Pakistan Meteorological Department

A STUDY OF WIND POWER POTENTIAL
AT
CHITRAL-NWFP

Technical Report No. PMD-03/2009
(Preliminary report based on 24 months data)
MAY-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 twenty four (24) months wind data which has been presented along with the wind generated electric power at Met. Observatory Chitral, 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 3.02 m/s during 24 months May-2007 to Apr-2009, the highest of **4.10** m/s is observed in July. 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 27% 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 Chitral is **126.40** W/m^2 according to international wind classification, this power density categorize Chitral 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 422,480 KWh which shows the capacity factor of 8% for Chitral. 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 Chitral 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 (42) stations for collecting wind data have been installed to study the wind regime as shown in Wind Mapping Sites (Phase-II) map. The list of stations is given below:

Fatehpur, Bahrain, Kalam, Khawazakhaila, Malamjabba, Tahash, Khungipayan, Dir, Tarbela, Nizampur, Warsak, Chitral City, Drosh, 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.

Tower is installed at Met. Observatory in Chitral City (NWFP). Latitude & Longitude of Chitral is: **Latitude: 35.85º, Longitude: 71.83º, Elevation: 4900 Ft.**

2.2 Data source:

To undertake this study 30-meter high towers are erected at the locations mentioned above. On each of these high towers two wind speed anemometers are installed at the height of 10 meters and 30 meters, respectively; wind vane for recording wind direction is installed at 30 meters height. NRG Automatic data loggers developed locally have been installed to record data at each site. These data loggers are recording, ten-minute average wind speed at 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
$\mathbf{Z_o}$ 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.

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

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

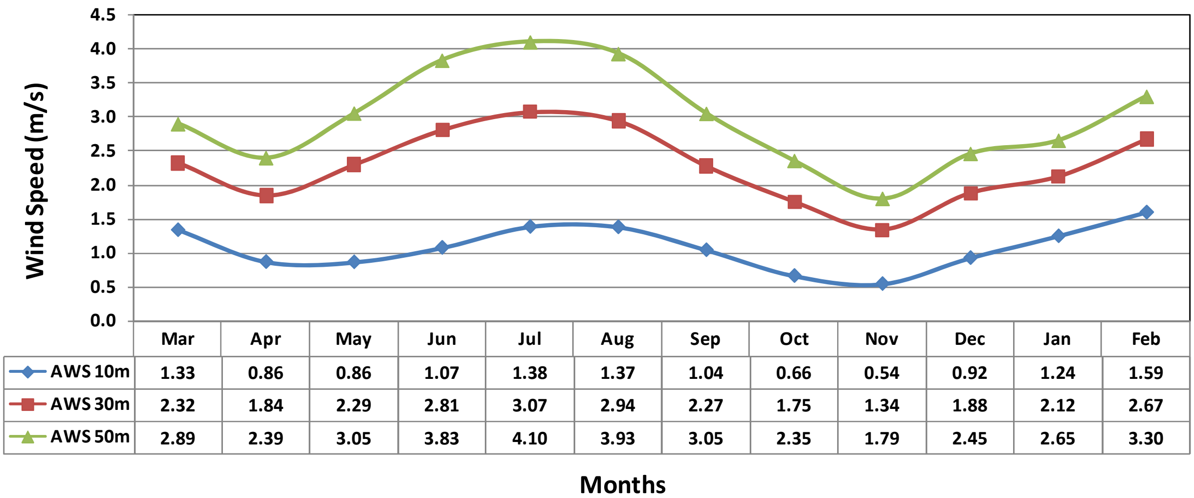
Type of terrain	Z_0	α
Mud Flats, Ice	10^{-5} to 3x 10^{-5}	
Calm Sea	2×10^{-4} to 3×10^{-4}	
Sand	2×10^{-4} to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 to 2	0.32
City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

3.2 Average Wind Speed:

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

Fig-1 shows monthly average wind speed at height of 10 meters, 30 meters and 50 meters. At 30 meters height, we have the maximum average wind speed of 3.07 m/s during July. At 50 meters we have the average wind speed of 3.02 m/s and the highest average wind speed of 4.10 m/s is observed during the month of July.

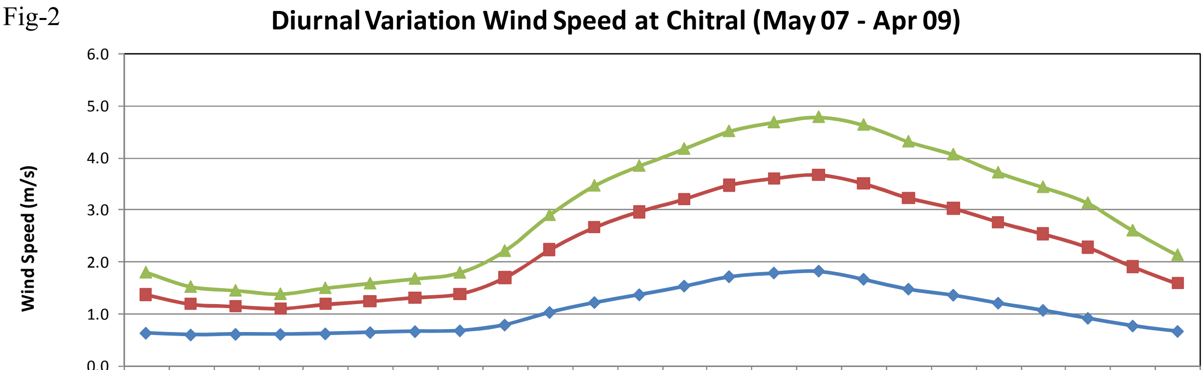
Fig-1 **Monthly Average Wind Speed at Chitral (May 07 - Apr 09)**



3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Chitral from May-07 to Apr-09 (24 months). The wind speed is generally lower during night time and after sunrise it starts picking up. At afternoon it reaches maximum, wind speeds are around 3.68 m/s and 4.80 m/s at 30 meters and 50 meters height respectively. Figure-2 shows that the maximum wind speed during day times at 50 meters height reaches to 4.8 m/s at 3 pm.

Fig-2

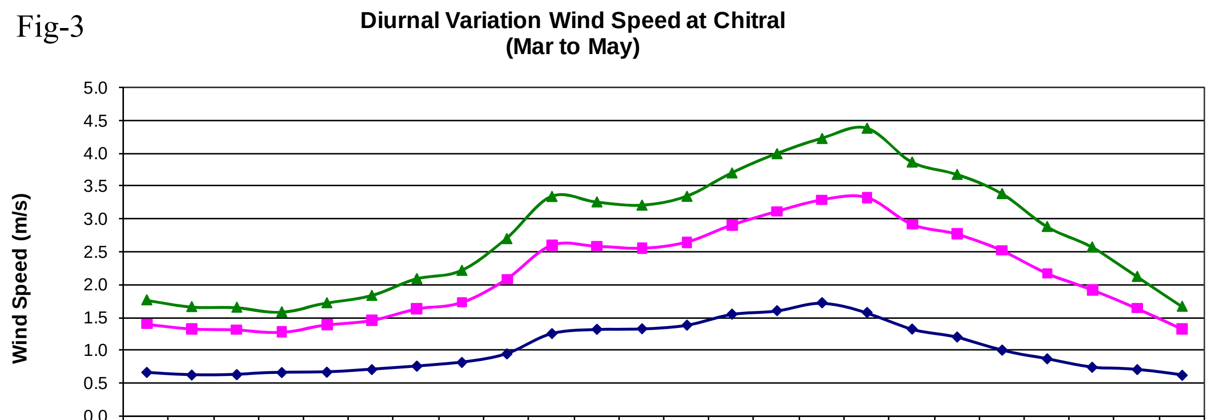


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.65	0.61	0.63	0.63	0.64	0.66	0.68	0.69	0.80	1.04	1.23	1.38	1.54	1.72	1.79	1.83	1.67	1.49	1.37	1.22	1.08	0.93	0.79	0.68
WS 30m	1.39	1.21	1.16	1.12	1.20	1.26	1.33	1.40	1.71	2.24	2.68	2.97	3.21	3.48	3.61	3.68	3.51	3.24	3.04	2.78	2.55	2.29	1.92	1.60
WS 50m	1.8	1.5	1.5	1.4	1.5	1.6	1.7	1.8	2.2	2.9	3.5	3.9	4.2	4.5	4.7	4.8	4.6	4.3	4.1	3.7	3.4	3.1	2.6	2.1

PST (Hours)

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

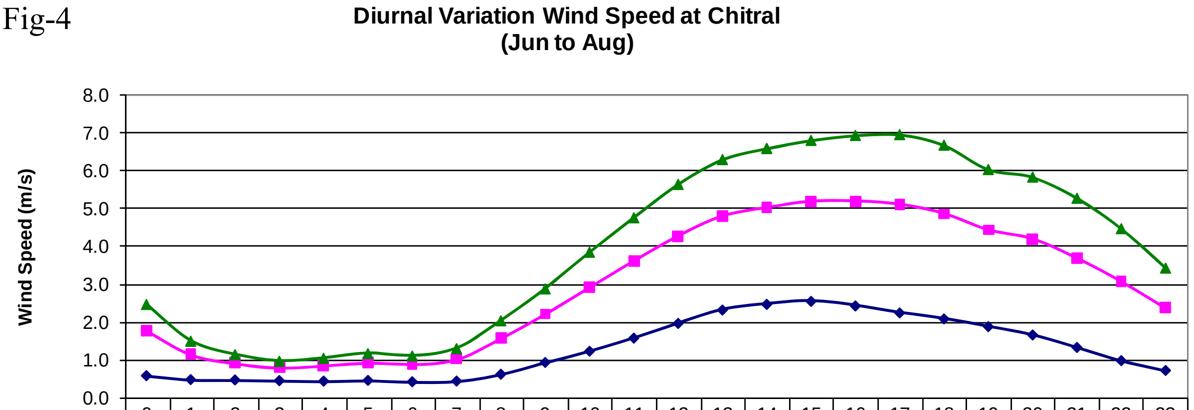
Fig-3



	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	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	1.2	1.3	1.3	1.4	1.5	1.6	1.7	1.6	1.3	1.2	1.0	0.9	0.7	0.7	0.6
WS 30m	1.4	1.3	1.3	1.3	1.4	1.4	1.6	1.7	2.1	2.6	2.6	2.5	2.6	2.9	3.1	3.3	3.3	2.9	2.8	2.5	2.2	1.9	1.6	1.3
WS 50m	1.8	1.7	1.6	1.6	1.7	1.8	2.1	2.2	2.7	3.3	3.2	3.2	3.3	3.7	4.0	4.2	4.4	3.9	3.7	3.4	2.9	2.6	2.1	1.7

PST (Hours)

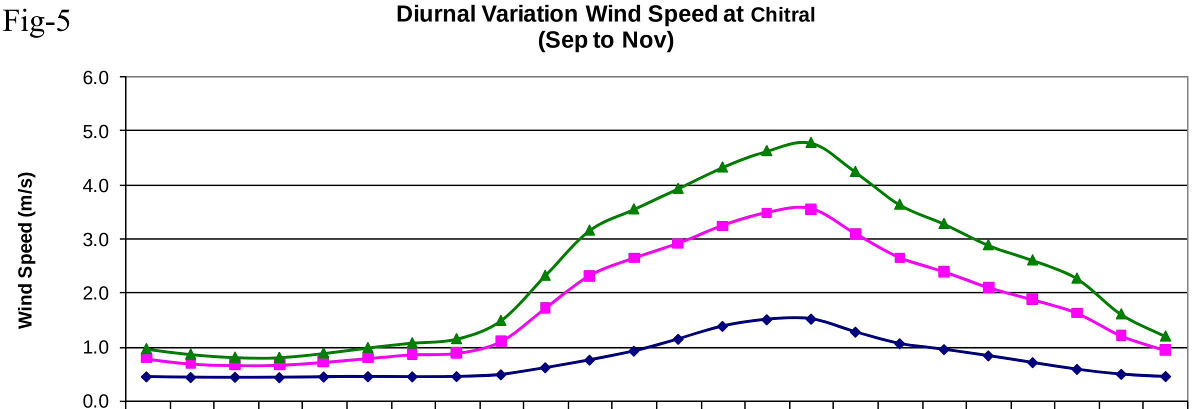
Fig-4



	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	0.6	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.6	0.9	1.2	1.6	2.0	2.3	2.5	2.5	2.4	2.2	2.1	1.9	1.7	1.3	1.0	0.7
WS 30m	1.8	1.1	0.9	0.8	0.8	0.9	0.9	1.0	1.6	2.2	2.9	3.6	4.3	4.8	5.0	5.2	5.2	5.1	4.9	4.4	4.2	3.7	3.1	2.4
WS 50m	2.5	1.5	1.1	1.0	1.0	1.2	1.1	1.3	2.0	2.9	3.8	4.7	5.6	6.3	6.6	6.8	6.9	6.9	6.7	6.0	5.8	5.3	4.5	3.4

PST (Hours)

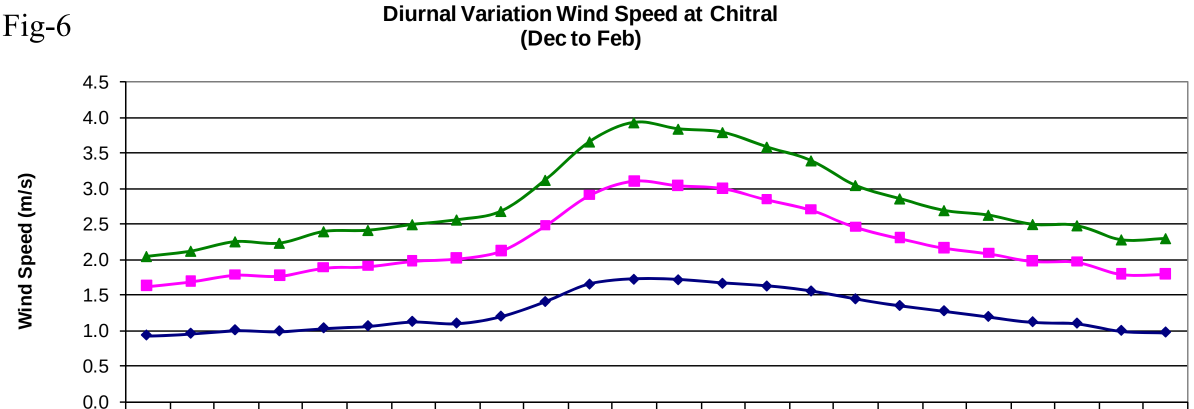
Fig-5



	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	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.9	1.1	1.4	1.5	1.5	1.3	1.0	0.9	0.8	0.7	0.6	0.5	0.4
WS 30m	0.8	0.7	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.7	2.3	2.6	2.9	3.2	3.5	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.2	0.9
WS 50m	1.0	0.9	0.8	0.8	0.9	1.0	1.1	1.1	1.5	2.3	3.2	3.6	3.9	4.3	4.6	4.8	4.2	3.6	3.3	2.9	2.6	2.3	1.6	1.2

PST (Hours)

Fig-6



	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	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.4	1.6	1.7	1.7	1.7	1.6	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.0	1.0
WS 30m	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.5	2.9	3.1	3.0	3.0	2.8	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.8	1.8
WS 50m	2.0	2.1	2.3	2.2	2.4	2.4	2.5	2.6	2.7	3.1	3.7	3.9	3.8	3.8	3.6	3.4	3.0	2.9	2.7	2.6	2.5	2.5	2.3	2.3

PST (Hours)

3.4 Wind speed Frequency Distribution:

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

3.4.1 *Binning of Data:*

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

3.4.2 *Relative Frequency:*

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

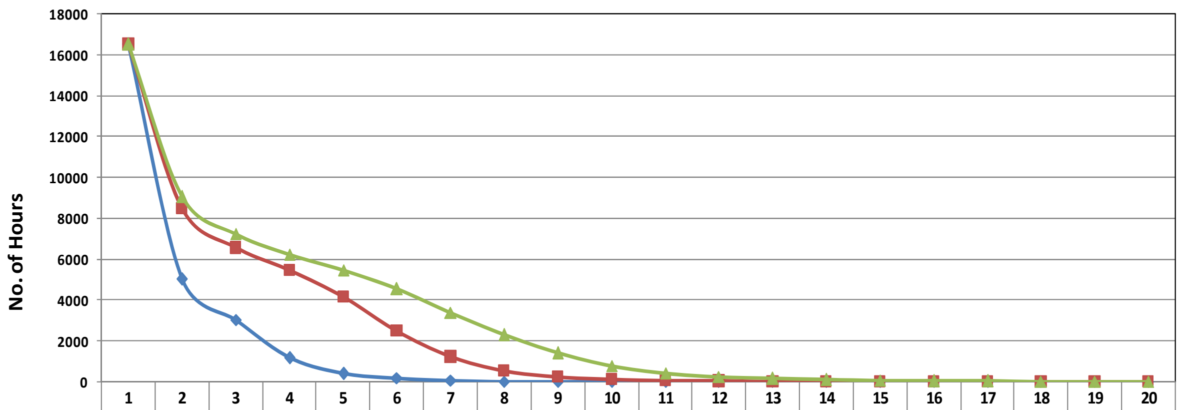
R .F = probability P (V_i) = Frequency of given wind speed / Total period

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters from May-2007 to April-2009. The analysis indicate that in a year at a height of 30 meters during 4160 hours the wind speed is greater than 5 m/s whereas at 50 meters, during Annual 5469 hours the wind speed is equal or greater than 5m/s.

Fig-7

Cumulative Wind Speed Distribution at Chitral (May 07 to Apr 09)



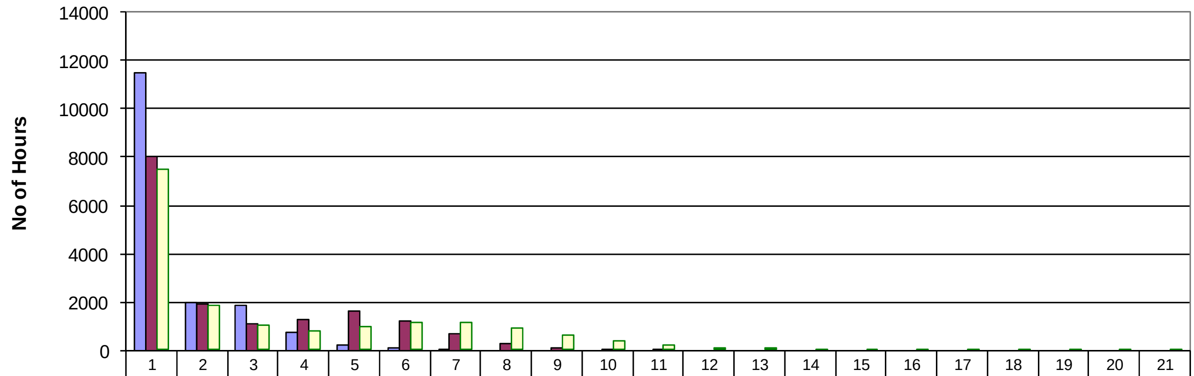
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	16505	5032	3041	1165	409	178	81	35	16	6	1	0	0	0	0	0	0	0	0	0
CWS 30m	16505	8490	6560	5468	4160	2497	1238	554	265	148	82	48	27	14	6	1	0	0	0	0
CWS 50m	16505	9053	7235	6235	5469	4544	3409	2304	1415	794	429	249	159	109	77	58	44	30	21	15

Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the wind frequency distribution at Chitral. We can see that at 50 meters during 925 hours wind speed is 5 m/s, 1136 hours speed is 6 m/s, 1104 hours speed is 7 m/s and so on.

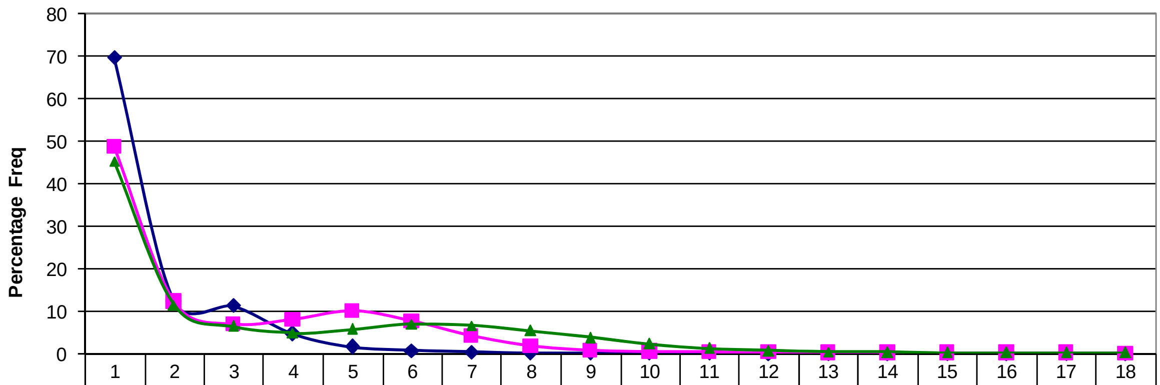
Fig-8 **Wind Frequency Distribution at Chitral (May 07 - Apr 09)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	11474	1990	1876	756	231	97	46	19	10	5	1	0	0	0	0	0	0	0	0	0	0
CWS 30m	8015	1931	1092	1308	1663	1259	684	289	117	66	34	21	13	8	5	1	1	0	0	0	0
CWS 50m	7453	1818	1000	766	925	1136	1104	889	621	365	180	90	51	31	20	14	13	9	6	5	11

Fig-9 gives this *frequency distribution in percentage*. At 50 meters we find that during 5.6% of time wind is 5m/s, 6.8% of the time 6m/s and 6.6% of the time it is 7m/s. Whereas at 30 meters height we get 9.9% of the time wind speed 5m/s, 7.5% of the times 6m/s and 4.0% of the time 7m/s and so on.

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



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	69.7	12.2	11.2	4.5	1.4	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	48.6	12.1	6.8	7.9	9.9	7.5	4.0	1.7	0.7	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
WS 50m	45.1	11.3	6.3	4.7	5.6	6.8	6.6	5.3	3.7	2.1	1.1	0.5	0.3	0.2	0.1	0.1	0.1	0.1

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

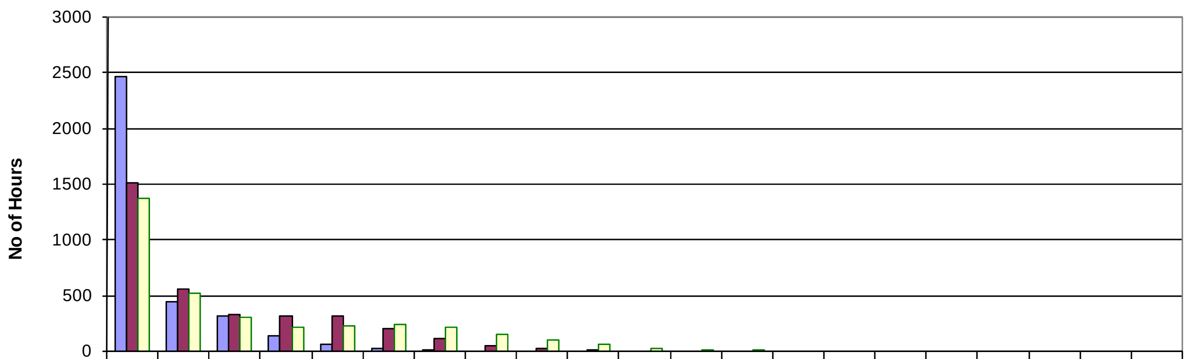
Figures 10–17 gives seasonal wind frequency distribution and percentage frequency distribution.

<u>Mar – May</u>

Fig-10 shows this distribution during the months of March to May. We can see that in this period at 30 meters height during 325 hours we get 5m/s, 207 hours 6m/s, 119 hours 7m/s. Similarly at 50 meters we get 229 hours 5m/s, 244 hours 6m/s, 214 hours 7m/s. Fig-11 shows percentage frequency distribution for Mar to May.

Fig-10

Wind Frequency Distribution at Chitral (Mar-May)

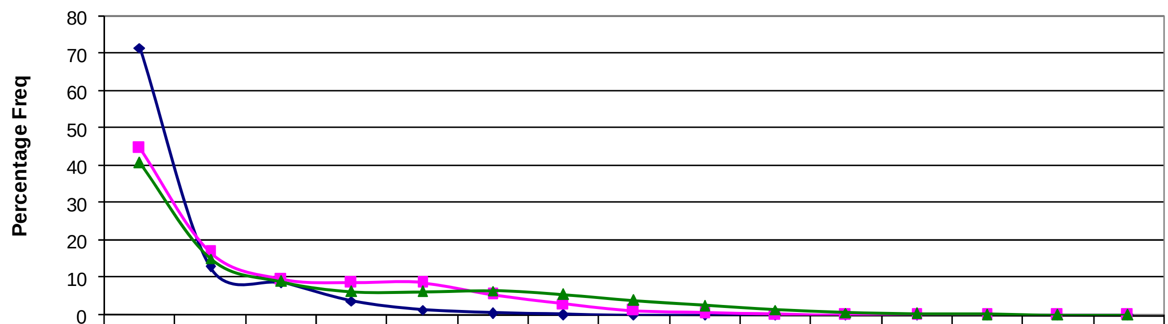


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2472	445	322	140	60	27	9	3	2	2	1	0	0	0	0	0	0	0	0	0	0
WS 30m	1519	566	327	314	325	207	119	53	24	12	6	4	1	2	1	1	1	0	0	0	0
WS 50m	1372	517	305	220	229	244	214	149	99	59	31	16	10	5	4	2	2	2	1	1	1

Wind Speed (m/s)

Fig-11

Percentage Wind Frequency Distribution Chitral (Mar-May)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	71.6	13.1	8.9	3.8	1.6	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	44.9	16.9	9.6	8.7	8.7	5.6	3.1	1.3	0.6	0.3	0.1	0.1	0.0	0.0	0.0
WS 50m	40.8	15.2	9.1	6.4	6.4	6.7	5.7	3.9	2.6	1.5	0.8	0.4	0.2	0.1	0.1

Wind Speed (m/s)

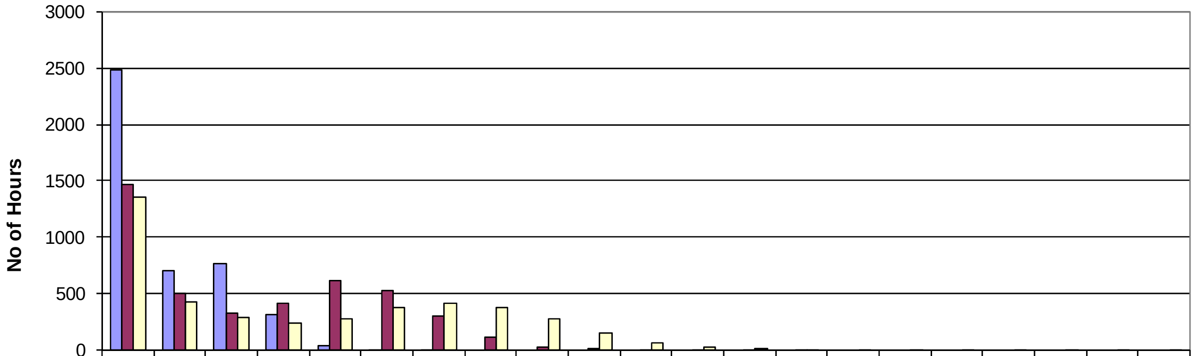
Jun – Aug

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 620 hours we get 5m/s, 528 hours 6m/s, 301 hours 7m/s.

Similarly at 50 meters height during 281 hours we get wind speed of 5m/s, during 374 hours 6m/s, 421 hours 7m/s, 379 hours 8m/s. Fig-13 shows this distribtution in percentage.

Fig-12

Wind Frequency Distribution at Chitral (Jun-Aug)

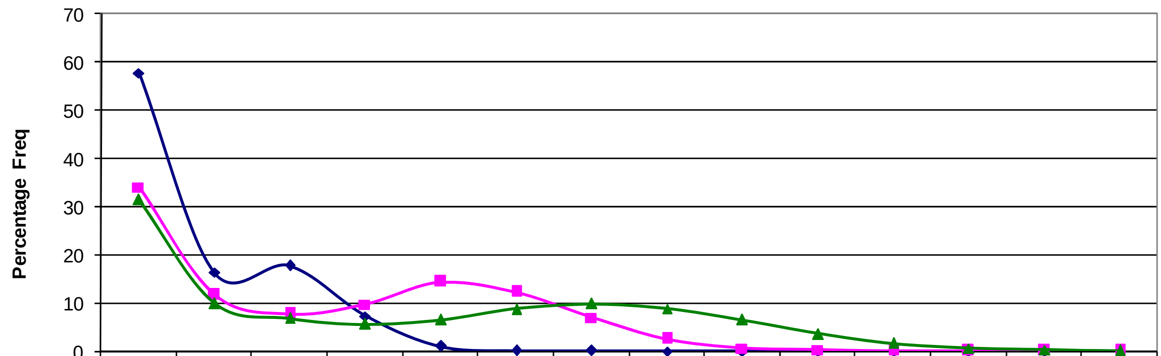


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2480	708	766	314	42	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1466	503	331	418	620	528	301	108	26	9	3	1	0	0	0	0	0	0	0	0	0
WS 50m	1351	425	288	239	281	374	421	379	277	153	68	26	11	5	2	1	2	1	1	1	4

Wind Speed (m/s)

Fig-13

Percentage Wind Frequency Distribution at Chitral (Jun-Aug)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	57.7	16.3	17.7	7.2	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	34.0	11.7	7.7	9.7	14.3	12.2	7.0	2.5	0.6	0.2	0.1	0.0	0.0	0.0
WS 50m	31.4	9.9	6.7	5.5	6.5	8.7	9.7	8.8	6.4	3.5	1.6	0.6	0.3	0.1

Wind Speed (m/s)

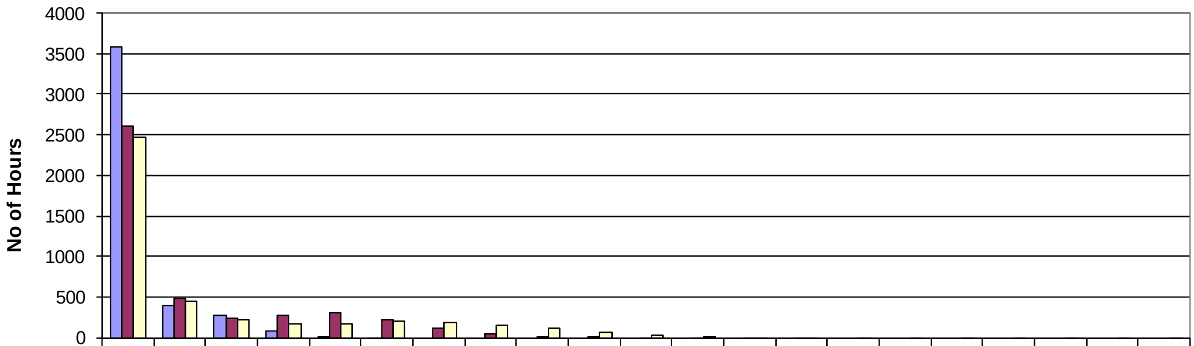
Sep – Nov

Fig-14 shows wind frequency distribution during the months of September to November. We can see that in this period at 30 meters height during 321 hours we get 5m/s, 225 hours 6m/s, 118 hours 7m/s.

Similarly at 50 meters height during 182 hours we get wind speed of 5m/s, during 209 hours 6m/s, 197 hours 7m/s, 153 hours 8m/s. Fig-15 shows distribution in percentage.

Fig-14

Wind Frequency Distribution at Chitral (Sep-Nov)

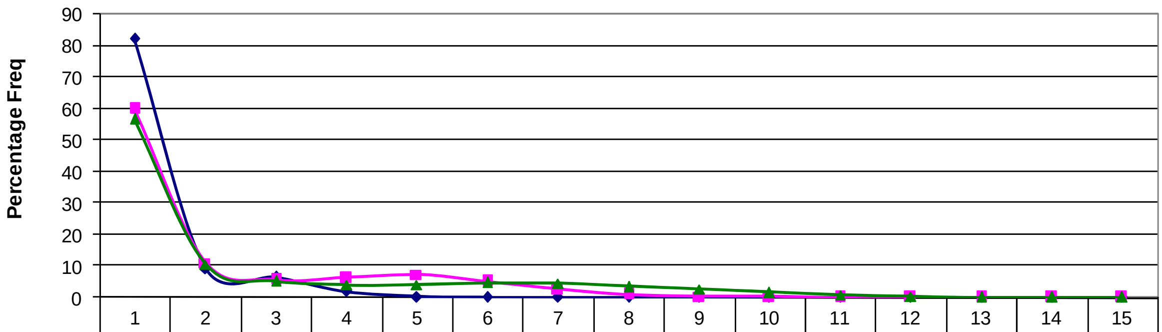


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	3586	404	283	81	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	2611	481	247	273	321	225	118	46	16	12	6	6	4	1	0	0	0	0	0	0	0
WS 50m	2466	461	232	176	182	209	197	153	119	73	36	17	10	8	5	5	4	3	2	3	6

Wind Speed (m/s)

Fig-15

Percentage Wind Frequency Distribution at Chitral (Sep-Nov)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	82.1	9.2	6.5	1.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	59.8	11.0	5.6	6.2	7.3	5.2	2.7	1.1	0.4	0.3	0.1	0.1	0.1	0.0	0.0
WS 50m	56.5	10.6	5.3	4.0	4.2	4.8	4.5	3.5	2.7	1.7	0.8	0.4	0.2	0.2	0.1

Wind Speed (m/s)

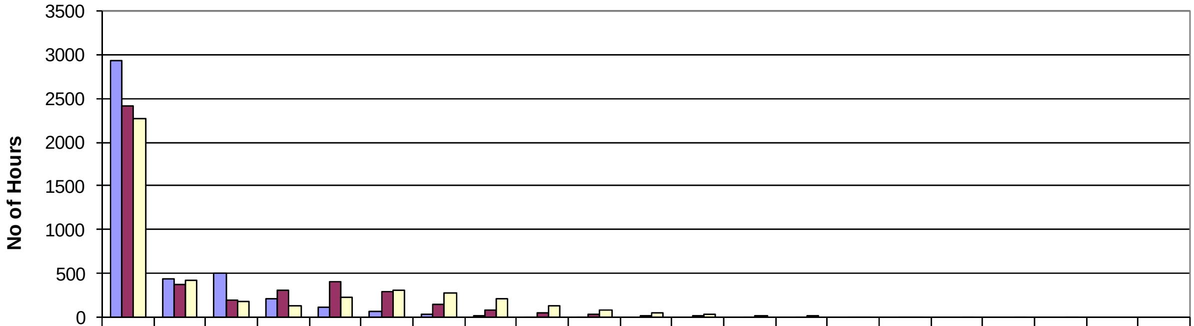
Dec – Feb

Fig-16 shows wind frequency distribution during the months of December to February. We can see that in this period at 30 meters height during 398 hours we get 5m/s, 299 hours 6m/s, 146 hours 7m/s.

Similarly at 50 meters height during 234 hours we get wind speed of 5m/s, during 308 hours 6m/s, 272 hours 7m/s, 208 hours 8m/s. Fig-17 shows distribution in percentage.

Fig-16

Wind Frequency Distribution at Chitral (Dec-Feb)

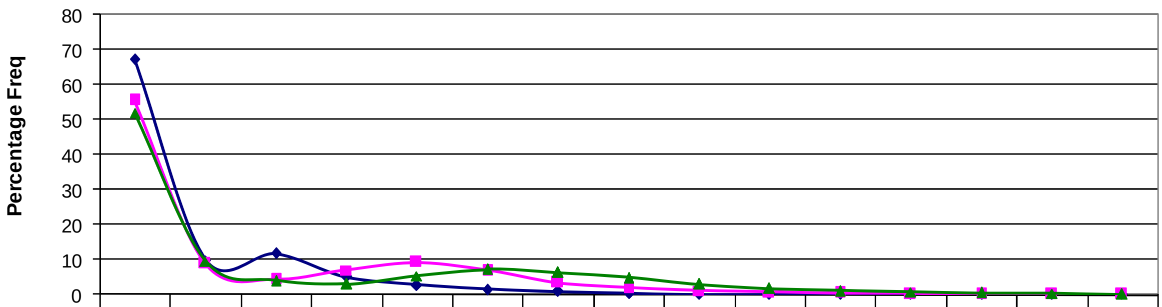


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2936	434	506	221	119	65	37	16	8	4	0	0	0	0	0	0	0	0	0	0	0
WS 30m	2420	381	187	303	398	299	146	82	51	33	19	10	7	6	4	0	0	0	0	0	0
WS 50m	2264	415	175	131	234	308	272	208	127	80	46	30	19	13	8	5	5	3	1	0	0

Wind Speed (m/s)

Fig-17

Percentage Wind Frequency Distribution at Chitral (Dec-Feb)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	67.4	10.0	11.7	5.1	2.8	1.5	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	55.5	8.8	4.3	7.0	9.2	6.9	3.4	1.9	1.2	0.8	0.4	0.2	0.2	0.1	0.1
WS 50m	52.0	9.5	4.0	3.0	5.4	7.2	6.3	4.8	2.9	1.8	1.0	0.7	0.4	0.3	0.2

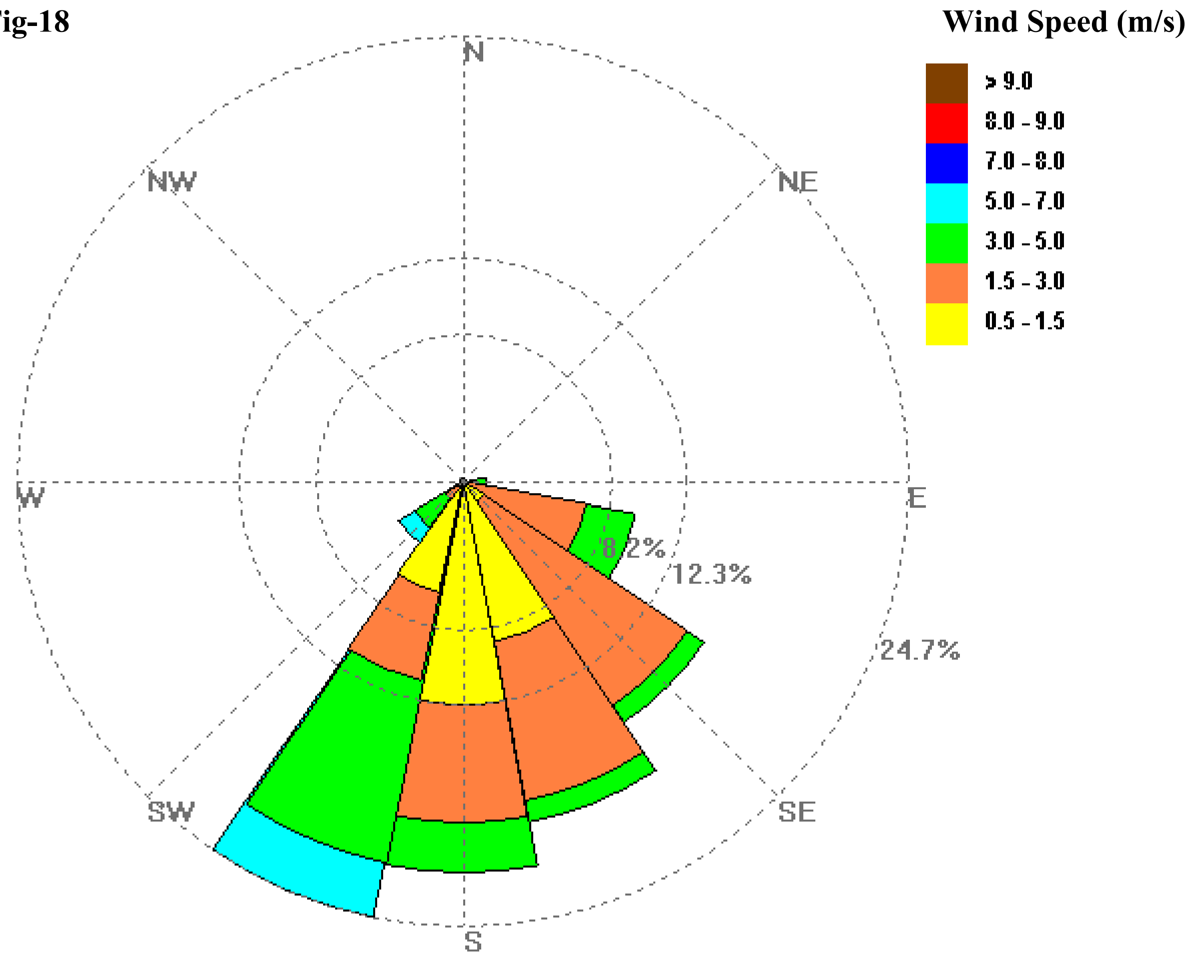
Wind Speed (m/s)

3.5 Wind Rose:

Fig-18 shows the Wind Rose based on 24 months data from May 2007 – April 2009 collected at 30 meters height. Wind Rose indicates that the wind direction is mostly between south east and south west. The average wind speed is 2.27 m/s and the percentage of wind speed greater than 5 m/s is 4.31%.

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

Fig-18



Average Wind Speed	Wind speed greater than 5 m/s	Comments
2.27 m/s	4.31%	

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

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

From this, power density is calculated as

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

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

From fluid dynamics, it can be proved that

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

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

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

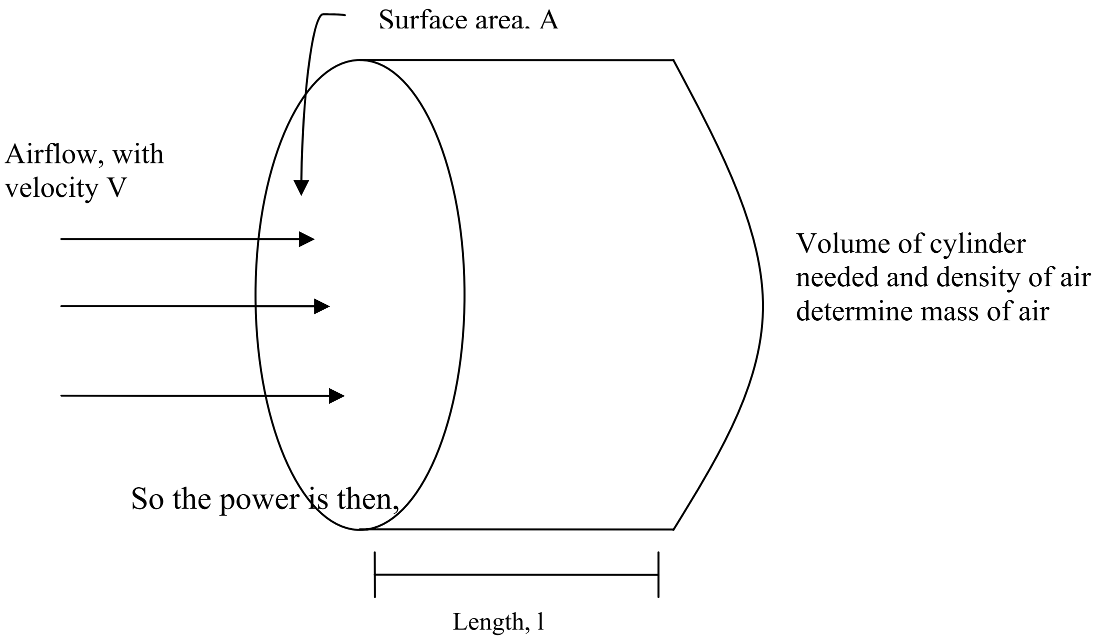
Now mass of wind can be written as

$$M = \varphi Avt$$

Differentiating

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

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



So the power is then,

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

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

And power density

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

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.

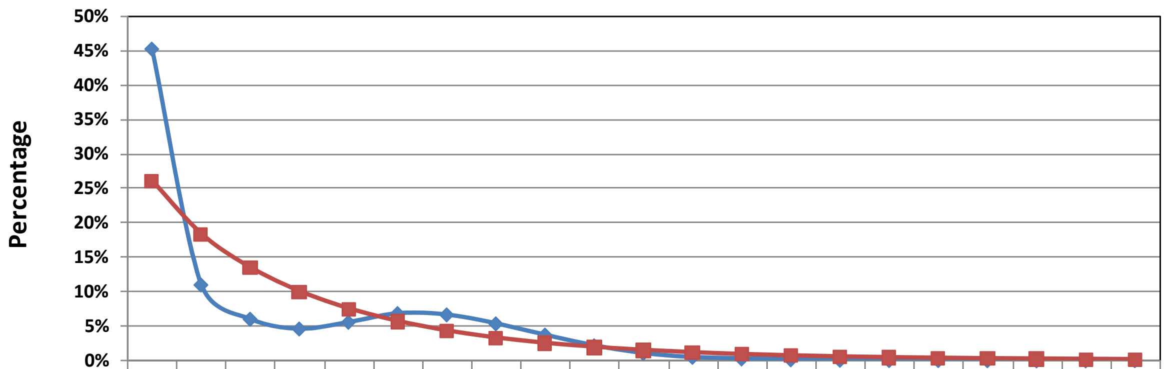
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion 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 Chitral (50 m height)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R.F 50m	45.2	11.0	6.1%	4.6%	5.6%	6.9%	6.7%	5.4%	3.8%	2.2%	1.1%	0.5%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%
Weibull 50m	26.0	18.3	13.4	10.0	7.5%	5.6%	4.3%	3.2%	2.5%	1.9%	1.4%	1.1%	0.8%	0.6%	0.5%	0.4%	0.3%	0.2%	0.2%	0.1%	0.1%

Wind Speed (m/s)

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in **Table-3** along with other key results of analysis. If we look at the shape parameters K and scale parameter C for 50 meters height we can find that the shape parameter K varies over a wind range from the lowest of 0.58 during November to the highest of 1.26 during the month of July with a Annual value of K being 0.98.

The lowest values of the scale parameter C, 1.14 is observed in November while the highest value of 4.41 is obtained in July and with an Annual value of 3.04.

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 1.09 m/s with Standard deviation of 1.0, at 30 meters this average speed is 2.29 m/s with Standard deviation of 2.19. At 50 meters the monthly average wind speed varies from the lowest of 1.81 m/s in November to highest of 4.10 m/s during July. Whereas the average wind speed is 3.02 m/s with Standard deviation of 3.08.

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 12.63 W/m^2 in January to 3.92 W/m^2 in December with Average of 6.26 W/m^2.

At 30 meters height the power density varies from 79.76 W/m^2 in January to 33.83 W/m^2 in December and the average values is about 49.67 W/m^2.

At 50 meters height the power density of Chitral varies from 175.17 W/m^2 in January to 94.09 W/m^2 in December. The average power density of the area is 126.40 W/m^2.

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

	10 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	1.27	1.32	1.43	0.96	**12.63**
February	1.61	1.68	1.81	0.95	**26.67**
March	1.34	1.36	1.33	0.98	**9.29**
April	0.88	0.79	0.91	1.12	**1.93**
May	0.87	0.84	0.89	1.05	**2.18**
June	1.08	0.94	1.14	1.17	**3.27**
July	1.38	1.11	1.48	1.26	**5.81**
August	1.37	1.05	1.49	1.34	**5.18**
September	1.06	0.91	1.13	1.19	**3.00**
October	0.71	0.57	0.77	1.28	**0.78**
November	0.60	0.46	0.65	1.33	**0.43**
December	0.96	1.03	0.92	0.93	**3.92**
Average	**1.09**	**1.00**	**1.16**	**1.13**	**6.26**
	30 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	2.12	2.35	2.40	0.90	**79.76**
February	2.66	2.82	3.00	0.94	**128.24**
March	2.30	2.32	2.29	0.99	**45.69**
April	1.98	1.83	2.04	1.09	**23.16**
May	2.37	2.11	2.47	1.13	**36.47**
June	2.78	2.22	3.00	1.28	**46.65**
July	3.04	2.35	3.30	1.32	**57.47**
August	2.93	2.26	3.18	1.32	**50.93**
September	2.27	2.15	2.33	1.06	**37.19**
October	1.76	1.89	1.70	0.93	**24.38**
November	1.36	1.95	1.04	0.68	**32.21**
December	1.88	2.10	1.77	0.89	**33.83**
Average	**2.29**	**2.19**	**2.38**	**1.04**	**49.67**
	50 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	2.66	3.01	3.01	0.88	**175.17**
February	3.31	3.53	3.21	0.93	**159.60**
March	2.90	2.95	2.87	0.98	**93.93**
April	2.62	2.66	2.60	0.98	**68.72**
May	3.19	3.04	3.26	1.06	**105.07**
June	3.82	3.32	4.32	1.17	**178.07**
July	4.10	3.32	4.41	1.26	**153.53**
August	3.93	3.22	4.22	1.24	**139.26**
September	3.06	3.13	3.02	0.98	**111.72**
October	2.37	2.82	2.14	0.83	**83.27**
November	1.81	3.00	1.14	0.58	**154.32**
December	2.47	2.94	2.23	0.83	**94.09**
Average	**3.02**	**3.08**	**3.04**	**0.98**	**126.40**

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 $\eta = 1$. 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, $\overline{P_{WTA}}$:

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

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

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

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 Chitral 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 Chitral 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 Chitral.

PMD Calculator (using 50M at Chitral) from May 2007 to April 2009				
Month	**Input W/m²**	**Output W/m²**	**C.F.**	**KWh / Month**
January	181	37	9%	42,154
February	167	38	10%	40,258
March	99	28	7%	31,499
April	72	22	6%	24,028
May	111	32	8%	36,452
June	188	51	13%	55,850
July	162	49	12%	55,224
August	147	45	11%	50,909
September	118	31	8%	34,396
October	87	21	5%	24,285
November	124	18	4%	19,202
December	98	23	6%	26,486
Annual	**119**	**32**	**8%**	**422,480**

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

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

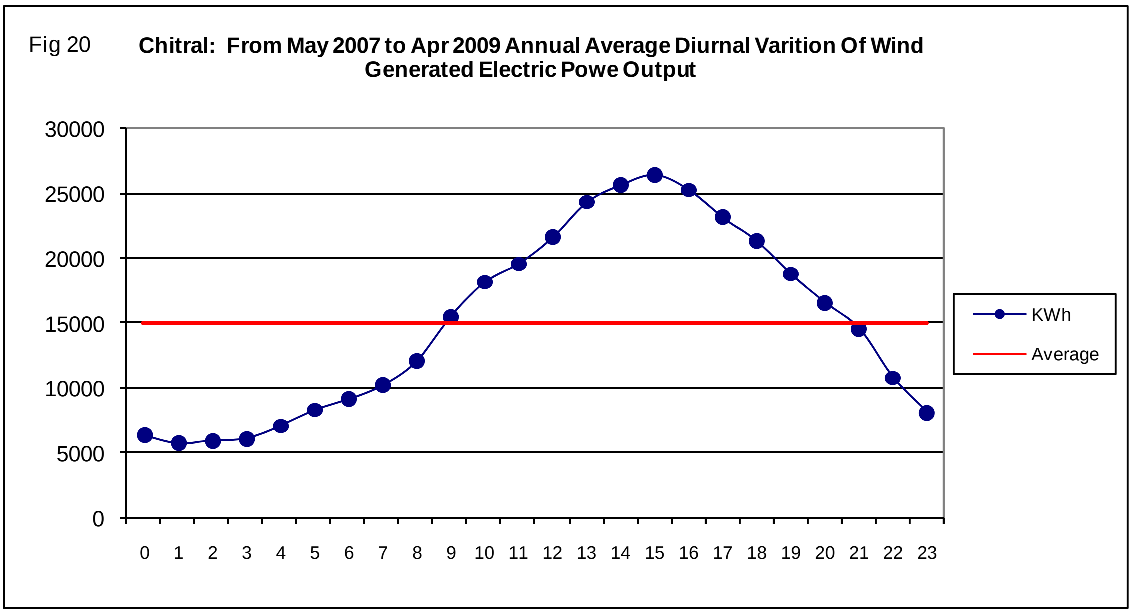


Fig 20
Chitral: From May 2007 to Apr 2009 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output
30000
25000
20000
15000
10000
5000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average

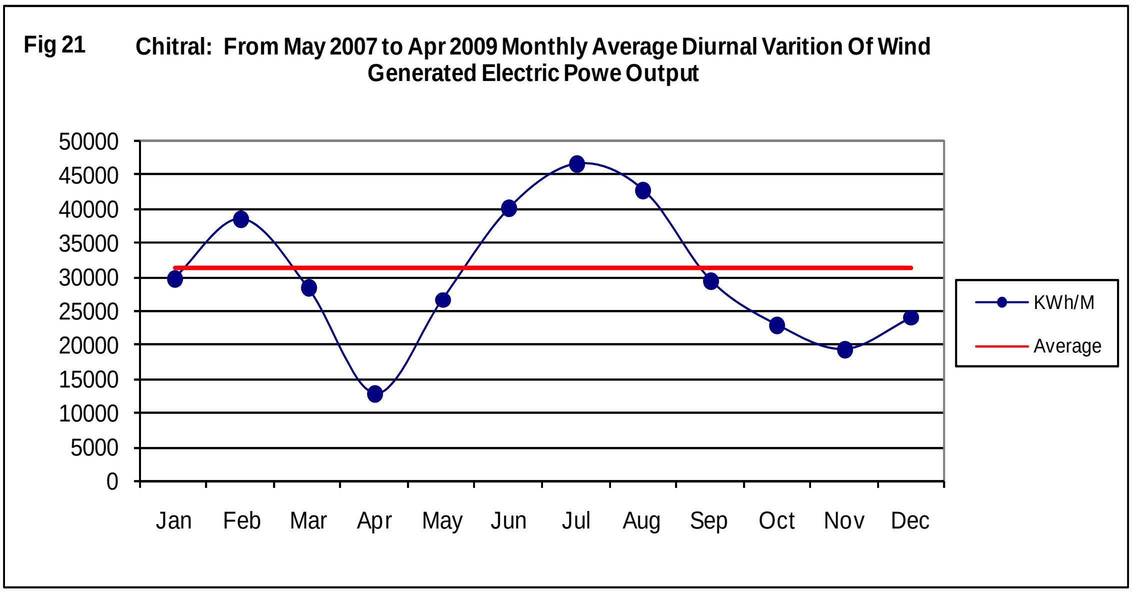


Fig 21
Chitral: From May 2007 to Apr 2009 Monthly Average Diurnal Varition Of Wind Generated Electric Powe Output
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
KWh/M
Average

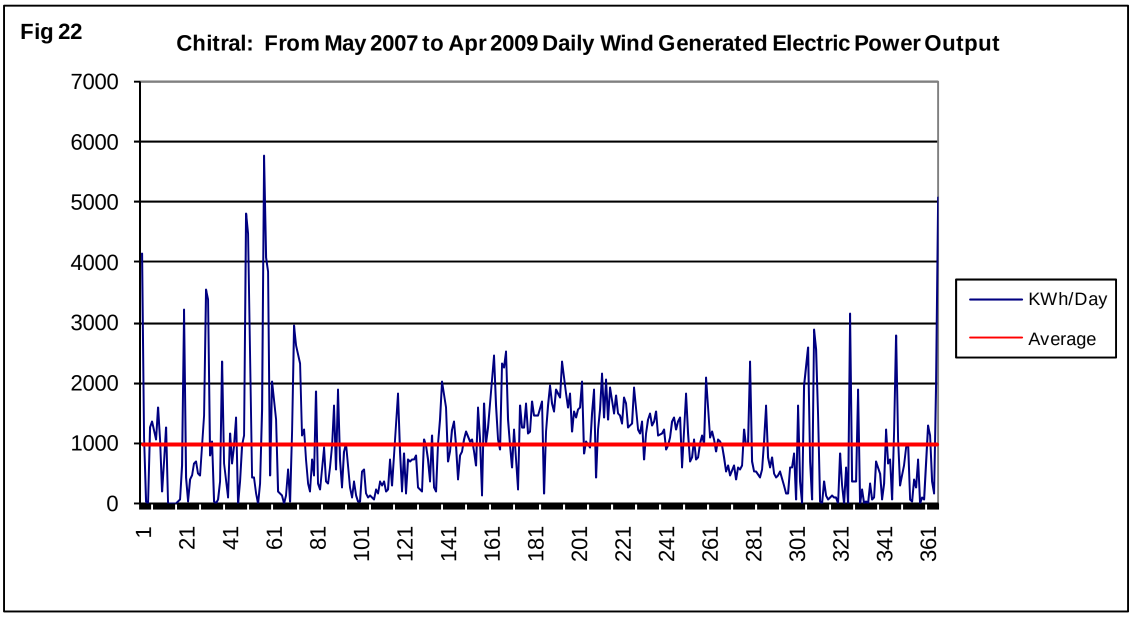


Fig 22
Chitral: From May 2007 to Apr 2009 Daily Wind Generated Electric Power Output
7000
6000
5000
4000
3000
2000
1000
0
1 21 41 61 81 101 121 141 161 181 201 221 241 261 281 301 321 341 361
KWh/Day
Average

Fig 23

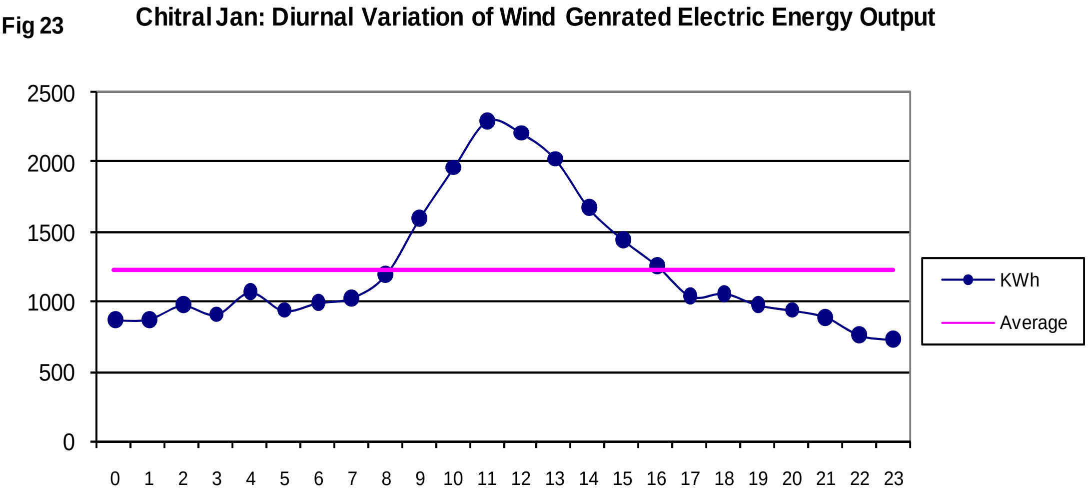
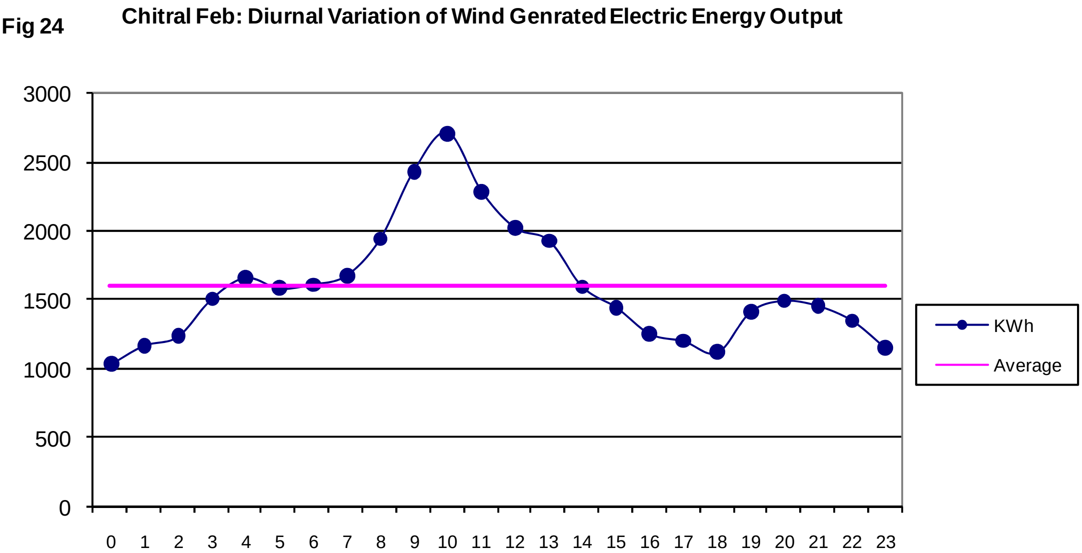
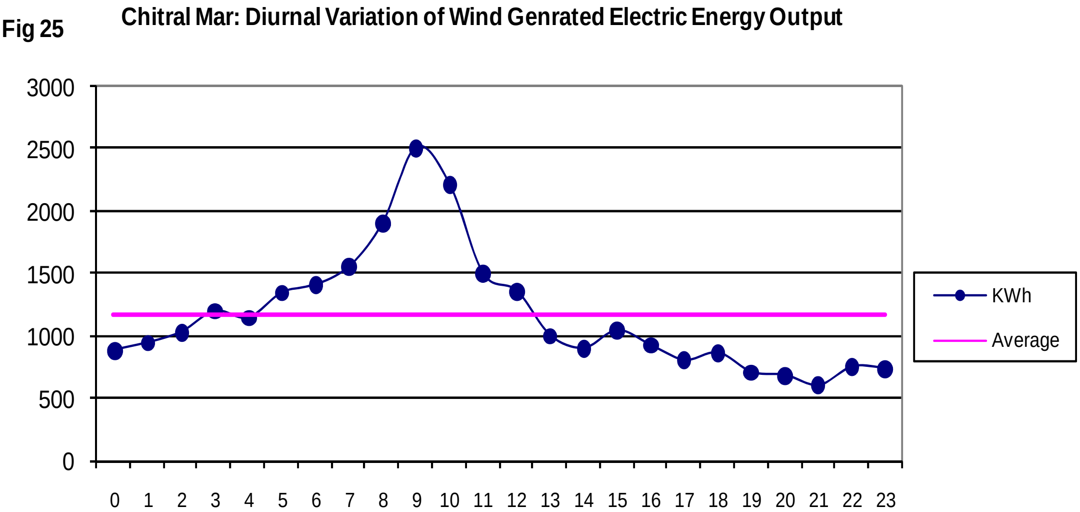


Fig 24



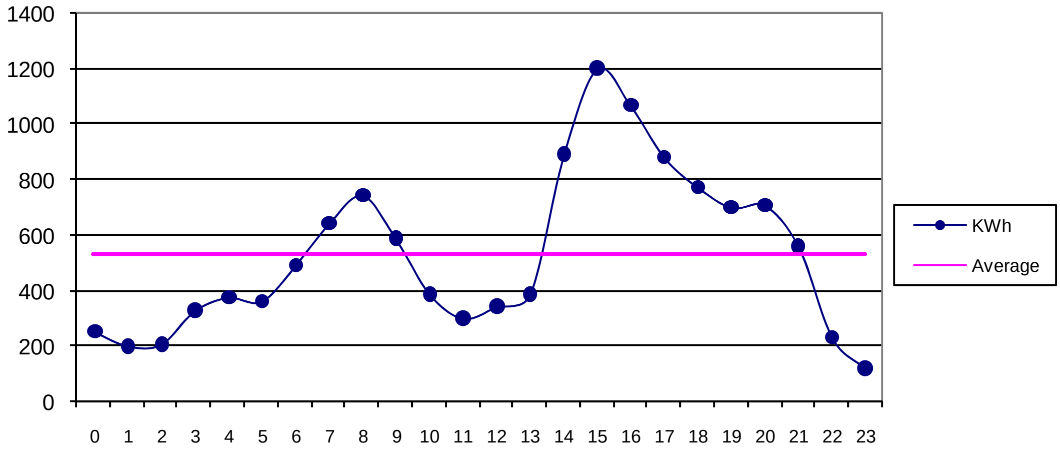
Source: Pakistan Meteorological Department

Fig 25



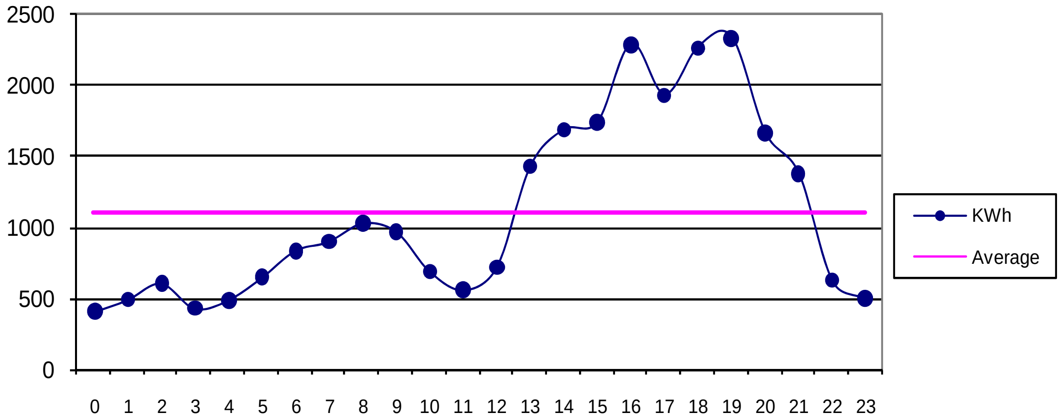
Source: Pakistan Meteorological Department

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



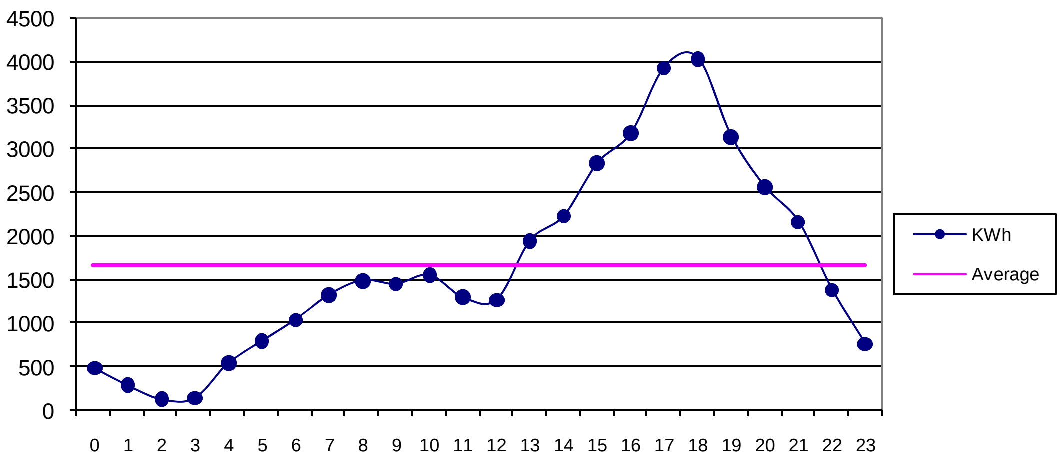
Source: Pakistan Meteorological Department

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



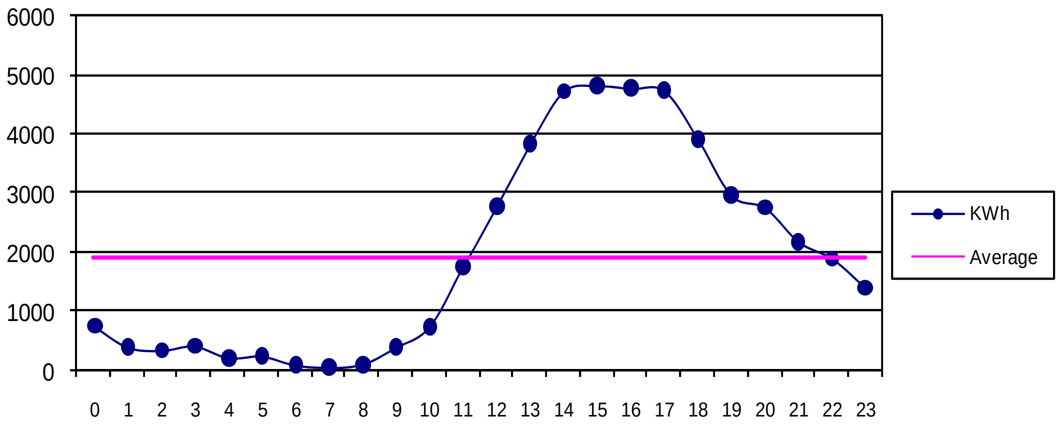
Source: Pakistan Meteorological Department

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



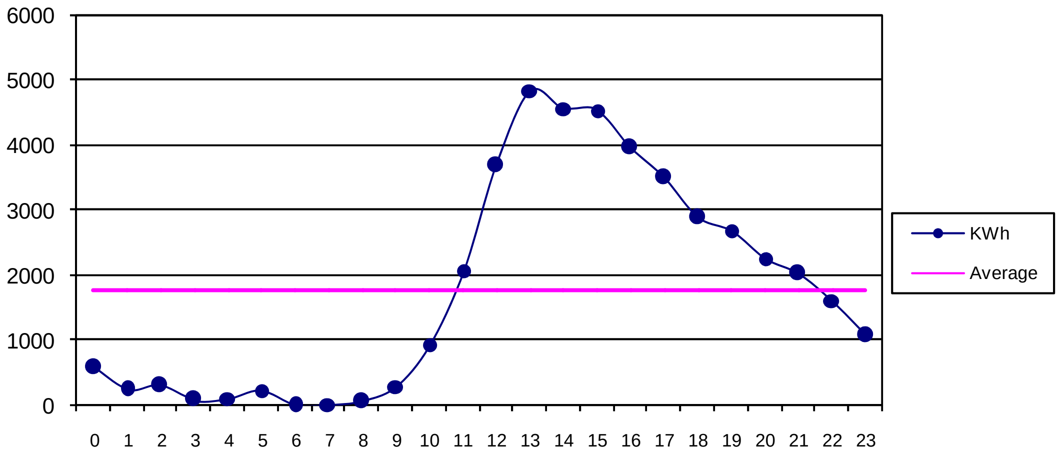
Source: Pakistan Meteorological Department

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



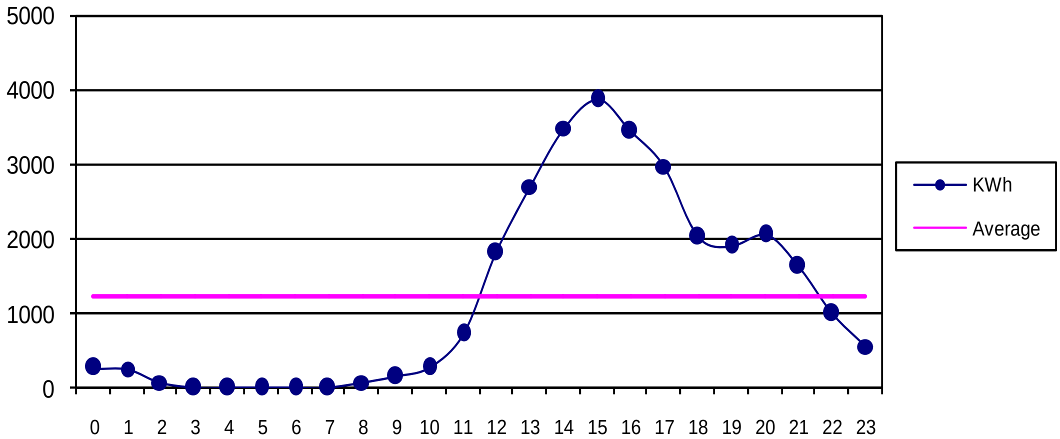
Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

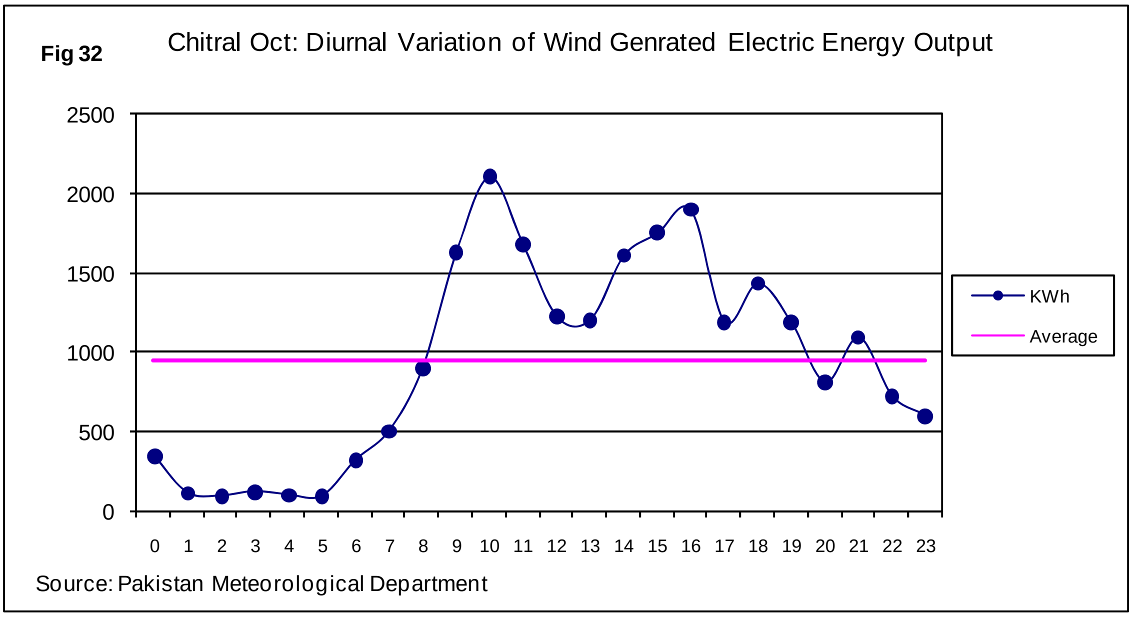


Fig 32
Chiltral Oct: Diurnal Variation of Wind Genrated Electric Energy Output
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

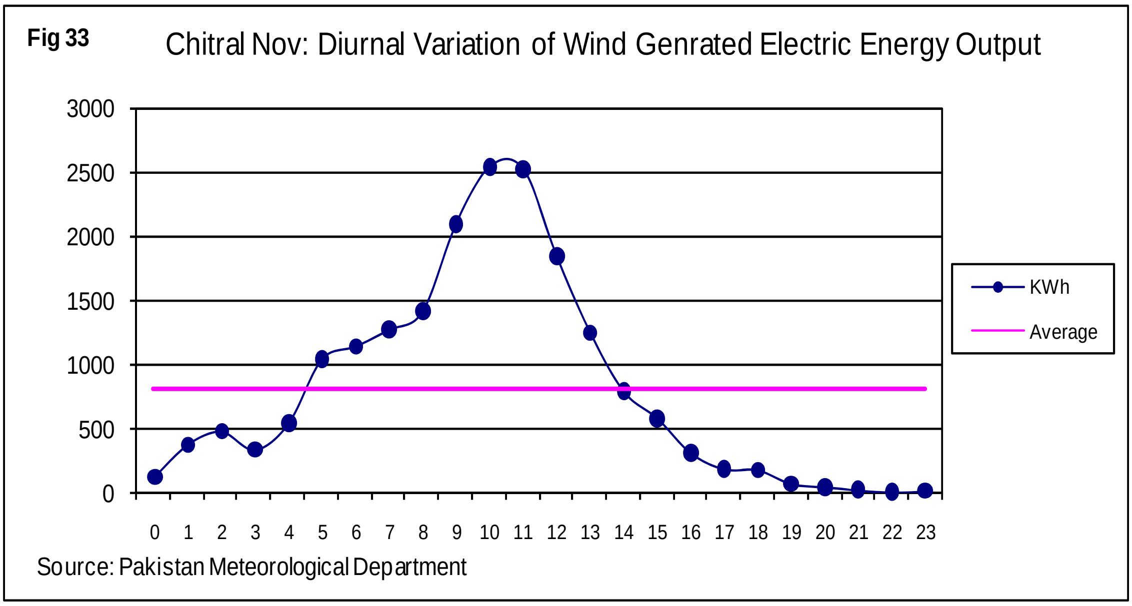


Fig 33
Chitral Nov: Diurnal Variation of Wind Genrated Electric Energy Output
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

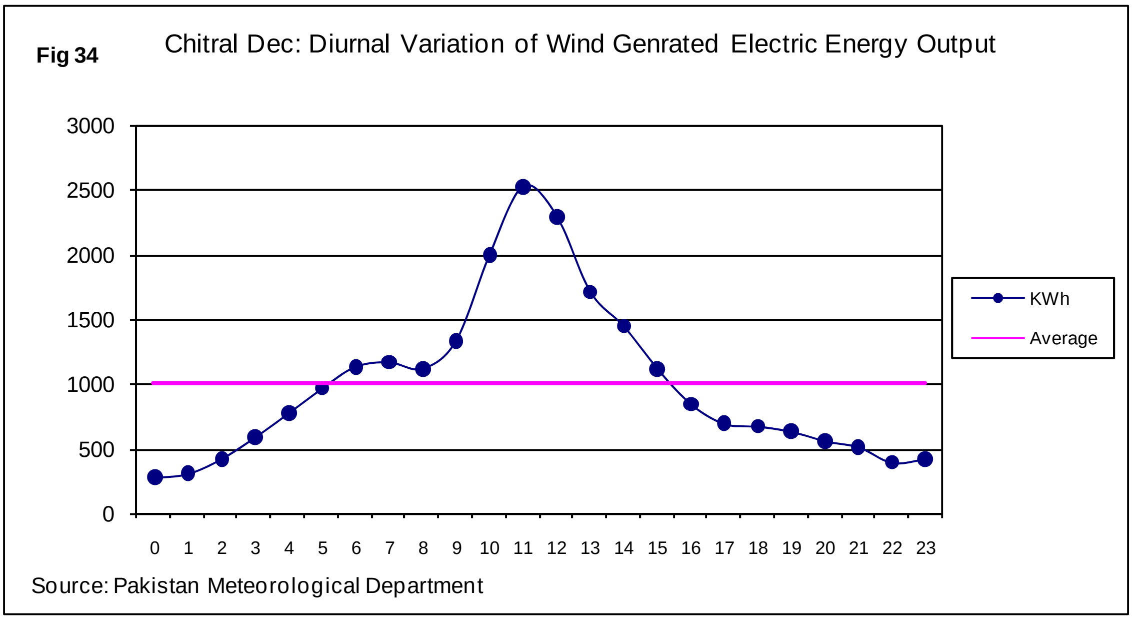
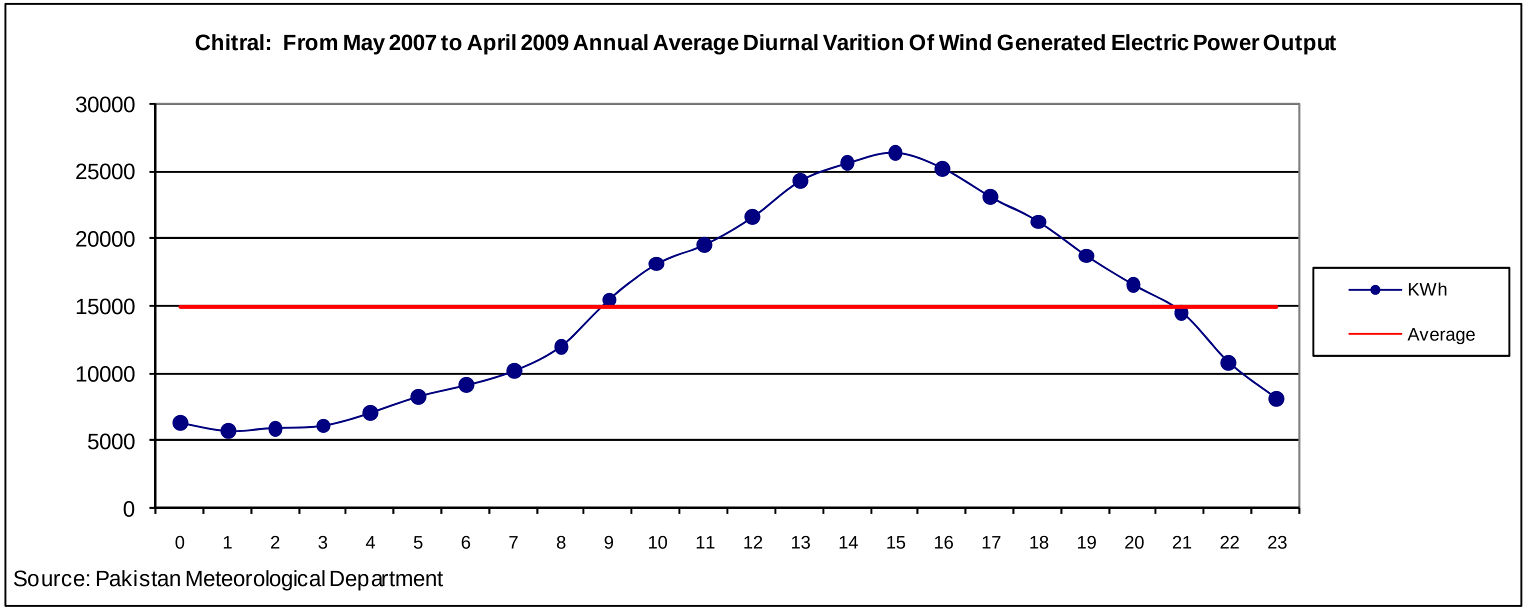


Fig 34
Chitral Dec: Diurnal Variation of Wind Genrated Electric Energy Output
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
Jan	867	873	971	907	1065	935	990	1026	1190	1595	1958	2296	2209	2023	1670	1444	1259	1039	1057	974	937	887	756	726	29655
Feb	1039	1176	1241	1511	1666	1589	1616	1681	1946	2438	2713	2289	2024	1933	1599	1451	1260	1208	1126	1423	1499	1461	1354	1154	38397
Mar	896	955	1038	1207	1153	1353	1418	1561	1910	2515	2218	1505	1368	1011	912	1053	933	815	873	718	694	613	763	749	28229
Apr	255	203	208	329	378	364	492	643	745	588	390	302	344	389	890	1202	1067	881	774	701	708	559	232	121	12762
May	404	489	604	428	487	646	833	898	1025	968	688	558	719	1428	1685	1736	2286	1929	2263	2333	1663	1376	625	501	26574
Jun	494	292	132	146	545	799	1045	1328	1496	1454	1555	1299	1274	1951	2231	2836	3179	3934	4039	3140	2565	2166	1388	765	40052
Jul	762	407	348	423	226	252	102	62	117	402	752	1769	2781	3840	4735	4832	4783	4746	3924	2974	2765	2190	1903	1407	46500
Aug	590	251	308	86	113	228	9	15	72	299	937	2072	3687	4837	4566	4534	3969	3497	2893	2685	2262	2019	1610	1067	42605
Sep	269	261	80	3	0	0	0	1	83	157	270	732	1820	2710	3492	3867	3448	2980	2031	1898	2049	1642	1009	560	29362
Oct	348	117	99	126	105	97	322	507	902	1627	2107	1681	1228	1206	1610	1751	1897	1193	1436	1185	811	1096	725	604	22781
Nov	127	380	483	342	544	1044	1145	1274	1416	2099	2542	2523	1845	1251	794	586	315	191	183	75	52	26	10	20	19265
Dec	280	310	424	591	775	969	1136	1172	1123	1339	2004	2530	2297	1716	1449	1123	847	696	675	636	562	516	397	425	23993
KWh	6329	5715	5936	6099	7057	8276	9109	10168	12026	15480	18133	19556	21595	24295	25631	26414	25244	23110	21273	18741	16567	14551	10772	8099	**360175**
Avg	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	15007	



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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	168	157	205	141	300	216	275	229	213	299	297	358	269	199	148	119	127	147	96	82	36	23	18	22	4143
2	10	0	0	0	0	0	0	0	0	30	52	86	76	38	36	46	53	46	69	140	172	108	83	50	1095
3	13	0	0	0	0	0	2	0	0	0	1	0	0	10	6	0	0	0	0	0	0	0	0	0	33
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	7
5	0	0	0	1	25	52	43	22	18	31	68	99	147	165	77	84	80	81	79	53	36	34	31	28	1251
6	30	33	27	36	39	27	34	34	42	36	58	69	66	61	53	53	91	114	121	102	69	69	47	42	1354
7	36	43	25	30	22	26	27	40	22	47	77	71	73	53	65	46	50	53	50	50	40	46	46	36	1073
8	33	42	39	37	59	53	57	53	71	83	115	86	84	77	83	57	91	70	63	61	57	70	68	76	1589
9	77	0	57	50	53	57	69	67	61	67	96	146	80	36	42	28	20	13	18	9	5	9	10	0	1073
10	0	0	0	0	0	0	0	0	0	0	0	3	19	19	3	7	1	0	0	0	4	44	53	47	200
11	36	53	57	67	46	23	0	0	0	15	33	58	41	54	33	30	20	15	20	11	13	27	30	26	710
12	25	47	95	110	53	1	6	36	63	59	37	66	90	82	73	73	69	56	62	56	46	31	12	9	1256
13	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	6
14	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
15	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
16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	3
18	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	10	41	66
19	7	4	0	2	10	0	0	4	7	0	0	0	28	33	22	13	36	31	31	50	73	85	96	89	621
20	109	108	115	140	153	121	108	102	166	172	159	202	222	204	204	222	172	102	153	84	105	62	1	15	3200
21	40	71	40	5	2	2	0	0	34	32	25	20	13	15	11	8	14	20	18	30	22	2	0	0	424
22	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7	0	0	0	0	0	0	23
23	0	0	0	0	0	0	0	0	0	8	33	84	66	47	34	36	26	11	15	3	3	16	11	0	391
24	0	16	19	6	16	0	6	7	33	36	50	35	14	18	67	50	28	15	22	22	12	0	0	0	472
25	0	0	0	4	36	67	64	55	44	61	69	90	71	66	33	13	0	0	0	0	0	0	0	0	674
26	0	0	0	0	0	2	2	0	0	17	93	83	63	59	53	22	31	39	23	39	36	39	42	47	690
27	59	65	71	51	12	9	13	42	24	7	0	0	0	3	8	14	15	15	18	9	23	18	10	2	490
28	0	0	0	0	0	0	0	0	14	43	23	18	25	16	48	50	59	45	13	22	20	18	18	18	449
29	16	41	20	1	2	13	4	7	12	23	61	75	121	115	83	92	62	67	83	57	89	121	128	165	1458
30	191	192	187	213	199	204	153	121	159	232	237	228	228	248	219	231	149	34	27	20	22	33	4	0	3533
31	0	0	13	13	37	62	121	209	205	296	373	417	413	398	268	142	64	59	77	73	52	25	39	13	3368
KWh	867	873	971	907	1065	935	990	1026	1190	1595	1958	2296	2209	2023	1670	1444	1259	1039	1057	974	937	887	756	726	29655

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	2	12	6	0	23	12	20	17	25	26	123	65	59	58	61	30	40	36	33	27	33	33	22	36	800
2	40	29	79	43	50	55	43	43	45	17	25	30	27	47	61	53	58	46	98	61	36	23	15	14	1037
3	7	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	2	1	0	0	0	0	32
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	6	32	0	0	0	0	60
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	16	39	108	96	103	365
7	122	53	53	57	84	65	97	104	127	96	155	181	166	179	166	103	108	89	73	71	51	68	60	24	2354
8	12	4	0	4	0	5	10	3	1	27	67	48	63	69	67	54	38	27	30	20	30	25	27	21	655
9	16	0	9	17	9	4	1	0	8	0	0	0	0	0	4	20	0	0	0	0	0	0	0	0	90
10	0	0	0	0	0	14	47	28	92	217	153	115	96	32	16	9	12	20	47	52	38	51	65	61	1167
11	39	53	33	33	40	40	33	36	33	57	77	43	46	46	30	20	1	0	0	0	0	0	0	0	659
12	0	0	0	0	0	9	46	51	0	33	127	133	84	83	71	51	20	27	39	27	26	27	39	58	952
13	83	108	159	140	96	45	24	98	96	102	153	108	90	53	23	18	31	7	0	0	0	0	0	0	1434
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	3
15	0	0	0	0	0	0	0	0	0	0	0	0	0	14	25	25	22	20	20	30	37	66	59	58	376
16	43	46	39	50	40	47	33	47	51	53	42	36	36	42	42	20	27	36	38	64	53	33	13	27	956
17	13	11	13	2	6	0	0	0	0	0	0	0	2	20	18	36	104	98	108	102	101	146	185	166	1132
18	228	251	222	228	237	247	224	233	264	313	264	282	314	280	226	158	117	185	96	54	83	105	105	92	4810
19	115	103	162	262	272	298	281	183	165	217	261	160	160	228	162	196	219	242	165	266	207	83	51	8	4465
20	4	23	17	30	33	33	7	0	0	0	0	51	46	42	36	33	12	1	3	9	46	16	2	0	444
21	0	5	2	2	0	0	0	0	0	0	0	0	0	20	90	48	21	25	10	57	27	37	36	41	419
22	0	0	0	4	0	1	0	0	0	0	0	2	1	50	8	47	22	15	2	0	0	0	0	0	153
23	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
24	0	0	0	0	0	0	0	0	20	53	68	27	34	21	10	56	36	4	0	0	0	0	0	0	330
25	0	0	0	0	0	12	61	95	95	302	213	138	89	54	37	47	24	22	18	38	62	66	73	97	1542
26	102	199	227	247	281	292	306	322	336	355	407	322	209	177	161	158	182	151	155	251	300	266	252	98	5758
27	100	144	108	252	311	187	156	199	324	237	210	237	316	230	126	115	89	80	60	84	127	135	133	129	4085
28	113	128	111	140	184	223	227	222	262	314	300	247	117	143	119	116	71	52	118	128	147	147	121	96	3845
29	0	0	0	0	0	0	0	0	0	19	67	61	67	46	39	18	1	7	2	32	56	26	1	28	470
KWh	1039	1176	1241	1511	1666	1589	1616	1681	1946	2438	2713	2289	2024	1933	1599	1451	1260	1208	1126	1423	1499	1461	1354	1154	38397

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	76	146	155	106	62	86	46	52	47	75	73	108	121	50	39	58	78	47	55	94	166	102	59	108	2008
2	77	39	46	55	42	101	65	50	73	87	77	39	123	87	63	48	75	77	50	55	18	16	8	4	1376
3	4	12	0	0	0	0	0	0	1	0	0	0	1	1	7	46	27	1	43	53	4	0	1	0	202
4	0	2	0	0	0	0	0	0	0	0	1	1	23	15	19	20	18	51	19	8	4	0	0	0	181
5	0	0	0	0	0	0	0	0	0	0	0	21	82	8	8	0	0	1	0	0	0	0	10	6	136
6	2	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	12
7	32	18	0	0	0	0	0	0	0	0	1	0	0	5	1	1	2	58	6	1	0	0	0	0	127
8	0	0	0	0	0	0	0	0	0	33	46	50	23	30	13	79	95	67	39	27	25	18	20	10	575
9	12	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	0	2	0	0	1	0	0	19
10	0	0	0	0	0	0	8	1	15	44	57	51	28	28	48	24	24	57	73	89	121	166	204	165	1202
11	217	159	226	282	162	162	163	208	230	255	154	94	61	56	78	44	81	96	70	46	37	36	20	10	2947
12	28	27	47	31	6	6	78	123	204	289	346	269	244	160	69	63	67	73	95	67	77	89	80	89	2629
13	67	70	120	204	179	133	153	171	184	166	226	167	100	60	50	43	40	13	20	15	18	20	53	60	2332
14	34	35	20	10	30	81	88	80	90	169	111	85	75	35	22	17	15	9	12	30	25	25	18	20	1136
15	20	39	36	34	26	46	55	59	90	108	164	78	46	39	39	32	28	12	19	27	24	15	30	165	1230
16	77	48	18	37	28	34	25	32	28	22	25	22	36	8	40	80	24	34	28	2	59	2	14	1	723
17	27	111	42	2	0	0	0	0	0	0	0	0	1	62	28	19	27	2	0	0	0	0	0	0	323
18	0	0	21	15	9	0	6	9	1	57	39	34	4	2	0	0	3	0	0	0	0	0	0	0	202
19	0	0	0	26	48	84	76	74	124	96	43	27	20	8	8	61	28	2	0	0	0	0	0	0	723
20	0	0	0	0	0	0	0	0	1	119	47	44	10	3	6	8	10	16	39	2	8	0	117	40	472
21	69	153	217	238	275	228	217	75	90	108	52	26	6	10	28	30	10	15	0	0	0	0	0	0	1848
22	0	0	0	0	0	0	4	6	0	9	39	64	38	31	6	4	21	14	1	2	34	35	15	9	333
23	12	2	1	0	0	0	0	0	0	20	74	57	40	15	2	0	5	1	0	0	0	0	0	1	230
24	0	0	0	45	63	108	126	141	99	159	70	39	42	11	0	10	12	0	0	0	0	0	0	0	923
25	0	0	0	0	0	0	0	0	0	36	28	30	2	3	10	3	2	0	92	62	17	13	63	2	364
26	0	0	0	0	0	0	2	0	0	0	66	40	76	67	32	36	4	2	0	0	0	3	0	7	335
27	50	7	0	0	0	0	0	65	40	34	1	0	0	22	157	127	54	27	15	0	0	0	0	2	600
28	1	0	0	0	0	0	1	0	95	145	117	44	5	13	50	81	98	108	49	59	26	30	30	26	976
29	59	53	50	67	153	202	222	202	173	85	89	19	68	60	21	8	2	17	36	28	4	1	0	0	1619
30	0	0	0	0	0	0	0	0	27	61	63	47	53	68	25	63	44	3	80	3	4	0	0	18	558
31	30	33	40	54	70	82	83	212	299	337	210	51	41	50	43	45	34	13	28	44	23	42	21	7	1890
KWh	896	955	1038	1207	1153	1353	1418	1561	1910	2515	2218	1505	1368	1011	912	1053	933	815	873	718	694	613	763	749	28229

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	15	12	0	0	0	14	30	28	63	70	8	10	2	10	20	36	51	31	45	53	65	118	45	5	733
2	9	13	1	0	0	0	0	0	0	2	10	26	26	14	15	16	12	12	14	32	21	8	7	12	249
3	5	1	0	0	0	0	0	3	0	9	1	11	4	5	120	271	240	174	10	4	0	2	2	0	862
4	0	0	0	0	1	0	0	1	0	1	14	44	182	94	68	136	43	95	156	46	45	30	39	12	1009
5	12	12	2	2	5	7	2	0	0	1	0	0	0	12	45	44	62	42	1	0	1	1	1	3	256
6	0	0	0	2	2	0	0	0	0	3	0	4	0	12	7	33	13	16	3	0	0	0	0	0	95
7	0	0	0	4	3	0	0	0	0	1	0	5	3	55	83	118	78	7	3	1	0	0	0	0	361
8	0	0	0	0	0	0	0	0	0	0	0	0	14	25	1	1	1	3	5	34	26	11	0	0	121
9	1	0	0	0	2	1	4	0	0	0	0	0	0	0	10	4	10	4	0	0	0	0	0	0	37
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	1	22	2	2	0	0	33
11	0	0	0	0	0	0	0	0	9	23	1	4	0	6	9	38	59	47	43	140	124	38	1	0	540
12	0	0	0	0	0	0	0	0	0	0	0	0	0	50	204	147	88	50	31	0	0	0	0	0	570
13	0	0	0	0	0	0	0	0	0	0	13	18	3	0	9	27	9	15	33	22	0	0	0	0	149
14	0	0	0	0	0	0	0	0	72	26	0	6	1	0	0	0	0	4	0	0	0	0	2	0	112
15	0	1	0	1	0	0	0	0	5	16	65	30	7	0	2	0	0	0	4	0	0	0	0	0	131
16	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0	17	21	21	0	0	0	0	0	0	67
17	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	39	40	30	25	36	25	12	0	6	236
18	0	0	0	0	0	0	0	0	0	0	0	0	0	2	24	33	46	27	11	3	11	0	0	0	158
19	0	0	0	0	0	0	0	0	0	0	0	1	24	15	24	50	50	61	21	69	26	31	2	0	373
20	0	0	0	0	0	0	0	0	15	77	26	20	0	12	1	0	0	0	0	0	31	88	5	8	284
21	35	10	0	0	0	9	23	12	39	18	2	0	1	6	1	13	68	55	39	24	4	5	4	0	368
22	0	0	0	0	1	0	0	0	0	0	0	0	0	4	94	11	6	28	4	2	3	15	24	0	194
23	4	0	3	6	27	4	0	0	4	30	39	8	0	0	4	20	35	53	8	0	0	0	0	0	246
24	0	0	0	0	0	0	10	147	153	102	71	22	8	1	0	0	0	10	0	17	159	34	8	0	743
25	0	0	0	0	29	33	50	53	38	20	6	0	0	2	0	0	0	2	0	0	25	50	0	0	309
26	0	0	55	67	50	44	77	73	46	61	33	30	23	4	2	0	0	10	51	53	2	9	47	71	810
27	172	134	102	179	185	179	204	204	109	53	33	32	27	11	70	52	17	14	22	23	2	0	0	0	1821
28	0	19	47	67	72	73	90	121	191	76	67	31	11	2	0	0	1	2	2	0	0	0	0	0	872
29	0	0	0	0	0	0	0	0	0	0	1	0	0	20	7	15	40	51	2	3	14	4	22	2	182
30	0	0	0	0	0	0	0	0	0	0	0	0	2	23	45	77	77	17	240	115	121	102	23	0	841
KWh	255	203	208	329	378	364	492	643	745	588	390	302	344	389	890	1202	1067	881	774	701	708	559	232	121	12762

Chitral **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	0	0	0	0	0	0	0	0	56	31	5	0	0	1	2	2	0	5	12	40	20	2	0	0	177
2	0	0	0	0	18	84	114	83	128	128	102	47	25	12	0	0	2	0	0	0	0	0	0	0	743
3	0	0	0	0	0	0	0	0	0	28	27	33	0	2	15	2	60	122	216	36	54	69	35	0	701
4	2	0	2	27	44	53	33	39	43	36	7	0	2	45	129	15	86	28	41	9	48	28	9	0	726
5	6	45	79	33	33	0	0	0	0	0	0	0	0	1	40	22	4	0	9	49	172	133	43	50	720
6	65	61	53	50	46	53	79	71	96	78	55	51	28	2	0	0	0	0	0	0	0	0	0	0	788
7	0	0	0	0	0	0	0	0	0	0	5	4	0	1	0	1	27	23	30	159	15	8	0	0	274
8	0	0	0	0	0	0	0	0	0	0	0	0	6	23	33	6	26	14	15	53	33	0	0	0	211
9	0	0	0	0	0	0	0	0	1	4	2	7	72	121	65	42	138	59	217	228	91	25	1	0	1071
10	0	0	0	0	0	0	0	0	0	0	1	24	53	61	77	53	77	101	84	121	166	108	27	0	954
11	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	43	134	105	140	121	79	86	23	2	736
12	0	0	0	0	0	0	0	0	15	61	29	25	8	0	0	2	4	39	53	67	22	40	8	0	376
13	0	0	2	0	0	0	0	0	0	0	3	27	44	92	63	80	147	175	145	210	42	88	4	0	1121
14	0	2	0	0	0	0	0	0	0	4	51	27	25	0	12	21	30	20	4	32	23	15	3	0	269
15	0	0	0	0	0	0	0	0	0	0	0	1	22	48	62	44	1	1	2	1	8	0	0	0	190
16	1	0	6	0	1	0	0	0	46	53	13	20	69	17	42	151	58	92	38	30	102	135	52	53	979
17	63	65	50	43	84	71	109	114	83	40	40	36	25	8	33	50	120	86	91	103	29	9	19	17	1387
18	47	70	122	128	108	198	134	159	59	98	41	43	14	118	72	8	31	56	16	52	115	127	89	128	2031
19	60	124	206	140	115	128	120	102	140	48	13	13	30	5	5	7	8	37	99	134	37	8	6	0	1582
20	2	20	36	1	31	50	67	71	57	55	50	50	43	16	16	38	45	6	41	6	2	0	0	0	704
21	0	0	0	0	0	0	0	0	153	153	37	11	0	0	34	71	63	41	5	24	89	96	77	15	870
22	2	0	1	0	0	0	0	0	1	43	42	7	1	18	125	189	171	102	64	129	122	67	54	98	1235
23	132	74	45	6	0	7	78	66	17	2	70	65	5	39	78	59	197	114	122	105	41	17	1	1	1341
24	0	0	0	0	0	0	0	0	0	0	0	5	47	203	67	80	242	135	90	67	22	0	0	0	959
25	2	0	0	0	8	0	0	0	0	2	31	9	62	75	59	74	11	25	22	4	4	4	0	0	390
26	0	0	0	0	0	0	0	0	0	1	6	5	0	0	81	145	114	70	104	174	100	2	1	0	805
27	0	0	0	0	0	0	1	0	0	0	1	20	24	115	238	75	51	111	61	75	57	31	16	0	876
28	0	0	0	0	0	0	0	0	0	0	2	2	11	24	69	114	123	181	116	140	102	139	28	0	1049
29	0	0	0	0	0	0	0	0	1	0	8	3	27	189	163	180	155	52	26	15	12	124	113	136	1203
30	22	27	2	0	0	0	0	0	1	0	0	0	45	120	25	104	131	69	329	98	40	8	16	2	1041
31	0	0	0	0	0	2	96	191	128	102	50	26	27	72	80	58	27	61	71	51	15	6	2	0	1066
KWh	404	489	604	428	487	646	833	898	1025	968	688	558	719	1428	1685	1736	2286	1929	2263	2333	1663	1376	625	501	26574

Chitral 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	0	0	0	0	0	0	0	0	0	2	39	32	4	7	58	83	114	110	96	56	64	154	23	12	851
2	2	0	0	0	0	0	0	0	0	0	0	0	5	28	44	30	77	71	53	83	57	65	61	50	629
3	21	0	0	0	0	0	0	0	3	36	43	82	138	299	275	116	90	96	66	116	108	50	30	26	1595
4	1	0	0	0	0	0	0	0	0	0	2	31	93	85	66	71	104	104	140	180	126	54	2	0	1058
5	2	0	0	0	0	0	0	0	6	11	45	34	7	4	4	2	5	1	1	4	6	1	1	0	131
6	0	2	0	23	115	214	222	179	153	77	50	27	15	25	36	52	65	115	81	51	55	40	30	20	1648
7	8	0	0	0	0	0	0	0	0	43	19	15	25	47	74	134	127	114	108	87	78	67	41	1	989
8	0	0	0	1	24	10	34	83	84	75	7	2	3	4	8	18	90	170	319	122	95	73	36	8	1267
9	0	0	0	57	98	140	89	140	134	97	61	51	50	32	16	25	20	84	187	147	69	61	47	44	1649
10	6	0	0	0	108	184	222	243	272	187	218	145	60	64	90	127	114	107	82	57	65	51	21	23	2449
11	60	61	44	39	83	47	61	134	159	160	67	24	27	49	93	108	103	70	61	71	58	26	2	0	1608
12	0	0	0	0	0	0	0	0	0	1	6	33	63	95	97	114	125	154	150	68	62	63	33	4	1069
13	31	7	0	0	0	0	0	0	0	1	2	26	60	92	81	85	108	96	47	53	80	42	56	36	903
14	49	89	37	3	10	49	121	127	39	30	51	75	43	17	43	72	138	300	326	119	152	199	165	62	2313
15	37	14	17	5	2	7	7	49	44	9	58	46	58	83	153	190	209	276	279	185	154	107	125	150	2264
16	76	45	19	0	0	0	15	8	27	25	106	136	99	96	41	132	272	306	300	197	185	224	139	58	2504
17	37	10	2	6	1	16	108	96	96	70	10	2	24	62	77	100	67	86	156	152	136	61	16	14	1405
18	1	0	0	0	0	0	0	0	1	0	0	2	14	97	101	116	124	181	135	44	66	46	15	2	947
19	0	0	0	0	0	2	0	1	0	0	34	19	5	1	3	23	46	87	89	114	79	64	23	0	591
20	0	0	0	0	0	0	0	2	3	13	55	62	41	38	35	60	88	169	191	149	154	117	43	12	1234
21	0	0	0	0	0	0	0	0	0	3	3	6	9	7	15	50	47	55	9	2	2	32	2	0	242
22	1	0	0	0	0	0	0	0	24	27	11	21	28	33	57	66	96	216	259	285	246	122	88	32	1612
23	0	0	0	0	0	0	0	0	0	1	14	20	42	55	68	81	99	167	293	190	92	55	47	18	1242
24	0	0	0	0	0	34	63	96	110	104	68	79	79	78	97	102	123	57	24	30	37	23	28	23	1253
25	43	25	8	0	0	0	4	88	212	334	327	84	16	1	23	55	65	110	51	73	71	47	14	0	1650
26	0	0	0	0	0	0	0	0	1	5	68	69	72	105	108	204	105	99	99	112	35	42	28	9	1160
27	0	0	0	0	0	0	0	0	2	15	48	81	94	93	123	131	154	106	98	67	53	50	47	36	1197
28	42	0	0	13	102	96	96	77	108	75	22	10	15	178	80	146	181	154	61	48	43	38	46	46	1677
29	33	10	0	0	0	0	0	2	17	36	79	45	51	88	164	194	85	115	149	84	71	79	80	58	1441
30	45	29	4	0	0	0	0	0	0	18	41	42	33	89	99	151	137	158	129	193	69	113	100	22	1472
KWh	494	292	132	146	545	799	1045	1328	1496	1454	1555	1299	1274	1951	2231	2836	3179	3934	4039	3140	2565	2166	1388	765	40052

Chitral **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	0	0	0	0	0	0	0	0	0	1	19	75	107	172	192	154	110	138	104	101	99	84	46	55	1459
2	40	21	2	0	0	0	0	0	0	0	21	65	66	52	111	231	223	217	187	219	111	71	49	11	1698
3	0	0	0	0	0	0	0	0	6	1	4	1	1	2	1	0	0	37	7	15	93	7	0	0	176
4	19	2	0	0	0	0	0	0	2	2	23	51	13	26	68	107	161	197	154	113	77	67	71	25	1177
5	2	0	0	0	0	0	0	0	1	1	2	13	46	96	179	197	224	139	126	93	187	139	119	46	1609
6	43	2	0	0	11	50	7	0	0	1	7	63	131	149	84	146	265	350	242	116	81	114	56	33	1951
7	73	29	40	83	70	8	3	0	2	5	15	96	137	219	207	172	69	43	57	113	71	46	55	50	1664
8	35	22	0	0	0	7	0	0	0	1	4	18	97	108	190	172	125	137	149	83	60	106	129	74	1517
9	57	0	57	232	38	0	0	0	11	107	84	193	150	110	86	68	92	121	115	110	89	64	62	29	1876
10	28	11	0	0	0	0	0	0	0	0	9	63	146	162	242	280	156	123	62	80	127	127	110	100	1827
11	37	2	0	0	0	0	0	0	0	3	27	71	121	182	223	185	211	150	143	89	82	91	79	74	1768
12	10	0	0	0	0	0	1	0	8	56	62	111	151	228	269	216	211	166	145	116	166	192	133	110	2351
13	58	46	28	0	0	0	0	0	0	3	6	29	68	154	143	206	191	269	281	129	68	71	40	33	1823
14	0	0	0	0	0	0	0	0	1	2	12	48	76	79	63	113	178	253	192	94	115	84	191	95	1595
15	46	174	107	72	105	185	88	59	70	40	56	36	14	17	73	104	124	165	88	82	66	30	35	0	1834
16	0	0	0	0	0	0	0	2	0	40	46	52	76	86	83	121	137	169	127	71	66	46	36	24	1180
17	1	0	0	0	0	0	0	0	1	4	13	13	38	85	186	149	131	185	141	149	194	102	80	38	1511
18	28	27	0	0	0	0	0	0	2	4	6	15	46	77	89	77	63	197	83	94	177	192	144	87	1409
19	42	4	0	0	0	0	0	0	0	5	18	42	79	149	178	188	157	137	115	148	130	42	68	60	1560
20	61	28	101	32	1	0	3	1	10	53	47	44	31	92	206	204	134	35	79	20	19	67	89	219	1576
21	65	2	0	0	1	0	0	0	0	51	81	244	245	241	325	287	197	114	155	12	0	1	0	0	2021
22	11	0	0	4	0	0	0	0	0	0	2	18	80	79	33	37	198	162	70	26	50	52	1	0	823
23	4	2	2	0	0	0	0	0	0	3	5	67	91	61	40	70	204	139	87	50	94	72	36	9	1036
24	0	0	0	0	0	0	0	0	0	0	4	24	77	151	115	96	58	88	84	44	29	28	63	48	911
25	8	11	9	0	0	0	0	0	1	3	34	10	50	112	255	249	176	118	192	174	78	0	0	0	1480
26	0	0	0	0	0	0	0	0	0	0	22	38	187	327	254	239	260	223	149	76	64	42	0	0	1881
27	2	0	0	0	0	1	0	0	1	0	3	2	26	46	30	66	53	55	26	88	34	1	0	0	432
28	0	0	0	0	0	0	0	0	0	0	5	34	55	56	107	114	134	194	162	154	100	63	29	4	1213
29	0	0	0	0	0	0	0	0	0	0	44	106	92	92	99	160	191	172	166	130	79	81	73	84	1569
30	72	24	1	0	0	0	0	0	0	18	74	110	195	237	340	297	200	127	154	110	71	44	40	40	2154
31	20	0	0	0	0	0	0	0	0	0	1	18	91	191	262	125	151	128	78	74	89	63	71	58	1421
KWh	762	407	348	423	226	252	102	62	117	402	752	1769	2781	3840	4735	4832	4783	4746	3924	2974	2765	2190	1903	1407	46500

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	63	25	0	0	0	0	0	0	0	23	90	126	232	254	267	174	161	130	93	123	42	85	83	79	2051
2	49	17	0	0	0	0	0	0	9	71	54	137	150	152	126	40	140	133	98	43	31	43	53	59	1405
3	34	22	0	0	0	0	0	0	0	6	55	133	235	175	151	181	157	165	151	100	155	92	69	27	1907
4	0	0	0	0	0	0	0	0	0	6	47	68	125	153	165	231	193	151	81	87	54	46	50	28	1485
5	41	47	47	40	84	118	4	1	9	38	77	99	147	89	73	195	147	25	85	97	26	122	126	54	1790
6	57	6	2	0	0	0	0	0	0	5	6	50	223	209	140	136	72	75	66	158	103	67	74	47	1497
7	3	0	0	0	0	0	0	0	0	0	3	28	72	100	250	269	168	112	98	76	83	92	50	43	1446
8	40	21	0	0	0	0	0	0	0	9	42	62	120	183	129	115	147	80	54	62	99	87	47	27	1324
9	2	0	0	0	0	0	0	0	12	45	139	185	210	212	252	133	91	80	95	62	68	93	40	29	1747
10	0	0	0	0	0	0	0	0	0	2	13	64	101	194	261	306	195	131	80	66	117	85	38	4	1657
11	0	0	1	0	0	0	0	0	0	8	35	74	149	210	232	124	43	122	69	41	31	47	42	42	1270
12	14	0	13	0	0	0	0	0	0	1	24	47	119	195	107	118	60	175	173	57	100	42	26	18	1288
13	26	10	0	0	1	0	0	0	0	0	10	46	79	84	113	235	174	127	95	126	105	53	8	41	1333
14	28	21	11	13	25	11	0	0	0	2	75	191	236	232	242	203	53	94	189	198	25	28	35	1	1914
15	0	0	208	15	0	0	0	0	0	0	0	0	32	108	100	47	165	126	118	120	54	40	61	28	1224
16	0	0	0	0	0	0	0	0	0	0	3	26	88	90	103	146	165	78	160	121	49	56	63	25	1171
17	4	0	0	0	0	95	6	12	8	4	30	119	191	207	120	78	108	174	60	30	17	31	48	27	1370
18	7	0	0	0	2	2	0	0	0	2	46	45	144	39	67	89	68	46	23	31	24	25	30	31	722
19	14	10	0	0	0	0	0	0	0	0	1	59	55	109	189	136	161	116	56	76	65	79	16	12	1155
20	19	4	27	16	0	0	0	0	4	28	42	68	55	118	155	117	94	114	76	58	99	84	105	108	1389
21	61	2	0	0	0	0	0	0	0	0	0	7	36	202	213	164	114	49	64	200	143	124	65	31	1477
22	23	17	0	2	0	0	0	0	0	0	19	55	114	172	133	127	125	131	83	57	37	65	58	61	1277
23	9	0	0	0	0	0	0	0	1	0	17	102	145	197	87	100	149	129	130	66	67	48	55	41	1344
24	20	0	0	0	0	0	0	0	0	1	16	87	116	246	127	67	99	197	141	136	152	76	35	23	1538
25	27	0	0	0	0	0	0	0	0	0	2	8	61	137	181	312	120	92	35	44	36	39	36	4	1134
26	0	0	0	0	0	0	0	0	0	0	0	2	126	275	97	143	105	81	87	95	85	25	34	1	1156
27	0	0	0	0	0	0	0	0	0	0	0	9	84	168	89	91	111	139	122	56	99	117	88	39	1211
28	0	0	0	0	0	0	0	0	0	0	0	3	21	56	66	116	157	147	75	62	58	83	38	25	906
29	8	0	0	0	0	0	0	0	0	1	1	11	26	41	75	120	145	127	85	117	113	28	39	36	971
30	28	27	0	0	0	0	0	0	0	0	2	33	72	80	166	111	128	101	88	60	75	64	52	12	1098
31	14	22	0	0	0	2	0	1	28	45	89	131	124	148	90	108	154	50	63	61	50	54	47	66	1348
KWh	590	251	308	86	113	228	9	15	72	299	937	2072	3687	4837	4566	4534	3969	3497	2893	2685	2262	2019	1610	1067	42605

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	7	0	0	0	0	0	0	0	0	1	2	48	103	216	237	208	108	107	80	68	107	54	57	6	1408
2	0	0	0	0	0	0	0	0	0	0	2	1	56	117	274	191	151	111	81	59	75	59	39	23	1237
3	0	0	0	0	0	0	0	0	0	0	1	9	38	87	162	230	235	162	104	95	101	99	41	0	1365
4	0	0	0	0	0	0	0	0	0	1	2	14	84	128	141	191	205	151	116	131	91	79	61	26	1420
5	4	0	0	0	0	0	0	0	0	0	1	2	22	46	94	71	62	64	41	33	58	48	2	33	580
6	102	62	50	0	0	0	0	0	0	0	14	62	172	233	223	149	100	77	94	82	129	108	79	72	1807
7	24	51	13	0	0	0	0	0	0	1	2	17	156	187	159	122	99	72	68	81	49	31	16	1	1150
8	15	2	0	0	0	0	0	0	0	0	1	25	90	167	71	81	37	22	23	22	46	53	42	0	695
9	0	0	0	0	0	0	0	0	0	0	0	2	25	89	119	112	70	136	88	40	42	36	12	0	770
10	0	0	0	0	0	0	0	0	0	0	1	21	53	107	198	265	110	96	66	67	39	23	2	0	1047
11	0	0	0	0	0	0	0	0	0	0	0	5	9	53	90	108	174	121	67	43	37	20	0	0	726
12	0	0	0	0	0	0	0	0	0	0	0	1	8	29	104	154	173	96	58	50	36	42	4	0	755
13	0	0	0	0	0	0	0	0	0	0	1	4	17	56	119	249	204	102	68	68	20	28	28	14	980
14	0	0	0	0	0	0	0	0	0	0	8	53	138	147	152	115	120	98	37	88	84	73	16	1	1131
15	0	0	0	0	0	0	0	0	0	0	0	17	78	142	179	109	96	101	57	43	69	32	27	36	988
16	0	0	0	0	0	0	0	0	0	0	1	58	95	117	137	212	210	208	106	255	274	256	127	21	2078
17	0	0	1	0	0	0	0	0	0	0	1	4	65	121	96	80	147	130	84	84	102	111	54	0	1079
18	0	0	0	0	0	0	0	0	0	0	0	0	13	21	17	163	161	109	57	53	109	72	210	202	1186
19	96	147	16	2	0	0	0	0	0	0	2	16	120	132	150	144	36	35	82	58	29	11	0	1	1074
20	0	0	0	0	0	0	0	0	0	5	26	46	43	26	34	74	122	108	64	61	120	74	64	2	870
21	1	0	0	0	0	0	0	0	0	0	2	27	56	86	118	177	178	103	105	22	25	21	42	96	1059
22	20	0	0	0	0	0	0	0	36	14	16	126	135	73	75	107	64	84	84	78	23	30	53	20	1037
23	0	0	0	0	0	0	0	0	0	0	0	10	34	41	115	72	111	126	58	53	133	188	9	0	949
24	0	0	0	0	0	0	0	0	0	0	0	0	36	36	82	97	130	135	89	76	70	13	0	0	764
25	0	0	0	0	0	0	0	0	0	0	0	0	9	99	62	44	108	82	53	50	35	0	0	0	544
26	0	0	0	0	0	0	0	0	0	79	101	74	81	53	41	24	37	21	36	27	33	14	0	0	621
27	0	0	0	0	0	0	0	0	0	0	44	71	36	3	50	71	30	34	43	14	31	26	0	0	454
28	0	0	0	0	0	0	0	1	47	55	42	17	27	29	72	108	19	21	69	67	37	4	2	0	618
29	0	0	0	0	0	0	0	0	0	1	0	1	6	12	25	0	91	222	28	0	0	0	0	0	388
30	0	0	0	0	0	0	0	0	0	0	0	0	14	59	98	141	60	47	26	28	46	37	22	7	583
KWh	269	261	80	3	0	0	0	1	83	157	270	732	1820	2710	3492	3867	3448	2980	2031	1898	2049	1642	1009	560	29362

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	0	0	0	0	0	0	0	0	0	1	5	52	75	108	111	112	55	48	0	0	0	0	567
2	0	0	0	0	0	0	0	0	0	0	58	84	48	96	53	80	90	19	15	29	39	4	0	0	616
3	0	0	0	0	0	0	0	0	0	56	114	77	66	53	31	80	68	54	15	0	35	234	185	166	1235
4	70	6	0	0	0	0	0	0	0	64	160	62	11	4	47	69	101	94	105	48	28	44	20	32	966
5	4	0	0	0	0	0	0	0	0	0	0	1	11	38	58	25	89	47	53	29	23	146	194	265	982
6	156	59	73	86	84	11	1	61	267	262	241	199	101	89	104	168	221	24	23	26	43	50	4	0	2351
7	0	0	0	0	0	0	0	0	0	1	96	73	161	57	131	77	80	24	0	0	0	0	0	0	700
8	0	0	0	0	0	0	0	0	1	18	62	38	11	58	91	39	82	21	42	52	0	0	0	0	515
9	0	0	0	0	0	0	0	0	0	0	0	0	1	66	98	76	89	76	35	46	26	7	0	0	520
10	0	0	0	0	0	0	0	0	0	0	0	0	3	30	88	108	77	44	27	36	6	0	0	0	419
11	0	0	0	0	0	0	0	0	0	0	0	0	2	14	14	35	33	48	121	114	66	39	47	39	573
12	2	0	0	0	0	0	0	0	0	0	0	0	0	11	20	97	97	59	172	147	146	122	115	30	1017
13	4	19	7	6	1	59	95	101	221	319	264	109	103	17	5	8	6	0	1	49	11	124	55	28	1612
14	2	0	0	0	0	0	0	0	13	52	103	48	4	17	20	61	84	94	112	76	57	4	13	3	763
15	98	33	2	0	0	0	0	0	0	0	0	2	5	7	48	78	122	89	50	43	29	0	0	0	604
16	0	0	0	0	0	0	0	0	0	69	134	121	53	46	45	60	71	24	57	47	22	18	7	0	773
17	0	0	0	0	0	0	0	0	0	0	0	17	60	64	54	62	110	17	33	15	15	25	11	0	483
18	0	0	0	0	0	0	0	0	0	0	0	0	0	48	86	41	68	34	67	18	43	16	0	0	420
19	0	0	0	0	0	0	0	0	0	0	4	29	2	13	27	89	27	48	129	57	16	33	2	0	476
20	0	0	0	0	0	0	0	0	7	210	153	55	49	37	15	2	0	0	0	0	0	0	0	0	528
21	0	0	0	0	0	0	0	0	0	11	39	40	31	7	45	35	23	17	25	29	7	1	0	0	311
22	0	0	0	0	0	0	0	0	0	0	0	0	0	11	34	33	38	9	11	20	6	0	0	0	162
23	0	0	0	0	0	0	0	0	0	0	0	0	2	10	7	9	9	5	57	36	7	22	0	0	163
24	0	0	0	0	0	0	0	0	0	0	0	0	0	6	65	52	4	31	46	3	101	179	59	36	582
25	3	0	0	0	0	0	0	0	0	0	0	4	4	18	25	49	61	36	69	200	85	23	4	0	583
26	0	0	0	0	0	0	0	0	0	40	59	71	27	46	129	97	102	161	104	3	0	0	0	0	840
27	0	0	0	0	0	0	0	0	0	0	12	43	21	1	0	3	1	0	0	0	0	0	0	0	82
28	0	0	0	0	0	0	92	127	172	278	261	247	224	141	64	13	6	0	0	0	0	0	0	0	1624
29	9	0	16	34	20	3	0	0	0	4	20	55	8	1	55	69	22	5	13	15	1	4	8	6	369
30	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	1	0	0	0	0	0	0	7
31	0	0	0	0	0	22	134	217	222	244	323	304	215	150	75	27	4	0	0	0	0	0	0	0	1938
KWh	348	117	99	126	105	97	322	507	902	1627	2107	1681	1228	1206	1610	1751	1897	1193	1436	1185	811	1096	725	604	22781

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	0	0	179	222	228	233	278	371	362	303	217	118	48	17	2	0	0	0	0	0	0	0	2578
2	0	0	7	27	11	1	0	2	35	191	140	121	89	65	4	2	0	0	0	0	0	0	0	0	697
3	0	0	0	0	0	0	0	0	0	0	19	27	10	5	6	2	6	0	0	0	0	0	0	0	75
4	28	147	191	166	134	204	204	198	239	290	244	276	223	112	62	99	48	13	2	0	0	0	0	0	2881
5	93	233	284	121	33	166	33	76	77	114	241	366	255	232	110	60	27	12	0	0	0	0	0	0	2534
6	0	0	0	22	91	185	217	217	147	183	162	127	83	25	0	5	6	0	0	0	0	0	0	0	1469
7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	12	0	0	0	0	0	0	0	0	26
8	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
9	0	0	0	0	0	0	0	0	0	0	0	0	4	22	59	69	26	47	36	34	16	20	9	17	359
10	5	0	0	0	0	0	0	0	0	0	0	0	4	33	31	15	12	11	6	19	0	0	0	0	137
11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	17	2	0	2	29	1	0	0	55
12	0	0	0	0	0	0	0	0	0	0	0	0	7	50	12	16	0	0	32	12	6	2	1	0	137
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	73	5	0	0	0	0	96
14	0	0	0	0	0	2	2	0	0	0	0	16	3	15	35	7	3	2	5	2	0	2	0	3	97
15	1	0	0	0	0	0	0	0	0	0	0	0	0	4	8	1	0	0	0	0	0	0	0	0	13
16	0	0	0	0	0	0	0	0	0	118	210	185	153	61	36	27	27	6	0	0	0	0	0	0	823
17	0	0	0	0	0	0	0	0	0	68	69	59	48	20	0	1	6	20	2	0	0	0	0	0	293
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	0	0	0	0	0	0	0	8
19	0	0	0	0	0	0	0	0	0	0	2	43	50	134	121	107	98	27	13	1	0	0	0	0	595
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	7
21	0	0	0	0	0	131	293	344	445	520	501	406	264	98	89	49	3	0	0	0	0	0	0	0	3144
22	0	0	0	0	0	0	0	0	0	0	50	140	59	50	49	27	0	0	0	0	0	0	0	0	376
23	0	0	0	0	0	0	0	0	0	38	204	74	35	0	0	1	0	0	0	0	0	0	0	0	351
24	0	0	0	6	95	134	166	204	191	206	265	232	191	72	37	26	18	30	13	0	0	0	0	0	1887
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
26	0	0	0	0	0	0	0	0	0	0	28	73	37	46	34	19	9	2	0	0	0	0	0	0	247
27	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0	6	0	0	0	0	0	0	0	0	13
28	0	0	0	0	0	0	0	0	0	0	0	0	11	18	0	2	0	0	0	0	0	0	0	0	31
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	2
30	0	0	0	0	0	0	1	1	3	0	40	73	102	67	39	6	1	0	0	0	0	0	0	0	332
KWh	127	380	483	342	544	1044	1145	1274	1416	2099	2542	2523	1845	1251	794	586	315	191	183	75	52	26	10	20	19265

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	0	0	0	0	0	0	0	0	4	0	4	34	16	9	10	0	0	4	0	0	0	0	0	82
2	0	0	0	0	0	0	0	0	0	0	0	4	53	33	17	1	0	0	0	0	0	0	0	0	109
3	0	0	0	0	0	0	0	0	2	0	68	191	166	102	114	39	5	0	0	0	0	0	0	0	687
4	0	0	0	0	0	0	0	0	0	0	75	152	135	99	24	0	0	0	0	0	0	0	0	0	486
5	0	0	0	0	0	0	0	0	0	0	0	0	40	10	0	0	0	0	0	0	0	0	0	0	50
6	0	0	0	0	0	0	0	0	0	11	7	95	76	67	57	5	0	0	0	0	0	0	0	0	320
7	0	7	25	53	114	102	102	133	109	152	95	41	104	31	42	8	15	33	30	37	0	0	0	2	1235
8	7	4	1	0	24	19	15	9	0	1	0	55	114	108	108	84	50	31	12	0	6	4	4	12	666
9	0	0	13	60	65	134	180	127	67	35	6	0	0	0	0	0	0	0	0	31	2	2	1	0	723
10	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	43	15	0	0	0	0	67
11	0	0	0	0	0	0	0	0	0	24	198	205	121	67	75	64	73	89	53	90	77	32	10	29	1207
12	0	0	13	66	64	104	252	272	286	196	282	220	192	197	174	134	59	30	37	44	37	50	51	33	2795
13	42	50	67	57	77	56	48	40	57	57	90	90	53	57	39	37	33	21	20	20	22	13	12	7	1065
14	0	8	11	13	0	0	0	0	0	0	67	69	29	42	22	25	13	6	0	0	0	0	0	0	305
15	0	0	0	0	0	0	0	16	36	104	127	141	63	37	36	33	18	8	0	0	0	0	0	0	619
16	0	2	0	2	19	26	29	68	46	105	147	115	89	64	69	60	29	26	9	6	0	0	0	0	913
17	0	6	8	31	46	77	43	78	63	108	95	95	69	39	61	67	61	39	20	0	0	0	0	0	1005
18	0	0	0	0	4	2	0	0	0	0	0	0	4	0	0	0	0	1	18	15	9	2	0	0	56
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	7	2	0	10	14	37
20	5	5	1	0	0	0	0	0	0	0	0	0	28	43	31	55	29	5	44	85	41	31	6	0	409
21	0	0	0	0	1	0	0	0	0	4	4	25	18	18	7	9	4	20	28	15	22	27	30	43	275
22	46	50	44	47	43	50	37	32	18	37	53	61	39	26	37	36	33	30	12	11	1	0	0	0	741
23	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	4	0	0	0	0	0	0	0	0	11
24	0	0	0	0	0	0	0	0	0	0	0	2	4	25	25	18	4	0	5	5	0	0	0	0	88
25	0	0	0	0	0	0	0	0	0	0	0	0	5	9	4	2	2	9	14	14	0	4	0	5	68
26	6	16	18	33	55	73	50	46	21	0	80	166	99	102	73	50	62	62	73	36	43	30	46	48	1286
27	50	25	37	36	20	22	18	36	32	72	128	122	115	89	69	51	26	27	22	20	25	25	22	20	1110
28	2	0	0	0	0	0	0	0	0	0	0	32	42	57	67	55	35	15	15	13	9	11	6	0	359
29	0	0	0	0	0	0	0	0	8	6	21	28	18	3	1	1	2	9	8	6	9	14	14	18	166
30	27	25	40	39	49	51	78	53	102	102	128	282	244	144	91	73	75	65	55	42	37	31	54	91	1977
31	96	112	145	154	196	254	286	261	273	321	331	336	343	230	192	200	216	164	151	123	219	240	132	104	5078
KWh	280	310	424	591	775	969	1136	1172	1123	1339	2004	2530	2297	1716	1449	1123	847	696	675	636	562	516	397	425	23993