PAKISTAN METEOROLOGICAL DEPARTMENT

A STUDY OF WIND POWER POTENTIAL

AT

BESHAM-NWFP

Technical Report No. PMD-09/2008

(Preliminary Report based on 18 months data)

December-2008

Executive Summary

Pakistan Meteorological Department (PMD) conducted a wind power potential survey of the northern areas of Pakistan. Funding for this project was provided by the Ministry of Science & Technology. Under this wind data was collected at 42 sites along the Northern parts of the Country.

In this report the analysis based on *18 months* wind data has been presented along with the wind generated electric power at Besham. Wind data with ten minute average speed and direction were collected at 10 meters and 30 meters height and 50 meters values were computed from models.

At 50 meters we have the average wind speed of 4.64 m/s during Eighteen months *February-2007 to July-2008* the highest of 5.59 m/s is observed in October. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the night time through-out the whole period. Wind frequency distribution shows that during 32% of the time wind speed is above 5 m/s.

Sometimes simply wind speed averages do not give the true picture of the wind power optional of an area. For the purpose it is common to assign areas to one of the seven wind classes based on "Wind Power Density" of the area. Monthly and annual wind power density has been computed and added in the report. The average power density of Besham at 50m is **131.48** w/m^2 according to international wind classification, this power density categorize Besham as a below marginal site for wind power generation.

Wind generated electric power has also been computed on hypothetical 600KW wind turbine and its hourly, monthly and annual values has been added in this report. The total power production from a single 600kw wind turbine come out to 668,587 KWh which shows the capacity factor of 13% for Besham. 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 Besham 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 wind mapping sities (Phase-II) map. The list of stations is given below:

Besham, Bahrain, Kalam, Khawazakhaila, Malamjabba, Tahash, Fatehpur, 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, owaramaina, Ramatkore, ShahidaSir, Danakool, Besham, Moorti Pahari, Rangla, Pedar, Lempiapatian, Dargai.

Besham is situated in District Shangla (NWFP). Latitude & Longitude of Besham is:
Lat = 34.99°, Long = 72.76°, Elevation = 2425 Ft.

2.2 Data source:

To undertake this study 30-meter high towers are erected at the locations mentioned above. On each of these high towers two wind speed anemometers are installed at the height of 10 meters and 30 meters, respectively; wind vane for recording wind direction is installed at 30 meters height. Temperature sensors are also installed at 10 meters height. NRG Automatic data loggers have been installed to record data at each site. These data loggers are recording, ten-minute average wind speed at both level, ten-minute average wind direction and 10-minute average minimum and maximum wind speed. While selecting the above-mentioned locations for wind monitoring; the main objective was to identify potentially windy areas that also possess other desirable qualities of wind energy developed site. Further following guidelines as far as possible were also kept in mind while choosing an exact location for monitoring towers.

- Towers are placed as for as possible away from the local obstruction to the wind
- Selected location should be representative of the majority of the site.

Since sating a tower near obstructions such as trees or building can adversely affect the analysis of the site's wind characteristics such as magnitude of wind resource, wind shear and turbulence levels the tower in most cases are placed as for as possible away from local obstructions to the wind. But where this rule could not be followed, the tower was placed at horizontal distance of 10 times the height of the obstruction in the prevailing wind direction as required internationally. The following parameters have been recorded during the study.

i. Wind speed ten minute average at 10 & 30 meters
ii. Maximum wind speeds during 10 minutes
iii. Minimum wind speeds during 10 minutes
iv. Wind direction ten minutes average at 30 meters

Every month a team of observers and Maintenance Engineers visit site to inspect the instruments and to download the data on a laptop. Finally, the data is compiled and analyzed at Renewable Energy Research Cell established at Meteorological Department Islamabad.

3.0 Methodology; Analysis & Discussion:

3.1 Wind speed variation with height:

Wind speed tends to increase with height in most locations, a phenomenon known as wind shear. The degree of wind shear depends mainly upon on two factors, atmospheric mixing and the roughness of the terrain.

Atmospheric mixing typically follows a daily cycle driven by solar heating. At the hub height of a wind turbine, this cycle often causes wind speeds to increase in the daytime and decrease at night. However, the range of variation between night and day typically diminishes as hub height increases. At a height of approximately 50 meters, it weakens or may even disappear in some cases.

Terrain roughness also affects wind shear by determining how much the wind is slowed near the ground. In areas with a high degree of roughness, such as forests or cities, near- surface wind speeds tend to be low and wind shear high, whereas the converse is true in areas of low roughness such as flat, open fields. Wind shear may be greatly reduced or eliminated where there is an abrupt change in terrain height such as a sea cliff or mountain ridge.

To save money wind measurements sometimes are taken at a lower height than the wind turbine tower. In that case, it is essential to measure wind shear at different times of day in different seasons to accurately predict the performance of a wind power plant. The shear can be measured by monitoring wind speeds at two or three heights on a tower. Since wind turbines produce much more power in stronger winds, wind turbine designers try to put turbines on the tallest possible towers. At some point, however, the increased cost of towers outweighs the benefits. With current wind turbine technology, the optimum tower height for large wind machines appears to be approximately 40 to 50 meters.

For calculating the wind speed at 50 meters the following two methods has been used in this study.

3.1.1 *Log Law:*

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

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

Where

u_* is the friction notify

k is the von Karman constant

$\mathbf{Z_o}$ 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

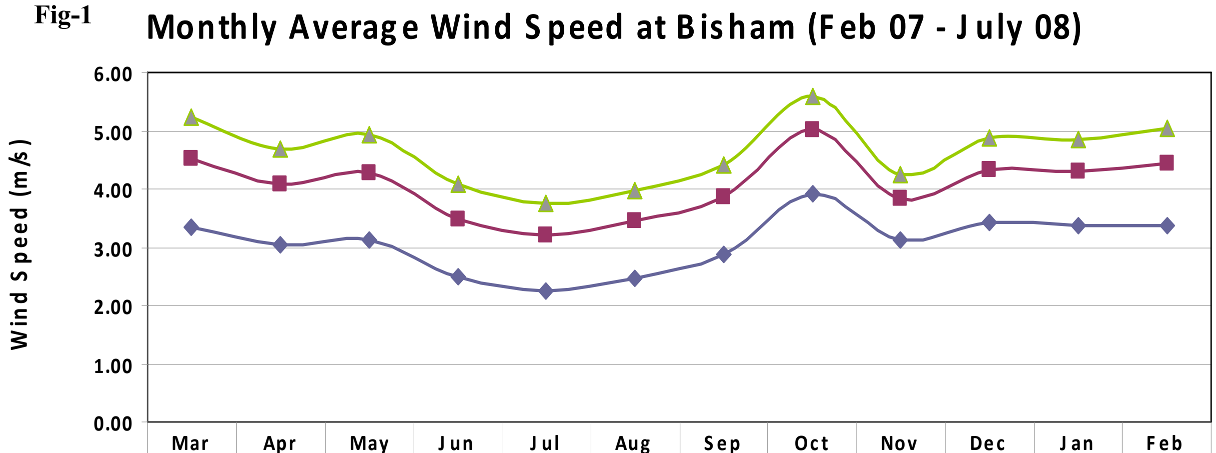
Type of terrain	**Z_0**	**α**
Mud Flats, Ice	10^{-5} to 3x 10^{-5}	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	1 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 average wind speed of 4.07 m/s from February-2007 to July-2008 where as maximum average wind speed of 5.00 m/s at this height is during October. At 50 meters we have the average wind speed of 4.64 m/s from February-2007 to July-2008.

Fig-1



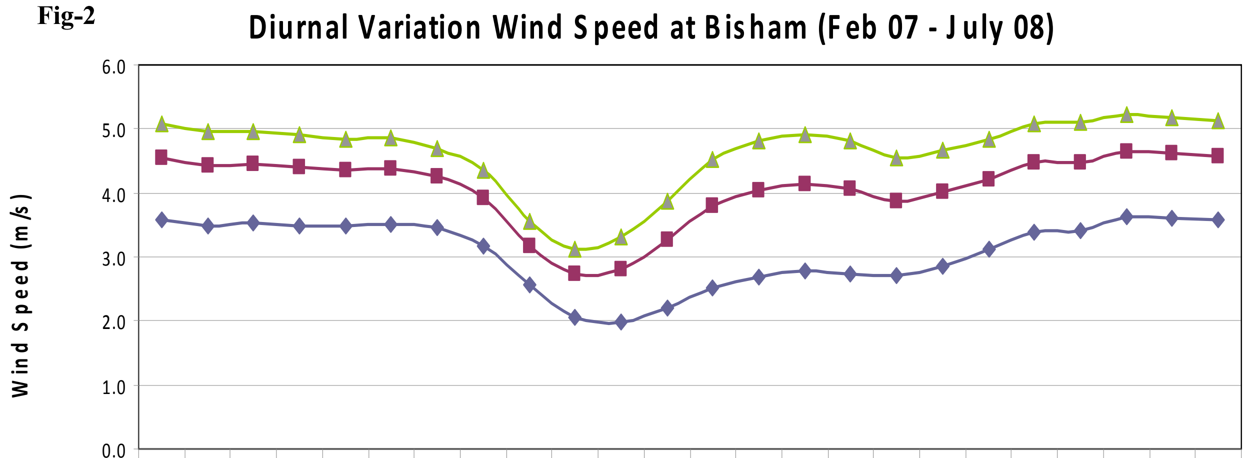
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AWS 10m	3.33	3.05	3.12	2.50	2.25	2.47	2.86	3.90	3.13	3.42	3.37	3.37
AWS 30m	4.53	4.08	4.26	3.49	3.20	3.45	3.87	5.00	3.84	4.34	4.31	4.43
AWS 50m	5.23	4.68	4.92	4.07	3.75	3.98	4.42	5.59	4.24	4.87	4.86	5.05

Months

3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Besham for 18 months (Feb-2007 to July-2008). The wind speed is generally lower during morning and in the noon it starts picking up and reaches maximum around 9 p.m. which is around 4.6 m/s and 5.2 m/s at 30 meters and 50 meters height respectively. Figure-2 shows that the maximum wind speed during night times at 50 meters height reaches to 5.2 m/s at 8 p.m.

Fig-2

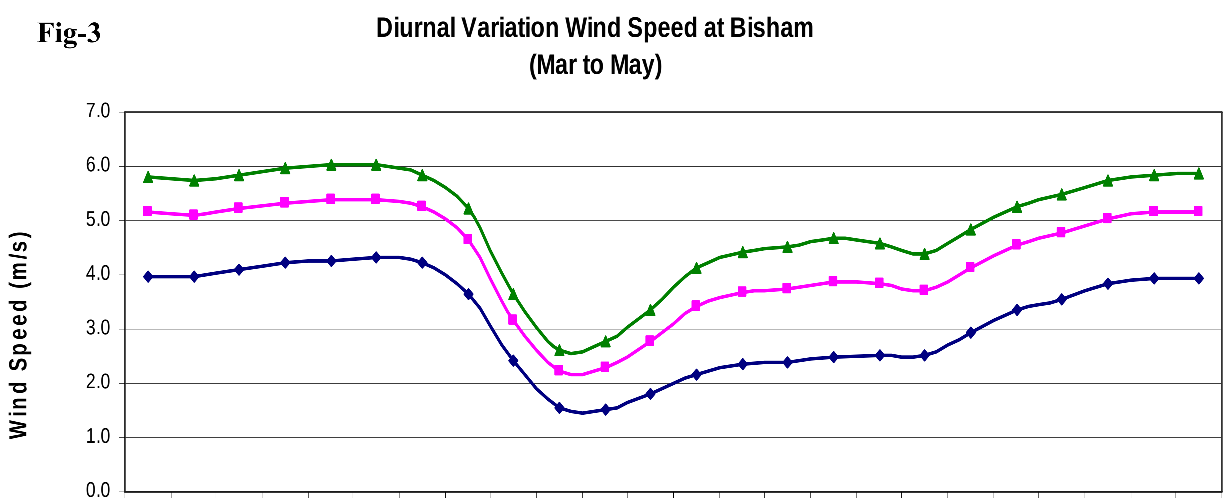


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	3.6	3.5	3.5	3.5	3.5	3.5	3.5	3.2	2.6	2.1	2.0	2.2	2.5	2.7	2.8	2.7	2.7	2.9	3.1	3.4	3.4	3.6	3.6	3.6
WS 30m	4.5	4.4	4.5	4.4	4.4	4.4	4.3	3.9	3.2	2.7	2.8	3.3	3.8	4.0	4.1	4.1	3.9	4.0	4.2	4.5	4.5	4.6	4.6	4.6
WS 50m	5.1	5.0	5.0	4.9	4.8	4.9	4.7	4.3	3.6	3.1	3.3	3.9	4.5	4.8	4.9	4.8	4.6	4.7	4.8	5.1	5.1	5.2	5.2	5.1

PST (Hours)

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

Fig-3

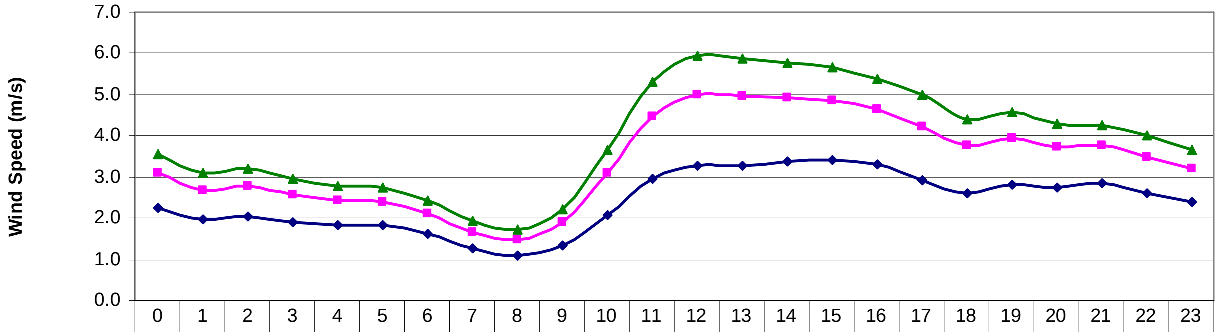


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	4.0	4.0	4.1	4.2	4.3	4.3	4.2	3.7	2.4	1.6	1.5	1.8	2.2	2.4	2.4	2.5	2.5	2.5	3.0	3.4	3.6	3.8	3.9	3.9
WS 30m	5.1	5.1	5.2	5.3	5.4	5.4	5.3	4.6	3.2	2.2	2.3	2.8	3.4	3.7	3.7	3.9	3.8	3.7	4.1	4.5	4.8	5.0	5.2	5.2
WS 50m	5.8	5.7	5.8	6.0	6.0	6.0	5.8	5.2	3.6	2.6	2.8	3.4	4.1	4.4	4.5	4.7	4.6	4.4	4.8	5.3	5.5	5.7	5.9	5.9

PST (Hours)

Fig-4

Diurnal Variation Wind Speed at Bisham (Jun to Aug)

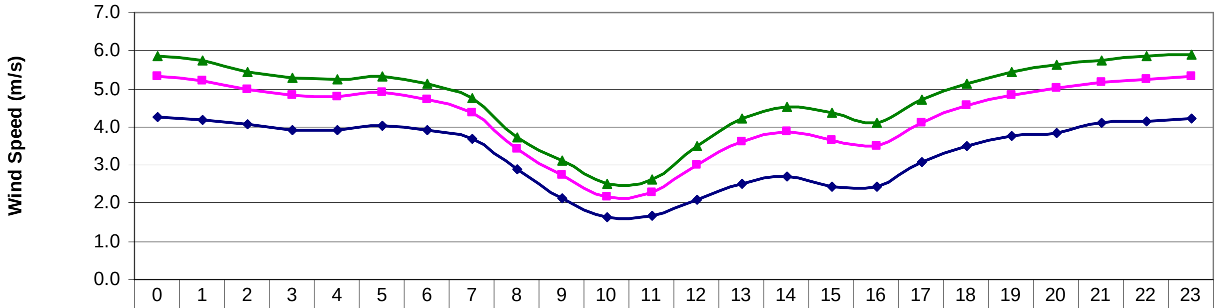


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	2.3	2.0	2.0	1.9	1.8	1.8	1.6	1.3	1.1	1.3	2.1	3.0	3.3	3.3	3.4	3.4	3.3	2.9	2.6	2.8	2.8	2.9	2.6	2.4
WS 30m	3.1	2.7	2.8	2.6	2.4	2.4	2.1	1.7	1.5	1.9	3.1	4.5	5.0	4.9	4.9	4.9	4.6	4.2	3.7	3.9	3.7	3.7	3.5	3.2
WS 50m	3.6	3.1	3.2	2.9	2.8	2.7	2.4	1.9	1.7	2.2	3.7	5.3	5.9	5.9	5.8	5.7	5.4	5.0	4.4	4.6	4.3	4.3	4.0	3.7

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Bisham (Sep to Nov)

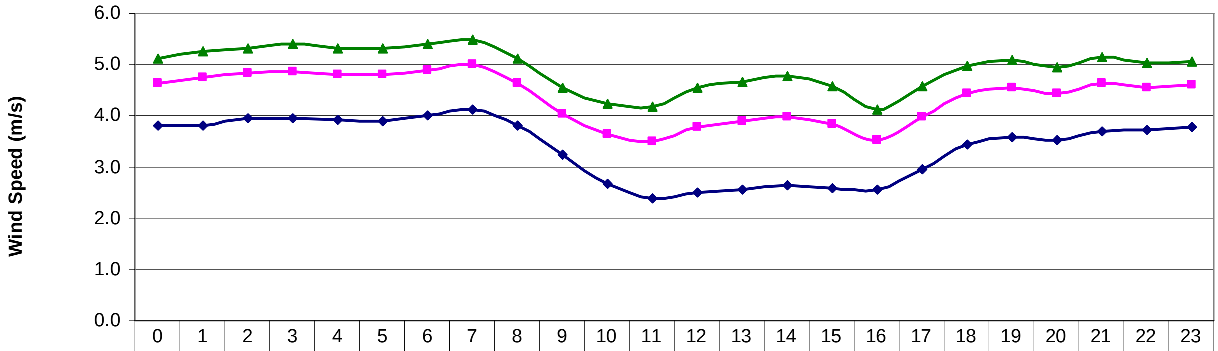


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	4.2	4.2	4.1	3.9	3.9	4.0	3.9	3.7	2.9	2.1	1.6	1.7	2.1	2.5	2.7	2.5	2.5	3.1	3.5	3.8	3.9	4.1	4.2	4.2
WS 30m	5.3	5.2	5.0	4.8	4.8	4.9	4.7	4.4	3.4	2.7	2.2	2.3	3.0	3.6	3.9	3.7	3.5	4.1	4.6	4.9	5.0	5.2	5.3	5.3
WS 50m	5.9	5.7	5.4	5.3	5.3	5.3	5.1	4.8	3.7	3.1	2.5	2.6	3.5	4.2	4.5	4.4	4.1	4.7	5.1	5.5	5.6	5.7	5.8	5.9

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Bisham (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	3.8	3.8	4.0	4.0	3.9	3.9	4.0	4.1	3.8	3.2	2.7	2.4	2.5	2.5	2.6	2.6	2.6	3.0	3.4	3.6	3.5	3.7	3.7	3.8
WS 30m	4.6	4.7	4.8	4.9	4.8	4.8	4.9	5.0	4.6	4.0	3.6	3.5	3.8	3.9	4.0	3.9	3.5	4.0	4.4	4.6	4.5	4.6	4.6	4.6
WS 50m	5.1	5.3	5.3	5.4	5.3	5.3	5.4	5.5	5.1	4.5	4.2	4.2	4.6	4.7	4.8	4.6	4.1	4.6	5.0	5.1	5.0	5.1	5.0	5.1

PST (Hours)

3.4 Wind speed Frequency Distribution:

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

3.4.1 *Binning of Data:*

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

3.4.2 *Relative Frequency:*

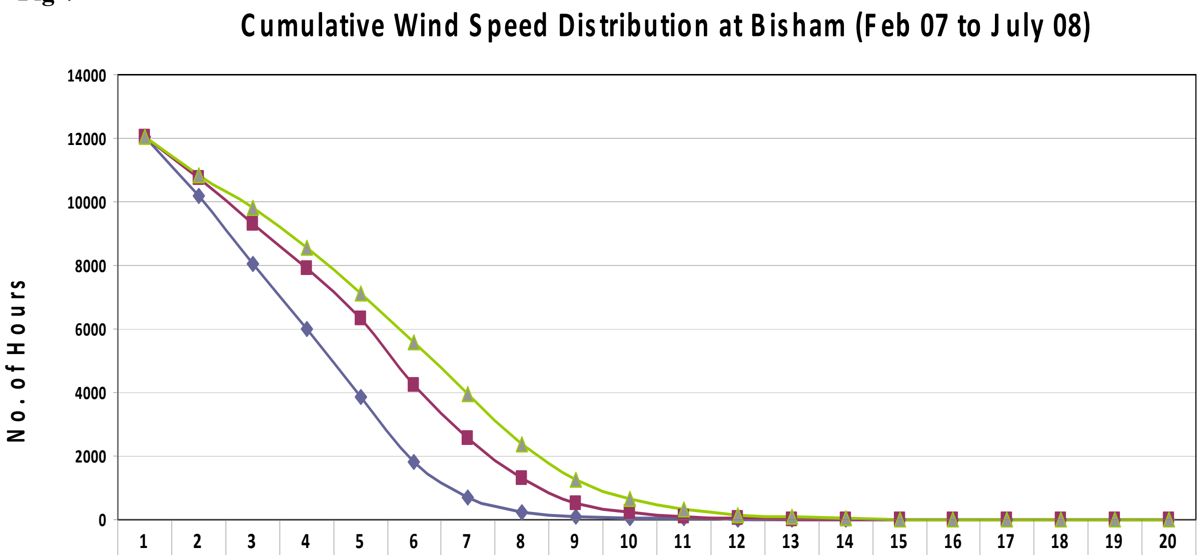
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as

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

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-7 shows the Cumulative Wind Frequency distribution from February 2007 to July 2008 at three heights 10, 30 and 50 meters. The analysis indicate that at a height of 30 meters during 6344 hours the wind speed is greater than or equal to 5 m/s. Whereas at 50 meters, during 7129 hours the wind speed is equal or greater than 5m/s.

Fig-7



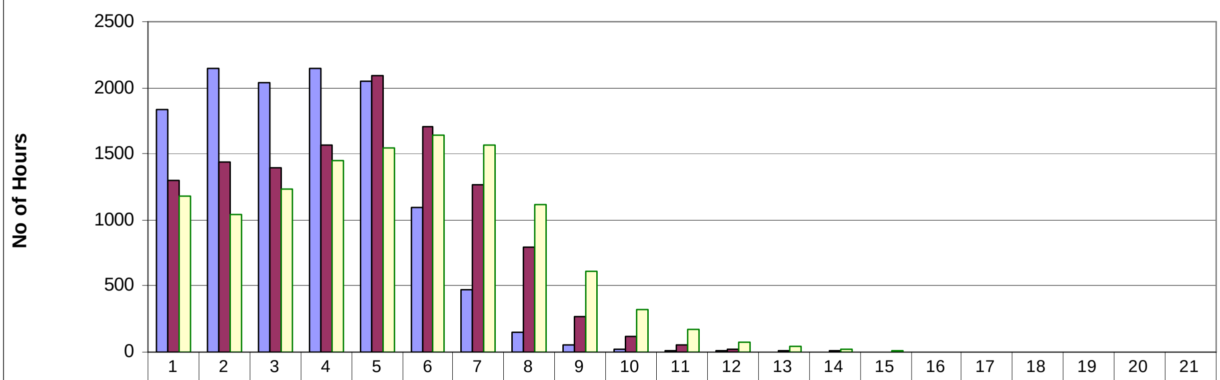
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS 10m	12032	10194	8048	6007	3857	1809	719	250	102	49	25	12	3	0	0	0	0	0	0	0
CWS 30m	12032	10733	9297	7907	6344	4254	2550	1286	491	219	104	48	23	11	3	0	0	0	0	0
CWS 50m	12032	10855	9814	8578	7129	5583	3936	2368	1253	645	329	154	77	39	18	7	2	1	1	0

Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the frequency distribution. We can see that at 50 meters during 1546 hours wind speed is 5 m/s, 1647 hours speed is 6 m/s, 1569 hours speed is 7 m/s, 1115 hours speed is 8 m/s and during 607 hours the wind speed is 9m/s and so on. This indicates wind potential in this area.

Fig-8 **Wind Frequency Distribution at Bisham (Feb 07 - July 08)**

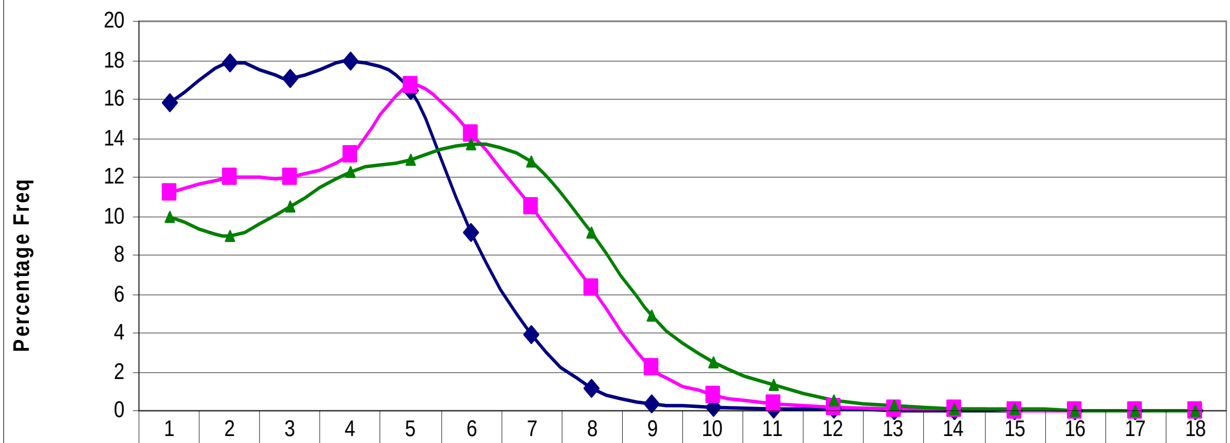


Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	1839	2146	2041	2150	2049	1090	469	148	53	25	12	9	2	0	0	0	0	0	0	0	0
CWS 30m	1299	1436	1391	1563	2090	1704	1264	795	272	115	56	25	12	8	2	0	0	0	0	0	0
CWS 50m	1177	1041	1235	1449	1546	1647	1569	1115	607	317	175	77	38	20	11	5	1	1	0	0	0

Wind Speed (m/s)

Fig-9 gives this frequency distribution in percentage from Feb-2007 to July-2008. At 50 meters we find that during 12.9% of time wind is 5m/s, 13.7% of the time 6m/s and 12.8% of the time it is 7m/s. whereas at 30 meters height we get 16.7% of the time wind speed 5m/s, 14.3% of the times 6m/s and 10.5% of the time 7m/s.

Fig-9 **Percenatge Wind Frequency Distribution at Bisham (Feb 07 to July 08)**



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	15.8	17.9	17.1	17.9	16.4	9.1	3.9	1.2	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	11.2	12.0	12.0	13.2	16.7	14.3	10.5	6.4	2.2	0.8	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0
WS 50m	10.0	9.0	10.5	12.3	12.9	13.7	12.8	9.2	4.9	2.5	1.3	0.5	0.3	0.1	0.1	0.0	0.0	0.0

Wind Speed (m/s)

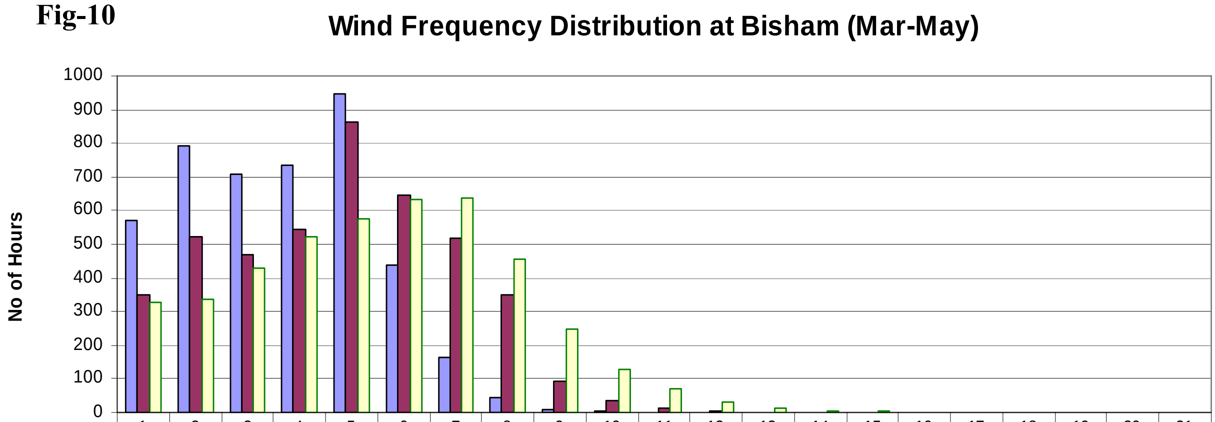
3.4.5 ***Seasonal Wind Frequency Distribution:***

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

<u>March - May</u>

Fig-10 shows frequency distribution during the months of March to May. We can see that in this period at 30 meters and 50 meters height during 865 hours and 574 hours we get 5m/s respectively.

Fig-10

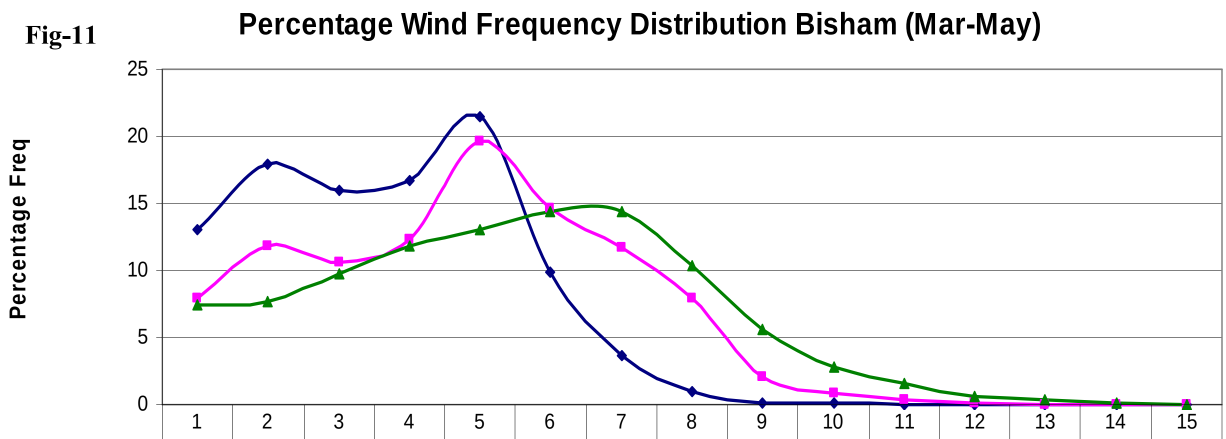


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	572	793	706	736	948	438	163	46	8	3	1	1	0	0	0	0	0	0	0	0	0
WS 30m	350	520	468	544	865	648	517	349	94	37	14	7	2	0	0	0	0	0	0	0	0
WS 50m	328	338	428	522	574	633	636	455	248	127	70	29	14	6	2	2	1	0	0	0	0

Wind Speed (m/s)

Similarly in Fig-11 shows percentage frequency distribution. At 50 meters we get 13.0% of wind equal to 5m/s, 14.3% of wind equal to 6 m/s and at 30 meter 19.6% wind equal to 5m/s, 14.7% wind equal to 6 m/s respectively.

Fig-11



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	13.0	18.0	16.0	16.7	21.5	9.9	3.7	1.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	8.0	11.8	10.6	12.3	19.6	14.7	11.7	7.9	2.1	0.8	0.3	0.1	0.0	0.0	0.0
WS 50m	7.5	7.7	9.7	11.8	13.0	14.3	14.4	10.3	5.6	2.9	1.6	0.7	0.3	0.1	0.1

Wind Speed (m/s)

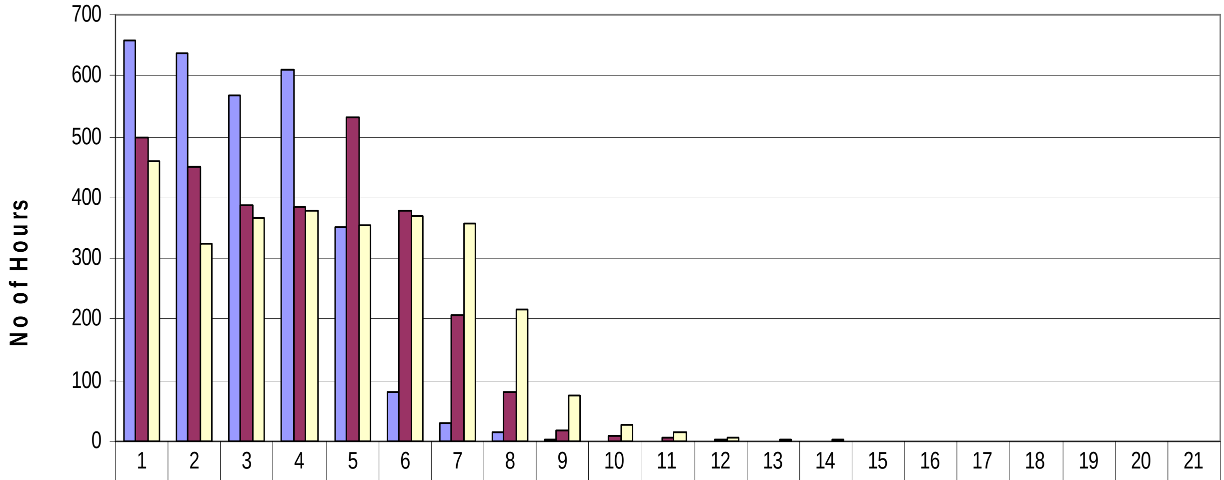
<u>June - August</u>

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 531 hours we get 5m/s, similarly at 50 meters height during 355 hours we get wind speed of 5m/s.

Fig-13 shows percentage distribution of wind frequency during the months of June to August. It shows that 16.9% and 11.7% we get wind speed of 5m/s at 30m and 50m respectively.

Fig-12

Wind Frequency Distribution at Bisham (Jun-Aug)

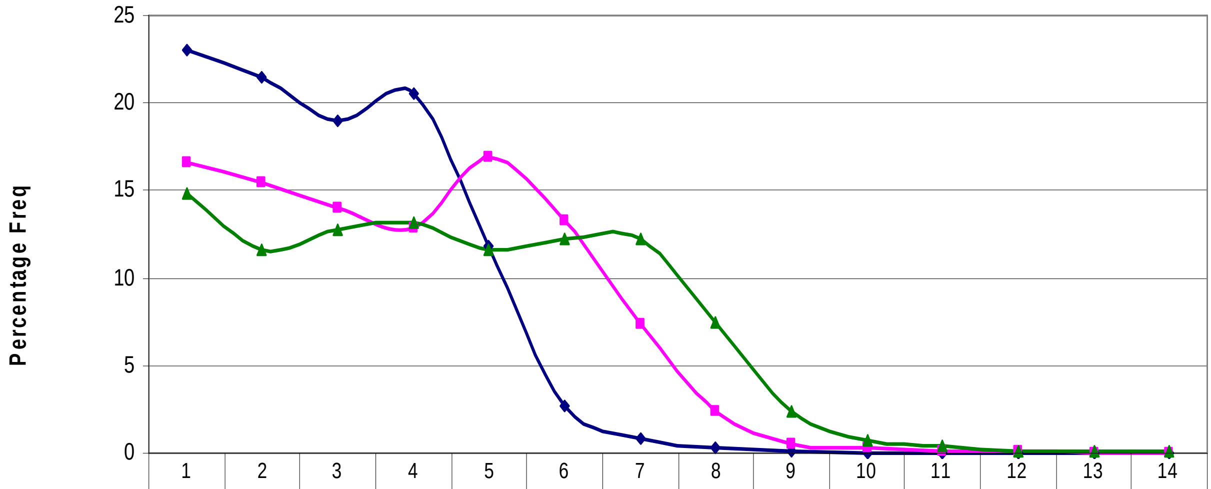


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	659	638	567	609	351	81	31	14	3	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	499	449	387	384	531	380	206	81	18	10	5	3	1	1	1	0	0	0	0	0	0
WS 50m	458	325	365	377	355	369	356	215	76	27	14	6	4	2	1	1	1	0	0	0	0

Wind Speed (m/s)

Fig-13

Percentage Wind Frequency Distribution at Bisham (Jun-Aug)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	23.1	21.5	19.0	20.5	11.8	2.7	0.9	0.4	0.1	0.0	0.0	0.0	0.0	0.0
WS 30m	16.6	15.5	14.0	12.9	16.9	13.3	7.3	2.4	0.5	0.3	0.1	0.1	0.0	0.0
WS 50m	14.9	11.7	12.7	13.1	11.7	12.3	12.2	7.5	2.4	0.7	0.4	0.2	0.1	0.1

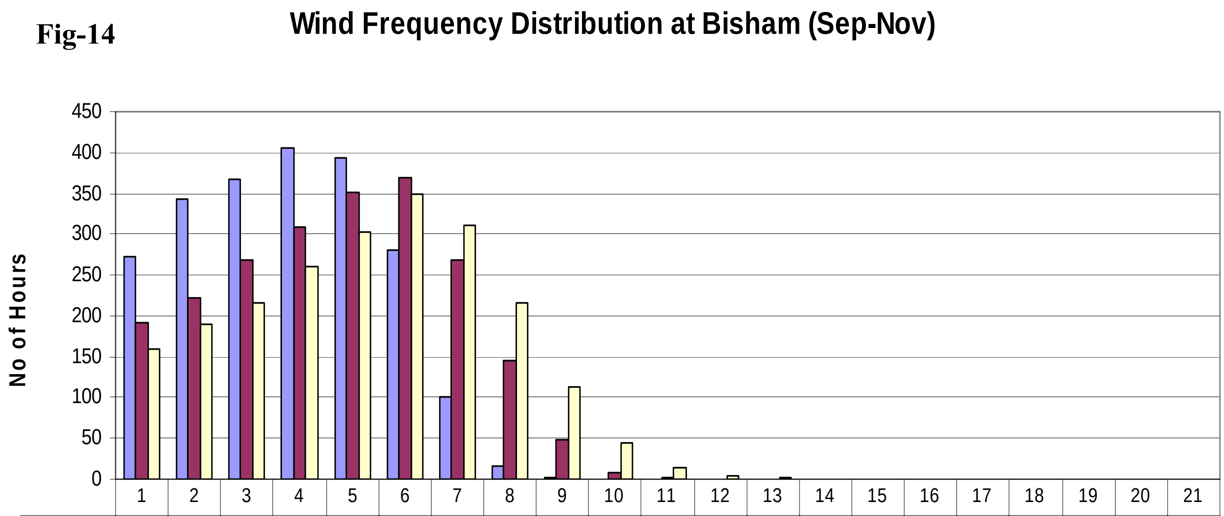
Wind Speed (m/s)

September - November

Fig-14 shows wind frequency distribution during the months of September to November. We can see that in this period at 30 meters height during 350 hours we get 5m/s, similarly at 50 meters height during 303 hours we get wind speed of 5m/s.

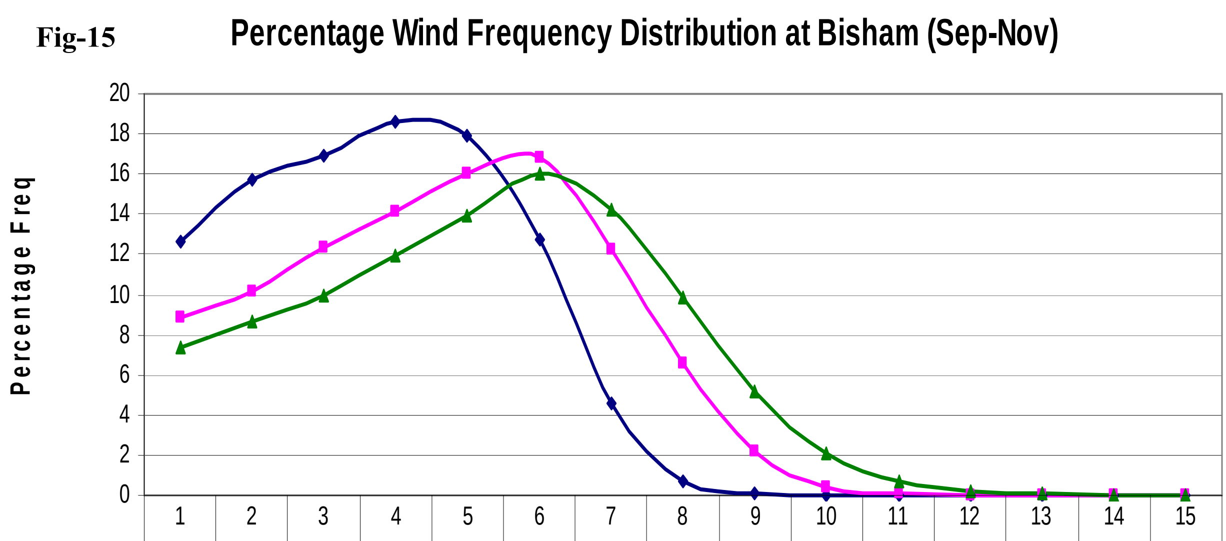
Fig-15 shows percentage distribution of wind frequency during the months of Sep to Nov. It shows that 16.1% and 13.9% we get wind speed of 5m/s at 30m and 50m respectively.

Fig-14



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	273	344	368	406	393	280	102	16	2	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	192	222	268	309	350	368	268	145	49	9	3	0	0	0	0	0	0	0	0	0	0
WS 50m	160	189	216	260	303	349	311	216	114	45	15	4	1	1	0	0	0	0	0	0	0

Fig-15



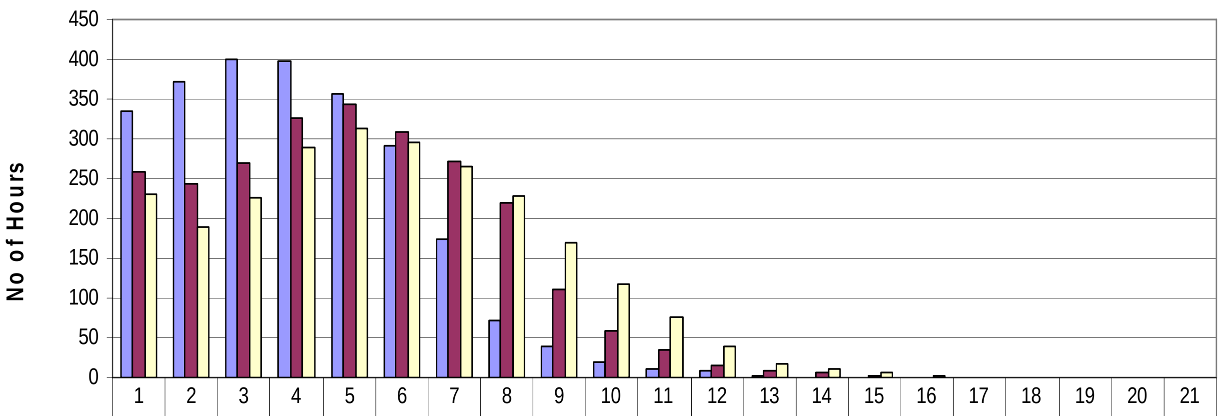
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	12.6	15.8	16.9	18.6	17.9	12.7	4.6	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	8.9	10.2	12.3	14.2	16.1	16.8	12.2	6.6	2.2	0.4	0.1	0.0	0.0	0.0	0.0
WS 50m	7.4	8.7	9.9	11.9	13.9	16.0	14.2	9.9	5.2	2.0	0.7	0.2	0.1	0.0	0.0

December – February

Fig-16 shows wind frequency distribution during the months of Dec to Feb. We can see that in this period at 30 meters height during 344 hours we get 5m/s, similarly at 50 meters height during 313 hours we get wind speed of 5m/s.

Fig-17 shows percentage distribution of wind frequency during the months of Dec to Feb. It shows that 14.3% and 13.0% we get wind speed of 5m/s at 30m and 50m respectively.

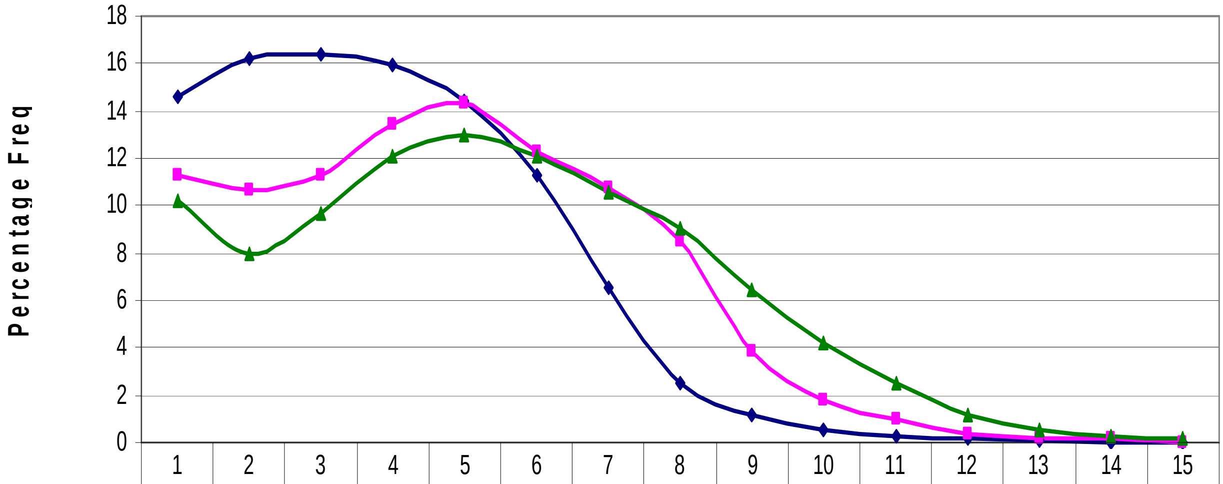
Fig-16 Wind Frequency Distribution at Bisham (Dec-Feb)



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	334	371	399	398	357	292	174	72	40	20	11	8	2	0	0	0	0	0	0	0	0
WS 30m	258	245	269	326	344	308	273	220	111	59	34	15	8	8	2	0	0	0	0	0	0
WS 50m	231	189	226	290	313	296	266	228	170	118	76	38	18	10	7	2	0	0	0	0	0

Wind Speed (m/s)

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



Wind Speed (m/s)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	14.6	16.2	16.4	16.0	14.4	11.3	6.5	2.5	1.1	0.5	0.3	0.2	0.0	0.0	0.0
WS 30m	11.3	10.7	11.3	13.4	14.3	12.2	10.7	8.5	3.9	1.8	1.0	0.4	0.2	0.2	0.0
WS 50m	10.2	8.0	9.7	12.1	13.0	12.1	10.5	9.0	6.5	4.2	2.5	1.2	0.5	0.3	0.2

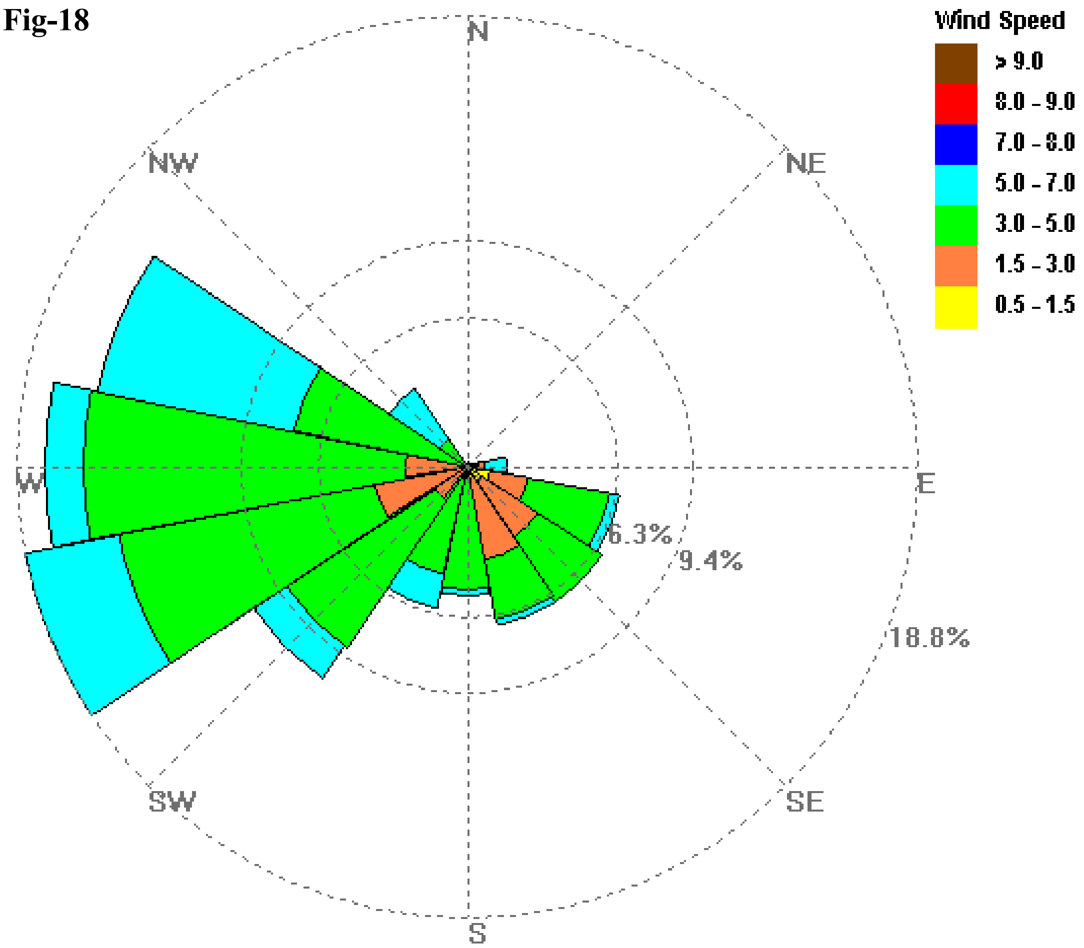
Wind Speed (m/s)

3.5 Wind Rose

Fig-18 shows the Wind Rose based on 18 months data from Feb-2007 to Jul-2008 collected at 30 meters height. Wind Rose indicates that most of the time the wind direction was West and South west. The annual average wind speed at 30 meter height is 4.07 m/s and the percentage when wind speed greater than 5m/s is 21%.

Wind Rose at Besham (30m height)

Fig-18



Average Wind Speed	Wind greater than 5 m/s
4.07 m/s	21%

3.6 Wind speed statistic:

3.6.1 *The statistical Mean:*

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

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

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

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

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

3.6.2 *Variance:*

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

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

Where V is mean of data set

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

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

3.6.3 *Standard Deviation*

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

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

3.7 Wind power density:

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

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

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

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

3.7.1 *Wind power classes:*

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

Table-2: International Wind Power Classification

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

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

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

A parcel of Wind possesses kinetic energy

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

From this, power density is calculated as

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

Where 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

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

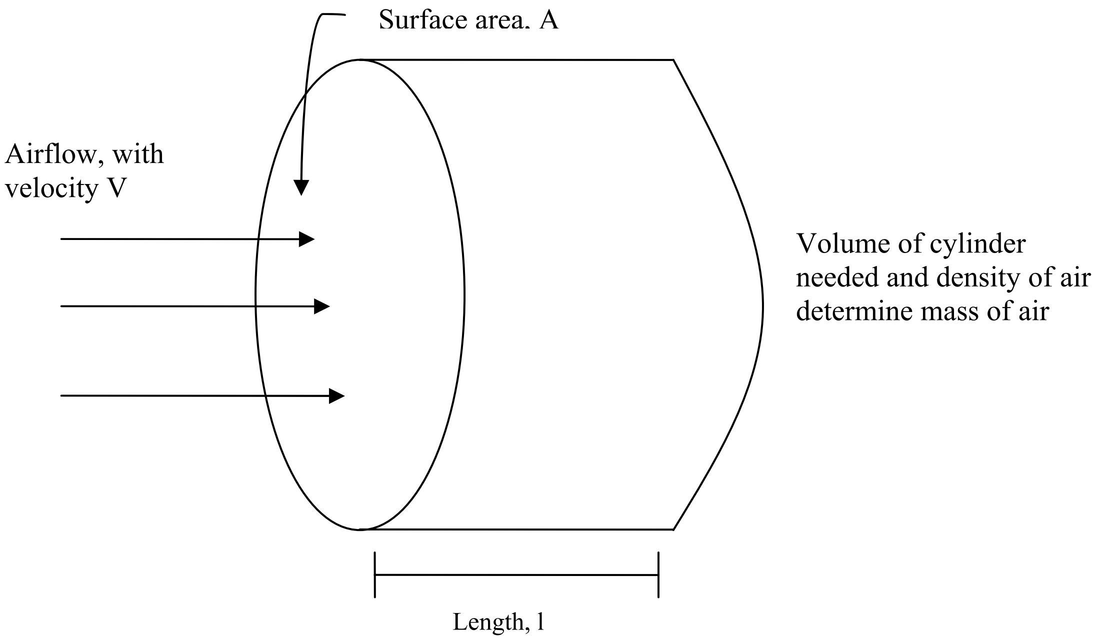
Now mass of wind can be written as

$$M = \varphi Avt$$

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

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

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

At 15° C, The area depends upon the size of the rotor. Therefore, it is clear that power density chiefly depends on wind velocity and goes up as a cube of it.

3.7.3 *Wind power calculation using Mean Wind Speed:*

Wind power calculated from Mean wind speed is not true representative of wind power. In real world, the wind varies constantly. Actual wind power density at most sites can rang from 1.0 to 3 times greater then that calculated. For example, we take wind speed of 5, 7 and 8 m/sec respectively the respective power densities are 76 wat/m^2, 210 watt/m^2 and 313 watt/m^2. The average of which is 200 watt/m^2. On the other hand, the average wind speed is 6.7 m/sec and power density of average wind is 181 watt/m^2. So the power of wind calculated by mean wind speed is less than the actual power present in wind i.e. Mean wind speed is not true representative for the wind power calculations.

To overcome this drawback we find some alternative arrangement, which reduces the deficit. The Weibull distribution is the best fit of wind data to calculate wind power based on mean wind speed and variance/standard deviation.

3.7.4 *Weibull distribution:*

The Weibull distribution (named after the Swedish physicist W. Weibull, who applied it when studying material strength in tension and fatigue in the 1930s) provides a close approximation to the probability laws of many natural phenomenons. It has been used to represent wind speed distribution for application in wind loads studies for sometime. In recent years most attention has been forced on this method for wind frequency applications not only due to its greater flexible and simplicity but also because it can give a good fit to experimental data.

The Weibull distribution function, which is a two-parameter function, has been found to fit much wind data with acceptable accuracy is expressed mathematically as

$$\phi(u) = \frac{k}{c}\left(\frac{u}{c}\right)^{k-1} \exp\left(-\left(\frac{u}{c}\right)^{k}\right)$$

Where:

u is the wind speed
c is the scale parameter with units of speed
k is the shape parameter and is dimensionless

When k = 2 the distribution reduces to Rayleigh distribution and if k=1 an exponential distribution is found. These are special cased of Weibull distribution.

Solving the equation, we find that the scale factor c is closely related to the mean wind speed for the site.

$$\overline{u} = c\tau\left(1 + \frac{1}{K}\right)$$

Where τ is the complete gamma function
Similarly

$$\overline{u^n} = c^n\tau\left(1 + \frac{n}{k}\right)$$

And so

$$\overline{u^3} = c^3\tau\left(1 + \frac{3}{k}\right)$$

The available power density is obtained:

$$E = \frac{1}{2}\varphi c^3\tau\left(1 + \frac{3}{k}\right)$$

Where

E is the power density in watts / m^2

The shape factor k is related to the variance of the wind

$$\sigma^2 = c2\left[\left(1+\frac{2}{k}\right)-\left(\tau\left(1+\frac{1}{k}\right)\right)^2\right]$$

The two Weibull parameters k and c may be derived from site data.

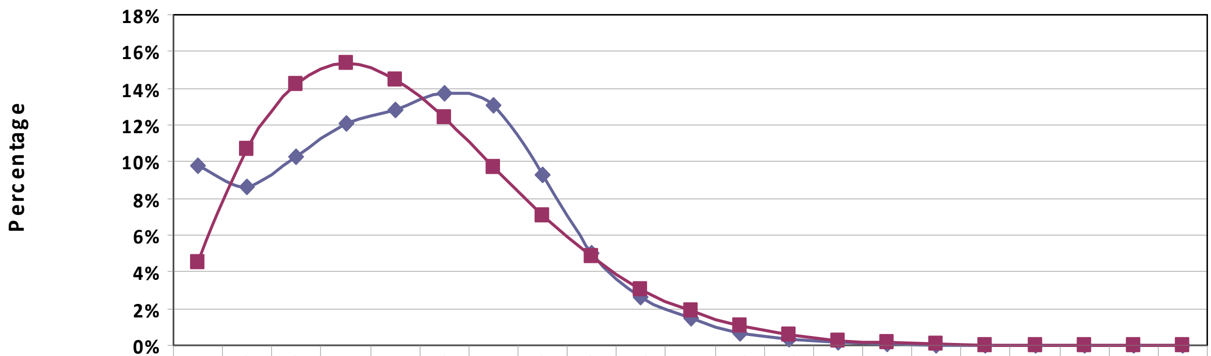
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion of wind does not contribute greatly to the overall power production.

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

3.7.5 *Weibull Parameters:*

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

Fig-19 **Relative Frequency and Weibull Probability at Bisham (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	9.8%	8.7%	10.3	12.0	12.8	13.7	13.0	9.3%	5.0%	2.6%	1.5%	0.6%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	4.5%	10.7	14.2	15.4	14.5	12.4	9.7%	7.1%	4.8%	3.1%	1.8%	1.0%	0.6%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Wind Speed (m/s)

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in **Table-3** along with other key results of analysis. If we look at the *shape parameters* K and *scale parameter* C for 50 meters height we can find that the shape parameter K varies over a wind range from the lowest of 1.57 during July to the highest of 2.56 during the month of October with an annual of K being 1.93

The lowest values of the scale parameter C 4.27 m/s observed in July while the highest value of 6.28 is obtained in October and with an annual value of 5.29 m/s.

3.7.6 *Average Wind Speed & Standard Deviation:*

In Table-3 monthly average wind speed and standard deviation at three different heights are also given. The average wind speed values for 10 meters and 30 meters height have been obtained from the recorded data, whereas the values for the 50 meters height have been computed by using the power law as explained in the earlier section.

At 10 meters height the average wind speed is 3.09 m/s with Standard deviation of 1.78, at 30 meters this average speed is 4.08 m/s with Standard deviation of 2.24.

At 50 meters the monthly average wind speed varies from the lowest of 3.84 m/s in July to highest of 5.59 m/s during February. Whereas the average wind speed is 4.69 m/s with Standard deviation of 2.57.

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 49.67 W/m^2 in January to 46.48 W/m^2 in December with Average of 41.45 W/m^2.

At 30 meters height the power density varies from 99.97 W/m^2 in January to 91.83 W/m^2 in December cand the average values is about 87.58 W/m^2.

At 50 meters height the power density of Besham varies from 147.79 W/m^2 in January to 132.91 W/m^2 in December. The average power density of the area is 131.48 W/m^2.

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

10 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m^2)**
January	3.33	1.96	3.76	1.78	**49.67**
February	3.81	2.57	4.31	1.53	**94.29**
March	3.34	1.86	3.77	1.89	**46.47**
April	3.05	1.81	3.42	1.76	**38.07**
May	3.13	1.62	3.53	2.04	**35.08**
June	2.52	1.60	2.82	1.64	**23.51**
July	2.35	1.51	2.62	1.62	**19.38**
August	2.43	1.50	2.72	1.68	**20.37**
September	2.81	1.58	3.16	1.87	**27.88**
October	3.86	1.70	4.35	2.43	**56.78**
November	3.07	1.84	3.45	1.74	**39.37**
December	3.37	1.84	3.80	1.93	**46.48**
Average	**3.09**	**1.78**	**3.48**	**1.83**	**41.45**
30 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m^2)**
January	4.26	2.43	4.82	1.84	**99.97**
February	4.92	3.05	5.56	1.68	**174.28**
March	4.51	2.31	5.09	2.07	**103.97**
April	4.06	2.24	4.57	1.91	**81.94**
May	4.25	2.09	4.80	2.16	**83.37**
June	3.50	2.14	3.92	1.71	**59.72**
July	3.26	2.13	3.64	1.59	**53.23**
August	3.41	2.04	3.83	1.75	**53.94**
September	3.81	2.05	4.30	1.96	**66.05**
October	4.95	2.09	5.57	2.55	**115.34**
November	3.78	2.11	4.26	1.88	**67.30**
December	4.29	2.25	4.84	2.01	**91.83**
Average	**4.08**	**2.24**	**4.60**	**1.93**	**87.58**
50 m					
	AvgV (m/s)	**St Dev**	**C (m/s)**	**K**	**P/A (w/m^2)**
January	4.85	2.77	5.48	1.84	**147.79**
February	5.59	3.39	6.27	1.72	**240.77**
March	5.25	2.71	5.93	2.05	**165.48**
April	4.69	2.60	5.29	1.90	**127.49**
May	4.94	2.47	5.58	2.12	**133.29**
June	4.10	2.53	4.63	1.69	**100.26**
July	3.84	2.53	4.27	1.57	**87.79**
August	4.00	2.36	4.50	1.77	**85.39**
September	4.40	2.35	4.96	1.98	**100.93**
October	5.58	2.35	6.28	2.56	**164.81**
November	4.23	2.29	4.77	1.95	**90.87**
December	4.86	2.54	5.49	2.02	**132.91**
Average	**4.69**	**2.57**	**5.29**	**1.93**	**131.48**

ESTIMATING WIND GENERATED ELECTRIC POWER OUTPUT

Appendix-I

Monthly Average Diurnal Variation of Wind Generated Electric Power Output.

Appendix-II

Hourly Wind Generated Electric Power Output

4.0 Estimating Wind Generated Electric Power Output

The average power output of wind energy conversion technologies (WECT) is a very important parameter since it determines the energy output over time thereby influencing the economic feasibility of a wind project. It is by far more useful than the rated power, which does not account for the variability of wind velocity thereby easily overestimating energy revenues. The average power of wind turbine, $\overline{P_{WT}}$, is the power produced at each wind speed multiplied by the fraction that wind speed is experienced, integrated over all possible wind speeds. In integral form this can be expressed as (Manwell et al., 2002; Borowy and Salameh, 1996):

$$\overline{P_{WT}} = \int_0^\infty P_{WT}(v) df(v)$$

This integral can be replaced with a summation over bins, N_B, to calculate the average wind turbine power (Manwell et al., 2002).

$$\overline{P_{WT}} = \sum_{j=1}^{N_B} \left\{ \exp\left[-\left(\frac{v_{j-1}}{c} \right)^k \right] - \exp\left[-\left(\frac{v_j}{c} \right)^k \right] \right\} P_{WT}\left(\frac{v_{j-1} + v_j}{2} \right)$$

Please note that the relative frequency, f_j /N, corresponds to the term in brackets and the power output is calculated at the midpoint between v_{j-1} and v_j .

The available power at any given wind speed *v* that is convertible by a turbine is defined by (Manwell et al., 2002 Johnson, 1985)

$$P_{WT}(v) = \frac{1}{2} \rho A C_p \eta \upsilon^3$$

Where η is the drive train efficiency (i.e. generator power/rotor power), C_p, is the machine power coefficient. In an idealized wind turbine no losses are experienced and the power coefficient, C_p, is equal to Betz' limit (i.e. $C_{p,Betz}$ = 16/27) and η = 1. Of course, in reality both the drive train efficiency and the power coefficient cannot be maximized. The extent to which the power output is limited by physical laws as well as engineering inefficiency is dependent on the specific characteristics of individual wind turbine types. This aspect will be discussed further in the analysis of the case study.

WECTs have a range of different power output performance curves, which need to be recognized when estimating the potential power output. The power output performance curves are not only defined by parameters such as the power coefficient and the drive train efficiency but also constrained by cut-in speed, furl-out speed and rated wind speed. Where the cut-in wind seed, v_c, is the minimum wind velocity to generate power from a turbine, the rated wind speed, v_R, is the wind speed at which the 'rated power' of a WETC is achieved and generally corresponds to the point at which the conversion efficiency is near its maximum and furl-out wind speed, v_F, is the wind speed at which the turbine shuts down to prevent structural damage.

To account for the above-mentioned constraints we can formulate a novel formula for the average electrical power output of a turbine, $\overline{P_{WTA}}$:

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

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

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

Another way of stating the energy output from a wind turbine is to look at the capacity factor for the turbine in its particular location. The capacity factor CF, is the actual energy output over a given period of time, WE(t), divided by the theoretical maximum energy output (i.e. this means that the machine is constantly running at its rated output) during the selected time-span, RO(t). This can be formulated as

$$CF = \frac{WE(t)}{RO(t)}$$

Theoretically capacity factor vary from 0 to 100%. In practice they usually range from 20 to 70% and mostly be around 20-30 percent. However, the economic feasibility of a wind turbine does not of course depend on the capacity factor of a wind turbine alone but also depends on the costs of alternative power systems. Therefore, a low capacity factor does not automatically render a wind turbine project unfeasible.

In order to maximize the energy output of a given wind regime the optimum wind speed, v_{opt}, needs to be determined. The optimum wind speed indicates at what wind velocity most energy is available in a given wind regime. It is at this particular wind speed that engineers should ensure that the power coefficient is most efficient to allow for the highest energy conversion of a turbine. The optimum wind speed can be calculated as follows (Lu et al., 2002):

$$v_{opt} = c\left(\frac{k+2}{k} \right)^{\frac{1}{2}}$$

In this regard, the power density of a turbine is a good comparative indicator to show the average power output per m^2 of wind swept area, A, at a given site. This can be defined as

$$\text{Power Density} = \frac{\overline{P_{WTA}}}{A}$$

Another important aspect of that critically determines the energy output of a turbine is elevation. In many cases the available recorded wind speed data has been measured at a lower level than the planned hub height of the wind turbine. As wind velocity increases vertically the recorded wind speed data can be adjusted using the following standard formula (Borowy and Salameh, 1996.) where v is the projected wind speed, v_i the wind speed at reference height, H the hub height of a turbine, Hi the reference height and α the power-law exponent.

$$v = v_i \left(\frac{H}{H_i} \right)^{\alpha}$$

α is often quoted to have a value of 1/7 and is seen as a reasonable power law exponent for even and unobstructed landscapes. However, where WECT development is planned either offshore or near woodlands or close to any other non flat terrains this value can differ subsequently and a more through analysis of α is necessary. Justus as well as Counnihan offer mathematical solution for 'fitting' α to these environments (Manwell et al., 2002).

4.1 **Hypothetical Wind Generated Electric Power**:

A **wind turbine** is a machine for converting the kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator.

Hypothetical wind generated electric power output at Besham 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 Besham 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 Besham.

PMD Calculator (using 50M) Feb 2007 to Jul 2008				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	156	57	15%	64,858
February	254	82	21%	87,040
March	175	65	17%	73,964
April	134	51	13%	55,649
May	141	54	14%	61,467
June	106	40	10%	43,283
July	93	34	9%	38,790
August	90	34	9%	38,885
September	106	41	10%	45,121
October	174	69	17%	77,454
November	96	37	9%	40,649
December	140	54	14%	60,657
Annual	**132**	**50**	**13%**	**668,587**

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 average diurnal variation of wind generated electric energy output at Besham (Feb 07-Jul 08). The graph shows that the maximum power is produced at about 2200; 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 Besham the wind have more potential in the first five months of the year as compared to other months. Figure 23 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20

Bisham: From Feb 2007 to July 2008 Annual Average Diurnal Varition Of Wind Generated Electric Powe Output

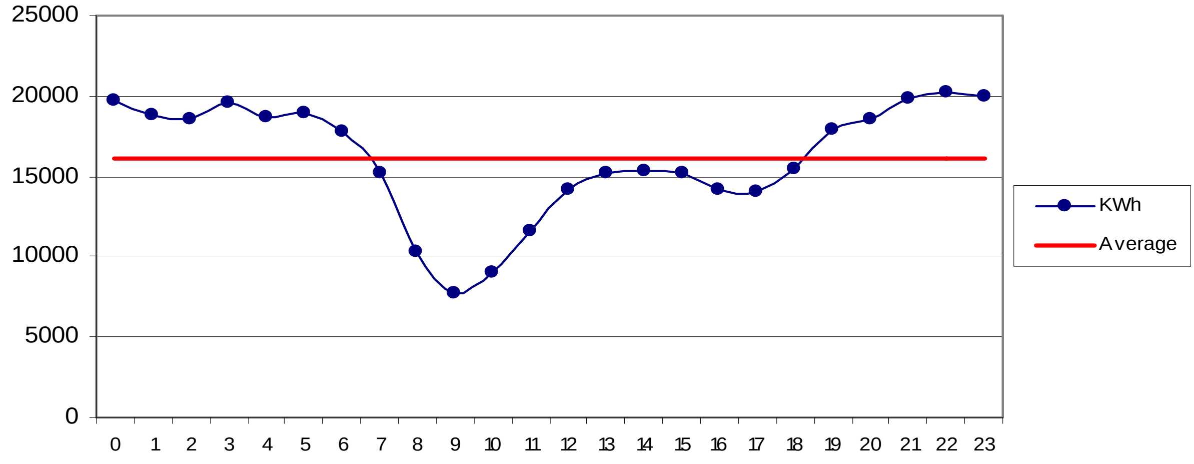


Fig 21

Besham: From Feb 2007 to July 2008 Monthly Average Diurnal Varition Of Wind Generated Electric Powe Output

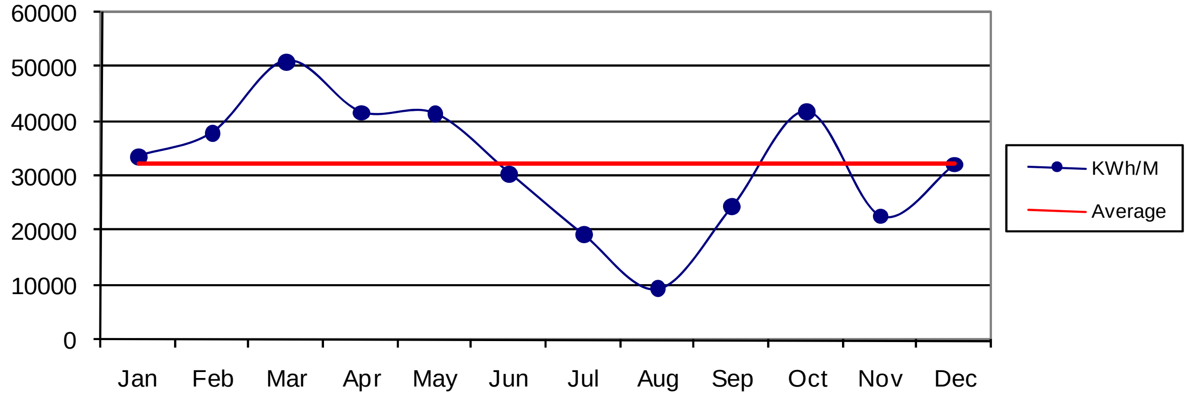


Fig 22

Bisham: From Feb 2007 to July 2008 Daily Wind Generated Electric Power Output

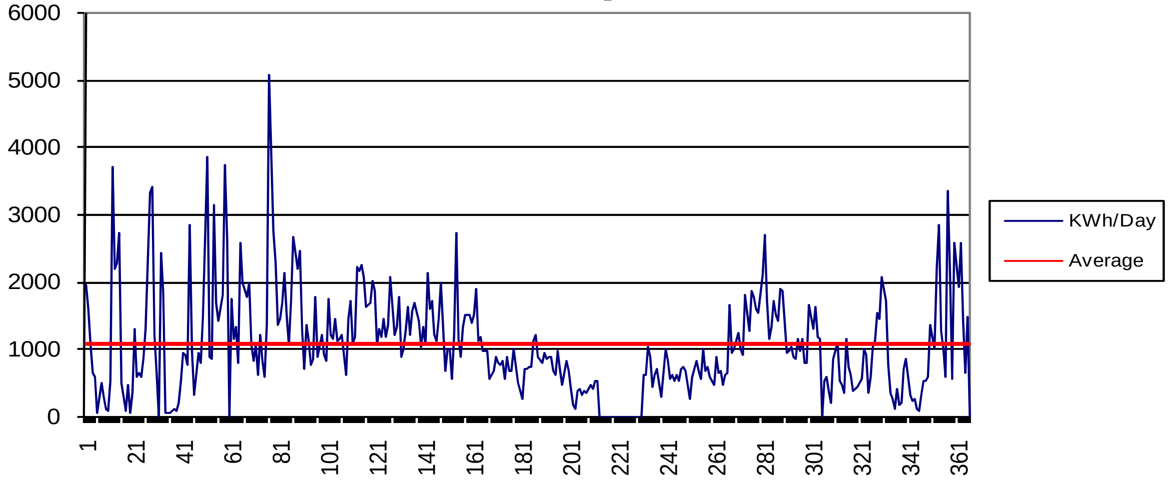


Fig 23 **Bisham Jan: Diurnal Variation of Wind Genrated Electric Energy Output**

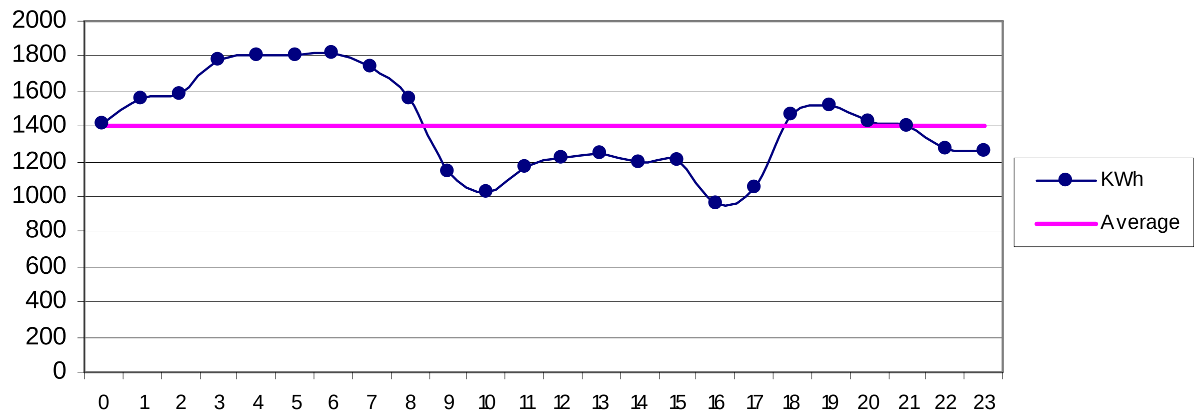
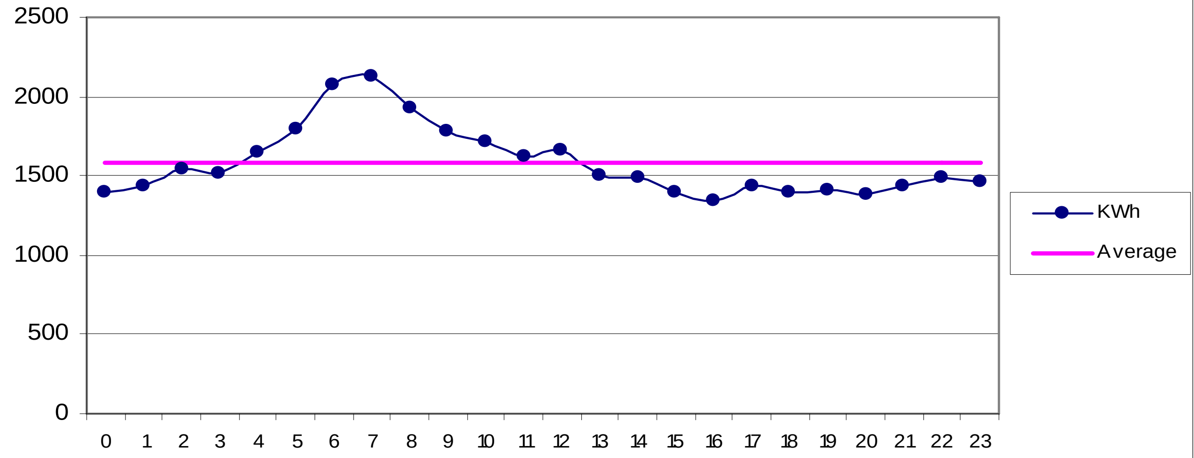
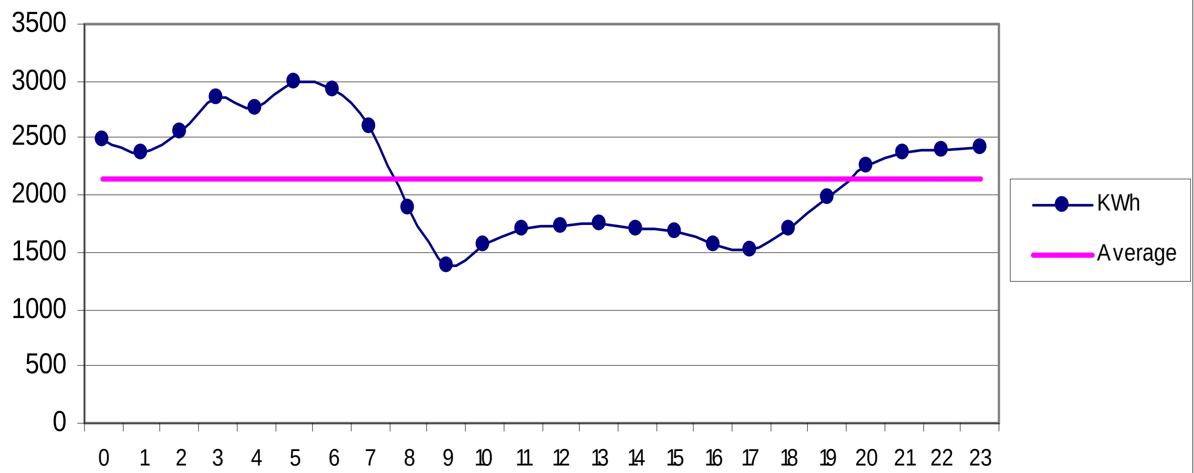


Fig 24 **Bisham Feb: Diurnal Variation of Wind Genrated Electric Energy Output**



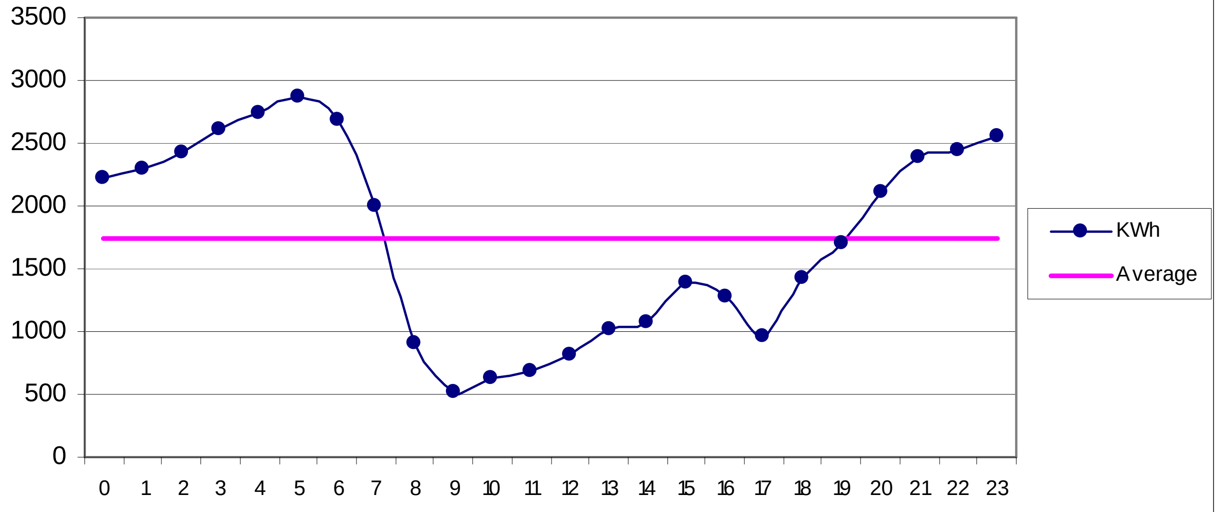
Source: Pakistan Meteorological Department

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



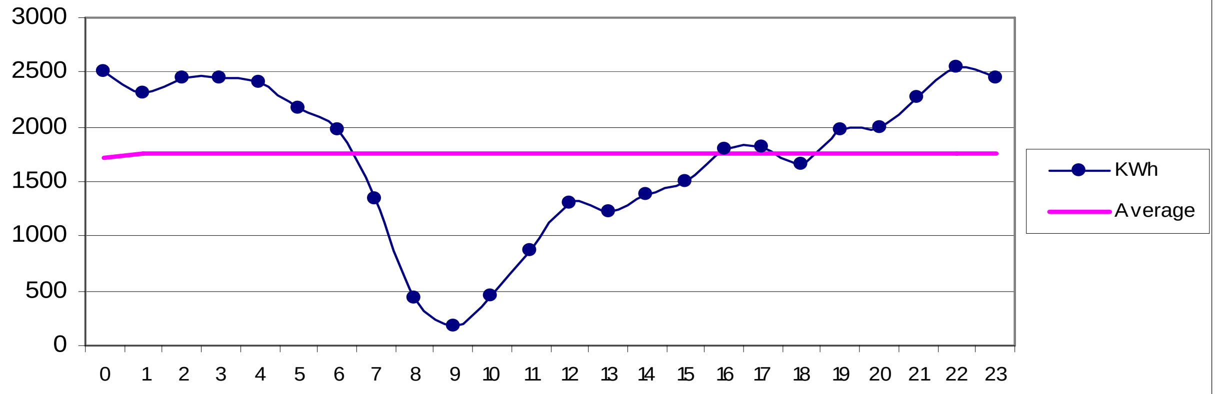
Source: Pakistan Meteorological Department

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



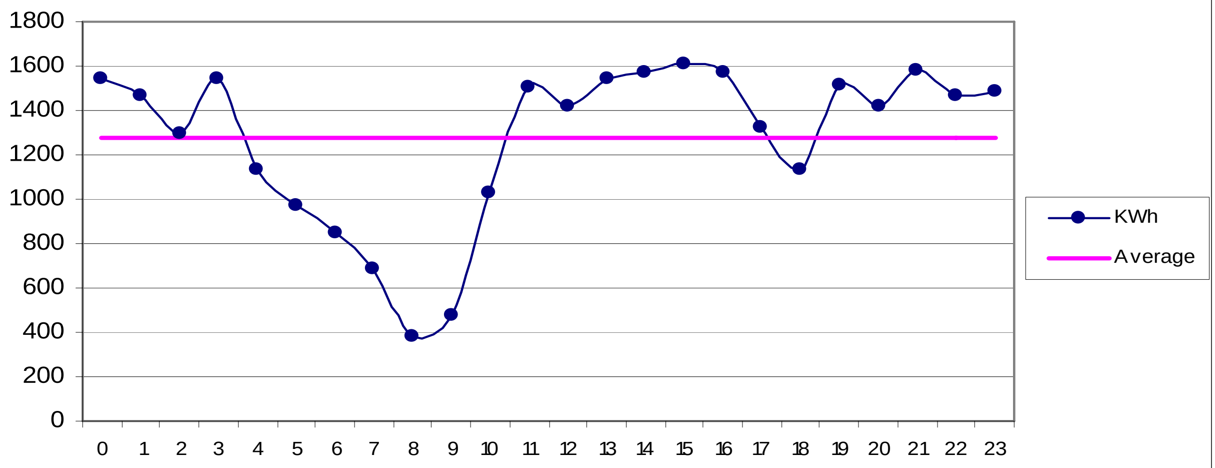
Source: Pakistan Meteorological Department

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



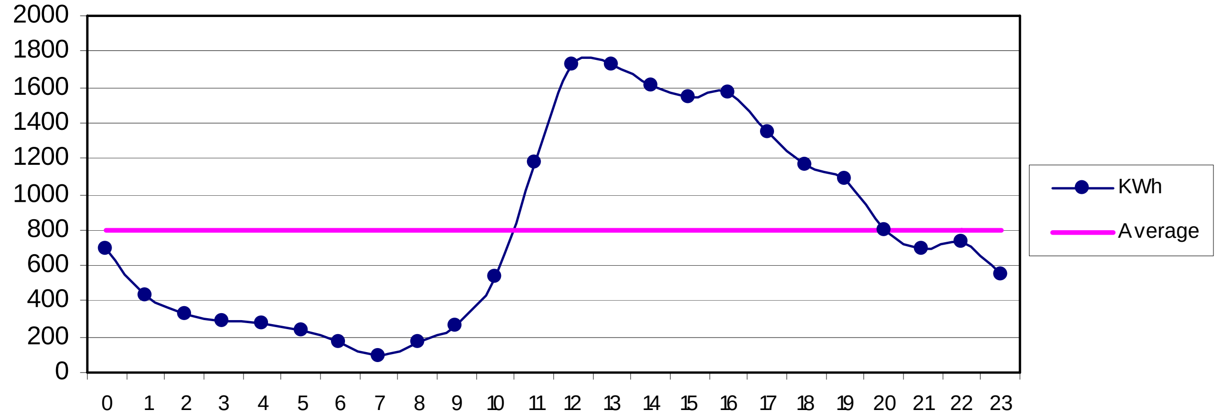
Source: Pakistan Meteorological Department

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



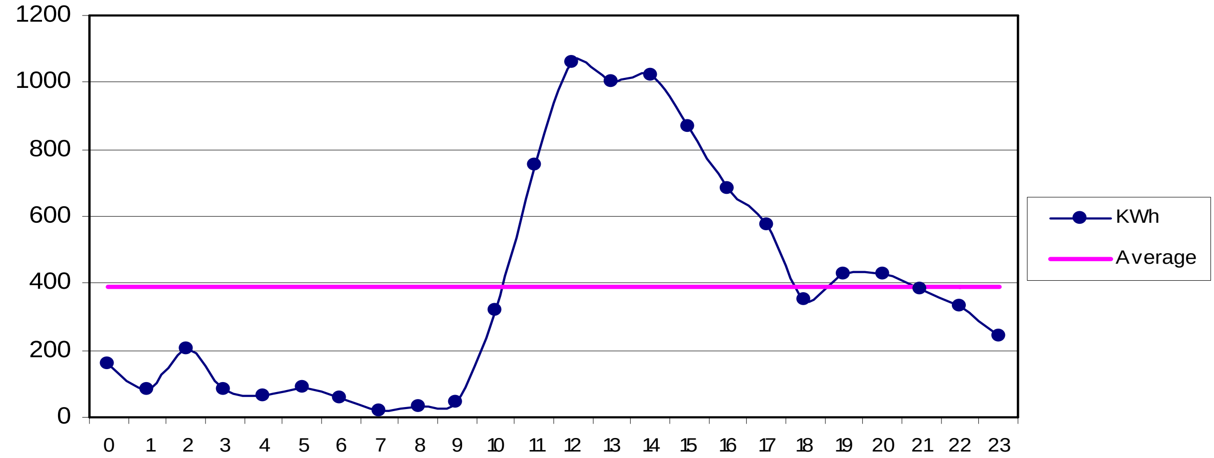
Source: Pakistan Meteorological Department

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



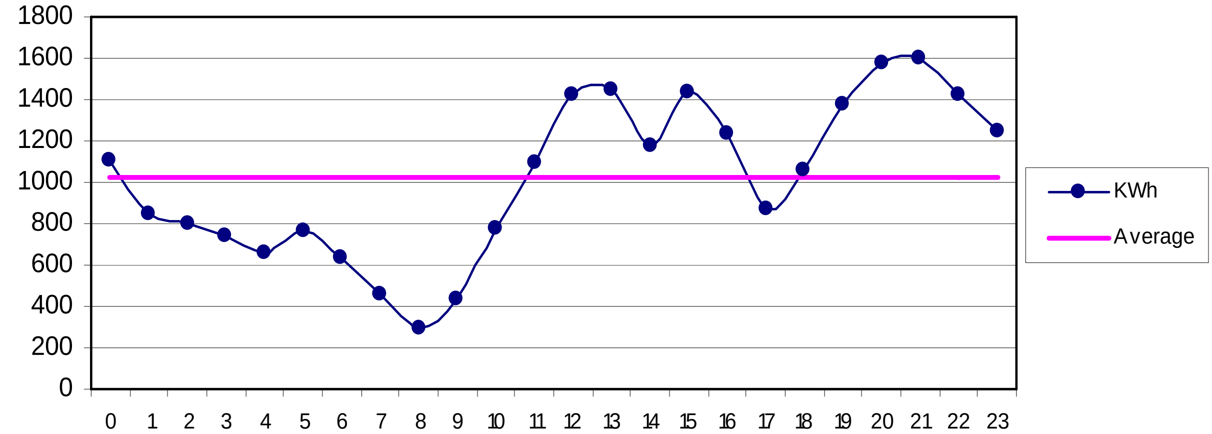
Source: Pakistan Meteorological Department

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



Source: Pakistan Meteorological Department

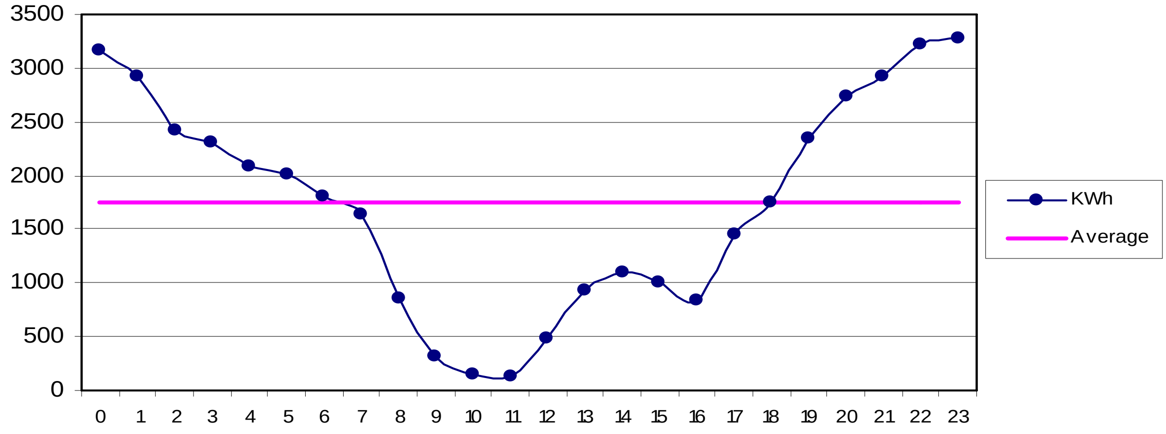
Fig 31 **Bisham Sep: Diurnal Variation of Wind Genrated Electric Energy Output**



Source: Pakistan Meteorological Department

Fig 32

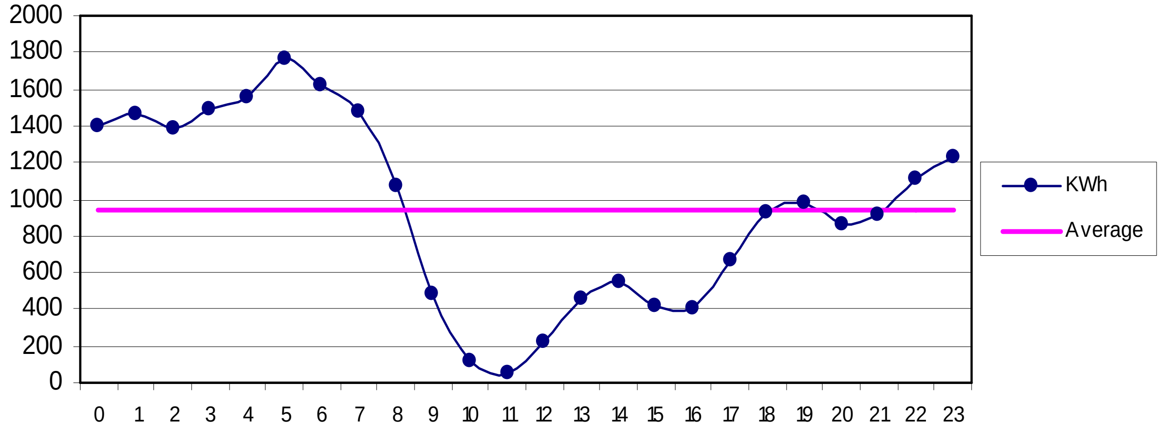
Bisham Oct: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 33

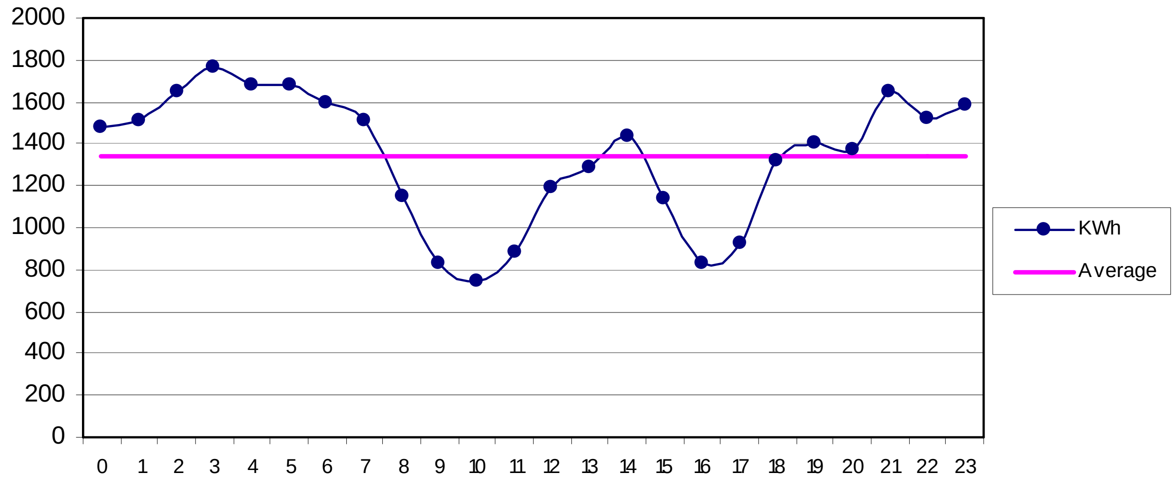
Bisham Nov: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Fig 34

Bisham Dec: Diurnal Variation of Wind Genrated Electric Energy Output

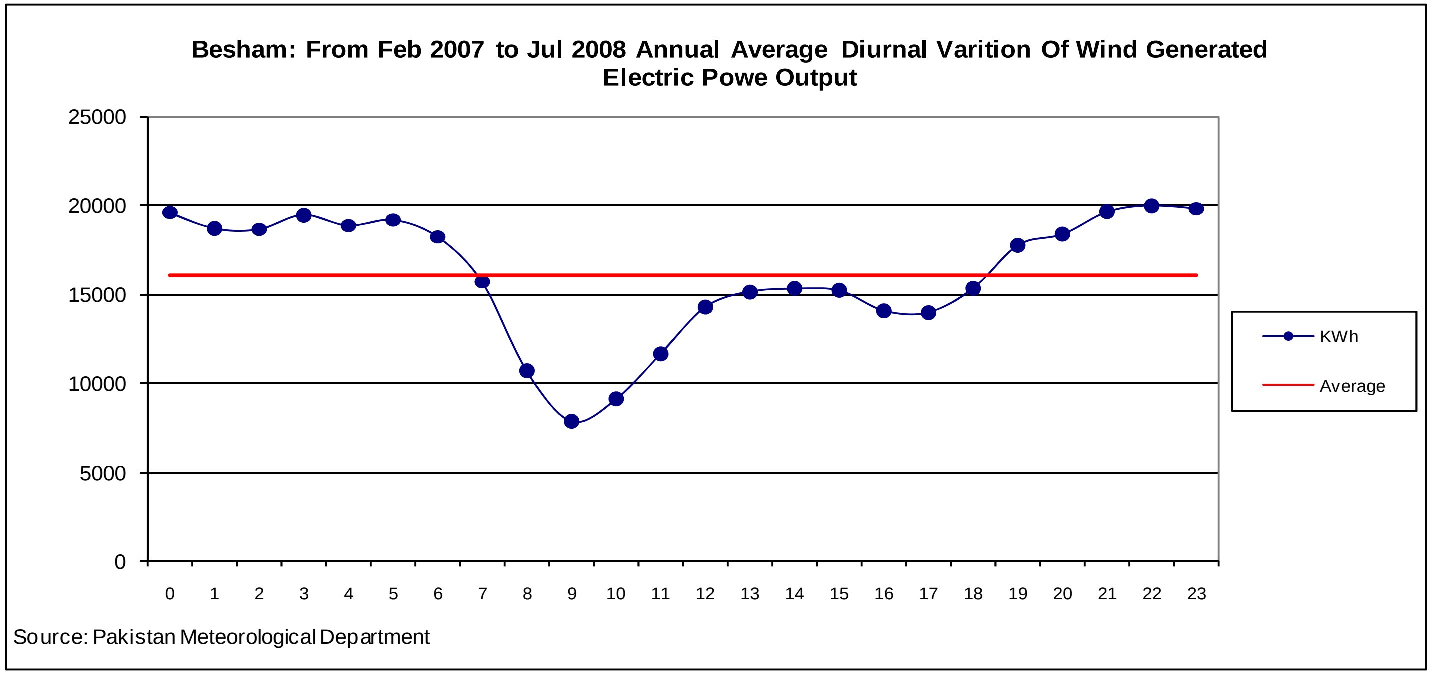


Source: Pakistan Meteorological Department

Appendix I

Besham **February 2007 to July 2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
Jan	1419	1560	1579	1775	1810	1808	1820	1743	1557	1139	1028	1175	1227	1251	1197	1206	961	1054	1470	1521	1430	1408	1279	1261	33678
Feb	1566	1591	1531	1610	1549	1622	1615	1623	1604	1671	1642	1599	1591	1563	1569	1470	1469	1525	1483	1520	1512	1625	1711	1709	37971
Mar	2493	2360	2552	2864	2768	2993	2922	2594	1888	1383	1567	1705	1732	1739	1696	1671	1555	1521	1702	1988	2251	2361	2405	2415	51123
Apr	2225	2288	2431	2613	2739	2869	2686	2007	902	511	632	677	822	1027	1071	1381	1272	967	1422	1712	2116	2390	2452	2551	41765
May	2509	2308	2441	2452	2412	2178	1967	1338	442	180	449	865	1295	1223	1380	1507	1789	1821	1653	1975	1992	2278	2538	2457	41446
Jun	1543	1469	1297	1538	1132	970	849	683	380	473	1033	1504	1419	1539	1575	1612	1571	1322	1138	1512	1422	1578	1469	1489	30516
Jul	696	428	328	293	278	234	173	89	175	259	541	1175	1721	1726	1611	1543	1572	1340	1167	1081	797	694	730	555	19205
Aug	157	85	202	86	62	92	60	21	29	47	321	755	1061	1003	1020	867	682	573	353	429	429	382	331	244	9291
Sep	1103	846	804	737	664	760	635	457	297	430	771	1091	1428	1447	1175	1432	1239	876	1058	1381	1575	1595	1426	1248	24474
Oct	3160	2924	2416	2309	2087	2011	1812	1631	855	315	147	132	482	924	1093	1014	833	1457	1747	2353	2733	2930	3215	3280	41858
Nov	1396	1466	1388	1493	1557	1761	1620	1474	1068	484	121	52	222	457	545	417	407	673	927	985	863	919	1106	1231	22633
Dec	1477	1516	1645	1769	1677	1685	1598	1514	1147	834	748	885	1196	1286	1441	1142	829	929	1316	1409	1377	1652	1524	1588	32184
KWH	19745	18841	18613	19539	18734	18983	17756	15175	10344	7725	8999	11615	14196	15183	15372	15263	14177	14058	15436	17866	18497	19814	20184	20028	**386143**
Average	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	16089	



Source: Pakistan Meteorological Department

Besham **January 2008** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	84	75	121	115	96	138	126	139	99	81	131	25	48	30	30	30	7	55	81	102	93	107	81	64	1955
2	81	86	107	86	78	93	107	114	100	69	13	0	0	10	36	30	15	59	86	86	86	93	88	81	1601
3	102	138	0	76	130	123	56	107	86	74	26	5	0	4	9	4	1	14	36	40	8	1	3	34	1077
4	48	26	26	52	35	28	43	40	45	25	27	19	7	2	3	1	43	17	17	40	28	24	34	14	644
5	33	53	24	31	68	102	93	81	37	21	7	0	7	27	1	0	0	0	0	0	0	1	2	1	586
6	0	0	0	12	17	9	3	19	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	63
7	0	3	7	45	23	1	0	2	14	9	25	36	30	30	27	43	34	33	30	40	9	29	24	5	498
8	5	29	81	69	52	31	11	3	0	0	0	0	0	0	0	0	0	8	5	3	4	3	0	0	304
9	0	0	0	4	1	1	12	0	0	0	5	4	33	36	14	11	7	0	0	2	0	0	0	1	131
10	0	3	12	24	15	0	0	0	0	0	0	1	1	0	0	17	3	1	7	4	3	1	0	0	93
11	0	0	1	0	0	0	3	2	1	8	1	0	1	0	0	6	14	33	88	88	57	50	92	83	528
12	57	88	168	192	177	146	215	252	292	213	176	169	169	200	177	161	137	146	110	67	108	96	88	100	3700
13	129	81	125	115	105	107	111	118	131	98	62	19	7	27	33	24	17	64	115	108	146	145	177	123	2186
14	107	145	93	83	137	161	185	123	115	76	40	22	15	27	30	50	27	66	138	122	161	138	103	115	2276
15	116	108	103	111	107	138	161	110	168	88	70	138	201	208	207	161	90	84	30	36	40	81	93	59	2706
16	43	76	40	41	50	34	27	40	21	14	13	21	18	14	11	10	8	3	3	8	5	5	0	0	504
17	0	0	0	0	0	0	1	0	3	2	0	0	0	0	3	0	1	18	26	13	1	0	0	9	78
18	40	46	0	16	24	114	71	45	10	0	8	5	12	9	13	19	5	0	10	9	9	9	2	1	479
19	2	1	0	0	0	0	12	3	0	0	0	0	1	11	22	3	7	1	1	0	0	0	0	1	67
20	0	0	2	3	8	21	18	21	11	5	0	0	0	1	14	27	25	8	20	40	34	40	22	37	355
21	27	33	43	43	60	68	100	83	110	117	36	21	70	81	74	64	33	3	5	22	34	40	67	71	1304
22	76	64	71	45	56	36	40	36	25	16	3	0	0	0	3	15	0	2	10	25	18	6	23	21	591
23	27	57	21	14	9	6	10	2	4	6	0	1	3	14	29	111	80	51	63	71	57	12	9	5	664
24	11	21	9	3	18	10	3	16	21	9	0	2	4	10	5	12	37	30	45	36	64	93	76	64	599
25	47	33	33	57	69	60	69	58	51	28	2	5	7	12	0	0	0	11	48	40	69	75	40	30	844
26	40	40	67	64	69	36	47	56	36	36	60	123	139	64	47	13	1	1	57	81	51	74	39	48	1287
27	47	51	81	76	55	43	81	103	60	51	153	215	200	177	169	161	161	193	252	253	237	207	107	184	3315
28	215	224	223	265	245	184	154	108	40	55	107	183	176	125	146	168	177	145	146	139	53	27	36	43	3383
29	56	41	50	83	65	84	37	34	53	26	63	161	78	131	95	55	28	6	5	9	9	6	12	11	1198
30	25	40	71	51	40	36	27	27	25	12	1	0	0	1	0	11	5	3	36	40	47	48	61	56	662
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KWh	1419	1560	1579	1775	1810	1808	1820	1743	1557	1139	1028	1175	1227	1251	1197	1206	961	1054	1470	1521	1430	1408	1279	1261	33678

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	76	80	84	115	136	122	139	154	171	166	131	104	96	80	76	76	76	96	96	85	76	72	51	55	2418
2	65	88	107	88	96	69	112	108	92	88	84	80	58	77	115	129	130	96	80	41	4	9	0	0	1818
3	0	0	0	0	0	0	0	3	8	5	4	8	2	12	1	0	0	0	0	0	0	4	3	1	50
4	3	0	3	1	0	0	0	0	3	0	0	0	0	0	1	1	3	8	3	0	0	5	16	10	58
5	4	0	6	1	0	0	0	0	1	0	0	0	0	0	8	2	9	18	11	2	1	3	1	1	69
6	3	3	6	7	4	5	5	3	4	3	0	1	0	0	0	1	4	2	14	18	15	6	3	7	115
7	0	0	1	1	0	0	3	9	0	1	10	4	0	7	7	4	3	1	0	17	19	5	1	0	95
8	0	0	3	0	0	0	0	0	0	6	1	0	18	32	30	40	23	25	13	1	5	1	2	5	206
9	5	0	12	13	20	25	40	54	40	6	0	1	0	0	0	0	0	9	30	38	57	40	61	77	529
10	73	65	72	72	84	61	58	73	38	21	13	19	28	32	24	17	19	9	17	32	13	15	57	45	958
11	30	48	46	17	28	53	65	52	32	34	24	7	14	27	37	72	43	55	26	57	24	43	44	51	929
12	72	61	51	58	76	96	100	76	38	21	1	1	12	4	1	3	3	2	15	23	24	20	6	6	773
13	52	32	29	75	126	126	162	172	172	177	156	146	137	116	104	130	133	139	146	143	130	107	69	63	2842
14	51	42	30	33	73	88	84	67	74	28	28	80	61	53	55	22	36	13	15	11	9	3	6	6	971
15	6	6	7	9	5	8	8	1	2	2	17	15	14	39	46	57	30	11	17	11	5	7	6	4	334
16	26	27	55	36	24	26	57	53	48	16	93	95	42	15	18	36	18	41	18	44	36	46	35	31	941
17	30	40	62	32	29	23	46	49	45	22	8	11	15	16	22	33	52	40	38	34	35	35	37	53	809
18	93	107	77	76	46	52	91	100	71	40	17	32	61	39	47	64	59	77	60	28	48	65	61	58	1470
19	61	54	84	47	80	100	104	104	116	130	152	139	152	119	108	106	106	103	113	133	133	145	142	103	2634
20	129	128	163	166	164	201	217	213	187	237	207	155	128	138	171	78	100	124	151	129	166	173	184	138	3846
21	75	97	87	54	62	63	77	38	28	30	39	18	28	23	21	16	24	17	27	12	7	10	10	9	873
22	14	4	7	14	5	6	6	14	4	7	9	23	40	44	47	57	31	18	28	70	61	106	124	123	860
23	97	86	61	66	84	111	133	164	187	177	139	156	175	148	112	113	145	165	129	143	129	117	156	131	3126
24	49	59	83	72	79	83	88	91	53	137	161	111	156	89	81	31	17	15	7	14	39	54	36	66	1670
25	106	128	62	135	93	133	80	64	62	40	30	76	49	56	49	17	6	2	5	10	28	45	58	71	1403
26	63	62	57	53	43	28	68	115	118	78	110	89	89	77	67	73	77	117	81	61	73	65	66	83	1813
27	60	104	142	123	135	160	174	194	200	169	148	146	176	166	159	136	127	144	166	173	173	195	186	175	3729
28	155	116	142	153	158	148	159	153	126	133	135	104	113	98	76	79	65	81	85	73	70	46	73	93	2633
29	1084	1095	1260	1159	1352	1417	1713	1750	1571	1355	1327	1272	1322	1196	1167	1174	1118	1156	1158	1134	1119	1065	1034	1005	29999
KWh	1566	1591	1531	1610	1549	1622	1615	1623	1604	1671	1642	1599	1591	1563	1569	1470	1469	1525	1483	1520	1512	1625	1711	1709	15943

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	56	59	103	139	111	105	57	84	104	96	85	66	65	76	112	59	48	35	25	29	55	54	56	63	1741
2	63	65	92	107	100	113	96	88	33	18	0	3	14	4	1	10	14	18	26	73	40	29	51	87	1144
3	58	70	0	116	72	71	66	90	139	177	70	16	16	33	56	52	42	25	11	44	49	26	15	15	1328
4	20	17	22	7	15	24	28	20	20	8	24	54	47	45	47	46	58	57	43	43	36	50	40	37	805
5	41	36	32	54	98	101	140	163	144	54	85	93	116	138	160	113	105	95	159	145	117	121	102	148	2559
6	177	131	130	158	148	150	164	74	40	57	35	64	34	74	82	74	8	19	53	40	47	70	72	79	1979
7	80	89	113	172	146	96	96	92	50	53	59	39	27	30	41	44	55	43	21	48	45	88	114	134	1778
8	165	155	190	136	129	122	147	109	55	17	87	72	55	39	32	20	12	8	42	61	78	80	88	92	1992
9	95	37	77	43	39	75	84	58	20	2	50	52	36	37	39	17	5	1	8	29	51	76	58	62	1051
10	57	47	65	80	50	67	57	62	58	21	6	13	25	16	0	0	4	4	24	10	37	34	43	41	825
11	48	75	59	72	89	75	50	67	33	29	55	32	28	20	17	39	47	8	30	34	21	45	34	40	1050
12	26	26	23	23	19	39	25	26	10	2	16	14	13	23	17	9	3	18	51	60	45	36	44	41	611
13	78	105	76	100	100	80	96	61	12	3	15	4	29	29	28	11	3	19	43	56	131	52	47	36	1215
14	48	44	28	46	34	46	53	50	34	3	8	9	0	2	15	21	59	82	74	24	27	54	36	20	818
15	21	26	32	38	46	47	73	61	25	0	0	0	0	4	9	11	9	6	23	34	36	21	23	45	593
16	30	29	30	37	30	84	74	43	24	31	70	101	109	82	43	41	53	58	49	72	67	70	77	47	1351
17	37	38	39	121	115	147	128	106	244	209	263	308	334	309	289	314	335	319	256	193	232	239	244	232	5051
18	143	74	74	113	148	152	149	152	141	79	60	105	136	163	119	122	77	56	80	133	150	112	104	114	2756
19	113	112	125	103	123	143	127	47	109	68	87	127	72	115	111	132	103	70	88	77	53	90	53	34	2283
20	35	51	76	47	60	88	95	76	36	14	26	17	15	25	18	79	88	81	71	79	76	84	67	65	1369
21	57	63	74	88	100	143	113	118	25	10	3	2	5	2	5	36	38	70	62	27	64	107	130	89	1433
22	97	106	94	111	136	105	110	89	50	0	0	0	3	58	63	30	17	72	53	51	108	127	100	118	1695
23	143	90	103	118	80	82	89	74	69	135	144	126	122	67	44	45	57	67	65	67	45	59	111	110	2112
24	117	146	120	148	156	153	117	110	52	24	11	4	21	4	7	14	9	11	46	57	26	39	55	58	1505
25	56	55	67	61	78	83	115	155	57	4	0	0	0	1	9	2	20	2	10	40	29	57	69	88	1058
26	121	105	132	90	52	81	43	78	12	13	16	60	84	62	61	53	22	3	20	65	111	121	169	150	1725
27	121	101	110	119	152	111	105	108	44	67	115	152	145	111	103	107	128	138	88	42	118	108	138	131	2659
28	148	170	182	156	125	128	142	148	101	79	42	12	4	7	21	18	9	43	72	103	92	156	135	102	2195
29	123	121	133	118	112	147	110	76	60	71	104	129	138	132	119	130	107	67	33	43	94	97	99	89	2452
30	104	100	142	124	87	110	142	87	70	34	22	14	13	17	13	3	2	1	13	72	74	19	10	14	1287
31	17	19	8	18	16	24	29	23	15	0	8	16	27	16	13	18	18	24	66	137	98	39	22	32	703
KWh	2493	2360	2552	2864	2768	2993	2922	2594	1888	1383	1567	1705	1732	1739	1696	1671	1555	1521	1702	1988	2251	2361	2405	2415	51123

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	45	24	28	8	14	47	38	27	68	37	27	20	37	16	17	88	114	85	85	96	101	121	103	109	1356
2	86	88	132	134	121	105	97	96	26	4	12	22	67	25	17	3	0	0	2	4	13	22	24	25	1124
3	27	32	0	38	50	49	78	66	4	16	25	3	34	36	16	11	5	11	60	26	30	39	59	59	772
4	52	64	92	57	68	105	120	54	24	15	2	0	0	11	24	19	2	5	11	16	12	33	37	24	847
5	25	24	15	62	28	95	92	148	185	193	149	147	104	62	37	32	35	23	21	41	104	53	43	42	1759
6	84	82	79	69	84	94	48	51	30	3	0	3	18	5	5	16	23	5	11	27	33	37	37	38	882
7	46	55	61	55	79	90	68	62	46	10	7	5	6	3	20	25	43	36	63	99	159	107	38	41	1224
8	32	28	30	31	40	53	48	51	11	1	0	0	4	20	18	25	45	41	98	65	67	72	75	68	923
9	51	74	65	80	106	73	39	35	10	9	3	0	4	4	6	2	12	8	22	49	56	43	43	42	834
10	73	105	115	114	86	79	53	29	2	7	43	132	101	89	51	77	67	87	32	62	98	72	83	90	1746
11	94	101	79	77	53	51	52	42	4	38	115	64	25	25	56	54	35	5	23	37	40	54	39	46	1209
12	49	60	118	97	92	54	45	17	3	1	0	45	53	47	35	48	47	14	38	72	56	52	48	59	1150
13	88	96	117	119	154	133	137	129	14	0	0	0	10	10	15	31	19	4	16	42	44	87	92	98	1452
14	78	84	88	79	81	89	82	82	51	7	0	1	6	46	15	17	36	7	24	36	52	42	62	54	1119
15	48	56	78	92	114	119	104	51	16	3	0	7	1	17	24	23	38	35	26	25	52	63	71	83	1147
16	76	79	81	86	92	82	126	115	39	12	3	9	27	42	48	31	50	17	8	13	10	48	49	69	1213
17	28	32	32	39	42	50	52	23	7	5	0	0	2	21	11	12	2	6	21	22	36	62	63	57	625
18	95	113	83	97	121	138	148	81	21	1	5	0	1	3	6	6	21	5	53	70	84	98	102	88	1443
19	71	62	50	46	48	35	43	45	77	80	88	87	35	29	16	115	140	138	143	152	63	55	49	59	1726
20	63	80	67	78	75	85	81	61	17	2	0	0	7	38	60	18	13	13	29	53	73	58	75	46	1092
21	55	58	49	51	68	75	74	46	8	1	0	0	20	23	44	31	38	11	17	51	53	160	140	115	1187
22	119	82	55	87	100	100	103	87	32	0	0	0	16	24	20	17	11	58	252	179	284	264	164	152	2207
23	78	37	67	106	133	196	132	90	47	23	89	73	89	128	79	77	70	94	89	106	103	69	98	95	2170
24	95	125	137	152	129	110	125	76	16	15	62	22	6	15	94	103	51	72	82	73	137	181	172	200	2250
25	172	144	180	188	183	200	150	109	36	2	0	0	11	35	50	89	45	32	40	45	66	61	101	133	2072
26	68	70	87	119	124	97	77	44	12	8	1	21	45	76	101	67	53	62	31	42	51	105	122	130	1611
27	101	107	126	112	121	112	107	50	1	0	0	13	28	47	42	46	30	23	33	52	75	116	181	156	1678
28	127	143	141	166	181	179	200	125	54	12	0	2	19	53	43	45	43	15	11	34	52	76	111	165	1999
29	113	110	106	90	87	84	92	57	13	0	0	0	32	51	81	203	158	44	42	69	54	81	138	167	1874
30	90	72	74	84	65	91	73	61	27	4	0	0	13	27	19	52	25	11	39	52	60	60	33	41	1075
KWh	2225	2288	2431	2613	2739	2869	2686	2007	902	511	632	677	822	1027	1071	1381	1272	967	1422	1712	2116	2390	2452	2551	41765

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	45	56	52	73	74	69	81	80	41	3	0	0	12	47	28	9	16	26	64	88	77	101	122	135	1298
2	108	87	76	86	83	63	76	46	9	1	0	7	38	52	38	22	23	16	25	46	41	108	74	71	1194
3	73	95	0	120	112	94	83	83	20	4	41	31	35	34	37	40	16	22	81	117	112	72	66	48	1436
4	66	45	71	45	8	27	31	48	24	11	2	0	19	67	52	16	27	62	47	187	156	50	63	56	1182
5	59	42	64	69	65	106	109	89	23	3	0	9	16	16	31	26	43	143	93	53	48	23	113	106	1350
6	141	169	162	148	201	126	113	50	3	0	1	9	23	25	15	14	35	88	95	108	110	145	142	147	2071
7	99	88	78	65	75	69	62	27	2	0	0	2	37	20	14	35	72	41	25	49	73	70	94	111	1209
8	93	99	119	87	126	105	99	68	17	0	3	4	24	28	18	12	90	60	49	41	23	29	55	90	1339
9	126	47	131	111	124	95	65	69	18	2	12	39	47	39	48	87	142	86	96	95	102	65	76	64	1785
10	76	66	57	52	46	45	37	17	2	1	1	2	2	21	82	14	32	46	17	28	66	53	60	66	887
11	98	67	75	72	73	82	71	26	2	0	0	0	22	56	55	42	18	19	19	22	31	47	86	32	1015
12	44	65	79	73	76	47	48	32	11	1	25	74	89	66	32	79	92	78	65	34	10	35	66	52	1273
13	47	72	67	58	79	76	68	30	2	1	21	70	49	24	14	26	101	155	161	84	58	100	106	166	1635
14	137	100	140	116	66	42	53	27	7	1	3	26	69	39	14	14	15	13	10	43	80	62	69	72	1218
15	101	150	107	96	88	82	73	36	2	0	14	40	58	23	19	62	47	87	62	134	42	164	54	31	1571
16	52	92	78	95	76	85	53	33	2	3	0	7	41	27	39	23	12	39	134	124	135	149	212	174	1682
17	207	108	78	94	120	137	113	73	16	0	1	19	23	12	18	111	14	6	28	50	53	50	55	40	1424
18	47	44	57	50	49	37	42	8	2	2	0	33	46	51	66	71	94	25	6	21	30	23	122	104	1031
19	95	79	106	104	85	57	82	86	29	2	33	41	22	11	9	24	7	16	16	24	67	121	110	99	1325
20	40	66	122	83	46	48	38	23	0	7	5	23	35	38	31	18	19	19	21	89	80	69	72	64	1056
21	67	54	77	71	56	75	61	30	2	11	113	185	231	142	214	82	55	48	49	45	73	136	123	131	2130
22	127	101	122	141	103	85	71	50	8	12	32	43	40	35	16	30	82	85	55	30	81	111	74	49	1583
23	60	56	50	58	73	73	48	28	8	8	30	32	92	109	240	246	167	114	43	21	6	9	75	74	1721
24	106	79	115	114	87	93	64	16	2	0	0	1	32	24	10	10	118	60	21	73	60	35	36	60	1216
25	40	66	28	47	37	44	79	32	31	11	1	21	37	11	4	26	39	78	48	73	78	113	101	89	1135
26	116	108	80	80	98	75	66	26	9	0	1	4	9	18	73	121	63	54	83	31	47	114	90	99	1462
27	58	64	71	80	110	109	79	155	140	92	108	126	113	119	72	30	74	127	73	72	41	19	19	16	1967
28	22	24	24	27	30	20	10	1	0	0	1	11	7	18	19	66	98	97	69	40	36	15	24	26	686
29	48	57	70	72	77	69	44	25	3	2	1	4	8	7	14	46	99	9	24	47	65	61	81	73	1006
30	86	39	69	48	46	24	26	6	3	1	0	4	19	20	48	92	72	90	55	45	61	71	43	35	1004
31	24	24	17	17	23	18	22	18	3	0	0	0	0	25	11	11	10	12	16	61	53	58	54	78	556
KWh	2509	2308	2441	2452	2412	2178	1967	1338	442	180	449	865	1295	1223	1380	1507	1789	1821	1653	1975	1992	2278	2538	2457	41446

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	100	63	65	69	64	54	35	11	2	1	0	8	36	24	29	31	56	90	33	91	93	71	81	93	1200
2	244	225	291	366	129	48	98	58	28	33	59	39	23	13	12	30	74	154	142	205	172	142	83	49	2718
3	47	95	0	61	37	19	6	54	55	68	33	12	14	13	67	26	48	49	28	60	68	88	78	119	1145
4	94	93	73	62	39	23	21	8	21	5	2	11	25	18	22	20	31	19	5	25	50	74	70	81	890
5	63	102	70	71	59	71	61	23	6	0	1	14	13	54	69	30	54	53	96	50	56	94	115	118	1341
6	65	46	53	76	78	98	77	50	2	1	26	34	22	25	29	60	176	119	78	49	81	81	101	67	1495
7	75	105	90	92	100	108	71	92	28	1	1	26	30	30	25	93	83	38	23	56	55	75	97	112	1504
8	71	59	48	82	61	59	53	27	2	0	0	5	64	41	30	20	22	36	48	110	137	118	121	169	1385
9	95	73	71	96	90	86	99	83	61	14	9	24	26	24	44	102	40	7	23	77	52	118	119	80	1513
10	76	93	104	120	109	128	126	135	112	28	12	34	42	57	47	41	35	31	26	78	84	115	128	126	1889
11	107	93	67	84	81	61	58	36	3	1	24	28	39	49	40	20	22	21	3	29	56	29	82	91	1123
12	110	117	89	92	69	59	38	25	1	23	40	74	84	48	23	19	12	18	4	6	39	119	47	30	1186
13	31	31	31	62	69	37	28	49	7	1	44	48	36	31	102	27	45	45	60	74	39	27	7	37	970
14	18	11	42	20	4	1	3	4	0	4	41	77	56	250	71	30	125	62	7	22	33	35	34	39	988
15	15	23	85	9	5	9	0	0	9	76	124	105	86	120	55	54	54	50	51	31	4	0	0	1	967
16	0	2	3	29	19	11	16	3	7	43	41	44	118	30	42	58	51	19	6	0	0	0	0	7	549
17	25	17	6	1	2	14	2	0	0	11	73	60	27	102	169	47	27	15	17	16	22	12	9	10	684
18	4	28	5	3	1	0	1	2	3	3	9	57	45	49	134	248	65	22	32	20	16	38	52	45	880
19	19	6	19	24	17	12	11	4	9	0	19	82	55	28	145	184	56	24	13	4	12	19	11	39	811
20	83	15	9	21	23	21	12	4	0	0	16	72	64	36	51	42	54	60	46	37	16	30	21	22	756
21	40	36	12	0	1	7	2	0	0	30	63	54	73	44	27	71	128	101	65	30	20	10	10	7	832
22	2	10	5	4	1	1	1	1	0	15	54	59	46	30	16	20	24	31	22	136	40	38	10	5	571
23	28	20	5	0	2	0	1	1	0	2	23	70	66	49	74	70	51	38	60	111	107	64	39	14	895
24	42	49	24	12	6	5	8	2	1	9	34	47	53	64	68	56	34	27	27	34	21	19	17	14	672
25	6	2	7	65	40	11	12	5	0	0	23	64	33	24	17	12	15	8	29	48	68	82	67	34	673
26	23	29	13	4	4	5	2	0	18	64	83	90	76	91	48	36	28	42	94	74	60	42	49	44	1017
27	4	4	3	11	18	13	0	1	0	0	21	61	38	61	35	46	70	36	49	16	3	7	3	16	516
28	36	16	4	1	4	3	3	1	6	40	99	110	34	3	2	0	0	5	0	0	4	9	5	7	393
29	13	3	0	0	0	2	1	0	0	0	34	27	19	36	15	12	7	59	10	4	5	5	1	3	257
30	6	4	2	2	1	4	2	1	0	0	27	68	77	95	66	105	83	42	39	17	11	19	13	11	695
KWh	1543	1469	1297	1538	1132	970	849	683	380	473	1033	1504	1419	1539	1575	1612	1571	1322	1138	1512	1422	1578	1469	1489	30516

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	9	1	2	11	15	16	7	4	0	0	0	30	60	76	64	58	52	44	37	39	41	45	74	14	698
2	41	20	29	33	23	16	12	3	0	0	9	56	70	51	27	33	56	62	27	44	20	20	48	35	738
3	17	21	0	31	23	7	4	1	0	1	10	37	63	55	53	52	42	45	43	72	33	57	48	26	739
4	42	34	4	5	4	0	0	0	0	4	38	82	90	88	44	30	38	34	100	112	121	91	96	59	1120
5	23	5	38	26	0	0	0	0	0	32	58	78	121	92	70	68	38	12	28	151	99	165	79	33	1214
6	55	25	40	27	12	19	9	1	26	7	3	46	91	90	65	43	39	56	98	70	42	11	3	1	881
7	2	0	0	1	1	0	1	27	84	14	4	13	71	82	71	60	68	59	53	16	3	14	56	92	793
8	243	123	8	1	1	2	1	2	2	14	39	58	74	59	55	45	35	68	48	16	23	20	8	11	956
9	7	8	11	6	39	18	9	3	2	1	0	4	28	71	94	80	110	120	98	32	36	26	31	33	867
10	5	15	12	1	9	9	11	2	1	0	10	56	83	106	124	107	71	39	51	63	46	25	27	1	873
11	5	15	4	8	1	8	0	3	28	35	44	85	98	94	64	89	148	79	31	17	8	5	6	0	877
12	2	0	2	0	9	2	0	0	0	6	47	67	82	91	75	115	81	55	16	10	1	7	3	1	674
13	0	1	8	35	7	1	5	7	10	56	25	45	76	49	32	32	33	39	32	37	29	22	11	41	631
14	86	58	48	38	52	28	22	14	1	0	0	6	43	19	155	190	151	29	5	5	7	6	1	2	967
15	0	2	4	1	1	0	1	4	1	0	1	59	58	71	69	56	76	81	58	39	42	38	31	2	696
16	1	1	2	1	2	9	7	1	0	9	37	57	70	47	23	14	12	33	47	49	16	12	12	15	479
17	14	5	4	1	4	12	9	1	17	38	61	88	76	67	60	49	51	41	38	30	29	16	54	76	841
18	43	2	6	10	13	7	3	0	0	1	0	9	89	66	76	62	67	78	55	42	35	1	3	5	673
19	2	2	1	0	0	0	0	0	0	23	51	34	34	48	43	40	42	76	19	7	0	0	0	0	425
20	0	0	0	0	0	0	0	5	0	1	0	0	9	48	20	10	27	32	9	1	0	1	1	0	165
21	0	7	33	0	1	2	1	0	0	3	1	0	0	1	0	25	14	24	3	3	4	6	2	0	131
22	4	0	0	0	2	7	2	0	0	0	5	34	32	25	22	28	28	27	36	54	28	20	26	15	396
23	22	24	15	22	15	16	17	1	0	0	1	15	32	34	37	33	30	8	23	15	6	10	13	13	402
24	17	22	18	9	16	21	19	4	0	1	12	39	43	27	19	13	7	8	3	0	0	7	9	4	318
25	0	0	0	1	0	0	0	0	0	7	43	38	42	15	13	17	95	3	25	28	24	8	2	15	375
26	8	27	38	20	15	14	14	2	1	0	0	4	3	14	38	22	22	30	36	16	6	5	0	14	347
27	48	9	0	4	2	9	9	0	0	0	3	44	51	68	54	39	37	38	28	5	4	4	15	3	473
28	0	0	1	1	10	11	11	4	0	0	1	37	39	48	40	27	28	46	46	38	20	0	0	0	408
29	0	0	0	0	0	0	0	0	0	5	22	26	53	68	53	50	48	53	44	34	25	18	28	4	533
30	0	0	0	0	0	0	0	0	0	1	18	25	37	54	50	53	28	20	32	34	50	34	43	38	517
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KWh	696	428	328	293	278	234	173	89	175	259	541	1175	1721	1726	1611	1543	1572	1340	1167	1081	797	694	730	555	19205

Besham **August 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	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
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
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
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
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
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	1	1	18	43	56	86	100	68	53	59	50	24	24	11	6	9	608
19	5	2	0	0	3	0	0	0	0	0	0	25	55	83	81	64	74	81	38	40	66	5	3	10	634
20	0	0	114	26	0	21	2	0	0	1	8	18	64	93	64	69	93	107	55	76	88	51	61	13	1023
21	1	0	0	0	0	0	7	1	0	9	81	122	129	114	74	93	107	53	26	20	24	34	2	0	894
22	1	1	2	0	1	0	0	0	0	2	24	55	74	69	47	36	36	24	12	40	18	4	5	3	453
23	12	7	5	2	0	16	0	0	0	0	11	64	74	74	78	50	40	40	34	43	18	20	21	4	613
24	0	0	0	0	0	0	1	1	0	18	78	102	61	22	80	63	45	47	34	20	12	57	58	12	711
25	17	0	0	0	5	1	0	0	0	0	13	74	93	64	78	49	34	6	3	3	13	14	17	17	499
26	5	0	12	1	0	3	0	0	0	0	0	37	127	43	17	31	5	0	0	0	0	8	8	6	301
27	17	11	12	8	14	11	12	6	12	5	0	12	83	69	78	64	33	9	2	43	131	123	115	131	1000
28	80	60	50	43	36	34	31	8	2	0	1	67	55	51	81	76	21	4	9	33	22	23	21	27	833
29	18	3	5	6	2	4	8	5	14	5	0	0	35	88	114	86	76	71	0	7	4	4	5	5	566
30	1	0	0	0	0	1	0	0	0	1	43	56	69	74	64	81	45	42	40	51	9	26	8	2	614
31	0	0	0	0	0	3	0	0	0	5	43	81	88	74	64	36	22	30	51	30	1	3	2	8	542
KWh	157	85	202	86	62	92	60	21	29	47	321	755	1061	1003	1020	867	682	573	353	429	429	382	331	244	9291

Besham **September 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	8	1	3	3	5	14	24	1	0	82	162	139	55	9	15	5	3	5	27	37	10	5	2	7	621
2	7	1	0	2	3	1	0	3	0	3	33	50	86	64	63	48	33	31	18	43	12	4	12	5	522
3	5	2	0	0	1	4	0	0	0	19	25	59	76	93	93	110	86	69	45	3	6	0	2	2	699
4	9	10	6	25	36	25	21	8	3	0	1	27	88	98	34	134	148	40	14	0	0	3	4	5	741
5	14	6	1	4	0	0	0	1	0	1	74	88	86	27	24	99	58	42	25	35	7	28	34	27	680
6	4	26	22	0	0	4	9	8	3	6	3	3	8	49	10	29	23	12	27	0	3	17	8	1	275
7	1	14	16	1	0	0	5	12	1	2	0	23	59	47	30	12	6	20	26	18	131	115	45	13	596
8	20	32	12	1	9	14	17	13	0	0	1	33	69	62	49	33	43	46	39	48	31	42	59	42	715
9	57	0	15	15	11	20	8	8	5	19	3	0	32	48	14	214	123	3	12	53	45	34	37	45	822
10	69	30	50	17	21	48	40	8	1	0	3	0	0	0	21	41	18	51	65	46	7	31	59	47	673
11	37	3	4	18	16	21	21	2	6	0	0	55	69	47	30	10	19	18	3	32	13	24	40	64	552
12	51	36	27	21	30	27	24	4	2	0	3	28	74	100	108	86	78	47	43	69	69	61	13	8	1007
13	4	1	0	0	0	0	0	0	0	0	0	32	59	47	69	64	69	64	53	40	50	69	37	18	676
14	12	8	0	0	0	0	0	0	0	10	31	40	86	59	69	74	64	55	59	64	43	47	22	1	744
15	11	4	1	2	2	0	0	0	0	19	78	74	55	74	53	36	30	36	40	50	21	5	2	4	595
16	1	0	0	1	0	0	0	0	0	0	32	74	81	55	59	47	30	18	25	17	15	6	9	3	471
17	21	4	3	27	24	34	33	48	10	0	0	30	97	130	101	114	81	13	5	6	33	56	0	12	881
18	2	16	5	0	7	5	3	3	0	0	0	61	81	78	81	69	64	51	31	34	26	27	9	6	658
19	2	6	1	3	1	0	0	0	0	1	48	61	31	55	38	45	125	96	36	32	10	24	31	36	682
20	59	68	102	43	22	12	8	9	0	51	6	7	1	0	1	0	0	0	5	23	27	18	14	8	485
21	11	18	10	6	0	7	9	1	2	0	0	0	0	0	0	4	0	3	22	127	68	122	130	92	633
22	56	31	19	13	4	3	5	5	0	0	0	0	0	0	6	9	14	14	11	88	198	50	36	81	643
23	59	21	31	25	51	100	37	46	188	200	266	200	145	123	31	7	9	1	17	12	27	19	11	13	1641
24	13	18	31	34	36	59	83	81	18	0	0	0	0	2	40	33	3	28	88	59	115	83	68	53	946
25	47	34	43	43	36	18	24	27	6	4	0	0	9	47	27	40	56	18	64	64	76	95	93	129	999
26	69	69	56	61	43	48	37	18	6	1	0	5	43	43	31	30	21	12	10	49	125	169	177	129	1251
27	100	122	90	48	36	33	36	17	8	1	0	0	1	39	22	9	10	7	3	35	95	62	124	115	1012
28	107	88	43	51	26	40	5	3	1	0	0	1	38	8	9	2	13	15	37	43	87	114	108	76	913
29	138	116	137	208	193	177	130	86	25	4	0	0	0	17	18	8	11	10	56	86	73	114	111	88	1804
30	108	64	76	64	50	47	55	48	13	6	1	0	1	27	30	21	1	50	153	168	153	153	129	121	1537
KWh	1103	846	804	737	664	760	635	457	297	430	771	1091	1428	1447	1175	1432	1239	876	1058	1381	1575	1595	1426	1248	24474

Besham October 2007 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	88	108	74	81	69	83	48	28	13	13	1	1	3	41	27	17	11	20	61	56	122	100	93	115	1270
2	93	107	88	67	43	55	43	35	14	7	0	0	0	0	85	258	99	52	35	107	129	161	193	200	1871
3	185	193	0	161	137	161	122	114	45	10	1	0	0	0	1	42	16	104	9	29	76	115	137	107	1762
4	114	122	81	40	64	71	51	53	14	2	0	0	0	0	28	25	20	38	99	208	193	138	100	121	1581
5	88	121	69	64	71	95	64	53	21	8	1	0	0	19	21	9	31	26	47	111	169	169	153	138	1547
6	154	125	104	86	67	67	40	40	16	11	0	0	12	22	22	90	188	259	192	88	61	169	131	162	2104
7	185	177	193	207	193	169	161	108	43	7	0	0	0	8	24	9	4	84	216	192	169	216	185	130	2677
8	177	122	108	74	59	85	69	48	15	11	3	0	6	43	17	11	7	64	81	138	138	133	161	137	1705
9	137	0	78	69	43	49	51	47	22	27	7	0	12	81	71	22	0	37	56	78	64	73	78	61	1163
10	64	115	90	75	64	61	56	40	11	6	0	0	21	59	30	12	13	26	76	66	105	116	101	115	1322
11	100	122	81	86	59	55	40	36	13	9	0	0	29	59	36	30	9	57	107	139	153	145	185	161	1711
12	145	153	107	59	55	59	45	30	13	4	0	0	16	47	40	19	13	12	24	71	145	161	153	130	1499
13	102	76	83	88	69	55	64	51	36	21	3	0	11	26	40	13	3	11	43	22	107	129	177	177	1407
14	137	108	114	86	67	64	59	40	23	13	7	0	17	61	32	19	81	252	110	169	73	66	110	178	1884
15	161	193	185	100	108	71	69	59	27	9	4	2	0	3	24	17	37	76	145	201	110	71	97	95	1864
16	137	81	56	67	55	55	59	43	18	4	0	1	59	50	24	17	21	3	18	34	17	33	43	53	946
17	42	56	37	27	36	40	36	30	7	0	0	11	46	11	11	1	2	19	34	69	146	93	138	89	982
18	100	122	56	73	51	30	40	31	11	0	0	0	27	40	64	55	40	15	6	9	36	33	67	129	1034
19	88	64	58	63	40	33	43	34	15	0	0	5	29	56	61	53	36	39	8	24	17	18	22	73	880
20	100	86	36	40	47	45	55	36	19	2	0	29	78	64	56	27	24	17	1	28	30	10	27	10	867
21	17	58	110	161	137	58	88	103	58	12	0	2	0	2	24	18	19	12	7	12	61	81	64	55	1160
22	45	36	40	34	37	40	47	56	37	8	1	0	0	10	30	9	1	40	21	50	93	95	122	130	981
23	129	76	78	55	59	69	64	56	48	11	1	0	1	32	43	13	17	5	19	57	86	53	65	115	1152
24	100	86	108	51	43	56	48	37	16	11	3	0	0	0	0	1	2	8	2	27	25	40	43	81	786
25	88	76	57	50	30	34	27	21	11	9	7	0	1	22	61	40	15	10	40	48	68	30	34	13	791
26	7	2	1	1	10	10	29	114	107	61	95	78	98	108	115	81	53	34	83	129	108	123	107	101	1653
27	107	71	88	101	103	81	96	86	83	7	0	0	1	0	0	1	20	69	69	50	55	64	81	69	1301
28	76	69	84	122	168	161	93	88	48	5	0	0	10	24	27	29	7	53	89	81	76	100	114	88	1611
29	76	88	81	59	59	47	65	69	34	13	3	0	0	15	37	48	21	5	27	25	34	91	130	169	1194
30	121	114	71	66	43	56	40	47	16	14	9	0	1	21	43	30	24	10	21	36	71	108	107	83	1152
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KWh	3160	2924	2416	2309	2087	2011	1812	1631	855	315	147	132	482	924	1093	1014	833	1457	1747	2353	2733	2930	3215	3280	41858

Besham November 2007 Wind Power Output of Bonus 600/44 Turbine (Month's Summary)

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	27	33	24	21	7	3	1	1	0	0	1	9	31	52	69	27	1	29	36	14	13	22	61	45	525
2	47	45	45	0	0	0	0	0	0	0	8	26	138	88	57	21	10	4	21	24	19	2	8	34	598
3	56	44	0	55	47	33	35	38	0	0	0	0	1	3	1	1	0	7	27	21	9	1	1	0	381
4	0	9	12	1	1	24	11	3	2	1	1	0	0	1	2	0	3	22	31	16	5	1	14	34	193
5	30	30	40	43	45	51	81	81	53	10	5	0	0	0	2	0	10	12	17	59	59	64	76	86	855
6	145	153	74	81	103	122	108	66	45	9	0	0	2	9	8	12	16	10	24	13	8	19	34	48	1107
7	3	38	34	12	43	36	31	18	9	6	0	0	2	26	64	43	43	37	12	24	15	3	8	22	529
8	27	27	34	43	27	33	24	27	14	7	0	0	3	46	48	40	14	0	1	8	1	3	5	55	485
9	47	0	14	30	30	30	12	5	5	0	0	0	23	70	31	16	13	0	1	1	3	17	4	7	358
10	5	60	50	12	41	35	18	27	9	4	0	0	14	86	76	72	101	74	88	131	88	50	48	51	1141
11	40	41	53	83	74	81	71	55	56	6	1	0	0	1	14	25	10	9	8	3	5	24	43	48	749
12	30	34	24	51	70	88	100	95	41	17	1	0	0	0	5	0	2	18	12	9	9	15	1	5	627
13	19	30	40	19	30	25	31	27	25	9	4	1	1	5	2	27	15	6	18	11	10	1	12	1	369
14	24	34	23	27	21	34	27	37	18	8	12	0	0	1	32	44	12	2	16	2	0	10	14	24	421
15	40	24	36	34	16	27	21	27	22	13	4	0	4	0	25	36	0	17	21	8	2	5	24	24	429
16	30	27	43	34	31	40	43	37	36	12	0	0	0	0	1	0	0	13	27	36	40	33	33	50	566
17	69	83	81	93	100	93	71	43	28	11	0	0	1	24	21	5	5	11	34	30	47	47	47	55	996
18	64	69	48	81	74	93	122	130	123	41	5	0	0	0	1	0	1	21	21	18	4	0	1	0	916
19	22	36	27	24	25	21	19	13	2	8	2	0	2	43	65	21	3	4	11	2	5	1	5	5	366
20	21	27	33	19	30	40	37	47	45	19	4	0	0	0	0	0	5	23	51	30	37	36	43	49	597
21	74	95	93	96	86	95	55	30	5	5	0	0	0	0	0	7	11	31	27	59	59	61	59	74	1022
22	81	93	95	108	83	95	61	63	18	11	0	0	0	0	14	3	4	24	22	48	43	59	107	88	1121
23	83	74	110	122	172	175	123	104	37	21	4	1	0	0	0	0	13	61	93	78	48	59	86	69	1533
24	74	51	50	64	56	114	121	129	86	72	13	0	0	0	0	0	26	64	88	86	81	86	100	100	1460
25	115	88	108	114	114	129	145	138	178	63	29	0	0	0	1	15	48	71	100	122	145	129	108	114	2073
26	137	161	122	145	146	146	137	137	109	96	18	0	0	0	0	0	19	47	69	61	48	40	40	43	1720
27	30	24	36	34	30	48	64	55	69	21	3	0	0	1	4	3	17	47	43	59	48	45	40	40	758
28	37	27	40	20	23	36	37	28	33	15	7	2	0	0	0	0	5	9	9	12	7	2	0	0	352
29	0	0	0	7	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	86	61	257
30	22	11	1	21	22	10	12	12	0	0	1	9	1	0	0	0	0	0	0	0	4	1	0	0	128
KWh	1396	1466	1388	1493	1557	1761	1620	1474	1068	484	121	52	222	457	545	417	407	673	927	985	863	919	1106	1231	22633

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

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	0	1	3	1	5	9	9	31	30	12	5	3	2	1	5	63	71	48	31	21	10	7	20	22	410
2	10	5	15	1	1	3	6	0	5	2	0	0	0	0	3	0	0	14	8	14	11	16	21	40	174
3	34	33	0	25	24	18	27	15	2	0	0	3	2	0	0	0	3	9	4	5	0	3	8	2	214
4	2	5	14	21	89	70	84	88	37	1	7	2	17	25	34	14	3	17	19	24	11	27	51	41	703
5	43	57	69	108	55	78	104	75	42	51	30	11	0	0	0	1	7	15	9	3	24	24	18	27	850
6	34	28	17	24	18	12	36	34	17	5	0	0	0	0	0	0	0	9	9	22	16	18	3	11	312
7	24	21	18	16	30	17	0	3	9	4	0	0	1	0	57	8	1	9	11	1	2	2	0	3	237
8	2	4	0	2	18	17	17	25	37	16	5	0	0	2	8	2	3	22	27	13	21	2	14	24	279
9	38	0	21	0	0	4	3	5	0	0	0	0	0	0	5	10	21	23	1	0	0	0	0	0	132
10	0	14	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	18	11	11	8	8	77
11	4	2	9	7	22	45	50	56	51	24	1	0	0	0	2	0	5	2	2	11	2	11	2	7	314
12	9	5	9	17	27	25	33	33	23	3	2	0	1	0	5	0	0	9	37	48	59	74	51	68	538
13	47	37	21	15	21	33	34	31	27	30	21	31	21	0	1	0	0	4	8	30	24	22	25	40	520
14	24	24	22	27	21	30	31	27	25	14	8	1	0	0	1	0	1	5	34	34	48	64	55	83	577
15	103	115	138	122	60	53	31	20	30	47	29	64	86	88	51	19	0	27	40	53	30	51	60	45	1361
16	36	17	27	32	21	15	31	27	23	19	15	37	78	55	21	10	7	27	71	81	93	76	81	109	1008
17	81	115	146	137	40	27	11	7	7	19	79	153	130	129	215	215	169	30	57	88	34	81	78	138	2185
18	74	86	83	133	153	107	127	69	76	59	59	90	103	124	159	146	116	169	229	153	145	169	130	64	2822
19	80	61	107	100	153	201	133	95	76	64	25	5	17	22	17	5	2	10	14	18	26	17	5	5	1256
20	85	106	88	83	29	5	7	17	16	13	17	24	38	60	81	46	64	60	34	16	24	42	28	17	998
21	1	2	1	0	0	0	3	2	1	2	1	0	0	0	7	11	3	1	15	51	107	161	130	99	598
22	138	130	201	245	161	103	108	118	74	61	126	184	184	200	185	169	122	116	98	59	93	176	154	145	3348
23	162	169	161	153	169	176	155	100	50	94	95	90	95	66	69	61	45	40	51	31	30	27	21	21	2129
24	3	19	31	36	34	24	14	10	2	3	3	0	4	30	15	18	38	24	30	56	51	25	43	56	568
25	93	107	122	145	100	139	137	129	163	89	37	80	100	121	145	122	76	31	68	122	131	131	88	88	2561
26	115	83	74	49	61	45	51	50	46	45	45	25	76	130	153	93	27	65	114	138	81	145	107	100	1917
27	93	93	93	83	100	170	131	207	80	23	35	49	177	185	170	102	35	48	122	130	122	118	88	107	2558
28	100	115	93	114	177	137	104	75	51	55	60	32	64	47	25	22	0	34	50	43	22	6	2	2	1428
29	2	14	22	19	31	55	50	69	69	32	10	1	0	3	0	0	0	17	40	50	43	33	40	40	640
30	43	48	36	56	59	69	74	100	81	47	34	0	0	0	10	5	8	48	83	78	107	115	193	178	1471
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KWh	1477	1516	1645	1769	1677	1685	1598	1514	1147	834	748	885	1196	1286	1441	1142	829	929	1316	1409	1377	1652	1524	1588	32184