PAKISTAN METEOROLOGICAL DEPARTMENT

A STUDY OF WIND POWER POTENTIAL AT Bahrain - SWAT

Technical Report No. PMD-02/2010

(Final report based on 36 months data)

FEBRUARY-2010

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 thirty (36) months wind data which has been presented along with the wind generated electric power at Bahrain-Swat, NWFP. 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 4.74 m/s during 36 months August-2006 to August-2009, the highest of 5.61 m/s is observed in December. Diurnal Wind variation indicates that maximum wind speed is available in the day time thought-out the year. Wind frequency distribution shows that during 48% 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 Bahrain is 139 W/m^2 according to international wind classification, this power density categorize Bahrain as a below marginal site for wind power generation.

Wind generated electric power has as also been computed on hypothetical 600KW wind turbine and its hourly, monthly and annual values has been added in this report. The total power production form a single 600KW wind turbine come out to 666,172 KWh which shows the capacity factor of 13% for Bahrain. 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 Bahrain and surrounding areas can be classified as non-suitable site for installing big economically viable wind farms but small wind turbines can be installed.

1. Introduction:

Wind energy is the fastest growing renewable energy source today. A continued interest in wind energy development worldwide has produced steady improvements in technology and performance of wind power plants. New wind power projects have proven that wind energy not only is cost competitive but also offers additional benefits to the economy and the environment.

A steady supply of reasonably strong wind is necessary requirement for utilizing the power in the wind. Development of wind energy depends upon a clear understanding of wind resources. Site location, turbine performance and physical effects of turbulence and energy extraction represent a few of the issues that must be addressed by anyone interested in developing wind energy.

As such any plan to develop wind energy must begin by understanding the wind resource. Where are the best potential wind sites located? How much energy could be extracted from the wind at those sites?

1.1 **Characteristic of wind:**

The global winds are caused by pressure differential across the earth's surface. The amount of solar radiation absorbed at the earth's surface is greater at the equator than at the poles. This variation in incoming heat sets up convective cells in the lowest layer of the atmosphere. In the simplest form air rises at the equator and sinks at the poles. However the rotation of the earth complicates this simple heat transfer. A series of circulations are set up in both northern and southern hemispheres.

The areas of the globe where air is descending are zones of high pressure and where the air is ascending, low-pressure zones are formed. The pressure gradient drives the flow of air from high to low pressure, thus causing the wind. The wind is then acted on the corriolis force due to the earth's rotation. The resultant wind is turned easterly or westerly. On a smaller scale, wind is created because of temperature difference between land and sea and mountains and valleys. The local topographical features and roughness of the terrain also cause air movements.

2.0 **Wind Mapping Project of Pakistan Meteorological Department:**

As any plan to develop wind energy must begin by understanding the wind resources. Where are the best potential wind sites located? How much energy could be extracted from the wind at those sites? Will the wind turbine performance be affected by the turbulence or other wind resource characteristics?

To answer these questions and to provide wind resource database for the different potential parts of the country, Pakistan Meteorological Department prepared a phased programme. Government of Pakistan, Ministry of Science and Technology provided the necessary funding for undertaking the Phase II. Second phase covers the Northern areas of Pakistan.

2.1 Study Area:

The project area for the wind mapping Phase-II covers the Northern areas of Pakistan including Districts are Swat, Dir, Chitral, Gilgit, Skardu, Haripur, Shangla, Buneer, Nowshara, Peshawar, Mohmad Agency, Khyber Agency and Azad Kashmir.

Forty-Two (42) stations for collecting wind data have been installed to study the wind regime as shown in Wind Mapping Sites (Phase-II) map. The list of stations is given below:

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

Bahrain site is situated district Swat (NWFP). Latitude & Longitude of Bahrain is: **Latitude = 34.71° Longitude = 72.19°, Elevation = 4682 Ft.**

2.2 Data source:

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

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

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

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

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

3.0 Methodology; Analysis & Discussion:

3.1 Wind speed variation with height:

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

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

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

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

For saving money in this survey also the wind has been recorded at 10 & 30 meters and for calculating the wind speed at 50 meters the following two methods has been used in this study.

3.1.1 *Log Law:*

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

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

Where

u_* is the friction notify

k is the von Karman constant

$\mathbf{Z_o}$ is the roughness length

D is the displacement height

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

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

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

Where

U_R is the wind speed at reference height Z_R

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

3.1.2 ***Power Law:***

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

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

Where:

α is the power law exponent

u_R is the wind speed at reference height z_R

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

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

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

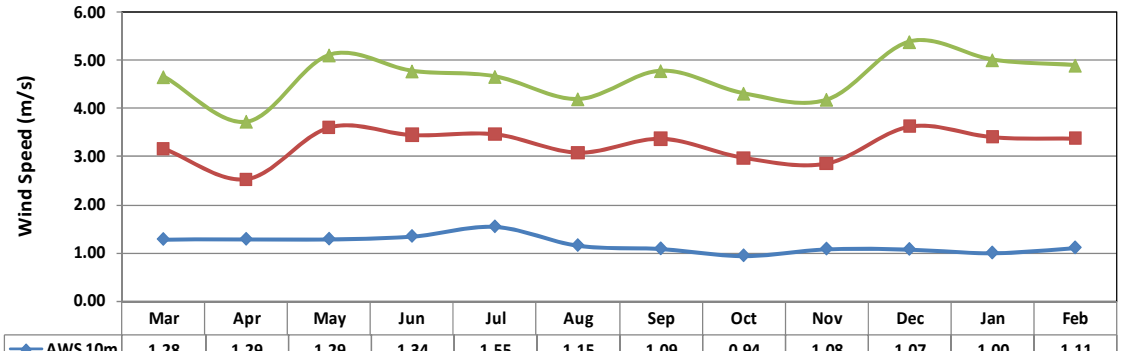
Type of terrain	**Z_0**	**α**
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb	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 03 years monthly average wind speed at height of 10 meters, 30 meters and 50 meters. At 30 meters height, we have the maximum average wind speed of 3.63 m/s during December. At 50 meters we have the average wind speed of 4.74 m/s and the highest average wind speed of 5.39 m/s is observed during the month of December.

Fig-1

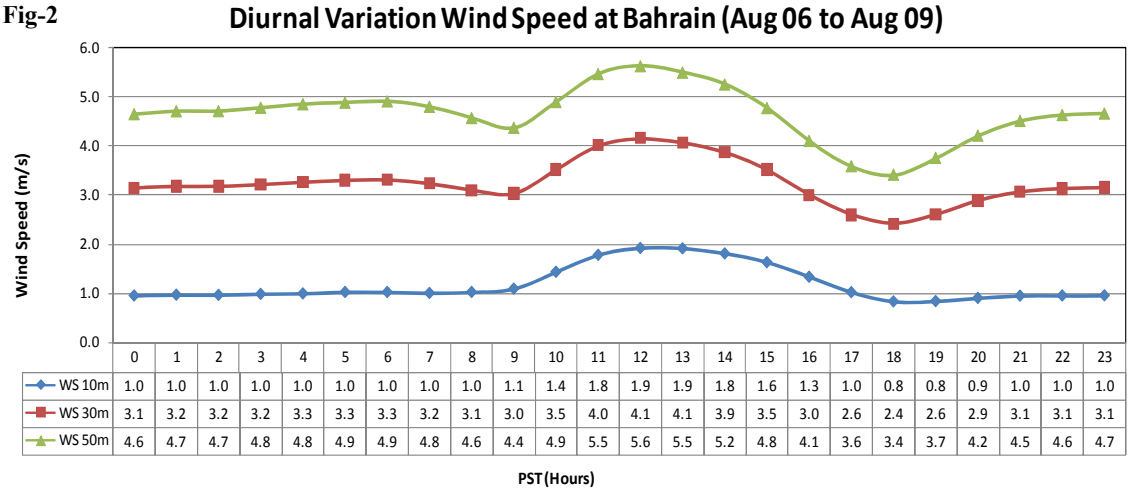


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AWS 10m	1.28	1.29	1.29	1.34	1.55	1.15	1.09	0.94	1.08	1.07	1.00	1.11
AWS 30m	3.16	2.53	3.61	3.45	3.47	3.08	3.37	2.97	2.86	3.63	3.40	3.37
AWS 50m	4.66	3.73	5.11	4.78	4.66	4.20	4.78	4.32	4.19	5.39	5.01	4.90

3.3 Diurnal Wind speed Variation:

Fig-2 shows the diurnal wind speed variations at Bahrain from Aug-06 to Aug-09 (36 months). The wind speed is generally higher during day time as compare to night time. At mid day it reaches maximum, wind speeds are around 4.0 m/s and 5.6 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 5.6 m/s at 12 pm.

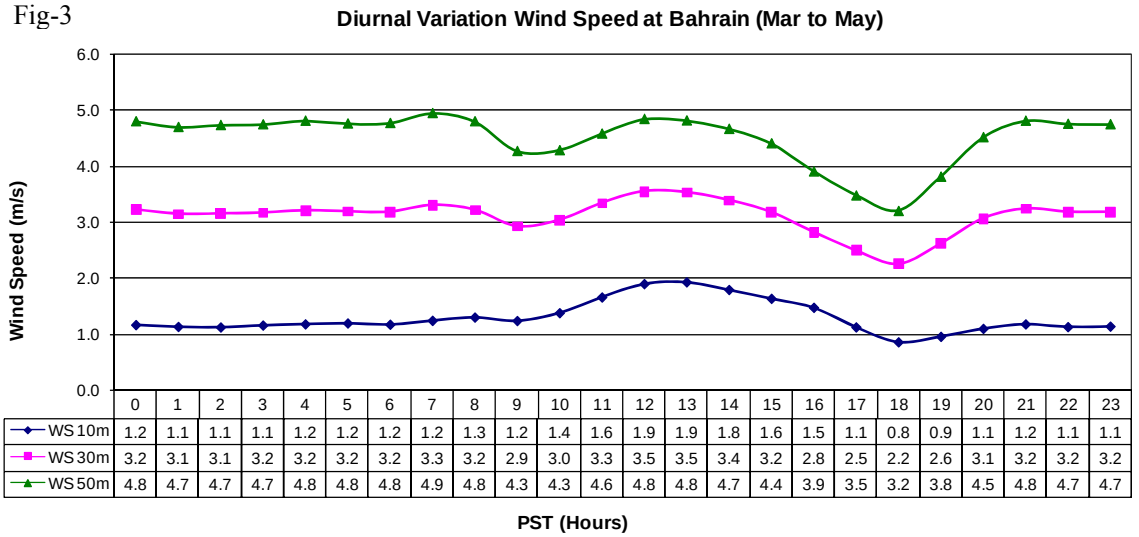
Fig-2



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.4	1.8	1.9	1.9	1.8	1.6	1.3	1.0	0.8	0.8	0.9	1.0	1.0	1.0
WS 30m	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.2	3.1	3.0	3.5	4.0	4.1	4.1	3.9	3.5	3.0	2.6	2.4	2.6	2.9	3.1	3.1	3.1
WS 50m	4.6	4.7	4.7	4.8	4.8	4.9	4.9	4.8	4.6	4.4	4.9	5.5	5.6	5.5	5.2	4.8	4.1	3.6	3.4	3.7	4.2	4.5	4.6	4.7

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

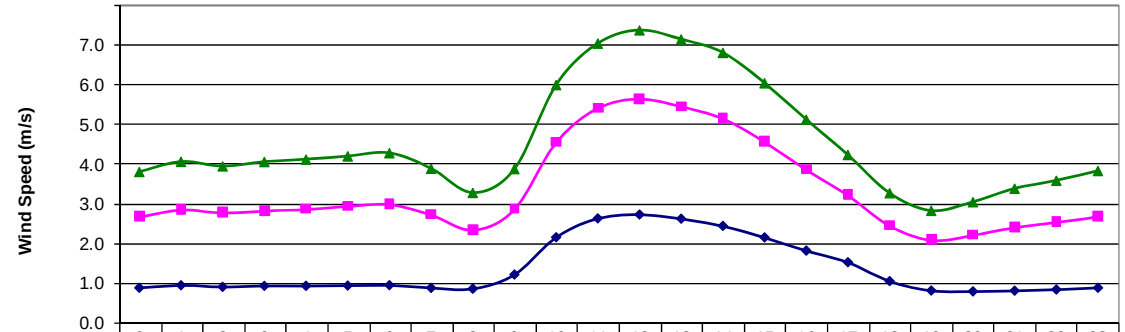
Fig-3



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.2	1.4	1.6	1.9	1.9	1.8	1.6	1.5	1.1	0.8	0.9	1.1	1.2	1.1	1.1
WS 30m	3.2	3.1	3.1	3.2	3.2	3.2	3.2	3.3	3.2	2.9	3.0	3.3	3.5	3.5	3.4	3.2	2.8	2.5	2.2	2.6	3.1	3.2	3.2	3.2
WS 50m	4.8	4.7	4.7	4.7	4.8	4.8	4.8	4.9	4.8	4.3	4.3	4.6	4.8	4.8	4.7	4.4	3.9	3.5	3.2	3.8	4.5	4.8	4.7	4.7

Fig-4

Diurnal Variation Wind Speed at Bahrain (Jun to Aug)

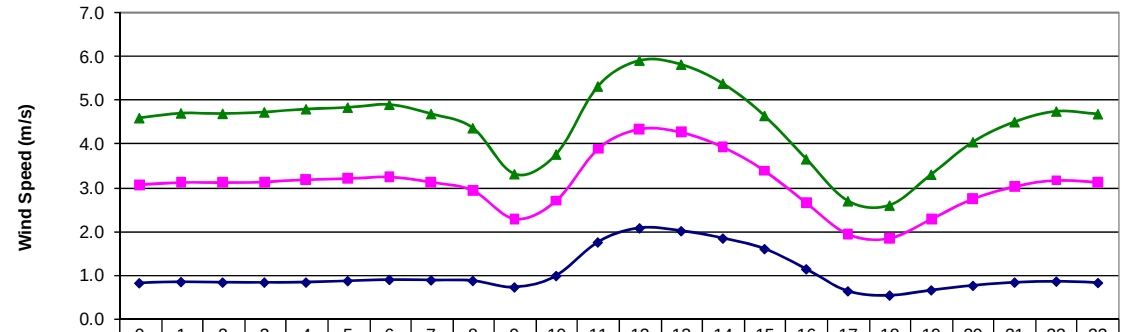


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	1.2	2.2	2.6	2.7	2.6	2.4	2.1	1.8	1.5	1.0	0.8	0.8	0.8	0.8	0.9
WS 30m	2.7	2.8	2.8	2.8	2.9	2.9	3.0	2.7	2.3	2.9	4.5	5.4	5.6	5.4	5.1	4.6	3.9	3.2	2.4	2.1	2.2	2.4	2.5	2.7
WS 50m	3.8	4.1	3.9	4.1	4.1	4.2	4.3	3.9	3.3	3.9	6.0	7.0	7.4	7.1	6.8	6.0	5.1	4.2	3.3	2.8	3.0	3.4	3.6	3.8

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Bahrain (Sep to Nov)

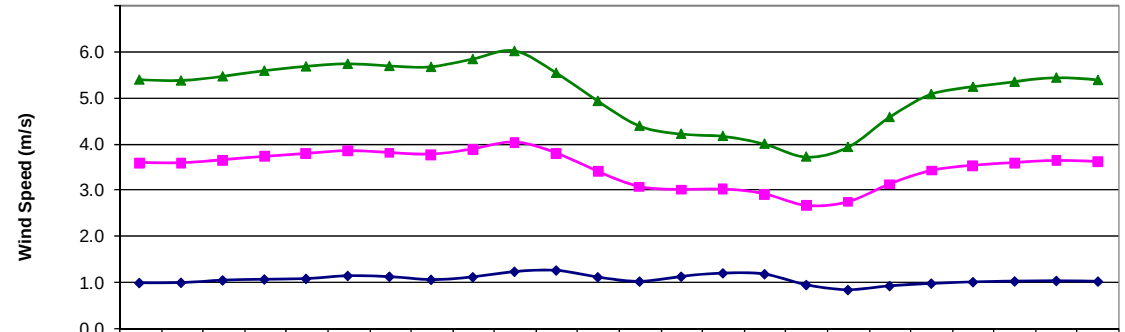


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.7	1.0	1.7	2.1	2.0	1.8	1.6	1.1	0.6	0.5	0.7	0.8	0.8	0.9	0.8
WS 30m	3.1	3.1	3.1	3.1	3.2	3.2	3.2	3.1	2.9	2.3	2.7	3.9	4.3	4.3	3.9	3.4	2.6	1.9	1.8	2.3	2.7	3.0	3.2	3.1
WS 50m	4.6	4.7	4.7	4.7	4.8	4.8	4.9	4.7	4.4	3.3	3.8	5.3	5.9	5.8	5.4	4.6	3.6	2.7	2.6	3.3	4.0	4.5	4.7	4.7

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Bahrain (Dec to Feb)



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.3	1.1	1.0	1.1	1.2	1.2	0.9	0.8	0.9	1.0	1.0	1.0	1.0	1.0
WS 30m	3.6	3.6	3.7	3.7	3.8	3.8	3.8	3.8	3.9	4.0	3.8	3.4	3.1	3.0	3.0	2.9	2.7	2.7	3.1	3.4	3.5	3.6	3.6	3.6
WS 50m	5.4	5.4	5.5	5.6	5.7	5.7	5.7	5.7	5.8	6.0	5.5	4.9	4.4	4.2	4.2	4.0	3.7	3.9	4.6	5.1	5.2	5.3	5.4	5.4

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:*

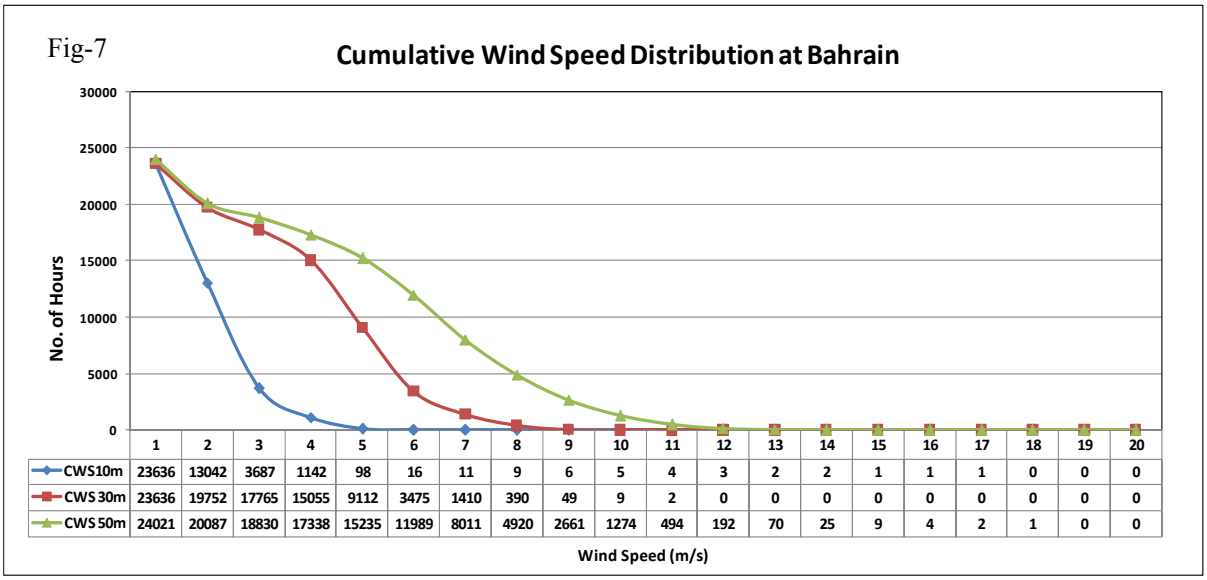
It is proportional wind speed in each bin. It can be viewed as the estimate of probability of given wind speed in the bin. Relative frequency is defined as:

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 (Aug-06 to Aug-09) Cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters. The analysis indicate that in 03-years at a height of 30 meters during 9112 hours the wind speed is greater than 5 m/s whereas at 50 meters, during 15235 hours the wind speed is equal or greater than 5m/s.

Fig-7

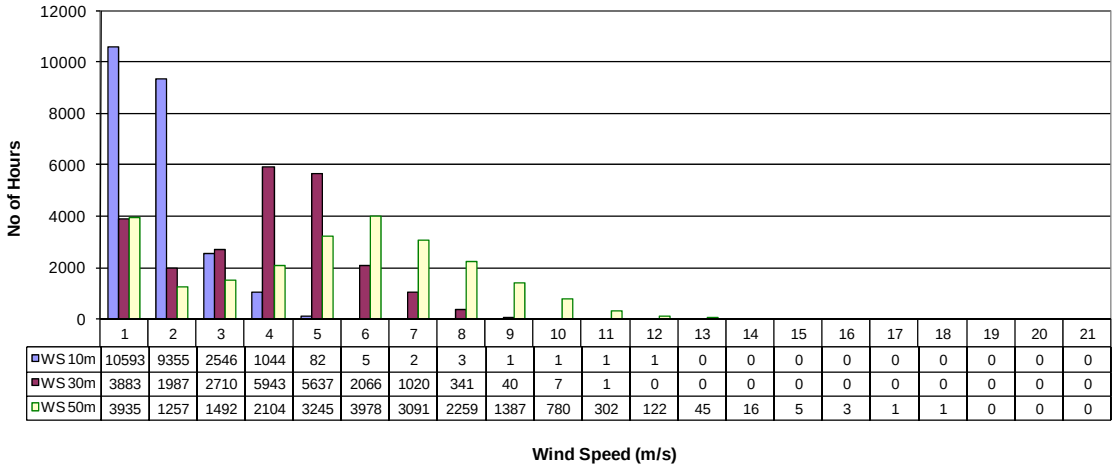


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CWS10m	23636	13042	3687	1142	98	16	11	9	6	5	4	3	2	2	1	1	1	0	0	0
CWS 30m	23636	19752	17765	15055	9112	3475	1410	390	49	9	2	0	0	0	0	0	0	0	0	0
CWS 50m	24021	20087	18830	17338	15235	11989	8011	4920	2661	1274	494	192	70	25	9	4	2	1	0	0

3.4.4 *Wind Frequency Distribution:*

Fig-8 shows the total wind frequency distribution at Bahrain for three years. We can see that at 50 meters during 3245 hours wind speed is 5 m/s, 3978 hours speed is 6 m/s, 3091 hours speed is 7 m/s and so on.

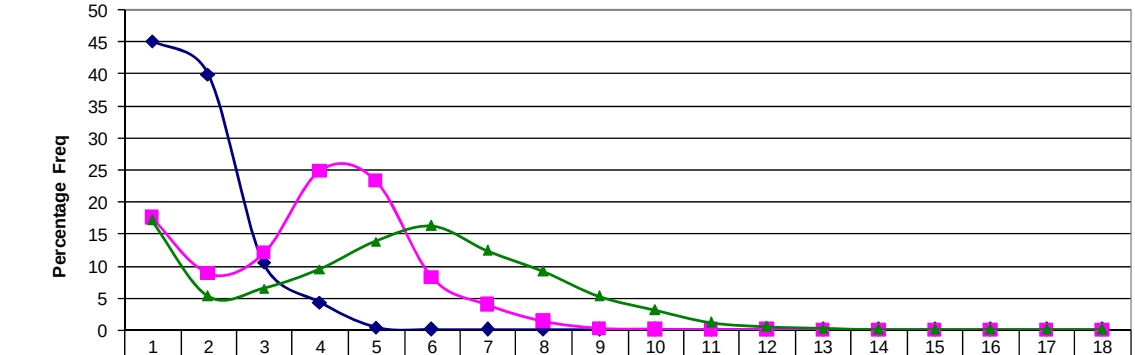
Fig-8 **Wind Frequency Distribution at Bahrain (All Data)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	10593	9355	2546	1044	82	5	2	3	1	1	1	1	0	0	0	0	0	0	0	0	0
WS 30m	3883	1987	2710	5943	5637	2066	1020	341	40	7	1	0	0	0	0	0	0	0	0	0	0
WS 50m	3935	1257	1492	2104	3245	3978	3091	2259	1387	780	302	122	45	16	5	3	1	1	0	0	0

Fig-9 gives this frequency distribution in percentage. At 50 meters we find that during 13.8% of time wind is 5m/s, 16.2% of the time 6m/s and 12.4% of the time it is 7m/s. whereas at 30 meters height we get 23.3% of the time wind speed 5m/s, 8.1% of the times 6m/s and 4.0% of the time 7m/s.

Fig-9 **Percentage Wind Frequency Distribution at Bahrain (All Data)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	45.0	39.9	10.4	4.2	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	0.0
WS 30m	17.5	8.8	12.0	24.8	23.3	8.1	4.0	1.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	17.1	5.2	6.5	9.5	13.8	16.2	12.4	9.1	5.3	3.1	1.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0

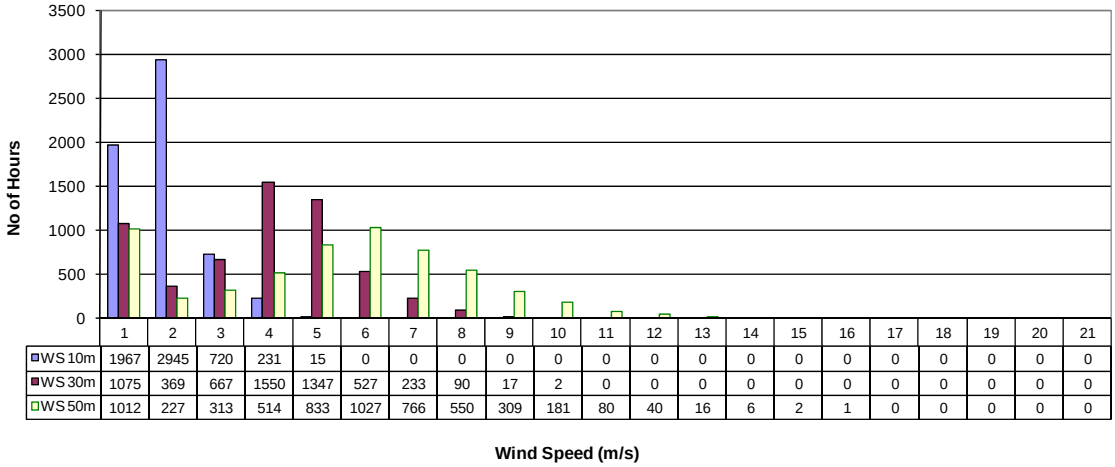
3.4.5 *Seasonal Wind Frequency Distribution:*

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

Mar – May

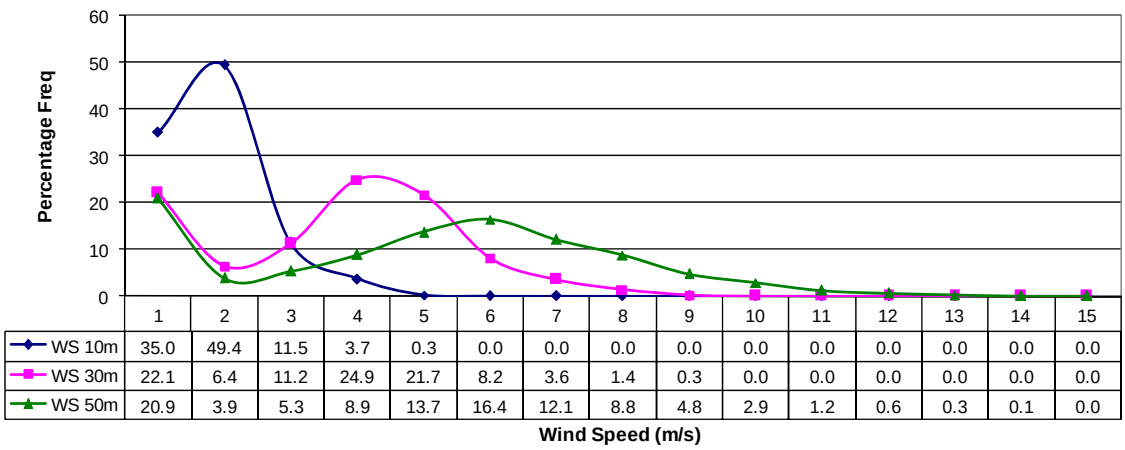
Fig-10 shows this distribution during the months of March to May. We can see that in this period at 30 meters height during 1347 hours we get 5m/s, 527 hours 6m/s, 233 hours 7m/s. Similarly at 50 meters we get 833 hours 5m/s, 1027 hours 6m/s, 766 hours 7m/s. Fig-11 shows percentage frequency distribution for Mar to May.

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	1967	2945	720	231	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1075	369	667	1550	1347	527	233	90	17	2	0	0	0	0	0	0	0	0	0	0	0
WS 50m	1012	227	313	514	833	1027	766	550	309	181	80	40	16	6	2	1	0	0	0	0	0

Fig-11



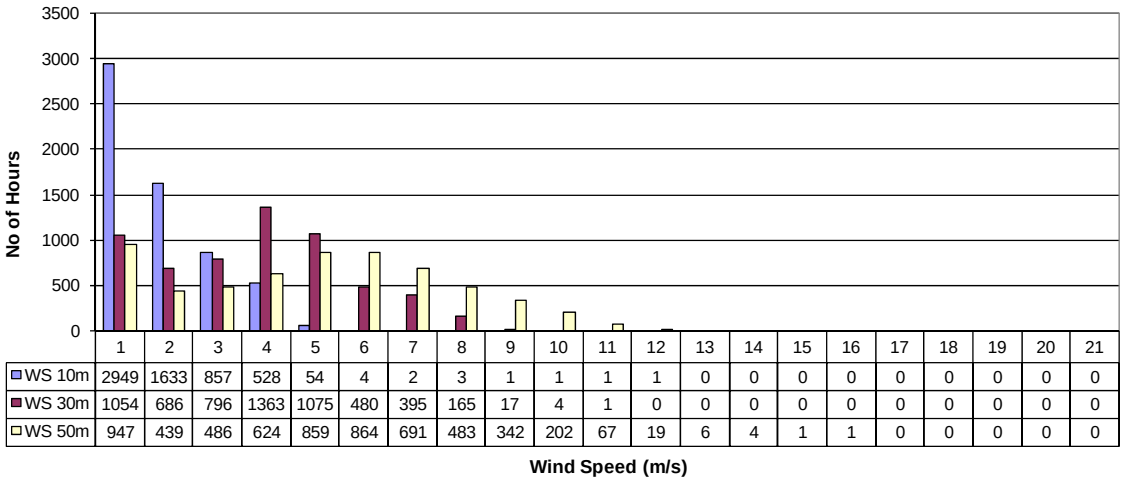
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	35.0	49.4	11.5	3.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	22.1	6.4	11.2	24.9	21.7	8.2	3.6	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	20.9	3.9	5.3	8.9	13.7	16.4	12.1	8.8	4.8	2.9	1.2	0.6	0.3	0.1	0.0

Jun – Aug

Fig-12 shows wind frequency distribution during the months of June to August. We can see that in this period at 30 meters height during 1075 hours we get 5m/s, 480 hours 6m/s, 395 hours 7m/s.

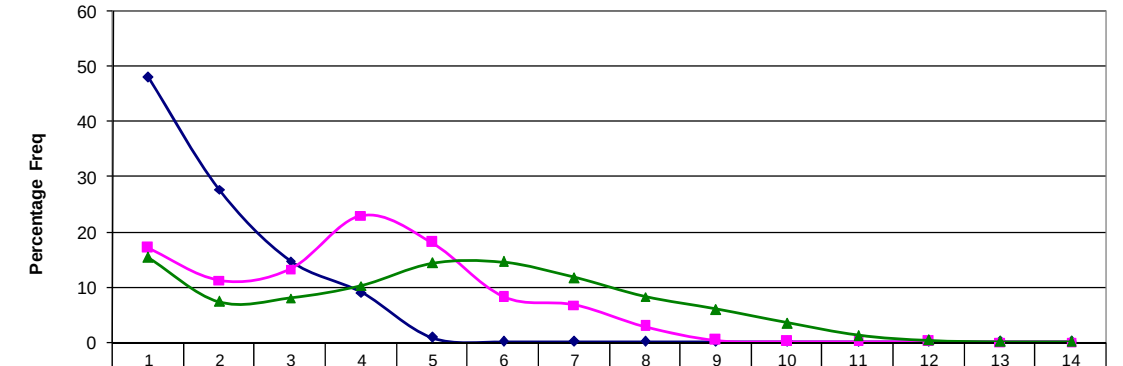
Similarly at 50 meters height during 859 hours we get wind speed of 5m/s, during 864 hours 6m/s, 691 hours 7m/s, 483 hours 8m/s. Fig-13 shows this distribtution in percentage.

Fig-12



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	2949	1633	857	528	54	4	2	3	1	1	1	1	0	0	0	0	0	0	0	0	0
WS 30m	1054	686	796	1363	1075	480	395	165	17	4	1	0	0	0	0	0	0	0	0	0	0
WS 50m	947	439	486	624	859	864	691	483	342	202	67	19	6	4	1	1	0	0	0	0	0

Fig-13



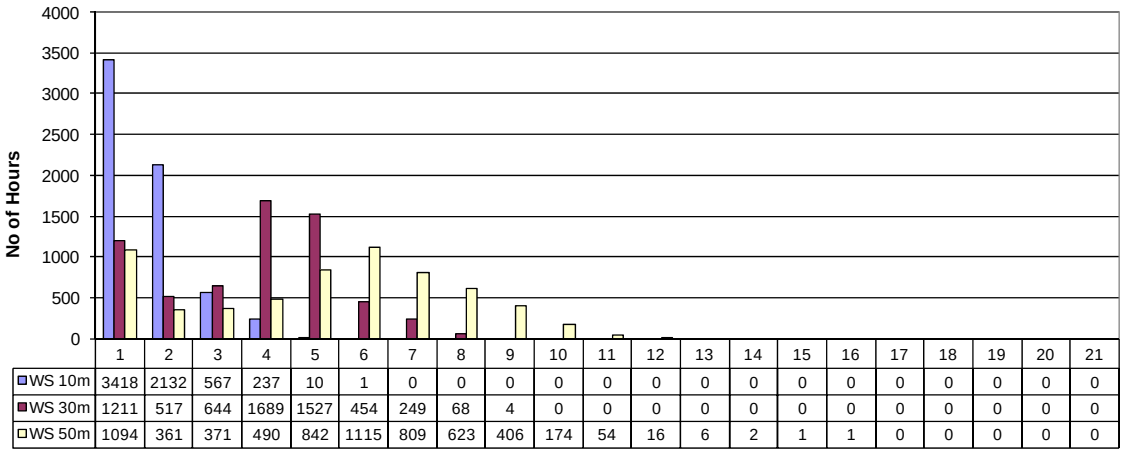
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WS 10m	47.8	27.6	14.7	8.9	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	17.0	11.1	13.1	22.8	18.0	8.1	6.7	2.7	0.3	0.1	0.0	0.0	0.0	0.0
WS 50m	15.2	7.3	7.9	10.2	14.3	14.5	11.6	8.2	5.9	3.4	1.1	0.3	0.1	0.1

Sep – Nov

Fig-14 shows wind frequency distribution during the months of September to November. We can see that in this period at 30 meters height during 1527 hours we get 5m/s, 454 hours 6m/s, 249 hours 7m/s.

Similarly at 50 meters height during 842 hours we get wind speed of 5m/s, during 1115 hours 6m/s, 809 hours 7m/s, 623 hours 8m/s. Fig-15 shows distribution in percentage.

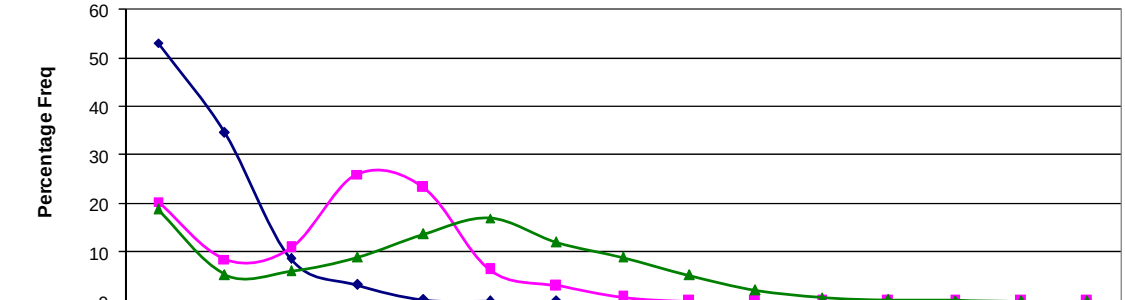
Fig-14 **Wind Frequency Distribution at Bahrain (Sep-Nov)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	3418	2132	567	237	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	1211	517	644	1689	1527	454	249	68	4	0	0	0	0	0	0	0	0	0	0	0	0
WS 50m	1094	361	371	490	842	1115	809	623	406	174	54	16	6	2	1	1	0	0	0	0	0

Wind Speed (m/s)

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



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	53.0	34.6	8.8	3.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	20.4	8.6	10.9	26.1	23.4	6.5	3.2	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	18.9	5.4	6.2	8.9	13.8	17.1	12.1	9.0	5.3	2.3	0.6	0.2	0.1	0.0	0.0

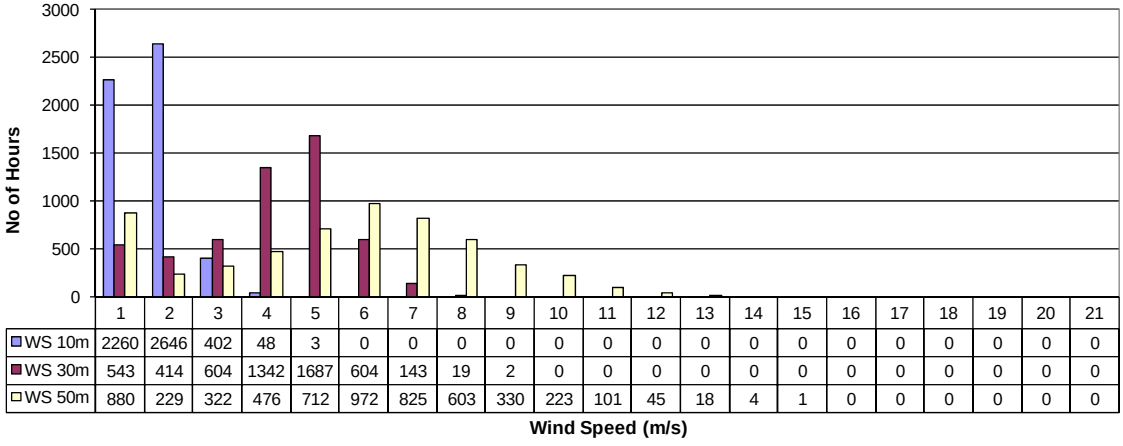
Wind Speed (m/s)

Dec – Feb

Fig-16 shows wind frequency distribution during the months of December to February. We can see that in this period at 30 meters height during 1687 hours we get 5m/s, 604 hours 6m/s, 143 hours 7m/s.

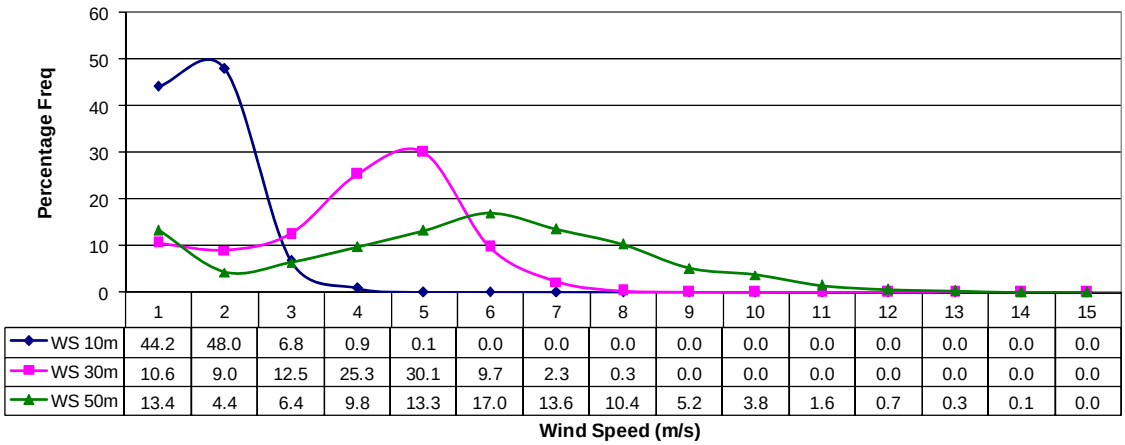
Similarly at 50 meters height during 712 hours we get wind speed of 5m/s, during 972 hours 6m/s, 825 hours 7m/s, 603 hours 8m/s. Fig-17 shows distribution in percentage.

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	2260	2646	402	48	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	543	414	604	1342	1687	604	143	19	2	0	0	0	0	0	0	0	0	0	0	0	0
WS 50m	880	229	322	476	712	972	825	603	330	223	101	45	18	4	1	0	0	0	0	0	0

Fig-17



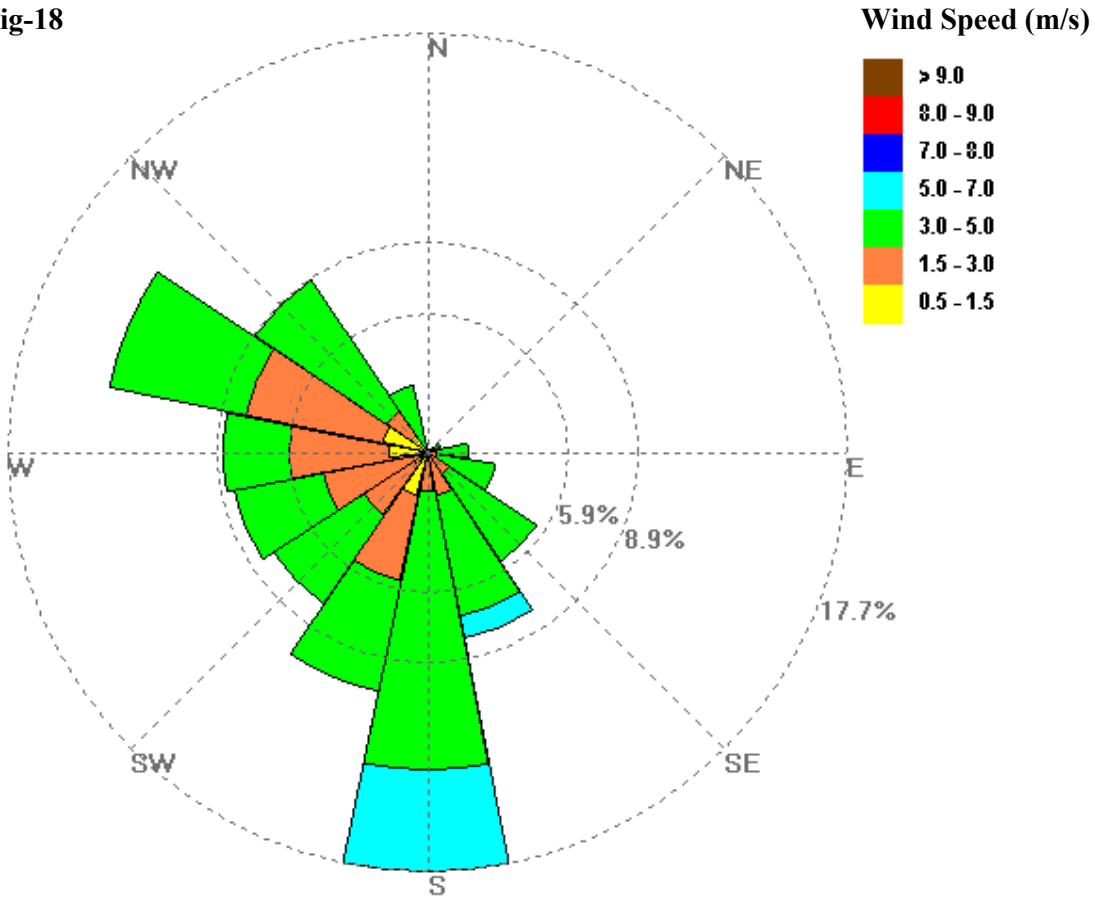
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	44.2	48.0	6.8	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	10.6	9.0	12.5	25.3	30.1	9.7	2.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WS 50m	13.4	4.4	6.4	9.8	13.3	17.0	13.6	10.4	5.2	3.8	1.6	0.7	0.3	0.1	0.0

3.5 **Wind Rose:**

Fig-18 shows the Wind Rose based on 36 months data from August 2006 – August 2009 collected at 30 meters height. Wind Rose indicates that the wind direction is distributed between south and North West. The average wind speed is 3.35 m/s and the percentage of wind speed greater than 5 m/s is 14%.

Wind Rose at Bahrain (30m height during 36 months)

Fig-18



Average Wind Speed	Wind speed greater than 5 m/s	Comments
3.35 m/s	14%	

3.6 Wind speed statistic:

3.6.1 *The statistical Mean:*

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

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

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

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

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

3.6.2 *Variance:*

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

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

Where V is mean of data set

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

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

3.6.3 *Standard Deviation*

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

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

3.7 Wind power density:

While investigating a wind power potential of an area, the average values of wind speed does not truly represent this potential because lot of information regarding frequency distribution of wind speed is suppressed in the process of averaging wind speed. As such the most important values for estimating the wind power potential of a given site is the value of the wind power density or the available theoretical instantaneous power from the wind. This available wind

power in the wind is the flux of Kinetic Energy crossing the wind energy conversion system and its cross – sectional area.

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

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

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

3.7.1 *Wind power classes:*

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

Table-2: International Wind Power Classification

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

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

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

A parcel of Wind possesses kinetic energy

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

From this, power density is calculated as

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

Where $\tfrac{dm}{dt}$ is the mass of air following time.

From fluid dynamics, it can be proved that

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

Volume of cylindrical cross section can be written as

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

Where r is radius of cylinder and L is length of it.

The wind moving with velocity V travels this distance L in time t so

$$S = L = Vt,$$

So equation L takes the form

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

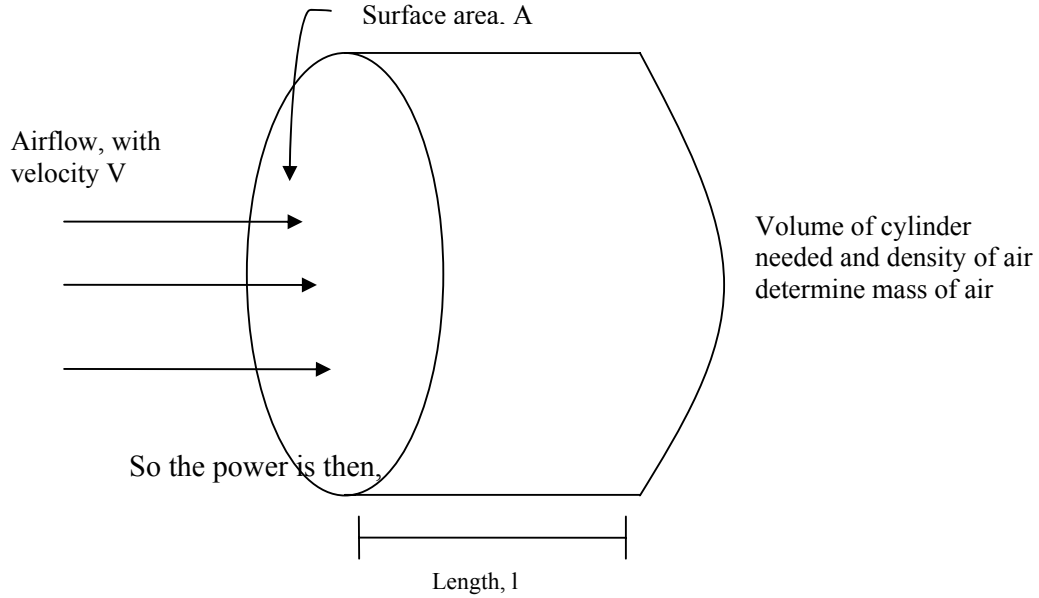
Now mass of wind can be written as

$$M = \varphi Avt$$

Differentiating

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

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



So the power is then,

$$P = \tfrac{1}{2} \, {dm}/{dt} \; V^2 = \tfrac{1}{2} \varphi A V T / t \; V^2$$

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

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.

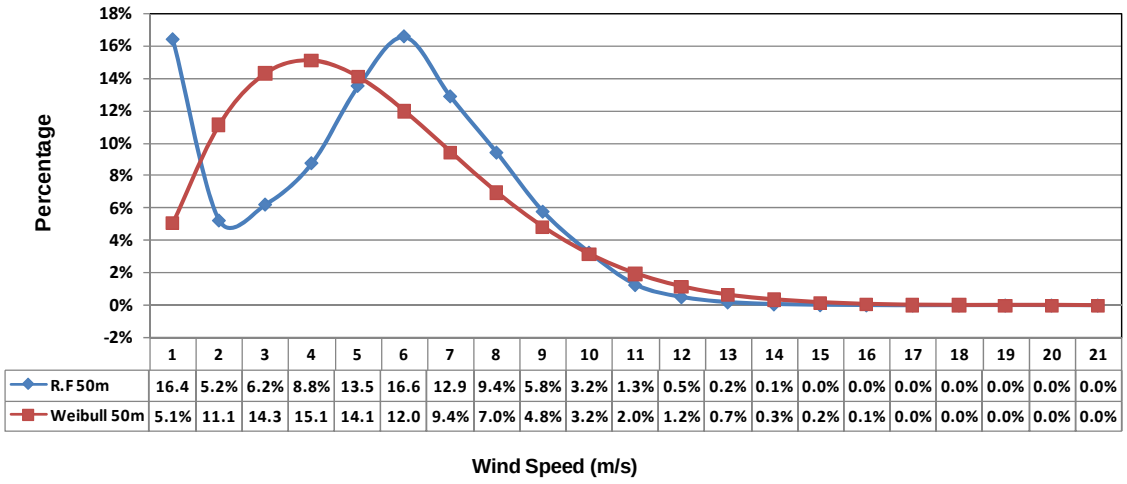
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion 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 and Weibull Probability at Bahrain (50m 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	16.4	5.2%	6.2%	8.8%	13.5	16.6	12.9	9.4%	5.8%	3.2%	1.3%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	5.1%	11.1	14.3	15.1	14.1	12.0	9.4%	7.0%	4.8%	3.2%	2.0%	1.2%	0.7%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in **Table-3** along with other key results of analysis. If we look at the shape parameters K and scale parameter C for 50 meters height we can find that the shape parameter **K** varies over a wind range from the lowest of 1.47 during January to the highest of 2.50 during the month of December with a Annual value of K being 1.86.

The lowest values of the scale parameter **C**, 4.62 is observed in August while the highest value of 6.32 is obtained in December and with an Annual value of 5.32.

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 1.27 m/s with Standard deviation of 0.83, at 30 meters this average speed is 3.35 m/s with Standard deviation of 1.75. At 50 meters the monthly average wind speed varies from the lowest of 4.14 m/s in August to highest of 5.61 m/s during December. Whereas the average wind speed is 4.74 m/s with Standard deviation of 2.70.

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 1.82 W/m^2 in January to 1.95 W/m^2 in December with Average of 3.42 W/m^2.

At 30 meters height the power density varies from 42.95 W/m^2 in January to 45.62 W/m^2 in December and the average values is about 44.08 W/m^2.

At 50 meters height the power density of Bahrain varies from 147.76 W/m^2 in January to 170.39 W/m^2 in December. The average power density of the area is 139.0 W/m^2.

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

	10 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	1.12	0.64	1.26	1.83	**1.82**
February	1.21	0.70	1.37	1.82	**2.35**
March	1.35	0.73	1.52	1.95	**2.93**
April	1.36	0.78	1.53	1.83	**3.24**
May	1.42	0.87	1.60	1.71	**4.01**
June	1.41	0.97	1.57	1.51	**4.65**
July	1.52	1.06	1.68	1.48	**6.00**
August	1.24	1.20	1.26	1.04	**6.41**
September	1.14	0.88	1.24	1.33	**3.00**
October	1.05	0.80	1.15	1.36	**2.29**
November	1.21	0.74	1.35	1.71	**2.44**
December	1.19	0.62	1.34	2.01	**1.95**
Average	**1.27**	**0.83**	**1.41**	**1.63**	**3.42**
	30 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	3.46	1.61	3.91	2.30	**42.95**
February	3.48	1.64	3.93	2.26	**43.99**
March	3.23	1.87	3.63	1.81	**43.89**
April	3.04	1.87	3.40	1.69	**39.50**
May	3.71	1.57	4.18	2.54	**48.89**
June	3.45	1.88	3.89	1.94	**49.50**
July	3.42	1.96	3.85	1.83	**51.48**
August	3.04	1.94	3.40	1.63	**41.91**
September	3.54	1.76	4.00	2.14	**48.89**
October	3.03	1.82	3.40	1.74	**37.85**
November	3.06	1.66	3.45	1.94	**34.47**
December	3.74	1.38	4.20	2.95	**45.62**
Average	**3.35**	**1.75**	**3.77**	**2.06**	**44.08**
	50 m				
	AvgV (m/s)	St Dev	C (m/s)	K	**P/A (w/m^2)**
January	4.32	3.03	4.88	1.47	**147.76**
February	5.10	2.68	5.76	2.01	**154.57**
March	4.67	2.95	5.22	1.65	**148.59**
April	4.33	2.85	4.82	1.58	**125.83**
May	5.27	2.33	5.95	2.43	**144.86**
June	4.79	2.70	5.42	1.87	**139.88**
July	4.66	2.69	5.24	1.82	**130.95**
August	4.14	2.70	4.62	1.59	**109.10**
September	5.15	2.67	5.82	2.04	**156.64**
October	4.34	2.78	4.84	1.62	**121.47**
November	4.44	2.61	4.99	1.78	**115.85**
December	5.61	2.41	6.32	2.50	**170.39**
Average	**4.74**	**2.70**	**5.32**	**1.86**	**139.0**

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

The watt-hour (symbol W·h or Wh) is a unit of energy. It is most commonly used on household electricity meters in the form of the kilowatt-hour (kW·h or KWh), which is 1,000 watt-hours.

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

PMD Calculator (using 50M at Bahrain) from Aug 2006 to Sep 2009				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	152	51	13%	57,721
February	158	59	15%	62,881
March	152	54	14%	60,655
April	125	44	11%	48,658
May	143	57	14%	63,887
June	138	51	13%	56,240
July	129	48	12%	54,226
August	107	39	10%	43,997
September	154	58	15%	63,706
October	121	44	11%	49,511
November	118	44	11%	48,409
December	177	69	18%	78,219
Annual	**134**	**50**	**13%**	**666,172**

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

Cut-in Speed:

Cut-in speed is the minimum wind speed at which the wind turbine will generate usable power. This wind speed is typically between 3 and 5 m/s for most turbines.

Cut-out Speed:

At very high wind speeds, typically between 20 and 35 m/s, most wind turbines cease power generation and shut down. The wind speed at which shut down occurs is called the cut-out speed. Having a cut-out speed is a safety feature which protects the wind turbine from damage.

Figure 20 shows the average diurnal variation of wind generated electric energy output at Bahrain (Aug-06 to Aug-09). The graph shows that the maximum power is produced at about 12:00 PM; of course, this is the same time when we have the maximum wind speed in 24 hours. Figure 21 and 22 shows the monthly and daily wind generated electric power output. Figure 21 depicts that at Bahrain the wind have more potential in the month of April as compared to other months. Figure 23 to 34 shows the monthly average diurnal variation of wind generated electric energy output.

Fig 20 **Bahrain: From Aug 2006 to Aug 2009 Annual Average Diurnal Varition Of Wind Generated Electric Power Output**

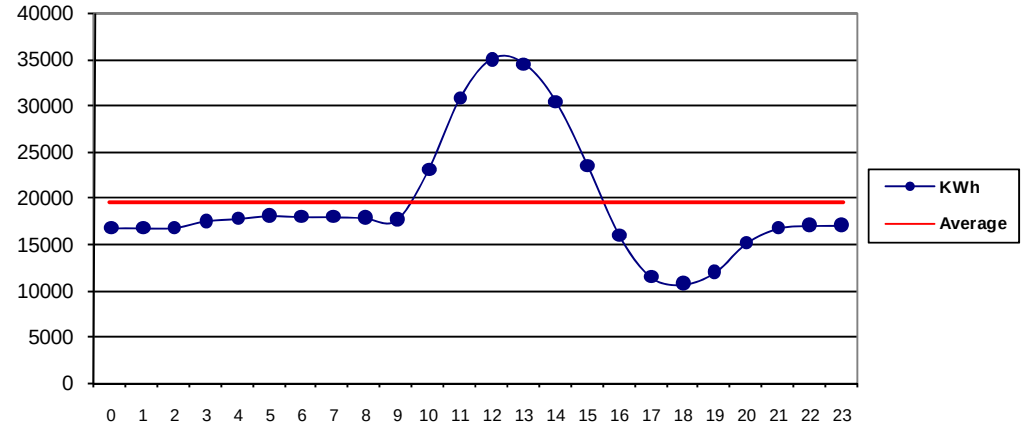


Fig 21 **Bahrain: From Aug 2006 to Aug 2009 Monthly Average Diurnal Varition Of Wind Generated Electric Power Output**

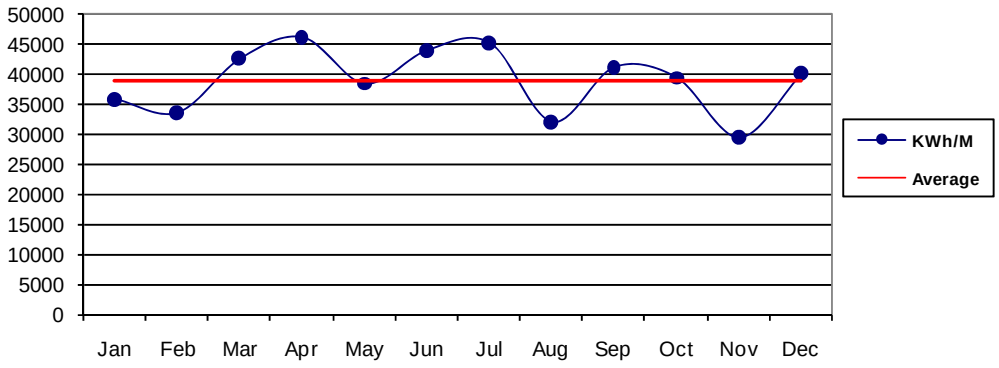


Fig 22 **Bahrain: From Aug 2006 to Aug 2009 Daily Wind Generated Electric Power Output**

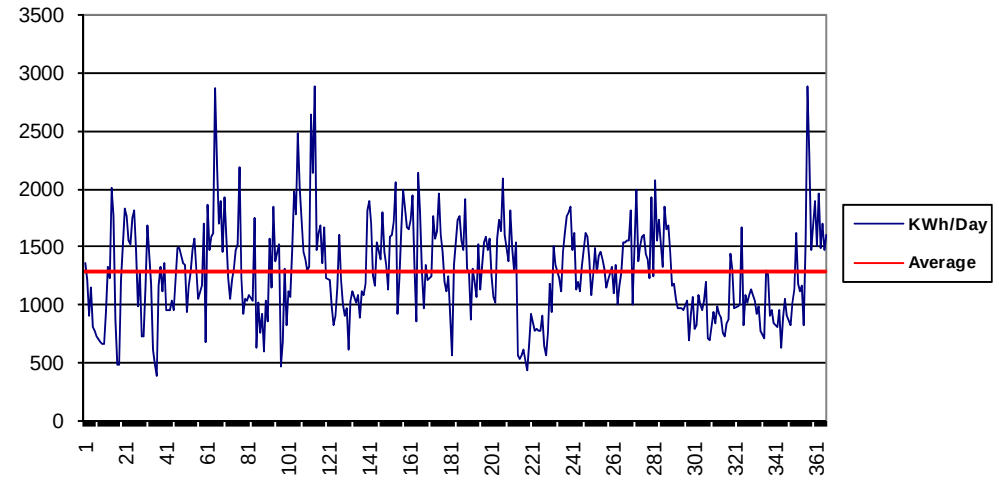


Fig 23 Bahrain Jan: Diurnal Variation of Wind Genrated Electric Energy Output

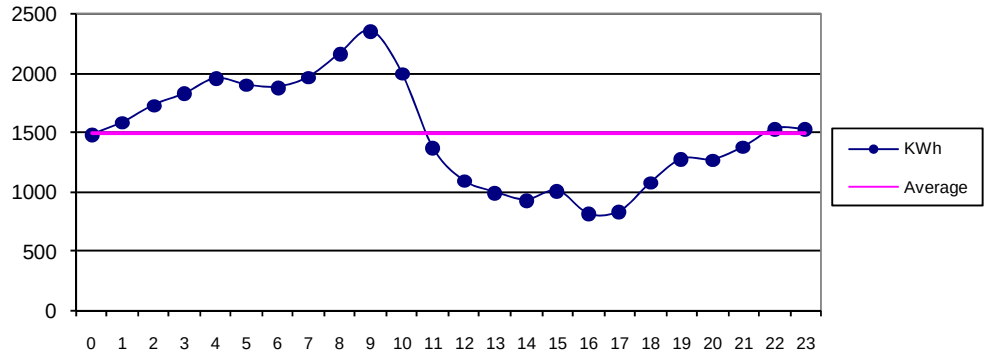
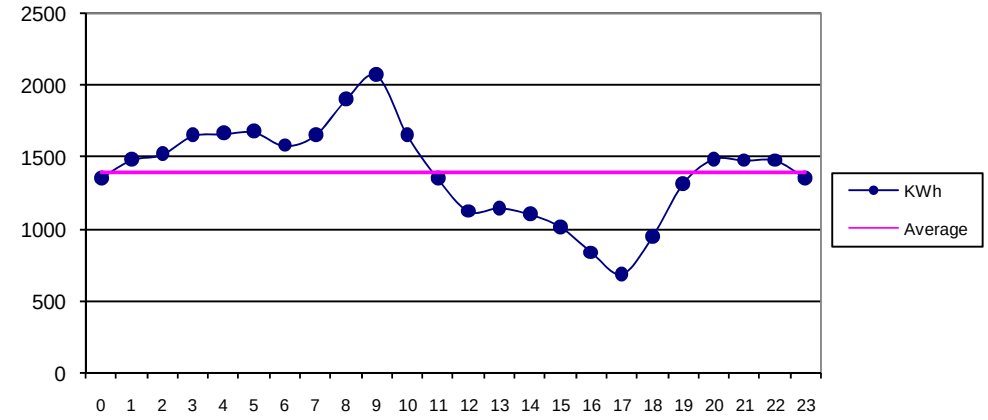
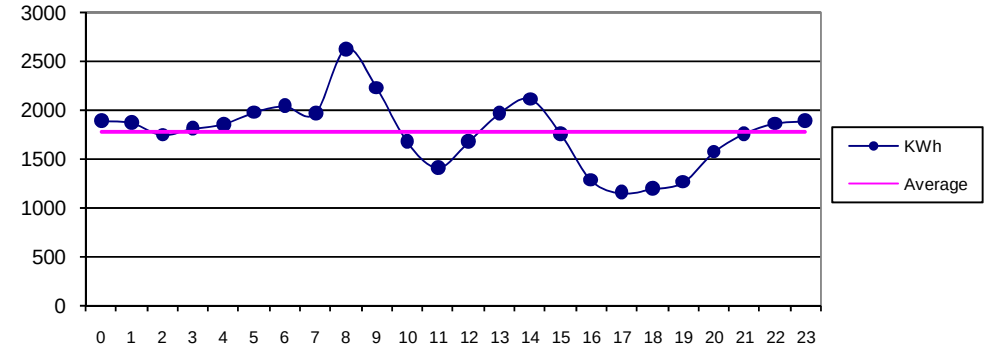


Fig 24 Bahrain Feb: Diurnal Variation of Wind Genrated Electric Energy Output



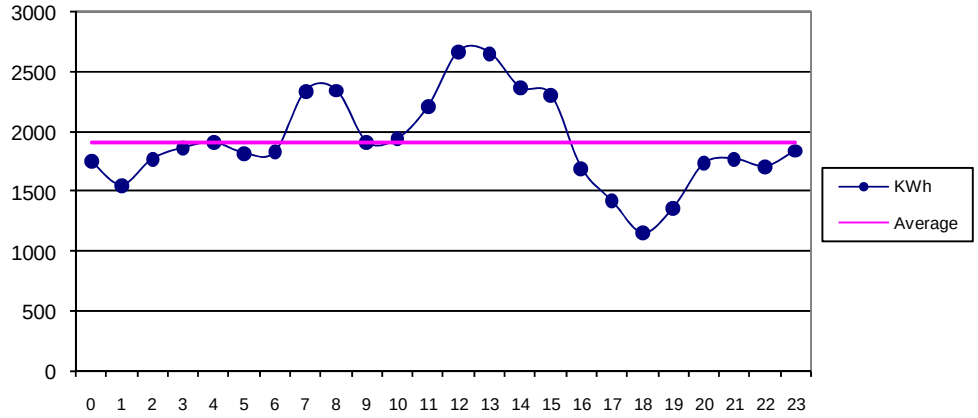
Source: Pakistan Meteorological Department

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



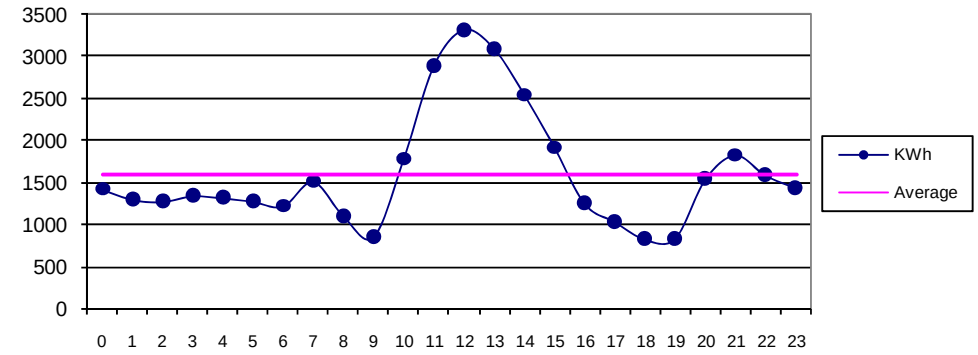
Source: Pakistan Meteorological Department

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



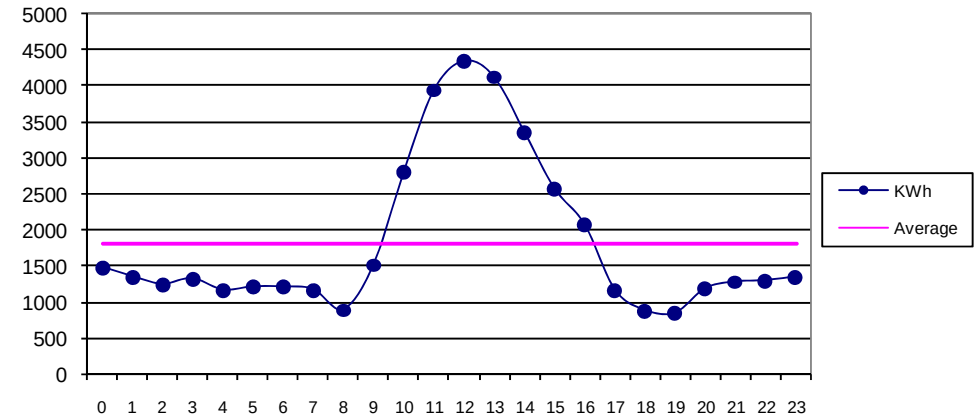
Source: Pakistan Meteorological Department

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



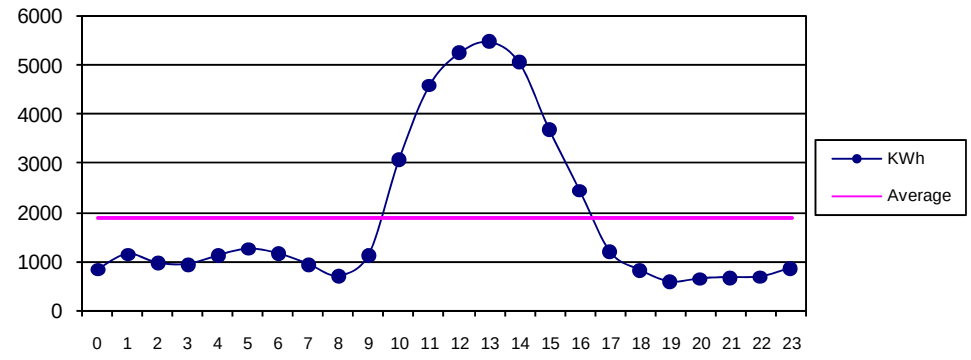
Source: Pakistan Meteorological Department

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



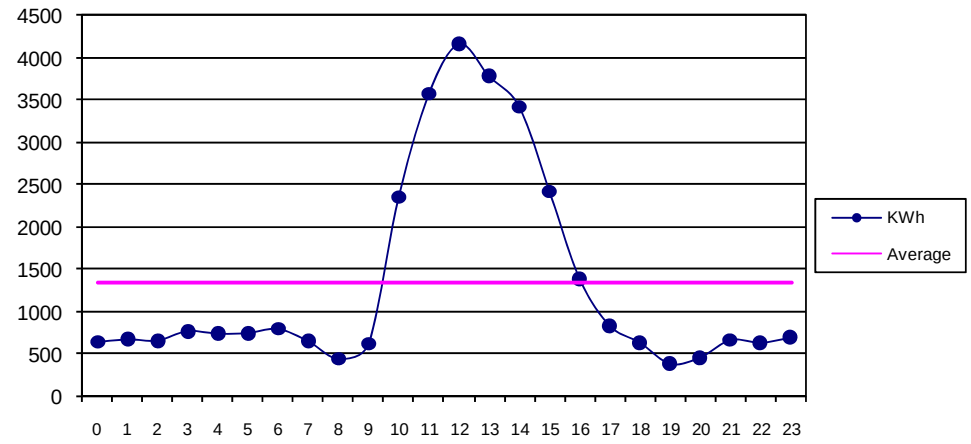
Source: Pakistan Meteorological Department

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



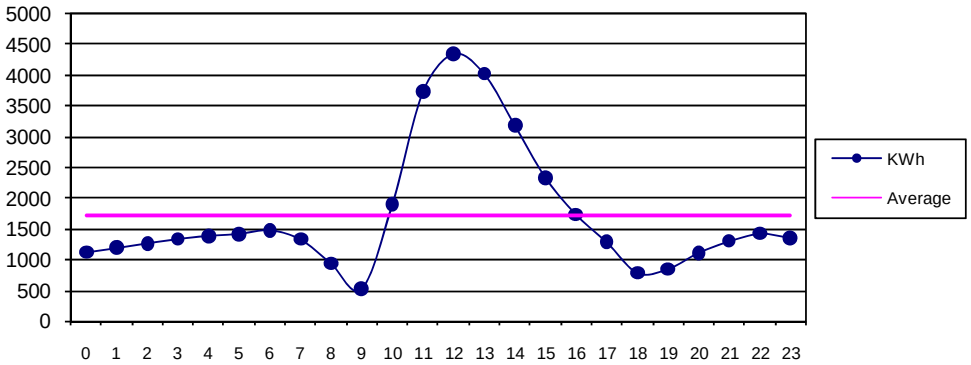
Source: Pakistan Meteorological Department

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



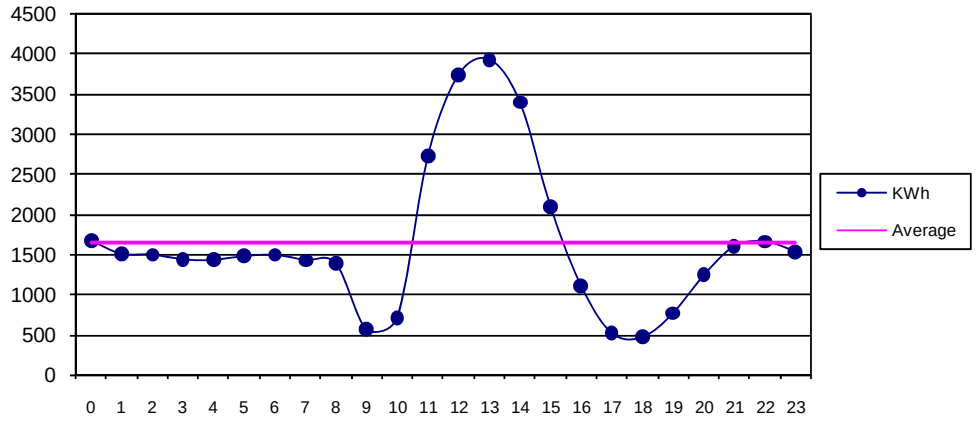
Source: Pakistan Meteorological Department

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



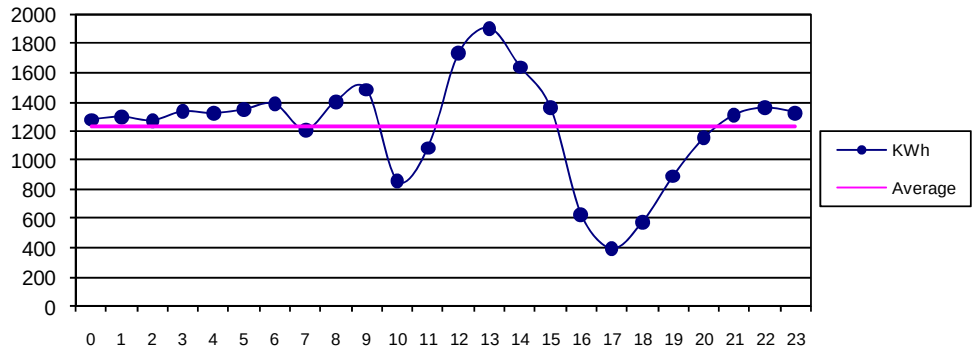
Source: Pakistan Meteorological Department

Fig 32 Bahrain Oct: Diurnal Variation of Wind Genrated Electric Energy Output



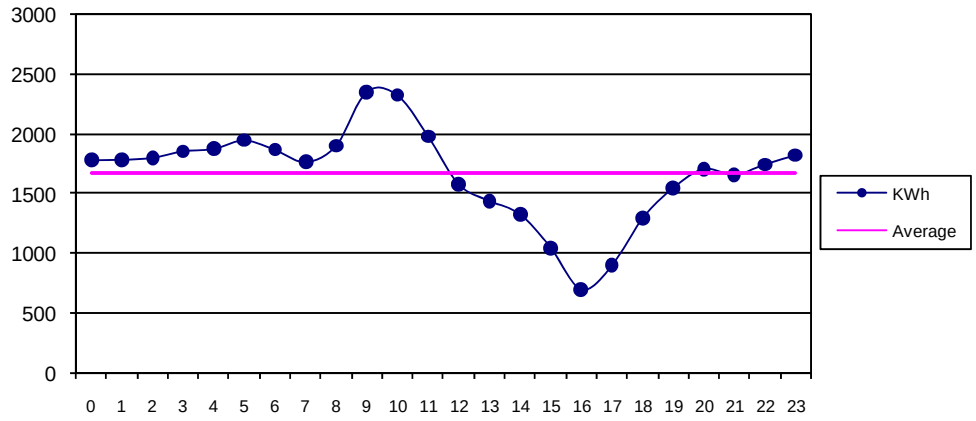
Source: Pakistan Meteorological Department

Fig 33 Bahrain Nov: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

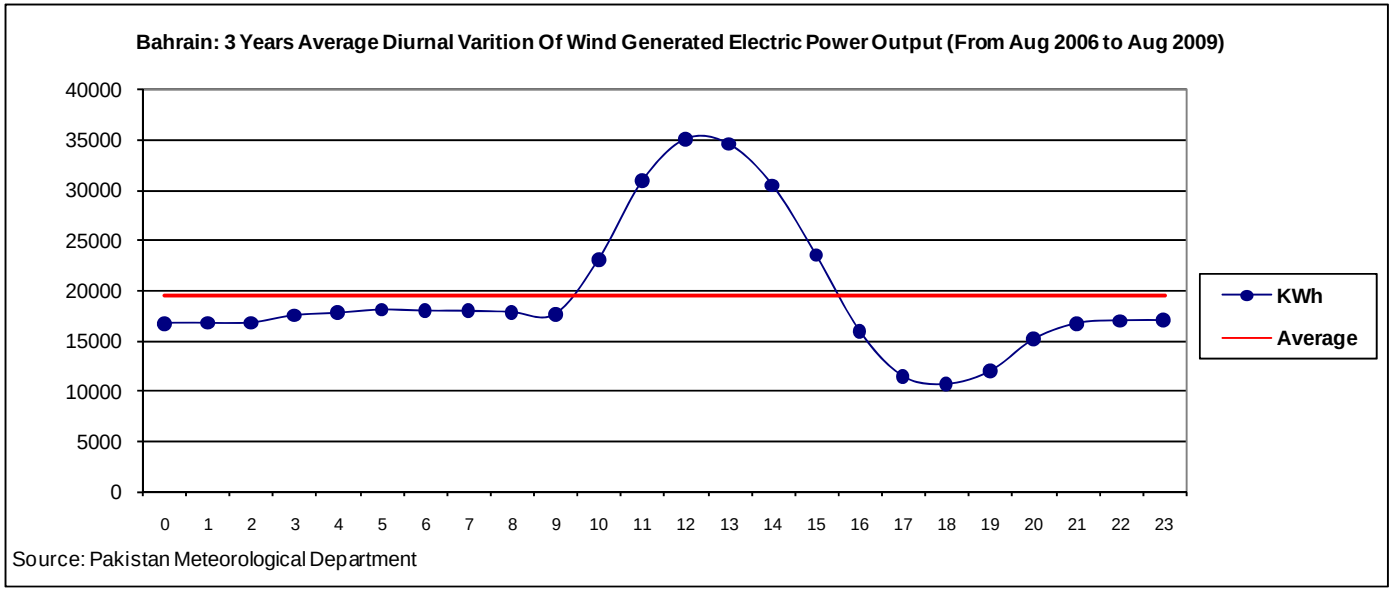
Fig 34 Bahrain Dec: Diurnal Variation of Wind Genrated Electric Energy Output



Source: Pakistan Meteorological Department

Bahrain **Aug 2006 to Sep 2009** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
Jan	1478	1581	1726	1824	1952	1897	1881	1964	2163	2353	1992	1364	1090	994	930	1006	812	832	1075	1273	1269	1378	1529	1522	35883
Feb	1360	1485	1524	1654	1667	1680	1585	1658	1906	2076	1659	1356	1130	1152	1108	1021	845	693	954	1324	1493	1483	1483	1360	33657
Mar	1890	1869	1746	1808	1855	1975	2040	1965	2630	2231	1675	1409	1674	1964	2115	1760	1278	1149	1191	1259	1568	1759	1864	1885	42559
Apr	1756	1560	1776	1870	1914	1826	1834	2344	2352	1919	1946	2215	2676	2662	2372	2315	1702	1425	1160	1372	1740	1777	1716	1850	46078
May	1418	1295	1268	1337	1312	1271	1216	1507	1100	850	1776	2888	3318	3092	2544	1917	1246	1029	822	833	1537	1824	1582	1433	38414
Jun	1490	1360	1252	1331	1171	1215	1216	1178	900	1521	2806	3950	4358	4130	3364	2579	2077	1171	887	852	1193	1285	1303	1357	43945
Jul	836	1147	971	943	1119	1256	1161	943	702	1130	3058	4566	5240	5468	5039	3662	2436	1195	818	586	650	676	690	867	45160
Aug	640	671	659	770	740	747	795	650	442	618	2351	3568	4162	3778	3417	2419	1386	832	633	383	460	664	633	691	32112
Sep	1108	1181	1256	1327	1380	1412	1471	1322	925	507	1887	3736	4355	4026	3182	2329	1722	1272	770	838	1104	1290	1415	1343	41159
Oct	1671	1507	1497	1437	1430	1477	1492	1428	1383	558	713	2730	3744	3934	3401	2092	1099	516	467	769	1241	1603	1659	1536	39385
Nov	1277	1296	1271	1332	1320	1346	1383	1207	1403	1482	859	1087	1728	1900	1638	1357	629	398	579	894	1151	1310	1358	1326	29532
Dec	1783	1788	1803	1858	1878	1950	1871	1768	1907	2358	2330	1985	1580	1441	1328	1046	695	898	1296	1552	1710	1659	1750	1827	40063
KWh	16707	16741	16748	17492	17738	18053	17944	17934	17813	17603	23053	30853	35054	34542	30437	23503	15929	11412	10653	11933	15117	16709	16982	16997	**467946**
Avg	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	19498	



Appendix-II

Bahrain **Jan 07,08,09** **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	49	55	61	70	67	74	85	74	75	98	84	36	7	41	50	42	18	28	34	55	40	79	62	70	1353
2	62	66	67	66	60	58	48	59	56	76	62	44	24	61	46	38	38	36	44	38	41	51	37	42	1220
3	44	43	0	57	46	51	80	86	103	94	70	40	13	35	35	21	27	7	0	4	7	2	26	23	914
4	29	39	77	90	125	90	106	68	72	53	40	45	34	23	9	0	8	24	33	34	19	27	45	61	1151
5	49	48	47	42	63	60	34	66	55	68	54	20	15	7	9	15	17	13	15	20	18	22	22	33	812
6	38	31	43	78	51	46	50	47	81	71	49	22	22	13	1	2	0	8	18	17	20	14	18	35	774
7	49	36	36	48	62	42	58	58	76	33	42	24	4	0	10	28	2	0	12	25	18	25	20	20	728
8	24	28	30	24	22	18	26	22	30	45	33	20	13	12	16	29	20	52	46	41	33	30	31	30	678
9	25	0	29	35	47	55	53	37	36	48	47	41	9	4	20	13	18	28	31	26	17	19	7	15	662
10	13	36	2	3	13	22	14	9	21	22	25	34	35	64	53	46	40	39	20	38	30	33	27	28	667
11	24	28	28	20	24	31	29	42	55	56	46	66	36	38	19	6	24	33	54	44	51	56	60	68	937
12	73	79	78	77	81	138	82	74	61	49	37	27	27	22	25	17	20	22	46	64	68	60	52	45	1325
13	37	49	51	66	51	67	70	82	85	89	67	28	16	14	22	16	19	24	48	66	66	46	77	71	1226
14	69	73	86	97	128	98	105	130	168	178	138	76	65	40	13	48	36	46	60	58	77	73	77	64	2003
15	67	51	58	66	40	52	47	52	55	79	111	115	140	153	67	48	90	78	74	49	39	73	86	76	1765
16	71	88	111	75	79	30	49	32	21	11	36	16	31	45	17	7	15	20	17	19	30	13	17	24	875
17	28	17	19	13	14	14	14	25	28	26	14	3	7	4	31	11	11	15	27	37	24	32	25	50	488
18	50	39	35	22	51	34	19	38	16	34	37	13	4	0	0	0	0	9	0	14	17	19	24	19	494
19	13	29	24	29	53	61	62	56	82	88	56	46	63	62	43	37	55	24	37	56	64	61	64	59	1223
20	57	47	62	46	107	102	112	132	143	164	89	69	38	29	15	48	22	68	66	78	58	89	104	83	1830
21	81	77	104	98	107	84	106	105	96	132	97	62	35	21	14	8	22	41	66	71	81	84	88	89	1768
22	81	89	95	75	84	80	74	72	83	98	99	74	99	53	34	17	4	12	46	66	63	68	42	40	1549
23	58	75	59	73	76	79	74	98	93	113	111	84	63	30	31	17	13	30	40	53	48	50	91	72	1530
24	67	64	83	139	121	125	74	86	94	102	65	52	18	19	81	120	79	59	48	51	55	45	47	51	1744
25	67	89	116	95	70	80	86	78	89	124	130	67	52	63	75	125	95	44	31	23	33	41	65	72	1813
26	63	55	77	88	75	80	104	97	96	69	67	72	58	17	9	26	21	33	56	55	51	56	76	64	1467
27	29	44	43	41	44	53	56	50	68	67	52	58	32	12	28	35	7	14	39	36	39	46	49	42	982
28	50	67	51	54	59	66	47	55	61	85	106	49	53	36	41	41	22	16	36	53	55	61	66	60	1287
29	39	59	80	45	34	20	38	49	39	30	22	3	1	8	25	56	46	6	8	16	23	31	26	31	736
30	36	38	34	49	41	24	25	35	38	32	13	15	53	31	42	43	17	2	5	21	32	31	32	37	726
31	35	42	44	44	55	64	54	52	87	118	92	42	21	34	47	46	6	2	15	43	51	45	66	48	1154
KWh	1478	1581	1726	1824	1952	1897	1881	1964	2163	2353	1992	1364	1090	994	930	1006	812	832	1075	1273	1269	1378	1529	1522	35883

Bahrain **Feb 07,08,09** **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	47	51	63	73	84	123	108	71	118	122	49	41	50	49	116	60	29	34	53	81	92	65	53	47	1678
2	42	47	40	50	53	44	43	58	102	112	95	39	68	31	10	23	31	34	60	54	58	49	19	27	1189
3	26	16	0	9	6	40	37	29	25	26	11	29	32	41	30	17	21	34	36	48	24	34	27	15	614
4	17	13	32	82	53	21	20	22	27	32	25	21	36	44	5	4	1	1	0	18	1	0	0	3	479
5	28	4	0	4	4	0	2	3	8	14	3	0	2	29	20	14	1	5	23	21	48	72	56	30	390
6	40	40	31	35	58	69	126	123	119	83	37	39	22	42	21	14	17	21	20	30	38	62	45	37	1168
7	45	92	85	131	78	76	52	56	42	66	64	56	34	19	12	46	34	32	37	58	65	60	44	43	1327
8	45	30	30	29	33	51	41	38	57	73	89	87	43	58	48	43	15	12	38	44	40	47	65	63	1121
9	52	0	49	62	71	69	78	84	106	82	33	51	25	24	75	84	50	25	41	37	54	71	68	72	1363
10	55	36	51	63	77	58	40	48	63	57	49	36	21	15	31	30	37	21	14	25	35	30	28	29	950
11	41	42	50	55	68	59	53	44	49	64	60	30	41	33	14	7	34	6	10	35	29	44	50	47	963
12	47	43	31	30	43	45	35	36	55	51	20	20	7	40	39	29	7	7	41	66	109	62	50	49	964
13	63	97	73	44	49	57	69	94	80	81	52	27	36	37	30	16	12	3	7	18	22	23	26	24	1040
14	27	21	28	21	37	33	20	19	33	64	85	68	33	11	29	25	32	29	30	27	47	68	79	90	956
15	76	98	94	95	77	61	75	77	104	121	93	71	62	36	12	7	6	29	36	56	67	43	49	43	1486
16	50	60	59	55	64	52	42	73	96	87	63	82	72	73	70	56	47	34	34	46	61	73	81	54	1483
17	57	93	99	107	73	57	46	25	47	54	60	80	58	65	53	59	75	38	49	51	49	42	40	52	1430
18	46	55	57	55	45	59	58	53	55	62	55	44	75	74	81	57	30	34	65	54	57	75	47	70	1364
19	75	63	73	48	50	58	57	55	79	104	95	97	65	53	25	13	6	65	50	29	49	35	38	59	1339
20	47	63	44	24	26	22	24	26	42	52	26	10	4	41	69	87	44	10	12	29	77	70	49	49	947
21	55	79	65	64	83	69	70	111	49	49	71	31	14	3	12	11	12	17	39	60	57	50	58	46	1174
22	56	84	101	84	84	81	46	52	58	56	73	61	58	32	28	7	20	21	39	63	40	27	65	48	1282
23	57	53	48	71	86	108	77	92	70	98	92	92	65	41	19	12	27	37	49	47	56	55	56	65	1471
24	54	56	52	54	59	69	98	89	86	91	67	51	73	21	48	54	111	55	19	70	56	69	106	57	1566
25	53	67	73	75	72	91	67	63	63	82	80	57	31	11	26	71	33	16	32	48	38	52	67	44	1310
26	53	52	55	60	56	39	35	34	71	67	56	35	25	56	51	36	13	5	22	53	45	36	50	45	1050
27	55	46	39	43	47	50	60	90	93	86	39	25	11	23	45	67	51	15	42	48	48	55	50	40	1168
28	51	58	74	98	105	92	77	66	72	93	93	57	63	118	64	64	32	32	35	89	93	60	51	66	1706
29	0	28	30	33	26	26	30	26	37	49	26	17	6	32	25	7	19	19	21	20	40	53	66	45	679
KWh	1360	1485	1524	1654	1667	1680	1585	1658	1906	2076	1659	1356	1130	1152	1108	1021	845	693	954	1324	1493	1483	1483	1360	33657

Bahrain **Mar 07,08,09** **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	99	165	120	93	101	93	91	79	104	89	110	79	89	60	59	56	26	12	36	33	54	65	68	75	1858
2	65	62	60	58	67	81	67	73	84	106	57	23	11	26	50	39	31	50	78	60	84	70	92	79	1474
3	74	59	0	87	131	97	76	77	110	91	46	20	17	25	27	41	38	33	23	48	95	134	132	114	1593
4	75	99	83	44	70	78	117	124	97	52	90	54	90	87	64	17	46	35	44	53	48	58	48	48	1622
5	52	57	67	70	62	83	100	106	121	201	149	157	181	247	241	194	134	103	93	96	103	97	82	73	2869
6	78	130	130	104	76	103	112	117	94	124	137	117	153	195	111	31	35	14	32	26	38	44	92	119	2212
7	145	77	93	74	83	100	123	87	104	108	105	36	13	25	41	32	27	14	35	46	46	85	100	100	1700
8	113	77	84	79	83	68	84	71	160	123	87	64	23	29	31	24	58	140	87	96	77	68	88	79	1892
9	60	10	53	55	68	60	56	40	59	80	55	72	43	51	49	65	89	122	103	63	56	65	43	35	1452
10	45	57	61	75	80	98	122	116	186	139	134	116	109	132	85	65	33	36	14	51	37	24	49	56	1922
11	50	63	69	67	64	55	56	52	99	98	27	17	30	76	47	38	36	23	5	24	55	59	66	51	1228
12	48	48	47	39	50	64	53	40	70	50	32	9	37	61	56	43	17	3	24	47	45	60	59	55	1057
13	56	48	62	56	47	50	45	40	87	68	49	33	14	54	87	68	14	0	16	61	72	72	65	49	1214
14	40	36	33	32	36	53	59	53	90	43	24	16	53	115	174	94	83	14	14	22	55	55	55	59	1305
15	66	58	51	45	46	47	52	55	115	78	39	13	69	125	159	93	22	2	8	24	44	55	74	138	1478
16	94	47	45	96	96	88	73	83	105	111	72	40	23	10	25	15	17	38	85	67	85	77	68	55	1516
17	139	143	73	106	121	161	152	114	99	112	77	66	32	41	51	99	100	124	43	29	99	66	78	59	2183
18	60	62	59	49	63	39	40	46	84	71	89	95	59	42	4	2	11	23	74	51	55	51	53	49	1232
19	45	48	57	64	34	44	64	47	85	60	29	19	8	10	35	19	4	1	59	43	37	49	39	30	930
20	34	31	30	35	34	34	42	38	62	41	15	19	32	19	35	51	41	89	88	53	51	61	64	57	1056
21	49	51	49	45	46	46	40	40	68	75	44	14	19	7	16	28	41	37	39	46	49	67	61	55	1030
22	50	67	72	71	65	79	46	42	95	61	44	32	28	22	32	27	27	20	14	28	35	37	39	48	1081
23	50	40	40	39	43	41	42	35	44	34	18	18	47	64	53	48	53	36	33	40	34	38	49	98	1038
24	58	56	78	90	70	87	95	113	102	41	38	38	90	101	172	180	69	27	6	21	38	44	75	62	1752
25	51	57	47	53	26	26	22	24	31	23	12	6	27	13	23	13	0	12	2	4	19	61	53	36	641
26	36	48	37	38	37	35	37	49	84	64	35	26	43	34	54	37	71	79	27	26	26	39	30	26	1019
27	29	37	46	44	46	35	41	65	45	19	5	16	42	33	22	9	9	4	4	19	41	46	53	51	761
28	36	23	15	22	26	29	41	37	29	4	8	63	89	71	64	86	32	17	15	48	49	37	38	52	929
29	37	39	30	23	33	33	22	34	29	27	11	23	57	20	23	17	24	10	0	4	20	36	24	29	608
30	22	26	20	21	28	27	29	29	35	22	5	45	91	94	123	155	58	23	87	18	7	30	13	33	1039
31	35	48	35	32	27	39	39	37	53	18	32	64	52	72	102	75	34	7	2	11	13	11	13	14	867
KWh	1890	1869	1746	1808	1855	1975	2040	1965	2630	2231	1675	1409	1674	1964	2115	1760	1278	1149	1191	1259	1568	1759	1864	1885	42559

Bahrain **Apr 07,08,09** **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	53	37	43	31	47	55	48	58	60	42	132	122	148	158	225	128	60	4	1	5	20	16	29	47	1568
2	41	41	29	30	33	35	26	37	50	73	78	116	115	94	67	30	25	43	16	18	18	40	41	55	1151
3	52	49	0	43	54	42	40	41	46	13	57	198	223	179	157	66	84	78	86	75	51	78	76	66	1853
4	65	71	58	48	50	56	35	42	76	64	87	90	132	148	65	65	107	5	3	9	20	16	22	45	1379
5	24	47	57	69	40	36	38	35	40	49	30	50	99	95	33	92	85	29	49	38	66	102	140	181	1524
6	72	13	14	5	5	28	25	29	4	9	4	40	48	16	18	22	27	16	7	13	14	29	4	3	463
7	17	2	4	43	65	34	52	40	11	3	6	10	16	3	0	23	4	1	4	40	54	87	80	84	682
8	63	65	82	86	98	73	48	23	26	45	5	14	61	64	24	48	68	94	63	65	74	53	63	15	1317
9	45	0	35	27	39	36	30	44	52	95	79	28	49	38	28	41	44	6	5	6	14	31	28	31	833
10	36	43	55	58	58	45	43	40	81	82	14	34	30	54	70	46	43	32	20	36	54	52	37	56	1120
11	64	53	45	29	35	53	49	40	50	11	16	15	3	37	35	23	28	56	83	74	91	46	55	70	1064
12	72	45	79	67	43	59	88	107	58	42	79	135	74	33	59	39	32	18	12	48	60	55	77	90	1471
13	85	102	96	115	99	80	82	95	107	81	29	27	76	100	88	66	57	126	102	72	79	67	75	73	1979
14	70	67	64	58	80	76	62	106	33	37	121	34	56	58	78	185	96	85	84	111	83	64	35	38	1780
15	68	79	112	129	136	135	99	83	99	55	92	61	92	125	143	173	114	124	101	75	37	80	85	184	2480
16	181	135	115	99	77	56	87	162	172	158	105	58	67	128	97	63	27	28	10	20	38	32	44	44	2003
17	57	69	54	62	59	46	40	80	70	44	54	75	123	114	147	43	24	37	22	38	46	45	61	53	1461
18	52	58	58	53	63	55	43	72	72	59	61	48	82	86	119	104	44	12	2	20	34	51	81	69	1398
19	55	53	67	55	53	49	53	91	87	64	39	77	75	76	53	43	38	21	8	42	47	36	47	67	1297
20	69	52	79	61	34	28	35	71	132	124	63	59	96	89	56	18	5	37	34	46	68	24	28	25	1333
21	25	30	67	181	175	88	58	105	149	126	161	144	113	187	69	106	126	83	91	111	139	121	123	66	2644
22	63	61	85	76	50	62	55	95	126	89	61	70	59	68	30	106	120	236	174	112	100	67	105	71	2143
23	67	72	73	43	139	187	234	208	229	135	149	149	199	218	190	147	76	71	35	51	40	50	53	66	2882
24	76	43	53	56	50	53	50	101	58	48	48	39	59	53	54	210	117	48	27	47	54	44	45	41	1474
25	42	45	43	48	59	63	54	113	93	104	58	32	63	55	107	142	89	43	23	50	158	69	35	31	1621
26	54	60	59	71	83	85	121	86	122	80	104	147	84	104	79	75	57	39	21	21	40	37	26	28	1683
27	25	31	54	51	55	58	67	87	49	60	108	115	79	58	83	62	32	28	25	25	62	54	45	52	1363
28	40	53	91	69	49	53	45	73	75	51	29	68	147	123	120	82	40	15	2	37	96	115	106	88	1665
29	83	47	45	53	50	52	66	106	65	34	37	74	118	81	40	44	23	4	8	30	46	52	33	40	1232
30	40	38	59	53	38	49	63	75	60	42	41	85	87	21	38	23	10	7	40	37	39	165	38	68	1216
KWh	1756	1560	1776	1870	1914	1826	1834	2344	2352	1919	1946	2215	2676	2662	2372	2315	1702	1425	1160	1372	1740	1777	1716	1850	46078

Bahrain **May 07,08,09** **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	47	53	35	33	33	34	25	52	49	31	20	54	68	88	81	69	43	14	13	16	39	38	27	27	990
2	32	27	31	29	32	31	30	42	34	25	12	36	40	39	27	20	21	6	3	34	83	79	65	54	831
3	39	53	0	45	36	29	18	52	40	47	55	69	62	36	75	63	44	18	15	14	25	32	19	19	904
4	33	29	28	18	14	42	47	56	90	90	40	17	28	32	34	11	44	68	73	64	82	82	56	72	1148
5	53	52	60	57	67	27	40	69	55	14	50	88	121	79	114	80	64	68	57	57	57	88	99	87	1604
6	89	70	57	39	40	39	43	80	49	40	47	58	83	145	82	23	11	3	15	22	41	52	46	42	1215
7	42	35	37	39	43	30	33	43	34	20	12	60	115	119	113	67	40	10	2	3	17	27	33	35	1009
8	30	30	27	30	30	33	27	31	28	12	18	63	54	76	93	109	36	4	4	12	22	86	27	29	911
9	36	0	29	30	37	30	24	16	24	17	27	94	94	74	115	142	56	11	1	7	49	31	2	29	974
10	27	17	43	20	6	13	22	22	8	4	31	56	40	53	30	49	27	18	12	9	23	35	32	21	618
11	22	34	33	37	37	34	32	46	37	3	56	102	151	125	82	55	18	11	1	2	22	33	37	35	1042
12	30	34	35	34	39	39	37	32	25	12	49	94	135	144	91	56	46	17	4	6	61	35	32	35	1122
13	34	39	27	37	26	30	39	49	26	28	58	89	140	74	51	29	16	20	35	16	41	32	40	45	1020
14	33	34	48	42	31	37	35	46	24	9	24	87	122	123	114	63	41	8	4	8	13	43	65	32	1087
15	35	35	39	37	33	32	32	56	26	13	71	122	57	71	66	31	11	6	0	0	29	33	32	19	887
16	24	31	22	27	38	39	39	41	26	16	39	77	140	167	141	79	34	5	0	3	22	40	41	22	1113
17	48	66	78	73	53	43	39	62	34	13	39	82	108	91	51	22	5	0	0	22	42	40	45	34	1088
18	40	40	44	39	39	44	44	38	34	15	15	72	127	118	112	99	38	14	0	7	47	63	50	35	1176
19	37	32	35	34	38	36	27	44	30	18	122	107	84	68	44	41	113	212	171	47	75	123	131	144	1812
20	137	72	53	67	48	44	59	49	68	80	62	65	96	136	87	96	64	102	70	71	85	122	88	69	1889
21	43	23	41	51	56	87	66	55	49	41	72	53	122	134	190	91	51	67	42	63	81	101	73	52	1703
22	54	47	55	34	30	28	37	55	27	38	68	138	162	126	66	41	7	13	11	43	31	29	36	63	1241
23	30	36	47	60	66	40	48	62	31	31	74	79	44	41	13	20	27	40	45	54	93	60	68	60	1167
24	68	42	36	50	65	56	46	83	37	3	42	106	123	59	57	123	58	87	86	65	42	48	85	74	1543
25	59	42	36	66	67	54	38	44	44	85	190	197	67	20	35	62	52	32	3	23	41	49	51	41	1395
26	55	52	41	44	44	37	34	48	36	25	108	101	96	147	87	77	80	83	92	89	170	143	64	49	1803
27	57	82	79	71	78	72	59	69	38	46	70	192	125	69	45	48	37	17	10	19	51	42	40	42	1457
28	42	51	40	41	46	46	36	32	10	33	86	143	152	138	70	48	54	45	24	17	66	45	45	30	1342
29	36	31	37	50	45	52	34	22	21	23	71	106	111	70	60	52	37	4	12	30	43	73	58	54	1134
30	54	54	42	49	51	67	75	63	30	7	85	139	300	198	100	51	40	14	7	9	35	44	31	36	1583
31	49	53	55	54	45	47	52	47	34	11	63	142	151	230	221	100	32	13	9	2	8	75	65	48	1607
KWh	1418	1295	1268	1337	1312	1271	1216	1507	1100	850	1776	2888	3318	3092	2544	1917	1246	1029	822	833	1537	1824	1582	1433	38414

Bahrain **June 07,08,09** **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	57	66	54	58	62	59	55	47	23	13	103	164	145	125	78	43	77	51	74	69	74	37	29	152	1715
2	174	178	164	144	97	74	68	64	48	46	91	100	126	112	156	57	28	31	17	54	62	50	45	72	2058
3	34	41	0	32	40	49	45	46	45	24	6	37	71	69	83	64	34	27	6	18	15	20	67	45	917
4	58	53	51	36	41	73	97	44	22	13	62	90	115	131	100	93	33	14	2	0	4	17	33	45	1227
5	38	40	43	43	43	51	58	49	61	53	56	83	124	115	175	80	58	51	22	66	111	79	102	58	1658
6	78	108	50	142	120	103	65	42	5	43	106	104	126	132	62	75	115	66	93	54	108	76	63	55	1994
7	54	44	50	44	46	42	60	70	40	18	76	98	113	96	141	131	54	74	69	69	71	74	79	54	1666
8	68	60	50	59	41	49	72	84	46	4	78	120	186	201	200	84	35	18	5	10	40	53	42	44	1648
9	48	18	54	49	52	59	50	64	28	26	134	159	181	195	206	66	94	28	3	20	45	70	48	42	1740
10	46	43	62	46	52	50	66	63	41	41	106	173	162	168	130	194	97	25	11	16	64	88	128	75	1950
11	47	46	41	54	52	42	33	44	46	63	55	126	121	154	84	97	53	30	5	6	12	53	51	39	1352
12	39	35	31	39	31	24	22	41	39	28	68	86	64	35	45	49	32	13	3	7	19	22	34	44	852
13	61	39	39	40	64	96	43	28	28	65	103	133	145	161	227	175	189	88	118	82	103	41	38	31	2140
14	20	23	15	12	18	20	19	21	25	56	103	124	199	257	126	161	126	109	64	41	47	108	54	56	1805
15	57	31	14	13	22	23	22	26	14	85	176	72	104	97	61	120	90	62	51	38	26	34	20	21	1281
16	49	7	2	3	11	24	26	7	14	47	89	179	135	87	69	44	48	39	23	6	7	4	20	30	970
17	15	17	20	27	23	21	16	26	32	83	157	195	209	130	72	62	57	39	34	16	14	29	26	30	1350
18	31	34	27	51	39	34	56	53	38	69	112	152	110	85	73	17	83	27	7	4	8	32	35	40	1218
19	21	20	27	33	26	25	24	27	34	62	66	143	186	178	61	55	74	53	23	7	5	23	38	32	1245
20	91	68	61	56	29	32	32	37	18	73	88	193	180	168	169	134	82	29	23	52	16	30	47	60	1764
21	75	88	85	59	27	35	27	43	47	45	126	164	239	213	107	62	27	14	6	15	15	10	21	26	1578
22	28	23	17	20	28	33	20	28	22	85	157	209	212	194	86	57	106	32	59	38	72	42	33	34	1635
23	44	49	56	31	19	32	28	28	19	54	114	176	190	218	228	104	84	48	73	40	78	82	82	82	1958
24	81	62	47	38	30	29	39	37	25	54	112	152	160	137	144	137	132	51	13	5	23	30	29	35	1603
25	37	33	35	42	37	35	39	36	24	62	76	119	164	154	126	129	98	39	18	33	40	41	28	19	1460
26	13	9	27	20	17	20	18	14	30	66	121	204	120	121	112	115	61	26	14	16	19	19	9	11	1202
27	16	22	22	34	20	11	21	20	32	64	55	93	106	144	104	72	54	46	32	32	25	21	26	45	1116
28	62	52	60	47	42	30	53	34	23	90	82	152	174	111	34	30	26	22	3	7	41	38	16	20	1249
29	24	21	21	18	22	21	12	17	18	66	67	106	138	110	79	41	19	12	10	18	20	17	24	28	928
30	25	29	27	36	19	19	25	35	9	19	57	40	50	29	23	25	4	2	3	6	4	36	29	23	575
KWh	1490	1360	1252	1331	1171	1215	1216	1178	900	1521	2806	3950	4358	4130	3364	2579	2077	1171	887	852	1193	1285	1303	1357	43853

Bahrain **July 08,09** **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	30	24	41	55	58	61	53	45	21	24	107	162	156	129	165	86	36	23	13	2	4	16	14	14	1339
2	10	32	44	48	55	71	61	42	19	26	137	204	238	202	145	145	83	28	29	6	5	26	28	47	1731
3	9	40	0	53	46	44	43	41	11	56	180	215	211	194	154	104	120	41	42	9	20	38	38	56	1765
4	58	55	66	63	64	41	24	23	24	58	135	155	84	121	154	123	66	35	27	25	33	36	39	49	1560
5	22	25	30	28	33	31	25	23	60	98	52	101	136	106	136	138	141	81	43	34	28	28	31	46	1476
6	28	137	72	53	119	174	129	94	90	26	93	96	174	141	146	69	23	10	33	57	63	29	24	35	1914
7	33	41	27	27	40	33	27	27	20	7	52	70	173	155	185	123	64	17	1	13	25	62	51	36	1310
8	38	48	34	48	63	67	50	35	21	27	43	94	110	94	62	102	21	58	46	44	49	49	42	36	1280
9	36	0	59	42	30	42	32	26	28	10	47	43	61	129	63	60	27	24	11	15	15	30	24	30	882
10	28	39	25	24	27	39	25	2	0	8	100	205	179	204	160	99	71	34	17	1	2	11	8	1	1310
11	5	4	22	12	1	4	15	15	13	43	106	178	232	232	161	65	19	14	27	13	1	0	3	20	1206
12	30	12	22	13	28	45	31	33	45	8	47	84	130	173	194	73	22	26	23	1	0	1	1	35	1076
13	28	25	20	25	23	63	43	32	33	67	93	251	169	112	171	74	53	34	34	24	27	20	38	55	1517
14	50	50	27	26	34	23	28	14	0	23	100	91	100	104	154	90	33	22	21	3	39	54	31	22	1141
15	27	27	27	33	36	17	23	28	12	35	81	106	163	261	198	179	139	52	21	1	0	3	31	34	1535
16	36	28	26	5	10	32	31	18	13	31	137	196	203	222	248	169	103	36	11	5	13	1	1	19	1591
17	22	46	30	48	34	28	25	12	17	28	138	191	197	185	122	165	112	31	16	11	4	4	1	2	1469
18	35	122	32	5	25	38	33	33	28	42	108	200	220	262	142	61	80	39	14	8	0	0	9	33	1569
19	31	11	28	31	32	19	34	16	5	34	58	179	178	202	160	122	65	25	6	0	0	0	6	14	1255
20	7	28	32	20	2	50	34	40	20	0	55	91	116	168	195	102	29	22	4	0	0	27	20	1	1064
21	12	24	31	6	36	17	12	27	18	82	73	95	97	122	88	84	75	29	6	6	10	8	25	30	1014
22	42	27	17	32	30	13	36	28	5	22	92	128	126	114	114	181	225	67	32	58	64	47	43	35	1578
23	50	67	72	59	56	69	53	51	27	1	49	109	223	223	171	180	126	28	19	6	1	7	39	42	1729
24	31	41	46	48	43	54	59	55	14	16	80	147	229	268	194	57	47	48	44	14	46	23	8	31	1644
25	50	27	19	27	28	22	41	33	4	47	162	162	197	171	242	331	161	90	22	104	27	44	37	37	2086
26	44	37	44	50	77	55	63	61	24	19	104	150	163	160	152	143	115	56	31	7	8	2	13	23	1603
27	30	20	20	27	30	27	36	20	20	55	75	128	178	183	145	103	85	30	61	25	5	32	29	6	1371
28	0	52	46	35	31	46	67	43	45	52	74	152	222	230	251	84	103	53	63	28	20	25	33	57	1813
29	4	0	0	1	8	17	9	2	30	62	171	149	197	210	160	120	102	53	39	48	69	22	20	0	1495
30	0	36	4	0	16	11	4	5	14	75	179	192	143	153	213	88	29	35	37	9	25	15	2	7	1291
31	9	20	4	0	3	1	14	18	24	47	131	242	236	238	192	143	62	54	25	7	44	15	2	15	1547
KWh	836	1147	971	943	1119	1256	1161	943	702	1130	3058	4566	5240	5468	5039	3662	2436	1195	818	586	650	676	690	867	45160

Bahrain **Aug 06,07,08,09** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	1	0	0	0	0	5	6	3	8	29	46	62	68	79	85	63	24	11	8	3	7	52	1	5	565
2	1	4	16	11	10	11	4	0	2	1	44	72	75	70	74	70	41	16	5	9	0	0	0	0	537
3	0	1	0	9	4	0	3	2	6	25	67	54	78	149	102	43	11	7	8	0	0	0	3	0	575
4	1	7	3	1	3	11	14	15	8	27	53	67	80	66	105	52	17	24	12	8	6	6	7	24	617
5	20	0	0	1	1	2	0	0	0	19	48	60	57	67	64	53	39	35	23	10	14	9	1	2	524
6	0	6	5	11	10	0	8	1	0	12	59	73	80	37	14	14	27	14	1	10	11	11	22	17	445
7	10	18	21	8	2	8	1	1	10	44	50	70	117	78	50	47	42	26	25	5	13	0	1	24	672
8	23	19	2	21	21	17	14	17	7	11	59	101	109	118	119	59	38	61	23	20	20	7	16	16	918
9	14	5	12	7	9	7	12	7	2	30	50	111	98	90	117	82	41	17	28	13	1	5	3	13	772
10	7	11	6	13	10	19	26	18	8	21	55	93	122	119	81	64	48	24	27	16	9	3	0	2	801
11	5	0	11	0	0	8	15	19	8	20	43	101	161	116	108	59	37	12	16	3	3	10	11	12	777
12	13	8	4	17	15	15	13	7	5	13	38	76	89	121	142	83	36	19	42	4	1	7	8	10	785
13	11	8	9	7	8	11	9	8	1	20	70	95	111	136	148	89	44	30	21	7	6	24	20	9	903
14	3	1	11	3	3	9	14	11	15	16	63	83	85	80	104	79	17	17	13	3	0	0	3	13	646
15	3	15	4	18	15	10	2	15	12	16	29	38	52	60	76	52	23	18	22	27	19	11	10	17	564
16	8	43	23	42	14	9	17	24	11	3	32	33	98	114	46	45	38	22	21	23	29	21	27	19	761
17	56	42	30	28	45	30	27	23	36	16	53	105	137	87	68	74	79	56	33	26	23	51	36	23	1185
18	28	26	31	31	33	47	35	25	36	49	55	72	70	81	36	19	9	36	70	14	23	32	31	47	938
19	39	46	36	49	56	58	60	43	24	31	99	132	213	147	140	131	78	35	13	1	1	12	39	31	1512
20	29	17	25	51	43	35	45	29	13	8	118	165	185	189	154	106	46	24	21	8	2	13	9	2	1339
21	12	32	21	15	19	15	24	18	1	12	121	156	152	120	56	117	126	45	39	14	22	26	38	28	1230
22	25	21	14	19	25	44	51	43	27	9	104	154	158	111	110	76	43	25	15	6	8	9	11	16	1124
23	18	40	32	31	37	34	40	45	9	27	144	217	281	168	117	63	39	32	8	2	9	9	23	26	1450
24	26	36	34	20	37	49	31	21	3	24	164	222	207	146	151	117	47	27	9	38	23	88	60	42	1623
25	43	27	25	54	45	38	43	27	21	22	114	198	246	227	177	108	44	21	8	22	53	66	67	74	1770
26	89	60	60	56	59	46	59	63	69	13	77	153	161	173	222	166	68	12	7	20	46	44	31	45	1800
27	52	70	57	79	71	58	71	61	39	18	116	167	133	170	182	129	70	42	34	23	48	50	49	48	1840
28	33	31	70	84	44	28	53	38	22	24	98	151	188	141	129	66	46	25	20	14	22	41	38	66	1472
29	53	45	41	32	56	53	48	37	25	20	128	242	246	214	153	91	54	29	24	4	8	4	5	15	1627
30	8	11	35	38	27	39	33	12	1	31	80	117	171	181	109	69	39	28	9	22	9	23	29	18	1138
31	8	19	19	14	18	30	18	18	11	8	75	130	132	124	180	133	74	40	26	8	22	31	34	25	1199
KWh	640	671	659	770	740	747	795	650	442	618	2351	3568	4162	3778	3417	2419	1386	832	633	383	460	664	633	691	32112

Bahrain **Sep 06,07,08** **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	12	28	32	48	58	60	43	41	17	9	95	148	124	98	102	57	48	32	1	0	10	2	27	20	1113
2	8	4	36	47	53	47	52	45	13	0	96	164	230	165	137	89	63	29	2	7	2	5	15	14	1322
3	23	23	0	59	47	43	39	18	30	3	99	192	219	189	210	137	66	27	3	8	25	52	48	60	1621
4	51	37	57	55	36	53	42	43	30	35	153	145	183	212	97	75	96	7	22	8	19	33	48	50	1590
5	17	44	38	44	69	77	62	45	15	8	74	147	98	117	80	103	49	60	42	44	17	32	54	51	1386
6	47	28	27	30	46	40	33	52	32	5	42	80	164	166	48	30	102	24	10	13	12	12	17	23	1084
7	27	27	57	46	42	30	37	32	7	23	111	179	152	113	113	77	27	8	15	15	9	16	39	40	1242
8	42	46	45	39	39	46	29	28	17	15	98	139	159	131	104	120	111	70	29	18	29	43	44	55	1497
9	50	10	44	46	29	37	60	56	47	13	39	99	119	156	118	86	49	17	3	23	26	44	52	60	1283
10	46	55	47	53	56	45	52	42	29	11	50	117	168	185	116	56	29	6	5	55	60	54	48	43	1427
11	38	40	21	37	67	53	49	57	30	9	71	145	152	172	150	109	43	23	7	16	20	28	79	37	1453
12	33	47	45	36	48	51	71	87	25	5	66	146	224	184	128	88	49	25	6	2	4	4	10	10	1394
13	12	1	2	20	26	46	34	29	19	37	115	160	197	187	141	97	61	23	12	21	12	13	24	19	1308
14	13	40	39	16	38	43	41	34	18	23	77	161	155	150	114	81	30	14	3	3	8	15	14	12	1145
15	20	33	29	27	33	42	51	39	36	29	63	137	145	181	134	83	57	15	7	5	3	11	17	19	1213
16	16	16	31	30	32	44	34	20	11	11	53	130	168	192	133	88	69	66	29	36	26	26	26	43	1332
17	33	39	25	24	22	43	76	55	24	0	50	158	126	44	45	74	89	52	26	0	1	23	32	40	1101
18	37	30	25	37	37	34	33	38	43	71	126	196	138	99	95	39	54	64	11	33	20	26	25	32	1340
19	26	18	29	40	35	35	51	47	37	14	33	82	84	126	76	45	30	26	17	25	28	47	28	18	997
20	42	61	69	47	43	30	47	29	15	2	60	105	127	140	90	42	61	35	10	13	39	20	17	18	1162
21	25	29	21	29	33	23	16	22	26	8	75	137	174	89	63	30	15	29	46	74	121	95	62	44	1286
22	25	47	49	54	25	55	42	41	20	36	39	105	171	98	90	62	99	166	35	42	52	63	61	57	1533
23	44	49	38	37	55	40	37	42	19	38	32	94	125	92	94	59	59	74	95	73	92	105	97	51	1541
24	52	61	53	54	42	45	60	51	65	25	36	55	74	55	49	35	39	129	102	91	107	103	95	73	1551
25	67	64	60	63	60	61	70	56	51	11	23	69	142	149	139	64	13	5	6	15	81	105	92	82	1548
26	78	88	111	85	90	81	77	69	49	14	28	122	120	117	104	133	91	100	28	21	39	58	56	63	1821
27	54	47	51	51	62	55	63	55	39	3	8	97	72	70	64	45	33	6	5	1	9	10	42	60	1001
28	45	50	61	63	65	53	62	50	26	7	56	94	113	106	100	143	109	129	171	93	98	103	104	82	1984
29	66	58	52	50	43	52	52	53	60	14	5	60	101	106	124	88	42	2	10	36	82	81	80	66	1381
30	58	60	60	60	51	50	54	48	76	30	13	75	133	137	123	92	41	7	12	46	53	59	61	101	1500
KWh	1108	1181	1256	1327	1380	1412	1471	1322	925	507	1887	3736	4355	4026	3182	2329	1722	1272	770	838	1104	1290	1415	1343	41159

Bahrain **Oct 06,07,08** **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	107	68	43	44	55	44	53	62	94	19	25	95	154	153	161	99	46	11	0	1	21	50	102	85	1591
2	82	63	53	49	28	45	57	51	46	19	34	91	163	215	213	87	47	30	12	21	34	62	54	53	1610
3	42	62	0	60	48	52	50	36	59	13	43	140	154	130	145	78	42	26	26	15	40	49	68	62	1439
4	51	42	43	41	28	29	30	36	28	13	56	134	156	172	148	86	44	32	26	24	41	45	46	37	1388
5	30	29	39	42	51	51	64	55	57	20	77	135	81	73	70	43	24	14	15	46	39	44	76	54	1229
6	78	67	50	62	57	67	63	70	49	7	44	177	162	88	73	106	148	97	69	77	96	91	75	52	1924
7	48	54	59	37	54	52	32	48	47	19	34	74	85	111	111	66	35	19	15	24	36	51	59	71	1242
8	67	65	60	63	75	64	58	62	43	24	25	150	249	281	177	135	52	22	30	14	81	120	75	75	2068
9	72	12	64	62	77	81	64	53	64	16	16	124	166	147	124	82	35	2	1	1	57	82	78	78	1554
10	66	65	63	56	65	67	69	68	54	12	31	155	184	202	192	108	42	2	0	5	30	68	62	59	1725
11	41	69	69	57	61	54	59	57	54	20	21	124	145	114	94	47	20	7	9	18	30	38	60	62	1332
12	71	79	65	69	73	68	67	58	42	16	23	143	226	251	163	94	36	9	11	31	73	50	77	53	1845
13	73	66	54	46	56	58	61	37	56	16	44	149	181	160	163	146	32	8	3	10	46	90	56	36	1644
14	60	81	84	29	52	68	65	61	35	19	3	77	96	89	82	89	133	121	55	93	103	98	56	35	1681
15	51	43	57	82	40	25	44	63	69	21	10	71	111	222	166	75	43	30	45	32	35	46	38	36	1458
16	61	63	55	58	42	44	62	64	64	19	17	123	138	115	57	28	12	5	0	0	18	43	33	40	1161
17	44	34	35	48	55	48	45	46	43	7	11	93	116	143	174	49	19	2	5	23	33	30	35	46	1185
18	44	41	42	35	37	39	32	37	26	1	15	94	144	136	145	73	34	5	0	0	7	14	32	20	1055
19	15	32	66	35	29	43	34	15	5	0	22	60	101	97	77	52	30	5	0	10	10	79	82	65	967
20	65	30	33	33	39	20	30	39	26	15	27	77	136	136	98	38	15	1	0	1	12	17	21	57	965
21	82	40	48	47	55	50	41	25	33	18	3	53	75	83	80	25	14	9	2	34	28	37	41	48	971
22	44	44	48	37	36	37	44	32	41	19	0	53	115	68	10	0	1	1	28	62	66	60	52	51	949
23	50	39	38	37	32	39	39	41	35	17	4	48	92	123	128	101	28	1	0	0	18	37	52	46	1045
24	39	47	42	43	37	43	27	30	33	11	1	15	40	55	48	52	14	0	0	0	9	20	32	52	690
25	43	39	38	37	42	32	37	25	27	8	7	60	109	146	80	46	2	2	6	15	26	32	35	27	918
26	34	37	41	24	21	57	77	59	56	57	46	89	90	53	46	38	21	8	13	22	40	49	45	44	1069
27	54	44	46	38	30	39	33	37	38	25	17	28	31	46	38	32	22	7	17	28	46	32	28	32	787
28	39	39	51	44	39	46	46	38	39	27	8	26	51	54	39	27	13	3	20	62	24	28	36	37	834
29	50	35	35	34	32	37	30	36	32	23	7	33	85	118	144	87	55	22	12	18	38	38	51	37	1089
30	29	36	34	46	35	32	39	50	37	21	22	36	77	89	87	64	29	15	16	33	42	53	47	37	1007
31	41	43	42	43	48	47	40	39	51	37	21	4	32	63	69	39	12	0	27	48	62	52	54	50	964
KWh	1671	1507	1497	1437	1430	1477	1492	1428	1383	558	713	2730	3744	3934	3401	2092	1099	516	467	769	1241	1603	1659	1536	39385

Bahrain **Nov 06,07,08** **Wind Power Output of Bonus 600/44 Turbine (Month's Summary)**

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	48	56	61	53	54	53	52	47	49	30	4	14	74	80	48	56	23	0	3	25	46	46	52	61	1036
2	48	50	48	43	48	39	76	66	73	77	57	75	73	48	75	55	29	10	19	27	37	51	42	35	1201
3	39	42	0	51	44	49	48	37	39	27	20	9	69	81	41	18	6	0	0	16	27	19	20	17	718
4	18	28	14	23	17	35	49	18	29	11	26	37	53	52	28	33	13	0	12	21	29	48	53	49	696
5	42	41	40	39	35	51	37	37	53	37	6	30	68	72	43	39	18	1	12	45	47	44	56	46	938
6	44	48	37	44	39	41	45	35	53	35	2	58	51	42	40	54	26	3	0	1	8	29	56	53	845
7	41	54	46	55	44	54	48	41	35	32	7	72	62	92	43	32	6	0	8	31	39	48	49	44	984
8	46	51	44	47	41	43	42	32	28	21	8	57	101	104	94	57	22	4	0	1	8	2	28	44	926
9	32	0	52	51	48	50	52	44	39	21	6	40	80	89	94	80	22	5	0	0	7	21	25	29	886
10	35	35	39	32	42	35	33	35	27	19	7	22	21	23	14	85	44	24	15	11	36	35	44	44	757
11	37	44	39	35	32	35	37	32	34	30	11	13	43	58	63	59	29	1	0	0	5	22	31	42	732
12	42	42	35	39	36	33	39	28	28	34	20	5	45	62	53	50	21	22	36	27	49	53	25	19	844
13	19	14	12	29	61	79	51	22	21	34	23	31	69	78	69	31	14	12	8	16	29	56	39	51	868
14	49	39	43	78	66	49	48	44	53	56	42	44	75	95	100	94	64	37	37	25	79	107	66	58	1448
15	62	68	52	51	48	49	51	49	71	76	53	46	61	64	61	95	71	35	51	41	43	37	39	33	1307
16	32	30	33	42	39	32	51	43	55	68	44	33	58	62	79	42	20	7	19	34	32	41	40	40	975
17	39	44	50	33	40	46	51	47	72	79	21	9	35	72	78	39	11	9	14	33	43	38	44	43	990
18	40	39	46	42	52	48	42	42	44	64	49	41	78	99	90	37	11	2	10	21	18	19	35	35	1005
19	50	54	60	42	48	65	54	46	68	45	46	153	178	191	152	115	47	16	17	28	37	34	51	75	1673
20	41	30	35	25	24	19	31	33	50	52	36	22	43	39	36	16	7	0	22	61	59	52	45	49	826
21	55	57	93	90	75	67	59	48	55	59	9	10	36	48	39	21	4	5	20	35	59	49	50	42	1084
22	52	71	53	42	46	48	53	39	37	57	26	23	36	55	47	21	8	24	31	47	53	64	49	48	1029
23	41	47	43	40	47	48	51	69	65	84	28	27	36	43	40	32	13	15	24	57	54	65	56	57	1083
24	57	58	59	55	53	58	54	47	42	63	54	45	38	54	38	18	5	23	37	53	64	61	54	53	1142
25	47	56	44	46	40	46	40	42	54	98	56	25	35	35	27	41	16	15	33	59	55	66	71	44	1093
26	53	46	46	50	44	40	43	41	48	53	34	23	60	40	31	37	16	25	43	61	42	46	57	60	1038
27	48	52	46	45	53	44	40	43	61	76	47	25	19	23	34	37	11	9	19	26	42	46	44	41	931
28	39	39	34	41	38	40	45	48	66	75	47	39	74	56	52	21	19	27	34	30	26	28	29	36	983
29	39	20	22	39	30	20	25	20	19	29	32	29	39	26	25	36	22	42	26	33	49	50	66	43	781
30	41	41	47	31	35	32	35	31	37	40	39	29	18	14	3	8	9	22	29	26	29	36	42	36	712
KWh	1277	1296	1271	1332	1320	1346	1383	1207	1403	1482	859	1087	1728	1900	1638	1357	629	398	579	894	1151	1310	1358	1326	29532

Bahrain **Dec 06,07,08** **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	50	55	42	41	40	36	39	42	54	72	80	85	71	64	24	34	39	44	51	45	62	66	64	93	1292
2	61	75	66	66	64	57	56	42	40	62	77	61	26	32	42	20	10	24	43	73	64	70	61	70	1261
3	62	54	0	47	47	48	47	49	44	78	72	37	18	9	21	12	3	14	41	40	48	46	33	43	913
4	44	41	39	35	45	46	61	45	54	83	52	26	12	27	34	25	2	8	44	54	49	49	44	42	958
5	42	35	41	37	39	44	42	40	43	59	46	19	4	41	45	20	2	3	24	30	39	51	52	50	848
6	39	39	34	31	35	30	40	39	40	54	30	35	45	63	20	5	12	37	35	18	28	37	34	44	825
7	40	39	52	54	46	35	33	43	36	31	19	28	66	76	64	36	11	5	0	0	7	30	37	21	808
8	28	41	49	58	39	39	44	43	33	42	62	37	59	51	88	49	31	18	19	23	37	14	32	19	955
9	29	0	18	7	9	25	32	26	17	22	22	22	24	25	38	52	49	40	17	27	32	33	33	31	631
10	35	46	30	33	34	49	49	16	15	33	46	50	50	65	31	37	7	16	25	30	33	52	59	46	888
11	62	33	38	34	61	56	74	61	71	67	60	54	33	21	29	60	18	16	26	28	29	30	54	37	1053
12	48	46	62	54	63	50	64	50	44	44	44	34	12	19	8	9	6	17	20	31	35	48	52	45	904
13	52	46	44	40	39	48	45	52	42	51	50	38	18	3	8	2	11	15	28	38	36	33	36	48	823
14	37	44	43	46	46	52	52	48	59	73	60	24	17	11	26	30	12	17	38	47	62	62	52	61	1016
15	76	89	75	66	64	55	54	49	35	51	44	26	12	23	30	13	0	8	21	41	49	64	100	94	1138
16	78	85	111	128	115	102	73	75	69	37	39	37	31	79	61	44	22	57	78	96	71	52	44	41	1626
17	43	32	37	44	76	86	62	69	48	42	28	66	39	29	89	45	15	22	52	64	52	54	43	42	1180
18	49	52	49	42	37	41	40	52	31	26	34	18	32	31	63	85	56	49	68	66	68	50	38	45	1121
19	63	87	73	96	81	100	65	79	66	41	37	54	34	18	33	15	14	14	24	7	10	17	52	90	1168
20	59	63	111	60	40	3	11	7	12	28	33	29	34	75	34	16	7	8	17	34	46	30	23	40	822
21	47	38	42	39	46	45	51	30	53	65	88	64	78	59	60	50	45	44	68	85	112	109	114	117	1550
22	123	108	118	134	128	167	163	158	161	160	181	195	118	98	53	38	48	69	96	108	101	111	117	127	2880
23	128	139	112	105	100	131	97	66	107	180	200	156	175	129	72	30	32	26	38	39	61	45	63	58	2288
24	60	57	52	65	66	75	79	67	89	113	57	59	56	53	34	46	39	34	50	56	71	77	57	59	1470
25	55	62	82	100	99	76	75	72	92	114	129	79	70	47	60	65	44	69	70	91	114	77	85	68	1896
26	49	57	57	51	51	64	54	55	78	101	122	118	88	57	32	20	35	41	48	49	73	69	73	69	1512
27	63	70	71	74	74	73	83	96	130	153	164	148	128	94	45	21	30	43	64	65	61	62	71	78	1961
28	64	61	66	81	72	85	92	86	75	117	116	86	56	19	36	45	31	21	39	46	49	36	41	71	1492
29	66	59	58	61	87	103	75	83	94	114	88	90	50	55	92	64	23	35	55	72	77	63	75	59	1696
30	68	66	66	60	63	60	65	80	110	135	110	66	33	19	25	18	6	43	43	82	71	65	58	67	1480
31	64	66	66	69	74	72	54	50	62	113	139	144	92	47	30	40	37	43	51	69	64	56	54	52	1609
KWh	1783	1788	1803	1858	1878	1950	1871	1768	1907	2358	2330	1985	1580	1441	1328	1046	695	898	1296	1552	1710	1659	1750	1827	40063