	584	280	199	138	76	42	22	13	6	7	3	1	0	0	0	0	0
CWS 50m	3734	2050	2076	1490	891	534	325	212	134	96	62	36	25	12	8	5	5	3	1	1	1

Wind Speed (m/s)

Fig-9 gives this frequency distribution in percentage from Mar-2007 to September-2008. At 50 meters we find that during 7.4% of time wind is 5m/s, 4.5% of the time 6m/s and 2.8% of the time it is 7m/s. whereas at 30 meters height we get 4.9% of the time wind speed 5m/s, 2.6% of the times 6m/s and 2.0% of the time 7m/s.

Fig-9 **Percenatge Wind Frequency Distribution at Warsak (Mar 07 to Sep 08)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	64.7	19.7	6.6	4.2	2.8	1.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	36.3	25.1	16.9	9.0	4.9	2.6	2.0	1.4	0.8	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
WS 50m	32.8	17.4	17.0	12.1	7.4	4.5	2.8	2.0	1.3	1.0	0.6	0.4	0.3	0.1	0.1	0.1	0.1	0.0

Wind Speed (m/s)

3.4.5 *Seasonal Wind Frequency Distribution:*

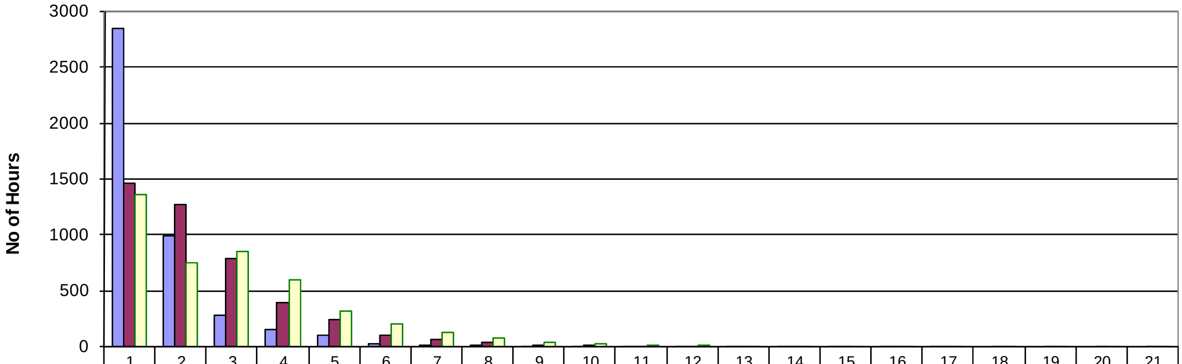
Figures 10–17 gives seasonal wind frequency distribution and percentage wind frequency distribution.

March - May

Fig-10 shows frequency distribution during the months of March to May. We can see that in this period at 30 meters and 50 meters height during 246 hours and 323 hours we get 5m/s respectively.

Fig-10

Wind Frequency Distribution at Warsak (Mar-May)



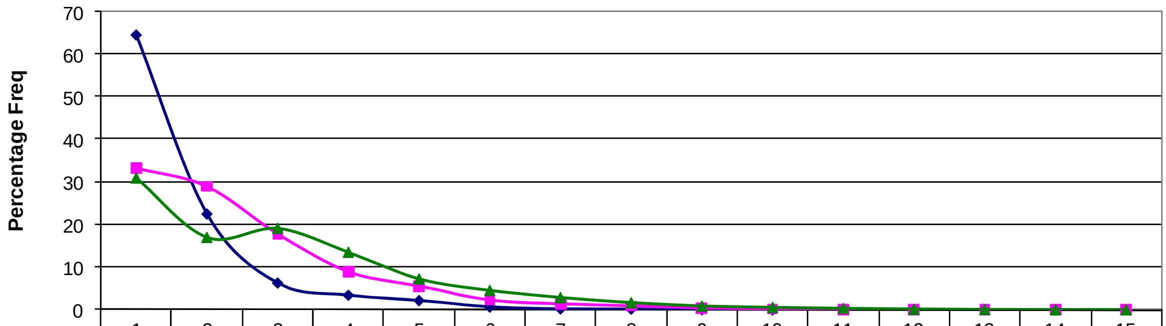
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2843	993	278	151	96	30	10	8	2	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1465	1274	785	394	246	102	62	42	19	10	5	5	3	2	1	0	0	0	0	0	0
WS 50m	1366	753	847	599	323	204	130	77	41	28	18	9	7	3	3	2	1	1	0	0	1

Wind Speed (m/s)

Similarly in Fig-11 shows percentage frequency distribution. At 50 meters we get 7.3% of time wind speed is equal to 5m/s, 4.5% of time wind equal to 6 m/s and at 30 meter 5.6% wind equal to 5m/s, 2.3% wind equal to 6 m/s respectively.

Fig-11

Percentage Wind Frequency Distribution at Warsak (Mar-May)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	64.4	22.5	6.3	3.4	2.2	0.7	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	33.2	28.9	17.8	8.9	5.6	2.3	1.4	1.0	0.4	0.2	0.1	0.1	0.1	0.0	0.0
WS 50m	31.0	17.1	19.2	13.6	7.3	4.6	2.9	1.8	0.9	0.6	0.4	0.2	0.1	0.1	0.1

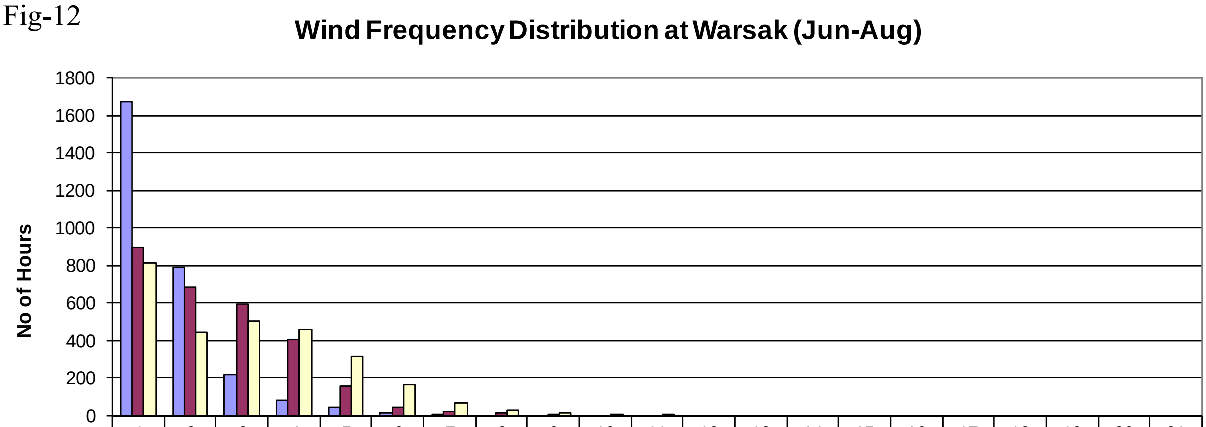
Wind Speed (m/s)

June - August

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 157 hours we get 5m/s, similarly at 50 meters height during 320 hours we get wind speed of 5m/s.

Fig-13 shows percentage distribution of wind frequency during the months of June to August. It shows that 5.2% and 10.5% we get wind speed of 5m/s at 30m and 50m respectively.

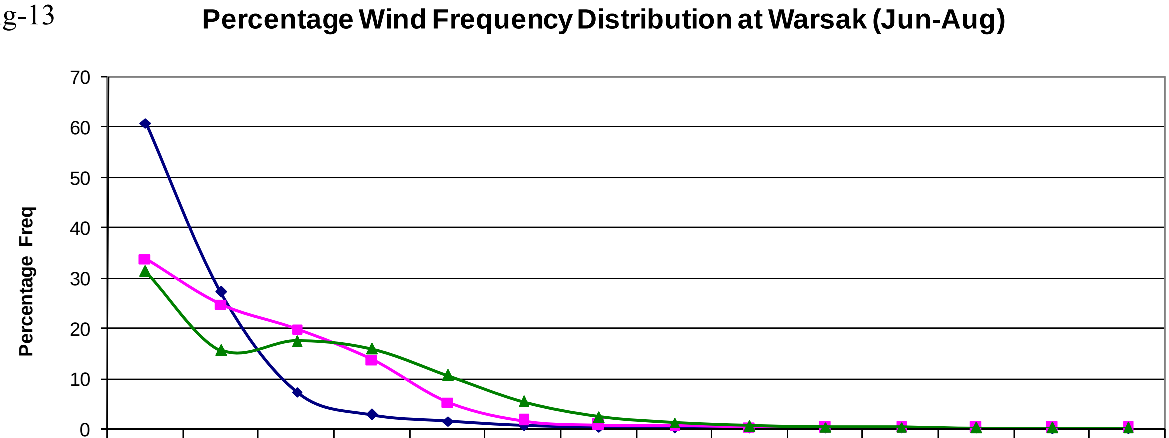
Fig-12



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	1670	788	222	85	43	16	8	3	2	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	896	685	593	409	157	46	23	14	7	3	2	3	0	0	0	0	0	0	0	0	0
WS 50m	813	448	501	460	320	164	69	31	13	7	5	3	3	2	1	0	0	0	0	0	0

Wind Speed (m/s)

Fig-13



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	60.7	27.1	7.2	2.7	1.4	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	33.6	24.6	19.8	13.6	5.2	1.5	0.7	0.5	0.2	0.1	0.1	0.1	0.0	0.0
WS 50m	31.1	15.5	17.3	15.7	10.5	5.3	2.2	1.1	0.4	0.3	0.2	0.1	0.1	0.1

Wind Speed (m/s)

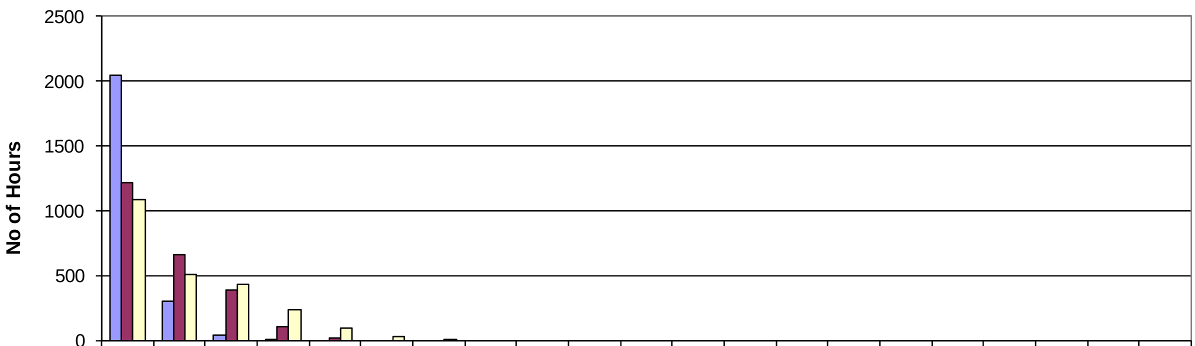
September - November

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 24 hours we get 5m/s, similarly at 50 meters height during 95 hours we get wind speed of 5m/s.

Fig-15 shows percentage distribution of wind frequency during the months of Sep to Nov. It shows that 1.0% and 4.1% we get wind speed of 5m/s at 30m and 50m respectively.

Fig-14

Wind Frequency Distribution at Warsak (Sep-Nov)

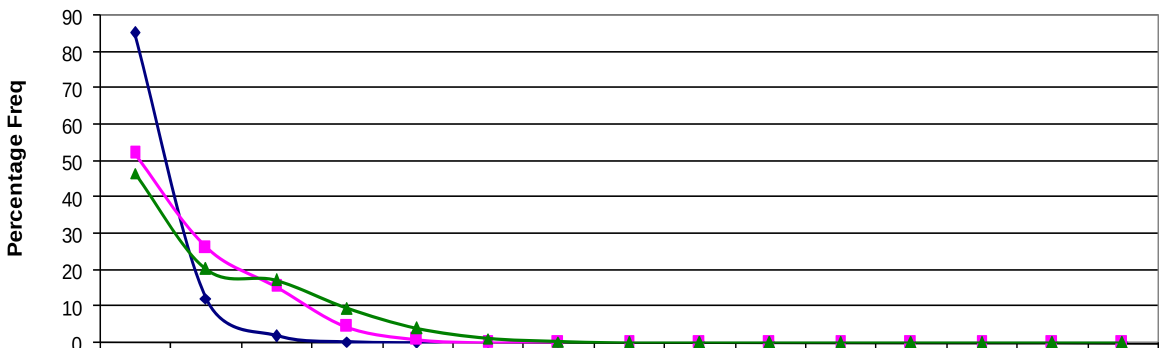


Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2047	309	45	8	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1222	663	392	105	24	3	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
WS 50m	1089	506	439	235	95	30	10	4	2	1	1	1	0	0	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-15

Percentage Wind Frequency Distribution at Warsak (Sep-Nov)



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	85.3	12.2	2.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	52.3	26.3	15.7	4.6	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	46.8	20.4	17.4	9.5	4.1	1.2	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

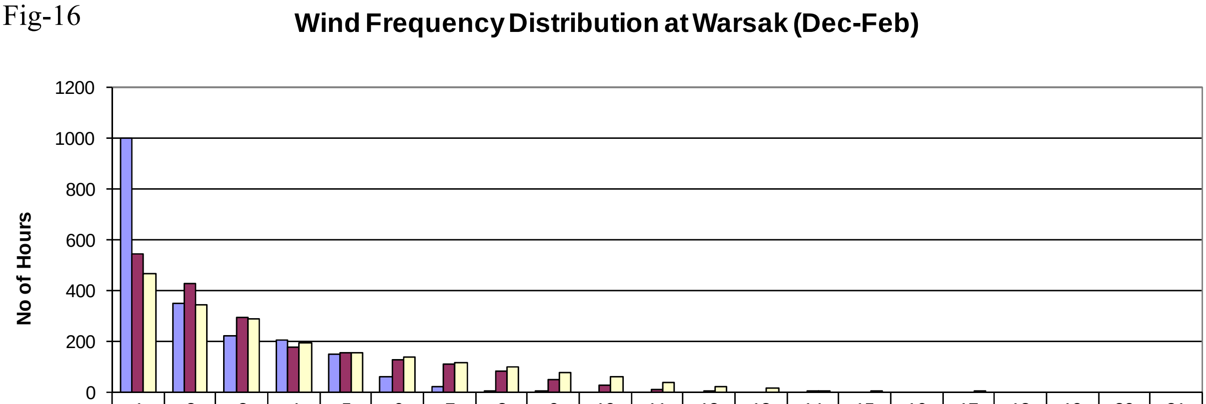
Wind Speed (m/s)

December – February

Fig-16 shows wind frequency distribution during the months of Dec to Feb. We can see that in this period at 30 meters height during 157 hours we get 5m/s, similarly at 50 meters height during 154 hours we get wind speed of 5m/s.

Fig-17 shows percentage distribution of wind frequency during the months of Dec to Feb. It shows that 8.0% and 7.7% we get wind speed of 5m/s at 30m and 50m respectively.

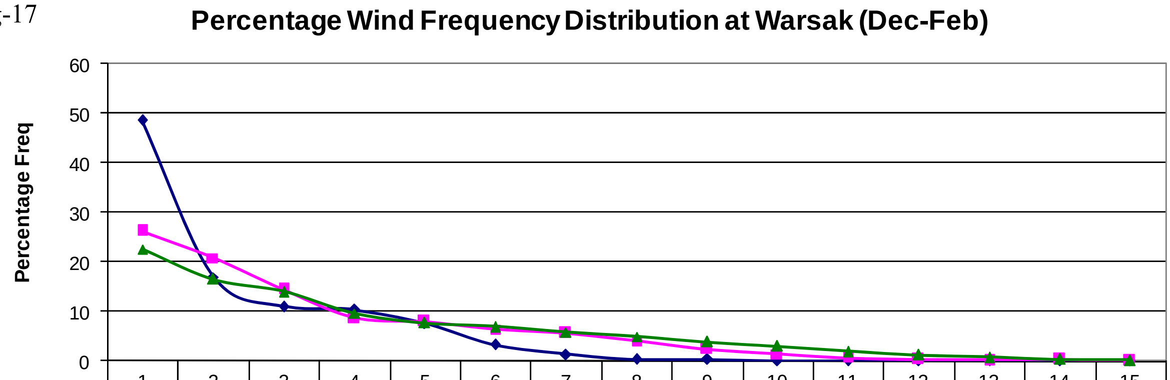
Fig-16



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	1000	351	222	207	152	64	25	6	6	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	544	430	297	177	157	129	113	81	49	28	14	5	3	5	2	0	0	0	0	0	0
WS 50m	466	344	288	196	154	136	116	100	78	59	38	24	15	7	3	3	4	2	0	0	0

Wind Speed (m/s)

Fig-17



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	48.6	17.0	11.1	10.4	7.6	3.3	1.3	0.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	26.3	20.8	14.5	8.8	8.0	6.5	5.6	4.1	2.5	1.4	0.7	0.3	0.2	0.3	0.1
WS 50m	22.6	16.5	14.0	9.6	7.7	7.0	5.8	5.0	3.9	3.0	1.9	1.2	0.8	0.3	0.2

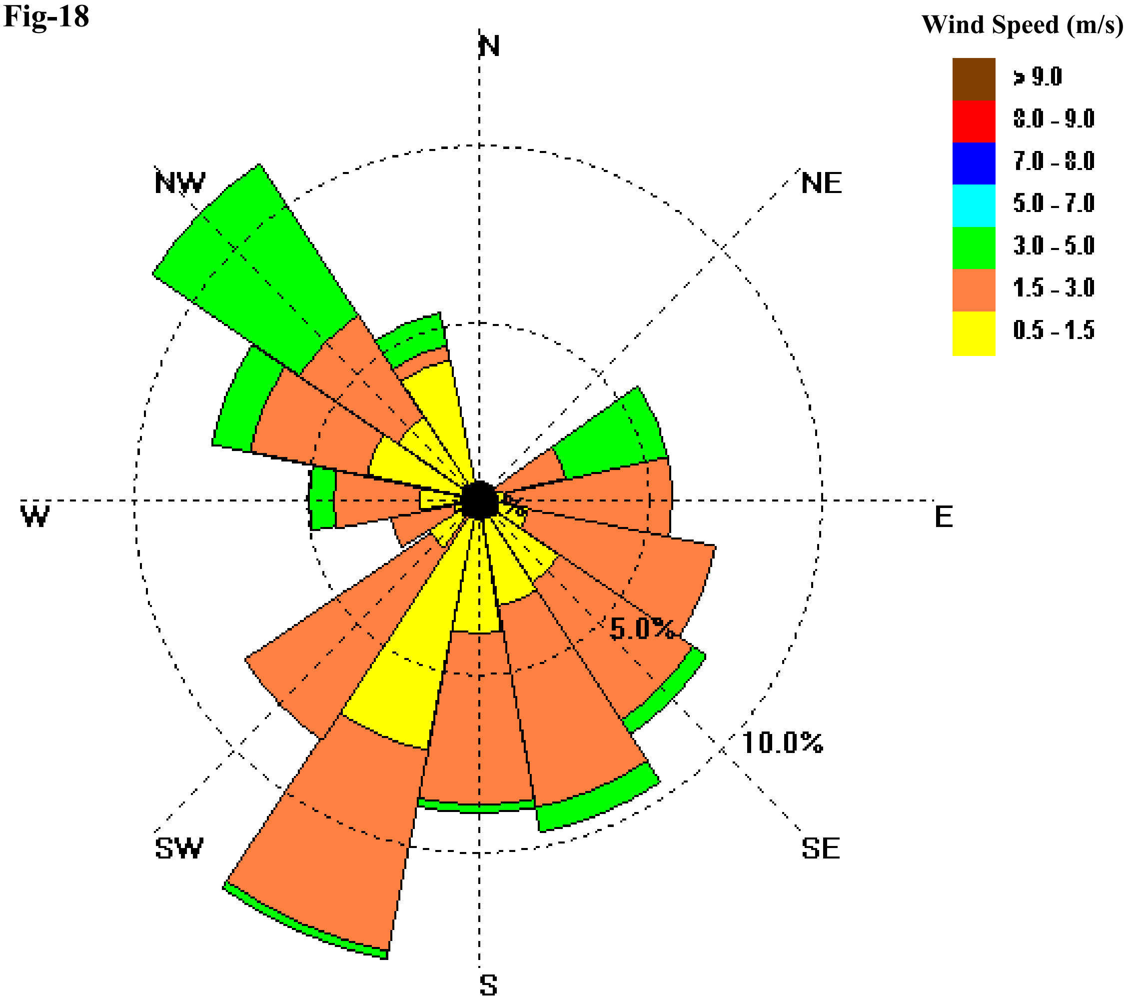
Wind Speed (m/s)

3.5 Wind Rose

Fig-18 shows the Wind Rose based on 18 months of data from March-2007 to September-2008 collected at 30 meters height. Wind Rose indicates that wind direction is distributed between South, South-West and North-West. The average wind speed at 30 meter height is 2.1m/s and the percentage when wind speed greater than 5m/s is 8%.

Wind Rose at Warsak (30m height)

Fig-18



Average Wind Speed	Wind greater than 5 m/s
2.1 m/s	8%

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

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

Where $\tfrac{dm}{dt}$ 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

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

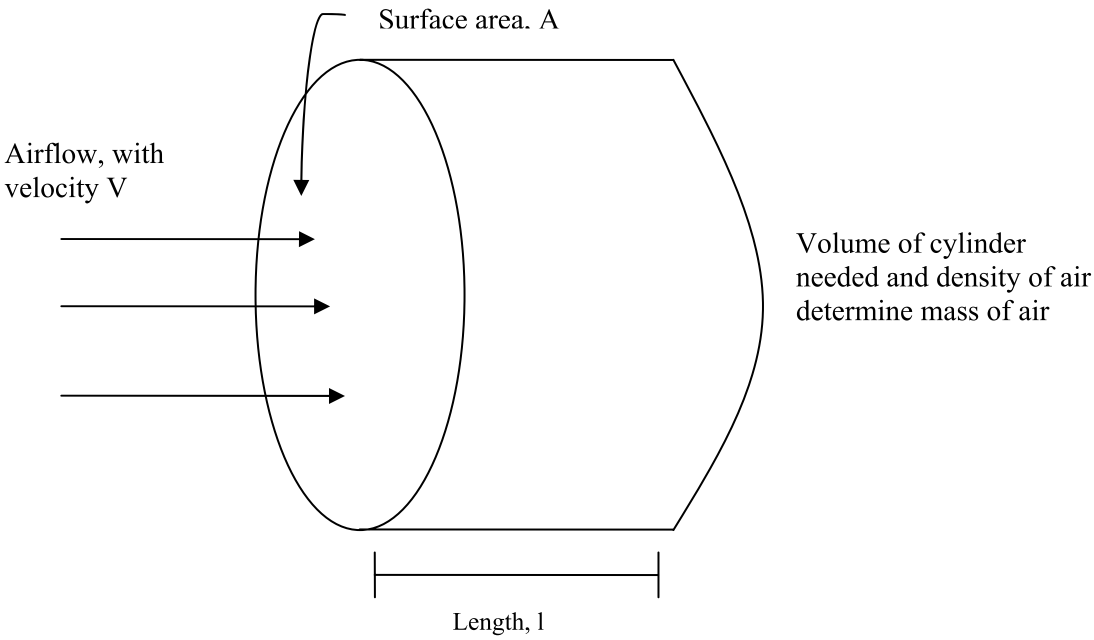
Now mass of wind can be written as

$$M = \varphi Avt$$

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,

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

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

And power density

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

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 rang 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 watt/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.

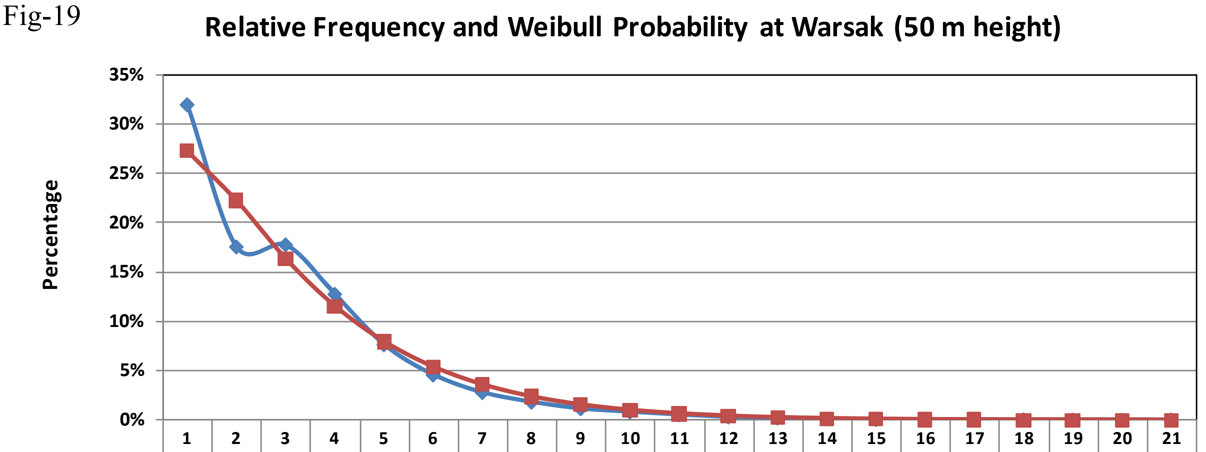
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion 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



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R.F 50m	31.9	17.5	17.7	12.7	7.6%	4.6%	2.8%	1.8%	1.1%	0.8%	0.5%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	27.2	22.2	16.3	11.5	7.9%	5.4%	3.6%	2.4%	1.5%	1.0%	0.6%	0.4%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

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 1.05 during November to the highest of 1.51 during the month of July with an annual of K being 1.25.

The lowest values of the *scale parameter* C 1.24 m/s observed in November while the highest value of 4.74 is obtained in February and with an annual value of 2.82 m/s.

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 1.18 m/s with Standard deviation of 1.03, at 30 meters this average speed is 2.08 m/s with Standard deviation of 1.67.

At 50 meters the monthly average wind speed varies from the lowest of 1.22 m/s in November to highest of 4.42 m/s during February. Whereas the average wind speed is 2.61 m/s with Standard deviation of 2.13.

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 0.46 W/m^2 in November to 35.81 W/m^2 in February with Average of 7.76 W/m^2.

At 30 meters height the power density varies from 2.16 W/m^2 in November to the highest of 126.71 W/m^2 in February and the average values is about 30.48 W/m^2.

At 50 meters height the power density of Warsak varies from 5.89 W/m^2 in November to 195.69 W/m^2 in February. The average power density of the area is 56.29 W/m^2.

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

10 m					
	AvgV (m/s)	St Dev	C (m/s)	K	P/A (w/m^2)
January	1.83	1.57	2.07	1.18	**18.88**
February	2.17	1.94	2.46	1.13	**35.81**
March	1.13	1.07	1.16	1.06	**4.65**
April	1.05	1.03	1.06	1.02	**4.08**
May	1.15	1.16	1.14	0.99	**5.71**
June	1.36	1.19	1.44	1.16	**6.58**
July	1.16	0.94	1.25	1.26	**3.54**
August	0.90	0.84	0.92	1.08	**2.24**
September	0.80	0.62	0.87	1.32	**1.06**
October	0.67	0.44	0.74	1.58	**0.46**
November	0.54	0.22	0.61	2.65	**0.15**
December	1.43	1.39	1.44	1.03	**9.99**
Average	**1.18**	**1.03**	**1.26**	**1.29**	**7.76**
30 m					
	AvgV (m/s)	St Dev	C (m/s)	K	P/A (w/m^2)
January	3.11	2.47	3.51	1.28	**74.34**
February	3.60	2.96	4.07	1.23	**126.71**
March	1.99	1.68	2.12	1.20	**19.24**
April	1.92	1.67	2.02	1.16	**18.52**
May	2.09	1.82	2.20	1.16	**23.66**
June	2.39	1.74	2.62	1.41	**24.86**
July	2.08	1.41	2.31	1.53	**14.59**
August	1.60	1.25	1.73	1.31	**8.54**
September	1.57	1.16	1.72	1.39	**7.27**
October	1.24	0.89	1.37	1.44	**3.39**
November	0.97	0.81	1.04	1.23	**2.16**
December	2.39	2.24	2.45	1.07	**42.44**
Average	**2.08**	**1.67**	**2.26**	**1.28**	**30.48**
50 m					
	AvgV (m/s)	St Dev	C (m/s)	K	P/A (w/m^2)
January	3.84	3.04	4.34	1.29	**137.84**
February	4.42	3.60	4.74	1.25	**195.69**
March	2.51	2.15	2.66	1.18	**39.90**
April	2.44	2.15	2.57	1.15	**39.15**
May	2.66	2.31	2.81	1.17	**48.67**
June	3.02	2.19	3.41	1.42	**54.59**
July	2.65	1.82	2.94	1.51	**30.90**
August	2.02	1.62	2.18	1.27	**18.17**
September	2.03	1.56	2.21	1.33	**16.87**
October	1.57	1.21	1.71	1.33	**7.88**
November	1.22	1.16	1.24	1.05	**5.89**
December	2.96	2.77	3.04	1.08	**79.94**
Average	**2.61**	**2.13**	**2.82**	**1.25**	**56.29**

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 Warsak 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 Warsak along with the capacity factor are given in table 4.

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

PMD Calculator (using 50M) Mar 2007 to Sep 2008				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	145	46	12%	51,842
February	206	58	15%	60,898
March	42	15	4%	16,864
April	41	15	4%	15,879
May	51	18	5%	20,296
June	58	21	5%	23,195
July	33	12	3%	13,247
August	19	6	2%	7,322
September	18	6	1%	6,443
October	8	2	1%	2,506
November	6	2	0%	1,889
December	84	26	7%	29,896
Annual	**43**	**16**	**4%**	**206,556**

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

The annual values of Table-4 are calculated using Eighteen months data and not the total or average of monthly values, therefore annual values may slightly vary with monthly values.

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.

Figure 20 shows the average diurnal variation of wind generated electric energy output at Warsak (Mar 07-Sep 08). The graph shows that the maximum power is produced at about 1100; of course, this is the same time when we have the maximum wind speed in 24 hours. Figure 22 & 23 shows the monthly and daily wind generated electric power output. Figure 21 depicts that at Warsak the wind have more potential in the month of March as compared to other months. Figure 22 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20 **Warsak: From Mar 2007 to Sep 2008 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output**

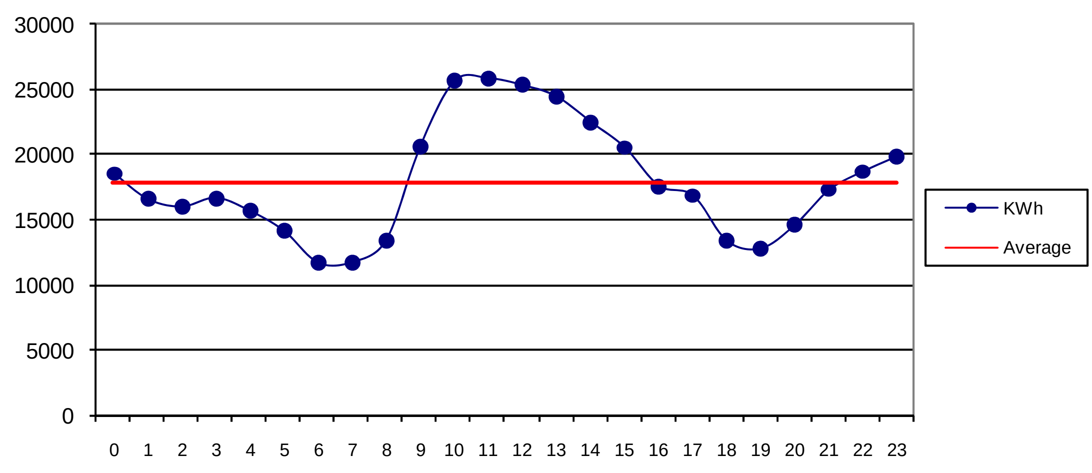


Fig 21 **Warsak: From Mar 2007 to Sep 2008 Monthly Average Diurnal Varition Of Wind Generated Electric Powe Output**

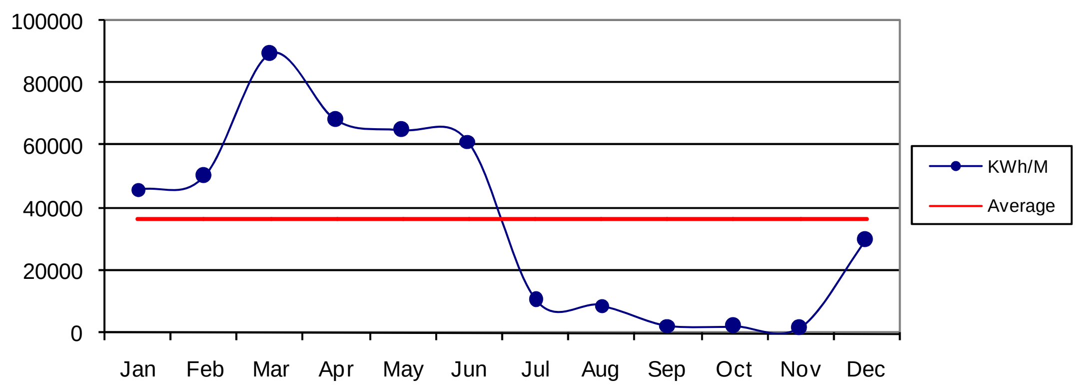


Fig 22 **Warsak: From Mar 2007 to Sep 2008 Daily Wind Generated Electric Power Output**

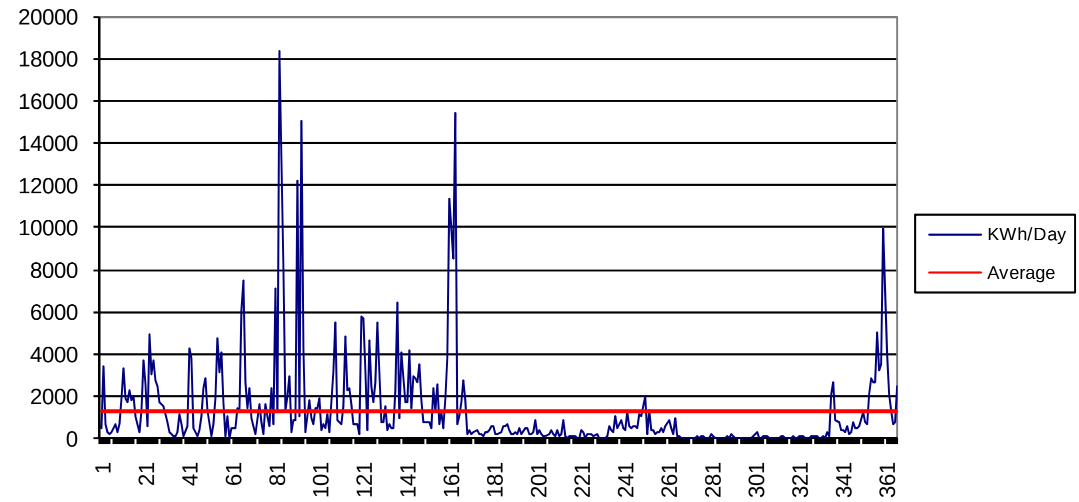


Fig 23 Warsak Jan: Diurnal Variation of Wind Genrated Electric Energy Output

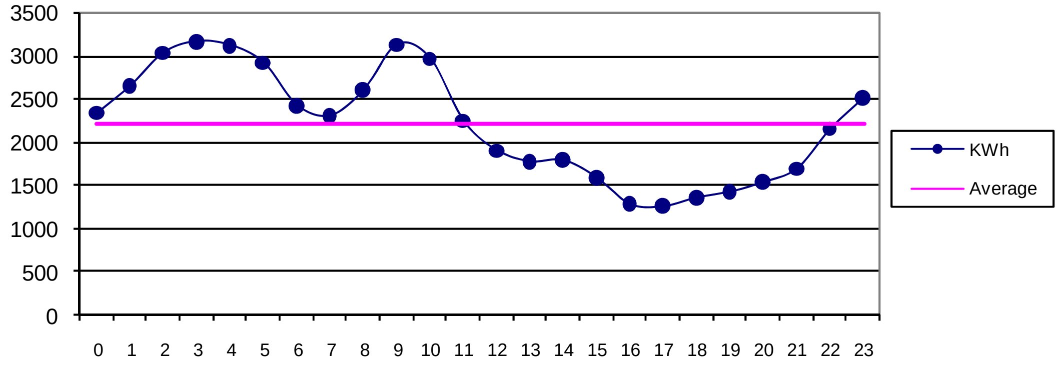
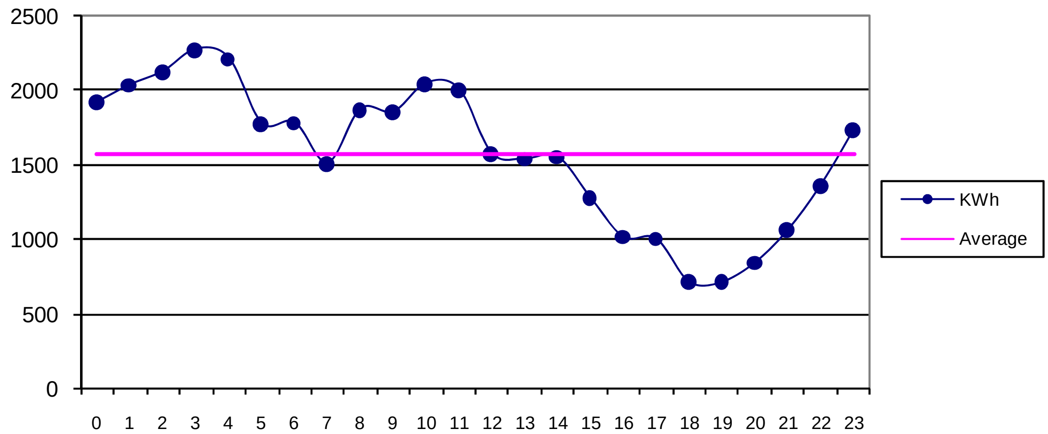
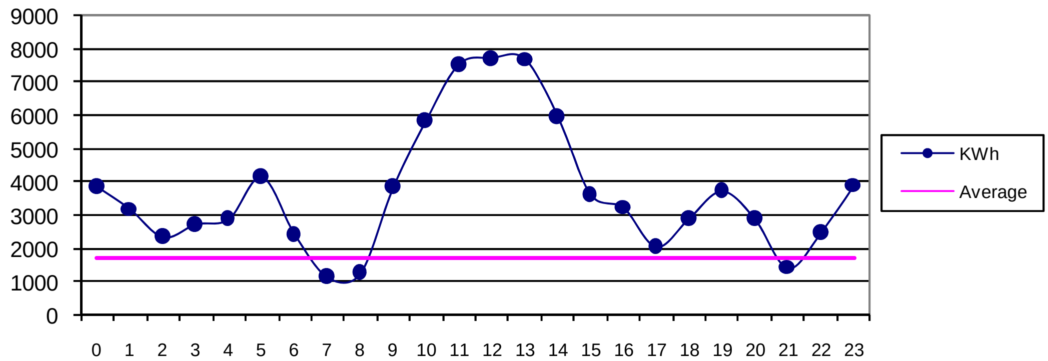


Fig 24 Warsak Feb: Diurnal Variation of Wind Genrated Electric Energy Output



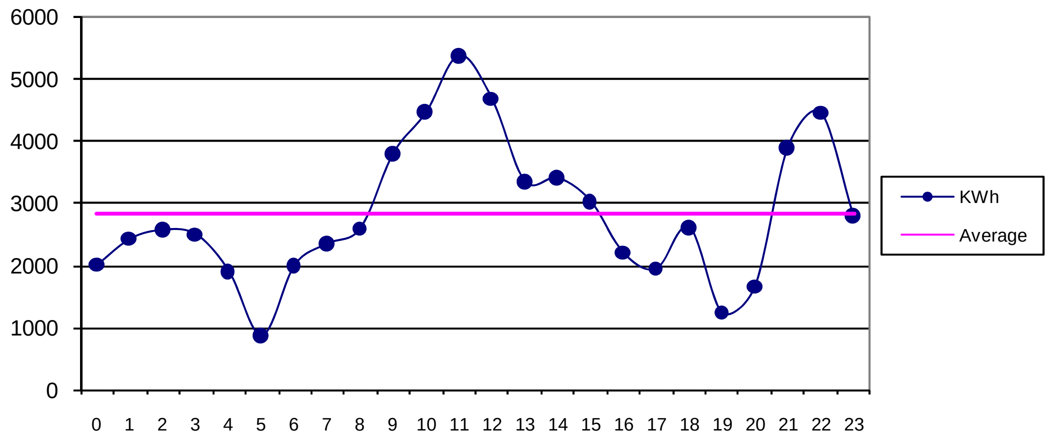
Source: Pakistan Meteorological Department

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



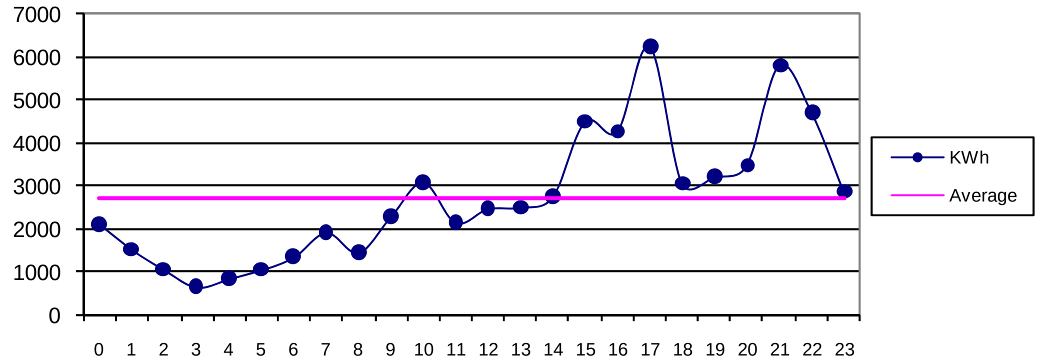
Source: Pakistan Meteorological Department

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



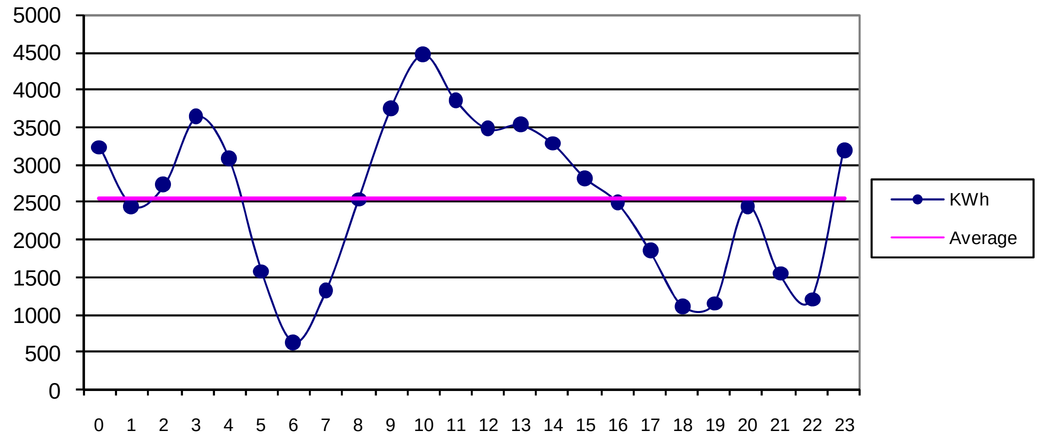
Source: Pakistan Meteorological Department

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



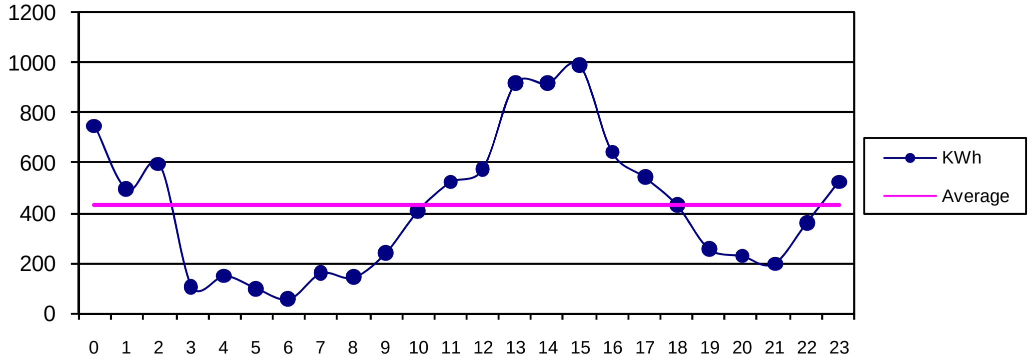
Source: Pakistan Meteorological Department

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



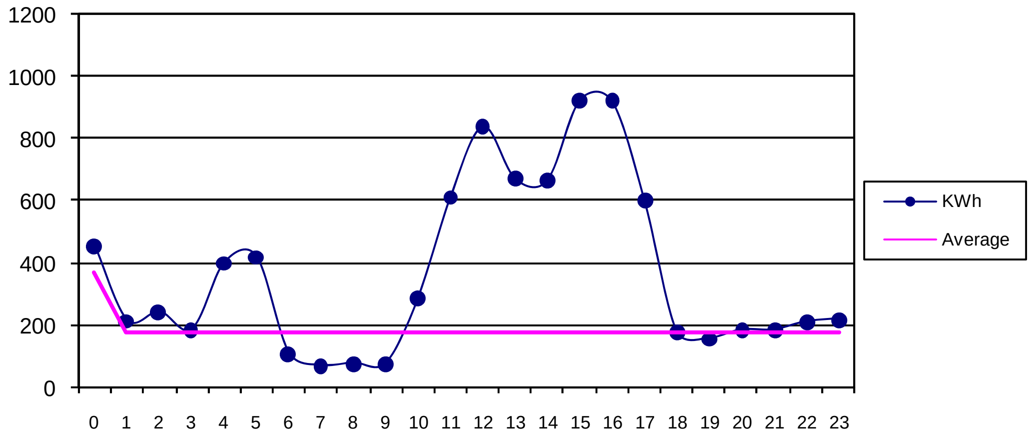
Source: Pakistan Meteorological Department

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



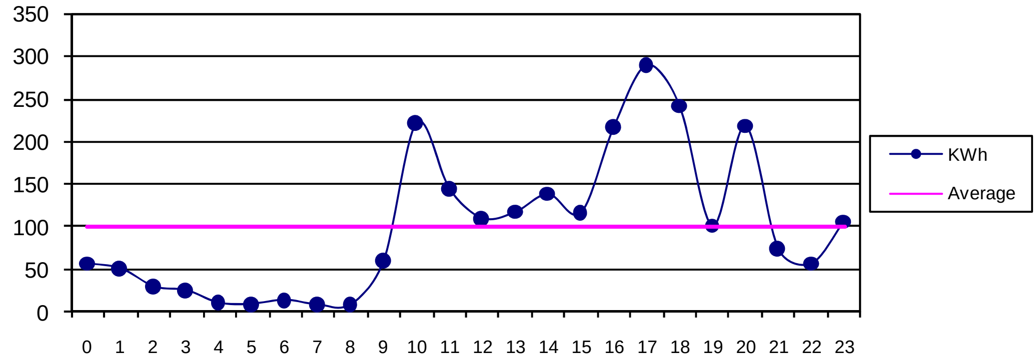
Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

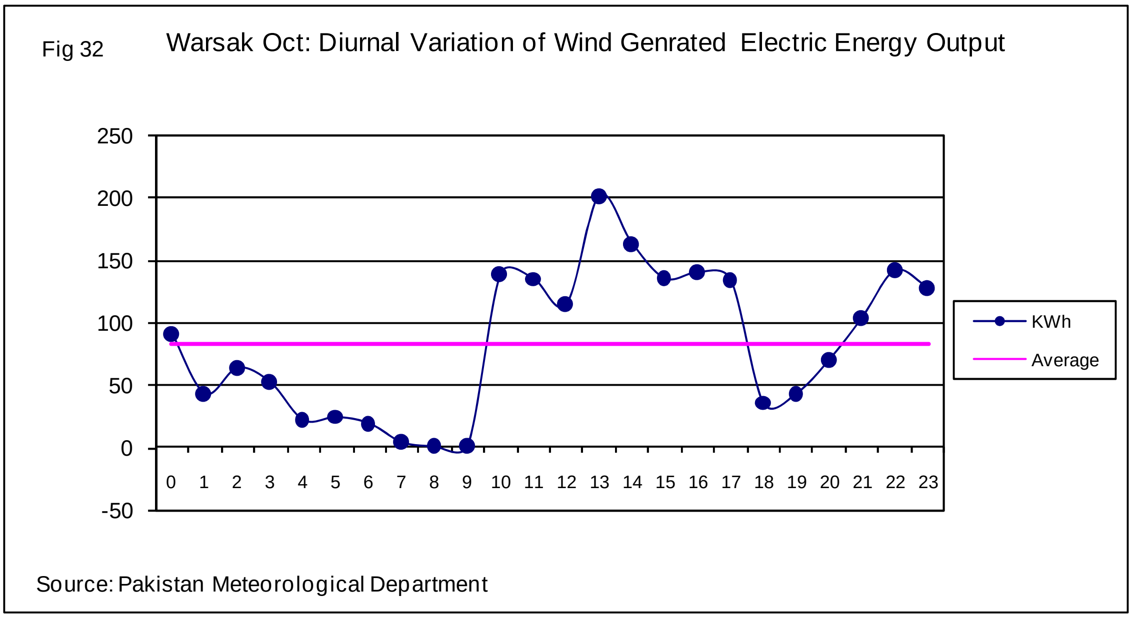


Fig 32
Warsak Oct: Diurnal Variation of Wind Genrated Electric Energy Output
250
200
150
100
50
0
-50
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

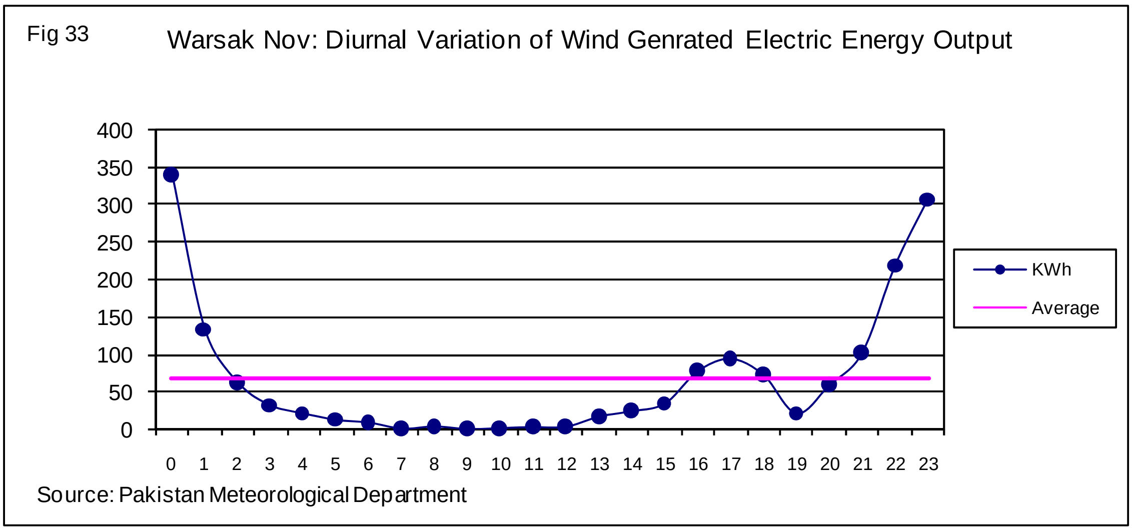


Fig 33
Warsak Nov: Diurnal Variation of Wind Genrated Electric Energy Output
400
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

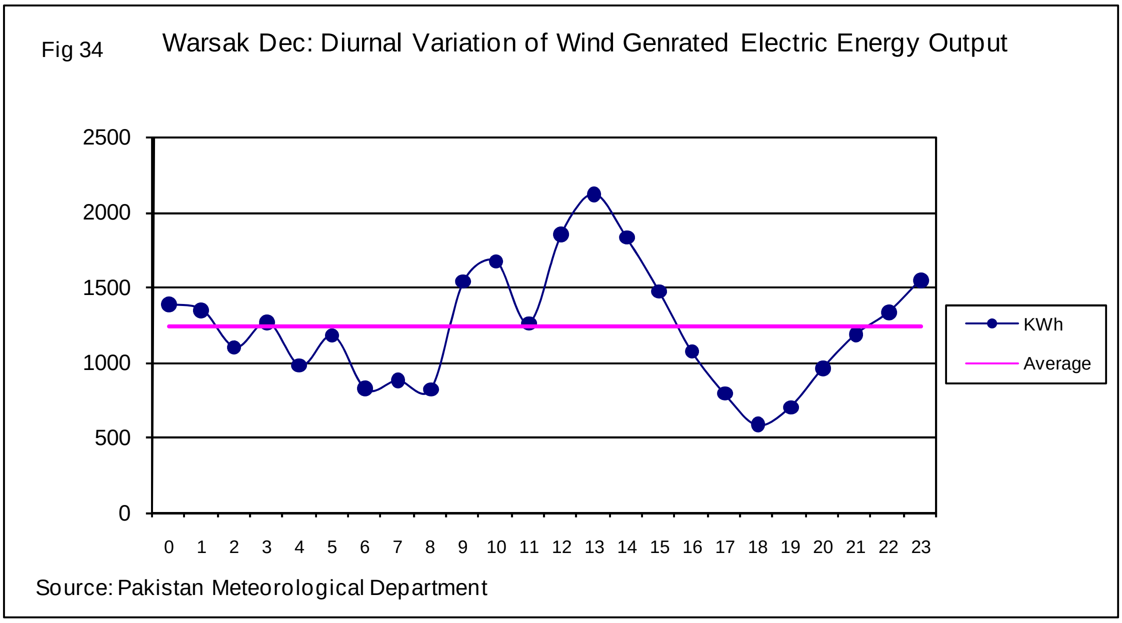
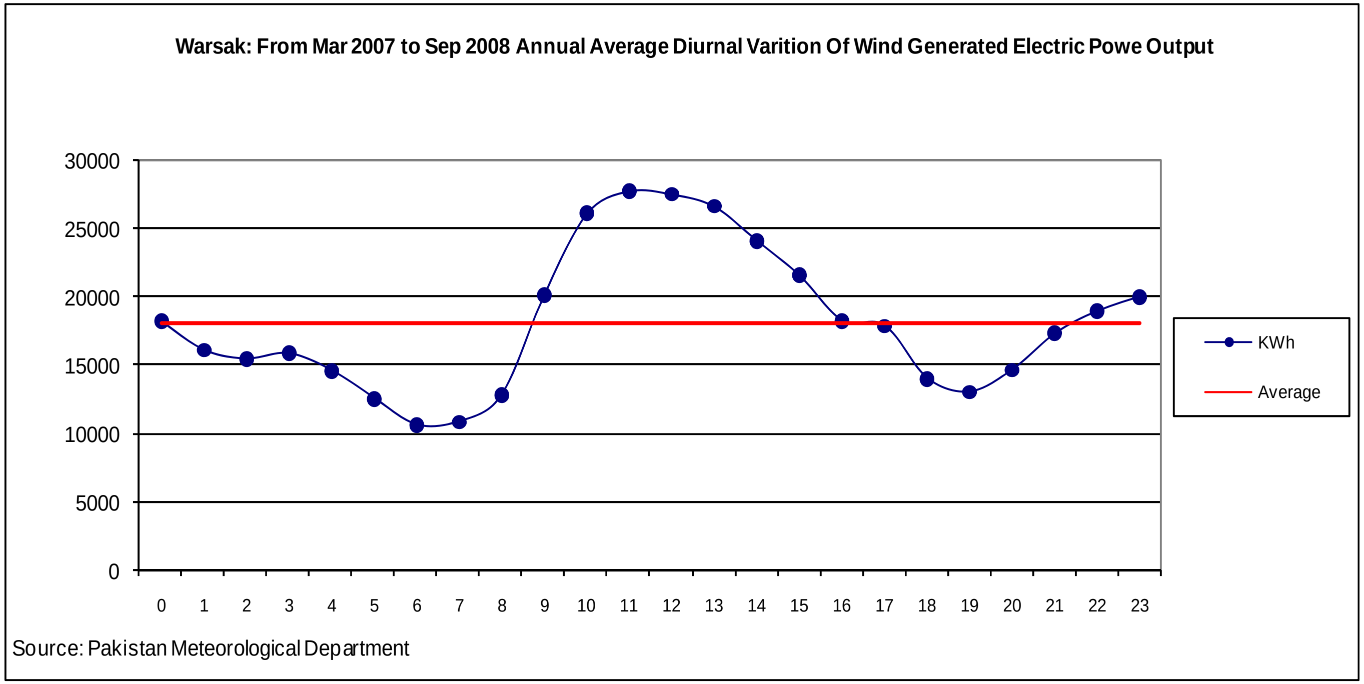


Fig 34
Warsak Dec: Diurnal Variation of Wind Genrated Electric Energy Output
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

Appendix-I

Warsak **Mar 2007 to Sep 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	15	16	17	18	19	20	21	22	23	24 Hrs
Jan	1949	1927	2199	2056	1798	1523	1348	1603	1752	2179	2488	2734	2766	2681	2157	1611	1189	1465	1490	1377	1360	1542	2273	2572	46038
Feb	2000	2331	2471	2605	2531	1682	1856	1401	2149	2291	2943	3370	2863	2768	2782	2264	1799	1854	1290	1064	1125	1277	1517	1861	50093
Mar	3882	3203	2369	2760	2916	4181	2456	1166	1285	3867	5875	7554	7746	7716	5996	3659	3256	2079	2933	3752	2912	1438	2490	3907	89396
Apr	2008	2426	2569	2495	1902	864	2001	2347	2594	3803	4467	5383	4681	3355	3406	3034	2201	1944	2616	1236	1656	3900	4462	2791	68140
May	2097	1511	1039	641	836	1044	1335	1910	1446	2278	3074	2140	2457	2492	2735	4485	4255	6237	3044	3199	3464	5784	4705	2864	65067
Jun	3230	2452	2733	3639	3081	1578	632	1327	2543	3756	4473	3856	3476	3529	3282	2823	2495	1856	1123	1157	2454	1551	1211	3198	61456
Jul	747	495	596	108	151	101	58	161	144	242	410	524	576	918	918	990	644	545	434	258	230	198	358	525	10331
Aug	454	215	243	186	400	421	111	71	79	78	288	611	838	671	665	922	919	602	179	158	185	185	211	221	8912
Sep	57	51	30	25	11	10	14	9	9	61	223	145	110	118	139	117	218	290	242	101	219	74	57	106	2434
Oct	91	43	64	52	22	24	19	4	1	1	139	135	114	201	163	135	140	134	35	43	70	104	141	128	2003
Nov	342	134	63	32	21	12	9	1	4	0	1	3	3	17	24	34	77	94	72	21	59	102	219	308	1651
Dec	1389	1349	1101	1269	978	1181	823	882	821	1538	1674	1260	1854	2121	1830	1471	1072	793	584	701	959	1184	1331	1548	29712
KWH	18245	16137	15476	15869	14646	12619	10661	10880	12825	20094	26053	27714	27484	26586	24095	21545	18266	17892	14042	13066	14693	17338	18975	20029	**435233**
Average	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	18135	



Warsak **January 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	9	4	4	4	8	2	2	14	1	0	0	2	3	7	1	6	4	1	0	0	1	7	24	6	108
2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	3	1	1	1	0	2	2	0	0	17
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	19	5	0	1	12	38
4	5	0	4	9	1	0	0	1	1	0	1	13	0	0	0	1	8	8	0	1	0	7	0	0	60
5	0	0	0	0	1	1	15	0	1	1	5	8	1	0	0	4	6	0	3	10	3	6	0	11	76
6	15	1	1	0	26	24	4	0	5	0	1	2	0	7	10	13	1	0	0	0	1	4	5	1	121
7	9	1	0	0	1	0	0	0	5	1	0	0	0	0	0	0	0	0	1	1	7	17	1	0	41
8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9	0	0	3	1	2	24	5	0	1	0	4	0	0	2	1	1	0	0	0	8	12	191	307	183	746
10	50	9	0	0	0	0	0	4	0	2	0	0	0	16	31	47	256	319	100	5	2	1	4	0	844
11	4	3	2	7	4	0	0	4	1	12	64	136	154	166	123	108	127	190	268	293	293	344	434	408	3145
12	255	293	427	430	306	120	72	82	51	64	67	25	96	280	255	185	73	54	3	1	0	6	4	7	3153
13	15	41	46	17	2	29	166	344	205	125	72	160	111	108	35	29	25	78	33	12	8	50	23	12	1746
14	5	2	0	3	23	37	11	32	40	45	114	46	145	119	81	46	1	1	0	17	1	0	15	28	811
15	32	74	127	17	18	171	5	27	11	11	65	203	228	215	135	85	66	1	134	178	190	190	101	147	2432
16	96	109	72	135	56	63	218	70	44	9	8	8	13	1	1	8	0	21	99	85	32	0	0	0	1148
17	0	0	0	1	0	0	0	0	0	1	0	0	1	8	5	0	0	1	9	67	62	34	24	21	232
18	0	11	14	4	4	0	0	1	0	0	1	5	21	3	4	12	2	0	1	3	10	1	0	8	102
19	0	0	5	8	0	4	1	0	5	1	3	85	80	62	43	38	5	3	3	1	4	1	155	370	875
20	147	20	12	5	34	62	66	168	215	216	190	127	146	230	119	78	21	1	2	13	18	33	99	75	2098
21	5	1	16	8	127	107	135	101	195	307	281	255	197	203	166	99	85	50	69	25	1	1	8	38	2479
22	11	0	1	1	3	6	0	0	0	0	12	35	72	35	9	1	10	35	23	8	0	4	97	166	531
23	281	203	255	293	383	408	445	466	477	474	513	515	532	477	434	243	197	408	419	357	485	394	383	357	9398
24	292	268	241	164	16	1	28	13	36	70	93	127	56	35	11	13	10	31	26	1	20	20	91	119	1780
25	131	154	241	319	216	125	22	9	78	332	280	203	135	147	178	72	40	50	72	72	56	77	254	268	3531
26	215	319	383	383	408	177	22	61	179	218	293	344	357	228	166	178	135	107	127	75	101	115	178	241	5012
27	281	268	230	205	79	60	48	56	102	230	319	267	218	127	123	119	24	56	97	123	37	1	43	78	3189
28	72	127	65	16	35	66	70	141	97	60	93	131	178	147	101	85	50	17	0	0	0	1	11	9	1572
29	8	17	46	14	23	21	1	2	1	2	11	37	19	48	107	134	28	12	2	0	1	1	0	1	538
30	1	0	0	0	0	0	0	0	0	0	0	0	1	9	15	4	5	0	0	0	1	21	4	5	66
31	8	4	5	15	23	15	13	8	0	0	0	0	0	0	0	0	9	20	1	2	7	13	6	1	148
KWh	1949	1927	2199	2056	1798	1523	1348	1603	1752	2179	2488	2734	2766	2681	2157	1611	1189	1465	1490	1377	1360	1542	2273	2572	**46038**

Warsak **February 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	1	2	1	0	0	0	0	0	1	28	6	2	2	0	1	7	11	0	0	0	0	0	62
2	0	5	8	0	0	0	0	0	1	1	8	0	0	4	3	22	0	66	19	9	5	48	2	9	209
3	13	6	0	14	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	36
4	0	0	0	0	0	0	0	0	0	0	2	1	10	80	31	69	17	10	3	1	0	0	0	1	222
5	1	7	1	0	0	0	0	0	0	0	11	35	35	49	48	4	83	78	99	62	69	53	1	0	637
6	0	1	16	0	1	10	1	4	13	1	47	80	127	195	88	172	269	241	203	154	125	24	230	293	2293
7	218	93	115	130	292	103	63	42	6	11	28	1	1	13	30	0	1	2	1	13	36	36	54	60	1349
8	29	21	66	105	15	11	0	0	0	0	0	0	1	1	1	4	2	0	0	0	3	7	0	1	266
9	2	0	0	0	0	0	0	4	8	28	17	50	179	85	62	56	45	31	7	0	0	23	222	319	1138
10	472	455	548	554	413	155	419	151	238	243	331	498	240	323	535	474	344	383	383	332	292	281	293	228	8587
11	228	419	434	434	464	466	332	445	509	558	532	466	455	408	319	228	178	319	203	100	38	0	18	22	7574
12	1	5	4	10	203	179	125	21	56	32	41	41	88	45	66	28	21	1	4	0	0	12	20	17	1020
13	34	1	5	32	3	1	33	36	23	38	28	45	88	59	91	62	28	17	15	3	5	0	1	18	664
14	14	7	21	0	0	0	1	0	0	0	0	0	0	0	0	1	9	3	0	0	2	0	4	40	100
15	26	4	1	10	8	1	1	16	55	61	80	217	127	50	41	23	13	18	6	8	1	1	8	16	793
16	0	4	47	59	55	37	45	35	32	61	83	72	78	83	91	113	166	154	191	166	168	131	127	154	2153
17	216	255	241	319	306	147	139	121	247	134	306	319	357	230	96	150	46	88	40	41	160	380	202	135	4673
18	319	441	445	464	205	241	319	190	468	430	488	466	344	273	324	66	59	29	15	0	0	0	4	105	5694
19	154	218	205	94	230	98	8	68	133	82	154	332	230	205	143	91	52	13	0	11	12	23	25	0	2580
20	13	40	17	1	0	0	0	0	0	0	0	0	0	0	1	3	5	3	0	0	0	1	0	0	85
21	2	0	4	1	2	4	0	0	0	0	0	12	5	56	53	3	1	1	1	10	24	37	85	62	363
22	21	31	20	66	72	50	44	105	20	8	26	40	83	85	67	85	61	55	26	8	1	0	0	1	977
23	1	12	38	14	65	97	216	19	33	88	170	191	127	139	85	78	72	91	28	17	8	1	3	0	1593
24	0	0	1	4	8	0	1	1	2	5	59	108	93	80	49	36	4	18	8	5	19	36	3	15	556
25	11	14	0	108	64	32	37	95	280	496	474	344	170	255	203	103	67	69	23	119	154	179	190	319	3809
26	216	294	209	173	115	36	72	47	24	15	58	25	19	32	344	380	242	150	2	5	1	1	0	8	2467
27	8	0	10	1	1	12	1	0	0	0	0	0	0	0	2	10	13	7	1	0	0	0	1	1	66
28	1	0	18	10	6	1	0	1	0	0	0	0	1	3	3	3	1	0	0	0	2	2	25	35	113
29	0	0	0	1	0	0	0	0	0	0	1	0	1	12	3	0	0	0	0	0	0	1	0	1	19
KWh	2000	2331	2471	2605	2531	1682	1856	1401	2149	2291	2943	3370	2863	2768	2782	2264	1799	1854	1290	1064	1125	1277	1517	1861	**50093**

Warsak March 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	22	8	34	4	8	0	5	3	8	5	42	106	82	38	25	28	30	0	7	2	4	1	8	31	502
2	120	70	5	2	19	22	17	10	8	11	63	29	2	3	5	7	2	1	0	0	0	0	9	43	448
3	8	71	0	397	136	387	141	100	9	32	50	19	23	0	1	2	1	1	2	1	14	0	1	29	1424
4	33	106	19	31	40	10	11	49	3	0	0	0	7	81	166	149	159	114	190	61	2	5	1	2	1238
5	2	3	26	24	71	79	6	122	107	86	823	1157	800	1002	617	533	338	121	21	59	26	14	31	37	6105
6	52	18	26	19	433	1228	985	270	107	635	814	972	870	460	196	157	67	52	48	14	39	11	16	33	7524
7	93	13	29	45	53	44	44	60	15	16	6	131	265	334	348	294	166	145	47	45	104	82	151	156	2688
8	24	149	206	35	40	45	42	32	58	80	72	149	115	84	87	79	69	39	16	0	0	0	10	17	1448
9	47	16	107	144	86	95	11	3	3	26	73	317	432	587	149	8	5	16	36	38	42	9	33	122	2406
10	72	262	98	21	1	1	87	22	0	0	3	9	18	36	136	137	25	4	2	12	0	12	5	4	969
11	8	2	4	15	6	1	0	0	1	13	87	17	28	48	275	6	5	11	7	13	1	3	18	6	574
12	23	41	37	6	1	16	0	1	1	4	0	1	4	4	3	35	29	3	1	2	0	1	4	1	220
13	1	4	6	20	24	0	0	3	1	1	1	4	155	92	25	2	555	461	85	14	43	44	69	16	1624
14	34	18	11	4	1	8	19	15	0	0	1	33	116	120	47	73	19	22	64	17	0	110	47	22	801
15	6	9	8	13	5	13	29	0	0	0	1	1	4	5	6	11	3	1	0	0	2	19	13	31	179
16	32	26	44	2	8	18	1	0	4	0	17	224	330	209	200	273	57	114	13	0	1	21	20	4	1617
17	5	29	9	22	12	9	16	10	21	14	1	1	56	87	52	66	138	183	91	16	27	64	39	35	1002
18	4	5	3	0	3	4	19	0	2	20	1	6	17	25	30	40	25	8	54	50	46	116	43	30	550
19	20	62	22	135	252	196	9	10	17	0	6	18	28	26	6	35	270	181	512	143	59	62	19	264	2350
20	9	2	17	87	7	0	3	6	1	0	0	8	31	52	10	2	6	0	32	82	21	26	75	149	625
21	487	348	238	603	680	1043	473	83	159	434	301	273	406	821	423	61	52	6	18	36	36	46	44	35	7106
22	10	16	3	79	6	1	1	0	3	2	16	20	33	10	5	8	5	13	31	0	1	16	253	695	1229
23	739	525	711	428	339	522	34	51	303	1247	1834	1963	1814	1644	1449	926	657	375	622	236	194	232	683	843	18371
24	293	93	37	2	4	1	5	8	136	821	1115	1748	1334	933	871	358	81	11	35	6	50	37	76	32	8086
25	77	65	76	123	174	230	44	2	1	2	0	2	14	82	2	3	41	37	71	29	44	81	33	116	1347
26	17	17	4	15	104	44	34	6	42	80	163	42	196	474	277	175	5	11	5	7	8	34	69	149	1978
27	127	64	65	105	13	32	17	18	116	142	146	124	390	328	530	159	366	56	16	11	1	1	60	2	2890
28	1	12	10	7	1	1	1	0	1	1	3	1	4	14	26	5	3	2	0	0	13	13	96	29	243
29	8	77	39	30	56	4	4	0	26	37	35	58	38	25	8	0	34	45	135	34	12	78	17	33	831
30	48	46	46	10	16	30	58	8	7	0	0	6	19	21	16	6	0	2	42	96	46	78	53	158	813
31	1458	1028	429	333	317	98	342	273	126	157	198	113	116	73	6	22	47	42	730	2728	2075	220	493	784	12208
KWh	3882	3203	2369	2760	2916	4181	2456	1166	1285	3867	5875	7554	7746	7716	5996	3659	3256	2079	2933	3752	2912	1438	2490	3907	**89396**

Warsak April 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	95	267	41	30	8	6	10	19	59	126	17	2	12	108	130	7	1	4	2	18	23	0	9	22	1016
2	33	60	115	290	305	173	11	140	629	2543	1910	2170	1774	1226	971	932	658	434	507	106	0	7	15	78	15086
3	194	75	0	10	8	21	3	1	2	51	416	868	724	493	543	134	94	303	116	107	6	10	13	55	4245
4	2	19	1	8	5	1	1	0	0	0	1	2	7	20	70	55	5	17	2	18	8	16	31	6	295
5	10	3	3	13	9	29	197	21	25	12	255	297	249	84	38	36	104	142	23	3	40	34	169	22	1818
6	17	120	62	71	104	69	16	10	0	0	1	0	86	21	18	21	58	37	16	20	2	1	61	167	979
7	27	25	60	2	0	10	2	11	2	2	33	149	105	93	36	9	9	33	4	1	1	5	30	14	663
8	170	218	255	230	49	32	46	77	3	6	19	4	4	4	1	1	5	7	0	2	191	55	13	39	1430
9	79	125	57	26	6	1	1	26	6	7	3	130	274	314	100	4	4	9	38	9	70	59	16	21	1384
10	78	32	12	9	0	0	3	8	17	30	41	158	149	180	364	67	9	25	43	16	195	190	177	87	1890
11	101	15	0	11	8	3	4	2	9	2	1	2	9	7	19	15	3	2	0	0	10	3	35	158	418
12	64	119	68	93	10	0	15	1	0	2	17	11	9	6	6	28	17	4	9	0	24	9	34	78	624
13	10	56	66	56	59	1	0	0	0	0	0	3	9	9	7	19	7	1	1	0	2	3	15	140	463
14	120	172	148	76	3	9	0	0	0	16	62	97	37	27	35	15	118	48	7	0	23	15	62	3	1091
15	23	2	0	1	14	12	8	8	18	0	7	19	10	1	14	12	35	51	19	6	0	3	1	5	268
16	20	2	0	2	54	52	37	10	13	31	6	17	12	16	0	0	3	46	41	70	748	1131	748	41	3102
17	119	166	914	989	852	11	97	391	776	236	468	178	17	13	136	30	0	13	14	2	14	2	9	22	5470
18	16	18	19	4	2	56	62	88	2	122	107	109	127	10	0	4	5	4	14	20	7	16	44	11	865
19	1	27	18	5	20	12	2	16	0	9	18	22	45	20	12	103	234	5	2	27	61	40	21	62	783
20	37	51	52	106	79	30	62	78	15	36	23	13	18	9	5	8	5	3	0	0	3	18	6	2	659
21	95	228	220	68	30	11	4	23	20	30	81	85	69	52	27	34	75	71	133	23	1	0	10	154	1543
22	121	24	18	101	107	77	37	0	1	8	45	92	150	188	217	1052	426	343	1052	313	134	271	77	16	4870
23	16	95	50	19	22	104	215	234	86	152	166	199	46	40	314	90	84	89	9	7	0	3	27	165	2232
24	7	14	30	79	24	7	0	0	1	90	137	195	81	98	194	166	56	118	427	408	20	161	5	11	2330
25	11	12	5	27	46	17	2	14	123	146	169	342	316	68	21	83	19	55	68	0	0	0	31	36	1611
26	54	132	41	43	9	22	9	0	32	34	31	17	32	20	18	28	47	9	0	0	6	39	1	32	655
27	154	157	124	82	2	2	0	0	0	0	1	2	2	11	10	27	29	5	2	0	2	1	12	12	637
28	0	15	31	7	2	0	1	0	0	0	0	7	4	16	32	21	4	0	0	0	28	21	33	12	234
29	0	9	7	2	11	0	0	0	0	1	1	15	15	28	4	0	2	12	42	27	33	1774	2669	1158	5812
30	331	170	151	34	54	98	1158	1170	754	111	431	181	287	175	63	35	86	54	24	31	6	13	89	164	5670
KWh	2008	2426	2569	2495	1902	864	2001	2347	2594	3803	4467	5383	4681	3355	3406	3034	2201	1944	2616	1236	1656	3900	4462	2791	68140

Warsak 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	151	1	8	10	293	328	138	14	4	227	840	425	221	28	272	137	59	0	0	0	0	1	13	78	3249
2	25	15	10	12	3	19	1	5	0	13	60	96	63	31	21	14	4	0	0	0	1	1	8	23	424
3	0	0	0	53	102	93	35	2	2	60	98	51	139	142	24	2	195	1423	353	526	139	293	631	296	4658
4	193	179	42	56	28	6	18	10	5	40	5	3	14	317	232	254	17	7	42	160	82	256	288	212	2465
5	92	146	3	16	28	6	58	9	63	57	65	46	59	47	125	90	78	41	34	12	26	159	222	268	1749
6	406	351	317	104	106	71	131	230	235	173	46	18	59	149	94	49	25	1	0	0	0	0	0	58	2624
7	144	151	112	1	2	18	0	0	3	1	8	89	69	14	13	0	18	89	97	56	196	1103	2637	691	5510
8	204	155	55	12	0	3	70	0	5	10	7	37	18	42	19	6	19	15	20	1	0	36	4	7	746
9	105	22	31	10	32	0	1	2	9	20	14	25	31	80	92	101	44	59	17	0	18	6	10	22	749
10	10	5	10	11	16	1	1	0	0	3	8	11	16	18	7	38	11	581	259	59	155	268	20	21	1529
11	2	1	5	3	4	1	6	2	0	0	0	11	66	124	57	40	27	23	2	0	0	6	12	8	400
12	1	46	11	18	2	2	0	2	0	4	18	46	171	90	80	81	61	9	0	0	31	6	13	10	703
13	0	0	1	4	4	56	12	1	5	10	79	84	33	20	40	57	18	3	0	24	16	19	15	12	514
14	0	0	11	3	2	0	0	3	0	31	71	115	176	25	21	21	11	4	0	3	0	1	3	12	513
15	65	11	2	10	5	7	2	0	0	3	17	38	98	102	37	4	58	575	70	119	316	668	23	29	2255
16	132	53	1	26	7	67	23	274	132	20	20	23	22	74	118	213	159	139	58	918	1376	2387	40	160	6442
17	102	8	1	10	2	10	3	16	52	72	218	76	67	91	82	74	66	16	0	0	1	9	0	3	979
18	13	10	2	3	4	10	0	32	2	8	2	58	242	59	556	2111	457	184	165	133	4	6	22	18	4102
19	47	36	43	7	45	52	13	72	43	68	55	31	13	14	12	26	45	60	13	283	149	19	23	525	1694
20	282	210	199	16	9	8	0	0	16	39	218	47	27	158	138	29	19	5	14	26	21	18	65	113	1677
21	26	13	11	1	5	146	658	603	142	513	550	354	94	54	162	74	79	91	79	216	52	127	92	22	4161
22	2	3	40	86	59	5	12	18	23	13	85	80	39	111	78	57	69	24	162	142	36	52	84	143	1422
23	8	11	21	2	2	33	22	6	7	17	30	29	14	3	18	91	1392	745	126	36	163	49	66	8	2898
24	0	37	28	7	4	13	7	12	0	0	34	29	52	27	53	154	192	869	905	175	52	38	91	89	2868
25	3	2	61	69	10	15	27	44	38	3	109	119	260	93	78	25	338	663	386	16	127	113	13	0	2615
26	3	5	3	15	2	7	66	506	552	730	205	58	129	283	2	147	308	154	31	33	5	62	163	24	3493
27	30	21	1	59	37	20	26	42	82	52	47	50	41	151	70	258	243	122	92	77	301	7	11	3	1842
28	36	7	0	3	12	38	2	1	23	28	44	33	36	24	98	219	94	67	2	0	0	0	0	0	769
29	8	1	1	7	9	0	0	2	0	1	6	17	64	6	15	14	38	180	90	67	117	18	53	2	715
30	4	1	1	5	2	7	2	1	4	54	89	21	60	52	49	54	48	40	29	113	35	54	75	3	803
31	3	10	7	4	2	3	0	0	0	9	26	20	64	65	70	47	64	48	0	3	46	1	5	3	499
KWh	2097	1511	1039	641	836	1044	1335	1910	1446	2278	3074	2140	2457	2492	2735	4485	4255	6237	3044	3199	3464	5784	4705	2864	65067

Warsak 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	10	75	2	3	1	2	4	0	1	2	7	23	36	43	31	22	25	13	66	135	1015	123	176	557	2371
2	98	25	102	3	2	4	1	8	31	59	89	95	87	55	74	76	112	152	106	42	5	4	23	28	1281
3	74	5	0	0	13	1	0	0	8	5	19	8	213	364	8	3	57	108	101	89	479	593	281	90	2520
4	51	25	38	49	10	0	0	30	3	7	57	54	68	70	90	68	51	3	1	0	0	0	0	1	677
5	17	6	4	3	12	10	28	0	3	66	36	46	45	199	156	120	77	73	53	4	9	138	46	54	1205
6	11	2	11	6	18	5	5	1	3	14	18	24	31	22	19	8	14	26	8	26	59	87	9	19	446
7	12	0	8	0	0	0	0	0	1	3	43	98	212	480	294	257	264	192	32	6	4	0	11	9	1927
8	11	0	4	1	1	5	12	33	60	109	648	380	390	567	627	499	210	105	26	22	5	22	5	18	3760
9	23	7	65	803	492	463	452	897	1549	1890	1464	638	635	646	443	424	153	141	59	114	28	17	5	1	11409
10	6	12	7	7	5	3	10	19	50	256	1029	1476	956	456	653	347	483	218	166	8	0	79	365	1910	8521
11	2490	2013	2239	2367	2358	999	21	246	400	475	561	293	128	95	283	223	50	9	0	0	0	5	3	137	15395
12	44	1	58	5	12	12	8	15	19	28	50	165	100	49	32	11	2	1	0	0	2	4	0	10	626
13	0	0	3	3	24	12	25	12	68	93	63	38	66	35	22	5	25	19	82	228	60	49	7	63	1000
14	125	35	53	63	32	8	33	22	21	138	107	50	26	26	29	45	12	18	73	223	330	110	90	60	1731
15	61	50	12	27	28	14	1	5	24	17	72	198	165	115	182	330	332	513	172	72	90	146	129	12	2765
16	22	117	84	194	31	2	3	10	227	478	42	52	28	30	20	100	294	43	2	0	0	0	0	0	1776
17	0	0	0	0	0	0	0	0	1	12	11	8	18	25	25	15	20	12	0	0	0	0	1	0	145
18	0	0	0	0	1	9	14	2	10	22	15	9	13	22	22	13	15	23	25	15	21	30	13	47	342
19	81	2	0	1	0	0	1	4	0	3	18	18	18	11	23	18	25	5	0	0	2	0	0	0	228
20	0	13	28	60	5	6	12	4	0	1	1	6	18	25	40	25	27	5	1	0	0	1	3	1	282
21	1	1	0	1	0	0	0	2	20	10	13	15	11	13	18	13	13	30	33	25	22	32	18	93	382
22	29	4	1	0	0	1	0	0	1	0	2	18	20	20	20	22	20	8	1	0	0	0	4	0	171
23	0	0	0	0	1	0	0	1	2	6	11	18	13	18	22	15	25	14	0	0	0	0	7	44	197
24	27	31	1	0	0	0	1	0	0	2	8	3	3	11	11	9	11	6	1	0	0	3	0	0	127
25	0	0	0	4	0	0	0	0	1	9	6	15	25	25	22	25	16	6	1	12	26	14	10	22	241
26	18	11	4	1	5	2	1	12	8	9	30	15	18	38	18	20	21	5	1	0	0	6	1	1	243
27	0	0	1	28	30	19	0	2	1	0	1	3	22	18	23	2	1	3	6	11	179	11	1	12	373
28	4	0	6	7	0	1	1	0	1	9	6	11	25	26	27	57	83	71	61	77	46	9	0	0	528
29	0	3	2	5	2	0	0	1	3	3	25	59	76	19	31	42	57	30	42	46	65	37	4	3	554
30	15	12	1	1	0	0	0	2	27	30	22	20	13	9	17	11	1	5	5	0	5	30	0	6	230
KWh	3230	2452	2733	3639	3081	1578	632	1327	2543	3756	4473	3856	3476	3529	3282	2823	2495	1856	1123	1157	2454	1551	1211	3198	61456

Warsak 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	8	28	7	0	0	0	0	0	0	3	15	14	26	31	13	15	18	7	1	0	0	0	0	0	186
2	0	11	4	0	5	1	1	0	1	16	49	45	21	21	31	40	35	6	3	2	0	0	0	0	293
3	0	0	0	0	0	0	1	0	4	18	3	31	61	66	72	66	61	61	57	8	1	3	26	35	573
4	26	4	3	15	10	25	2	32	41	35	45	40	50	72	66	40	19	5	0	0	0	1	9	18	560
5	31	26	15	18	2	3	7	3	28	40	13	28	31	72	50	40	31	12	4	30	9	9	23	182	705
6	38	18	4	4	1	0	0	0	0	15	41	23	7	21	23	18	13	18	59	72	26	10	1	7	419
7	12	56	78	1	5	5	3	0	1	2	1	4	13	6	23	15	2	0	0	0	0	0	0	1	227
8	3	1	30	5	1	8	0	9	0	0	1	1	3	26	31	40	21	21	8	0	0	0	0	0	209
9	0	0	0	0	0	1	0	3	1	8	15	40	26	40	46	32	4	10	13	3	4	1	5	35	287
10	13	9	1	0	0	0	0	0	0	2	21	26	13	4	13	31	26	21	7	0	0	0	0	0	186
11	0	0	3	1	1	4	1	1	5	8	21	18	21	26	35	56	40	28	17	0	1	0	35	154	475
12	172	49	0	1	2	0	0	0	0	0	0	1	1	3	1	0	1	1	0	1	1	0	0	0	233
13	0	0	0	0	0	1	0	0	1	3	6	13	12	18	50	72	61	35	26	40	66	66	14	1	485
14	0	129	217	1	11	5	0	1	3	19	5	18	21	18	21	15	2	0	0	0	0	0	0	0	486
15	0	0	0	0	0	0	0	0	0	2	3	20	40	26	35	23	25	13	2	0	0	0	0	0	188
16	0	0	1	27	2	4	0	9	4	5	15	10	10	21	26	29	3	2	0	1	17	20	6	4	218
17	1	0	1	0	1	2	5	1	0	8	35	15	6	45	45	35	8	1	7	1	0	0	22	33	272
18	423	29	5	12	13	1	18	4	1	0	2	18	26	40	40	23	18	13	1	3	3	17	179	1	890
19	4	0	0	0	1	0	0	0	1	6	1	7	13	23	31	35	40	31	5	0	1	0	0	1	198
20	13	118	202	12	16	2	0	1	2	0	0	1	4	18	13	15	1	0	0	1	0	0	0	0	418
21	1	1	0	3	77	38	17	68	20	4	0	0	0	1	1	1	1	0	2	0	0	0	0	0	234
22	0	0	0	0	0	0	0	2	9	6	10	15	18	21	21	20	1	0	1	0	0	1	0	1	126
23	0	0	1	0	0	0	0	0	0	1	2	10	26	18	15	1	12	13	1	17	0	3	9	0	128
24	1	10	18	4	0	0	1	0	0	0	3	15	21	40	26	35	13	10	5	0	0	0	0	0	203
25	0	0	0	0	0	0	0	0	0	2	18	13	15	13	18	58	13	33	114	17	21	8	0	5	348
26	0	0	1	0	0	0	0	0	0	1	1	1	3	10	10	13	47	19	0	4	15	27	4	3	158
27	1	5	0	0	4	0	0	0	0	0	1	13	7	15	26	18	13	22	0	0	0	0	0	0	125
28	0	1	0	0	0	0	0	1	7	4	23	35	46	139	54	35	15	15	0	0	0	0	0	0	373
29	1	0	0	0	0	0	0	0	1	2	1	7	13	13	3	4	18	21	5	1	0	0	0	1	91
30	0	0	0	0	1	1	0	0	3	23	35	18	7	10	15	35	23	13	5	8	5	1	0	3	206
31	0	1	3	3	0	2	1	27	13	7	21	26	18	41	66	127	61	115	93	50	61	31	24	40	830
KWh	747	495	596	108	151	101	58	161	144	242	410	524	576	918	918	990	644	545	434	258	230	198	358	525	10331

Warsak **August 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	31	27	0	1	0	1	3	12	7	0	4	8	12	3	0	0	0	0	0	1	1	0	0	0	111
2	1	0	0	0	0	2	0	0	0	0	0	1	1	0	5	9	3	1	0	0	0	0	0	1	25
3	0	0	0	0	0	0	1	1	0	0	2	0	8	18	18	0	3	10	9	3	1	0	0	15	91
4	12	3	39	27	6	1	0	5	1	0	0	0	0	2	1	0	5	2	5	0	0	1	0	0	107
5	0	1	9	5	1	0	0	0	0	0	1	5	1	1	0	1	4	5	16	7	11	14	1	0	82
6	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	5	3	1	0	0	0	0	0	12
7	0	0	0	0	0	0	0	0	0	0	1	1	1	3	1	8	8	9	1	0	0	0	0	0	34
8	0	2	1	0	0	1	1	0	1	6	3	1	8	9	11	20	15	16	4	36	30	85	66	52	368
9	194	0	30	8	2	4	6	0	0	0	0	0	0	2	9	8	20	12	1	0	0	0	0	0	296
10	0	0	0	0	0	0	0	0	0	0	1	1	1	3	15	5	12	7	2	0	0	0	0	1	48
11	2	0	0	0	58	15	31	0	0	0	0	0	5	5	1	1	0	0	0	9	22	0	0	18	166
12	115	69	2	2	2	0	0	0	0	0	0	1	1	1	2	3	9	6	0	0	0	5	4	0	221
13	0	1	0	0	0	0	0	0	0	0	2	1	1	8	15	43	25	18	20	22	8	20	10	0	193
14	19	33	22	0	1	1	1	0	0	0	0	0	1	2	5	2	2	1	0	0	0	0	0	2	92
15	13	26	103	7	4	26	5	0	2	7	4	1	1	0	0	0	0	4	0	0	0	0	0	1	206
16	0	5	4	1	0	0	4	0	0	0	0	0	2	2	0	0	1	1	0	0	0	0	0	0	19
17	0	0	0	0	1	0	0	0	0	0	4	12	0	0	2	0	7	2	3	2	13	0	0	0	46
18	0	0	0	0	0	2	2	0	0	0	0	1	1	0	0	1	1	0	2	0	0	0	0	0	11
19	0	1	0	6	0	0	0	0	0	0	0	0	1	2	6	3	1	2	0	0	0	0	0	1	25
20	0	0	2	2	3	0	0	0	1	0	1	11	6	9	6	14	14	15	24	0	2	0	2	0	111
21	0	1	0	0	0	0	0	0	0	0	2	33	26	17	21	58	96	212	32	5	2	2	1	18	527
22	6	0	0	102	151	2	1	1	0	1	1	7	10	13	8	41	2	4	0	0	0	0	0	1	352
23	0	0	0	0	0	4	1	14	2	1	7	17	39	36	67	79	41	10	2	0	3	0	2	1	324
24	10	21	12	0	0	3	0	9	40	32	15	124	267	169	77	90	44	4	4	3	7	10	3	55	998
25	1	3	2	16	1	1	0	0	0	0	19	99	82	58	59	79	38	9	0	0	0	0	0	2	470
26	11	3	0	0	2	6	33	28	0	2	137	196	231	53	26	32	44	44	11	8	0	1	0	0	869
27	0	1	0	3	14	0	1	0	2	9	4	5	30	53	121	137	94	17	6	0	0	0	0	6	502
28	6	14	7	2	0	1	0	0	0	0	41	28	24	28	24	17	115	37	0	0	0	0	2	0	346
29	0	0	0	0	144	347	21	0	4	7	6	2	14	134	82	122	149	39	0	2	10	15	111	8	1218
30	21	4	6	5	9	2	1	0	15	10	28	34	18	12	15	31	80	68	24	46	47	19	6	32	535
31	11	1	2	0	1	0	0	0	2	3	5	21	48	26	68	117	84	47	10	13	27	13	1	7	508
KWh	454	215	243	186	400	421	111	71	79	78	288	611	838	671	665	922	919	602	179	158	185	185	211	221	8912

Warsak September 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	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	0	1	2	0	53	52	2	59	4	127	111	26	20	34	53	12	0	0	0	1	9	16	581
2	0	0	0	0	2	0	11	10	7	16	43	19	19	33	78	171	105	22	1	0	5	2	0	11	554
3	4	4	0	2	5	15	13	1	71	17	36	28	18	32	25	117	51	15	1	0	0	1	0	1	456
4	12	0	4	3	21	8	30	2	17	27	29	54	45	52	68	67	155	49	44	6	1	18	284	142	1139
5	1	10	0	0	4	7	0	0	0	29	347	25	12	13	75	131	219	73	18	26	53	9	1	12	1065
6	0	7	5	17	2	1	0	0	0	1	7	31	87	162	661	144	24	34	194	463	39	77	67	3	2025
7	19	13	2	0	0	0	2	3	1	0	0	3	4	14	17	30	64	14	1	0	0	0	1	3	190
8	2	0	4	4	0	3	0	0	0	1	19	49	121	948	75	24	3	8	9	50	2	3	0	4	1329
9	3	0	0	7	1	46	20	0	0	0	0	1	1	7	19	26	50	89	14	10	1	16	49	19	380
10	6	15	4	1	84	0	0	0	0	0	5	5	21	15	20	16	17	1	17	2	0	1	57	107	394
11	6	0	0	0	4	0	7	0	0	0	0	44	18	11	15	19	54	45	0	0	1	0	0	0	227
12	0	1	0	0	1	4	3	0	0	0	5	12	26	4	25	55	81	15	0	0	0	1	6	1	239
13	0	2	2	0	0	0	3	0	1	3	38	44	17	9	9	57	71	18	4	0	3	13	5	1	299
14	36	15	7	2	2	0	1	13	2	39	88	39	59	39	6	26	63	17	2	0	1	0	7	24	489
15	8	3	1	0	0	1	1	0	2	21	60	23	23	17	32	29	30	4	0	0	0	0	1	0	256
16	0	0	0	0	0	1	1	0	2	11	22	23	28	12	57	26	66	182	42	27	8	2	1	15	524
17	4	1	1	6	1	0	0	348	52	5	1	3	1	2	6	3	21	166	27	161	7	44	5	7	870
18	1	0	0	2	0	0	1	0	0	0	1	0	4	1	2	1	0	38	128	63	194	27	0	14	477
19	3	0	0	0	0	2	0	0	11	64	18	20	13	12	4	30	3	0	0	1	0	0	0	2	184
20	0	1	0	0	0	1	0	0	114	408	214	32	42	22	12	3	8	13	0	0	1	2	21	18	913
21	5	5	2	0	0	2	2	0	4	26	5	6	8	2	3	5	18	4	1	2	1	1	12	8	120
22	1	1	0	1	0	0	0	0	0	1	3	36	23	18	7	0	1	0	1	1	0	0	0	0	93
23	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	3	2	0	0	0	0	0	0	1	9
24	1	4	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	2	1	2	14
25	2	4	2	0	0	0	0	0	0	0	0	1	1	1	1	8	5	0	0	0	0	0	0	0	25
26	2	0	12	6	0	1	0	0	0	1	1	2	6	6	3	0	1	0	0	0	0	0	0	0	43
27	0	0	0	0	1	0	0	3	0	0	0	0	1	1	1	7	3	0	1	0	0	0	5	0	25
28	0	0	5	0	0	0	0	1	0	1	2	3	1	1	1	5	1	0	0	1	0	0	6	9	39
29	0	0	0	0	0	0	0	0	0	0	0	2	1	2	1	1	1	0	0	0	0	0	3	2	14
30	1	8	1	4	0	1	1	0	0	0	2	11	10	2	1	1	0	0	0	0	2	13	0	4	62
KWh	57	51	30	25	11	10	14	9	9	61	223	145	110	118	139	117	218	290	242	101	219	74	57	106	2434

Warsak **October 2007** **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	1	0	0	0	0	0	1	0	0	0	1	2	7	7	1	13	10	0	0	0	2	4	0	1	48
2	0	0	0	14	0	4	0	0	0	0	0	1	2	1	3	2	4	8	13	0	0	12	1	1	64
3	11	0	0	0	0	0	1	0	0	0	1	1	6	7	21	15	6	23	4	0	6	1	4	0	108
4	4	1	7	0	0	0	0	0	0	0	2	1	1	3	3	1	0	1	0	4	1	0	11	8	47
5	1	0	1	1	4	1	0	0	0	0	0	1	3	5	2	3	5	6	1	0	0	0	0	0	33
6	1	0	0	0	5	0	0	1	0	0	0	1	5	3	1	4	1	0	0	10	8	2	0	5	46
7	3	1	7	6	0	0	0	1	1	0	41	45	2	2	23	10	5	0	0	0	0	1	1	0	146
8	0	0	0	5	0	0	1	1	0	0	66	27	12	13	3	4	8	0	0	0	0	0	0	0	140
9	0	0	1	0	0	0	4	0	0	0	0	3	0	2	5	2	0	0	0	0	0	0	0	0	17
10	1	1	1	0	0	0	0	0	0	0	0	0	1	1	3	1	1	0	0	0	1	4	0	0	14
11	0	1	1	0	0	1	1	0	0	0	0	0	0	0	3	1	0	0	0	0	0	2	0	0	8
12	1	0	0	0	0	1	2	0	0	0	0	0	1	1	1	1	0	0	0	0	3	1	1	1	14
13	0	1	1	0	0	0	0	0	0	0	0	1	2	3	7	1	1	0	0	0	0	1	1	15	33
14	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	4	13	2	0	0	7	5	45	13	89
15	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	7	5	11	28
16	10	8	0	10	0	3	1	0	0	0	0	6	7	7	2	0	0	1	0	0	7	11	45	45	161
17	8	0	1	1	3	0	0	0	0	0	1	1	16	26	15	2	0	0	0	0	1	0	0	0	75
18	0	0	3	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	2	10	20
19	10	1	0	0	0	0	0	0	0	0	1	0	1	3	3	6	0	0	0	0	5	18	0	0	47
20	1	0	0	5	2	0	0	0	0	0	0	0	0	1	1	2	15	0	1	5	0	0	0	0	33
21	0	4	9	0	0	0	5	0	0	0	0	1	2	2	5	13	1	0	0	0	0	0	1	1	43
22	4	5	0	0	0	1	0	0	0	0	0	0	0	1	1	7	5	19	0	3	1	0	0	0	46
23	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	1	9	0	3	18
24	0	0	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
25	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	0	1	1	4	8	5	25
26	5	8	11	0	4	10	4	0	0	0	0	0	4	7	10	12	0	0	0	3	4	3	19	4	107
27	0	0	0	0	0	0	0	0	0	0	0	9	15	30	35	15	40	46	15	0	0	5	0	0	212
28	1	0	0	0	1	2	0	0	0	1	25	35	22	66	8	3	21	28	0	17	21	9	0	0	260
29	0	5	0	8	1	0	0	0	0	0	0	0	3	2	2	0	0	0	0	0	0	1	0	1	24
30	13	8	17	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	4	0	0	0	43
31	17	0	0	0	0	0	0	0	0	1	1	0	0	10	3	7	4	0	1	0	0	0	0	5	49
KWh	91	43	64	52	22	24	19	4	1	1	139	135	114	201	163	135	140	134	35	43	70	104	141	128	2003

Warsak **November 2007** **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	40	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	12	35	4	100
2	7	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	5	18	6	3	43
3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6
4	0	0	0	0	7	7	1	1	4	0	0	1	0	3	0	0	0	0	0	1	0	0	10	1	34
5	4	0	2	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	9
6	0	0	1	5	11	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	5	8	4	8	43
7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	11	23
8	4	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	11	35	55
9	23	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	4	7	15	8	61
10	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	9
11	23	12	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	5	44
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	1	5	10	25
13	4	22	8	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	9	45	95
14	40	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	47
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	3	7
16	1	0	0	0	0	0	1	0	0	0	0	1	1	4	10	15	8	1	1	0	4	17	0	1	62
17	9	20	45	9	0	0	1	0	0	0	1	1	2	1	4	3	0	0	1	5	1	3	12	24	142
18	19	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	6	12	15	57
19	17	12	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5	0	0	47
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	2	1	0	0	1	7
21	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	5	11
22	49	55	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	23	133
23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	35	72	113
24	64	1	0	1	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	1	1	70
25	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	29	21	51
28	1	0	1	12	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	18
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	48	93	69	9	17	8	20	8	285
30	24	0	0	0	0	0	4	0	0	0	0	0	0	1	0	1	20	0	0	0	0	0	0	1	51
KWh	342	134	63	32	21	12	9	1	4	0	1	3	3	17	24	34	77	94	72	21	59	102	219	308	1651

Warsak **December 2007** **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	1	5	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	7	5	95	172	287
2	280	292	158	255	319	332	77	66	32	45	20	34	119	147	105	35	20	51	37	5	0	4	109	128	2674
3	1	1	0	24	0	5	5	0	1	7	3	27	51	93	80	5	0	2	0	1	1	0	0	1	306
4	1	1	1	0	1	1	1	1	0	0	0	1	1	2	1	0	0	0	0	0	1	9	8	1	30
5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
6	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	8
7	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	1	0	1	1	1	1	0	9
8	1	1	0	0	0	1	0	0	1	0	0	2	2	1	12	6	8	8	1	0	1	0	0	0	44
9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10	0	0	0	1	1	0	0	12
10	0	0	0	0	1	0	7	2	0	1	0	0	2	0	1	2	0	0	0	4	26	5	3	2	55
11	3	0	3	4	1	8	2	1	1	1	0	1	1	0	0	0	3	8	0	24	0	0	1	0	62
12	0	5	1	0	0	0	5	5	0	0	0	2	15	8	9	26	31	35	21	17	0	1	1	0	181
13	0	0	0	0	0	1	5	1	0	1	0	22	24	18	35	8	26	5	1	0	1	0	0	1	148
14	0	0	0	1	0	0	0	0	0	0	0	48	99	85	62	40	31	2	0	4	5	1	0	2	380
15	1	0	1	4	47	107	53	42	13	35	59	30	91	66	46	14	7	0	3	1	1	25	5	1	650
16	1	1	0	1	4	4	8	12	0	3	1	1	4	1	2	1	15	9	5	0	15	10	10	1	108
17	3	0	4	4	0	0	0	0	0	0	0	1	2	25	12	4	0	4	0	0	0	8	0	0	67
18	0	0	0	5	0	5	1	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	14
19	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	4	4	2	72	27	1	0	111
20	4	1	5	64	1	13	0	0	1	0	0	0	0	0	0	8	2	15	61	23	31	38	66	59	392
21	50	53	59	39	55	74	80	131	151	205	255	85	26	82	33	56	45	10	0	34	107	107	108	147	1991
22	131	147	178	197	51	126	141	72	87	404	343	37	255	319	254	255	137	37	24	9	15	4	1	12	3235
23	0	0	1	0	0	1	4	1	0	0	0	2	1	1	16	49	50	75	23	55	47	166	166	166	826
24	29	8	21	41	12	12	1	24	8	119	205	218	293	241	203	147	131	97	45	69	183	292	281	408	3087
25	408	434	434	455	434	445	383	477	445	513	528	474	496	493	445	455	370	408	332	408	434	430	445	434	10577
26	434	395	198	147	41	44	47	35	43	85	101	99	105	154	93	85	50	12	8	45	5	15	4	0	2246
27	3	0	1	4	4	4	0	2	0	98	135	127	154	205	215	143	105	2	10	0	0	0	0	0	1209
28	0	0	0	0	0	0	0	1	0	0	0	1	15	45	11	1	2	1	5	0	1	2	4	10	98
29	37	2	31	25	7	1	0	5	35	21	15	5	1	1	3	0	2	3	2	0	1	32	19	0	249
30	0	0	0	0	1	0	0	1	0	1	1	2	44	91	123	78	11	1	1	0	0	0	1	0	354
31	0	1	4	1	1	0	1	0	4	1	8	40	51	41	69	50	17	1	1	0	4	0	0	4	299
KWh	1389	1349	1101	1269	978	1181	823	882	821	1538	1674	1260	1854	2121	1830	1471	1072	793	584	701	959	1184	1331	1548	29712