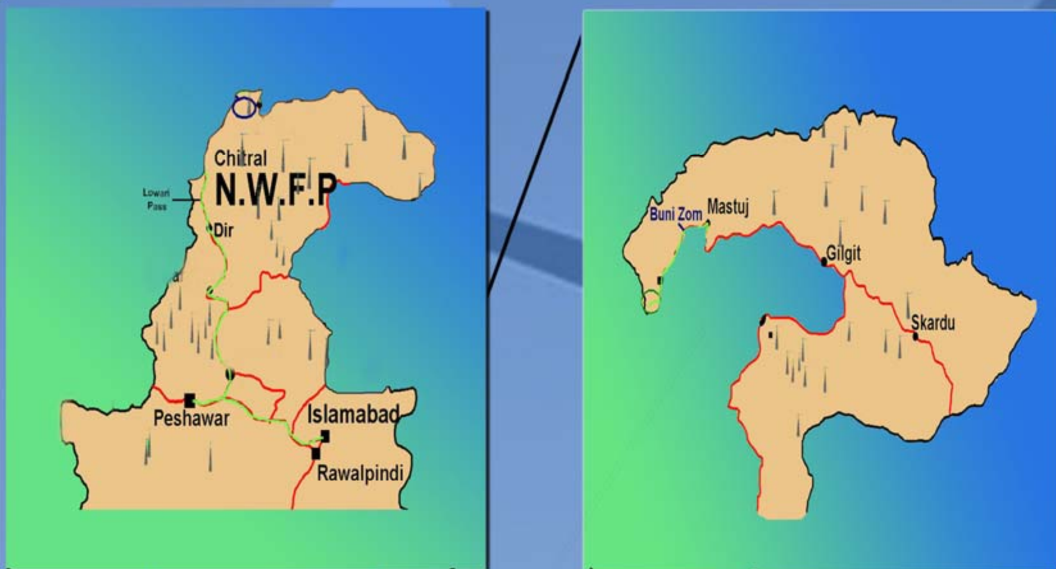
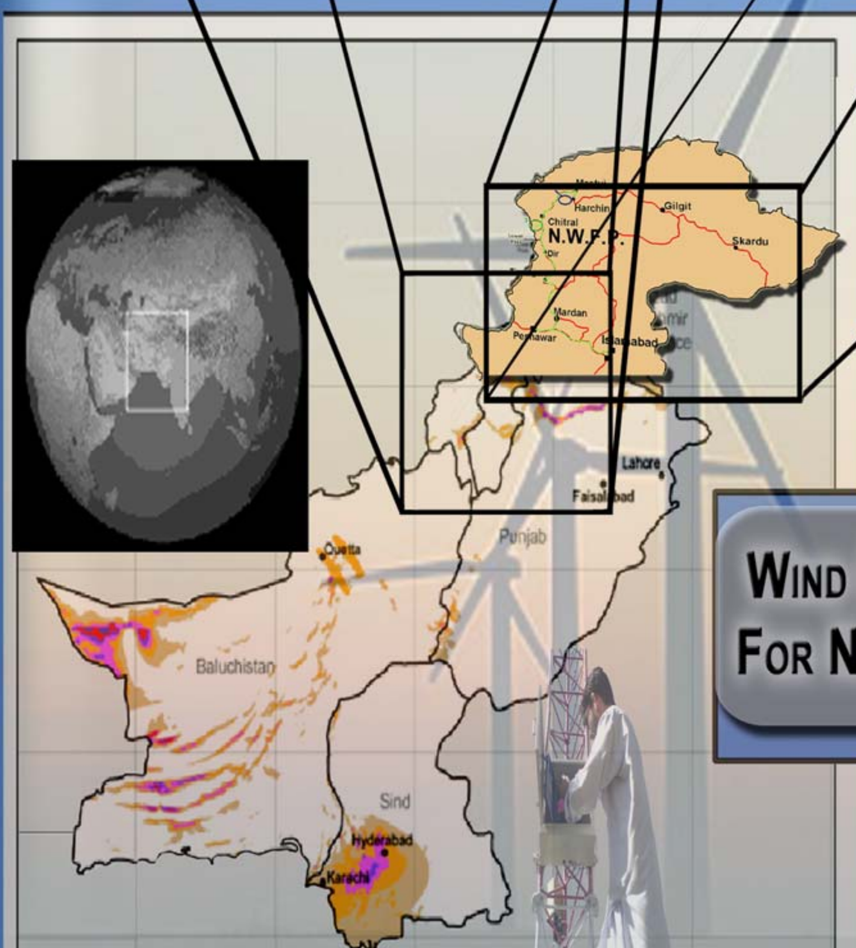
AN INVESTIGATION OF WIND POWER POTENTIAL





KHUNGIPAYAN-NWFP

Technical Report No. 07/2008

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WIND MAPPING PROJECT PHASE- II FOR NORTHERN AREAS OF PAKISTAN

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[Project is financed by Ministry of Science & Technology]

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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 one year wind data has been presented along with the wind generated electric power at Khungipayan (Dir), NWFP. Wind data with one 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 annual average wind speed of 1.77 m/s during eleven months August-2006 to June-2007, the highest of 2.61 m/s is observed in May. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the evening time thought-out the year. Wind frequency distribution shows that during 7.2% 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 Khungipayan is 27.49 w/m^2 according to international wind classification, this power density categorize Khungipayan 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 annual power production form a single 600kw wind turbine come out to 100,191 kWh which shows the capacity factor of 2% for Khungipayan. 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 Khungipayan 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:

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

Khungipayan is situated in district Lower Dir (NWFP). Latitude & Longitude of Khungipayan is: **Latitude=35.03º Longitude=72.28º, Elevation: 2290 Ft.**

2.2 Data source:

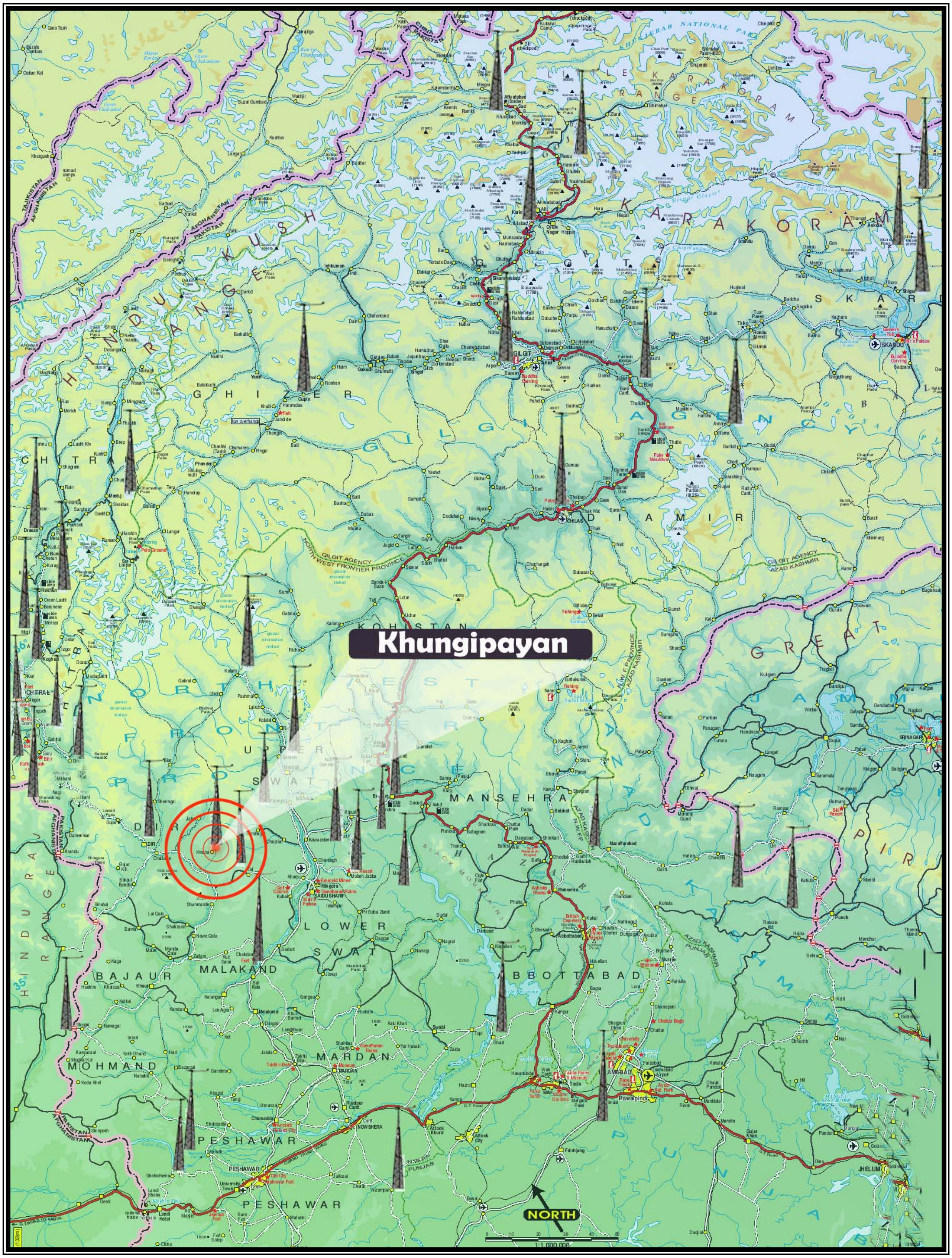
To undertake this study 30-meter high towers are erected at the locations mentioned above. On each of these high towers two wind speed anemometers are installed at the height of 10 meters and 30 meters, respectively; wind vane for recording wind direction is installed at 30 meters height. Temperature sensors are also installed at 10 meters height. Automatic data loggers developed locally have been installed to record data at each site. These data loggers are recording, one-minute average wind speed at both level, five-minute average wind direction, five-minute average temperature 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 one minute average at 10 & 30 meters
ii. Maximum wind speeds during 10 minutes
iii. Minimum wind speeds during 10 minutes
iv. Wind direction five minutes average at 30 meters
v. Temperature 5 minutes average in °C

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.



Map-1: Shows 42-Towers Installed in Wind Mapping Project in Northern Areas

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:*

3.1.2

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

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

Where

u_* is the friction notify

k is the von Karman constant

$\mathbf{Z_o}$ is the roughness length

D is the displacement height

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

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

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

Where
U_R is the wind speed at reference height Z_R

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

3.1.2 *Power Law:*

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

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

Where:
α is the power law exponent
u_R is the wind speed at reference height z_R

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

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

Where: Z is the measurement height
Z_R is the reference height
Z_0 is the roughness length

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

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

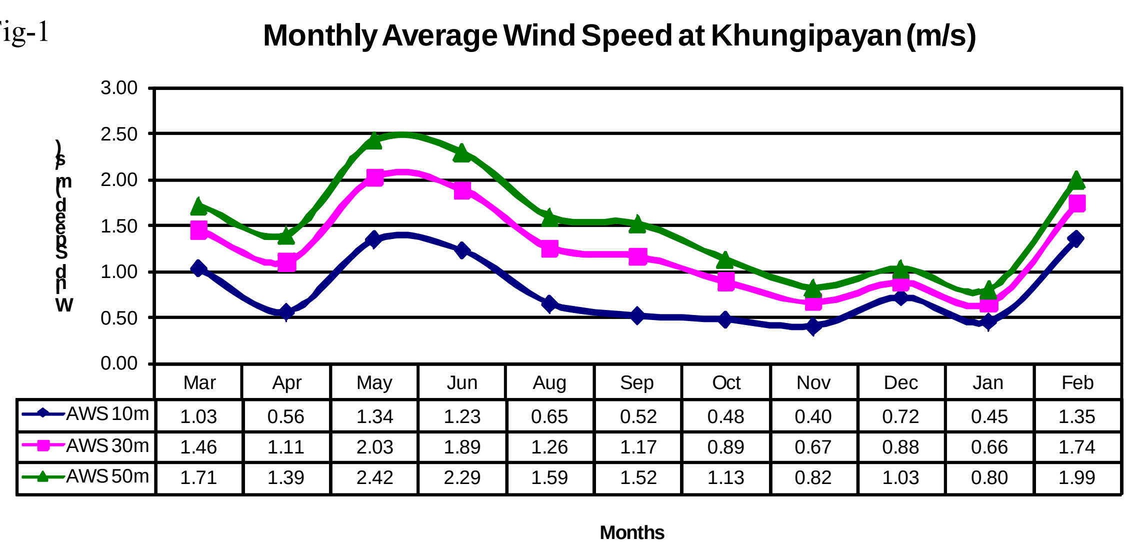
Type of terrain	Z_0	**α**
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 to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

3.2 **Average Wind Speed:**

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

Fig-1 shows monthly average wind speed at height of 10 meters, 30 meters and 50 meters. At 30 meters height, we have the maximum average wind speed of 2.03 m/s during May, 2007. At 50 meters we have the annual average wind speed of 1.52 m/s from August-2006 to June 2007 and the highest average wind speed of 2.42 m/s is observed during May.

Fig-1



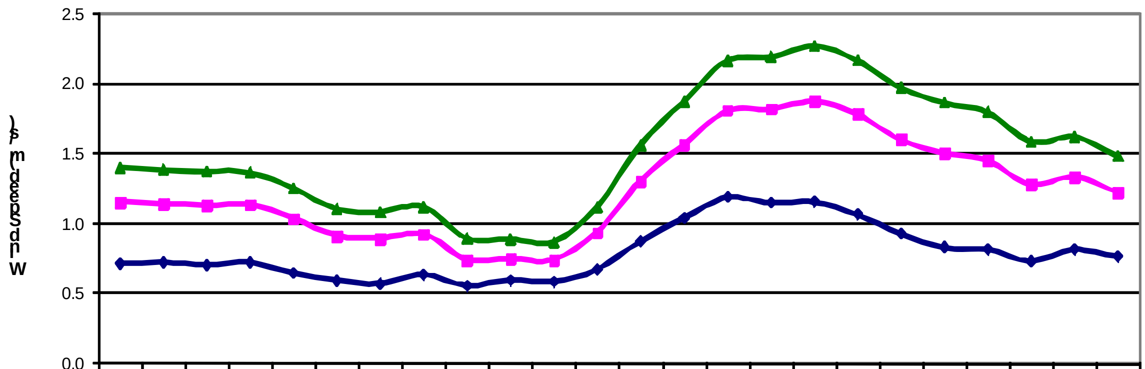
	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AWS 10m	1.03	0.56	1.34	1.23	0.65	0.52	0.48	0.40	0.72	0.45	1.35
AWS 30m	1.46	1.11	2.03	1.89	1.26	1.17	0.89	0.67	0.88	0.66	1.74
AWS 50m	1.71	1.39	2.42	2.29	1.59	1.52	1.13	0.82	1.03	0.80	1.99

3.3 Diurnal Wind speed Variation:

Fig-2 shows the Annual diurnal wind speed variations at Khungipayan (Aug-Jun). The wind speed is generally lower from mid-night to morning and after 1200 noon it starts picking up. At evening time it reaches maximum, wind speeds to 1.8 m/s and 2.2 m/s at 30 meters and 50 meters height respectively. Figure-2 shows that the maximum wind speed during (Aug-Jun) at 50 meters height reaches to 2.2 m/s at 5 pm.

Fig-2

Annual Diurnal Variation Wind Speed at Khungipayan



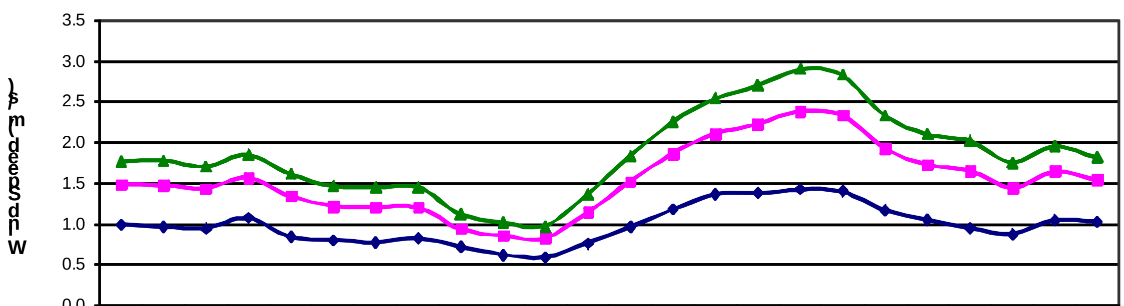
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.6	0.5	0.6	0.5	0.6	0.8	1.0	1.1	1.1	1.1	1.0	0.9	0.8	0.8	0.7	0.8	0.7
WS 30m	1.1	1.1	1.1	1.1	1.0	0.9	0.8	0.9	0.7	0.7	0.7	0.9	1.3	1.5	1.8	1.8	1.8	1.7	1.6	1.5	1.4	1.2	1.3	1.2
WS 50m	1.4	1.3	1.3	1.3	1.2	1.1	1.0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

PST (Hours)

Fig-3, Fig-4, Fig-5 and Fig-6 shows the seasonal diurnal wind speed variations at Khungipayan respectively. The wind speed is generally higher during night time for (Mar- May), (Jun-Aug) and (Sep-Nov). But during (Dec-Feb) wind speed is higher in evening and become low during night.

Fig-3

Diurnal Variation Wind Speed at Khungipayan (Mar to May)

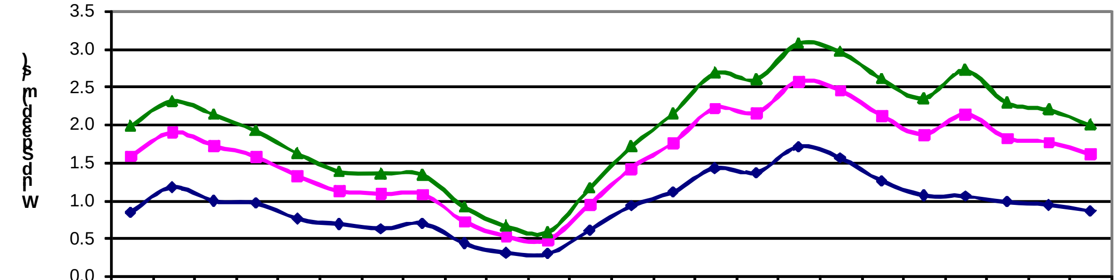


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	1.0	0.9	1.1	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.8	1.0	1.2	1.4	1.4	1.4	1.4	1.2	1.0	0.9	0.9	1.0	1.0
WS 30m	1.5	1.5	1.4	1.6	1.3	1.2	1.2	1.2	0.9	0.8	0.8	1.1	1.5	1.9	2.1	2.2	2.4	2.3	1.9	1.7	1.6	1.4	1.6	1.5
WS 50m	1.8	1.8	1.7	1.8	1.6	1.4	1.4	1.4	1.1	1.0	1.0	1.3	1.8	2.2	2.5	2.7	2.9	2.8	2.3	2.1	2.0	1.7	1.9	1.8

PST (Hours)

Fig-4

Diurnal Variation Wind Speed at Khungipayan
(Jun to Aug)

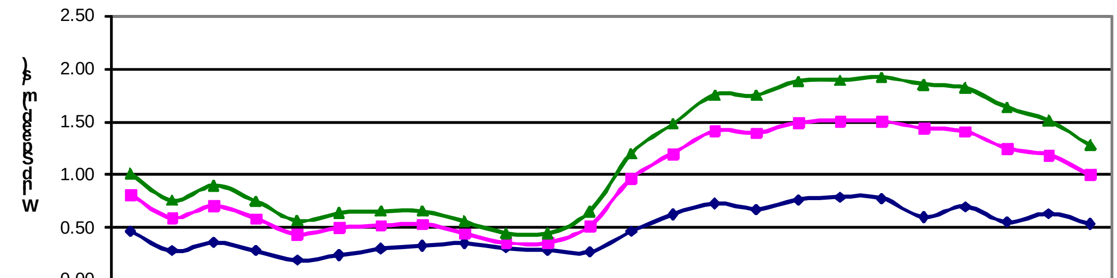


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.8	1.2	1.0	1.0	0.8	0.7	0.6	0.7	0.4	0.3	0.3	0.6	0.9	1.1	1.4	1.4	1.7	1.6	1.3	1.1	1.1	1.0	0.9	0.9
WS 30m	1.6	1.9	1.7	1.6	1.3	1.1	1.1	1.1	0.7	0.5	0.5	0.9	1.4	1.8	2.2	2.1	2.6	2.4	2.1	1.9	2.1	1.8	1.8	1.6
WS 50m	2.0	2.3	2.1	1.9	1.6	1.4	1.3	1.3	0.9	0.7	0.6	1.2	1.7	2.1	2.7	2.6	3.1	3.0	2.6	2.3	2.7	2.3	2.2	2.0

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Khungipayan
(Sep to Nov)

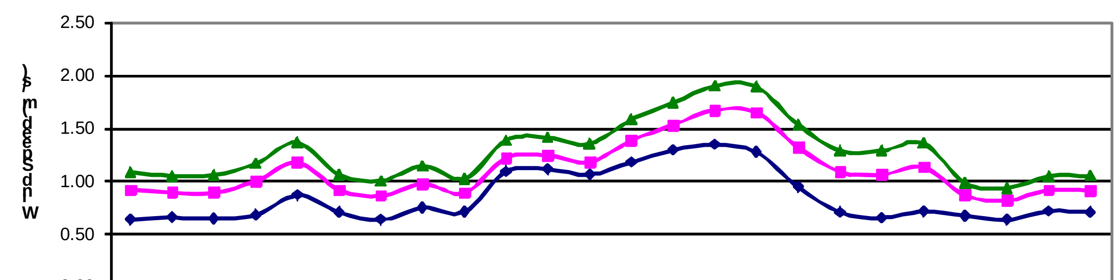


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.4	0.2	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.4	0.6	0.7	0.6	0.7	0.7	0.7	0.5	0.6	0.5	0.6	0.5
WS 30m	0.8	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.4	0.3	0.3	0.5	0.9	1.1	1.4	1.3	1.4	1.5	1.5	1.4	1.4	1.2	1.1	0.9
WS 50m	1.0	0.7	0.8	0.7	0.5	0.6	0.6	0.6	0.5	0.4	0.4	0.6	1.1	1.4	1.7	1.7	1.8	1.8	1.9	1.8	1.8	1.6	1.5	1.2

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Khungipayan
(Dec to Feb)



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

PST (Hours)

3.4 Wind speed Frequency Distribution:

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

3.4.1 *Binning of Data:*

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

3.4.2 *Relative Frequency:*

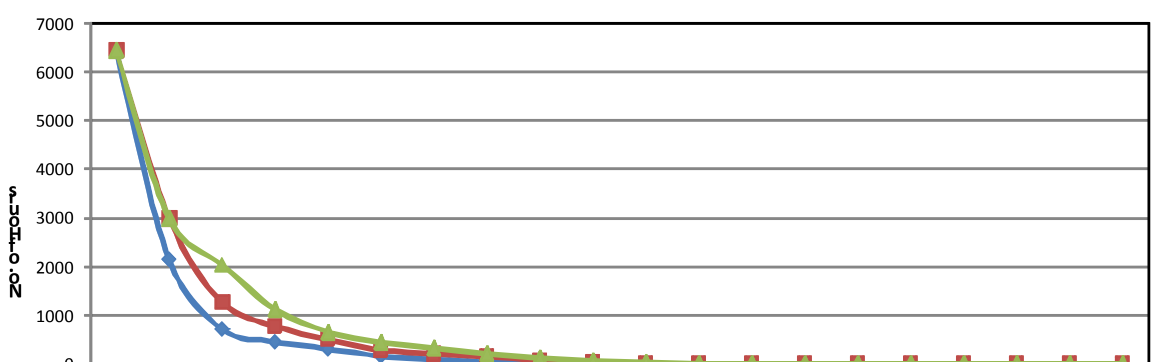
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as

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

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Annual Cumulative Wind Frequency distribution at Khungipayan (Aug-06 to Jun-07) at three heights 10, 30 and 50 meters. The analysis indicate that in this period at a height of 30 meters during 508 hours the wind speed is equal or greater than 5 m/s whereas at 50 meters during 643 hours the wind speed is equal or greater than 5m/s, 440 hours 6m/s, 315 hours 7 m/s and so on.

Fig-7 **Annual Cumulative Wind Speed Distribution at Khungipayan**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	6434	2136	723	444	309	150	88	47	14	8	5	3	1	1	0	0	0	0	0	0
CWS 30m	6434	2977	1275	769	508	284	206	139	54	30	17	11	5	3	3	1	1	0	0	0
CWS 50m	6434	2982	2028	1105	643	440	315	204	123	70	39	20	13	7	5	4	2	2	1	1

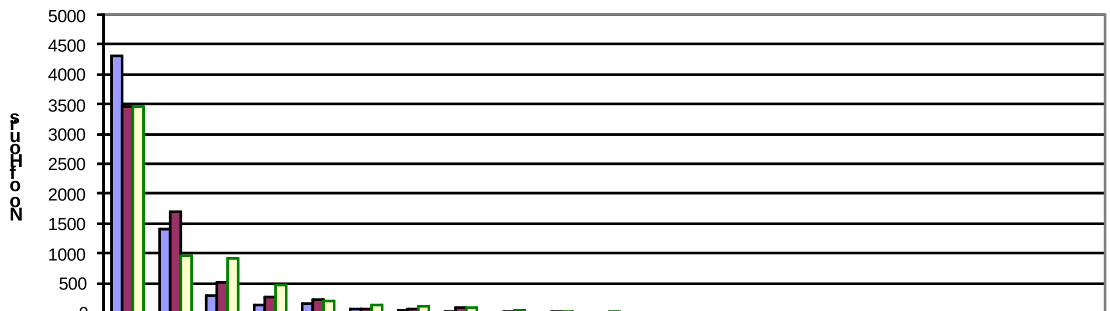
Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the frequency distribution at Khungipayan during Aug-06 to Jun-07. We can see that at 50 meters height during 203 hours wind speed is 5 m/s, 125 hours speed is 6 m/s, 110 hours speed is 7 m/s and so on.

Fig-8

Annual Wind Frequency Distribution at Khungipayan



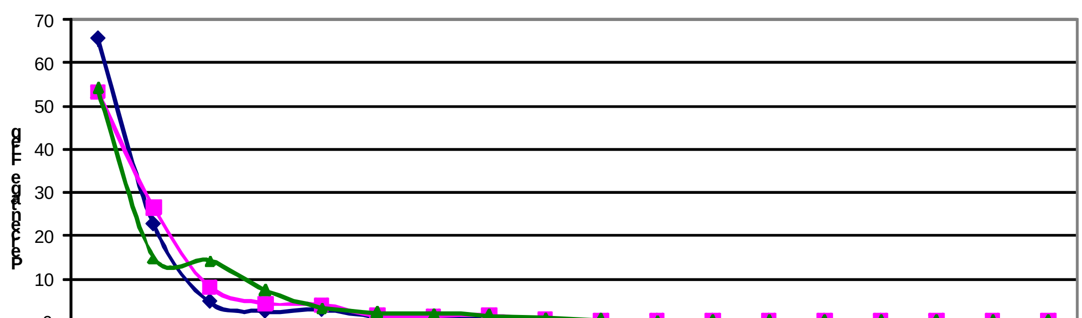
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	4297	1413	280	135	159	62	41	33	6	3	2	2	1	0	0	0	0	0	0	0	0
CWS 30m	3457	1702	506	261	224	78	67	85	24	13	7	6	2	1	1	0	0	0	0	0	0
CWS 50m	3451	954	923	462	203	125	110	81	53	31	20	7	5	2	2	1	1	1	0	0	0

Wind Speed (m/s)

Fig-9 gives shows annual frequency distribution in percentage. At 50 meters we find that during 3.15% of time wind is 5m/s, 2.03% of the time 6m/s and 1.85% of the time it is 7m/s. whereas at 30 meters height we get 3.71% of the time wind speed 5m/s, 1.33% of the times 6m/s and 1.14% of the time 7m/s.

Fig-9

Annual Percenatge Wind Frequency Distribution at Khungipayan



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	65.4	22.4	4.62	2.28	2.72	1.06	0.68	0.51	0.08	0.04	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00
WS 30m	53.2	26.3	7.96	4.11	3.71	1.33	1.14	1.42	0.36	0.18	0.09	0.08	0.02	0.01	0.02	0.01	0.00	0.01
WS 50m	53.8	14.6	14.0	7.17	3.15	2.03	1.85	1.35	0.88	0.46	0.28	0.10	0.08	0.03	0.03	0.02	0.01	0.01

Wind Speed (m/s)

3.4.5 *Seasonal Wind Frequency Distribution:*

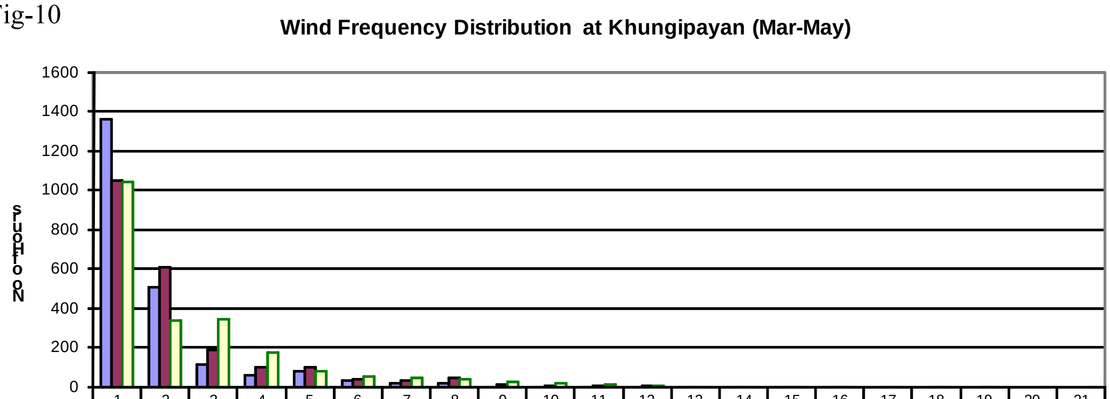
Figures 10–17 gives seasonal wind frequency distribution and seasonal wind frequency distribution in percentage.

<u>March – May</u>

Fig-10 shows Wind frequency distribution during the months of March to May. We can see that in this period at 30 meters height during 100 hours we get 5m/s, 38 hours 6m/s, 34 hours 7m/s. Similarly at 50 meters we get 82 hours 5m/s, 54 hours 6m/s, 51 hours 7m/s.

Similarly Fig-11 shows the above mentioned seasonal frequency distribution in percentage.

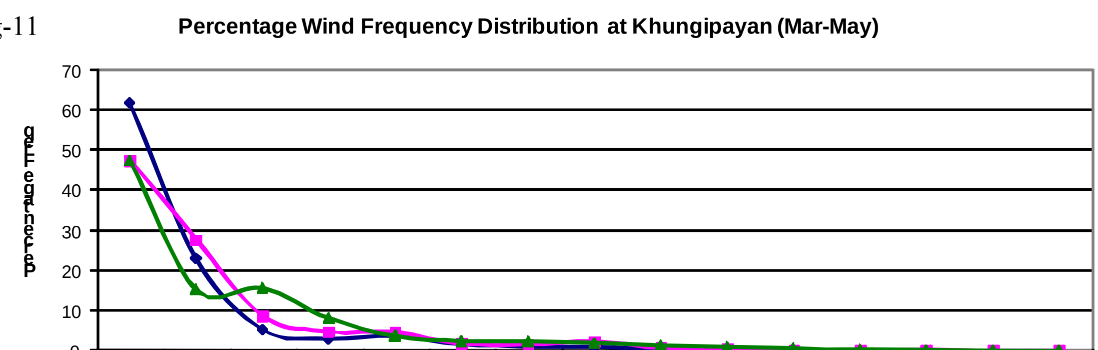
Fig-10



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	1360	508	116	63	80	33	22	19	3	2	1	1	0	0	0	0	0	0	0	0	0
WS 30m	1048	611	189	104	100	38	34	48	15	8	4	4	1	1	1	0	0	0	0	0	0
WS 50m	1045	336	344	179	82	54	51	42	30	19	12	4	3	1	1	1	0	0	0	0	0

Wind Speed (m/s)

Fig-11



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	61.8	23.0	5.2	2.8	3.6	1.5	1.0	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	47.5	27.7	8.6	4.7	4.5	1.7	1.5	2.2	0.7	0.4	0.2	0.2	0.0	0.0	0.0
WS 50m	47.4	15.3	15.6	8.1	3.7	2.4	2.3	1.9	1.4	0.9	0.6	0.2	0.1	0.1	0.0

Wind Speed (m/s)

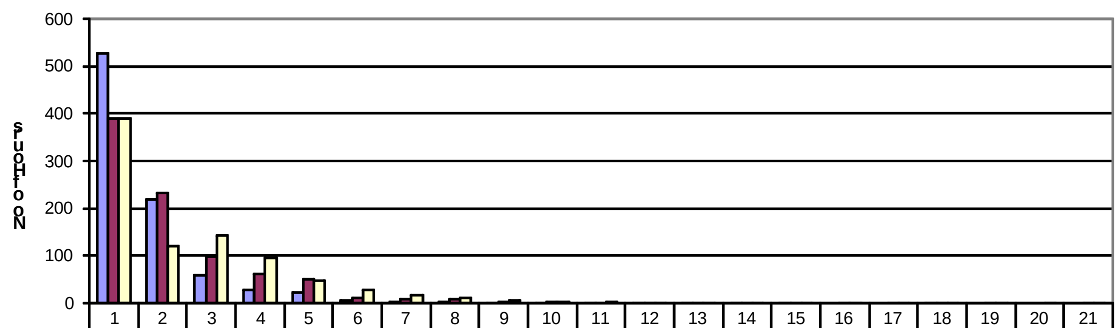
<u>June & August</u>

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 52 hours we get 5m/s, 12 hours 6m/s, 8 hours 7m/s. Similarly at 50 meters we get 48 hours 5m/s, 27 hours 6m/s, 17 hours 7m/s.

Similarly Fig-13 shows the above mentioned seasonal frequency distribution in percentage.

Fig-12

Wind Frequency Distribution at Khungipayan (Jun-Aug)

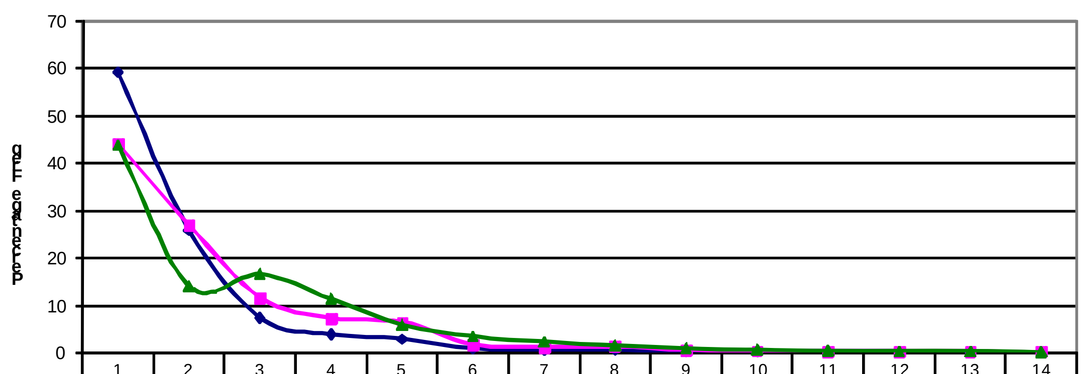


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	528	220	60	29	21	5	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	391	233	99	60	52	12	8	9	3	1	1	1	0	0	0	0	0	0	0	0	0
WS 50m	389	121	144	96	48	27	17	11	6	4	3	1	1	0	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-13

Percentage Wind Frequency Distribution at Khungipayan (Jun-Aug)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.00	59.0	25.7	7.2	3.7	2.7	0.6	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0
0.00	43.8	26.7	11.4	7.1	6.3	1.5	1.0	1.1	0.4	0.2	0.1	0.1	0.0	0.0
0.00	43.7	13.9	16.5	11.2	5.7	3.3	2.1	1.4	0.8	0.5	0.3	0.1	0.1	0.1

Wind Speed (m/s)

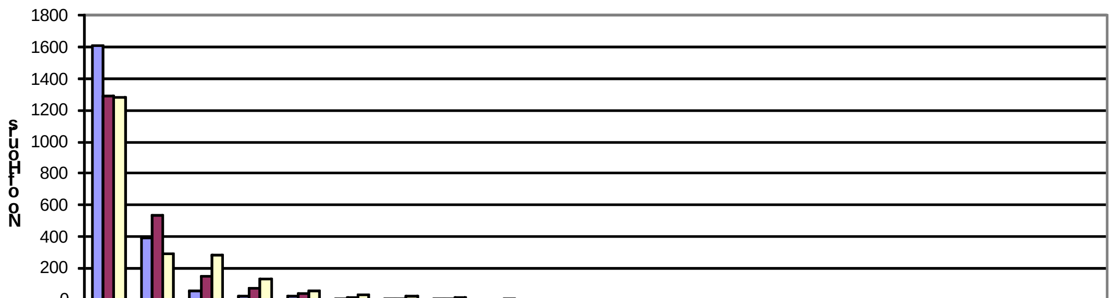
September – November

Fig-14 shows frequency distribution during the months of September to November. We can see that in this period at 30 meters height during 45 hours we get 5m/s, 14 hours 6m/s, 11 hours 7m/s.

Similarly at 50 meters we get 55 hours 5m/s, 29 hours 6m/s, 23 hours 7m/s, 14 hours 8m/s, 7 hours 9m/s, 4 hours 10m/s.

Similarly the above mentioned seasonal frequency distribution percentage terms have been presented in figure 15.

Fig-14 **Wind Frequency Distribution at Khungipayan (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	1605	392	59	23	28	10	7	6	2	1	1	1	0	0	0	0	0	0	0	0	0
WS 30m	1287	534	151	73	45	14	11	11	3	2	1	1	0	0	0	0	0	0	0	0	0
WS 50m	1283	293	286	133	55	29	23	14	7	4	3	1	1	0	0	0	0	0	0	0	0

Wind Speed (m/s)

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

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	75.68	17.99	2.68	1.05	1.31	0.49	0.31	0.28	0.07	0.06	0.04	0.03	0.01	0.00	0.01
WS 30m	61.09	24.60	6.85	3.30	2.08	0.67	0.54	0.52	0.12	0.10	0.06	0.05	0.01	0.01	0.00
WS 50m	63.53	12.85	12.14	5.59	2.21	1.26	1.03	0.63	0.30	0.17	0.14	0.06	0.05	0.01	0.01

Wind Speed (m/s)

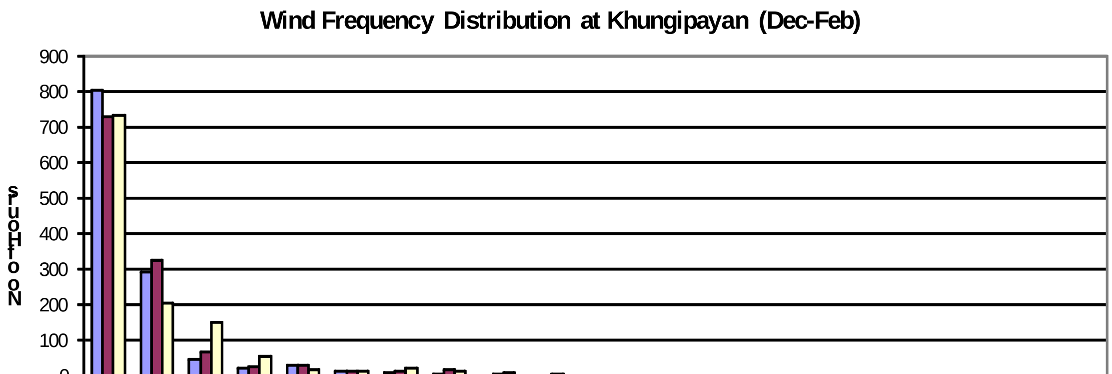
December– February

Fig-16 shows frequency distribution during the months of December to February. We can see that in this period at 30 meters height during 27 hours we get 5m/s, 14 hours 6m/s, 14 hours 7m/s.

Similarly at 50 meters we get 18 hours 5m/s, 14 hours 6m/s, 19 hours 7m/s, 14 hours 8m/s, 3 hours 9m/s, 1 hours 10m/s.

Similarly Fig-16 shows seasonal frequency distribution percentage for the months of Dec to Feb.

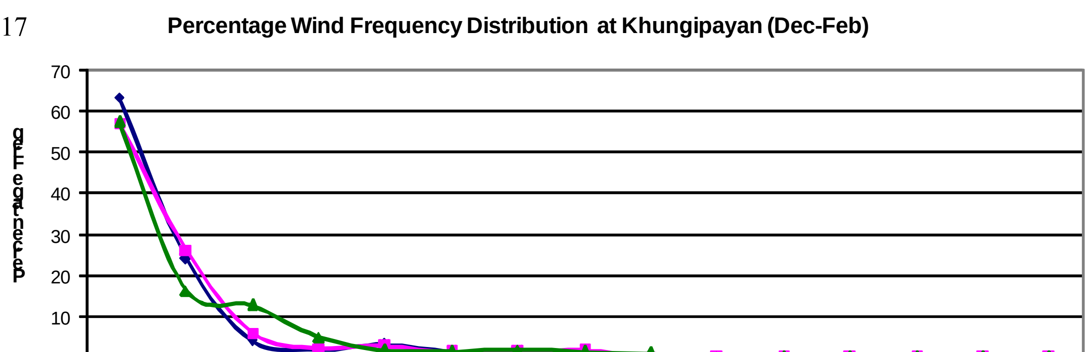
Fig-16



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	804	293	45	20	30	14	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	731	323	66	24	27	14	14	17	3	1	0	0	0	0	0	0	0	0	0	0	0
WS 50m	734	204	149	53	18	14	19	14	10	4	1	0	0	0	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-17



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	63.38	24.23	4.26	2.03	3.24	1.47	0.91	0.48	0.01	0.00	0.00	0.00	0.00	0.00	0.00
WS 30m	57.22	26.34	6.15	2.37	2.82	1.50	1.46	1.76	0.28	0.07	0.02	0.00	0.00	0.00	0.00
WS 50m	57.45	16.37	12.70	5.10	1.82	1.53	2.05	1.51	1.04	0.32	0.09	0.02	0.01	0.00	0.00

Wind Speed (m/s)

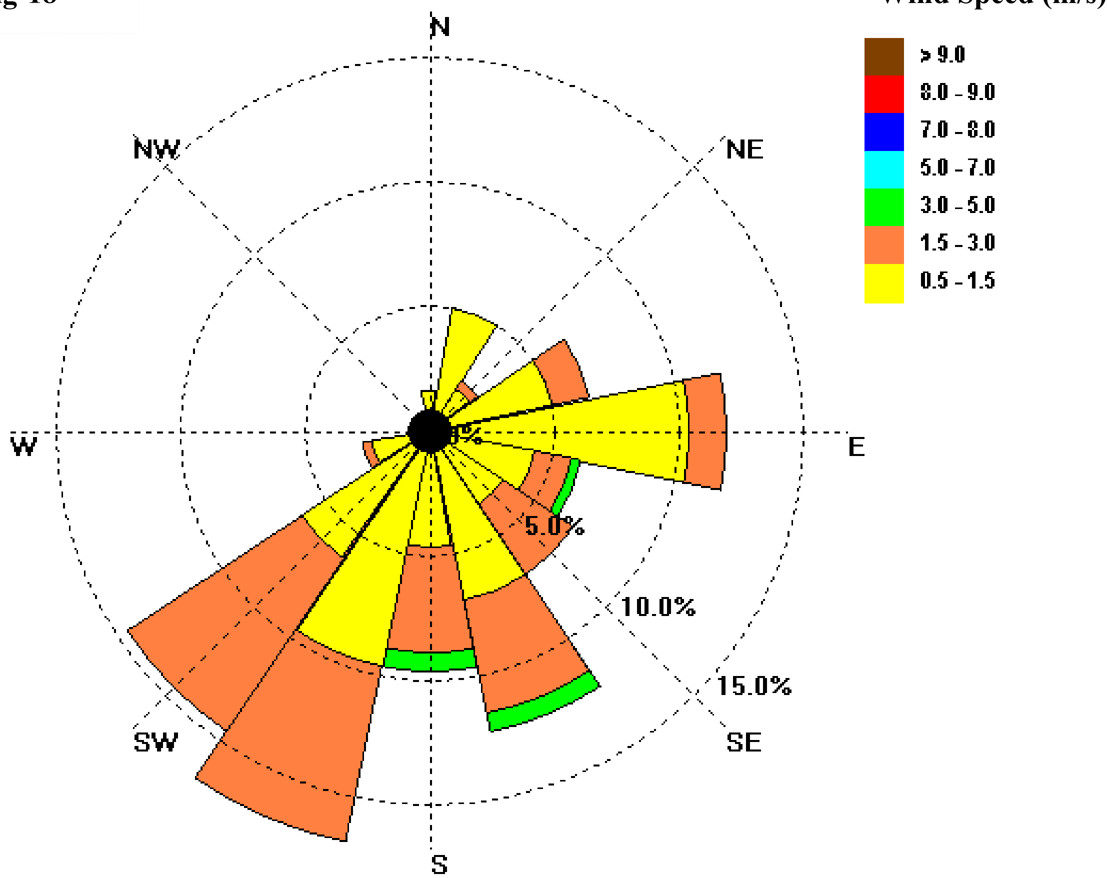
3.5 Wind Rose

Fig-18 shows the Wind Rose based on 11 months data from August 2006 – June 2007 collected at 30 meters height. Wind Rose indicates that the wind direction is mostly between east and south west. The average wind speed is 1.51m/s and the percentage of wind speed greater than 5m/s is 5.0%.

Wind Rose at Khungipayan (30m height during 11 months)

Fig-18

Wind Speed (m/s)



Average Wind Speed	Wind speed greater than 5 m/s	Comments
1.51 m/s	5.0%	

3.6 Wind speed statistic:

3.6.1 *The statistical Mean:*

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

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

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

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

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

3.6.2 *Variance:*

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

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

Where V is mean of data set

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

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

3.6.3 *Standard Deviation*

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

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

3.7 Wind power density:

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

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

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

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

3.7.1 *Wind power classes:*

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

Table-2: International Wind Power Classification

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

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

3.7.2 ***Power of wind Energy:***

A parcel of Wind possesses kinetic energy

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

From this, power density is calculated as

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

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

From fluid dynamics, it can be proved that

$$dm/dt = \varphi AV$$

Volume of cylindrical cross section can be written as

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

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

$$S = L = Vt,$$

So equation L takes the form

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

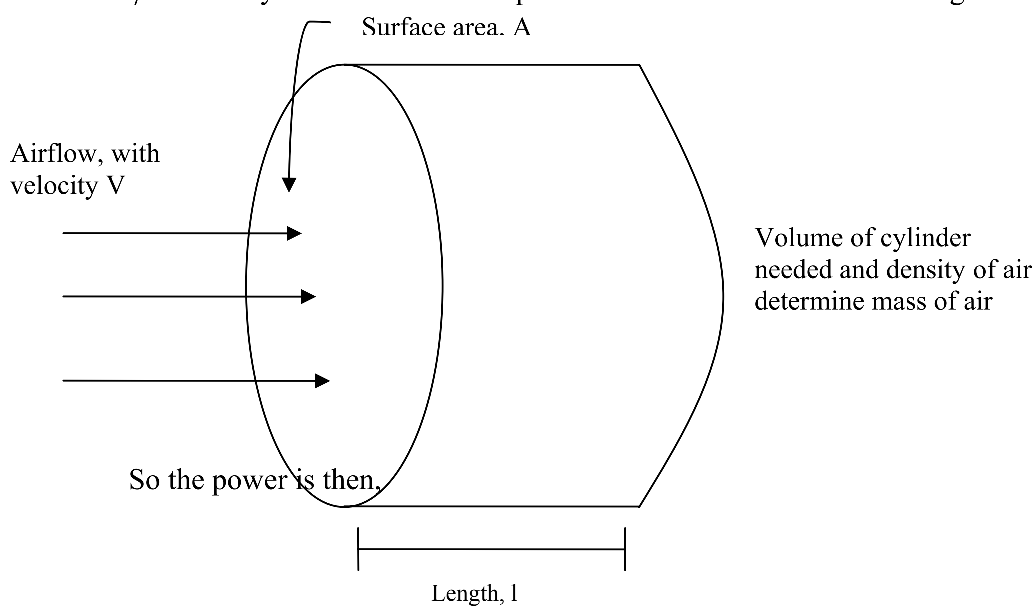
Now mass of wind can be written as

$$M = \varphi Avt$$

Differentiating

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

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



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

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

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.

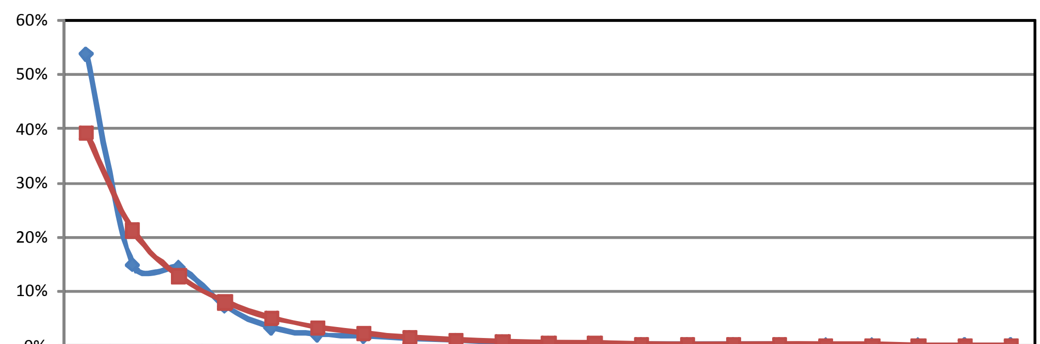
The mathematical description of the wind frequency allows us to match with the turbine power curve. Thus a measure of the average total power capture in a year is achieved. Additionally the choice of turbine cut in and furling speed may be chosen to maximum the total energy capture.

3.7.5 ***Weibull Parameters:***

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

Fig-19

Relative Frequency an Weibull Probability at Khungipayan (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	53.6	14.8	14.4	7.2%	3.2%	1.9%	1.7%	1.3%	0.8%	0.5%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	39.1	21.2	12.8	8.0%	5.1%	3.3%	2.2%	1.5%	1.0%	0.7%	0.4%	0.3%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Pakistan Meteorological Department

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 0.76 during December to the highest of 1.21 during the month of January with a annual value of K being 0.96.

The lowest values of the scale parameter C, 1.03 is observed in November while the highest value of 2.57 is obtained in May and with an annual value of 1.73.

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 1.14 m/s with Standard deviation of 1.18, at 30 meters this average speed is 1.51 m/s with Standard deviation of 1.54. At 50 meters the monthly average wind speed varies from the lowest of 1.15 m/s in January to highest of 2.61 m/s during May. Whereas the average wind speed is 1.77 m/s with Standard deviation of 1.85.

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 1.14 W/m^2 in January to 6.76 W/m^2 in December with Average of 7.41 W/m^2.

At 30 meters height the power density varies from 1.91 W/m^2 in January to 13.69 W/m^2 in December and the average values is about 16.50 W/m^2.

At 50 meters height the power density of Khungipayan varies from 3.69 W/m^2 in January to 21.10 W/m^2 in December. The average power density of the area is 27.49 W/m^2.

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

10 m							
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**Zo**	**Temp**	**P/A (w/m^2)**
January	0.86	0.62	0.95	1.43	0.07	6.27	**1.14**
February	1.60	1.60	1.60	1.00	0.00	8.42	**15.18**
March	1.32	1.41	1.27	0.93	0.02	11.29	**10.14**
April	0.94	1.06	0.89	0.88	0.14	19.65	**4.33**
May	1.60	1.71	1.54	0.93	0.04	24.04	**18.30**
June	1.47	1.44	1.48	1.02	1.30	28.42	**11.13**
August	0.99	0.92	1.02	1.08	0.15	26.41	**2.95**
September	1.03	1.22	0.93	0.83	0.16	23.17	**6.70**
October	0.87	0.84	0.88	1.03	0.15	18.94	**2.22**
November	0.82	0.90	0.79	0.91	0.08	11.76	**2.65**
December	1.07	1.23	1.00	0.87	0.01	5.85	**6.76**
Average	**1.14**	**1.18**	**1.12**	**0.99**	**0.19**	**16.75**	**7.41**
30 m							
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**Zo**	**Temp**	**P/A (w/m^2)**
January	1.00	0.75	1.09	1.37	0.07	6.27	**1.91**
February	1.94	1.96	1.93	0.99	0.00	8.42	**27.63**
March	1.67	1.78	1.61	0.93	0.02	11.29	**20.48**
April	1.36	1.47	1.30	0.92	0.14	19.65	**11.53**
May	2.21	2.31	2.16	0.96	0.04	24.04	**44.62**
June	2.05	1.99	2.08	1.03	1.30	28.42	**29.18**
August	1.49	1.41	1.53	1.07	0.15	26.41	**10.46**
September	1.43	1.33	1.47	1.08	0.16	23.17	**8.93**
October	1.18	1.25	1.15	0.94	0.15	18.94	**7.09**
November	1.02	1.18	0.94	0.86	0.08	11.76	**5.98**
December	1.22	1.53	1.06	0.78	0.01	5.85	**13.69**
Average	**1.51**	**1.54**	**1.49**	**0.99**	**0.19**	**16.75**	**16.50**
50 m							
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**Zo**	**Temp**	**P/A (w/m^2)**
January	1.15	0.97	1.22	1.21	0.07	6.27	**3.69**
February	2.21	2.21	2.21	1.00	0.00	8.42	**39.79**
March	1.93	2.04	1.88	0.94	0.02	11.29	**31.06**
April	1.64	1.80	1.56	0.90	0.14	19.65	**21.19**
May	2.61	2.70	2.57	0.96	0.04	24.04	**71.89**
June	2.44	2.36	2.47	1.04	1.30	28.42	**48.99**
August	1.82	1.78	1.84	1.03	0.15	26.41	**20.86**
September	1.78	1.74	1.80	1.02	0.16	23.17	**19.60**
October	1.40	1.56	1.32	0.89	0.15	18.94	**13.78**
November	1.16	1.41	1.03	0.81	0.08	11.76	**10.45**
December	1.36	1.75	1.15	0.76	0.01	5.85	**21.10**
Average	**1.77**	**1.85**	**1.73**	**0.96**	**0.19**	**16.75**	**27.49**

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

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

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

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

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 Khungipayan 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 Khungipayan 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 Khungipayan.

PMD Calculator (using 50M)				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	4	1	0%	875
February	41	14	3%	14,296
March	31	10	3%	11,710
April	21	7	2%	7,542
May	70	21	5%	23,241
June	47	15	4%	16,938
August	20	7	2%	7,761
September	19	7	2%	7,116
October	14	4	1%	5,066
November	11	3	1%	3,713
December	22	7	2%	7,403
Annual	**22**	**8**	**2%**	**100,191**

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 **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 annual average diurnal variation of wind generated electric energy output at Khungipayan (Aug-Jun). The graph shows that the maximum power is produced at about 6 PM; 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 Khungipayan the wind have more potential in the month of May as compared to other months. Figure 23 to 33 shows the monthly average diurnal variation of wind generated electric energy output.

Fig-20

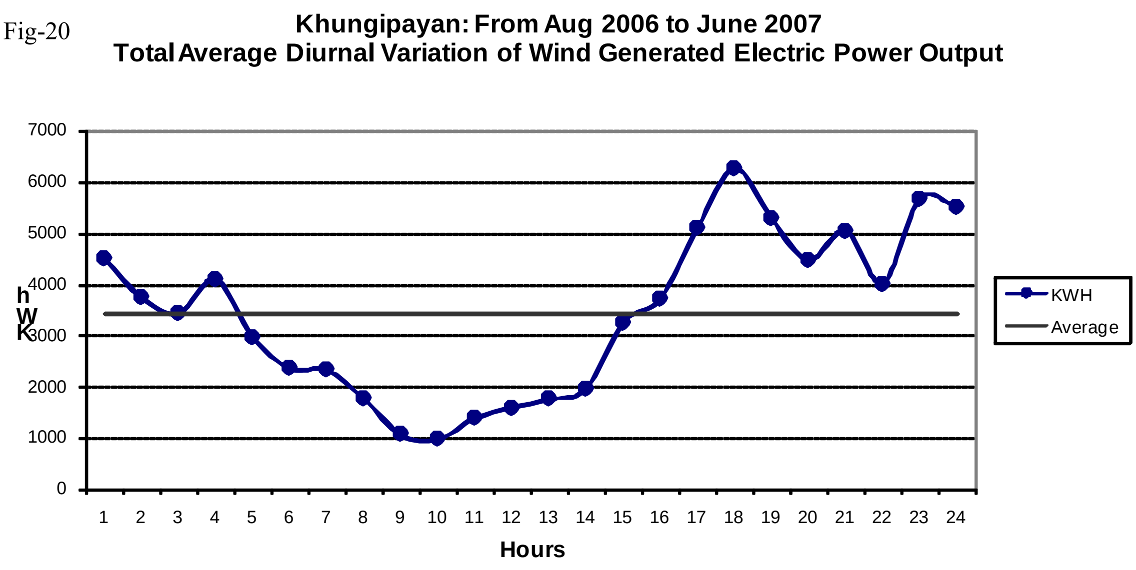


Fig-21

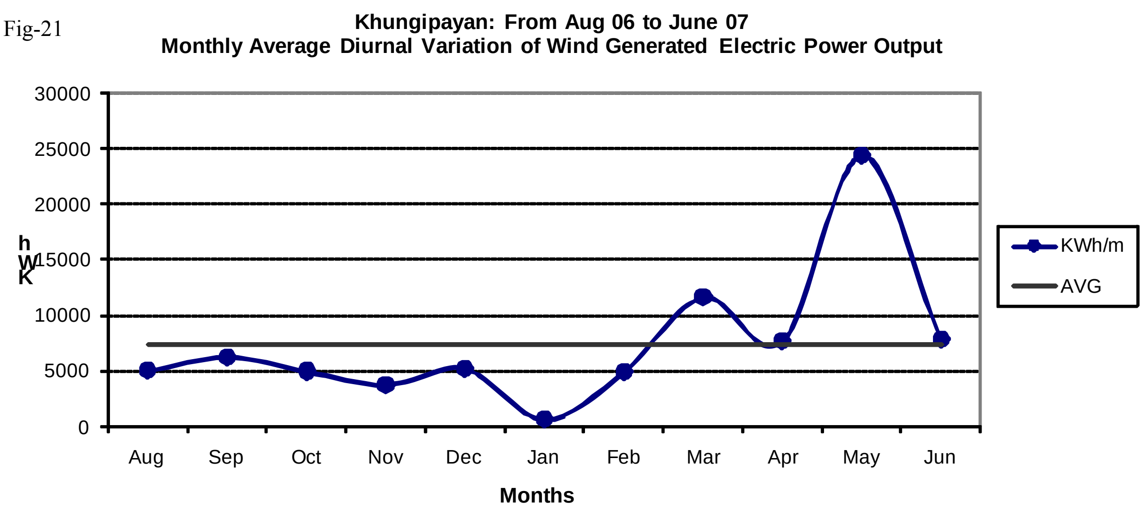


Fig-22

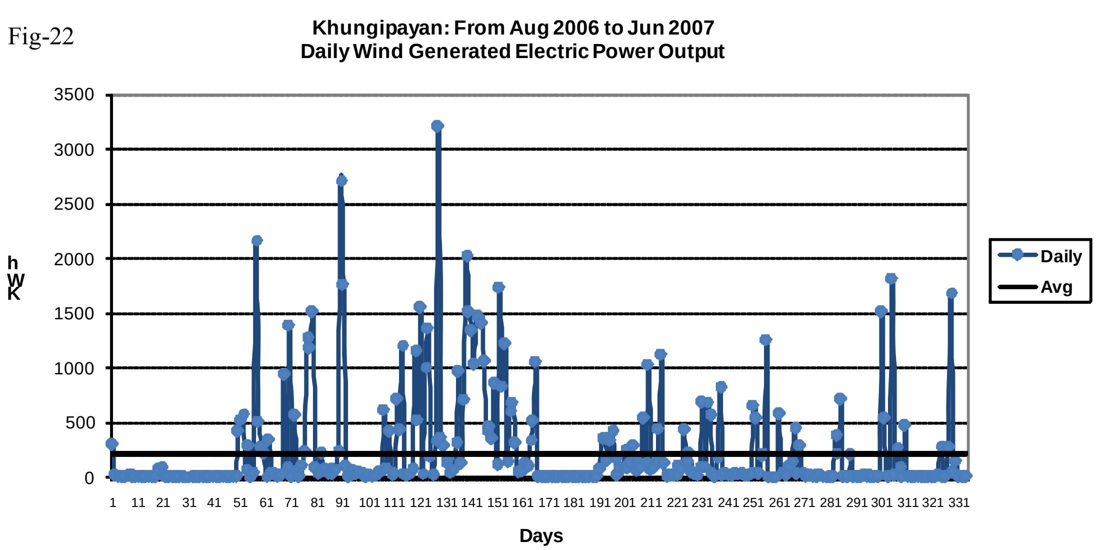


Fig-23

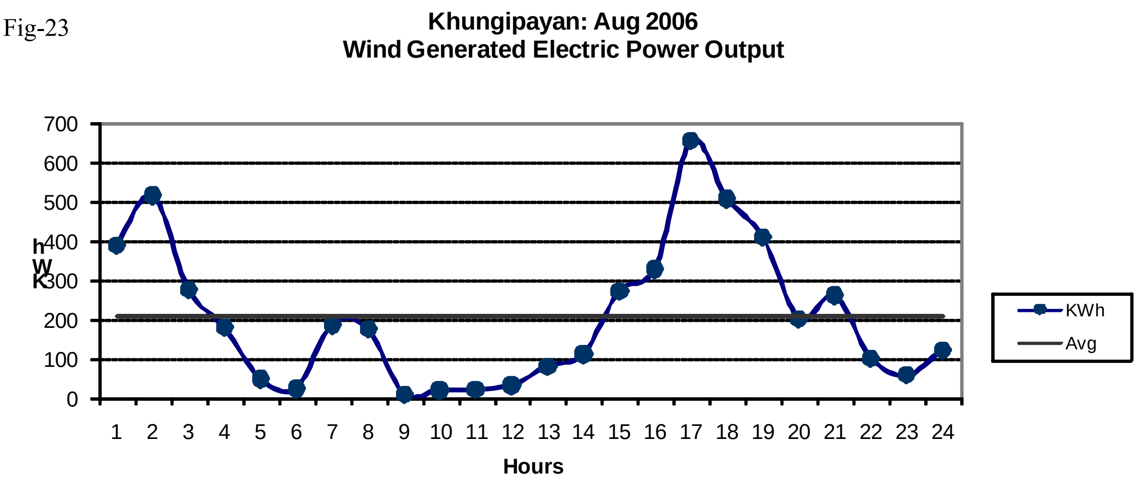


Fig-24

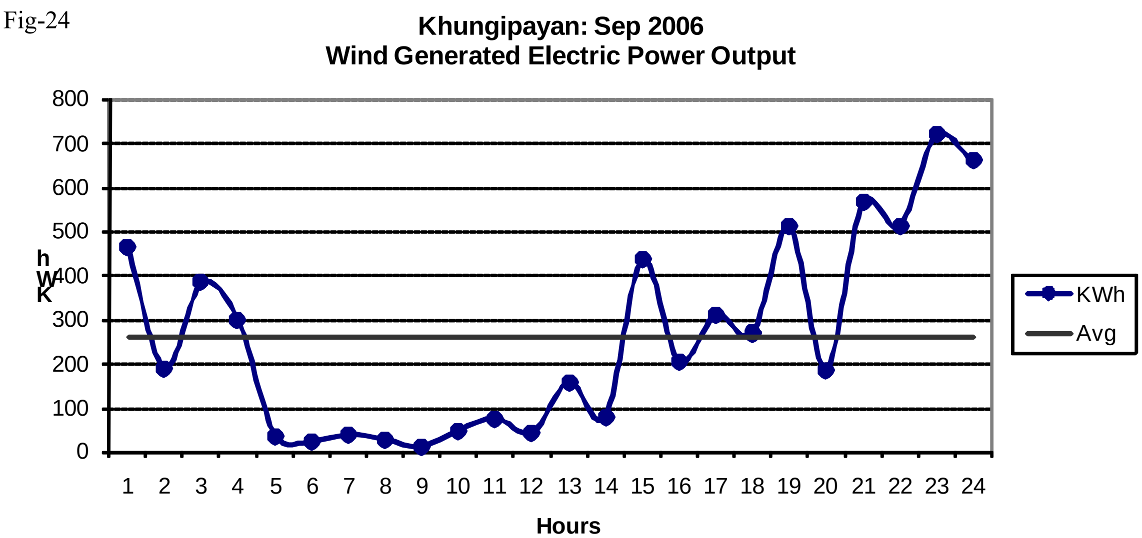


Fig-25

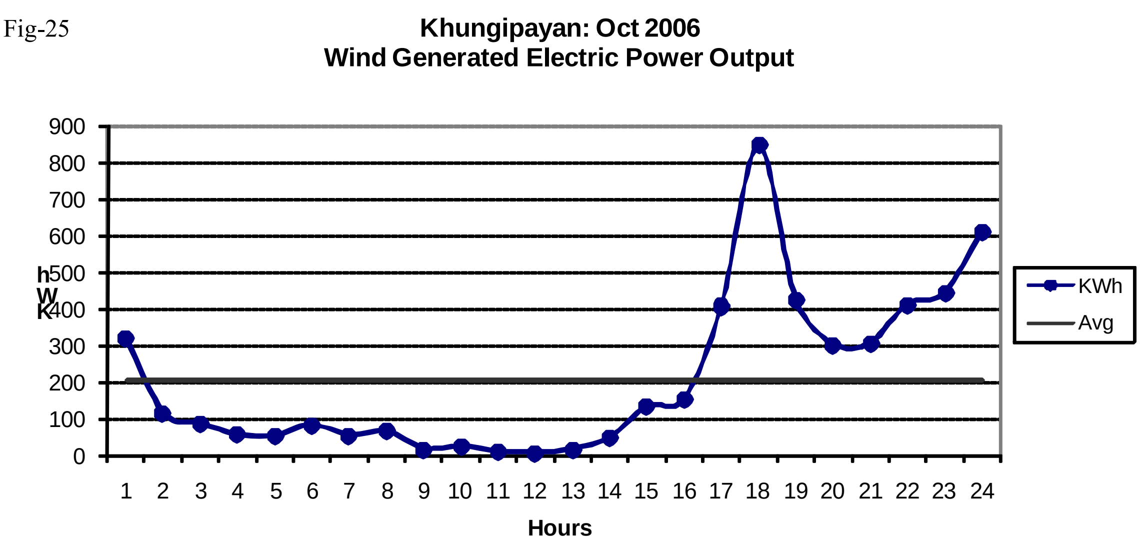


Fig-26

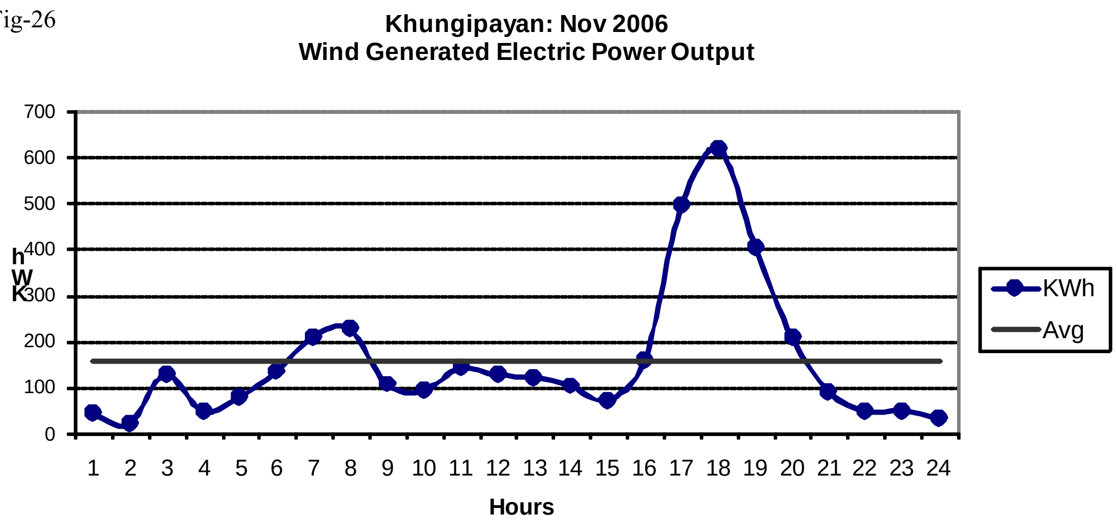


Fig-27

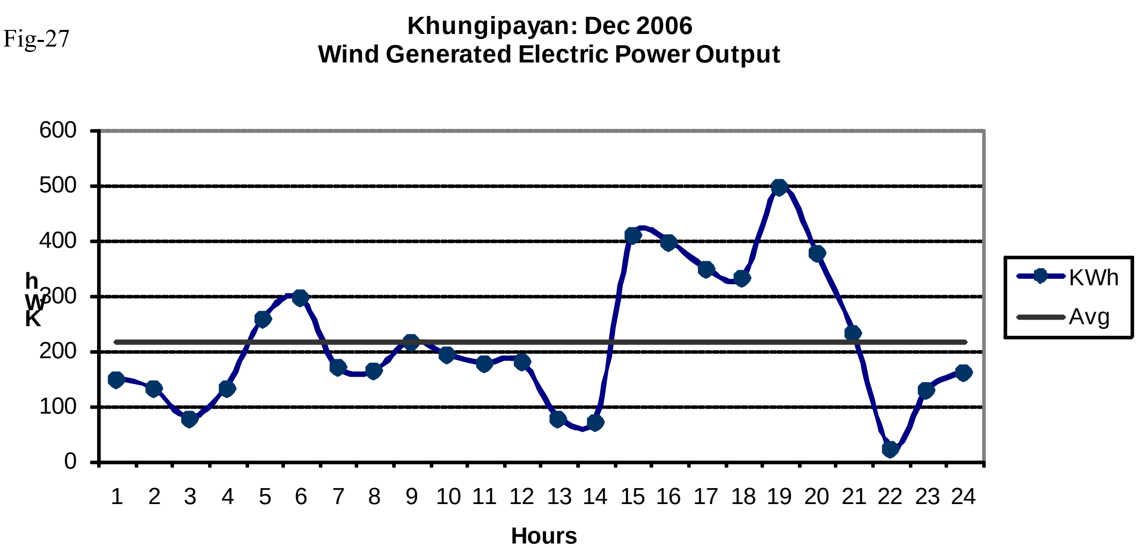


Fig-28

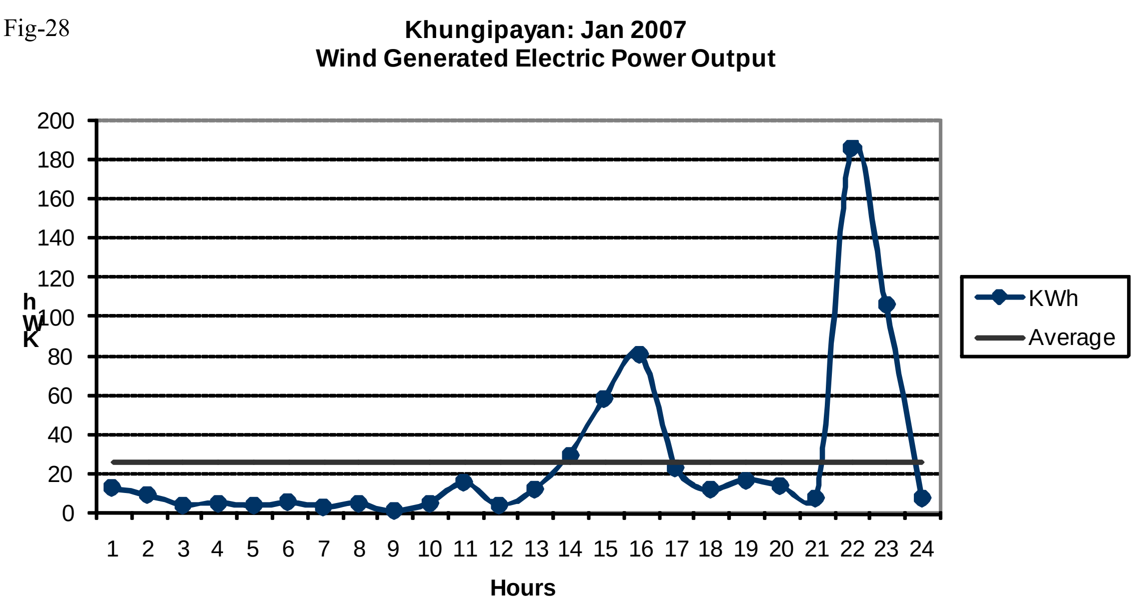


Fig-29

Khungipayan: Feb 2007
Wind Generated Electric Power Output

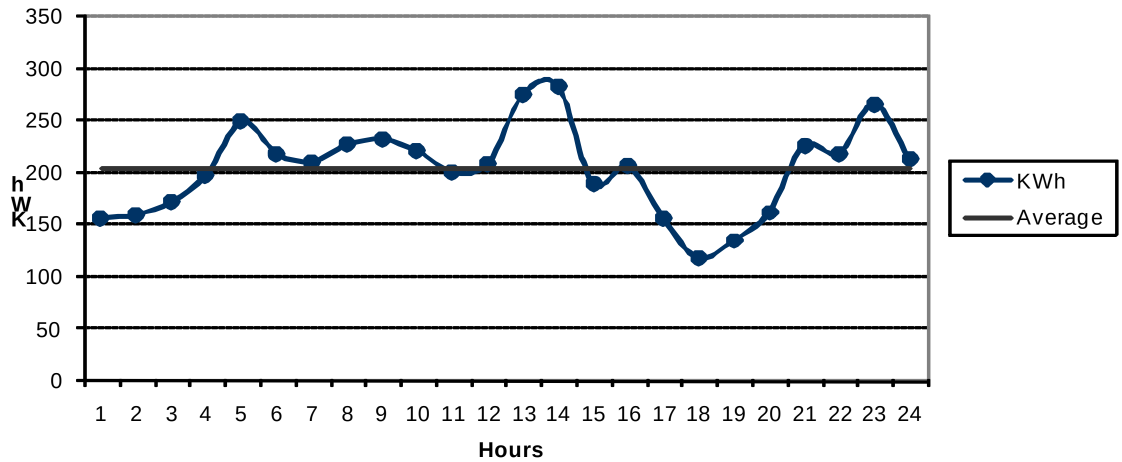


Fig-30

Khungipayan: Mar 2007
Wind Generated Electric Power Output

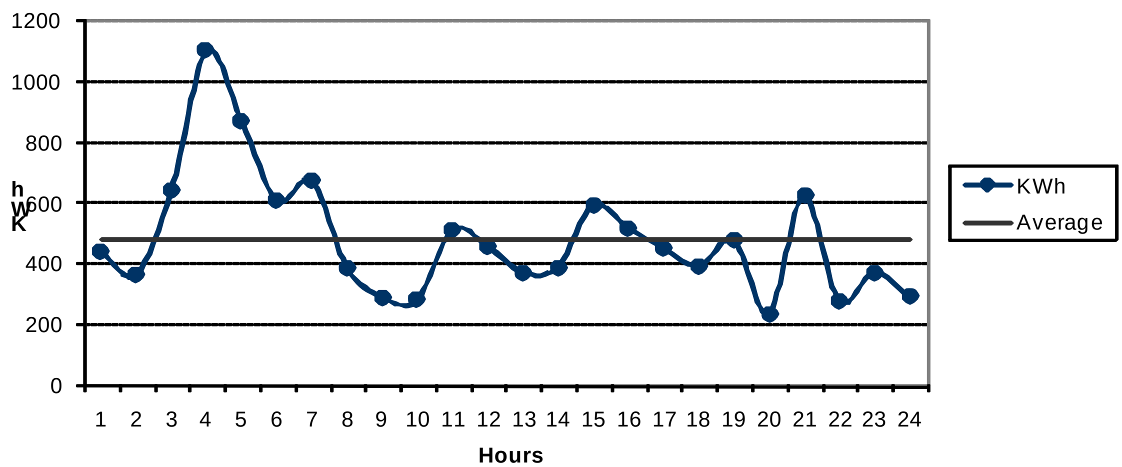


Fig-31

Khungipayan: Apr 2007
Wind Generated Electric Power Output

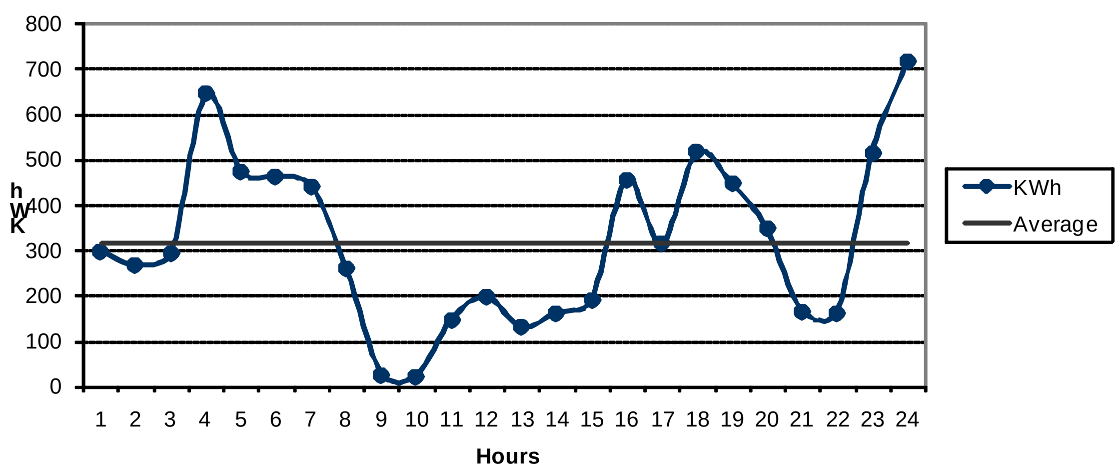


Fig-32

Khungipayan: May 2007
Wind Generated Electric Power Output

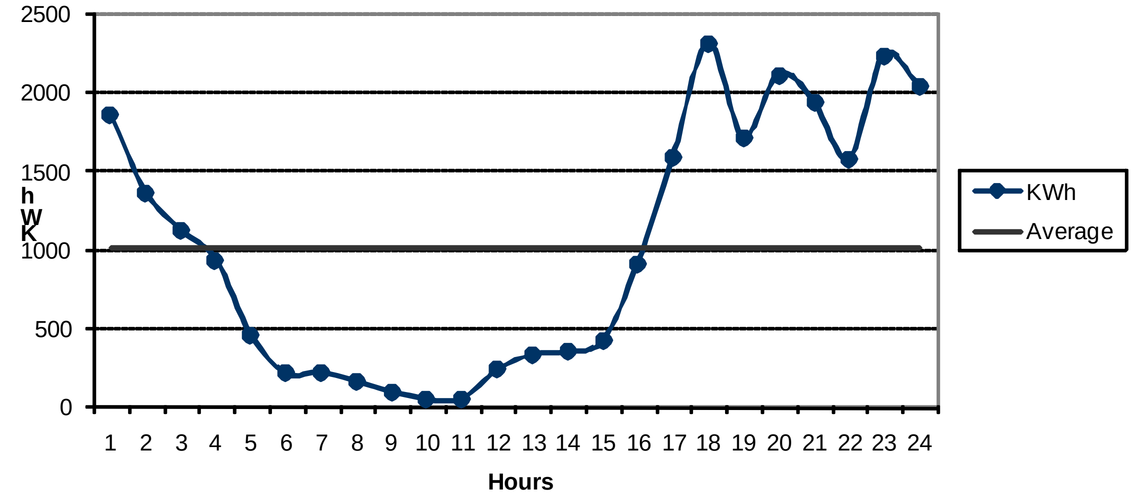
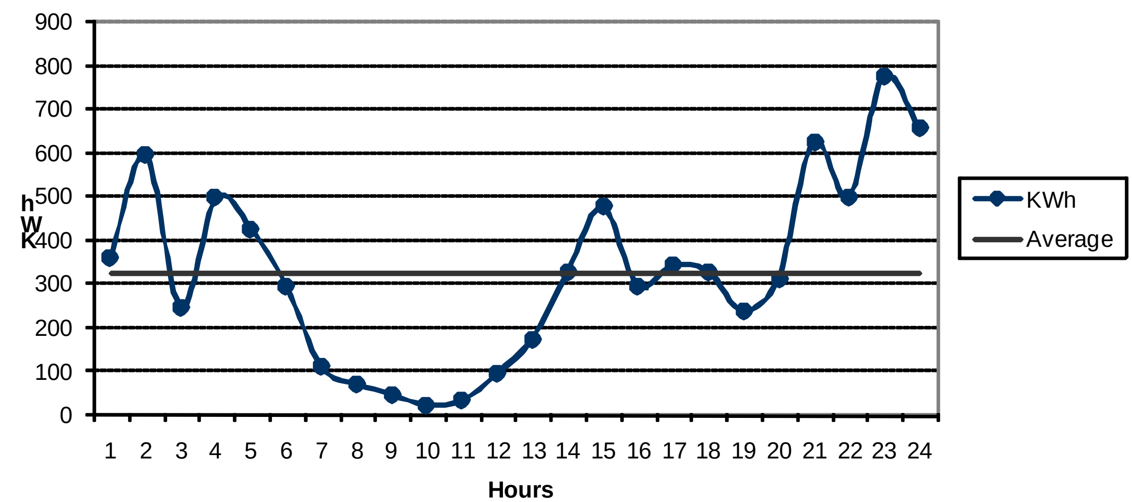


Fig-33

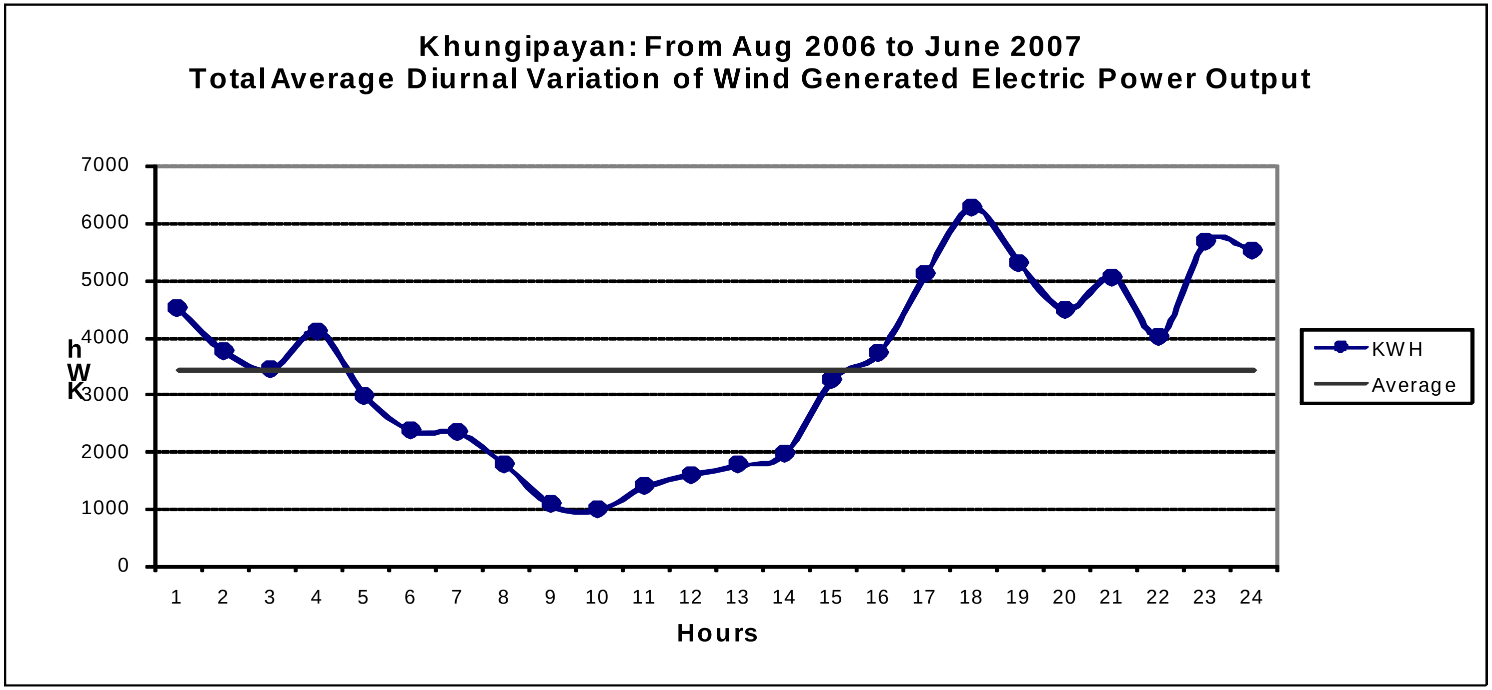
Khungipayan: June 2007
Wind Generated Electric Power Output



Appendix-I

Khungipayan **August-2006 to June-2007** **Wind Power Output of Bonus 600/44 Turbine (Eleven 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	13	9	4	5	4	6	3	5	1	5	16	4	12	30	59	81	23	12	17	14	7	186	107	8	**631**
Feb	156	160	172	198	249	218	210	227	232	221	201	209	275	283	189	207	156	117	134	161	226	218	266	213	**4897**
Mar	441	365	642	1103	872	608	674	387	291	281	514	459	372	389	595	518	452	393	478	235	624	278	372	293	**11637**
Apr	298	266	294	644	473	462	440	258	26	21	147	195	129	161	190	455	314	515	446	347	164	161	513	714	**7637**
May	1869	1367	1125	939	457	216	222	165	102	51	56	242	335	358	422	915	1592	2317	1717	2118	1947	1577	2240	2045	**24394**
June	361	595	245	497	427	296	110	70	46	22	32	96	174	327	476	295	343	329	237	312	626	498	776	658	**7850**
Aug	388	516	277	179	49	24	186	175	9	20	21	32	80	111	273	328	655	508	410	201	261	101	57	122	**4983**
Sep	461	188	383	299	36	23	38	26	11	48	76	41	157	79	436	204	310	268	511	186	565	509	718	659	**6230**
Oct	317	113	83	55	52	79	52	64	15	22	8	4	14	46	131	150	406	845	422	301	305	410	441	609	**4944**
Nov	41	19	128	48	77	133	209	226	106	92	142	126	120	102	70	157	496	619	405	207	89	46	48	31	**3738**
Dec	149	131	79	133	258	295	170	163	217	192	177	180	78	71	408	397	348	332	496	376	230	22	129	162	**5194**
KWH	**4495**	**3730**	**3431**	**4100**	**2955**	**2359**	**2314**	**1766**	**1057**	**976**	**1388**	**1588**	**1748**	**1958**	**3249**	**3707**	**5095**	**6256**	**5273**	**4459**	**5045**	**4007**	**5668**	**5514**	**82135**
Average	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	



Appendix-II

Khungipayan August 2006 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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
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	0.0	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	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.4	2.8	2.2	0.9	2.1	15.0	15.2	25.6	1.9	5.2	0.8	**73**
11	1.4	0.0	0.0	0.0	0.0	0.3	176.2	148.0	0.7	0.2	0.3	0.0	0.0	0.6	2.1	0.1	0.5	2.9	14.7	3.1	0.1	0.5	0.3	0.7	**353**
12	1.0	0.0	0.7	1.1	0.5	0.0	0.0	0.1	2.6	0.7	0.0	0.0	1.8	1.3	24.2	46.4	52.7	22.7	87.8	65.9	49.5	10.7	0.3	1.3	**371**
13	7.8	4.4	0.3	3.8	4.8	0.0	0.0	0.3	2.1	0.0	0.0	0.0	0.1	0.7	0.5	3.4	111.5	9.3	0.2	0.0	0.0	2.4	0.1	0.3	**152**
14	2.6	1.6	3.2	0.5	0.3	0.0	0.0	0.0	0.0	0.3	3.0	0.1	17.0	7.4	75.8	38.3	5.1	5.5	18.0	6.2	78.8	4.2	16.7	60.7	**345**
15	118.8	116.4	25.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.9	6.8	1.7	2.5	44.5	25.6	23.1	39.0	7.7	2.9	0.1	0.0	0.0	0.4	**416**
16	3.0	0.7	0.0	0.3	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.1	1.3	3.4	2.9	13.2	29.5	35.5	18.5	8.2	8.3	32.8	2.7	0.1	**161**
17	0.4	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.5	1.3	1.4	0.6	9.2	4.7	**20**
18	6.8	5.4	8.7	2.4	5.2	12.4	2.6	14.2	0.7	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.9	6.4	8.4	0.8	3.9	0.7	**80**
19	0.3	3.9	4.5	2.6	3.6	1.0	1.7	6.1	0.1	0.2	0.0	0.0	0.0	0.0	2.5	14.9	12.8	21.9	0.8	2.4	1.7	0.1	0.2	4.3	**86**
20	2.3	4.8	0.2	0.3	0.0	1.7	1.3	0.1	0.0	18.1	16.2	10.8	8.8	3.7	12.7	5.9	30.5	28.2	32.2	32.3	34.5	0.9	0.3	0.3	**246**
21	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.7	5.4	3.9	0.9	3.0	0.3	20.5	24.4	5.1	4.2	2.4	15.2	1.6	0.2	**89**
22	0.3	0.1	0.1	0.0	0.3	0.2	0.0	0.5	0.4	0.0	0.1	3.8	8.5	12.9	23.7	11.4	24.3	22.9	2.8	0.2	0.8	2.8	3.4	0.7	**120**
23	2.4	9.0	0.7	0.8	1.8	0.3	0.7	1.5	1.1	0.0	0.0	0.5	4.0	1.1	3.5	7.9	32.5	65.7	140.6	6.6	0.2	0.3	0.0	0.0	**281**
24	0.0	0.0	0.0	0.0	0.4	0.8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.4	17.9	28.2	5.2	2.6	1.6	4.3	0.7	0.0	0.0	**63**
25	0.1	2.1	0.3	0.0	0.3	0.3	0.1	2.2	0.0	0.0	0.0	0.8	4.1	9.7	8.9	12.5	14.9	27.7	26.0	2.2	31.7	13.7	0.3	0.3	**158**
26	4.5	2.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	2.9	3.3	2.5	11.8	19.8	14.3	17.8	0.0	0.0	0.8	1.7	**82**
27	0.1	0.4	2.3	0.0	0.0	0.0	1.2	0.5	0.0	0.2	0.0	3.0	13.2	17.3	27.5	92.8	232.5	146.5	0.0	1.4	0.2	0.0	0.0	0.0	**539**
28	0.0	0.1	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.1	15.2	40.4	29.6	20.0	11.6	5.8	2.7	1.2	1.7	8.9	1.9	6.0	**146**
29	234.0	311.5	229.5	164.9	31.1	3.8	1.3	0.0	0.0	0.0	0.0	0.0	0.1	5.5	3.3	4.8	9.4	2.0	7.1	12.3	0.3	1.1	5.8	7.5	**1035**
30	1.6	52.4	0.5	1.1	0.2	2.5	0.0	0.2	1.4	0.0	0.0	0.0	0.1	0.1	0.3	1.6	0.0	0.3	0.4	0.1	5.5	3.0	4.7	2.7	**79**
31	0.0	0.3	0.2	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	6.4	2.2	20.6	12.0	9.8	5.9	0.6	0.0	28.8	**88**
KWh	**388**	**516**	**277**	**179**	**49**	**24**	**186**	**175**	**9**	**20**	**21**	**32**	**80**	**111**	**273**	**328**	**655**	**508**	**410**	**201**	**261**	**101**	**57**	**122**	**4983**

Khungipayan September 2006 **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	18.4	24.0	24.5	0.9	4.5	0.9	15.7	0.2	1.5	0.3	0.0	0.7	1.2	2.7	2.4	4.2	5.5	4.1	6.3	4.8	10.9	0.8	0.5	0.0	135
2	0.0	0.0	0.0	0.0	0.1	0.0	1.2	0.8	0.0	15.7	18.7	5.4	18.8	19.3	9.6	1.3	27.3	63.8	265.7	0.3	1.1	0.0	0.0	0.3	449
3	2.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.6	2.3	4.8	3.9	2.2	2.8	1.7	0.1	294.2	228.8	333.8	249.5	1129
4	110.9	0.0	5.6	2.5	0.6	0.9	0.1	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.3	0.5	0.1	0.0	123
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	3.2	2.9	1.5	0.3	0.0	0.0	8
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	1.0	0.4	2.5	5.3	4.4	2.7	0.7	18
7	1.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	1.7	2.1	6.0	2.8	1.8	4.4	21
8	2.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.7	6.8	0.3	2.0	3.1	2.4	0.5	21
9	0.2	2.2	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.4	1.3	0.8	2.2	4.6	7.1	1.5	2.9	0.0	0.3	1.1	25
10	1.3	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.4	3.1	6.3	13.8	13.0	9.5	2.8	9.7	51.9	0.5	2.3	0.5	117
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	2.3	4.6	15.4	22.1	20.4	1.1	0.0	0.5	1.0	68
12	0.3	10.5	244.4	71.5	3.2	4.8	4.3	0.8	0.3	0.0	0.0	0.0	0.2	0.1	1.8	1.1	16.7	11.0	8.5	16.2	0.4	19.1	16.8	0.5	433
13	0.3	0.2	2.8	1.5	1.8	0.0	0.0	0.0	0.0	4.3	35.1	26.4	9.5	3.6	10.1	4.4	11.2	19.1	2.0	0.8	0.7	0.2	0.8	2.7	137
14	1.5	1.6	0.5	0.0	0.0	0.0	0.7	0.6	0.0	0.0	5.9	2.9	16.5	7.2	8.8	2.0	34.3	18.3	7.5	37.5	51.3	14.1	7.0	0.0	218
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1.2	7.8	0.3	4.3	5.5	4.3	5.0	5.8	1.5	1.9	0.0	0.1	0.0	40
16	0.3	0.4	0.0	0.0	0.0	2.6	6.3	1.8	1.8	0.3	0.1	0.0	2.4	3.2	1.1	1.4	2.9	3.3	0.7	0.2	0.2	1.0	1.1	0.1	31
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.7	8.4	2.3	6.7	1.5	2.2	0.7	1.4	0.6	25
18	2.7	2.8	3.0	3.4	2.8	1.0	1.0	1.5	0.2	0.0	0.2	2.6	7.5	12.0	12.4	2.2	8.4	1.4	1.7	1.6	4.4	4.4	2.3	1.9	81
19	0.3	1.1	0.0	0.0	0.0	0.1	6.8	14.0	2.8	26.5	13.2	0.3	87.1	16.7	358.0	145.0	2.2	0.2	0.1	0.2	0.0	0.2	0.1	5.7	680
20	30.3	4.4	16.9	0.0	0.0	2.5	0.1	4.8	4.3	0.6	0.0	0.0	0.1	0.7	2.2	0.5	2.0	8.3	0.3	4.1	15.6	0.3	5.7	0.3	104
21	9.3	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.2	1.3	3.6	6.1	4.0	3.4	3.8	11.5	5.8	6.0	9.0	295.4	327.0	688
22	208.7	75.8	40.6	214.6	0.7	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.8	2.0	2.8	1.0	1.4	1.6	0.1	3.4	3.2	0.5	0.0	4.2	562
23	0.0	0.0	0.0	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.6	1.6	0.0	0.0	3.1	4.2	9.9	1.8	5.9	0.1	29
24	0.2	1.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.9	1.4	0.4	0.0	0.1	0.3	6
25	0.0	0.0	0.0	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	1.0	4.3	5.5	6.3	7.9	4.4	3.2	90.7	23.5	27.4	176
26	68.1	61.4	42.1	3.2	21.9	8.8	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	152.0	70.1	127.1	37.4	72.1	119.6	8.0	28.0	821
27	1.9	0.2	1.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.0	0.3	1.7	1.1	2.1	3.1	2.0	0.1	15
28	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	5.5	1.0	11.6	5.3	2.3	0.5	0.1	27
29	0.3	0.0	0.4	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5	4.4	6.0	8.0	0.5	0.1	0.1	21
30	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.2	2.1	7.4	1.2	1.4	0.8	0.1	2.3	1.7	21
KWh	461	188	383	299	36	23	38	26	11	48	76	41	157	79	436	204	310	268	511	186	565	509	718	659	6230

Khungipayan October 2006 **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	1.9	0.0	1.0	0.3	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.2	0.7	4.6	0.8	5.2	0.2	0.3	**17**
2	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.1	0.1	0.0	0.0	0.0	3.5	15.5	0.4	0.7	4.6	4.8	**31**
3	1.2	1.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.3	2.9	2.8	6.5	11.1	5.6	0.7	**36**
4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	3.4	3.1	3.2	3.4	10.1	2.0	0.1	**27**
5	0.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.2	2.2	4.0	7.3	4.9	11.1	4.1	2.2	**39**
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	1.3	2.0	3.2	9.7	6.0	1.2	**24**
7	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.4	6.0	9.2	0.1	0.5	1.2	**23**
8	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	3.4	4.7	3.5	6.2	3.2	9.7	0.9	1.3	0.1	0.3	**34**
9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.4	0.8	5.5	7.1	16.3	4.4	5.7	7.5	192.7	424.6	**666**
10	252.0	80.7	56.0	45.2	8.9	24.7	17.0	8.4	5.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	23.4	0.7	0.6	3.4	0.6	1.3	6.6	**536**
11	1.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.0	9.8	0.5	6.2	0.9	3.7	0.1	5.3	**32**
12	6.6	9.6	4.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.8	5.5	2.0	9.5	5.5	6.6	0.6	3.3	6.8	36.4	91.6	**190**
13	20.9	14.4	3.1	0.3	0.3	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.5	8.6	30.1	22.1	17.5	39.5	14.2	42.8	2.0	0.8	1.5	4.1	**223**
14	0.3	0.4	2.2	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.1	4.5	5.8	11.9	222.7	422.3	277.0	69.1	66.2	112.0	61.4	8.4	**1265**
15	5.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.3	0.3	0.0	0.0	0.8	0.3	0.1	0.0	0.0	0.0	**9**
16	0.6	0.0	0.1	0.4	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.2	0.3	0.0	3.3	0.0	0.0	2.7	0.0	0.1	**9**
17	0.5	0.0	0.5	0.1	0.6	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.5	0.7	0.5	0.5	0.0	1.9	0.8	0.7	0.5	0.4	0.0	**9**
18	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.9	0.9	1.1	2.6	0.2	3.0	1.3	0.9	0.2	0.1	0.2	**12**
19	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.9	20.5	42.1	111.9	315.4	41.1	7.7	11.3	1.7	11.4	12.5	**577**
20	0.3	2.2	1.6	0.2	30.6	1.1	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	5.0	3.5	0.8	1.3	1.1	0.1	0.4	0.0	0.0	0.0	**51**
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.6	3.8	6.0	11.4	12.7	9.7	0.3	0.0	0.0	0.3	2.1	0.3	0.5	**51**
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	0.6	2.0	8.0	4.4	0.1	0.0	0.5	1.6	1.6	1.1	1.2	0.2	**21**
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	6.6	14.5	35.1	33.6	4.2	1.7	0.4	1.2	0.6	1.2	0.5	0.1	**100**
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	0.0	0.7	0.2	0.4	0.5	1.0	3.8	67.5	21.4	31.8	11.5	0.2	**139**
25	0.0	0.0	0.8	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.9	0.0	1.4	13.3	29.0	134.2	169.2	83.2	8.2	**442**
26	5.6	1.0	6.3	0.6	0.3	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.3	0.4	0.3	0.1	0.3	0.1	0.5	0.8	0.5	1.3	11.2	**30**
27	6.8	1.2	6.2	5.9	9.4	51.8	30.8	54.1	8.8	21.0	7.3	0.0	0.0	0.2	0.3	2.9	1.5	0.8	2.8	9.6	14.4	15.3	8.4	23.8	**283**
28	13.1	1.5	1.0	0.1	0.3	0.1	0.0	1.1	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	2.6	1.6	2.1	0.5	4.9	0.2	**29**
29	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0	1.7	1.4	1.8	0.0	0.0	0.2	**7**
30	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.5	0.9	2.5	3.1	0.1	3.3	1.8	1.0	0.0	0.4	0.0	**16**
31	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.5	1.5	0.2	0.5	2.9	2.2	2.1	2.8	1.6	0.1	**16**
KWh	**317**	**113**	**83**	**55**	**52**	**79**	**52**	**64**	**15**	**22**	**8**	**4**	**14**	**46**	**131**	**150**	**406**	**845**	**422**	**301**	**305**	**410**	**441**	**609**	**4944**

Khungipayan November 2006 | 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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	1.0	0.6	1.7	0.4	1.0	0.8	2.2	0.5	0.2	0.0	**9**
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.5	1.2	2.0	0.5	0.0	3.7	2.2	2.3	2.2	0.3	1.2	**16**
3	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	3.3	0.7	1.5	1.0	0.0	0.0	**8**
4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.3	0.2	1.7	3.2	1.0	2.6	1.8	0.5	0.1	**13**
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.4	1.5	0.0	0.0	1.9	1.7	3.3	1.9	0.5	0.0	**13**
6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	1.5	0.5	2.4	0.0	0.8	0.8	2.2	0.0	0.2	0.5	**10**
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	0.0	0.3	0.1	0.5	1.0	0.5	2.0	1.9	1.4	0.3	0.5	2.1	**11**
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.5	0.4	1.2	0.3	0.0	0.0	**3**
9	0.3	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.0	0.9	0.0	0.0	0.0	0.0	**4**
10	0.0	0.0	0.0	0.0	0.0	0.3	1.2	21.9	2.0	0.0	0.0	0.0	0.0	0.5	0.6	45.7	177.4	92.1	3.9	1.6	0.3	3.3	9.5	13.8	**374**
11	23.7	16.4	126.3	45.6	2.2	0.9	0.6	0.1	0.1	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.5	0.7	0.0	0.0	**222**
12	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.2	0.0	0.0	0.0	28.2	224.7	325.3	123.6	8.2	0.0	0.0	0.0	0.0	**714**
13	0.1	0.0	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.1	0.0	2.4	0.0	0.0	0.0	0.0	0.0	**4**
14	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	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	0.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.5	0.3	0.7	**6**
16	0.1	0.0	0.3	0.1	0.4	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	71.8	70.0	2.6	51.4	2.2	1.6	0.0	**202**
17	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	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	0.0	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	0.0	0.1	0.0	0.0	0.0	0.3	1.3	0.7	0.0	0.0	0.0	0.0	**2**
20	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.1	0.1	0.0	0.0	0.2	**1**
21	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	4.4	3.5	0.2	0.1	0.4	1.0	0.2	0.1	1.6	1.4	0.8	0.9	**15**
22	0.8	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.3	4.5	0.9	0.0	0.1	0.7	0.4	0.0	0.3	0.4	**10**
23	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.9	0.2	0.2	0.1	0.0	0.5	19.7	8.9	4.7	**36**
24	0.1	0.0	0.8	0.3	0.5	0.1	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.3	0.0	0.2	**4**
25	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.5	1.0	1.7	0.0	0.0	0.0	0.1	0.0	**4**
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	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	**0**
27	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1	0.4	0.0	0.0	1.0	0.1	0.0	**3**
28	0.0	0.0	0.0	0.0	0.0	21.4	82.7	76.1	49.4	87.8	140.8	125.3	112.0	80.1	59.3	69.8	79.8	121.1	182.9	174.9	13.6	7.4	23.1	0.0	**1508**
29	13.6	1.5	0.0	0.0	73.2	109.6	123.8	126.4	53.0	0.1	0.0	0.0	3.1	12.4	1.9	0.0	4.8	2.2	0.0	7.0	0.1	0.1	1.0	6.3	**540**
30	1.1	1.4	0.2	0.1	0.5	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.7	1.6	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	**7**
KWh	**41**	**19**	**128**	**48**	**77**	**133**	**209**	**226**	**106**	**92**	**142**	**126**	**120**	**102**	**70**	**157**	**496**	**619**	**405**	**207**	**89**	**46**	**48**	**31**	**3738**

Khungipayan December 2006 **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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.0	0.2	0.1	1.0	0.3	0.0	0.3	0.0	0.0	0.5	6
2	0.0	0.1	0.2	0.0	0.7	0.0	0.0	0.0	0.1	1.5	0.0	0.0	1.3	10.3	309.4	335.1	242.0	275.6	298.0	188.7	126.4	16.7	0.0	16.9	1823
3	1.7	0.6	0.0	0.0	0.0	0.0	0.1	0.1	0.4	8.4	1.2	1.4	0.0	0.5	0.1	1.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5	16
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.3	7.8	56.4	47.3	23.0	13.2	93.8	31.1	0.2	0.3	0.0	1.2	276
5	0.8	3.3	7.5	35.2	29.1	2.0	7.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	86
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.1	0.0	0.6	0.3	0.8	1.0	0.0	0.1	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	9
7	0.0	0.1	0.1	0.1	0.1	0.9	0.3	0.4	0.3	0.0	1.3	11.9	10.5	0.0	1.7	0.0	61.3	37.5	98.0	146.8	95.3	4.7	0.6	0.0	472
8	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.1	0.5	0.0	0.4	0.3	0.0	0.0	4
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.2	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
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	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	2.0	0.0	0.0	0.0	0.0	0.0	0.1	2.0	6.3	0.1	0.0	0.3	0.0	11
20	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.9	0.1	0.0	0.4	0.4	4.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	1.1	13.2	21
21	7.4	0.1	0.0	0.0	0.1	2.4	53.0	3.6	3.4	23.5	56.6	112.6	20.1	4.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	289
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	0.0	0.0	0.0	0.0	0.1	0.5	1.6	0.0	0.0	0.0	0.0	0.0	2
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.5	0.1	0.0	0.0	0.0	0.0	1
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	0.0	0.0	1.3	2.3	5.8	0.3	0.2	1.6	0.0	0.0	126.8	130.0	269
25	122.7	110.5	68.7	94.6	226.0	285.0	106.3	150.9	210.7	154.3	114.7	20.5	0.0	0.0	0.0	4.8	13.3	0.3	0.2	0.5	7.2	0.4	0.1	0.0	1692
26	15.7	16.5	1.7	1.9	0.4	4.6	0.8	2.0	0.9	2.1	0.1	0.4	0.3	0.1	0.6	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	48
27	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.8	30.6	42.7	45.0	30.3	6.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158
28	0.6	0.0	0.0	0.7	1.1	0.1	2.3	0.1	0.0	0.9	0.1	0.0	0.3	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7
29	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	1
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1
KWh	149	131	79	133	258	295	170	163	217	192	177	180	78	71	408	397	348	332	496	376	230	22	129	162	5194

Khungipayan January 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	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.3	2.8	0.7	1.0	0.3	0.4	0.0	0.0	7.0	185.7	101.8	0.7	**301**
2	9.2	5.9	1.4	0.3	0.1	0.0	0.3	0.5	0.1	0.5	0.1	0.0	0.0	0.5	1.2	0.8	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	**22**
3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.0	0.6	1.8	0.6	0.0	0.0	0.0	0.0	**4**
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.8	0.7	1.2	3.0	0.0	0.1	0.0	0.0	0.4	0.0	0.0	0.0	**11**
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	7.4	0.7	0.1	0.0	2.7	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**13**
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	3.5	1.0	2.5	1.0	3.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**16**
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.4	1.6	3.6	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**8**
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	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
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	0.0	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	0.0	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	0.0	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	0.0	0.0	0.0	0.0	0.0	1.4	0.1	1.1	0.0	0.0	0.0	0.0	**3**
18	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	**1**
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	0.1	8.5	7.2	33.0	16.0	0.9	2.0	1.6	0.0	0.0	0.0	0.0	**69**
20	0.0	0.0	0.1	0.0	0.1	1.8	0.4	0.4	0.0	0.5	0.0	0.1	0.1	6.4	30.9	33.9	4.4	2.1	2.6	3.0	0.0	0.0	0.0	0.0	**87**
21	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.1	0.1	0.0	0.1	0.2	3.8	7.4	3.8	0.5	2.0	0.9	0.8	0.0	0.0	0.0	0.0	**20**
22	0.1	0.0	0.2	0.8	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.9	0.1	4.1	0.3	0.0	0.0	0.0	0.0	**8**
23	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.7	0.1	0.0	0.0	0.0	0.6	0.9	2.0	0.3	0.0	0.0	1.1	1.0	0.0	0.0	0.0	0.0	**8**
24	0.0	0.0	0.0	0.3	0.0	0.0	1.3	0.6	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.3	5.0	**11**
25	1.4	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.3	0.0	0.0	0.2	1.0	0.0	0.0	0.0	0.0	**5**
26	0.0	0.0	0.1	0.1	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.1	0.9	0.7	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	**3**
27	0.7	0.8	0.0	0.0	0.2	0.5	0.0	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.0	0.2	0.0	0.0	0.2	0.1	**3**
28	0.3	0.3	0.2	1.4	1.4	1.1	0.0	0.3	0.2	0.5	0.2	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.5	**7**
29	0.8	0.1	0.7	0.8	1.4	1.2	0.6	0.7	0.2	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.7	0.0	0.0	0.7	1.2	**12**
30	0.3	0.7	1.5	1.0	0.1	0.1	0.0	0.1	0.3	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.4	1.6	2.3	0.0	0.1	0.3	0.0	**9**
31	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.3	0.0	0.0	0.0	0.0	0.0	3.2	1.6	0.6	0.0	0.0	0.3	0.1	**10**
KWh	**13**	**9**	**4**	**5**	**4**	**6**	**3**	**5**	**1**	**5**	**16**	**4**	**12**	**30**	**59**	**81**	**23**	**12**	**17**	**14**	**7**	**186**	**107**	**8**	**631**

Khungipayan February 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	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
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	0.0	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	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
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	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	0.1	4.7	3.8	0.9	0.3	0.0	30.3	120.2	99.0	111.7	47.2	418
20	25.7	1.8	0.7	1.1	3.7	2.1	2.5	6.5	5.0	1.8	1.2	0.2	0.0	0.3	0.0	0.1	0.0	0.0	0.1	65.2	83.8	99.5	106.6	121.9	530
21	123.9	144.9	121.5	91.7	85.9	10.8	0.0	0.0	0.2	0.7	0.5	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	582
22	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.6	6.1	9.0	13.2	3.8	13.0	3.0	3.2	0.1	0.3	0.8	0.0	0.3	0.0	0.1	57
23	1.7	10.9	4.1	8.1	8.0	11.6	5.4	3.7	0.7	0.6	0.1	8.1	42.1	77.5	47.8	32.5	15.5	0.6	2.1	3.2	0.3	0.0	0.0	0.0	284
24	0.0	0.0	0.1	0.1	3.9	1.4	0.1	0.7	0.2	0.1	0.0	0.0	0.0	0.1	0.1	0.3	1.0	0.1	0.0	0.6	0.0	0.3	1.3	0.4	11
25	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.5	0.1	0.0	0.0	0.0	13.1	31.2	2.6	0.4	0.7	0.0	0.9	0.0	0.0	0.1	0.0	0.0	50
26	0.1	1.0	1.4	2.6	128.1	192.3	201.9	215.7	222.7	215.1	192.7	189.3	204.1	153.3	108.4	34.4	0.1	1.1	1.6	1.2	0.0	16.0	46.8	42.9	2173
27	4.5	0.7	43.8	94.3	19.7	0.0	0.0	0.0	0.2	0.8	0.0	0.0	2.3	15.0	10.5	128.2	130.9	63.6	4.2	0.0	0.3	0.0	0.0	0.0	519
28	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	2.2	4.0	3.4	51.8	125.0	59.9	21.6	3.0	0.0	0.0	273
KWh	**156**	**160**	**172**	**198**	**249**	**218**	**210**	**227**	**232**	**221**	**201**	**209**	**275**	**283**	**189**	**207**	**156**	**117**	**134**	**161**	**226**	**218**	**266**	**213**	**4897**

Khungipayan March 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	2.5	1.2	0.1	1.2	0.9	0.5	0.8	10.2	32.7	16.0	36.0	0.0	0.0	10.2	70.9	27.8	0.4	0.5	2.7	0.0	0.0	0.0	0.0	0.0	**215**
2	0.0	0.0	0.2	0.1	0.0	0.1	0.9	0.3	0.1	0.0	0.0	0.0	0.2	1.7	0.7	6.6	0.3	0.0	0.4	0.0	0.0	0.0	0.2	1.0	**13**
3	0.7	0.3	0.0	0.0	0.0	125.3	122.2	39.0	1.0	7.3	31.1	8.8	1.0	1.7	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.1	**339**
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.5	2.3	9.5	6.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**30**
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.9	4.5	5.0	2.2	7.1	5.5	0.5	0.5	0.0	0.0	0.0	0.0	0.1	**27**
6	0.5	0.1	0.7	0.8	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.2	0.2	0.8	0.3	1.4	0.7	1.0	0.8	0.0	0.0	0.3	0.0	**10**
7	0.3	1.1	1.2	0.1	0.0	0.3	0.2	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.8	4.9	8.0	0.8	1.6	0.7	0.1	0.0	0.0	0.3	**21**
8	0.7	0.0	0.0	0.0	0.6	0.4	0.8	0.6	0.1	0.0	0.0	0.0	0.0	0.0	1.3	0.1	2.4	1.6	0.0	0.0	2.3	0.3	0.3	1.6	**13**
9	1.8	0.1	9.6	233.2	48.7	35.5	41.5	5.5	0.4	1.0	0.5	7.1	5.2	3.2	39.3	77.1	138.2	136.7	98.0	40.5	5.5	2.5	2.9	0.8	**935**
10	0.0	0.0	0.0	0.0	7.5	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	12.3	10.8	5.9	17.1	14.6	0.0	0.0	0.6	0.3	0.0	**102**
11	0.3	0.0	0.0	0.1	0.0	0.3	0.2	3.5	125.6	124.1	161.7	153.4	143.4	108.8	187.4	49.2	67.3	38.3	85.7	88.3	47.3	13.3	0.1	0.0	**1398**
12	0.0	0.7	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	2.3	0.7	0.0	0.1	0.2	0.1	0.0	0.0	**5**
13	0.0	0.0	0.0	0.0	0.7	0.0	9.7	7.6	0.1	0.0	0.0	0.1	2.0	3.8	96.1	196.6	80.2	89.1	68.9	2.3	3.2	0.3	0.0	0.2	**561**
14	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	37.9	14.7	0.7	0.1	0.0	0.2	0.1	0.0	0.0	**54**
15	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.3	0.8	0.4	1.0	0.8	0.0	0.3	0.6	0.0	0.6	0.1	**5**
16	0.1	0.2	0.0	0.0	0.1	0.4	0.1	0.7	0.3	0.3	0.1	0.2	6.0	20.5	40.9	30.3	15.0	0.2	1.7	0.5	0.0	0.1	0.0	0.5	**118**
17	0.9	0.2	0.0	0.9	0.1	0.0	0.0	0.1	0.1	0.2	0.0	0.0	1.3	0.3	0.1	0.0	0.7	0.0	0.3	0.1	0.5	4.6	166.1	53.9	**230**
18	2.4	7.0	162.5	223.5	122.0	66.0	218.5	223.7	11.1	4.6	2.6	34.2	4.5	8.2	4.1	0.2	1.0	0.7	125.9	32.9	4.4	1.5	5.2	0.2	**1267**
19	0.0	0.8	1.4	0.4	1.2	2.2	2.5	5.6	21.8	65.6	216.4	176.5	115.7	101.3	32.6	0.3	0.4	31.2	33.8	17.5	3.5	132.9	156.0	56.1	**1176**
20	253.8	178.3	386.6	358.7	158.3	60.9	11.6	7.4	35.5	6.0	28.4	15.9	0.0	2.3	2.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.2	**1508**
21	0.2	0.0	0.5	1.0	0.0	0.2	0.0	0.0	0.0	0.0	0.5	3.9	22.6	24.4	11.9	7.8	3.2	6.4	1.7	0.0	0.0	0.0	0.0	0.0	**84**
22	0.0	0.0	0.4	1.3	0.2	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.1	0.3	3.6	10.7	9.2	1.4	0.1	0.3	0.0	0.0	0.1	1.4	**29**
23	0.5	1.5	3.2	3.4	2.7	4.0	2.4	1.4	1.1	0.1	5.3	34.7	30.2	19.5	34.9	26.0	31.5	12.6	1.3	0.0	0.5	0.0	0.3	0.7	**218**
24	0.2	0.8	0.5	2.6	2.2	0.6	1.2	4.8	0.8	0.0	0.1	0.1	10.7	8.2	1.1	5.4	1.8	5.9	1.5	3.6	0.7	0.0	0.0	0.5	**53**
25	0.0	0.0	0.1	0.0	0.9	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.4	0.5	1.7	2.0	27.9	35.1	1.6	0.3	1.4	0.0	0.3	0.1	**73**
26	0.5	3.3	1.4	1.0	1.0	2.6	1.9	0.9	0.5	2.0	0.1	0.0	0.0	3.3	9.6	0.8	0.3	0.0	0.0	0.1	0.0	0.0	0.2	0.5	**30**
27	0.5	2.8	0.0	0.0	0.1	2.5	1.4	0.3	0.0	0.0	0.2	0.0	0.9	33.3	19.5	2.9	4.2	0.6	1.2	0.7	0.6	0.1	0.2	2.1	**74**
28	0.3	0.0	0.8	2.1	2.2	0.1	0.3	0.9	0.0	3.8	1.7	0.0	0.3	3.7	4.7	2.7	4.4	0.3	0.0	0.0	0.0	0.0	0.0	0.1	**28**
29	0.5	1.4	1.2	11.5	0.0	2.1	2.6	4.6	9.2	5.3	0.7	13.2	11.4	0.0	2.8	2.8	0.5	0.1	2.1	0.8	0.1	0.0	0.0	2.9	**76**
30	1.5	9.7	0.8	4.0	1.7	0.1	1.2	0.3	0.5	2.4	0.1	0.3	0.8	1.6	2.6	0.1	1.1	0.2	0.1	1.6	68.8	13.7	28.5	87.5	**229**
31	173.2	155.5	70.7	256.9	520.9	295.5	253.4	68.8	49.6	40.8	27.2	7.7	0.0	0.3	0.0	0.5	23.4	10.7	33.3	43.5	484.8	108.0	10.1	81.7	**2716**
KWh	**441**	**365**	**642**	**1103**	**872**	**608**	**674**	**387**	**291**	**281**	**514**	**459**	**372**	**389**	**595**	**518**	**452**	**393**	**478**	**235**	**624**	**278**	**372**	**293**	**11637**

Khungipayan April 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	36.2	94.5	216.3	353.7	198.4	216.9	311.7	193.8	13.4	0.8	61.3	62.7	0.8	0.0	0.4	0.1	0.4	6.7	3.5	0.0	0.0	0.0	0.0	0.2	**1772**
2	0.3	0.7	1.1	0.7	2.4	1.6	0.2	0.4	0.0	9.9	1.0	0.1	1.5	3.7	6.3	41.4	18.4	2.9	0.5	0.0	0.0	0.0	0.0	0.0	**93**
3	0.0	0.0	0.0	1.1	0.2	0.0	0.0	0.7	0.2	0.7	0.0	0.1	0.0	0.0	0.7	1.2	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.3	**6**
4	0.7	0.5	3.1	0.2	0.0	0.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.4	0.8	0.5	1.6	0.7	0.5	0.0	0.1	0.4	**15**
5	0.0	1.2	3.5	7.1	5.5	3.2	0.0	0.0	0.0	0.0	0.0	0.1	1.3	2.9	4.1	12.7	8.0	3.0	0.1	2.0	0.2	0.0	0.6	0.0	**56**
6	0.1	1.1	0.7	0.7	0.9	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.8	2.3	3.9	10.7	8.4	3.9	0.5	3.4	0.0	0.0	0.0	0.1	**38**
7	0.2	0.0	0.1	0.8	1.2	0.3	0.8	0.1	0.0	0.1	0.0	0.0	0.6	2.9	16.7	8.2	6.6	0.8	0.8	0.3	0.1	1.8	0.4	0.0	**43**
8	0.0	0.0	0.7	2.6	0.7	0.3	0.2	0.0	0.1	0.3	0.0	0.0	0.0	0.8	3.7	4.7	6.6	13.3	1.5	0.5	1.0	0.2	0.0	0.0	**37**
9	0.1	0.7	0.6	0.9	1.6	3.1	0.1	0.1	0.0	0.0	0.0	0.0	0.4	5.2	8.9	4.4	3.1	0.0	0.1	0.2	0.0	0.0	0.3	0.1	**30**
10	0.0	0.0	0.1	0.3	0.2	0.0	0.7	0.5	0.3	0.3	0.0	0.1	0.0	0.3	2.7	2.3	3.1	0.1	0.0	0.2	0.3	0.0	0.0	0.8	**12**
11	0.1	0.1	0.2	0.0	0.3	0.8	0.3	0.1	0.0	0.1	0.6	0.0	0.8	0.3	0.0	0.3	0.0	0.0	0.7	3.4	6.0	0.2	0.0	0.0	**14**
12	0.0	0.5	0.3	0.0	0.3	0.5	0.0	0.0	0.0	0.4	0.0	0.0	0.7	1.6	1.7	0.3	0.8	4.1	0.1	0.8	0.0	0.3	0.0	0.0	**12**
13	0.1	0.1	0.0	0.0	1.3	0.0	0.2	0.3	0.0	0.0	0.2	0.3	2.5	7.8	5.3	1.9	2.1	0.0	0.0	0.1	0.7	0.3	0.0	0.0	**23**
14	0.0	0.0	0.0	0.3	0.3	0.0	0.5	0.3	0.1	0.7	0.0	0.0	0.6	0.6	3.3	4.0	8.5	0.3	0.3	2.1	0.4	0.0	0.0	1.0	**23**
15	0.4	1.1	2.0	0.3	0.1	0.0	0.7	0.6	0.0	0.0	0.0	0.1	1.5	9.3	11.0	1.8	9.8	1.6	0.0	0.0	1.4	0.0	0.4	0.0	**42**
16	0.0	0.5	0.1	0.2	2.0	1.6	0.0	1.9	1.5	5.3	0.4	0.0	1.0	0.5	4.6	4.4	10.6	1.0	0.4	0.0	0.0	14.8	3.8	0.0	**55**
17	0.2	0.5	0.1	0.1	26.9	2.2	12.7	11.7	6.4	2.4	76.2	112.4	108.7	99.1	49.6	41.5	39.7	22.1	6.5	3.4	0.3	0.0	0.0	0.3	**623**
18	3.5	25.8	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	16.0	3.0	1.1	2.6	9.6	4.8	2.6	0.0	0.0	0.8	0.1	4.4	0.0	**91**
19	0.1	1.5	0.0	0.1	0.1	5.0	41.6	40.3	3.8	0.0	0.0	0.1	0.5	0.5	26.3	241.0	18.4	15.4	18.1	4.9	0.5	0.0	0.0	0.3	**418**
20	0.5	0.0	0.0	0.3	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.5	1.0	0.9	1.0	1.9	1.4	0.7	0.0	0.0	4.3	0.7	1.6	0.2	**15**
21	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.1	3.3	0.4	4.0	0.5	8.6	6.2	3.1	0.8	**28**
22	0.9	0.7	0.0	0.0	0.2	0.5	1.5	0.0	0.0	0.0	0.0	0.2	0.1	2.7	13.5	31.5	26.1	9.7	26.1	42.3	25.5	65.7	197.7	262.6	**707**
23	212.3	133.9	29.3	17.6	1.4	0.5	0.1	1.8	0.0	0.0	0.0	0.9	1.0	1.1	4.6	1.7	1.6	1.8	5.3	0.0	8.8	0.3	5.1	0.1	**429**
24	0.2	0.7	20.0	238.3	223.2	222.1	63.1	1.3	0.1	0.1	0.5	0.0	0.7	0.1	0.5	0.9	53.7	229.3	128.4	15.4	10.2	0.1	0.0	0.0	**1209**
25	0.0	0.0	0.5	0.0	0.3	0.4	0.0	0.0	0.1	0.1	0.0	0.0	0.1	1.9	2.6	9.2	5.9	1.1	4.4	8.8	1.0	0.4	0.8	0.0	**38**
26	0.0	0.0	0.0	1.0	0.4	0.2	1.4	2.4	0.0	0.0	0.1	0.5	0.1	0.7	1.9	0.4	2.9	3.0	0.1	1.1	1.0	0.1	0.0	0.1	**17**
27	0.8	0.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.1	0.0	1.1	1.1	11.3	9.5	2.9	3.1	0.0	0.3	0.6	3.5	1.4	0.0	0.0	**36**
28	0.0	0.1	0.0	0.0	0.5	0.9	0.7	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.0	9.2	29.3	15.4	2.9	7.8	4.1	0.0	0.0	0.0	**72**
29	0.2	0.9	0.1	0.5	1.4	0.0	0.2	0.9	0.1	0.0	0.0	0.0	0.5	2.6	1.3	2.5	29.0	146.7	239.6	247.6	84.5	56.3	127.7	210.3	**1153**
30	40.6	1.0	4.7	17.4	3.3	0.5	2.4	0.5	0.2	0.1	0.0	0.0	0.0	1.0	0.8	1.4	8.0	28.9	0.7	0.5	0.8	12.2	167.6	236.7	**529**
KWh	**298**	**266**	**294**	**644**	**473**	**462**	**440**	**258**	**26**	**21**	**147**	**195**	**129**	**161**	**190**	**455**	**314**	**515**	**446**	**347**	**164**	**161**	**513**	**714**	**7637**

Khungipayan **May 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	238.0	286.0	359.7	334.6	236.4	48.3	33.0	4.2	0.4	1.7	0.1	0.0	0.1	0.0	0.2	0.8	0.5	0.1	0.1	2.7	0.8	1.7	0.0	0.1	**1549**
2	0.5	0.1	1.4	0.0	0.1	0.4	0.2	0.0	0.3	0.0	0.0	0.5	0.1	0.1	3.4	1.7	1.9	8.0	9.5	1.7	3.9	1.4	1.0	0.0	**36**
3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	11.2	40.6	25.3	34.9	38.8	32.5	22.8	27.3	11.6	5.1	1.5	67.1	369.9	322.6	**1012**
4	54.3	43.3	49.6	71.9	4.1	0.5	0.5	0.7	0.8	6.5	0.4	0.0	2.0	15.6	25.8	6.2	18.8	69.4	2.3	95.7	159.9	205.0	288.8	246.9	**1369**
5	155.3	18.1	6.3	0.1	0.0	0.5	0.1	2.8	0.0	0.0	0.0	0.0	0.8	0.4	2.4	2.8	2.7	1.1	0.8	2.0	0.3	0.3	0.0	0.0	**197**
6	0.0	0.1	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.6	0.5	0.7	3.7	3.4	3.4	5.0	0.1	0.0	**19**
7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.7	0.3	5.3	11.3	9.3	3.0	46.1	21.0	3.9	13.8	7.1	80.5	140.8	**344**
8	269.0	194.3	153.8	179.0	95.1	111.6	129.8	52.3	68.5	0.1	0.0	0.0	0.0	0.1	16.6	3.5	87.9	406.2	351.1	278.4	226.3	148.8	190.9	238.1	**3201**
9	138.6	67.3	48.9	13.7	15.0	7.4	25.7	17.4	0.5	0.0	0.0	0.0	0.3	3.9	1.6	7.6	0.6	2.7	6.9	2.2	1.6	5.8	2.3	0.0	**370**
10	0.1	2.8	10.3	1.3	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	11.4	143.4	67.9	19.5	25.1	0.9	0.1	0.0	**283**
11	0.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.4	4.5	8.6	16.9	30.9	13.3	5.5	34.5	3.5	2.6	2.4	0.6	**126**
12	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3	0.9	9.0	6.0	10.8	67.8	33.3	28.2	5.6	0.0	0.5	0.0	2.0	**164**
13	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.5	0.5	2.0	0.7	7.8	13.0	10.3	6.6	4.0	1.6	2.1	0.7	**50**
14	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	7.2	14.5	19.1	3.5	1.4	2.6	4.9	4.8	3.3	0.6	2.9	5.8	4.6	**75**
15	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.2	1.0	3.7	17.1	54.2	7.9	2.7	0.7	0.2	68.7	154.0	**311**
16	78.4	99.9	99.4	111.7	19.0	1.8	6.4	7.3	0.1	1.3	1.1	2.0	5.5	9.3	30.3	25.4	25.3	38.1	16.8	7.3	101.1	182.1	77.0	21.7	**968**
17	18.4	73.2	8.9	0.1	1.0	0.3	0.8	0.0	2.5	0.0	0.0	0.0	0.5	1.8	1.1	1.3	0.7	0.4	6.9	2.8	0.7	2.2	2.8	0.0	**127**
18	0.0	0.0	0.0	0.0	0.3	0.5	0.7	0.0	0.0	0.0	0.1	0.4	12.6	48.3	73.1	228.8	104.6	73.8	103.3	9.6	0.7	57.5	4.6	0.7	**719**
19	1.9	1.4	0.0	0.0	2.5	0.0	0.0	0.0	0.2	0.0	0.1	1.0	1.7	0.3	2.6	12.2	7.9	204.5	254.3	574.9	472.2	207.3	265.0	8.5	**2018**
20	31.5	70.5	211.1	122.4	34.8	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.9	2.1	3.1	0.3	2.1	0.9	55.5	131.2	266.6	256.3	317.6	**1508**
21	317.6	122.6	37.6	15.7	19.5	21.3	3.1	13.8	0.5	0.0	0.0	0.1	0.9	1.0	5.0	34.7	56.8	97.5	272.0	155.8	89.1	52.0	5.7	15.3	**1337**
22	28.8	30.7	4.5	0.0	0.1	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.5	1.4	2.6	63.9	283.2	58.4	86.2	214.9	115.4	65.8	50.4	20.8	**1029**
23	15.2	27.3	0.7	0.1	0.1	0.1	0.7	0.1	0.1	0.0	0.0	0.1	4.7	28.3	38.7	38.9	2.8	266.8	88.7	207.1	135.2	93.6	228.1	291.6	**1469**
24	257.0	85.3	14.0	21.1	7.1	9.3	13.4	16.1	6.8	4.9	0.0	0.0	0.1	2.0	0.6	0.2	31.4	64.4	113.1	345.5	405.3	57.2	4.8	0.7	**1460**
25	4.3	0.9	0.0	0.8	2.8	0.5	1.8	0.2	0.2	31.7	34.5	147.1	180.8	79.4	54.1	76.9	196.6	165.7	10.2	0.1	31.0	88.6	154.9	142.6	**1406**
26	194.5	173.2	29.9	15.1	0.0	3.1	0.3	26.5	11.7	3.6	4.7	16.2	54.3	51.2	6.1	141.3	206.9	114.7	2.6	1.0	0.3	0.0	0.0	0.0	**1057**
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	2.7	2.1	2.4	14.8	18.2	31.6	6.8	0.3	7.5	47.9	166.8	112.5	**414**
28	44.1	60.1	69.7	4.6	5.8	3.6	0.3	2.5	0.3	0.0	2.2	24.9	20.1	19.5	20.2	98.5	77.2	4.0	0.3	0.0	0.0	0.0	0.1	0.0	**458**
29	3.0	0.1	3.8	24.4	9.1	3.7	3.7	21.2	8.0	1.4	1.6	0.0	0.0	3.8	31.5	40.1	67.8	52.1	55.1	6.4	9.7	0.2	0.0	0.0	**347**
30	0.2	0.7	0.0	0.2	0.1	0.1	0.6	0.1	0.0	0.0	0.0	0.1	3.8	12.6	25.9	32.5	235.4	308.9	158.4	67.8	2.2	1.0	7.5	2.3	**860**
31	17.8	9.2	15.6	22.7	2.8	1.3	0.0	0.0	0.1	0.0	0.0	0.1	0.3	2.8	4.6	2.5	0.3	10.5	9.9	2.1	0.0	4.4	3.1	0.6	**111**
KWh	**1869**	**1367**	**1125**	**939**	**457**	**216**	**222**	**165**	**102**	**51**	**56**	**242**	**335**	**358**	**422**	**915**	**1592**	**2317**	**1717**	**2118**	**1947**	**1577**	**2240**	**2045**	**24394**

Khungipayan June 2007 **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	1.4	7.4	2.6	1.1	2.9	0.1	0.0	0.5	0.0	0.0	0.0	0.0	1.1	0.9	1.6	10.8	17.0	19.0	6.7	109.4	368.8	229.1	542.6	421.6	1744
2	159.6	264.0	152.1	147.9	9.4	6.4	19.7	22.0	1.1	2.2	0.0	0.1	2.1	17.0	13.1	5.8	1.8	0.0	0.1	0.1	4.9	2.6	3.7	0.1	836
3	0.0	84.3	0.0	256.0	299.3	209.3	25.5	24.3	27.6	1.4	0.0	24.4	38.4	24.4	124.6	44.3	24.1	1.4	0.0	0.1	2.7	2.8	0.1	0.1	1215
4	0.0	1.9	0.3	3.1	0.0	1.0	0.1	0.0	0.0	0.0	2.8	26.9	16.5	12.6	16.1	5.4	1.8	2.8	4.8	11.4	1.1	19.1	9.7	1.9	139
5	28.4	90.6	26.3	46.3	38.4	12.3	14.0	17.4	9.6	0.5	0.0	0.0	0.3	0.9	0.5	1.2	20.2	35.2	36.9	8.8	37.1	85.3	91.5	7.6	609
6	4.3	1.6	2.9	8.5	0.0	0.1	0.0	0.0	1.2	0.0	0.1	1.7	3.1	19.8	32.2	4.5	0.4	26.1	49.8	123.1	72.2	63.8	90.8	182.8	689
7	100.3	85.7	14.4	14.8	21.4	23.8	34.1	1.9	6.0	3.1	0.1	0.0	0.0	0.0	0.0	0.1	0.8	0.0	0.0	0.4	0.8	0.0	0.0	1.1	309
8	1.5	0.4	0.1	1.1	0.8	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.5	0.9	0.7	0.4	0.1	0.0	2.1	12.3	4.2	17.3	4.9	48
9	0.0	0.1	1.3	0.2	2.2	1.7	0.4	0.1	0.0	0.3	0.0	0.1	0.0	0.3	0.1	0.2	0.9	0.6	0.0	6.2	12.3	17.2	3.1	7.6	55
10	6.0	0.3	1.2	0.9	0.7	1.4	2.2	1.6	0.4	0.0	0.0	0.0	0.0	0.2	0.0	1.0	7.1	6.9	5.9	3.0	18.9	3.8	1.0	2.2	65
11	10.0	0.1	0.5	0.1	0.7	0.6	0.5	0.0	0.0	0.4	0.0	0.4	0.5	26.5	25.8	7.7	10.6	7.4	20.2	2.2	4.9	1.8	2.5	0.2	124
12	0.7	0.0	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.0	1.6	0.3	10.8	41.2	17.7	20.7	2.6	0.3	0.0	0.3	101
13	0.3	0.2	9.7	1.6	0.0	0.0	0.0	0.3	0.1	0.0	0.0	1.4	3.6	21.4	39.4	78.7	78.4	60.4	32.9	12.2	1.7	0.0	0.3	0.7	343
14	0.0	0.0	0.1	2.3	0.5	4.3	10.9	1.4	0.3	12.7	10.9	9.7	15.9	23.1	46.2	40.8	46.8	40.2	38.2	12.5	85.3	68.3	13.3	27.0	511
15	49.2	58.6	32.1	13.2	50.4	34.9	2.0	0.1	0.1	1.6	18.6	31.1	92.3	177.1	174.4	93.9	122.1	87.7	23.4	0.0	0.0	0.0	0.0	0.0	1063
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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
KWh	361	595	245	497	427	296	110	70	46	22	32	96	174	327	476	295	343	329	237	312	626	498	776	658	7850