PAKISTAN METEOROLOGICAL DEPARTMENT

A STUDY OF WIND POWER POTENTIAL AT LOWARAMINA-Khyber Agency FATA

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Revised Technical Report No. PMD-18/2008
(Report based on 18 months data)
February 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 Lowaramina. Wind data with ten minute average speed and direction were collected at 10 meters and 30 meters height and 50 meters values were computed from models.

At 50 meters we have the average wind speed of 3.44 m/s during Eighteen months *April-2007 to September-2008* the highest of 5.45 is observed in January & Feburary. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the noon through-out the whole period. Wind frequency distribution shows that during 10.4% 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 Lowaramina at 50m is **83.43** W/m^2 according to international wind classification, this power density categorize Lowaramina as a below marginal site for wind power generation.

Wind generated electric power has 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 316,862 KWh which shows the capacity factor of 6% for Lowaramina. 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 Lowaramina 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:

Lowaramina, Bahrain, Kalam, Khawazakhaila, Malamjabba, Tahash, Fatehpur, Dir, Tarbella, Nizampur, Warsak, Chitral City, Drosh, Mirkhani, Shagore, Garam Chasma, Khagozi, Reshan, Mastuj, Kalash, Ayune, Astore, Bunji, Khungi-Payan, Gilgit, Gupis, Sost, Passu, Aliabad, Shigar, Barapayan, Sermik, owaramaina, Ramatkore, ShahidaSir, Danakool, Besham, Moorti Pahari, Rangla, Pedar, Lempiapatian, Dargaye, Chilas.

Lowaramina is situated in Khyber Agency, FATA. Latitude & Longitude of Lowaramina is: **Lat = 34.08°, Long = 72.19°, Elevation = 2362 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. Temperature sensors are also installed at 10 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 for 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
Z_o is the roughness length
D is the displacement height

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

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

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

Where

U_R is the wind speed at reference height Z_R

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

3.1.2 *Power Law:*

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

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

Where:

α is the power law exponent

u_R is the wind speed at reference height z_R

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

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

Where: Z is the measurement height

Z_R is the reference height

Z_0 is the roughness length

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

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

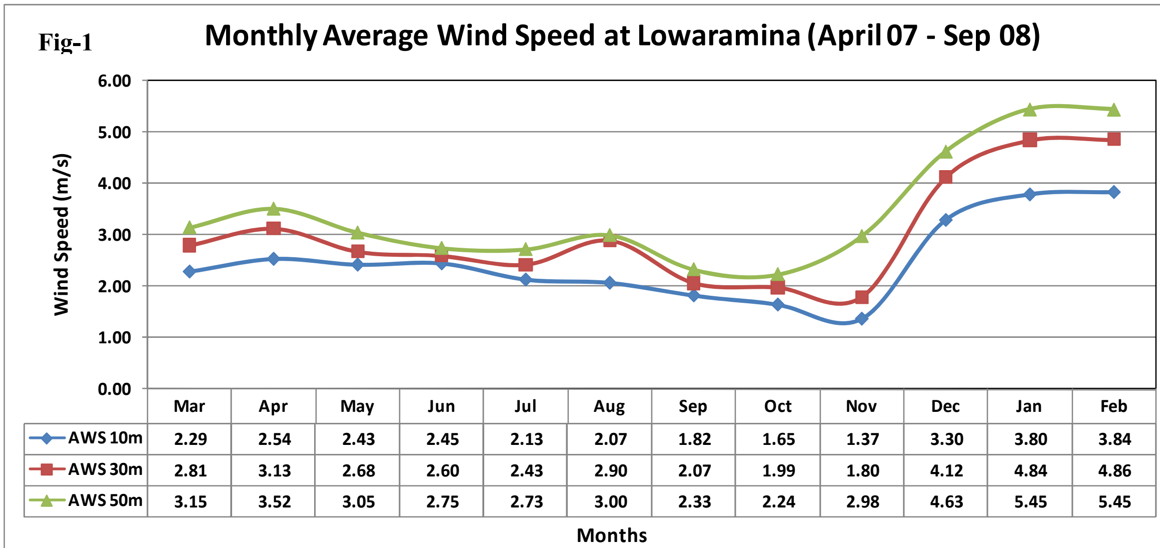
Type of terrain	Z_0	α
Mud Flats, Ice	10^{-5} to 3x 10^{-5}	
Calm Sea	2x10^{-4} to 3x10^{-4}	
Sand	2x10^{-4} to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 to 2	0.32
City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

3.2 Average Wind Speed:

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

Fig-1 shows 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 2.84 m/s from April-07 to Sept-08 where as maximum average wind speed of 5.45 m/s at this height is during January & February. At 50 meters we have the annual average wind speed of 3.44 m/s from May-07 to Oct-08.

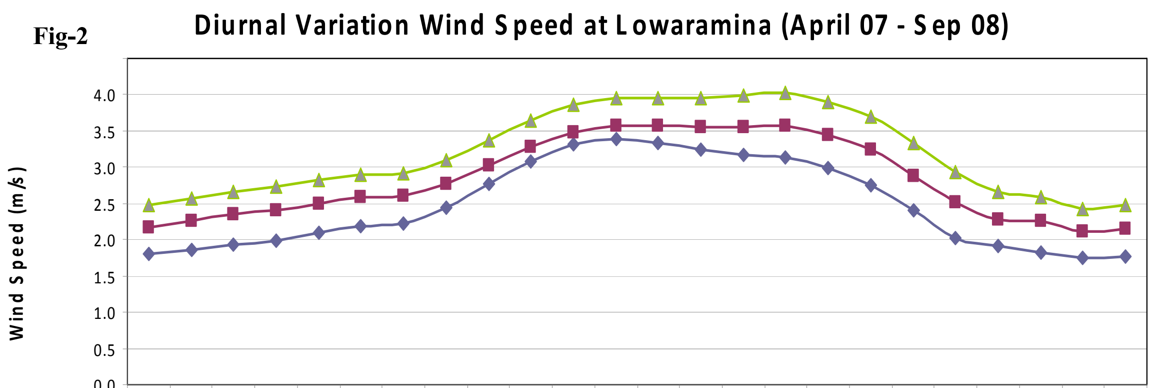
Fig-1



3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Lowaramina for 18 months (April-07 to Sep-08). The wind speed is generally lower during morning and in the noon it starts picking up and reaches maximum around 11 a.m. which is around 3.6 m/s and 4.0 m/s at 30 meters and 50 meters height respectively. Figure-2 shows that the maximum wind speed during noon times at 50 meters height reaches to 4.0 m/s at 11 p.m.

Fig-2

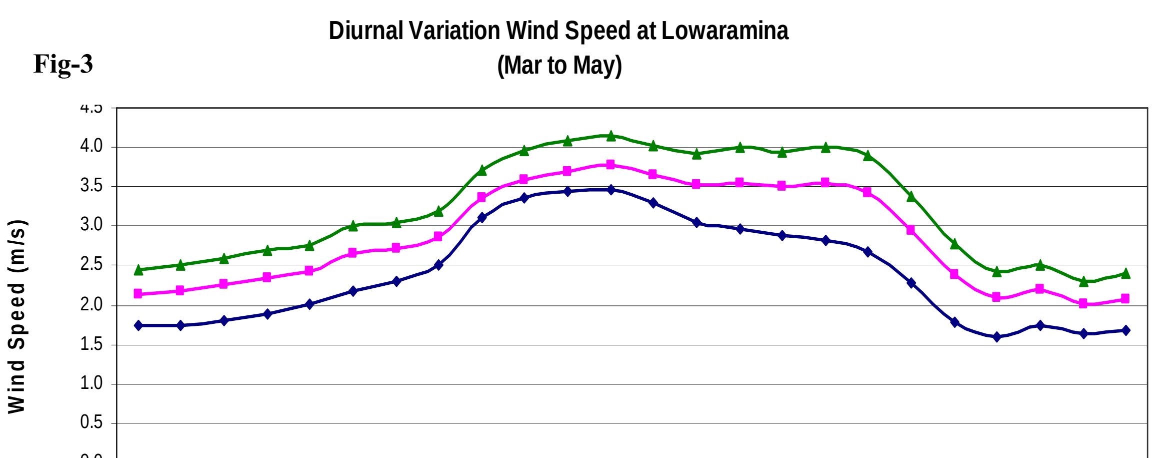


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.8	1.9	1.9	2.0	2.1	2.2	2.2	2.4	2.8	3.1	3.3	3.4	3.3	3.2	3.2	3.1	3.0	2.8	2.4	2.0	1.9	1.8	1.7	1.8
WS 30m	2.2	2.3	2.3	2.4	2.5	2.6	2.6	2.8	3.0	3.3	3.5	3.6	3.6	3.5	3.6	3.6	3.4	3.3	2.9	2.5	2.3	2.3	2.1	2.2
WS 50m	2.5	2.6	2.7	2.7	2.8	2.9	2.9	3.1	3.4	3.6	3.9	4.0	4.0	4.0	4.0	4.0	3.9	3.7	3.3	2.9	2.7	2.6	2.4	2.5

PST (Hours)

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

Fig-3

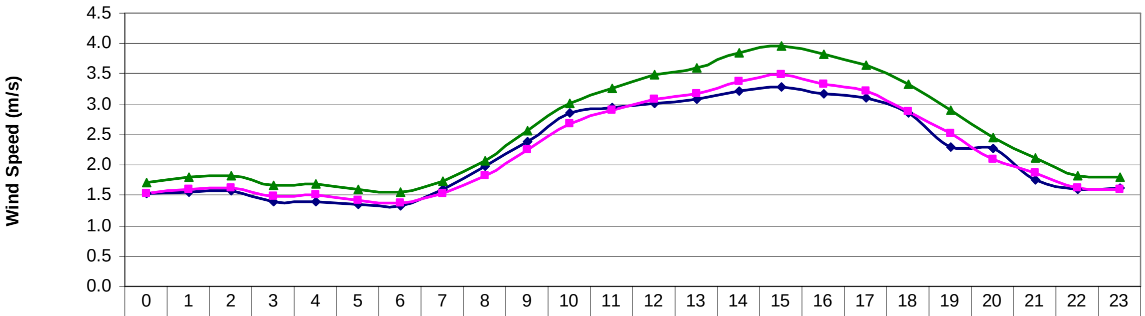


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.7	1.8	1.8	1.9	2.0	2.2	2.3	2.5	3.1	3.4	3.4	3.5	3.3	3.1	3.0	2.9	2.8	2.7	2.3	1.8	1.6	1.8	1.6	1.7
WS 30m	2.1	2.2	2.3	2.4	2.4	2.7	2.7	2.9	3.4	3.6	3.7	3.8	3.7	3.5	3.6	3.5	3.5	3.4	2.9	2.4	2.1	2.2	2.0	2.1
WS 50m	2.4	2.5	2.6	2.7	2.8	3.0	3.0	3.2	3.7	4.0	4.1	4.1	4.0	3.9	4.0	3.9	4.0	3.9	3.4	2.8	2.4	2.5	2.3	2.4

PST (Hours)

Fig-4

Diurnal Variation Wind Speed at Lowaramina (Jun to Aug)

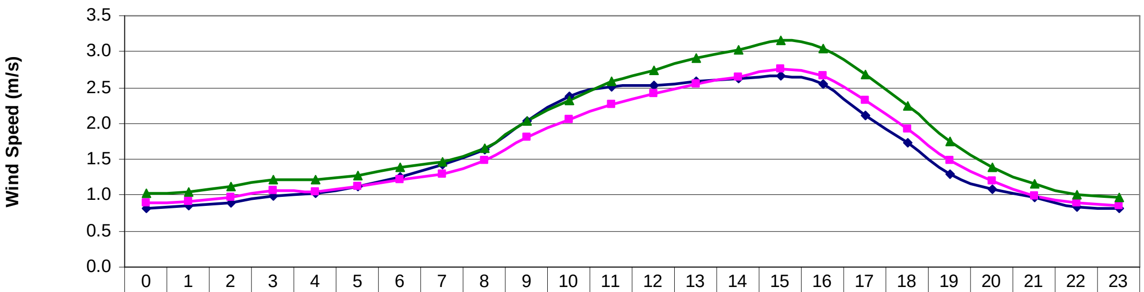


PST (Hours)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.5	1.6	1.6	1.4	1.4	1.4	1.3	1.6	2.0	2.4	2.8	2.9	3.0	3.1	3.2	3.3	3.2	3.1	2.9	2.3	2.3	1.7	1.6	1.6
WS 30m	1.5	1.6	1.6	1.5	1.5	1.4	1.4	1.5	1.8	2.3	2.7	2.9	3.1	3.2	3.4	3.5	3.3	3.2	2.9	2.5	2.1	1.9	1.6	1.6
WS 50m	1.7	1.8	1.8	1.7	1.7	1.6	1.5	1.7	2.1	2.6	3.0	3.3	3.5	3.6	3.8	4.0	3.8	3.7	3.3	2.9	2.5	2.1	1.8	1.8

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Lowaramina (Sep to Nov)

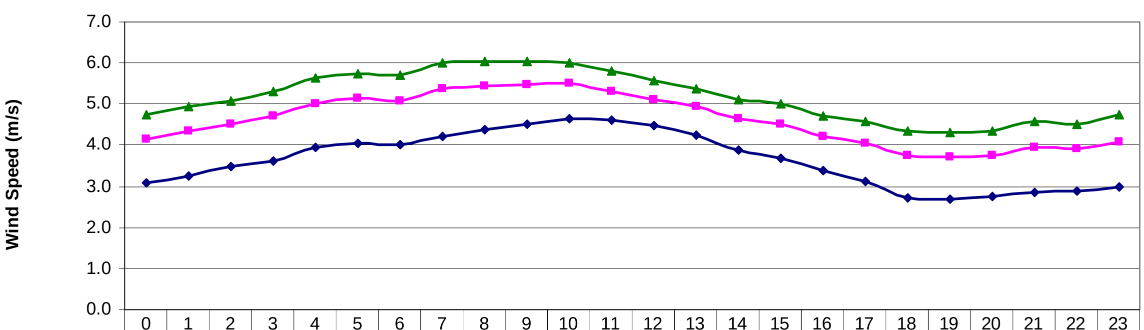


PST (Hours)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.8	0.9	0.9	1.0	1.0	1.1	1.3	1.4	1.6	2.0	2.4	2.5	2.5	2.6	2.6	2.7	2.6	2.1	1.7	1.3	1.1	1.0	0.8	0.8
WS 30m	0.9	0.9	1.0	1.1	1.1	1.1	1.2	1.3	1.5	1.8	2.1	2.3	2.4	2.6	2.7	2.8	2.7	2.3	1.9	1.5	1.2	1.0	0.9	0.9
WS 50m	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.7	2.0	2.3	2.6	2.7	2.9	3.0	3.2	3.0	2.7	2.2	1.7	1.4	1.2	1.0	1.0

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Lowaramina (Dec to Feb)



PST (Hours)	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	3.1	3.2	3.5	3.6	3.9	4.1	4.0	4.2	4.4	4.5	4.6	4.6	4.5	4.2	3.9	3.7	3.4	3.1	2.7	2.7	2.7	2.9	2.9	3.0
WS 30m	4.1	4.3	4.5	4.7	5.0	5.1	5.1	5.4	5.4	5.5	5.5	5.3	5.1	4.9	4.7	4.5	4.2	4.0	3.8	3.7	3.7	3.9	3.9	4.1
WS 50m	4.7	5.0	5.1	5.3	5.6	5.7	5.7	6.0	6.0	6.0	6.0	5.8	5.6	5.4	5.1	5.0	4.7	4.6	4.4	4.3	4.3	4.6	4.5	4.7

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:*

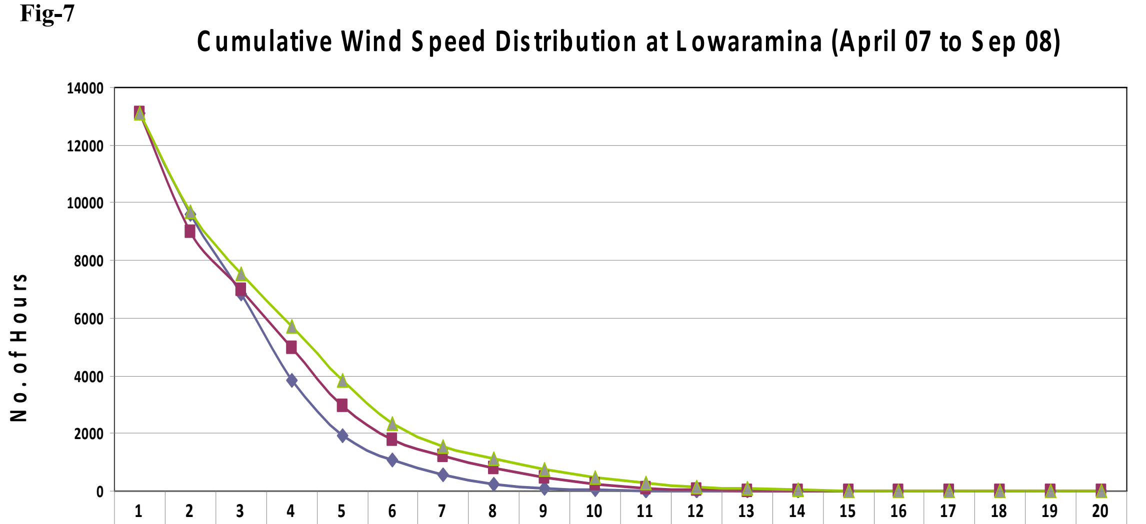
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as

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 May 2007 to October 2008 at three heights 10, 30 and 50 meters. The analysis indicate that at a height of 30 meters during 4272 hours the wind speed is greater than or equal to 5 m/s. Whereas at 50 meters, during 5191 hours the wind speed is equal or greater than 5m/s.

Fig-7



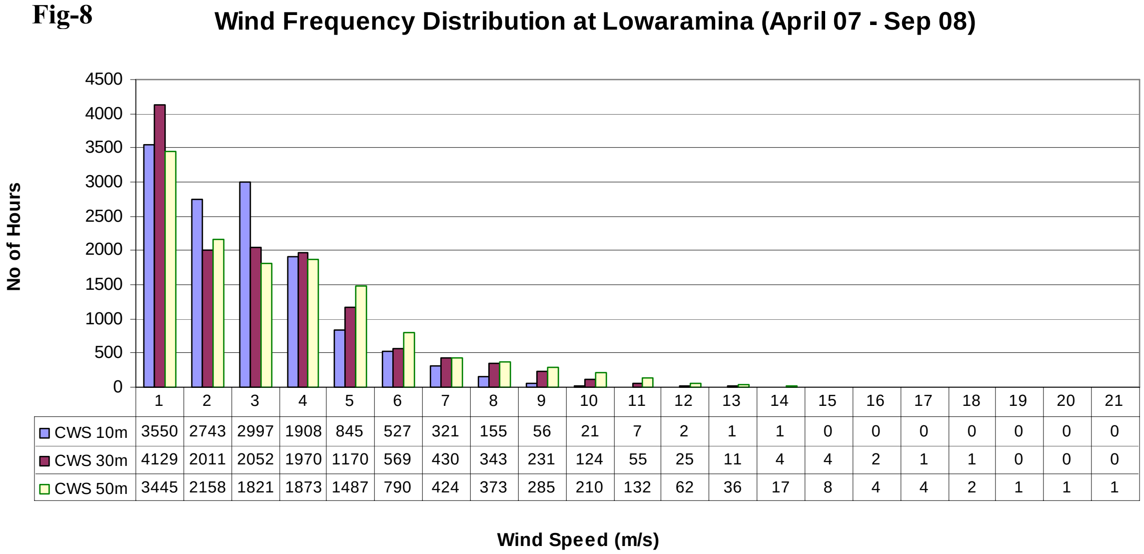
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS 10m	13133	9583	6840	3843	1935	1090	563	243	88	32	11	4	2	1	1	0	0	0	0	0
CWS 30m	13133	9003	6993	4941	2971	1801	1231	801	458	227	103	48	23	12	7	4	2	1	0	0
CWS 50m	13133	9688	7530	5709	3837	2350	1560	1136	763	478	268	136	74	38	21	13	9	5	3	2

Wind Speed (m/s)

3.4.4 ***Wind Frequency Distribution:***

Fig-8 shows the frequency distribution. We can see that at 50 meters during 1283 hours wind speed is 5 m/s, 1188 hours speed is 6 m/s, 958 hours speed is 7 m/s, 755 hours speed is 8 m/s and during 442 hours the wind speed is 9m/s and so on. This indicates wind potential in this area.

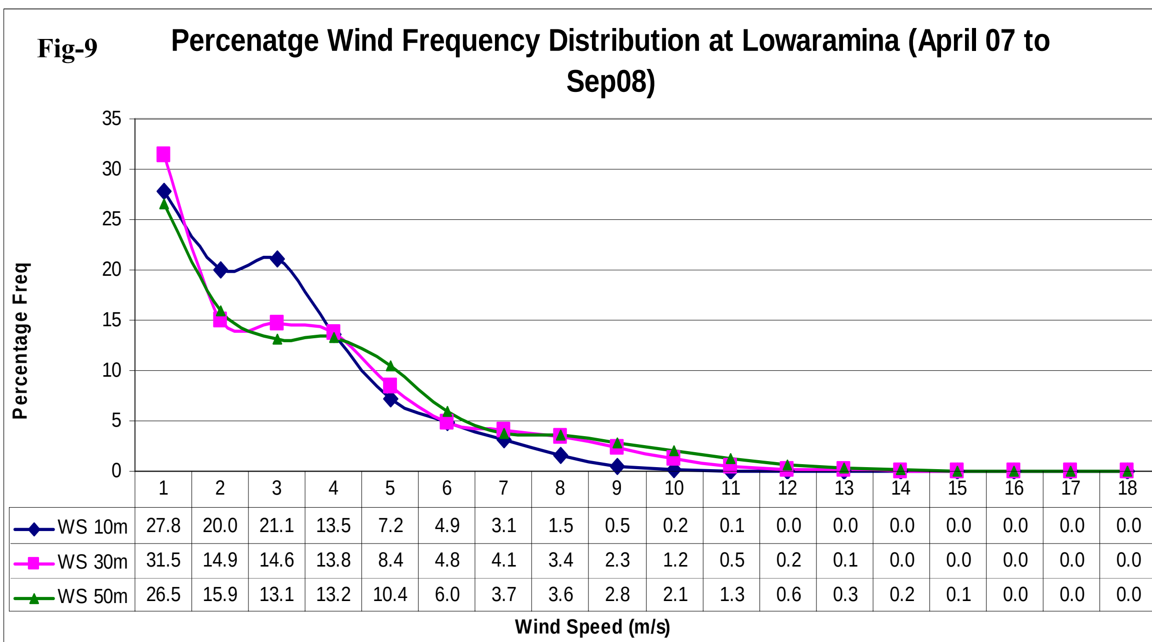
Fig-8



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	3550	2743	2997	1908	845	527	321	155	56	21	7	2	1	1	0	0	0	0	0	0	0
CWS 30m	4129	2011	2052	1970	1170	569	430	343	231	124	55	25	11	4	4	2	1	1	0	0	0
CWS 50m	3445	2158	1821	1873	1487	790	424	373	285	210	132	62	36	17	8	4	4	2	1	1	1

Fig-9 gives this frequency distribution in percentage from May-2007 to Oct-2008. At 50 meters we find that during 9.0% of time wind is 5m/s, 8.1% of the time 6m/s and 6.3% of the time it is 7m/s. whereas at 30 meters height we get 9.1% of the time wind speed 5m/s, 7.3% of the times 6m/s and 6.3% of the time 7m/s.

Fig-9



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	27.8	20.0	21.1	13.5	7.2	4.9	3.1	1.5	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	31.5	14.9	14.6	13.8	8.4	4.8	4.1	3.4	2.3	1.2	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
WS 50m	26.5	15.9	13.1	13.2	10.4	6.0	3.7	3.6	2.8	2.1	1.3	0.6	0.3	0.2	0.1	0.0	0.0	0.0

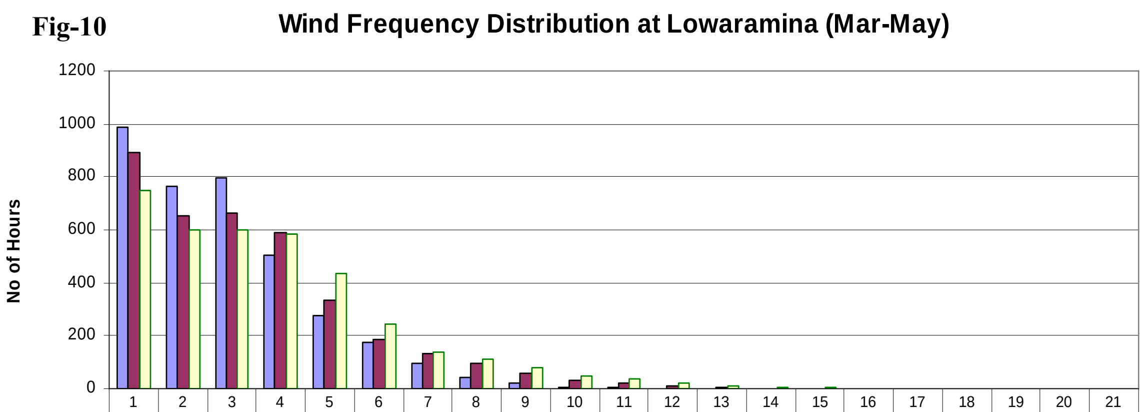
3.4.5 *Seasonal Wind Frequency Distribution:*

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 324 hours and 294 hours we get 5m/s respectively.

Fig-10

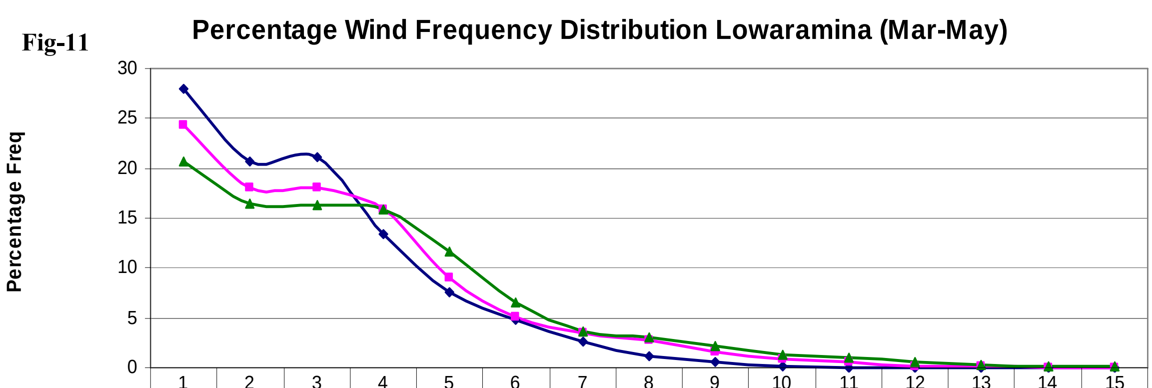


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	987	766	796	504	277	175	95	41	19	6	3	1	1	0	0	0	0	0	0	0	0
WS 30m	893	651	665	588	335	186	131	96	56	32	20	9	5	3	2	0	0	0	0	0	0
WS 50m	751	601	601	585	433	242	137	111	79	48	35	20	12	6	4	2	2	1	0	0	1

Wind Speed (m/s)

Similarly in Fig-11 shows percentage frequency distribution. At 50 meters we get 10.4% of wind equal to 5m/s, 10.3% of wind equal to 6 m/s and at 30 meter 11.2% wind equal to 5m/s, 8.9% wind equal to 6 m/s respectively.

Fig-11



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	27.9	20.7	21.1	13.4	7.5	4.8	2.6	1.2	0.6	0.2	0.1	0.0	0.0	0.0	0.0
WS 30m	24.4	18.1	18.0	15.8	9.0	5.1	3.5	2.7	1.5	0.9	0.5	0.2	0.1	0.1	0.0
WS 50m	20.7	16.5	16.3	15.8	11.6	6.5	3.7	3.1	2.2	1.3	1.0	0.5	0.3	0.1	0.1

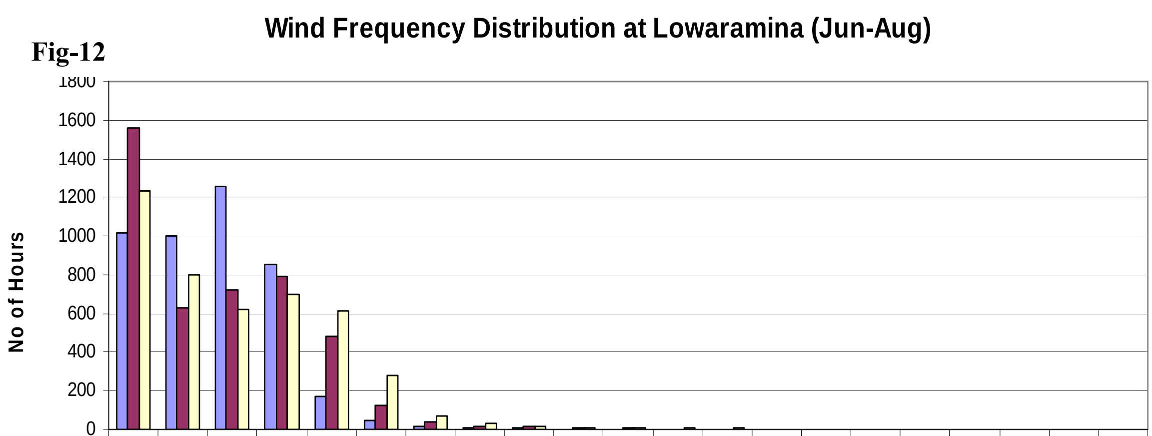
Wind Speed (m/s)

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 659 hours we get 5m/s, similarly at 50 meters height during 536 hours we get wind speed of 5m/s.

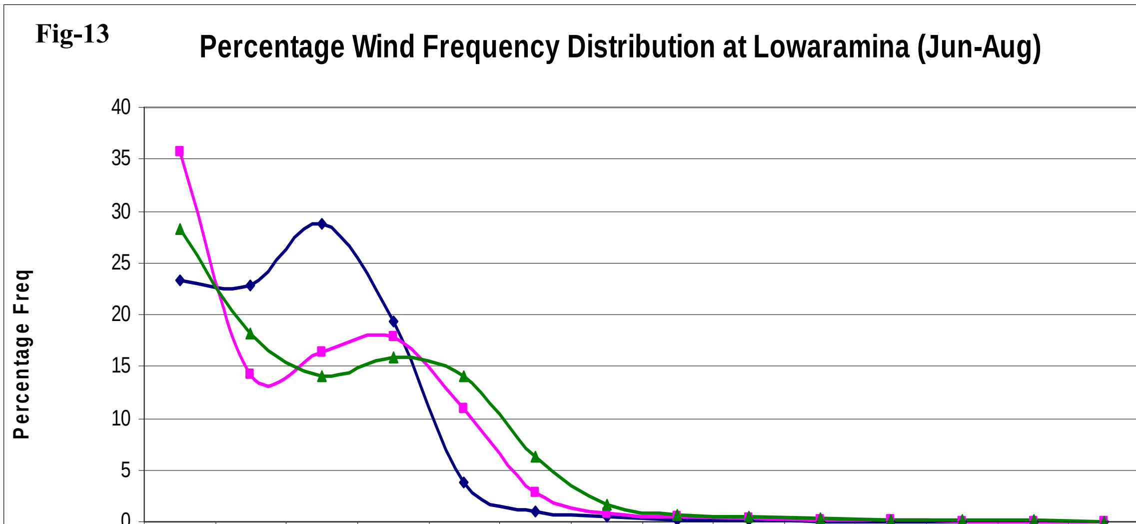
Fig-13 shows percentage distribution of wind frequency during the months of June to August. It shows that 14.9% and 12.1% we get wind speed of 5m/s at 30m and 50m respectively.

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	1019	1005	1260	851	169	46	18	10	5	3	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1560	628	720	789	479	123	39	19	13	9	6	3	0	0	0	0	0	0	0	0	0
WS 50m	1230	800	617	696	616	278	71	29	19	11	9	5	4	1	0	0	0	0	0	0	0

Fig-13



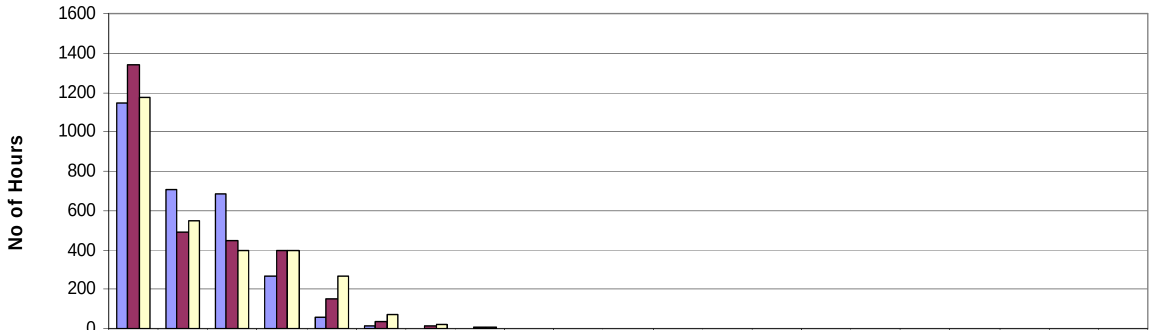
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	23.2	22.9	28.7	19.4	3.9	1.1	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0
WS 30m	35.8	14.2	16.3	17.9	10.9	2.8	0.9	0.4	0.3	0.2	0.1	0.1	0.0	0.0
WS 50m	28.2	18.3	14.0	15.8	14.0	6.3	1.6	0.7	0.4	0.3	0.2	0.1	0.1	0.0

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 254 hours we get 5m/s, similarly at 50 meters height during 327 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 6.0% and 7.8% we get wind speed of 5m/s at 30m and 50m respectively.

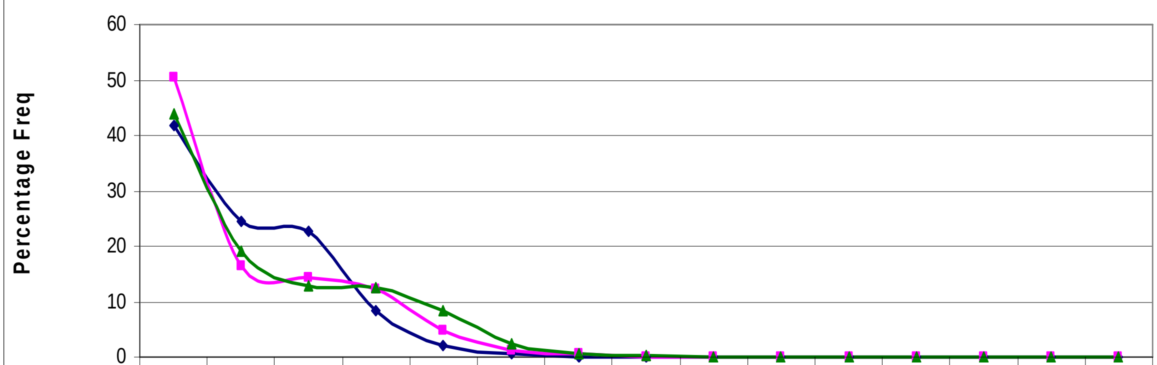
Fig-14 Wind Frequency Distribution at Lowaramina (Sep-Nov)



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	1145	709	685	270	61	16	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1343	493	450	396	153	34	13	4	2	1	1	0	0	0	0	0	0	0	0	0	0
WS 50m	1172	545	396	399	266	75	21	7	4	2	1	1	1	0	0	0	0	0	0	0	0

Wind Speed (m/s)

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



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	41.7	24.4	22.6	8.5	2.1	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	50.5	16.5	14.2	12.4	4.6	1.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	43.9	19.1	12.7	12.4	8.2	2.4	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0

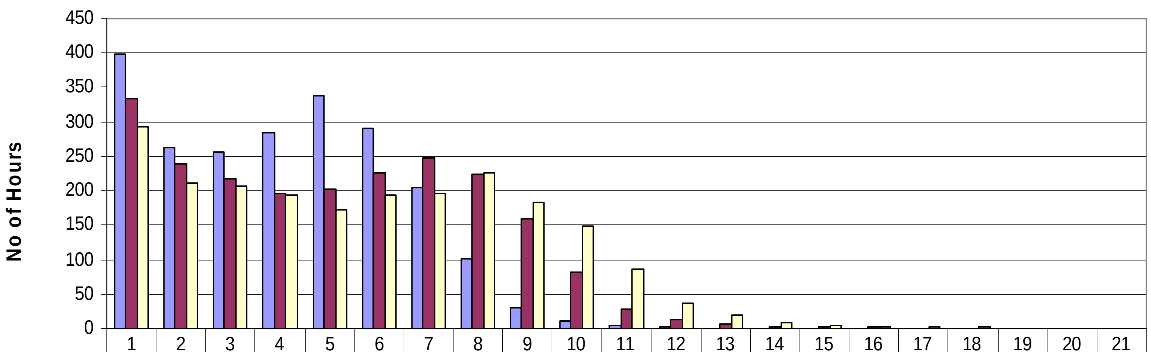
Wind Speed (m/s)

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 93 hours we get 5m/s, similarly at 50 meters height during 126 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 4.3% and 5.8% we get wind speed of 5m/s at 30m and 50m respectively.

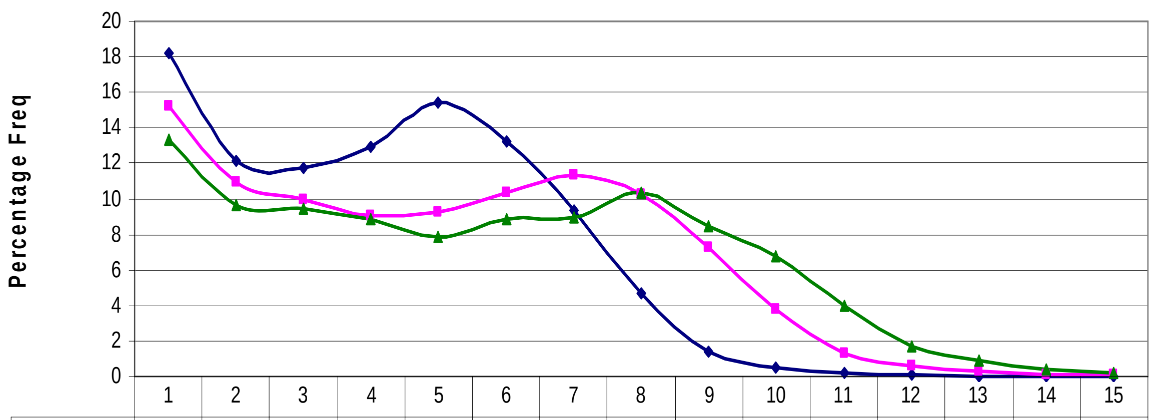
Fig-16 Wind Frequency Distribution at Lowaramina (Dec-Feb)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	399	264	256	284	338	290	204	101	31	12	4	2	0	0	0	0	0	0	0	0	0
WS 30m	333	239	217	197	203	226	248	224	160	83	28	13	6	2	2	2	1	0	0	0	0
WS 50m	292	211	207	194	172	194	195	225	184	148	87	36	19	9	4	2	1	2	1	0	0

Wind Speed (m/s)

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



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	18.2	12.1	11.8	13.0	15.4	13.3	9.4	4.7	1.4	0.5	0.2	0.1	0.0	0.0	0.0
WS 30m	15.2	11.0	10.0	9.0	9.2	10.3	11.3	10.3	7.3	3.8	1.3	0.6	0.3	0.1	0.1
WS 50m	13.3	9.7	9.5	8.9	7.9	8.8	8.9	10.3	8.4	6.8	4.0	1.7	0.9	0.4	0.2

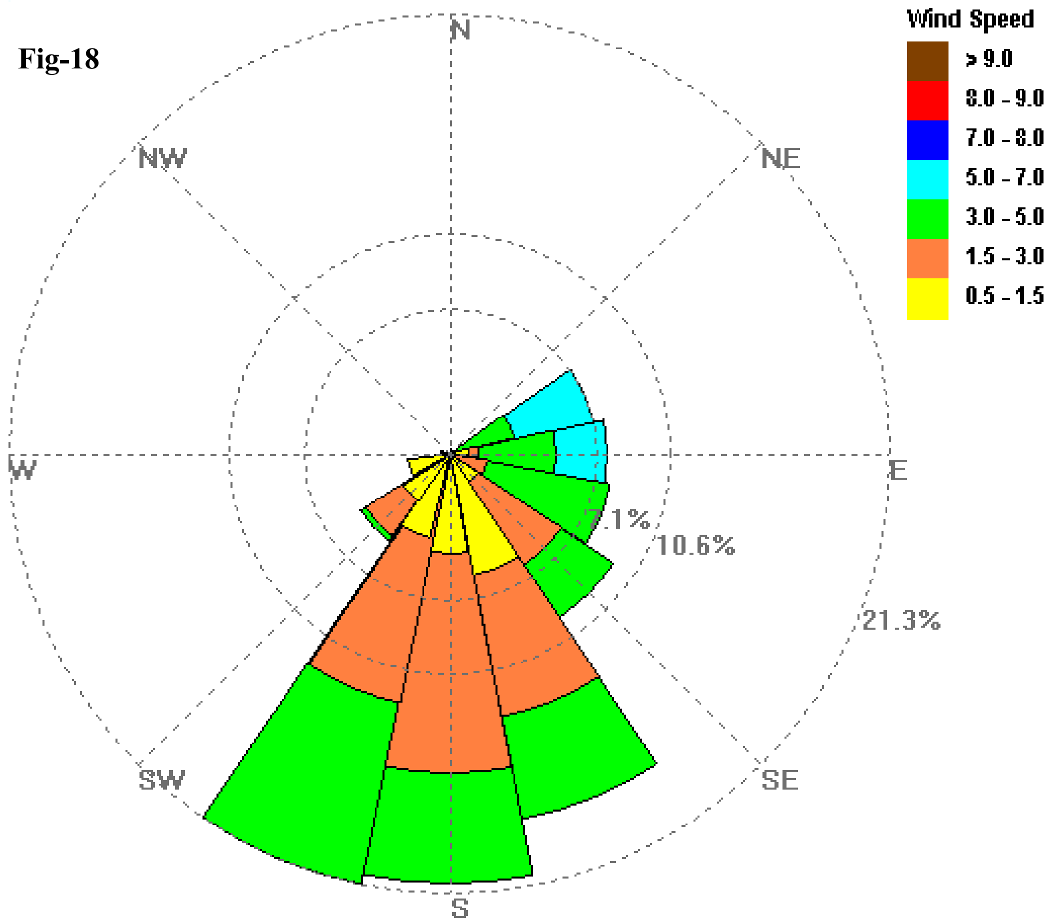
Wind Speed (m/s)

3.5 Wind Rose

Fig-18 shows the Wind Rose based on data from April-2007 to September-2008 (18 months) collected at 30 meters height. Wind Rose indicates that most of the time the wind direction was South and South West. The average wind speed at 30 meter height is 3.02m/s and the percentage when wind speed greater than 5m/s is 10.4%.

Wind Rose at Lowaramina (30m height)

Fig-18



Average Wind Speed	Wind greater than 5 m/s
3.02 m/s	10.4%

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

$$E = \tfrac{1}{2} m V^2$$

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

$$\tfrac{dm}{dt} = \varphi A V$$

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

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

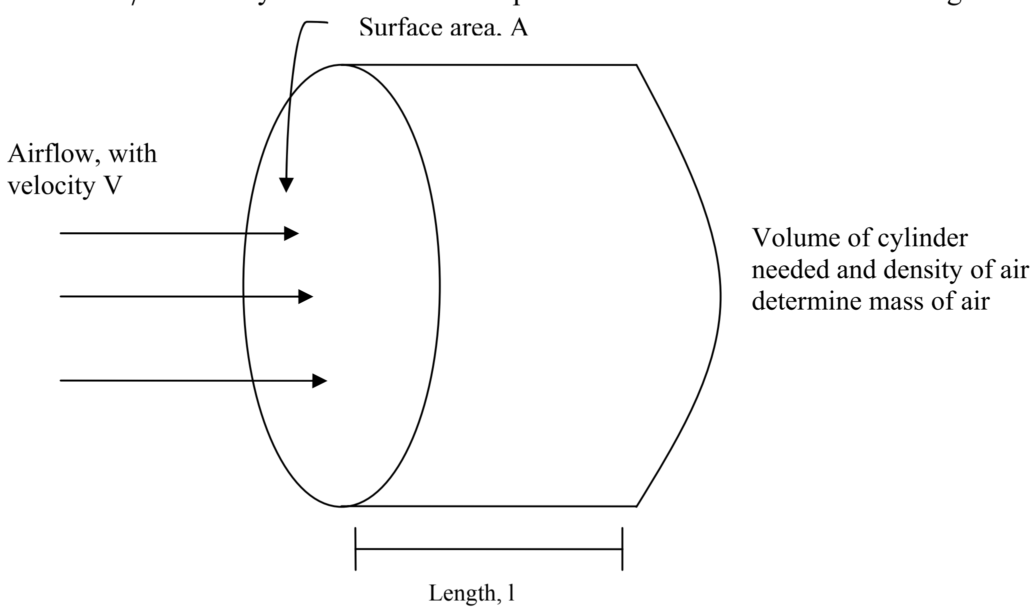
Now mass of wind can be written as

$$M = \varphi A v t$$

Differentiating

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

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 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 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.

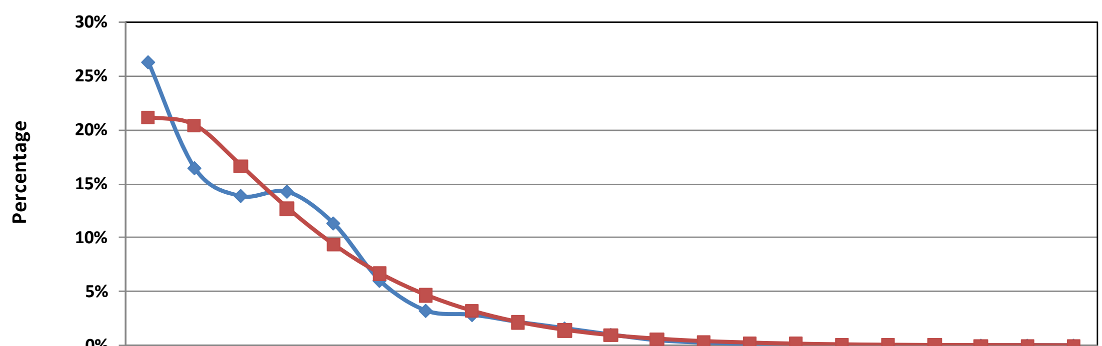
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion 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 Lowaramina (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	26.2	16.4	13.9	14.3	11.3	6.0%	3.2%	2.8%	2.2%	1.6%	1.0%	0.5%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	21.2	20.4	16.6	12.7	9.4%	6.7%	4.7%	3.2%	2.2%	1.4%	1.0%	0.6%	0.4%	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%

Wind Speed (m/s)

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in **Table-3** along with other key results of analysis. If we look at the ***shape parameters*** K and scale parameter C for 50 meters height we can find that the shape parameter K varies over a wind range from the lowest of 0.78 during December to the highest of 1.79 during the month of June with an annual of K being 1.24.

The lowest values of the *scale parameter* C 0.87 m/s observed in November while the highest value of 5.84 is obtained in June and with an annual value of 3.38 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 2.47 m/s with Standard deviation of 1.62, at 30 meters this average speed is 2.84 m/s with Standard deviation of 2.03.

At 50 meters the monthly average wind speed varies from the lowest of 0.93 m/s in November to highest of 5.17 m/s duringJune. Whereas the average wind speed is 3.14 m/s with Standard deviation of 2.45.

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 4.70 W/m^2 in November to 88.86 W/m^2 in February with Average of 29.49 W/m^2.

At 30 meters height the power density varies from 2.41 W/m^2 in November to the highest of 190.60 W/m^2 in February cand the average values is about 57.90 W/m^2.

At 50 meters height the power density of Lowaramina varies from 3.92 W/m^2 in November to 263.23 W/m^2 in February. The average power density of the area is 83.43 W/m^2.

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

10 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m²)**
January	3.75	2.18	4.24	1.80	**69.82**
February	3.81	2.50	4.30	1.58	**88.86**
March	2.26	1.84	2.43	1.25	**25.96**
April	2.50	1.86	2.73	1.37	**29.72**
May	2.38	1.69	2.62	1.45	**23.64**
June	2.41	1.46	2.70	1.72	**19.31**
July	2.08	1.19	2.34	1.84	**11.53**
August	1.97	1.22	2.20	1.68	**10.86**
September	1.78	1.17	1.98	1.57	**8.73**
October	1.60	1.19	1.75	1.38	**7.80**
November	1.34	1.01	1.46	1.36	**4.70**
December	3.26	2.12	3.64	1.60	**52.94**
Average	**2.43**	**1.62**	**2.70**	**1.55**	**29.49**
30 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m²)**
January	4.81	2.77	5.44	1.82	**145.51**
February	4.82	3.26	5.44	1.53	**190.60**
March	2.77	2.19	3.00	1.29	**45.51**
April	3.09	2.29	3.39	1.38	**55.92**
May	2.66	2.23	2.83	1.21	**45.17**
June	2.40	2.02	2.56	1.21	**33.46**
July	2.39	1.52	2.67	1.63	**20.20**
August	1.91	1.53	2.06	1.27	**15.19**
September	2.03	1.49	2.23	1.40	**15.62**
October	1.94	1.41	2.14	1.42	**13.35**
November	0.84	0.87	0.83	0.96	**2.41**
December	4.08	2.79	4.53	1.51	**111.85**
Average	**2.81**	**2.03**	**3.09**	**1.39**	**57.90**
50 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m²)**
January	5.45	3.12	6.16	1.83	**210.60**
February	5.45	3.70	6.04	1.52	**263.23**
March	3.15	2.45	3.42	1.31	**64.51**
April	3.51	2.58	3.85	1.40	**80.48**
May	3.06	2.55	3.26	1.22	**67.83**
June	2.78	2.24	3.14	1.26	**54.79**
July	2.72	1.71	3.04	1.65	**29.16**
August	2.21	1.70	2.40	1.33	**21.92**
September	2.32	1.70	2.55	1.40	**23.08**
October	2.21	1.60	2.44	1.43	**19.51**
November	1.02	1.02	1.01	0.99	**3.92**
December	4.62	3.15	5.12	1.51	**162.09**
Average	**3.44**	**2.29**	**3.54**	**1.41**	**83.43**

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, $\overline{P_{WTA}}$:

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

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 Lowaramina 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 Lowaramina 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 Lowaramina.

PMD Calculator (using 50M) April 2007 to Sep 2008				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	222	77	19%	86,568
February	278	81	21%	86,092
March	68	24	6%	27,522
April	85	30	8%	33,349
May	72	25	6%	27,955
June	58	21	5%	22,577
July	31	11	3%	12,343
August	23	8	2%	9,046
September	24	8	2%	9,245
October	21	7	2%	7,824
November	4	1	0%	1,143
December	171	57	14%	64,472
Annual	65	24	6%	316,862

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 twenty-six 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 Lowaramina (April 07- Sept 08). The graph shows that the maximum power is produced at about 0700; of course, this is the same time when we have the maximum wind speed in 24 hours. Figure 21 & 22 shows the monthly and daily wind generated electric power output. Figure 21 depicts that at Lowaramina the wind have more potential in the February as compared to other months. Figure 23 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20 Lowaramina: From April 2007 to Sep 2008 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output

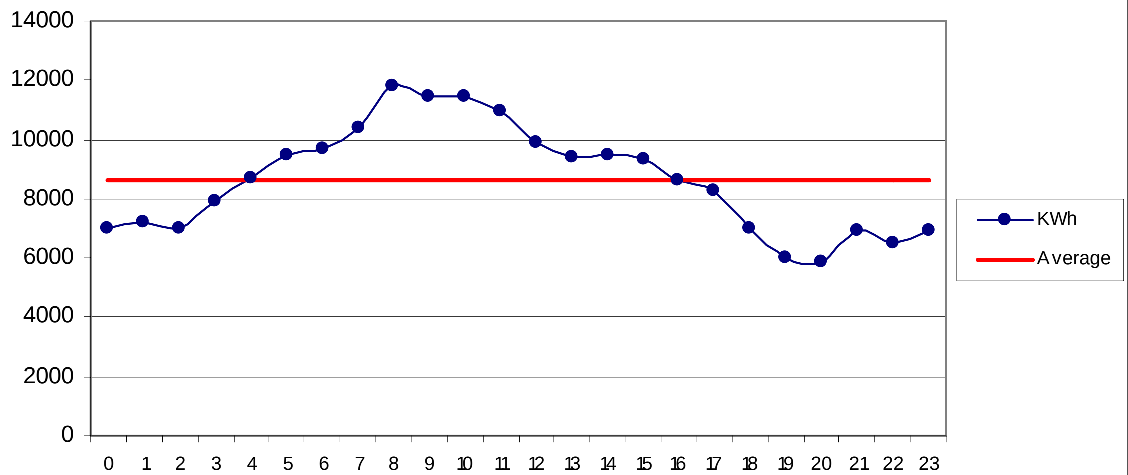


Fig 21 Lowaramina: From April 2007 to Sep 2008 Monthly Average Diurnal Varition Of Wind Generated Electric Powe Output

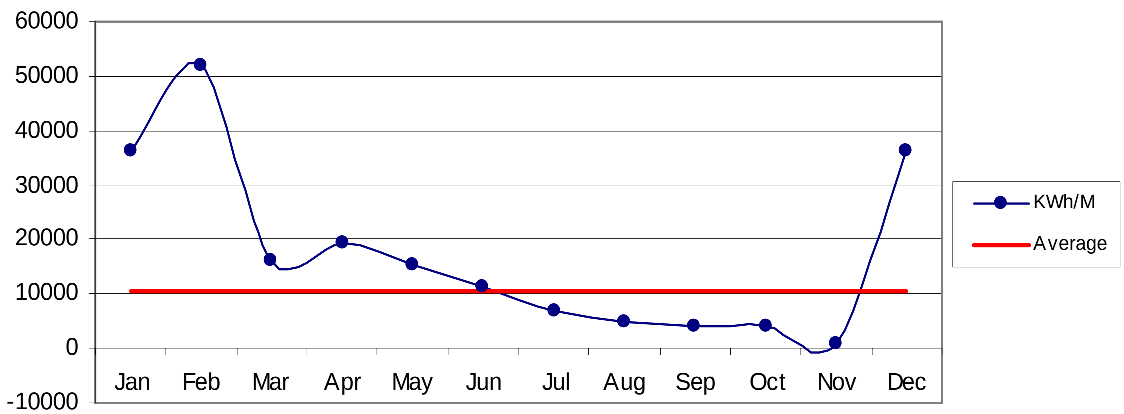
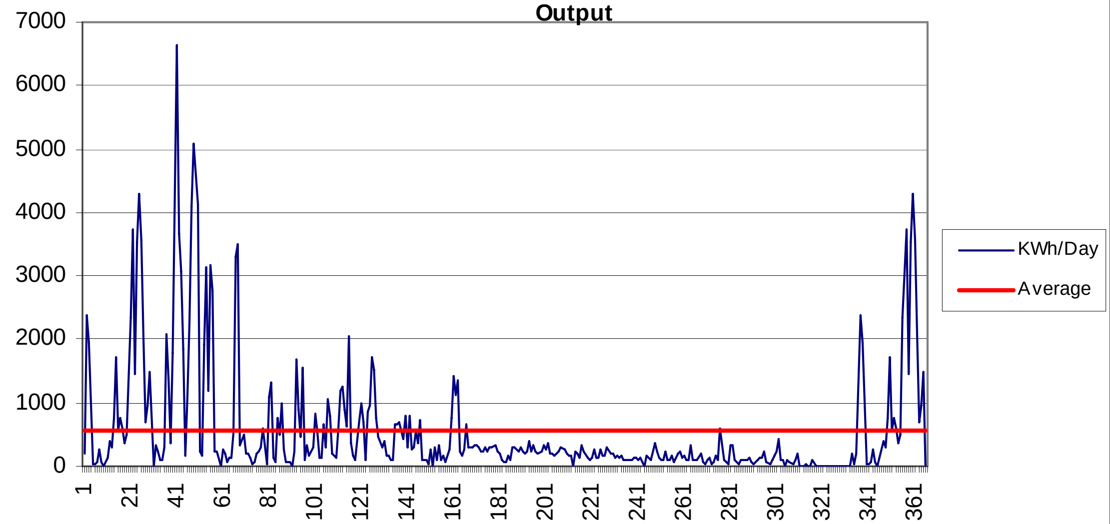


Fig 22 Lowaramina: From April 2007 to Sep 2008 Daily Wind Generated Electric Power Output



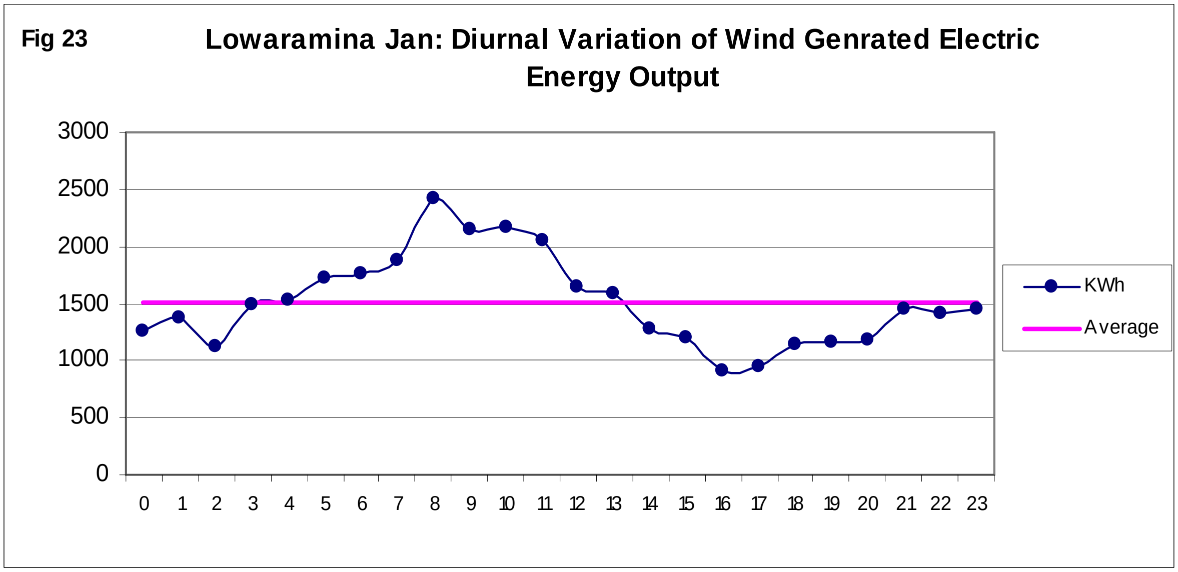


Fig 23
Lowaramina Jan: Diurnal Variation of Wind Genrated Electric Energy Output
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average

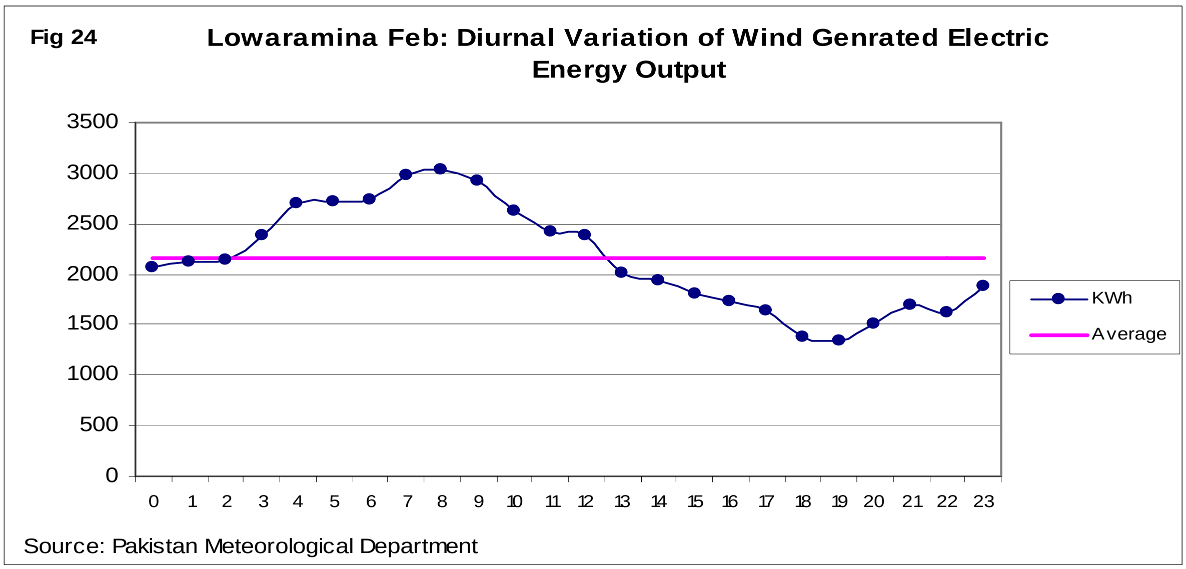


Fig 24
Lowaramina Feb: Diurnal Variation of Wind Genrated Electric Energy Output
3500
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

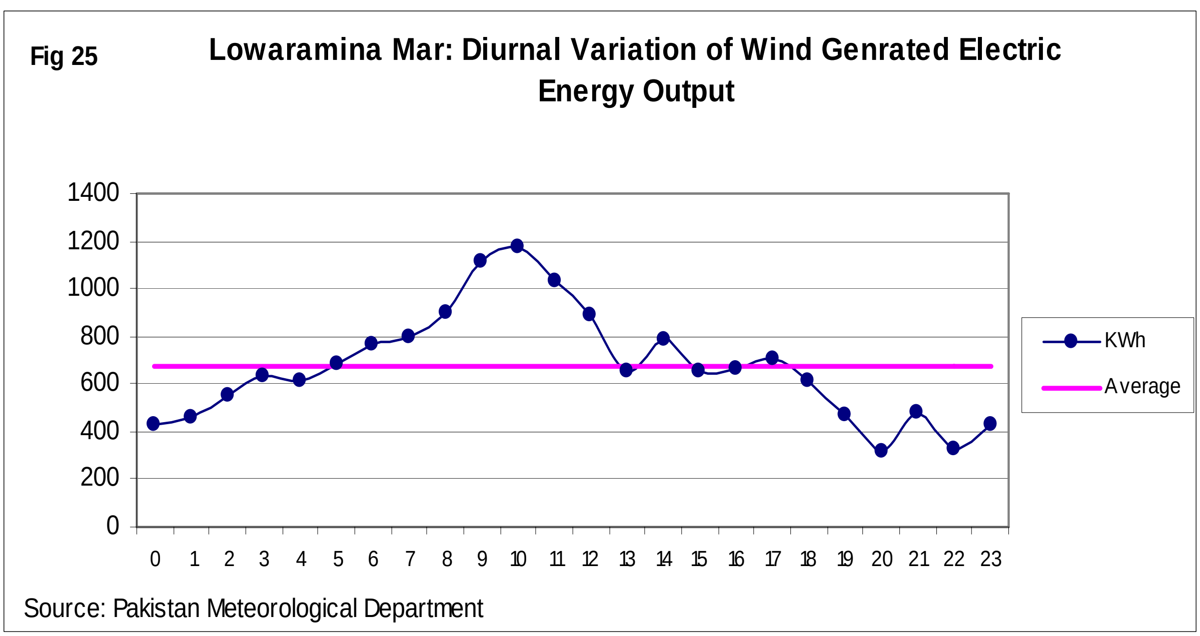
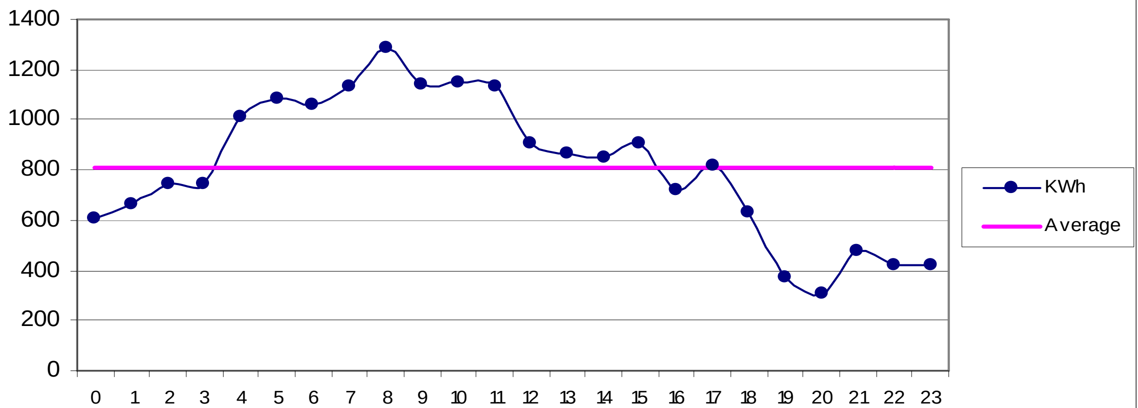


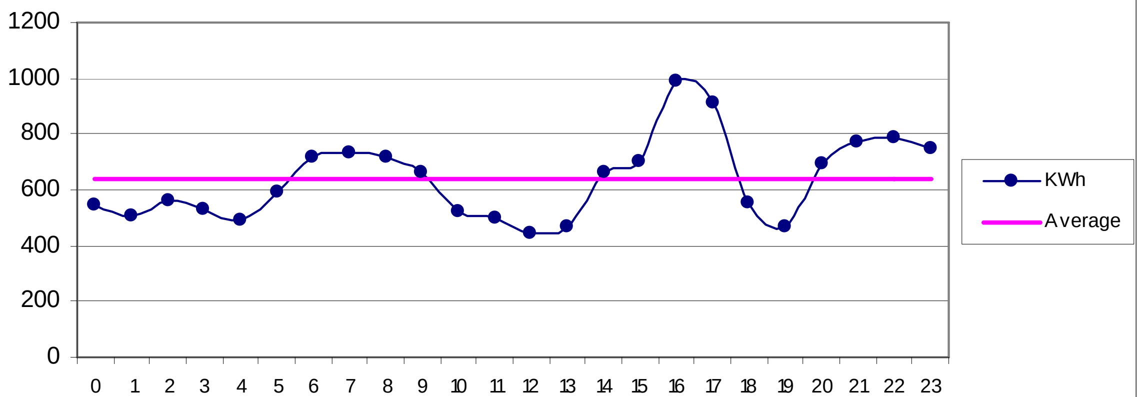
Fig 25
Lowaramina Mar: Diurnal Variation of Wind Genrated Electric Energy Output
1400
1200
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
KWh
Average
Source: Pakistan Meteorological Department

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



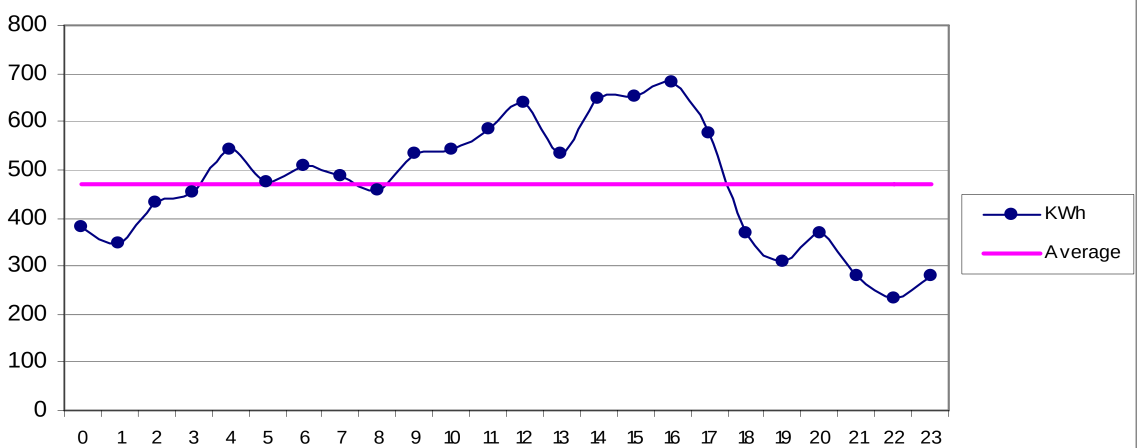
Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

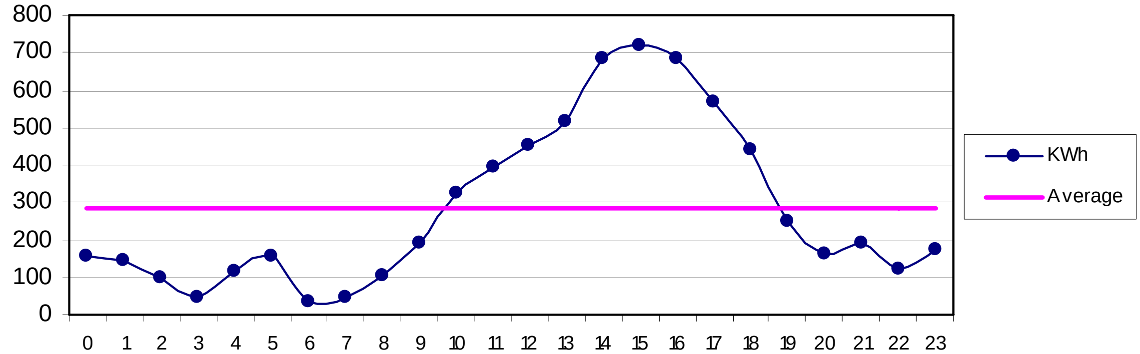
Fig 28 **Lowaramina Jun: Diurnal Variation of Wind Genrated Electric Energy Output**



Source: Pakistan Meteorological Department

Fig 29

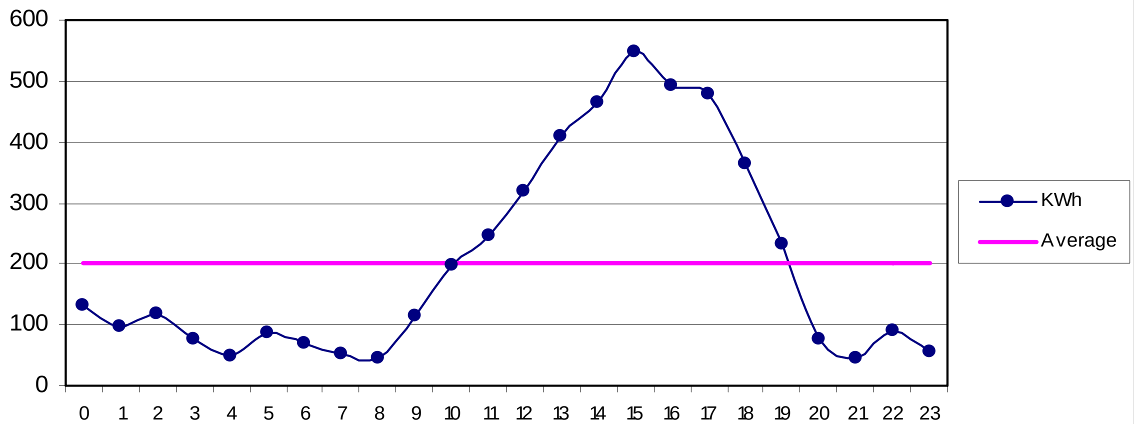
Lowaramina July: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 30

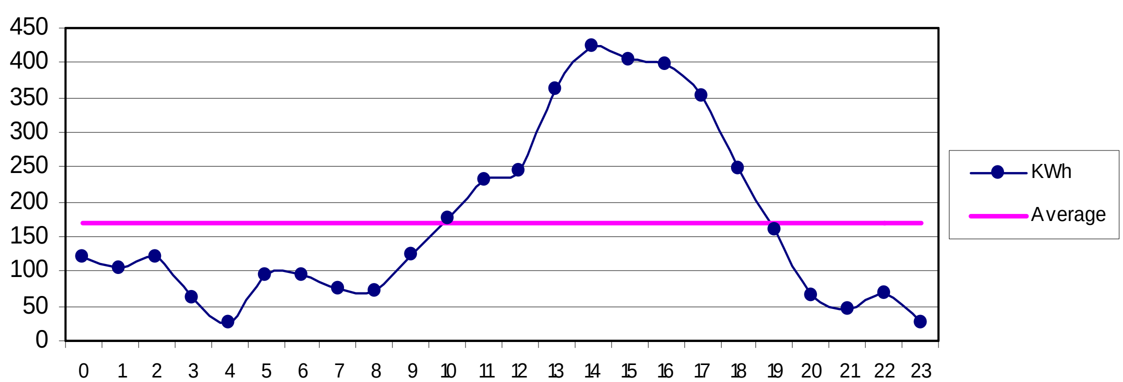
Lowaramina Aug: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 31

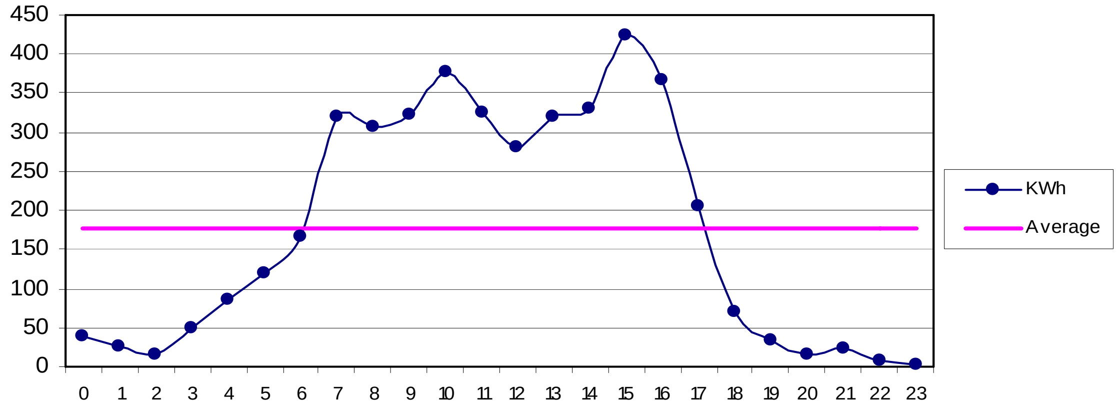
Lowaramina Sep: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 32

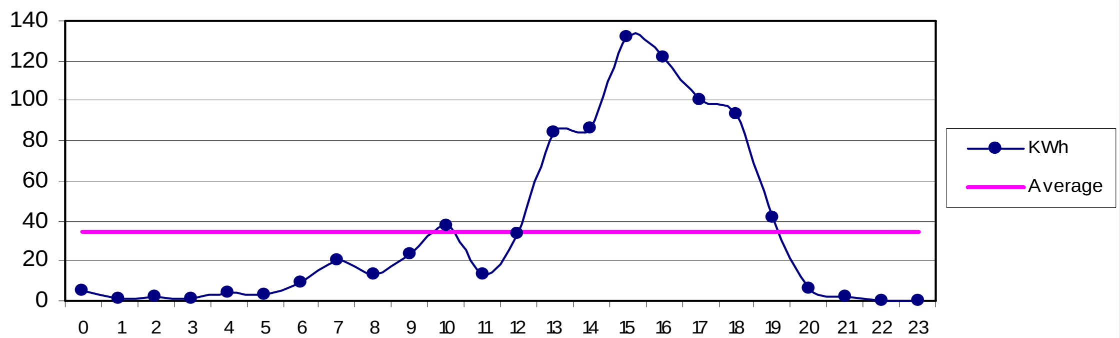
Lowaramina Oct: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 33

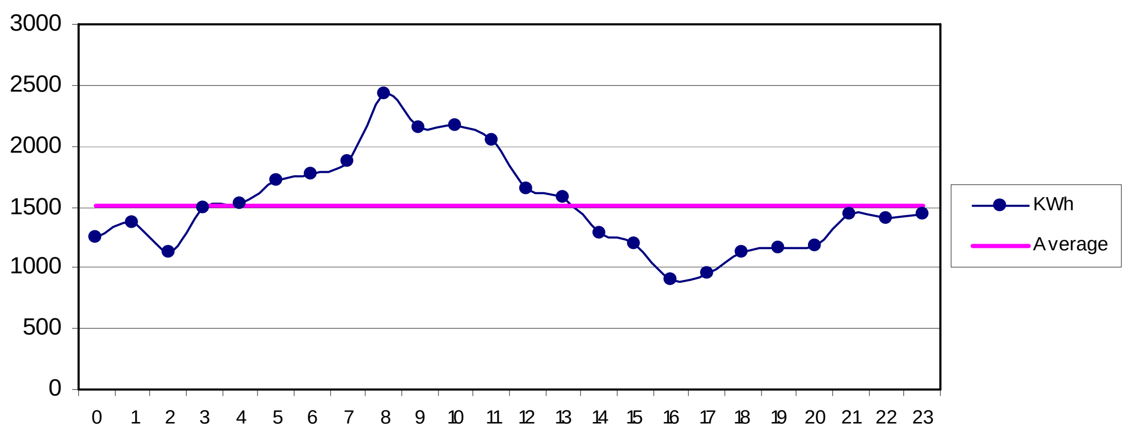
Lowaramina Nov: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 34

Lowaramina Dec: Diurnal Variation of Wind Genrated Electric Energy Output



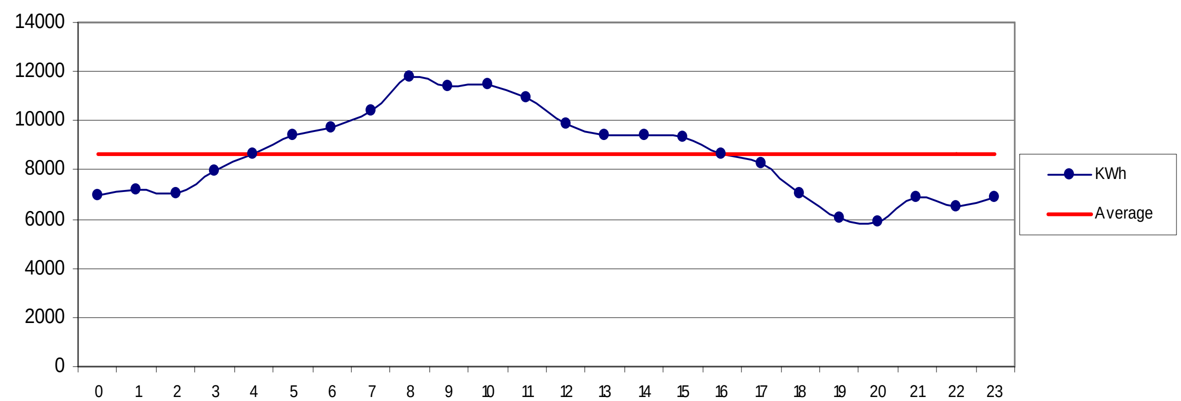
Source: Pakistan Meteorological Department

Appendix-I

Lowaramina **May 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	1249	1368	1123	1483	1524	1718	1763	1875	2424	2147	2174	2048	1646	1583	1280	1194	908	956	1133	1170	1178	1447	1412	1442	36244
Feb	2071	2124	2135	2381	2691	2716	2732	2976	3035	2918	2625	2411	2376	2015	1944	1808	1728	1642	1380	1337	1517	1687	1621	1885	51753
Mar	431	456	554	636	616	681	769	800	898	1109	1180	1033	892	651	792	656	660	705	609	475	321	483	332	424	16163
Apr	607	661	747	746	1009	1087	1060	1135	1289	1141	1152	1135	903	867	853	903	717	820	634	368	310	478	419	423	19464
May	542	503	560	532	493	589	714	732	718	660	524	500	441	465	661	705	990	914	552	470	696	770	791	745	15265
Jun	383	346	433	452	544	475	509	485	457	535	542	583	641	534	647	652	680	575	370	310	370	279	234	278	11314
Jul	157	147	98	48	114	157	36	48	103	192	322	393	453	514	683	721	683	570	438	249	161	194	123	175	6780
Aug	132	98	119	78	50	87	68	52	44	115	198	245	318	409	463	547	492	479	365	231	76	45	90	56	4859
Sep	121	105	121	61	25	94	95	76	70	125	175	231	243	362	424	405	399	352	246	160	64	47	68	27	4097
Oct	39	27	15	49	87	120	166	320	308	323	378	325	282	320	331	424	366	205	70	34	17	23	9	4	4240
Nov	5	1	2	1	4	3	9	20	14	23	37	13	33	84	86	132	122	100	93	41	6	3	0	0	832
Dec	1249	1368	1123	1483	1524	1718	1763	1875	2424	2147	2174	2048	1646	1583	1280	1194	908	956	1133	1170	1178	1447	1412	1442	36244
KWH	6985	7204	7029	7950	8681	9444	9686	10394	11783	11434	11481	10964	9875	9386	9446	9341	8652	8274	7023	6016	5894	6901	6509	6901	**207253**
Average	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	8636	

Lowaramina: From April 2007 to Sep 2008 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output



Source: Pakistan Meteorological Department

Appendix-II

Lowaramina **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	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	33	161	198
2	157	139	101	185	83	108	80	36	153	91	78	107	93	93	81	50	51	55	56	83	115	145	138	103	2379
3	122	129	0	122	107	93	122	86	107	97	53	71	55	83	100	108	56	72	107	59	34	39	71	71	1963
4	86	79	55	114	100	129	121	47	93	71	44	23	1	7	7	9	2	1	0	0	0	0	0	0	988
5	0	0	0	0	0	0	0	0	0	0	0	3	1	6	7	7	5	0	1	2	0	0	0	0	35
6	0	0	0	0	0	0	0	0	0	0	3	9	6	0	5	8	3	0	4	9	1	0	0	0	48
7	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	18	14	3	0	0	3	0	0	3	51
8	0	0	1	5	6	8	9	12	3	11	40	55	13	33	47	25	6	0	0	0	0	0	0	0	273
9	1	0	4	0	0	0	6	22	0	0	8	0	2	11	0	0	0	0	0	0	0	0	0	0	55
10	0	0	0	0	0	0	0	0	0	0	0	0	2	1	5	2	1	0	0	0	0	0	0	0	11
11	0	0	0	1	2	5	11	40	24	21	9	3	0	0	0	1	1	0	0	0	2	1	0	0	122
12	2	0	0	0	0	0	3	5	40	33	47	40	27	18	18	24	13	21	13	27	27	29	6	0	394
13	0	0	0	0	1	4	7	4	11	17	40	56	50	43	40	11	21	0	0	1	0	0	0	0	307
14	0	0	0	0	0	2	2	13	5	37	61	61	58	80	76	43	24	30	47	47	43	51	55	33	767
15	45	74	107	108	137	130	48	130	200	93	93	107	81	56	59	34	24	13	22	30	40	30	28	33	1720
16	33	36	36	43	71	93	45	48	27	25	12	37	7	38	16	6	0	2	0	0	0	0	0	0	575
17	0	0	7	3	45	40	40	51	48	35	47	86	64	61	18	45	76	57	18	5	0	0	13	12	772
18	0	35	25	40	27	63	45	42	66	68	31	47	31	36	36	9	1	3	0	0	0	0	0	0	604
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	10	42	123	129	57	368
20	35	24	0	0	16	24	10	11	24	27	20	4	8	0	0	1	0	1	11	5	63	85	42	100	509
21	28	47	11	36	64	95	123	102	177	105	145	83	67	95	68	93	74	48	83	123	161	230	130	154	2342
22	222	193	168	182	202	161	191	231	214	193	185	192	153	162	137	145	114	115	101	138	85	80	108	75	3743
23	37	24	37	33	51	50	31	55	42	17	5	34	63	52	36	48	55	61	88	116	138	103	146	138	1457
24	81	100	76	138	130	137	153	145	161	177	185	129	122	114	102	86	30	95	259	208	185	244	264	211	3530
25	161	223	246	223	215	230	245	230	231	251	224	147	177	133	130	115	81	138	199	192	106	137	137	123	4293
26	208	239	224	216	177	216	208	185	193	216	239	201	153	145	122	114	122	110	47	51	65	69	36	14	3566
27	34	26	22	3	21	49	154	153	169	177	217	216	185	138	74	111	78	86	47	26	28	26	0	0	2036
28	0	0	0	2	8	8	20	54	177	86	101	115	50	43	18	13	5	0	0	0	0	0	0	0	698
29	0	1	1	6	22	30	53	115	168	200	154	93	56	40	8	0	1	0	0	0	0	0	0	1	949
30	0	1	3	22	40	45	36	56	93	100	137	129	121	93	64	69	50	40	30	40	40	53	76	154	1490
31	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
KWh	1249	1368	1123	1483	1524	1718	1763	1875	2424	2147	2174	2048	1646	1583	1280	1194	908	956	1133	1170	1178	1447	1412	1442	36244

Lowaramina 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	5	10	41	37	30	32	1	2	18	12	53	53	17	17	2	2	0	0	0	0	1	0	0	0	332
2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	21	13	3	10	62	5	3	36	27	36	217
3	13	8	0	18	1	11	0	1	0	0	5	4	2	4	8	4	2	2	8	2	1	0	1	0	95
4	0	0	0	0	0	0	0	0	0	0	5	0	0	31	17	8	17	4	2	9	0	0	0	0	92
5	0	0	2	5	14	9	4	2	1	7	0	2	3	13	30	5	5	9	4	13	43	43	29	56	300
6	36	40	14	29	12	30	74	86	78	93	107	153	223	122	45	98	103	108	122	102	75	71	69	184	2073
7	145	78	76	115	107	137	122	108	100	93	65	1	3	21	11	5	1	3	22	72	51	0	27	9	1373
8	20	46	88	100	74	12	1	0	0	0	3	1	0	0	0	11	8	4	1	0	0	0	0	0	369
9	0	0	0	0	0	16	50	55	86	107	69	86	74	53	107	81	115	88	102	88	88	111	130	276	1779
10	341	253	237	304	249	355	325	272	282	305	328	310	327	298	307	265	324	323	267	223	208	206	161	153	6621
11	185	145	153	154	200	223	230	200	223	231	169	177	138	153	122	138	92	118	42	34	126	169	145	88	3652
12	137	177	168	129	185	140	221	222	243	184	116	111	153	95	177	246	201	110	28	7	1	0	4	3	3056
13	24	55	59	114	192	161	209	223	63	138	169	138	63	56	60	23	30	40	19	12	0	0	0	0	1846
14	0	2	0	0	14	22	24	10	0	12	28	3	2	1	5	30	15	5	0	1	0	0	0	0	175
15	5	7	27	38	48	96	76	86	107	169	129	81	50	47	51	30	24	13	5	0	0	1	0	0	1090
16	6	8	43	38	103	51	110	131	126	93	93	103	108	88	76	64	96	106	169	116	137	141	115	169	2289
17	184	183	114	130	153	90	58	126	145	61	86	215	193	243	170	95	145	169	123	222	282	336	308	278	4108
18	298	298	291	309	317	302	223	264	248	216	213	177	208	193	246	200	123	26	29	57	88	192	272	291	5078
19	310	285	309	330	335	303	253	265	337	286	284	222	192	138	138	95	37	20	0	0	0	0	0	0	4137
20	0	0	0	1	1	0	0	6	12	51	51	27	38	9	7	3	11	13	2	0	0	0	0	2	234
21	0	0	0	0	0	0	0	0	0	0	1	1	7	6	16	13	0	0	2	0	1	1	82	45	175
22	45	74	69	36	48	61	100	95	122	93	88	93	93	93	78	53	51	61	131	66	61	113	72	123	1916
23	116	222	223	277	266	269	277	301	238	137	115	111	123	55	51	40	21	31	36	84	71	32	23	16	3134
24	13	31	28	36	118	130	123	93	145	129	101	69	69	56	29	11	13	11	0	0	0	0	0	0	1203
25	0	4	31	63	138	161	86	161	201	193	185	153	239	131	39	91	118	183	116	154	231	208	154	146	3182
26	183	198	161	117	78	90	161	200	209	262	115	72	17	86	121	152	153	149	86	71	48	25	1	10	2767
27	5	2	0	1	8	12	3	37	6	29	26	15	18	8	11	11	3	21	1	0	0	0	0	0	217
28	0	0	0	0	2	1	0	35	48	17	25	36	18	1	1	22	18	16	2	0	0	0	0	0	241
KWh	2071	2124	2135	2381	2691	2716	2732	2976	3035	2918	2625	2411	2376	2015	1944	1808	1728	1642	1380	1337	1517	1687	1621	1885	51753

Lowaramina March 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	1	1	0	0	0	0	0	0	8	47	40	37	24	56	48	8	1	0	1	0	0	0	0	0	271
2	0	0	0	0	0	3	3	18	3	7	28	24	23	10	3	10	21	21	13	0	3	0	0	0	191
3	0	0	0	0	0	0	0	0	3	7	3	3	11	10	1	7	5	5	2	0	0	0	0	1	59
4	0	0	2	0	5	1	0	0	0	14	8	18	11	17	15	14	6	8	2	0	0	0	0	0	119
5	0	0	0	0	0	0	0	1	8	5	12	10	1	0	1	0	0	0	8	82	7	9	1	0	146
6	1	2	0	0	0	49	32	3	32	42	40	11	23	34	24	5	57	135	26	0	1	3	0	5	525
7	116	61	73	161	133	145	162	153	107	131	145	121	129	108	200	209	216	175	101	107	121	145	122	153	3292
8	161	193	239	209	231	253	260	293	273	266	231	201	146	161	122	81	64	21	17	24	18	5	1	43	3511
9	10	0	5	15	0	5	16	3	13	53	69	64	40	17	6	0	0	3	0	0	3	0	0	0	323
10	0	0	0	1	0	2	40	0	2	42	27	24	7	1	117	44	55	10	41	36	35	0	0	0	485
11	0	0	0	0	9	27	0	2	25	40	36	12	12	9	8	21	9	0	0	0	0	0	0	1	213
12	0	0	0	1	1	0	7	7	5	10	17	50	15	10	23	14	1	9	2	5	5	0	0	0	184
13	0	0	0	0	0	2	6	0	0	12	27	36	21	2	1	1	4	11	2	0	0	0	0	0	125
14	0	0	0	0	0	0	0	0	0	0	0	3	2	6	6	12	12	2	1	0	0	0	0	0	44
15	0	0	0	0	0	0	1	4	3	6	9	0	4	4	9	12	11	1	0	0	3	1	0	0	69
16	0	0	0	0	0	0	3	8	16	36	49	27	17	1	24	6	1	3	2	0	0	0	0	1	192
17	0	0	0	0	0	0	0	0	3	12	0	1	4	3	0	51	29	16	2	0	0	27	27	40	215
18	0	0	0	0	0	0	0	0	18	59	50	47	27	16	8	20	7	53	0	0	0	2	1	0	308
19	10	27	8	27	34	12	36	56	55	64	55	43	53	25	5	11	6	3	27	20	0	9	1	3	590
20	1	0	0	0	0	0	0	0	0	0	0	1	5	2	5	5	9	2	0	2	0	1	0	0	34
21	0	0	0	0	0	0	0	30	118	101	138	108	103	46	31	17	14	1	18	71	76	67	56	86	1082
22	74	100	107	114	107	122	145	137	103	76	59	56	30	11	26	3	5	27	24	4	0	0	0	0	1330
23	2	0	0	0	0	0	0	0	15	7	11	1	5	3	11	21	16	11	13	9	3	0	0	0	128
24	0	0	0	0	0	2	1	0	0	0	3	10	16	13	8	12	4	3	2	1	0	0	0	0	76
25	0	0	0	1	0	1	0	0	0	0	0	5	21	8	0	0	56	126	215	79	36	137	66	17	769
26	18	9	18	11	16	10	45	32	5	10	35	8	4	4	12	6	2	8	23	9	1	76	56	64	479
27	27	60	100	96	77	45	10	53	83	48	53	81	76	37	27	27	18	13	48	21	5	0	1	1	1006
28	0	0	0	0	0	0	0	0	0	14	27	16	52	26	43	30	25	24	11	2	0	0	0	9	278
29	11	2	0	0	0	0	0	0	0	0	1	11	9	6	2	2	2	4	0	2	1	0	0	0	54
30	0	0	1	0	0	0	0	0	0	0	9	4	4	8	7	7	4	9	8	0	3	0	0	0	63
31	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
KWh	431	456	554	636	616	681	769	800	898	1109	1180	1033	892	651	792	656	660	705	609	475	321	483	332	424	16163

Lowaramina 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	11	26	9	1	2	1	5	0	7	15	3	13	19	29	14	20	16	20	7	4	1	0	0	1	223
2	5	7	5	32	118	104	88	115	135	160	153	112	115	101	80	80	63	66	80	30	20	16	0	0	1685
3	0	5	0	14	22	22	34	38	46	51	65	78	84	65	75	38	50	53	46	27	2	40	30	2	889
4	6	5	2	2	4	0	0	0	6	12	13	45	17	27	30	25	23	20	24	42	51	44	18	33	451
5	41	66	67	56	86	114	117	85	93	30	48	150	123	155	173	137	15	2	0	0	1	0	3	0	1562
6	0	0	1	0	4	5	2	5	6	16	12	11	12	1	2	3	10	7	2	2	1	0	0	0	101
7	1	3	7	17	44	46	33	28	24	30	19	24	16	12	11	12	7	1	0	0	0	0	0	0	337
8	0	2	0	0	0	2	3	18	20	21	32	25	27	14	4	0	3	5	1	0	0	1	0	0	180
9	0	0	1	12	3	7	12	12	25	10	16	24	16	20	46	31	13	11	3	3	7	6	12	8	296
10	26	23	25	41	28	30	46	54	53	51	56	22	21	34	25	20	6	2	9	20	60	71	61	49	836
11	57	56	46	44	33	25	32	27	23	9	13	35	46	17	17	14	7	7	5	0	0	1	0	0	514
12	0	1	0	1	2	3	3	9	7	5	4	2	12	11	16	19	21	16	7	2	0	1	0	0	143
13	0	1	1	1	5	2	6	11	13	7	11	6	5	9	10	10	16	14	3	3	0	0	0	0	132
14	7	1	23	20	41	61	32	5	23	45	64	50	17	7	56	43	73	63	16	0	0	1	4	4	656
15	4	2	3	1	0	6	0	4	3	12	23	15	9	7	4	18	40	114	27	7	2	1	4	1	307
16	0	43	39	57	80	88	50	83	73	57	47	40	27	27	17	12	14	17	11	39	85	42	25	98	1071
17	136	28	89	71	59	61	65	50	58	56	44	24	18	12	6	5	1	1	0	0	0	0	7	0	795
18	0	0	2	8	7	14	20	23	23	21	20	25	13	6	1	2	5	4	4	3	0	0	2	0	203
19	0	0	1	0	0	0	1	1	5	10	3	9	5	7	7	13	14	16	3	3	3	5	10	3	119
20	22	88	80	22	30	69	33	35	45	41	36	27	13	13	5	8	9	6	1	1	0	0	0	3	589
21	50	88	100	96	111	44	18	45	79	76	57	54	28	30	21	27	29	33	86	17	35	28	29	18	1200
22	6	2	0	3	8	12	15	29	43	48	46	44	50	85	63	186	111	131	136	127	20	49	32	22	1266
23	25	27	18	30	33	74	91	88	100	71	72	53	45	20	30	26	43	25	11	3	1	0	0	0	885
24	0	0	0	0	2	4	2	12	56	55	115	77	55	50	43	52	23	18	14	1	0	0	16	32	628
25	77	145	158	196	196	185	181	205	200	122	87	69	38	36	27	20	16	41	34	10	0	0	0	1	2043
26	6	3	1	0	1	11	26	36	36	44	44	41	18	9	11	24	23	17	7	4	0	0	0	0	361
27	0	0	1	0	3	9	5	18	6	12	3	2	7	11	22	23	16	13	8	3	2	1	0	0	166
28	0	0	2	1	5	3	1	1	14	3	3	5	9	15	19	8	8	7	2	1	0	0	0	0	108
29	1	0	1	0	0	0	0	0	3	6	2	8	10	13	9	5	17	86	82	12	16	168	160	130	732
30	122	39	65	18	84	84	140	97	63	42	41	44	28	26	12	20	26	7	2	4	1	2	3	16	988
KWh	607	661	747	746	1009	1087	1060	1135	1289	1141	1152	1135	903	867	853	903	717	820	634	368	310	478	419	423	19464

Lowaramina 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	48	32	45	46	82	44	66	47	41	33	32	26	21	26	32	15	14	10	9	8	3	0	0	0	680
2	0	0	3	0	0	0	2	2	8	6	12	13	10	9	6	15	8	4	1	1	0	0	0	0	100
3	0	0	0	0	0	0	0	5	12	4	8	7	13	13	9	4	115	97	122	17	71	110	102	165	874
4	85	37	7	14	15	10	11	12	22	28	12	5	10	16	37	50	4	11	20	53	69	153	144	127	953
5	107	109	80	36	32	81	87	75	77	122	81	87	33	22	13	7	21	59	29	41	94	113	142	157	1704
6	155	179	171	150	162	95	142	112	130	64	25	25	16	12	17	21	19	19	6	0	0	1	0	0	1520
7	0	1	0	0	0	0	0	0	6	20	11	3	10	5	4	6	15	37	30	58	159	141	181	64	751
8	52	36	23	17	8	22	8	20	16	2	20	26	30	27	32	20	21	46	17	11	1	0	0	7	459
9	1	0	0	0	12	1	0	0	0	12	6	21	12	19	48	38	45	30	11	1	15	18	14	0	306
10	0	0	0	0	0	1	0	3	3	5	3	5	10	5	8	25	87	128	67	42	6	4	2	0	403
11	1	0	1	0	0	1	0	0	2	6	13	23	22	22	18	14	19	15	6	1	0	0	0	1	166
12	0	0	0	4	4	2	1	0	3	3	8	13	17	20	16	15	24	23	13	5	3	1	0	7	181
13	0	0	0	0	3	0	0	0	1	11	16	14	7	5	6	3	7	8	4	3	0	7	4	0	100
14	0	0	1	0	0	0	0	0	5	1	2	12	17	12	11	8	7	6	6	2	0	0	0	0	88
15	0	1	0	0	0	0	0	0	8	5	14	12	13	5	4	36	124	155	74	60	67	54	11	12	654
16	6	4	13	15	11	1	0	22	3	3	6	14	17	29	27	18	30	38	5	89	135	93	59	14	654
17	0	4	50	67	33	68	38	92	60	66	55	29	7	15	20	23	14	10	4	3	12	6	1	0	678
18	0	0	4	22	2	0	1	1	2	17	12	11	18	18	91	50	51	1	6	0	0	0	44	64	415
19	17	42	57	82	39	67	123	93	42	9	11	14	13	10	12	14	13	13	7	17	7	11	40	43	795
20	13	9	8	1	6	25	18	20	29	12	3	5	8	9	25	27	24	17	12	13	3	11	3	4	305
21	4	2	9	11	28	76	111	100	96	81	36	25	14	28	42	22	47	32	12	17	1	4	1	5	805
22	1	0	0	0	1	5	20	19	10	8	11	10	17	35	20	18	7	2	3	8	8	2	12	47	265
23	8	3	1	0	0	6	0	0	1	10	11	10	10	11	21	47	86	38	24	0	0	2	2	3	292
24	1	17	20	6	1	1	2	1	6	2	8	23	28	20	75	82	77	52	39	9	28	35	14	0	549
25	4	0	0	1	0	5	11	23	30	63	40	34	34	16	13	14	4	31	14	2	3	1	4	6	352
26	25	9	48	44	32	43	38	67	80	48	49	7	6	21	3	94	88	13	3	0	0	0	5	3	726
27	1	0	0	1	1	1	0	0	2	4	5	8	11	15	18	10	5	3	1	1	3	1	0	0	91
28	1	0	0	0	0	2	1	0	1	4	5	9	8	11	12	11	11	11	3	3	0	0	1	0	94
29	0	0	0	0	0	0	0	1	0	0	0	3	2	3	4	1	3	5	2	2	6	0	1	14	47
30	11	17	20	15	22	30	32	15	22	13	8	8	6	7	18	1	0	0	4	3	2	1	3	1	259
31	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
KWh	542	503	560	532	493	589	714	732	718	660	524	500	441	465	661	705	990	914	552	470	696	770	791	745	15265

Lowaramina 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	7	5	8	8	8	5	7	12	18	41	65	49	26	5	16	283
2	11	4	4	0	0	0	0	4	8	3	1	4	9	10	8	11	11	9	8	5	3	1	0	1	113
3	4	2	0	0	2	2	5	1	2	2	5	17	9	19	3	2	1	3	3	24	75	68	49	30	329
4	28	0	1	0	8	4	3	7	0	4	8	5	9	7	8	11	7	2	1	1	0	0	0	0	114
5	0	0	0	0	0	0	2	2	23	11	4	9	14	4	18	24	18	9	2	4	2	13	3	12	173
6	2	0	1	0	0	0	0	0	0	1	1	6	11	10	10	8	6	8	2	1	0	0	0	0	65
7	0	0	1	0	0	0	0	5	10	14	6	18	33	18	50	46	32	17	13	5	2	0	0	3	272
8	47	41	30	40	96	57	58	76	39	31	30	46	22	26	38	7	8	10	6	0	0	2	22	43	776
9	65	0	100	147	154	110	126	70	107	139	112	88	88	36	26	14	18	1	0	0	0	0	0	13	1413
10	34	41	30	26	36	69	43	42	50	58	76	88	81	61	17	14	20	14	5	26	61	40	77	115	1124
11	121	126	138	134	121	133	133	108	104	73	37	13	9	11	17	16	9	15	8	12	3	3	0	0	1344
12	1	15	4	1	0	5	9	15	20	21	10	9	17	7	8	18	18	23	12	8	4	1	0	0	227
13	0	0	0	0	0	0	2	0	1	3	11	13	8	7	8	11	15	44	28	9	15	2	0	0	178
14	1	5	17	0	0	1	0	2	8	11	7	11	11	12	10	9	20	29	28	9	26	27	4	2	248
15	1	10	8	16	30	66	80	104	28	23	21	19	23	14	19	23	82	26	23	22	15	13	6	1	675
16	4	33	27	28	10	1	0	1	9	18	9	11	8	14	38	32	17	17	8	6	5	7	0	0	303
17	0	0	1	6	11	3	0	3	3	11	17	18	18	24	37	21	18	27	20	5	22	15	1	2	282
18	1	0	0	0	0	0	12	3	1	2	13	16	17	24	39	50	53	35	17	18	6	6	1	9	323
19	23	7	13	0	5	0	0	1	2	7	18	15	28	16	36	33	50	34	16	4	2	5	12	3	329
20	1	4	4	12	15	9	12	18	2	3	7	12	26	36	40	34	20	19	12	5	1	6	8	0	306
21	0	0	0	0	0	0	3	0	3	14	15	10	16	16	24	24	21	17	13	5	5	12	12	7	219
22	5	7	3	1	1	4	0	0	5	8	9	15	15	15	27	35	33	24	16	10	6	0	1	0	239
23	0	5	6	3	9	5	5	2	2	13	18	23	23	28	34	32	40	24	17	12	2	0	1	2	306
24	8	7	8	0	1	0	3	6	5	9	17	15	10	11	14	27	27	20	19	14	2	0	0	2	226
25	5	2	0	0	1	0	0	0	2	3	24	35	44	37	34	27	18	14	14	21	19	5	4	0	309
26	1	5	1	0	0	0	3	0	3	7	20	12	17	19	30	38	42	67	18	8	0	1	3	2	295
27	2	0	1	3	18	1	6	4	7	11	11	13	14	22	23	42	35	25	7	2	31	17	22	12	328
28	19	28	30	23	6	0	2	10	10	11	17	12	17	2	0	4	0	1	1	5	12	10	2	1	224
29	0	0	1	1	1	0	0	0	1	11	8	18	34	19	16	21	22	23	8	6	3	1	0	4	197
30	0	2	5	8	19	3	0	0	5	6	3	5	2	1	12	11	5	1	5	1	0	0	0	0	94
KWh	383	346	433	452	544	475	509	485	457	535	542	583	641	534	647	652	680	575	370	310	370	279	234	278	11314

Lowaramina 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	1	6	7	5	8	8	11	12	11	4	0	0	0	1	75
2	0	0	0	2	4	15	12	1	0	2	5	5	10	5	2	4	4	3	0	0	0	0	0	0	74
3	0	1	0	0	4	3	0	0	1	2	5	9	18	23	20	16	15	15	13	7	1	8	4	4	171
4	1	0	0	0	0	0	0	0	1	1	9	11	20	13	12	15	12	7	5	4	2	0	1	0	114
5	1	1	2	0	0	0	0	0	1	6	16	13	17	16	27	41	40	30	15	48	4	2	1	6	288
6	4	2	25	5	11	9	1	1	4	21	18	17	20	19	23	24	30	27	16	10	2	0	1	1	289
7	1	4	10	0	1	1	9	6	2	8	10	12	13	15	18	32	30	23	16	3	1	1	0	2	217
8	4	0	5	4	6	31	3	10	13	20	13	10	13	20	23	35	25	28	14	9	6	1	1	1	296
9	1	0	1	1	0	0	0	0	1	3	9	24	19	21	42	32	30	16	17	14	4	6	3	0	245
10	0	0	0	0	0	0	0	0	1	6	10	9	12	14	18	27	31	30	23	7	5	2	0	1	197
11	0	0	0	0	0	0	0	1	6	5	13	7	9	23	22	30	28	19	20	7	2	1	9	25	228
12	18	70	6	10	9	0	1	2	1	7	9	9	16	18	29	29	25	16	10	5	26	20	37	13	385
13	0	1	4	0	0	1	0	1	3	5	7	15	18	22	33	36	30	23	16	4	4	1	0	0	224
14	0	3	17	2	19	16	2	0	3	11	19	17	14	32	36	38	35	13	11	11	6	10	2	3	319
15	1	0	2	2	0	0	0	0	9	7	12	23	29	14	18	14	30	24	15	12	9	1	0	0	222
16	0	0	0	7	5	0	0	0	4	3	8	16	12	13	19	29	21	30	21	5	7	5	1	1	209
17	1	0	1	0	2	6	3	4	6	7	9	17	17	21	32	28	28	16	13	7	5	2	2	2	231
18	52	15	5	3	12	2	3	2	1	9	9	13	21	23	30	32	19	17	10	8	6	2	6	13	315
19	5	1	0	2	1	0	0	0	7	16	25	18	12	18	29	29	30	19	10	2	3	5	8	7	248
20	5	3	17	5	26	9	0	1	3	4	7	9	20	22	21	30	18	15	13	5	3	75	10	36	358
21	28	10	1	2	8	60	1	7	8	1	5	15	4	3	6	9	6	5	4	4	1	2	1	0	192
22	0	0	0	0	0	0	0	0	1	10	6	13	14	21	23	25	33	21	13	4	1	0	0	1	187
23	0	0	0	0	0	0	0	0	1	1	8	9	18	14	16	17	19	32	13	6	1	0	0	0	158
24	0	0	0	0	0	0	0	0	0	3	6	20	20	19	21	24	20	10	36	11	13	0	0	0	205
25	0	0	0	0	0	0	0	0	2	3	9	13	15	21	48	15	18	13	34	21	7	13	3	5	240
26	0	0	0	0	0	0	0	3	1	4	11	12	16	10	20	11	18	18	14	9	32	29	32	44	284
27	33	35	1	0	1	0	0	3	7	0	22	12	14	12	20	17	17	37	13	6	0	0	1	0	253
28	0	0	0	2	4	0	0	0	1	4	20	18	13	17	20	22	19	21	15	6	4	5	1	6	199
29	1	0	0	1	0	0	0	0	3	10	12	11	11	24	24	32	15	11	13	8	3	1	0	1	180
30	1	0	0	0	0	0	0	5	10	12	8	10	9	16	23	20	24	18	15	2	3	1	1	1	177
31	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
KWh	157	147	98	48	114	157	36	48	103	192	322	393	453	514	683	721	683	570	438	249	161	194	123	175	6780

Lowaramina **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	4	17	10	1	4	3	0	4	3	0	10	8	14	17	25	24	12	13	11	19	6	7	7	1	219
2	0	2	0	1	3	6	11	7	7	3	16	10	9	18	22	27	18	20	17	7	3	3	2	0	212
3	0	0	0	1	0	1	0	0	3	4	9	8	12	8	9	6	17	12	15	9	3	1	1	0	119
4	6	1	30	21	0	0	10	2	4	1	13	2	4	9	9	22	16	68	63	54	3	1	0	0	341
5	0	1	0	0	0	0	1	0	1	11	11	7	14	16	10	13	14	51	28	17	20	11	6	1	233
6	0	0	0	0	0	0	0	0	0	6	10	3	2	6	7	22	10	8	19	19	12	1	6	6	138
7	0	0	0	0	0	0	0	0	3	8	7	7	9	9	7	14	6	8	5	1	0	0	0	0	85
8	0	0	0	0	0	0	0	0	0	3	5	11	12	9	17	14	12	7	5	1	0	0	22	2	119
9	45	0	16	26	6	0	6	1	1	3	3	15	34	49	19	15	9	9	6	11	0	0	0	0	274
10	0	0	1	1	0	0	0	0	0	0	5	6	12	13	19	13	20	19	8	6	4	1	0	0	128
11	0	0	0	0	0	9	7	0	2	4	8	10	9	12	6	22	18	18	10	5	6	1	0	1	148
12	56	15	2	3	5	4	2	22	0	3	9	12	15	12	12	15	15	12	11	9	1	1	9	34	279
13	12	2	0	3	2	0	1	0	0	0	4	6	4	10	13	20	20	16	13	5	2	2	28	3	168
14	1	28	2	3	1	0	1	0	0	0	3	1	6	21	27	17	12	15	14	8	1	2	2	2	169
15	2	25	38	7	12	43	10	0	0	4	5	5	9	20	24	26	24	26	23	5	2	1	0	0	311
16	0	0	4	1	2	0	0	2	1	6	11	16	20	26	23	26	13	16	13	7	1	1	0	0	189
17	0	0	0	0	1	1	3	1	0	1	10	21	10	8	23	18	51	26	2	3	2	0	0	3	187
18	0	0	1	0	0	0	0	0	0	2	4	13	17	17	32	25	14	12	4	2	1	1	1	0	148
19	0	1	0	0	0	0	0	0	2	2	3	16	8	14	20	28	17	11	16	5	0	3	0	0	149
20	3	4	5	3	1	3	9	1	3	0	2	7	8	9	10	13	17	23	10	3	0	4	1	0	138
21	0	0	3	4	2	2	1	0	1	5	8	11	12	15	15	24	15	12	11	5	2	2	0	0	152
22	2	0	0	1	1	0	0	1	1	2	1	2	7	6	8	18	12	9	15	3	0	0	0	0	91
23	0	0	0	0	0	0	0	0	3	7	4	6	9	11	13	20	11	5	7	7	1	0	0	0	104
24	0	1	6	0	0	0	0	0	1	10	2	4	7	5	12	11	13	8	4	1	0	1	0	0	86
25	0	0	0	0	0	0	0	0	0	2	3	5	11	12	17	20	13	8	9	5	1	0	0	0	107
26	0	0	0	0	0	0	3	6	1	0	13	11	6	13	20	30	15	2	4	2	0	0	0	0	127
27	0	0	0	0	5	3	0	0	2	18	12	7	14	12	17	16	22	9	4	3	1	0	0	0	144
28	0	0	0	0	3	1	0	0	0	4	3	9	6	8	8	8	23	12	7	1	0	0	0	0	94
29	1	0	0	0	2	10	0	4	2	1	3	2	12	15	11	12	19	11	6	4	1	1	0	0	117
30	0	1	0	0	0	0	0	0	0	5	4	8	7	7	7	5	12	13	6	5	1	0	1	1	82
31	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
KWh	132	98	119	78	50	87	68	52	44	115	198	245	318	409	463	547	492	479	365	231	76	45	90	56	4859

Lowaramina 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	3	16	9	1	0	0	5	18	5	0	1	5	4	8	13	12	14	11	7	9	6	4	0	0	152
2	0	0	0	1	3	6	12	9	0	1	7	9	4	6	14	11	12	12	7	5	3	2	0	0	124
3	0	0	0	0	0	0	3	0	4	4	6	4	6	8	13	7	13	11	11	5	2	2	0	0	100
4	6	0	30	21	0	0	10	2	7	7	5	5	5	11	11	12	15	75	67	51	1	1	14	8	363
5	0	0	1	1	0	2	0	0	1	9	11	5	14	21	13	27	33	32	20	10	16	10	6	0	232
6	0	0	0	0	0	0	0	0	0	1	6	8	6	11	60	5	3	4	10	10	8	2	9	2	145
7	1	0	1	0	0	0	2	1	3	5	4	9	6	11	13	15	9	4	6	3	4	0	0	0	95
8	0	0	0	0	0	0	0	0	0	0	3	3	3	43	4	11	0	1	3	0	0	0	22	2	96
9	45	0	16	26	6	0	6	1	0	1	2	8	12	14	16	20	17	16	7	10	1	4	3	3	232
10	1	0	0	0	0	0	0	0	0	0	2	7	10	10	15	11	16	11	7	13	0	0	2	5	111
11	3	2	0	0	0	9	7	0	1	0	2	2	7	12	9	19	17	12	4	1	3	0	0	1	114
12	56	15	1	3	1	1	1	14	0	3	2	5	5	8	6	12	15	8	3	1	0	0	7	1	168
13	2	2	0	0	0	0	0	0	0	4	4	3	5	5	7	13	13	7	3	3	1	2	1	0	76
14	0	24	2	2	0	0	0	0	0	3	7	7	6	18	23	23	18	19	14	8	2	4	1	2	184
15	2	0	37	4	1	43	10	0	0	5	5	5	9	16	17	18	19	12	9	9	1	0	0	0	224
16	0	0	4	1	2	0	1	1	1	8	8	5	12	15	21	17	5	7	6	3	1	0	0	0	117
17	0	0	0	0	0	1	0	3	3	1	8	15	5	6	15	5	38	29	10	1	5	5	0	0	149
18	0	0	0	0	2	0	1	0	0	3	5	8	9	11	21	15	6	1	2	7	3	1	0	0	96
19	0	1	0	0	0	0	0	0	2	3	3	15	11	8	12	16	9	6	8	3	1	0	0	0	96
20	0	0	0	1	0	6	0	0	1	15	24	37	47	60	52	23	30	21	4	0	1	0	0	0	322
21	0	0	0	0	0	0	0	0	1	8	7	8	12	17	14	21	6	5	2	0	0	0	0	0	101
22	3	43	19	1	1	7	6	1	1	5	0	0	0	1	0	5	5	3	2	2	0	0	0	0	105
23	0	0	0	0	0	1	1	4	13	22	20	7	3	0	4	3	3	4	3	0	1	0	0	0	86
24	0	0	0	0	8	15	30	20	12	10	15	23	13	7	6	3	12	15	6	2	1	6	0	0	205
25	0	0	0	0	0	0	0	0	1	1	0	7	10	8	10	11	9	5	2	1	2	0	0	0	64
26	0	0	0	0	0	0	0	0	5	0	0	2	5	2	4	5	5	8	7	0	0	0	0	0	44
27	0	0	0	0	0	0	0	1	2	2	5	11	2	2	9	6	24	6	14	0	3	1	1	1	89
28	0	0	0	0	0	0	0	0	0	2	0	1	8	15	13	52	24	6	4	0	0	0	0	1	127
29	0	0	0	0	0	0	0	0	0	0	1	5	4	3	4	5	2	0	0	0	2	2	0	0	29
30	0	0	0	0	0	0	0	0	5	3	12	2	1	7	6	4	6	4	0	0	0	0	0	0	50
KWh	121	105	121	61	25	94	95	76	70	125	175	231	243	362	424	405	399	352	246	160	64	47	68	27	4097

Lowaramina 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	0	0	0	0	0	0	0	0	2	2	11	18	21	16	27	27	30	12	1	0	0	0	0	0	166
2	0	0	0	0	0	0	0	1	0	16	1	13	6	7	3	12	10	26	10	0	0	0	0	3	109
3	0	0	0	1	28	40	93	145	88	59	56	24	14	4	5	27	9	2	1	1	0	0	5	0	601
4	0	0	0	0	0	0	2	0	0	0	0	13	4	11	13	13	6	23	3	0	0	0	0	0	89
5	0	0	0	0	0	5	1	2	3	7	1	0	4	13	6	2	16	1	2	1	0	0	0	0	63
6	0	0	0	0	0	0	0	0	0	0	7	11	4	9	1	4	9	1	0	0	0	0	0	0	46
7	0	0	0	3	2	8	33	78	53	40	27	18	4	3	1	27	23	0	1	1	0	0	0	0	320
8	0	0	9	2	12	34	9	35	51	38	46	7	12	14	13	18	6	2	2	2	2	2	0	0	316
9	0	0	0	0	0	0	0	0	9	9	27	5	4	9	11	8	1	0	0	0	1	0	0	0	86
10	0	0	0	0	0	0	0	0	0	0	1	9	8	13	13	13	6	1	6	0	0	0	0	0	69
11	0	0	0	0	0	0	0	0	0	5	2	6	11	9	4	6	2	0	2	0	0	0	0	0	48
12	0	0	0	0	0	0	0	0	0	0	0	11	9	16	16	14	18	11	0	0	0	0	0	0	96
13	0	1	0	0	0	0	0	0	3	8	2	4	4	1	8	27	30	14	1	9	0	0	0	0	112
14	0	0	0	0	0	0	0	0	0	7	0	0	12	11	21	18	13	4	0	0	0	0	0	0	88
15	0	0	0	0	1	0	0	0	0	6	11	3	0	9	16	8	6	14	6	9	13	16	1	0	118
16	2	8	1	0	0	0	0	0	2	2	0	3	8	12	4	2	2	9	5	0	0	0	0	0	60
17	0	0	0	0	0	0	0	0	0	0	6	1	10	2	2	4	2	1	0	0	0	0	0	0	29
18	3	0	0	0	0	0	0	0	0	0	3	6	8	9	16	16	4	2	2	0	0	0	0	0	69
19	0	0	0	0	0	0	0	0	0	0	5	14	16	21	13	11	6	1	0	0	0	0	0	0	87
20	0	0	0	0	0	0	0	1	0	5	1	6	17	18	30	18	27	16	2	0	0	0	1	0	142
21	0	0	1	1	0	0	0	0	0	0	0	5	8	14	18	24	18	18	9	0	0	2	2	0	119
22	0	0	0	0	0	0	6	14	21	18	61	38	30	8	0	2	8	9	1	0	0	0	0	0	217
23	0	0	0	0	2	4	0	7	4	3	7	0	0	2	13	9	2	2	2	0	0	0	0	0	57
24	0	0	0	0	0	0	0	0	0	5	0	1	6	4	4	0	0	0	0	0	0	3	0	0	22
25	0	0	0	0	0	0	1	2	5	0	13	30	8	0	3	11	9	2	0	0	0	0	0	0	84
26	32	15	0	5	3	0	0	0	0	12	14	4	1	0	7	33	27	6	4	6	0	0	0	0	168
27	0	0	0	0	1	6	7	13	12	45	9	12	26	37	12	18	13	1	1	3	0	0	0	0	217
28	0	2	2	36	36	24	13	21	55	33	59	56	18	36	27	3	1	0	0	0	0	0	0	0	423
29	0	0	0	0	0	0	0	0	0	2	3	1	1	12	18	21	30	17	10	0	0	0	0	0	115
30	0	0	0	0	0	0	1	0	0	1	4	5	11	1	9	30	33	10	0	0	0	0	0	0	105
31	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
KWh	39	27	15	49	87	120	166	320	308	323	378	325	282	320	331	424	366	205	70	34	17	23	9	4	4240

Lowaramina **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	0	0	0	0	0	3	1	8	0	4	1	0	6	18	9	13	13	9	1	5	0	0	0	0	91
2	0	0	0	0	0	0	0	0	0	0	0	2	8	8	13	16	13	4	1	0	0	0	0	0	62
3	0	0	0	0	1	0	0	0	0	0	0	2	6	8	6	4	3	0	0	1	0	0	0	0	30
4	0	0	0	0	0	0	0	0	1	8	17	3	0	6	9	18	11	11	2	0	0	0	0	0	86
5	0	0	0	0	3	0	0	7	12	8	17	0	10	27	19	61	22	0	0	0	0	0	0	0	189
6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7	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
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	0	0	16	3	1	0	0	0	0	0	0	0	19
10	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
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	6	1	0	0	0	0	13
12	0	0	0	0	0	0	0	0	0	3	3	5	1	7	11	13	11	7	11	20	2	0	0	0	94
13	0	0	0	0	0	0	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	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
18	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
19	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
20	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
21	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
22	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
23	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
24	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
25	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
26	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
27	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
28	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
29	0	0	0	0	0	0	0	0	0	0	0	0	0	10	3	1	39	60	72	15	5	3	0	0	208
30	5	1	0	0	0	0	0	1	0	0	0	1	2	0	0	4	8	4	0	0	0	0	0	0	26
KWh	5	1	2	1	4	3	9	20	14	23	37	13	33	84	86	132	122	100	93	41	6	3	0	0	832

Lowaramina **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	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	33	161	198
2	157	139	101	185	83	108	80	36	153	91	78	107	93	93	81	50	51	55	56	83	115	145	138	103	2379
3	122	129	0	122	107	93	122	86	107	97	53	71	55	83	100	108	56	72	107	59	34	39	71	71	1963
4	86	79	55	114	100	129	121	47	93	71	44	23	1	7	7	9	2	1	0	0	0	0	0	0	988
5	0	0	0	0	0	0	0	0	0	0	0	3	1	6	7	7	5	0	1	2	0	0	0	0	35
6	0	0	0	0	0	0	0	0	0	0	3	9	6	0	5	8	3	0	4	9	1	0	0	0	48
7	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	18	14	3	0	0	3	0	0	3	51
8	0	0	1	5	6	8	9	12	3	11	40	55	13	33	47	25	6	0	0	0	0	0	0	0	273
9	1	0	4	0	0	0	6	22	0	0	8	0	2	11	0	0	0	0	0	0	0	0	0	0	55
10	0	0	0	0	0	0	0	0	0	0	0	0	2	1	5	2	1	0	0	0	0	0	0	0	11
11	0	0	0	1	2	5	11	40	24	21	9	3	0	0	0	1	1	0	0	0	2	1	0	0	122
12	2	0	0	0	0	0	3	5	40	33	47	40	27	18	18	24	13	21	13	27	27	29	6	0	394
13	0	0	0	0	1	4	7	4	11	17	40	56	50	43	40	11	21	0	0	1	0	0	0	0	307
14	0	0	0	0	0	2	2	13	5	37	61	61	58	80	76	43	24	30	47	47	43	51	55	33	767
15	45	74	107	108	137	130	48	130	200	93	93	107	81	56	59	34	24	13	22	30	40	30	28	33	1720
16	33	36	36	43	71	93	45	48	27	25	12	37	7	38	16	6	0	2	0	0	0	0	0	0	575
17	0	0	7	3	45	40	40	51	48	35	47	86	64	61	18	45	76	57	18	5	0	0	13	12	772
18	0	35	25	40	27	63	45	42	66	68	31	47	31	36	36	9	1	3	0	0	0	0	0	0	604
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	10	42	123	129	57	368
20	35	24	0	0	16	24	10	11	24	27	20	4	8	0	0	1	0	1	11	5	63	85	42	100	509
21	28	47	11	36	64	95	123	102	177	105	145	83	67	95	68	93	74	48	83	123	161	230	130	154	2342
22	222	193	168	182	202	161	191	231	214	193	185	192	153	162	137	145	114	115	101	138	85	80	108	75	3743
23	37	24	37	33	51	50	31	55	42	17	5	34	63	52	36	48	55	61	88	116	138	103	146	138	1457
24	81	100	76	138	130	137	153	145	161	177	185	129	122	114	102	86	30	95	259	208	185	244	264	211	3530
25	161	223	246	223	215	230	245	230	231	251	224	147	177	133	130	115	81	138	199	192	106	137	137	123	4293
26	208	239	224	216	177	216	208	185	193	216	239	201	153	145	122	114	122	110	47	51	65	69	36	14	3566
27	34	26	22	3	21	49	154	153	169	177	217	216	185	138	74	111	78	86	47	26	28	26	0	0	2036
28	0	0	0	2	8	8	20	54	177	86	101	115	50	43	18	13	5	0	0	0	0	0	0	0	698
29	0	1	1	6	22	30	53	115	168	200	154	93	56	40	8	0	1	0	0	0	0	0	0	1	949
30	0	1	3	22	40	45	36	56	93	100	137	129	121	93	64	69	50	40	30	40	40	53	76	154	1490
31	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
KWh	1249	1368	1123	1483	1524	1718	1763	1875	2424	2147	2174	2048	1646	1583	1280	1194	908	956	1133	1170	1178	1447	1412	1442	36244