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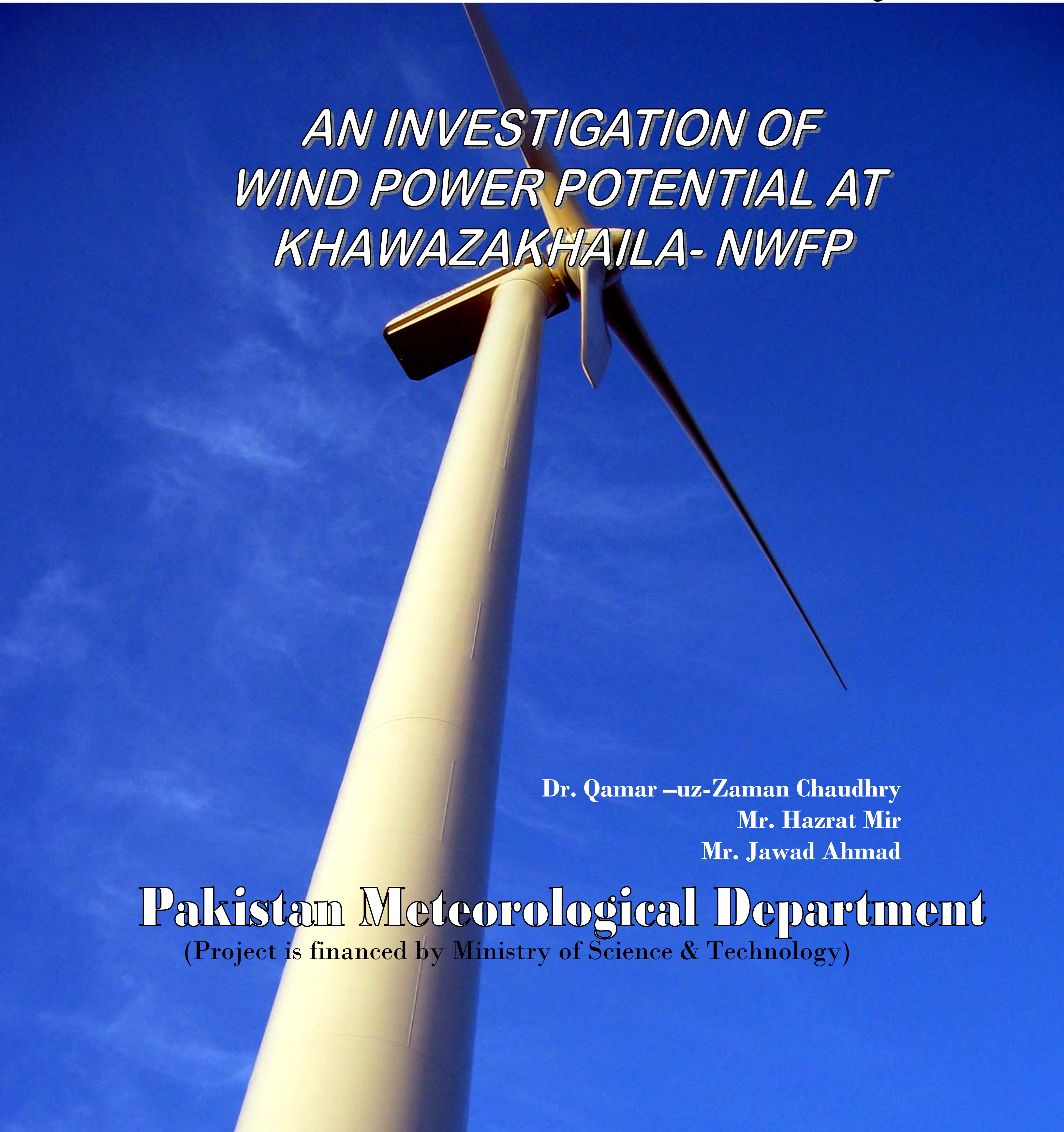

AN INVESTIGATION OF WIND POWER POTENTIAL AT KHAWAZAKHAILA- NWFP

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(Project is financed by Ministry of Science & Technology)

Executive Summary

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

In this report the analysis based on one year wind data has been presented along with the wind generated electric power at Khawazakhaila (Swat), NWFP. Wind data with one minute average speed and direction were collected at 10 meters and 30 meters height and 50 meters values were computed from models.

At 50 meters we have the annual average wind speed of 2.31 m/s during twelve months August-2006 to July-2007 the highest of 3.11 m/s is observed in February. Seasonal Diurnal Wind variation indicates that maximum wind speed is available in the morning thought-out the year. Wind frequency distribution shows that during 11.13% 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 Khawazakhaila is 37.38 w/m^2 according to international wind classification, this power density categorize Khawazakhaila as a below marginal site for wind power generation.

Wind generated electric power has as also been computed on hypothetical 600Kw wind turbine and its hourly, monthly and annual values has been added in this report. The annual power production form a single 600kw wind turbine come out to 164,904 kWh which shows the capacity factor of 3% for Khawazakhaila. 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 Khawazakhaila 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 <u>Wind Mapping Project of Pakistan Meteorological Department:</u>

As any plan to develop wind energy must begin by understanding the wind resources. Where is 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 Fig-1. The list of stations is given below:

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

Khawazakhaila is situated in district Swat at:
Latitude = 34.56º Longitude = 72.27º

2.2 Data source:

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

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

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

i. Wind speed one minute average at 10 & 30 meters
ii. Maximum wind speeds during 10 minutes
iii. Minimum wind speeds during 10 minutes
iv. Wind direction five minutes average at 30 meters
v. Temperature 5 minutes average in °C

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

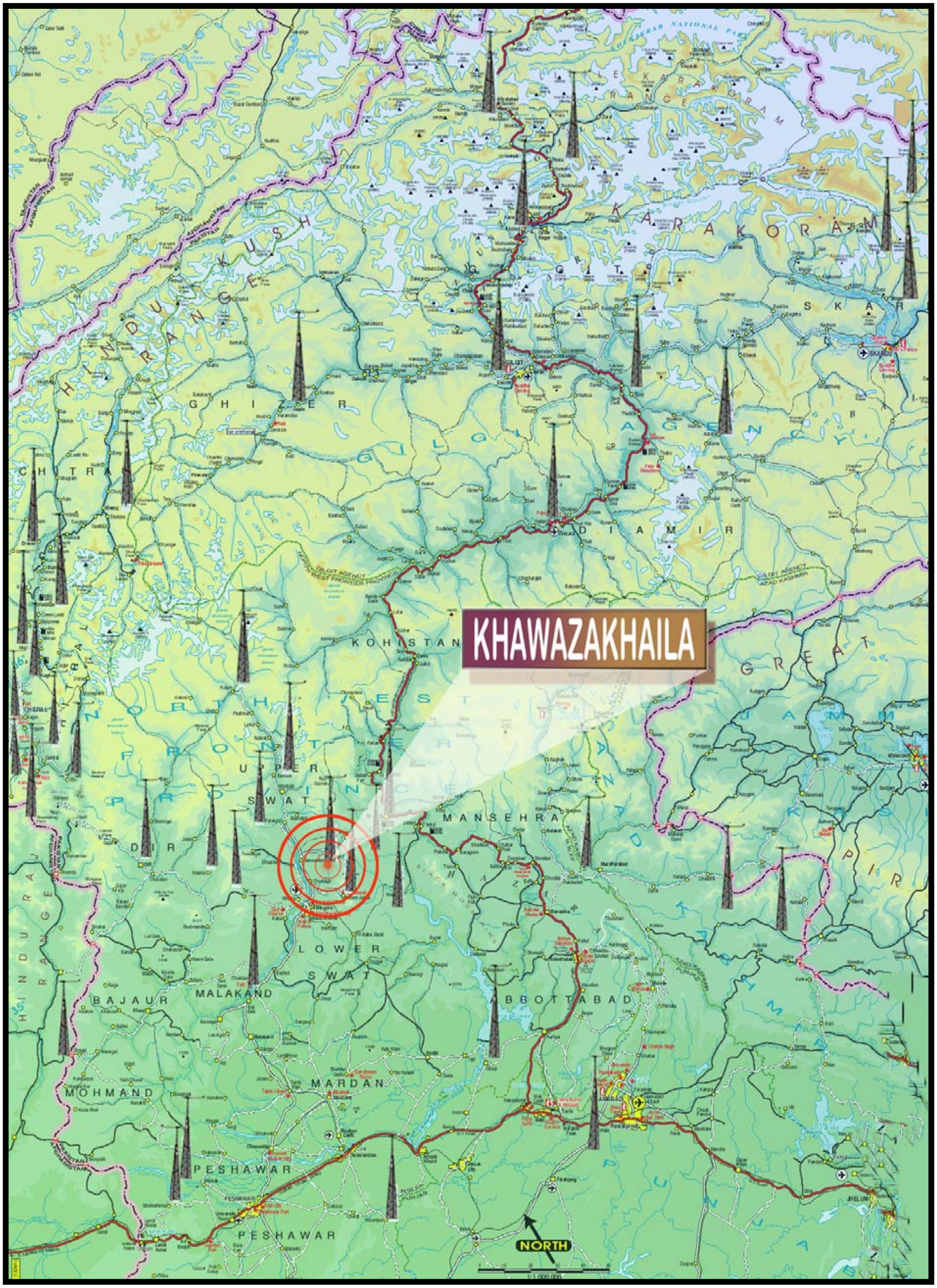


Figure # 1: Shows 42-Towers Installed in Wind Mapping Project in Northern Areas

3.0 Methodology; Analysis & Discussion:

3.1 Wind speed variation with height:

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

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

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

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

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

3.1.1 *Log Law:*

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

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

Where

u_* is the friction notify

k is the von Karman constant

$\mathbf{Z_o}$ is the roughness length

D is the displacement height

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

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

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

Where

U_R is the wind speed at reference height Z_R

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

3.1.2 ***Power Law:***

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

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

Where:

α is the power law exponent

u_R is the wind speed at reference height z_R

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

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

Where: Z is the measurement height

Z_R is the reference height

Z_0 is the roughness length

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

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

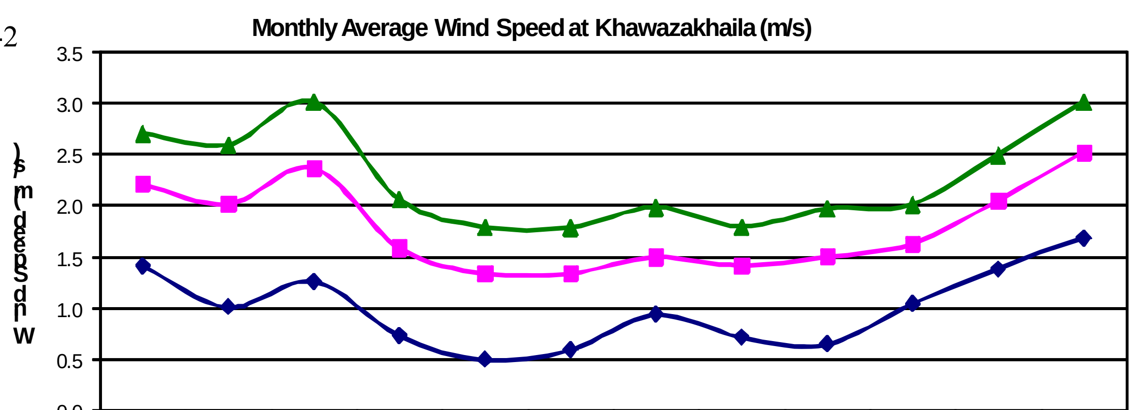
Type of terrain	**Z_0**	**α**
Mud Flats, Ice	10^{-5} to $3x\ 10^{-5}$	
Calm Sea	$2x10^{-4}$ to $3x10^{-4}$	
Sand	$2x10^{-4}$ to 10^{-3}	0.01
Mown Grass	0.001 to 0.01	
Low Grass	0.01 to 0.04	0.13
Fallow Field	0.02 to 0.03	
High Grass	0.04 to 0.1	0.19
Forest and Woodland	0.1 to 1	
Built up area, Suburb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

Fig-2 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 greater than 1.35 m/s during the year from with maximum average wind speed of 2.52 m/s in the month of February. At 50 meters we have the average wind speed of greater than 1.79 m/s and the highest average wind speed of 3.01 m/s is observed in the month of February.

Fig-2



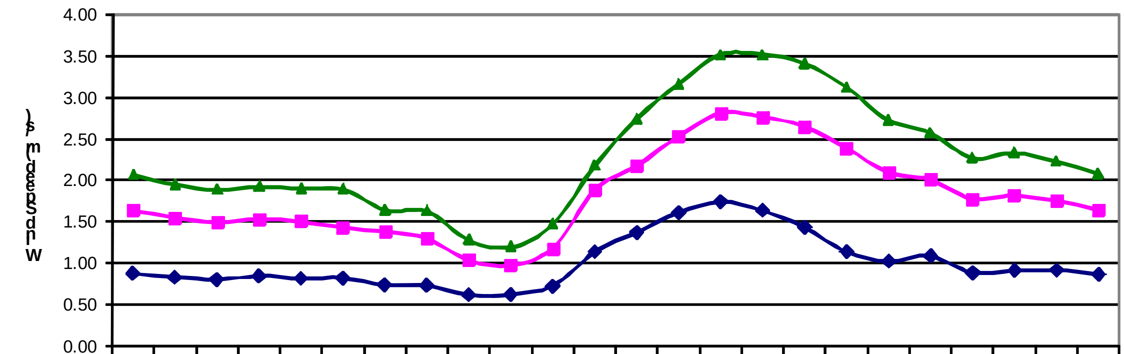
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
AWS 10m	1.42	1.01	1.26	0.74	0.50	0.59	0.94	0.72	0.65	1.04	1.39	1.69
AWS 30m	2.21	2.02	2.37	1.59	1.35	1.35	1.50	1.42	1.51	1.63	2.05	2.52
AWS 50m	2.70	2.59	3.01	2.06	1.79	1.79	1.98	1.79	1.97	2.01	2.49	3.01

Months

3.3 Diurnal Wind Speed Variation:

Fig-3 shows the annual diurnal wind speed variations at Khawazakhaila. The wind speed is generally lower during night and after sunrise it starts picking up and reaches maximum around 4 – 5 p.m. which is around 2.8 m/s and 3.5 m/s at 30 meters and 50 meters height respectively. Then after sunset it starts generally decreasing. Figures 4 to 7 shows seasonal diurnal variation of wind speed.

Fig-3 **Annual Diurnal Variation Wind Speed at Khawazakhaila**



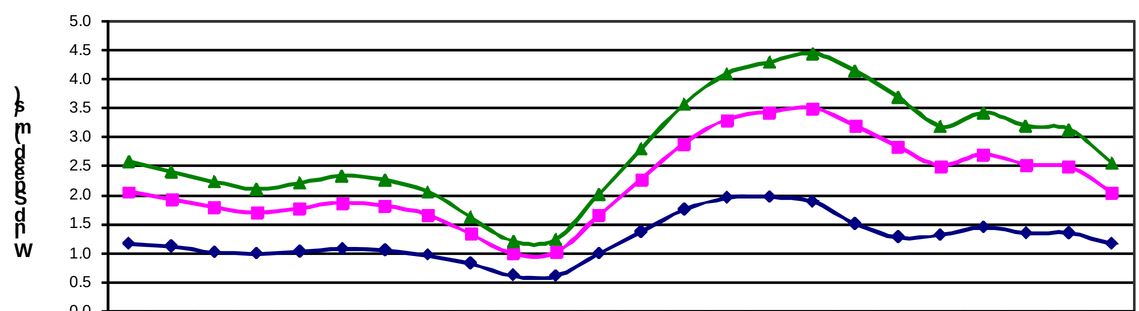
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WS 10m	0.8	0.8	0.7	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.7	1.1	1.3	1.6	1.7	1.6	1.4	1.1	1.0	1.0	0.8	0.9	0.9	0.8
WS 30m	1.6	1.5	1.4	1.5	1.4	1.4	1.3	1.2	1.0	0.9	1.1	1.8	2.1	2.5	2.8	2.7	2.6	2.3	2.0	2.0	1.7	1.8	1.7	1.6
WS 50m	2.0	1.9	1.8	1.9	1.8	1.8	1.6	1.6	1.2	1.1	1.4	2.1	2.7	3.1	3.5	3.5	3.4	3.1	2.7	2.5	2.2	2.3	2.2	2.0

PST (Hours)

Figure-4 shows the seasonal wind variations for the months of March to May. Maximum wind speed at 50 meters height reaches to 4.4 m/s during March to May period and Figure-5 shows the seasonal wind variations for the months of June to August. At 50m height it reaches to 3.5 m/s during June to August period.

Similarly Fig-6 and Fig-7 shows seasonal variations during the months (Sep to Nov) and (Dec to Feb). In Fig-6 the maximum wind speed is upto to 3.8 m/s at 50 meters and in Fig-7 the maximum wind speed is upto to 3.0 m/s at 50 meters height.

Fig-4 **Diurnal Variation Wind Speed at Khawazakhaila (Mar to May)**

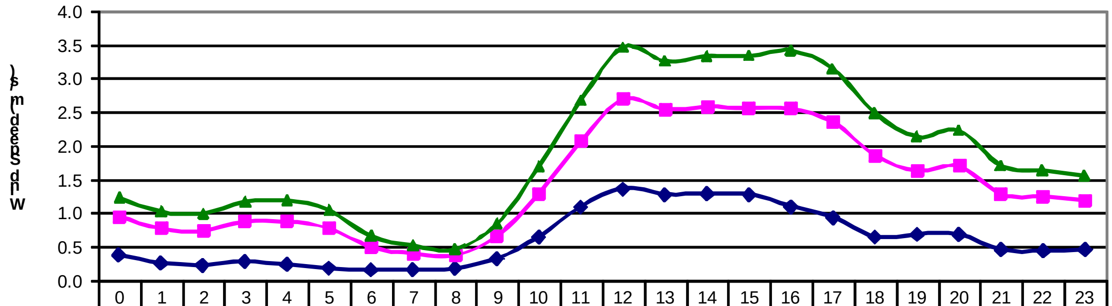


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	1.1	1.1	1.0	1.0	1.0	1.1	1.0	1.0	0.8	0.6	0.6	1.0	1.4	1.7	1.9	2.0	1.9	1.5	1.3	1.3	1.4	1.3	1.3	1.1
WS 30m	2.0	1.9	1.8	1.7	1.8	1.9	1.8	1.6	1.3	1.0	1.0	1.6	2.3	2.9	3.3	3.4	3.5	3.2	2.8	2.5	2.7	2.5	2.5	2.0
WS 50m	2.6	2.4	2.2	2.1	2.2	2.3	2.3	2.0	1.6	1.2	1.2	2.0	2.8	3.6	4.1	4.3	4.4	4.1	3.7	3.2	3.4	3.2	3.1	2.5

PST (Hours)

Fig-5

Diurnal Variation Wind Speed at Khawazakhaila (June to Aug)

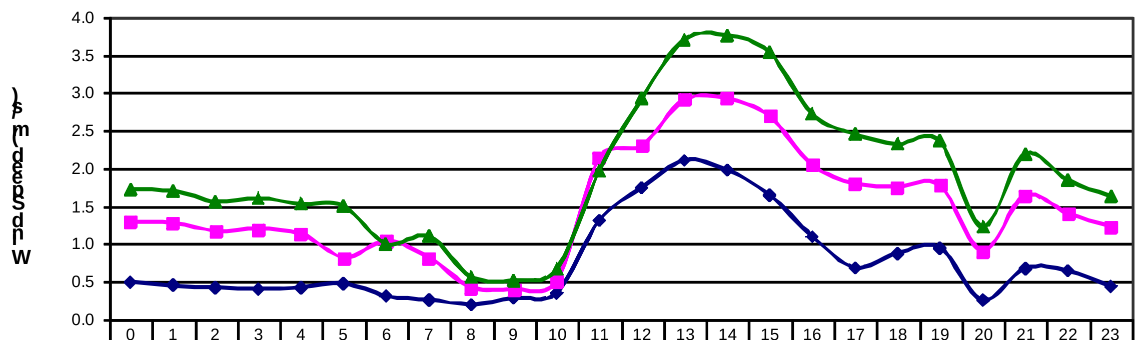


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.4	0.3	0.2	0.3	0.2	0.2	0.1	0.2	0.2	0.3	0.6	1.1	1.4	1.3	1.3	1.3	1.1	0.9	0.6	0.7	0.7	0.5	0.4	0.5
WS 30m	0.9	0.8	0.7	0.9	0.9	0.8	0.5	0.4	0.4	0.7	1.3	2.1	2.7	2.5	2.6	2.6	2.5	2.4	1.8	1.6	1.7	1.3	1.2	1.2
WS 50m	1.2	1.0	1.0	1.2	1.2	1.0	0.7	0.5	0.5	0.8	1.7	2.7	3.5	3.3	3.3	3.3	3.4	3.1	2.5	2.1	2.2	1.7	1.6	1.6

PST (Hours)

Fig-6

Diurnal Variation Wind Speed at Khawazakhaila (Sep to Nov)

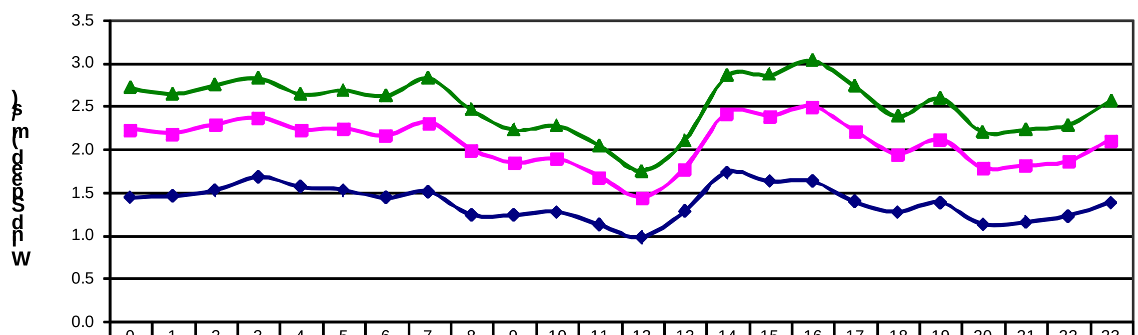


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
WS 10m	0.5	0.5	0.4	0.4	0.4	0.5	0.3	0.3	0.2	0.3	0.4	1.3	1.7	2.1	2.0	1.6	1.1	0.7	0.9	0.9	0.3	0.7	0.6	0.4
WS 30m	1.3	1.3	1.2	1.2	1.1	0.8	1.0	0.8	0.4	0.4	0.5	2.1	2.3	2.9	2.9	2.7	2.0	1.8	1.7	1.8	0.9	1.6	1.4	1.2
WS 50m	1.7	1.7	1.6	1.6	1.5	1.5	1.0	1.1	0.6	0.5	0.7	2.0	2.9	3.7	3.8	3.5	2.7	2.5	2.3	2.4	1.2	2.2	1.8	1.6

PST (Hours)

Fig-7

Diurnal Variation Wind Speed at Khawazakhaila (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	1.4	1.4	1.5	1.7	1.6	1.5	1.4	1.5	1.2	1.2	1.3	1.1	1.0	1.3	1.7	1.6	1.6	1.4	1.3	1.4	1.1	1.1	1.2	1.4
WS 30m	2.2	2.2	2.3	2.4	2.2	2.2	2.2	2.3	2.0	1.8	1.9	1.7	1.4	1.8	2.4	2.4	2.5	2.2	1.9	2.1	1.8	1.8	1.9	2.1
WS 50m	2.7	2.6	2.7	2.8	2.6	2.7	2.6	2.8	2.4	2.2	2.3	2.0	1.7	2.1	2.8	2.9	3.0	2.7	2.4	2.6	2.2	2.2	2.3	2.6

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

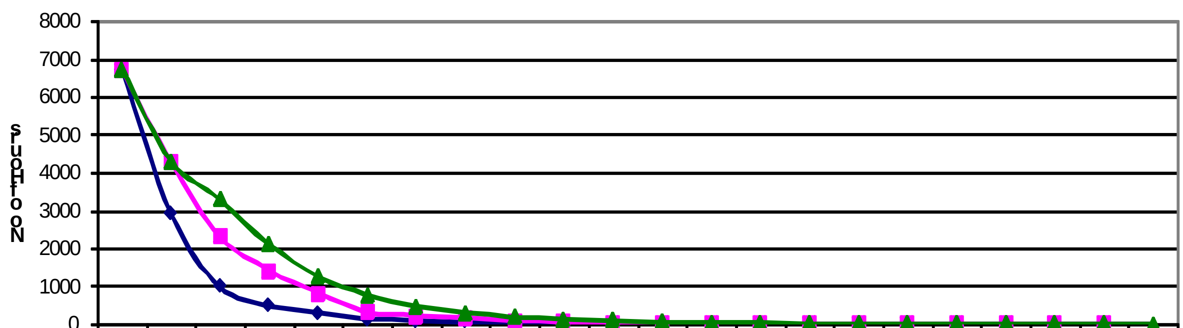
R .F = probability P (V_i) = Frequency of given wind speed / Total period

3.4.3 *Annual Cumulative Wind Frequency:*

Fig-8 shows the annual cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters. The analysis indicate that in a year at a height of 30 meters during 795 hours the wind speed is equal or greater than 5 m/s, 303 hours at 6m/s, 209 hours at 7m/s. Whereas at 50 meters, in a year during 1238 hours the wind speed is equal or greater than 5m/s, 755 hours at 6m/s and 468 hours at 7m/s.

Fig-8

Annual Cumulative Wind Speed Distribution at Khawazakhaila



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
CWS10m	6710	2897	985	489	280	126	84	57	31	22	14	9	2	1	1	0	0	0	0	0	0	0
CWS30m	6710	4272	2315	1401	795	303	209	149	77	51	35	23	9	5	3	1	1	1	0	0	0	0
CWS50m	6710	4280	3280	2095	1238	755	468	277	176	127	90	56	41	25	17	11	6	3	2	2	1	0

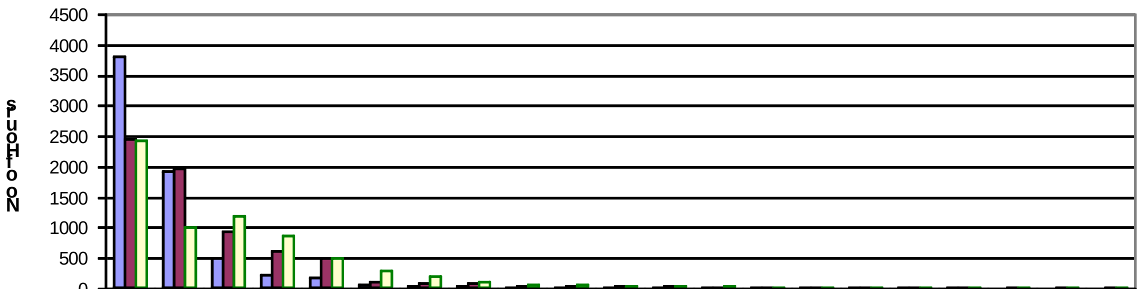
Wind Speed (m/s)

3.4.4 *Wind Frequency Distribution:*

Fig-9 shows the annual frequency distribution. We can see that at 50 meters during 483 hours wind speed is 5m/s, 287 hours wind speed is 6 m/s, 191 hours speed is 7 m/s, 49 hours speed is 8 m/s, 38 hours speed is 9 m/s and during 34 hours the wind speed is 10m/s and so on.

Fig-9

Annual Wind Frequency Distribution at Khawazakhaila



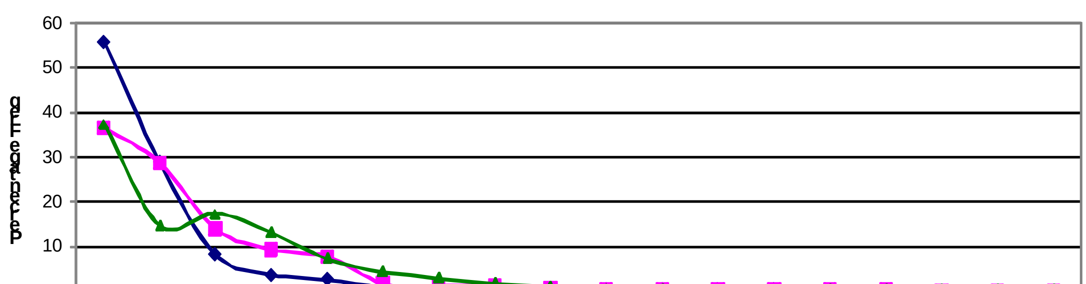
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CWS 10m	3813	1912	496	209	154	41	28	26	9	8	5	6	1	1	0	0	0	0	0	0	0
CWS 30m	2438	1957	915	605	492	95	59	72	25	17	12	13	4	2	2	0	0	1	0	0	0
CWS 50m	2429	1000	1185	857	483	287	191	101	49	38	34	15	16	8	6	5	3	1	1	1	1

Wind Speed (m/s)

Fig-10 gives this frequency distribution in percentage. At 50 meters we find that during 7.14% of time wind is 5m/s, 4.24% of the time 6m/s and 2.74% of the time it is 7m/s. whereas at 30 meters height we get 7.45% of the time wind speed greater than or equal to 5m/s.

Fig-10

Annual Percenatge Wind Frequency Distribution at Khawazakhaila



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WS 10m	55.60	28.74	7.90	3.49	2.45	0.66	0.43	0.36	0.11	0.09	0.07	0.07	0.01	0.01	0.01	0.00	0.00	0.00
WS 30m	36.43	28.56	13.71	9.12	7.45	1.48	0.95	1.15	0.41	0.26	0.18	0.18	0.05	0.03	0.02	0.00	0.00	0.01
WS 50m	37.23	14.47	17.17	12.86	7.14	4.24	2.74	1.51	0.76	0.59	0.53	0.23	0.23	0.11	0.08	0.06	0.03	0.01

Wind Speed (m/s)

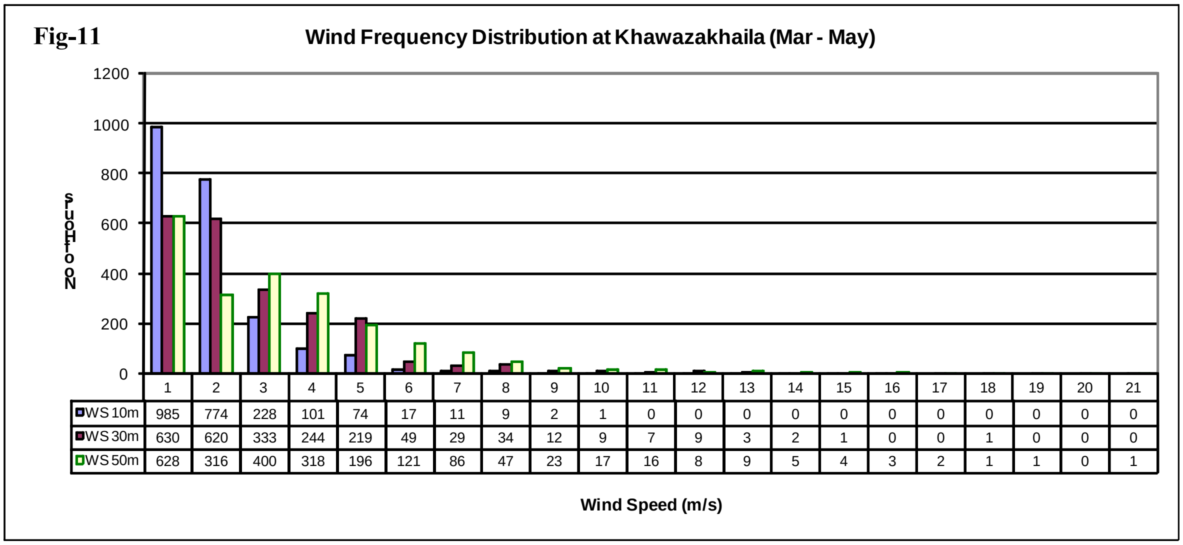
3.4.5 *Seasonal Wind Frequency Distribution:*

Figures 11–14 gives seasonal wind frequency distribution and figures 15–18 gives seasonal wind frequency distribution in percentage.

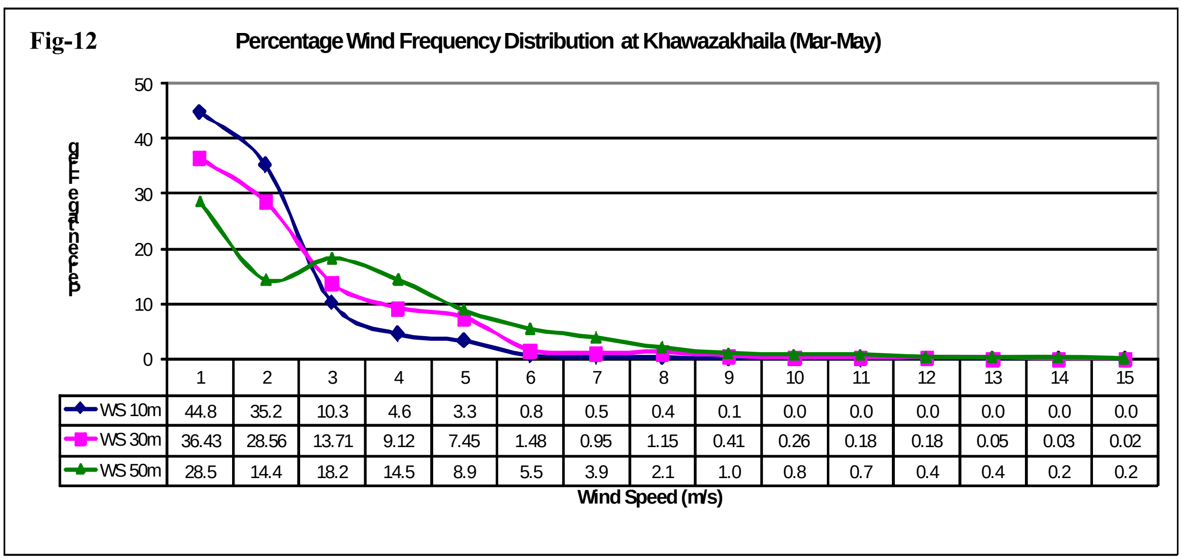
<u>March – May</u>

Fig-11 shows the Wind Frequency distribution during the months of March to May. We can see that in this period at 30 meters height during 219 hours we get 5m/s, 29 hours 6m/s. Similarly at 50 meters we get 196 hours 5m/s, 121 hours 6m/s, 86 hours 7m/s and so on.

Fig-12 shows the percentage frequency distribution at Khawazakhaila for the months of March to May. We can see that in this period 7.45% and 8.90% the wind speed equal to 5m/s at 30m and 50m respectively.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	985	774	228	101	74	17	11	9	2	1	0	0	0	0	0	0	0	0	0	0	0
WS 30m	630	620	333	244	219	49	29	34	12	9	7	9	3	2	1	0	0	1	0	0	0
WS 50m	628	316	400	318	196	121	86	47	23	17	16	8	9	5	4	3	2	1	1	0	1

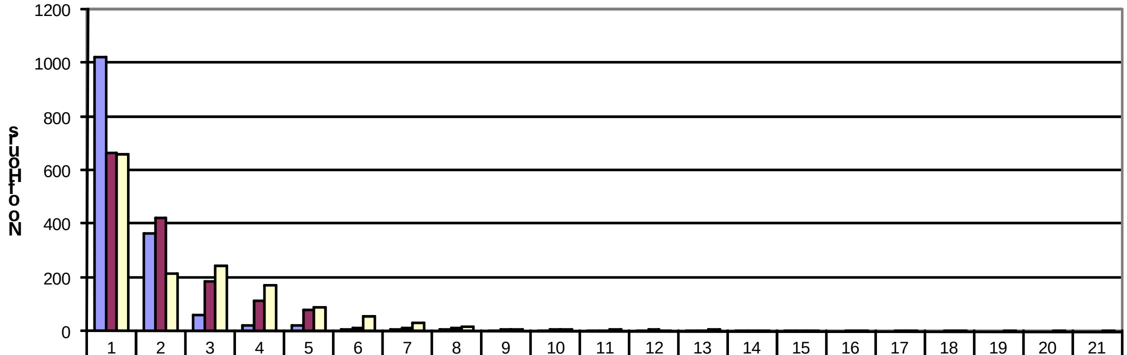


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WS 10m	44.8	35.2	10.3	4.6	3.3	0.8	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WS 30m	36.43	28.56	13.71	9.12	7.45	1.48	0.95	1.15	0.41	0.26	0.18	0.18	0.05	0.03	0.02
WS 50m	28.5	14.4	18.2	14.5	8.9	5.5	3.9	2.1	1.0	0.8	0.7	0.4	0.4	0.2	0.2

<u>June - August</u>

Fig-13 shows wind frequency distribution during the months of June to August. We can see that in this period at 30 meters height during 76 hours we get 5m/s, 11 hours 6m/s. Similarly at 50 meters height during 89 hours we get wind speed of 5m/s, during 51 hours 6m/s and so on. Fig-14 shows percentage wind frequency for the same period.

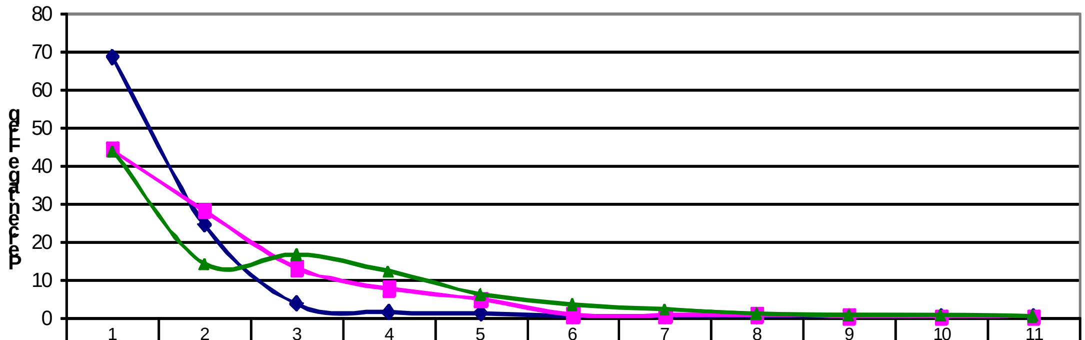
Fig-13 **Wind Frequency Distribution at Khawazakhaila (June - Aug)**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	1020	362	57	20	18	6	4	4	1	1	1	1	0	0	0	0	0	0	0	0	0
WS 30m	663	419	183	112	76	11	7	11	4	2	2	2	1	0	0	0	0	0	0	0	0
WS 50m	658	211	244	168	89	51	31	15	7	6	5	2	3	1	1	1	0	0	0	0	0

Wind Speed (m/s)

Fig-14 **Percentage Wind Frequency Distribution at Khawazakhaila (June-Aug)**



	1	2	3	4	5	6	7	8	9	10	11
WS 10m	68.7	24.4	3.5	1.2	1.0	0.3	0.2	0.2	0.1	0.1	0.0
WS 30m	44.2	28.1	13.0	7.5	4.7	0.7	0.4	0.6	0.2	0.1	0.1
WS 50m	43.9	14.0	16.5	12.0	6.0	3.4	1.9	0.9	0.4	0.4	0.3

Wind Speed (m/s)

<u>September to November</u>

Fig-15 shows wind frequency distribution during the period from September to November. We can see that at 30 meters height during 119 hours we get 5m/s, 17 hours 6m/s, 10 hours 7m/s, 12 hours 8m/s, 4 hours 9m/s and during 2 hour reaches upto 10m/s. Similarly at 50 meters height during 131 hours we get wind speed of 5m/s, 76 hours 6m/s, 49 hours 7m/s, 24 hours 8m/s, 9 hours 9m/s, 7 hours 10m/s and for 6 hours we get 11m/s and during 6 hour reaches upto 12m/s.

Fig-16 shows wind frequency distribution in percentage during the months of Sep to Nov. We can see that at 30 meter height 5.4% wind equal to 5m/s, 0.8 equal to 6m/s and so on. Similarly at 50 meter height 5.5% wind equal to 5m/s, 3.3 equal to 6m/s and 2.1% equal to 7m/s.

Fig-15

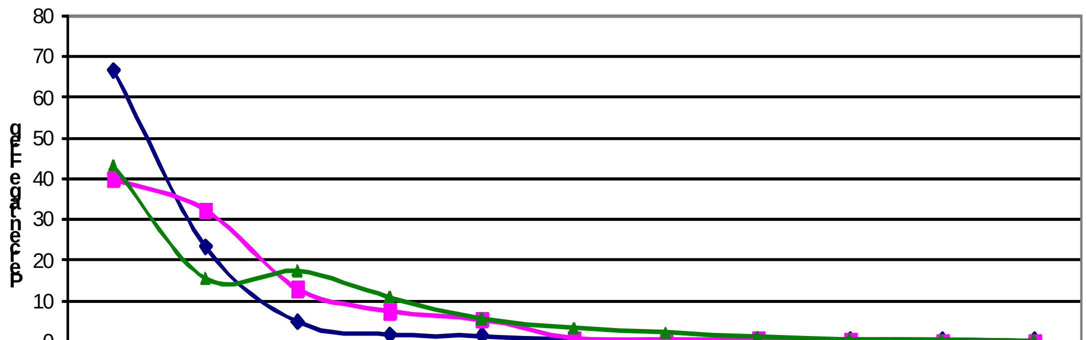
Wind Frequency Distribution at Khawazakhaila (Sep - Nov)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	1456	506	103	35	28	10	8	11	6	6	5	5	1	1	0	0	0	0	0	0	0
WS 30m	867	702	282	164	119	17	10	12	4	2	1	1	0	0	0	0	0	0	0	0	0
WS 50m	863	355	402	253	131	76	49	24	9	7	6	2	2	1	0	0	0	0	0	0	0

Wind Speed (m/s)

Fig-16

Percentage Wind Frequency Distribution at Khawazakhaila (Sep-Nov)



	1	2	3	4	5	6	7	8	9	10	11
WS 10m	66.7	23.2	4.7	1.6	1.3	0.5	0.4	0.5	0.3	0.3	0.2
WS 30m	39.7	32.2	12.9	7.5	5.4	0.8	0.5	0.6	0.2	0.1	0.1
WS 50m	43.1	15.5	17.3	10.9	5.5	3.3	2.1	1.0	0.4	0.3	0.2

Wind Speed (m/s)

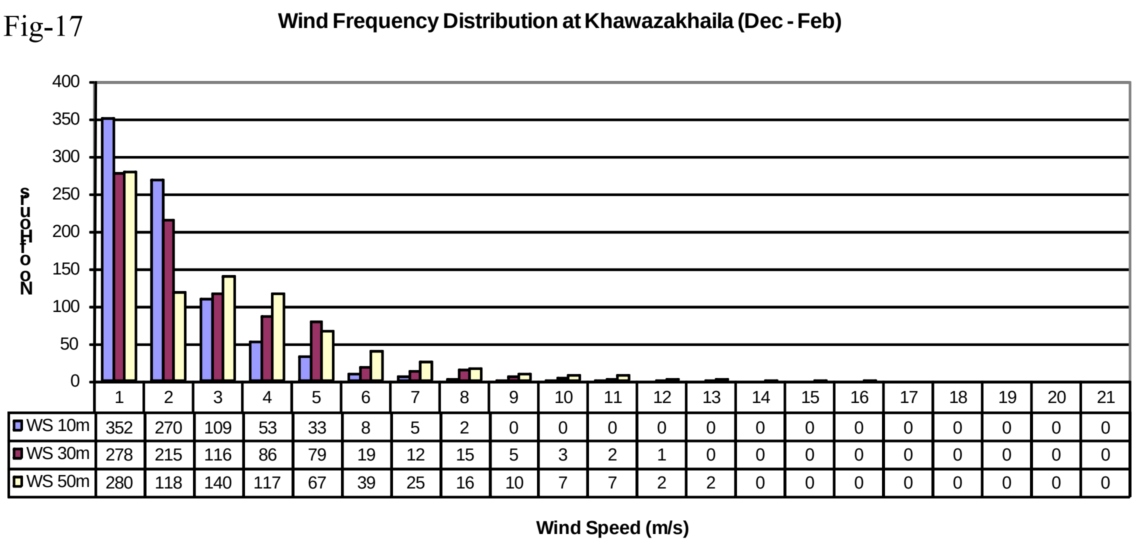
<u>December – February</u>

Fig-17 shows wind frequency distribution during the period from December to February. We can see that at 30 meters height during 79 hours we get wind speed of 5m/s, 19 hours 6m/s, 12 hours 7m/s, 15 hours 8m/s, 5 hours 9m/s and during 3 hours 10m/s.

Similarly at 50 meters during 67 hours we get 5m/s, 39 hours 6m/s, 25 hours 7m/s, 16 hours 8m/s and during 10 hours we get 9m/s and during 7 hours reaches upto 10m/s.

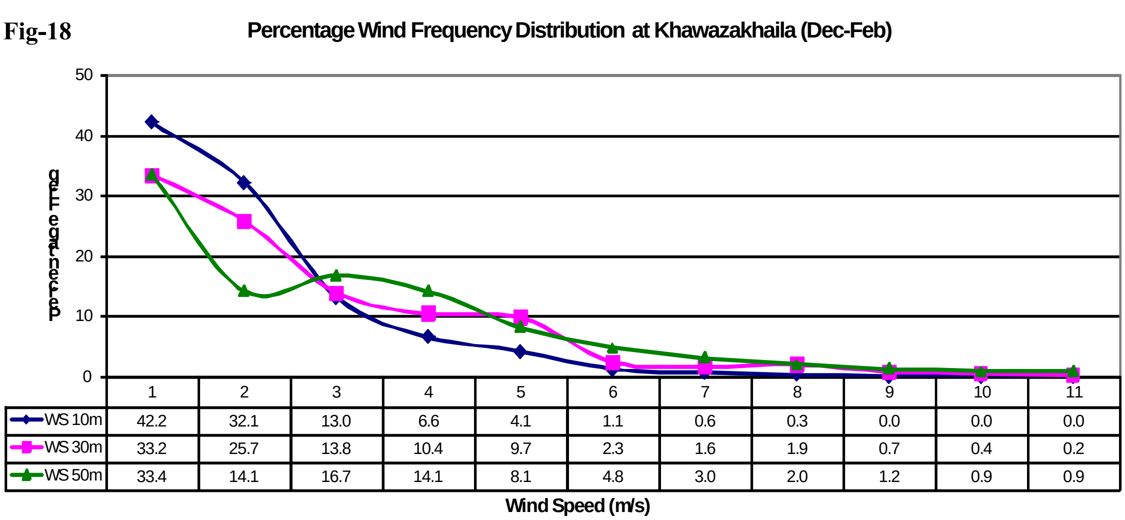
Fig-16 shows wind frequency distribution in percentage during the months of Sep to Nov. We can see that at 30 meter height 9.7% wind equal to 5m/s, 2.3 equal to 6m/s and so on. Similarly at 50 meter height 8.1% wind equal to 5m/s, 4.8 equal to 6m/s and 3.0% equal to 7m/s.

Fig-17



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WS 10m	352	270	109	53	33	8	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0
WS 30m	278	215	116	86	79	19	12	15	5	3	2	1	0	0	0	0	0	0	0	0	0
WS 50m	280	118	140	117	67	39	25	16	10	7	7	2	2	0	0	0	0	0	0	0	0

Fig-18



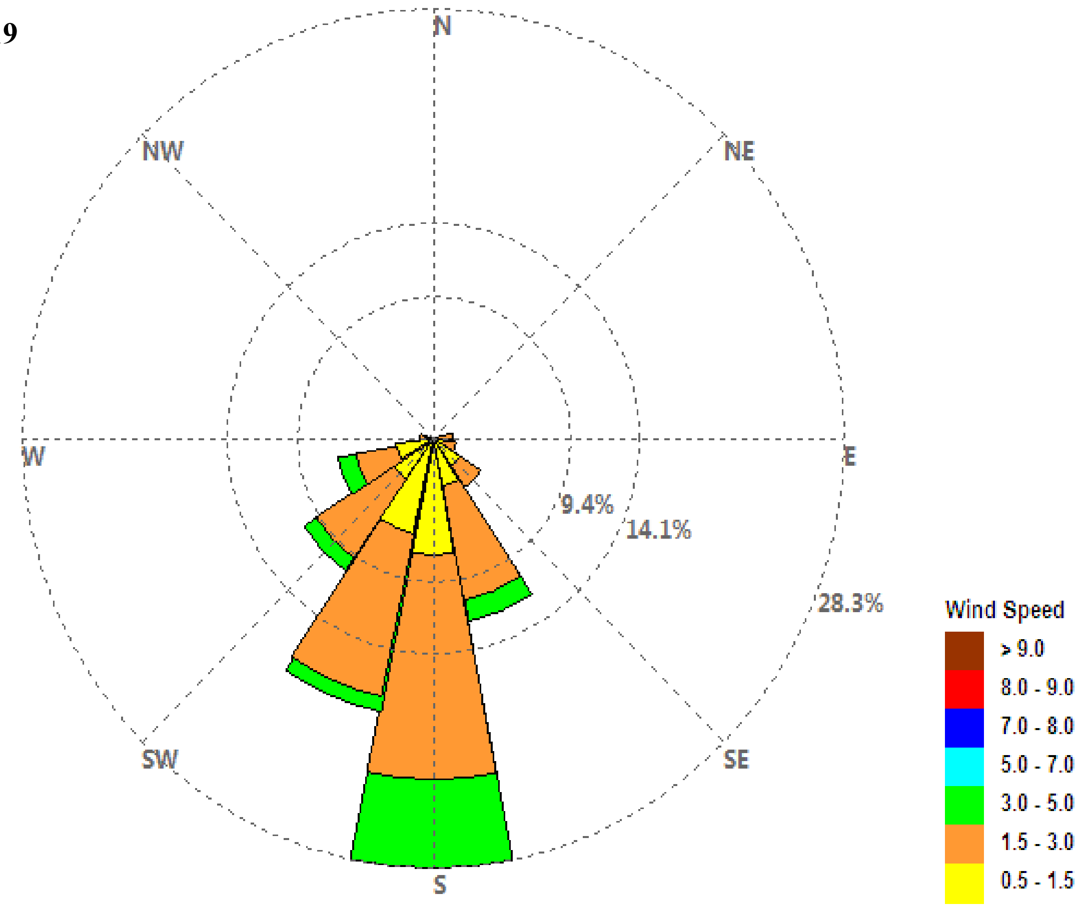
	1	2	3	4	5	6	7	8	9	10	11
WS 10m	42.2	32.1	13.0	6.6	4.1	1.1	0.6	0.3	0.0	0.0	0.0
WS 30m	33.2	25.7	13.8	10.4	9.7	2.3	1.6	1.9	0.7	0.4	0.2
WS 50m	33.4	14.1	16.7	14.1	8.1	4.8	3.0	2.0	1.2	0.9	0.9

3.5 Wind Rose:

Fig-19 shows the Wind Rose based on 12 months data from August 2006 – July 2007 collected at 30 meters height. Wind Rose indicates that most of the time the wind direction was in South and South West South (SWS). The annual average wind speed is 1.5m/s to 3.0m/s and is 47% of the total and 3.0m/s to 5.0 m/s and is 10% of the total.

Wind Rose at Khawazakhaila (30m height during 12 months)

Fig-19



Source: - Pakistan Meteorological Department

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

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

Where V is mean of data set

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

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

3.6.3 *Standard Deviation*

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

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

3.7 Wind power density:

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

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

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

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

3.7.1 *Wind power classes:*

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

Table-2: International Wind Power Classification

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

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

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

A parcel of Wind possesses kinetic energy

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

From this, power density is calculated as

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

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

From fluid dynamics, it can be proved that

$$dm/dt = \varphi AV$$

Volume of cylindrical cross section can be written as

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

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

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

$$S = L = Vt,$$

So equation L takes the form

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

Now mass of wind can be written as

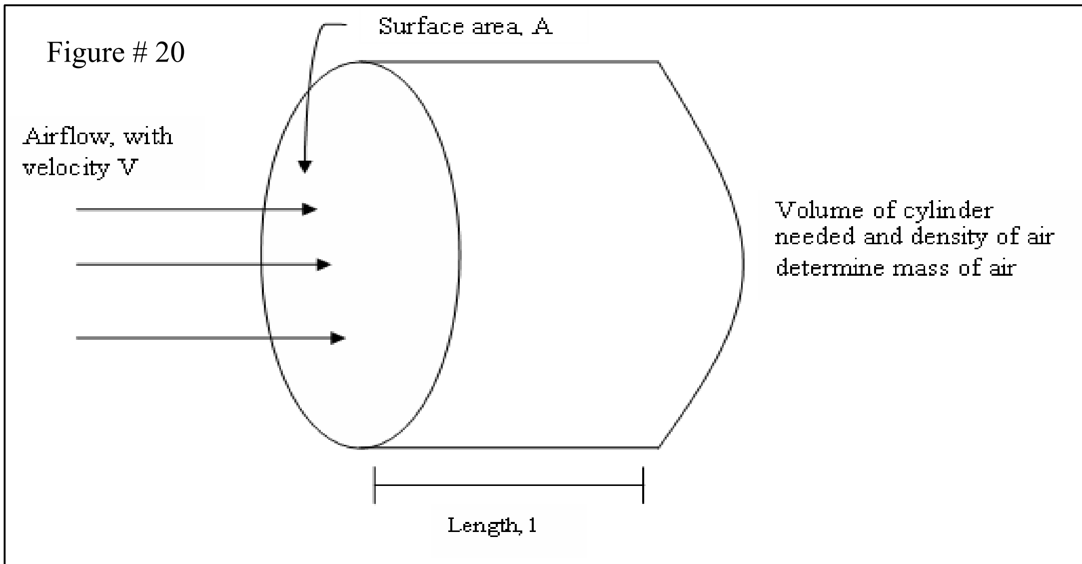
$$M = \varphi Avt$$

Differentiating

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

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

Figure # 20



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.

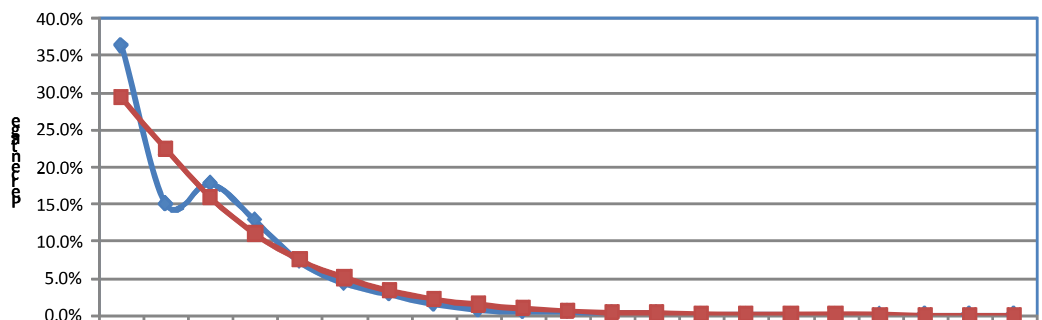
A measure of the confidence of the fit of the Weibull curve to the real data is also returned. Often the Weibull curve is a good fit to the most of the data, but a poor fit to some. If the poor fit is in the low wind speed range, i.e. below cut in it may be possible to ignore the poor fit as this portion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

Figure-20 shows the Weibull fit to the relative frequency of wind speed.

Fig-20 **Relative Frequency an Weibull Probability at Khawazakhaila (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	36.2	14.9	17.7	12.8	7.2%	4.3%	2.8%	1.5%	0.7%	0.6%	0.5%	0.2%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Weibull 50m	29.3	22.3	15.8	10.9	7.4%	5.0%	3.3%	2.2%	1.4%	0.9%	0.6%	0.4%	0.3%	0.2%	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 0.99 to the highest of 1.28. The lowest value of the scale parameter C is equal to 1.86 while the highest value is observed as 3.33.

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 annual average wind speed is 1.27 m/s with Standard deviation of 1.18, at 30 meters this average speed is 1.95 m/s with Standard deviation of 1.70. At 10 meters monthly average temperature from recorded data and assessed surface roughness Z_o is also given. Roughness varies accordingly to the prevailing wind direction during different months.

At 50 meters the monthly average wind speed varies from the lowest of 1.87 m/s in September to highest of 3.11 m/s during February. Whereas the annual average wind speed is 2.31 m/s with Standard deviation of 2.10.

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 1.60 W/m^2 in July to 21.39 W/m^2 in September with annual of 7.92 W/m^2.

At 30 meters height the power density varies from 9.33 W/m^2 in July to the highest of 40.80 W/m^2 in February and the annual values is about 21.41 W/m^2, which means that at 30 meters wind Power potential of this areas falls in Class-1.

At 50 meters height the power density of Khawazakhaila varies from 22.02 W/m^2 in July to 70.46 W/m^2 in February with annual wind power density of 37.38w/m^2

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

10 m					
Month	**AvgV (m/s)**	**St Dev**	**C (m/s)**	**K**	**P/A (w/m2)**
January	1.54	1.15	1.69	1.38	6.95
February	1.83	1.48	1.98	1.27	13.62
March	1.58	1.18	1.73	1.37	7.58
April	1.25	1.06	1.33	1.19	4.84
May	1.48	1.40	1.52	1.06	10.36
June	1.06	1.01	1.08	1.05	3.80
July	0.87	0.73	0.93	1.21	1.60
August	0.96	1.10	0.89	0.86	4.82
September	1.31	1.75	1.08	0.73	21.39
October	1.06	1.45	0.85	0.71	12.51
November	0.97	0.79	1.04	1.25	2.07
December	1.29	1.12	1.37	1.17	5.56
Annual	**1.27**	**1.18**	**1.29**	**1.11**	**7.92**
30 m					
Month	**AvgV (m/s)**	**St Dev**	**C (m/s)**	**K**	**P/A (w/m2)**
January	2.17	1.74	2.34	1.27	22.27
February	2.62	2.14	2.81	1.25	40.80
March	2.32	1.80	2.52	1.32	25.76
April	2.12	1.82	2.25	1.18	24.11
May	2.50	2.38	2.55	1.05	50.36
June	1.77	1.71	1.80	1.04	18.49
July	1.55	1.32	1.64	1.19	9.33
August	1.57	1.49	1.60	1.06	12.38
September	1.73	1.46	1.84	1.21	12.53
October	1.59	1.39	1.67	1.16	10.57
November	1.68	1.38	1.79	1.23	10.95
December	1.82	1.73	1.87	1.06	19.35
Annual	**1.95**	**1.70**	**2.06**	**1.17**	**21.41**
50 m					
Month	**AvgV (m/s)**	**St Dev**	**C (m/s)**	**K**	**P/A (w/m2)**
January	2.60	2.16	2.78	1.22	41.64
February	3.11	2.58	3.33	1.23	70.46
March	2.82	2.25	3.04	1.28	48.51
April	2.70	2.35	2.85	1.16	51.59
May	1.99	2.02	1.98	0.99	30.07
June	2.23	2.22	2.24	1.01	40.15
July	1.99	1.78	2.08	1.13	22.02
August	2.00	2.02	1.99	0.99	30.33
September	1.87	1.89	1.86	0.99	24.88
October	2.04	1.93	2.09	1.06	26.91
November	2.13	1.86	2.24	1.16	25.42
December	2.19	2.15	2.21	1.02	36.63
Annual	**2.31**	**2.10**	**2.39**	**1.10**	**37.38**

ESTIMATING WIND GENERATED ELCECTRIC 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 Khawazakhaila 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 Khawazakhaila are shown below in graphs and table-4.

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

PMD Calculator (using 50M)				
Month	**Input W/m^2**	**Output W/m^2**	**C.F.**	**KWh / Month**
January	42	15	4%	17,095
February	72	25	6%	26,308
March	49	18	4%	19,998
April	51	18	4%	19,315
May	29	10	2%	11,159
June	39	13	3%	14,139
July	21	7	2%	8,360
August	29	10	3%	11,229
September	24	8	2%	9,049
October	27	9	2%	10,458
November	26	9	2%	9,880
December	38	13	3%	14,408
Annual	**36**	**12**	**3%**	**164,904**

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 21 shows the annual average diurnal variation of wind generated electric energy output at Khawazakhaila. The graph shows that the maximum power is produced at about 5 pm. Of course, this is the same time when we have the maximum wind speed in 24 hours. Figure 22 & 23 shows the monthly and daily wind generated electric power output. Figure 22 depicts that at Khawazakhaila the wind have more potential in summer season as compared to that in winter season. Figures 24 to 35 show the monthly average diurnal variation of wind generated electric energy output.

Fig-21

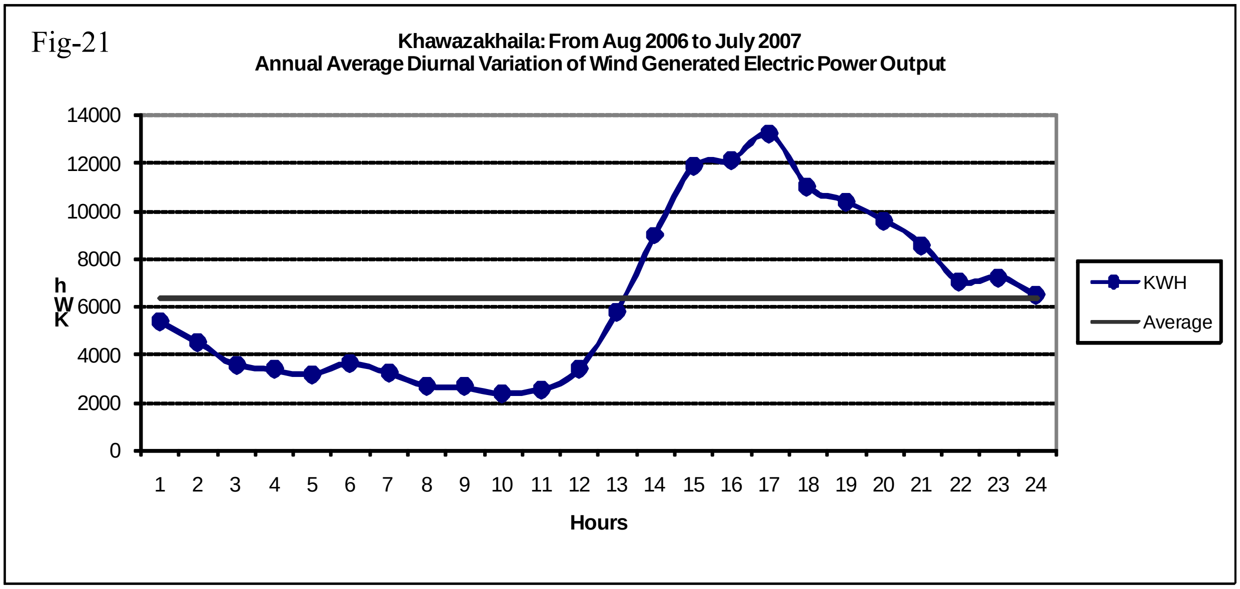


Fig-22

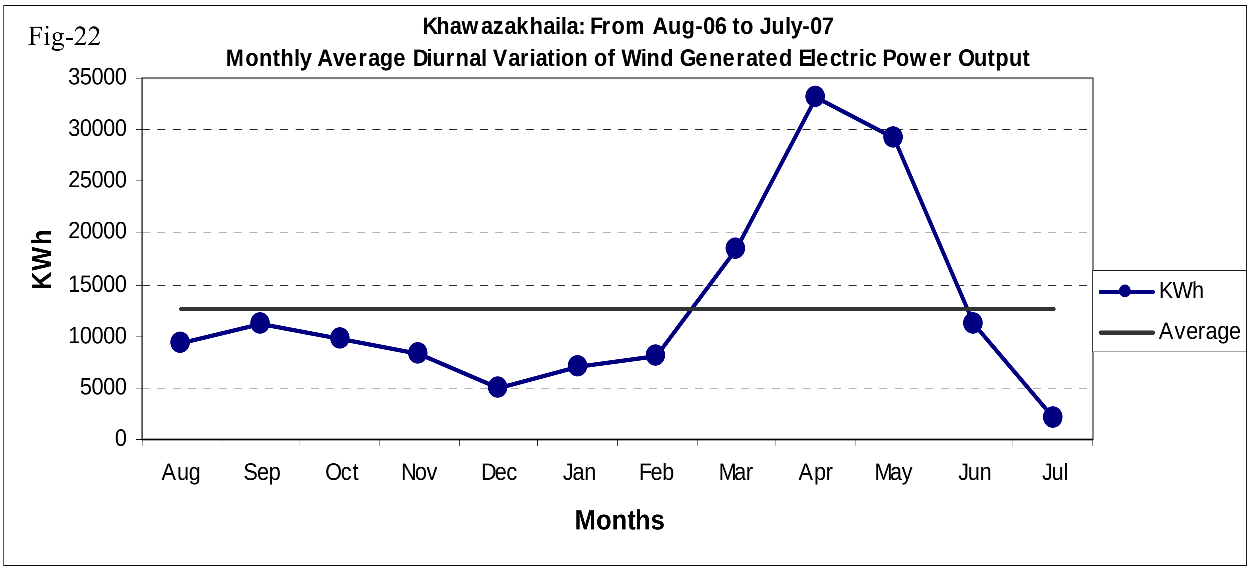


Fig-23

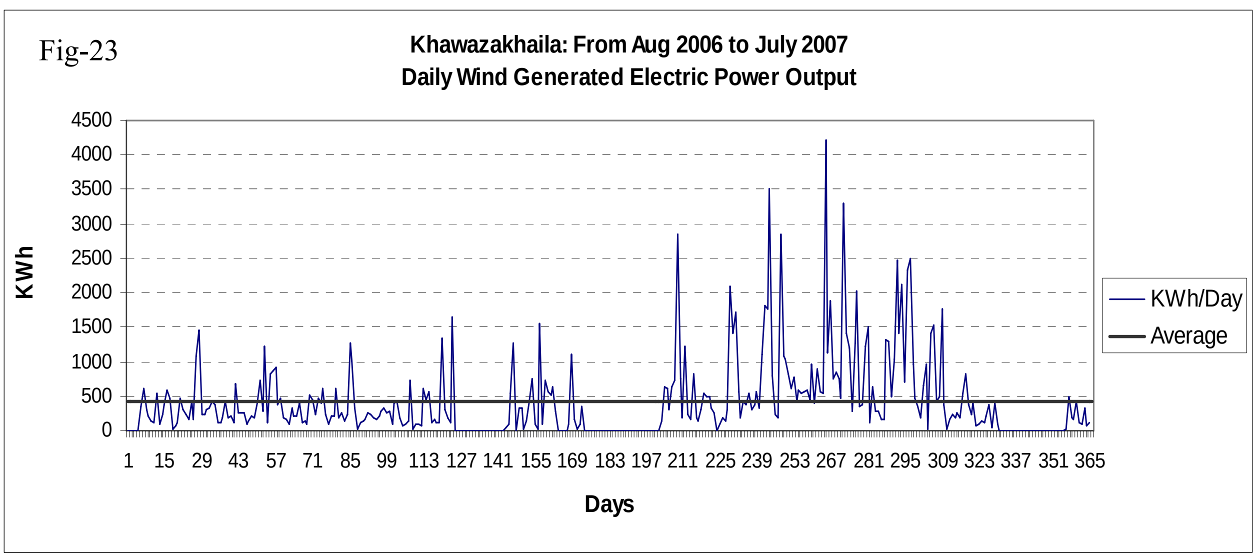


Fig-24

Khawazakhaila: Aug 2006
Wind Generated Electric Power Output

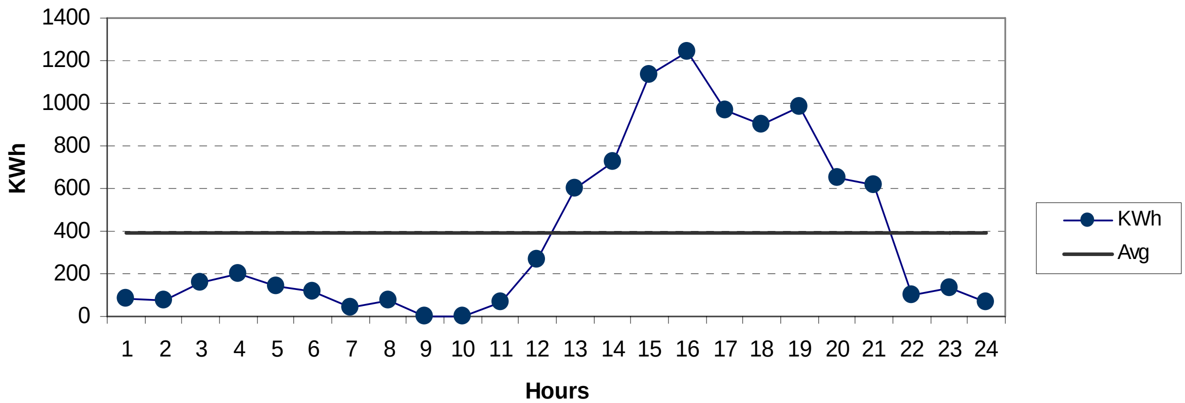


Fig-25

Khawazakhaila: Sep 2006
Wind Generated Electric Power Output

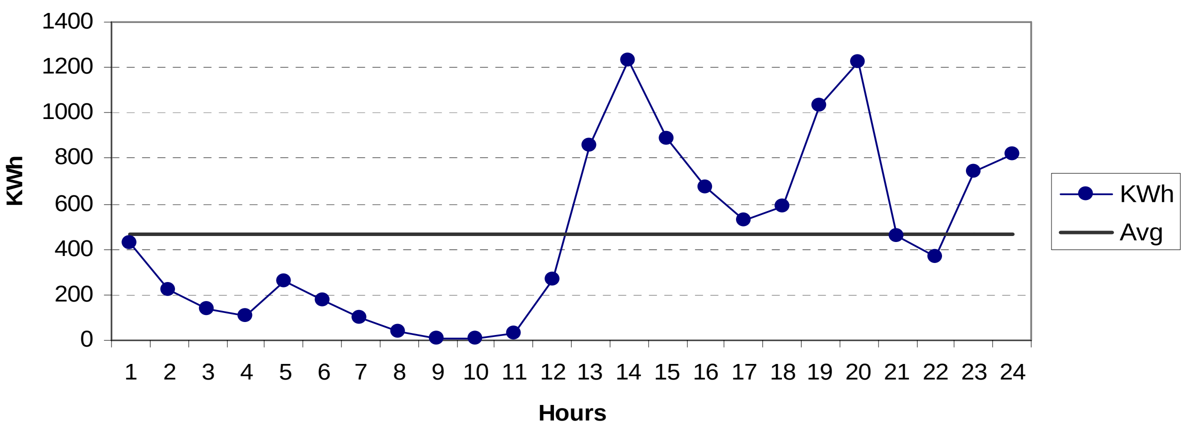


Fig-26

Khawazakhaila: Oct 2006
Wind Generated Electric Power Output

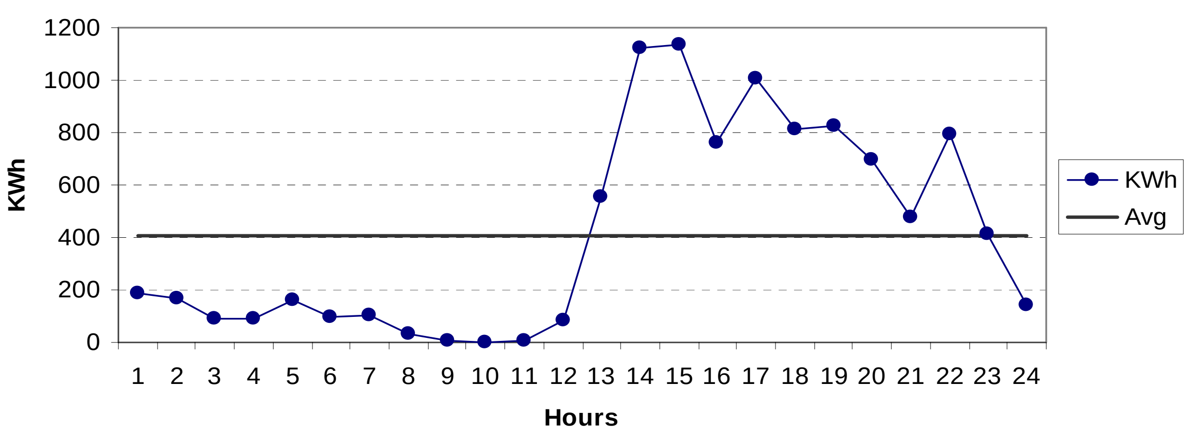


Fig-27

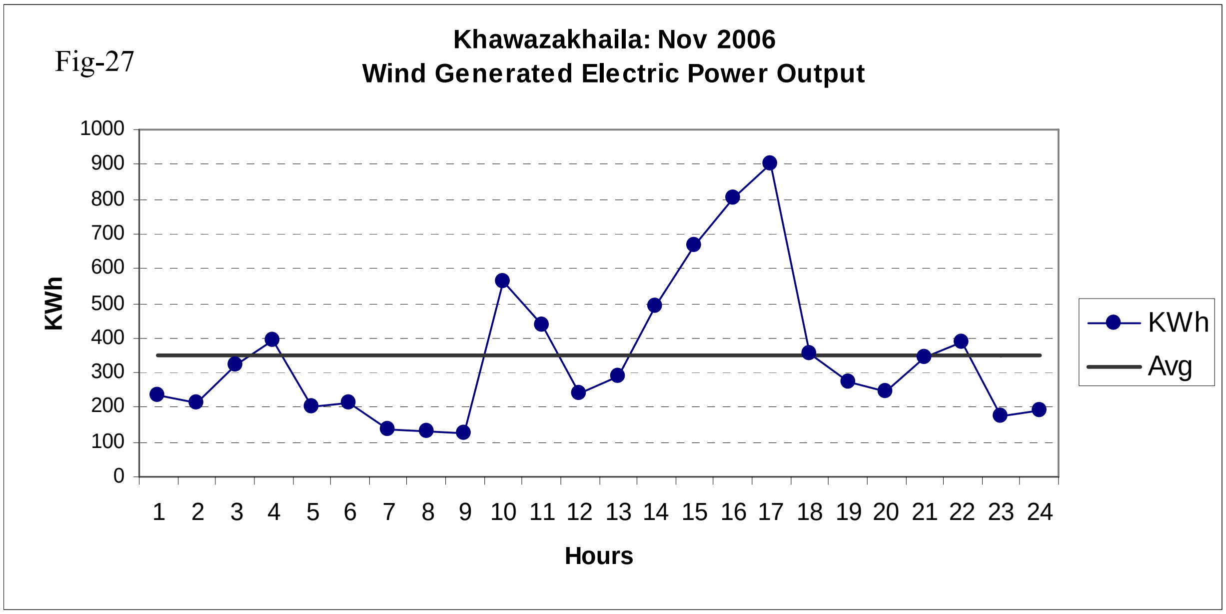


Fig-28

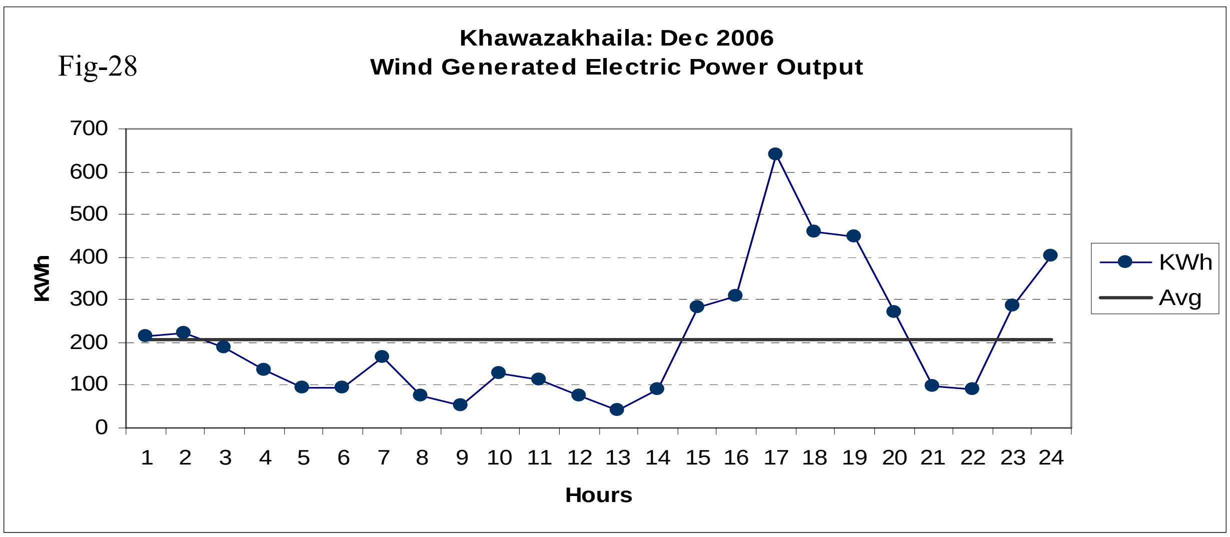


Fig-29

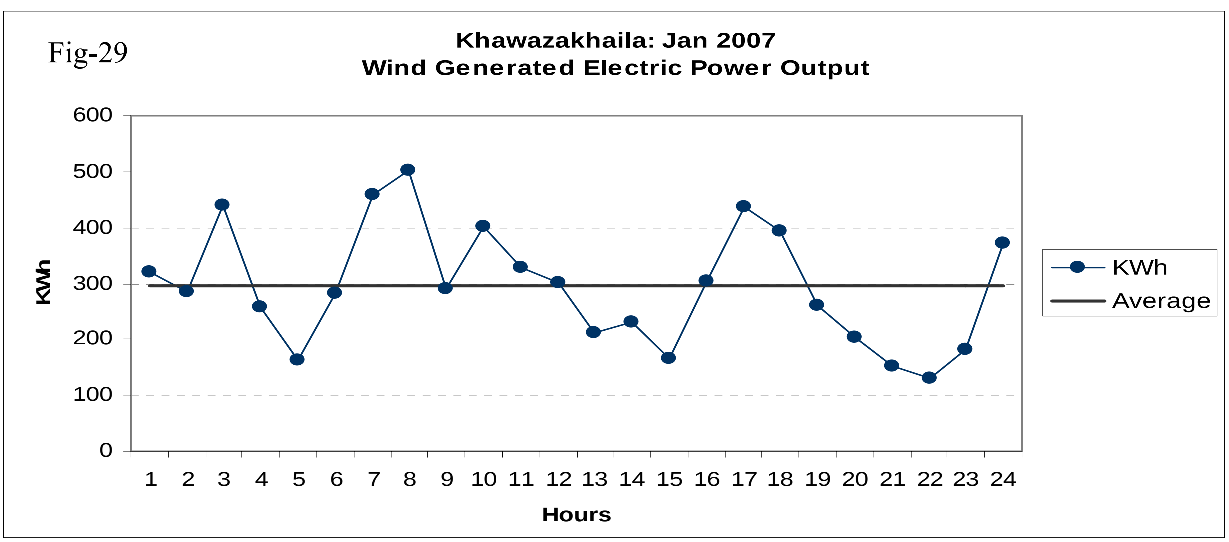


Fig- 30

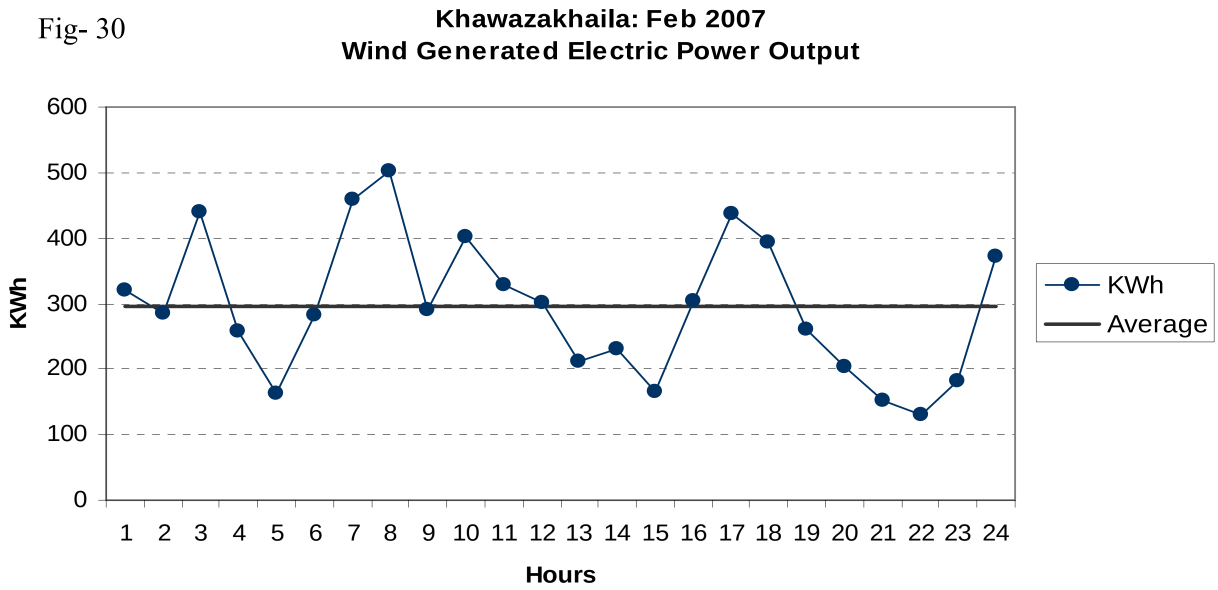


Fig-31

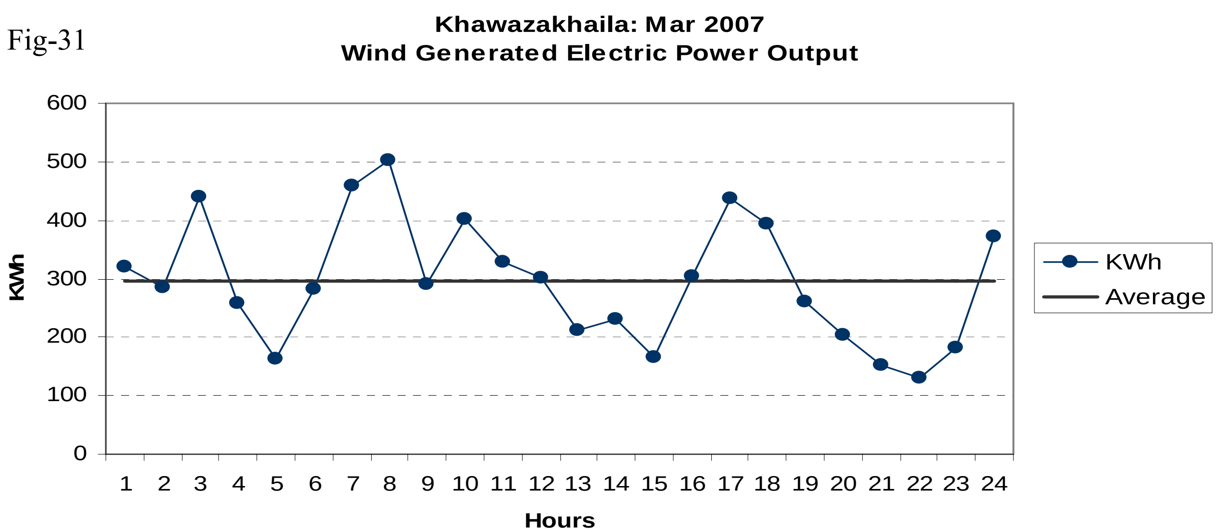


Fig-32

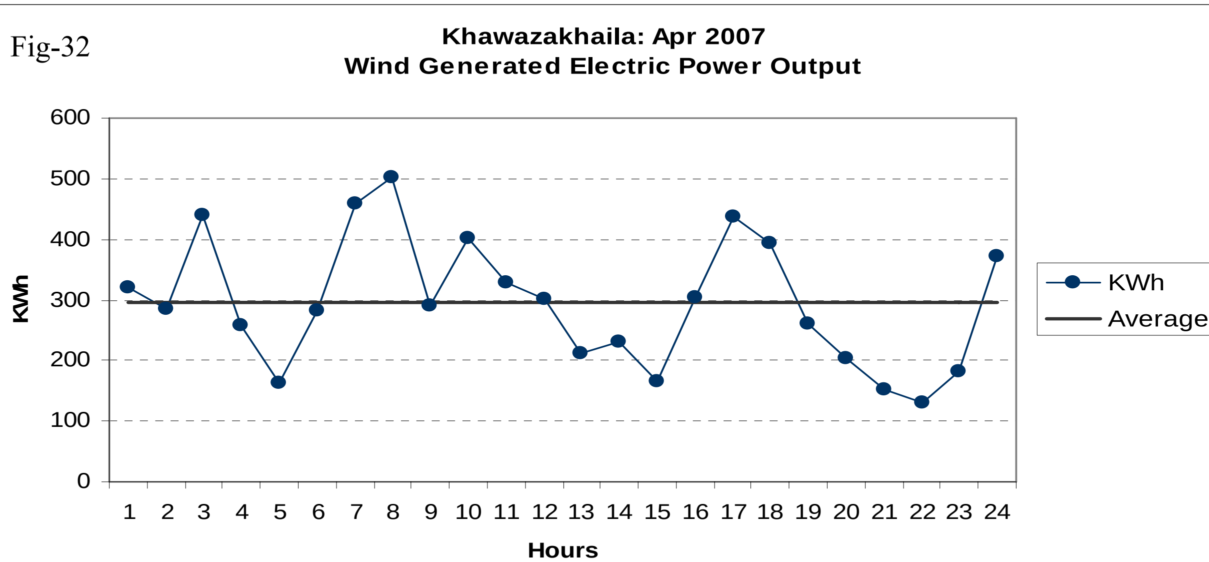


Fig-33

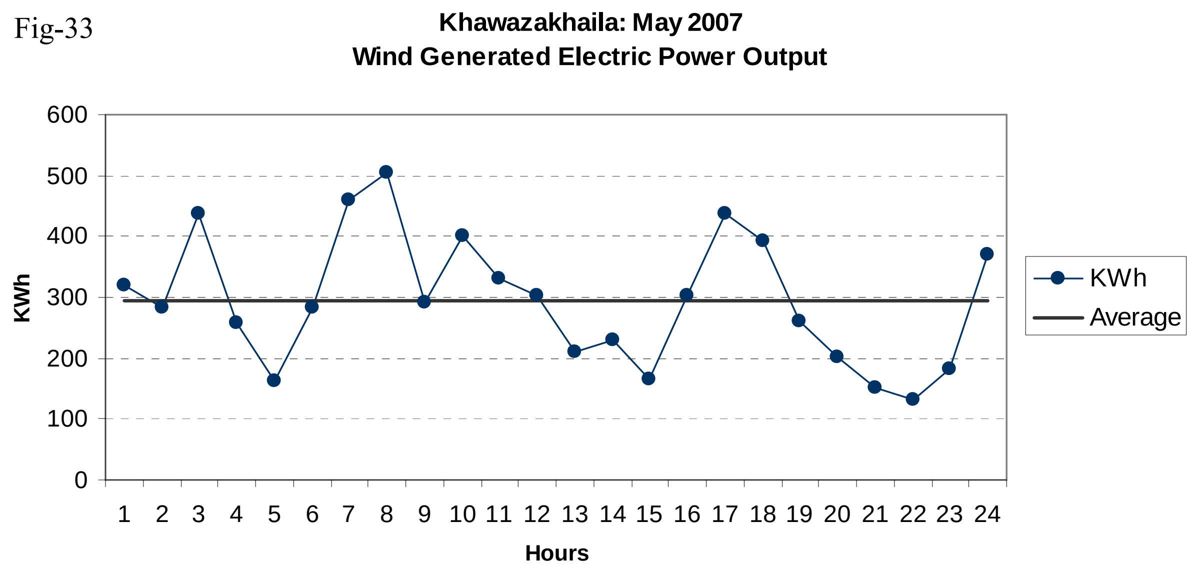


Fig-34

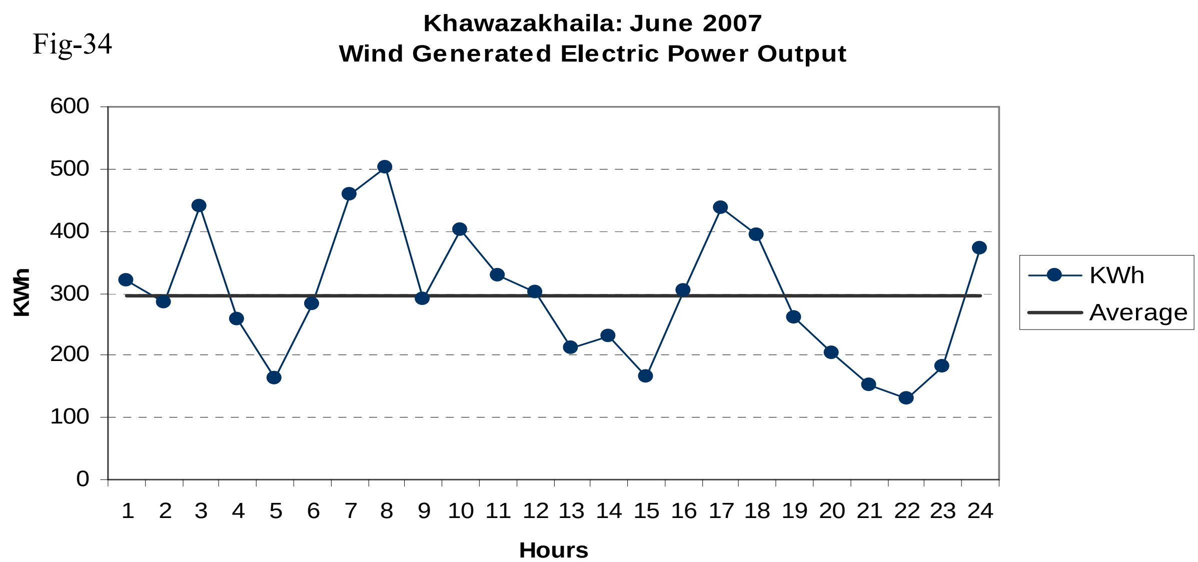
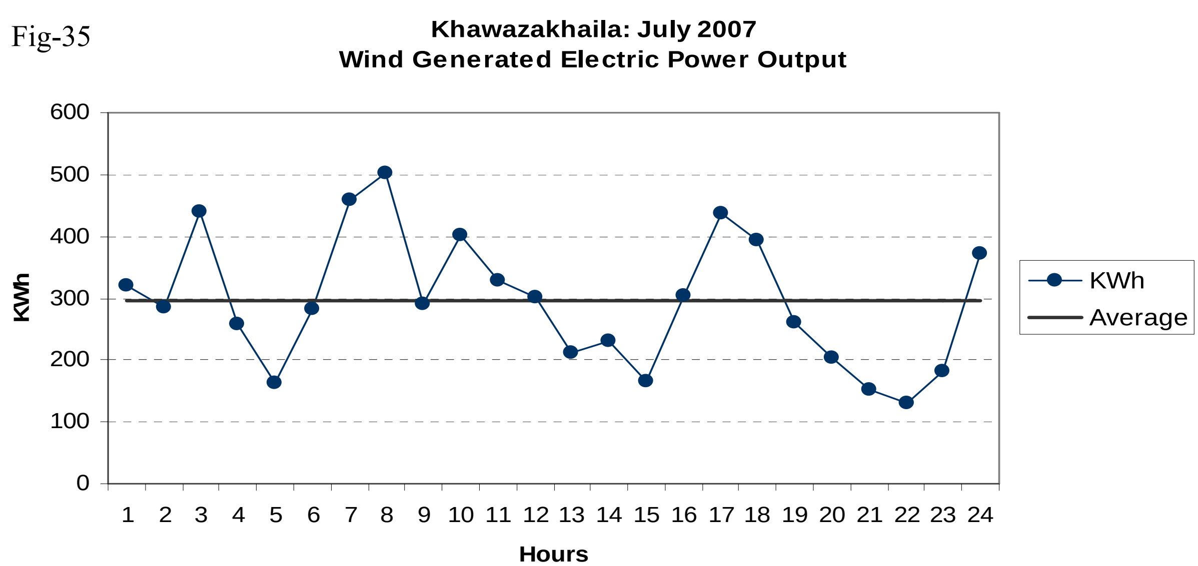


Fig-35



Pakistan Meteorological Department

Appendix-I

Monthly Average Diurnal Variation of Wind Generated Electric Power Output

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
Aug	86	73	155	201	145	118	41	72	1	3	66	269	601	729	1131	1238	966	902	985	647	620	100	136	63	9349
Sep	428	225	138	105	258	174	97	38	4	10	31	266	860	1229	890	675	530	589	1033	1223	460	365	743	818	11190
Oct	188	166	93	93	159	98	101	31	5	0	7	83	557	1126	1135	760	1007	812	826	695	475	795	412	144	9768
Nov	237	214	325	391	201	216	136	131	125	563	437	242	291	490	664	804	902	356	274	248	342	387	173	189	8339
Dec	216	223	188	137	94	94	165	74	54	128	112	75	42	91	281	310	639	460	449	269	97	91	288	403	4980
Jan	321	284	439	257	162	283	459	503	290	401	330	301	211	230	166	304	437	393	261	203	153	130	183	371	7073
Feb	478	682	578	881	635	540	128	142	170	210	422	322	138	121	583	368	305	191	223	266	223	180	129	164	8078
Mar	539	693	530	399	553	590	602	941	1183	659	682	819	648	506	613	975	1135	1340	743	667	928	844	1071	683	18343
Apr	773	552	595	552	642	1218	1258	578	497	65	75	194	758	1941	3058	3426	3297	2660	2313	2308	2016	1487	1491	1450	33205
May	1641	1183	478	253	240	198	183	110	139	210	157	382	818	1655	2162	2343	2664	2358	2605	2433	2249	2019	1678	1107	29264
Jun	469	208	54	77	54	88	52	33	164	67	115	272	485	744	1072	820	1165	544	541	576	958	592	921	1058	11127
Jul-07	7	6	5	11	13	4	14	16	6	41	102	137	379	130	112	102	196	385	137	82	65	44	15	11	2019
KWH	**5385**	**4508**	**3578**	**3357**	**3158**	**3621**	**3236**	**2670**	**2638**	**2357**	**2535**	**3360**	**5788**	**8992**	**11866**	**12124**	**13245**	**10989**	**10389**	**9618**	**8588**	**7032**	**7240**	**6461**	**152736**

Appendix-II

August 2006

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	1	0	0	0	0	1
6	0	0	0	0	0	0	0	0	0	0	3	37	84	55	38	20	34	38	27	3	0	1	0	0	343
7	0	0	0	0	0	0	22	59	0	0	0	2	20	17	20	63	40	24	5	148	153	4	19	5	602
8	4	3	1	0	0	3	0	0	0	0	0	7	48	49	44	41	33	18	31	15	11	0	1	1	310
9	0	1	0	1	2	1	1	0	0	0	0	2	20	18	39	42	49	16	9	1	0	0	1	3	205
10	2	0	0	1	0	0	0	0	0	0	0	1	15	33	48	23	8	5	3	0	3	1	0	1	145
11	3	1	4	33	5	7	1	0	0	1	1	1	9	13	12	7	3	2	1	1	3	3	1	3	116
12	0	0	0	0	1	0	0	0	0	0	0	0	12	15	3	7	45	20	199	222	5	5	4	0	539
13	1	0	0	1	3	3	0	0	0	0	0	0	9	23	25	15	5	3	0	3	0	0	6	1	98
14	0	9	47	64	36	35	1	0	0	0	10	1	0	0	0	0	0	0	0	0	5	3	0	15	228
15	47	26	3	13	2	0	0	0	0	0	0	1	32	11	102	112	17	3	8	1	0	0	1	1	379
16	0	2	0	1	0	3	0	0	0	0	1	2	2	5	13	22	122	342	70	3	5	0	0	0	594
17	4	1	3	2	1	0	1	0	0	0	0	1	5	7	16	5	1	99	188	67	52	8	2	1	466
18	0	1	3	0	4	1	1	1	0	0	0	0	0	0	1	5	1	0	0	3	4	2	5	0	32
19	2	1	1	1	3	9	0	0	0	0	0	1	8	4	11	11	5	3	6	0	2	0	1	1	72
20	1	1	4	0	0	0	0	0	1	0	0	1	2	1	1	0	0	80	17	0	0	2	0	0	112
21	0	0	0	0	0	0	0	0	0	1	38	78	59	49	89	61	56	26	14	2	0	1	0	1	475
22	0	0	64	59	37	4	0	1	0	0	0	13	21	30	25	20	20	5	0	0	3	0	0	0	304
23	0	0	0	1	1	1	1	0	0	0	0	0	1	2	17	33	23	24	75	54	2	2	0	4	243
24	0	4	0	1	1	0	0	0	0	0	0	4	20	26	30	26	11	17	11	3	2	1	0	0	157
25	0	9	9	5	0	6	0	0	0	0	0	4	35	28	27	121	150	17	3	9	1	0	1	4	429
26	3	9	0	0	0	5	0	0	0	0	0	0	6	25	23	17	16	15	7	2	17	6	1	1	155
27	3	5	1	0	4	2	3	1	0	0	0	16	41	77	325	383	144	48	12	8	5	10	1	4	1093
28	7	1	0	1	3	3	3	4	0	0	1	28	125	170	144	123	81	66	284	71	301	32	7	1	1458
29	3	1	12	8	33	30	1	3	0	1	1	0	2	32	39	12	24	9	8	13	3	2	2	2	243
30	4	0	1	5	1	4	2	0	0	0	0	1	2	26	25	50	46	12	4	13	38	1	6	1	245
31	1	0	0	4	7	1	1	0	0	0	11	66	23	12	12	19	31	8	4	2	2	14	76	12	308
KWh	86	73	155	201	145	118	41	72	1	3	66	269	601	729	1131	1238	966	902	985	647	620	100	136	63	9349

September 2006

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	10	4	9	13	7	11	11	14	185	62	9	0	2	338
2	21	4	0	3	0	0	2	1	1	0	0	56	95	25	10	6	5	0	0	159	33	0	1	2	424
3	0	1	0	3	1	1	0	0	0	0	0	7	59	46	40	29	17	14	13	4	0	1	112	28	377
4	26	22	19	21	6	2	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	3	1	3	109
5	0	2	13	4	4	1	1	0	0	0	0	0	0	4	47	13	0	2	3	4	6	3	6	1	113
6	0	1	0	1	5	13	9	0	0	0	0	0	5	30	16	14	14	17	8	8	37	2	1	2	183
7	1	1	2	7	0	5	3	0	0	0	0	40	66	49	52	59	53	20	3	23	25	13	9	2	433
8	1	0	2	1	1	1	2	4	0	0	0	2	27	36	31	19	8	5	2	10	2	10	16	5	186
9	14	1	3	0	2	1	1	2	0	0	0	2	29	38	20	22	13	12	11	1	15	3	15	4	210
10	1	2	0	0	0	0	0	0	0	0	0	5	23	20	22	7	10	1	0	8	3	9	10	0	121
11	1	0	1	2	0	0	0	0	0	0	0	30	60	41	35	12	8	11	1	4	2	22	180	275	685
12	3	3	2	1	0	0	2	0	0	0	0	4	7	21	18	14	10	16	5	16	10	81	44	3	259
13	2	1	0	1	4	6	5	1	0	1	18	27	36	39	29	24	9	11	6	0	2	17	10	9	258
14	16	7	3	11	1	1	6	0	0	0	5	23	21	14	44	29	5	2	16	33	0	12	2	7	260
15	4	2	0	1	1	0	2	0	0	0	3	19	3	30	1	1	0	2	4	2	6	2	1	0	83
16	0	0	0	1	1	0	0	1	1	5	0	5	36	22	16	6	3	3	5	24	0	0	3	1	134
17	0	9	3	24	11	10	12	0	0	0	0	8	26	16	16	10	11	16	0	4	6	14	2	1	200
18	14	7	1	1	0	2	0	0	0	0	0	8	34	34	25	24	11	9	0	15	1	4	1	4	197
19	1	2	0	1	2	2	2	0	0	1	0	3	30	192	68	53	12	4	2	14	0	8	4	3	406
20	1	0	4	2	24	12	4	7	0	3	3	1	7	19	31	51	86	28	240	140	64	6	1	2	733
21	2	0	5	0	0	2	0	0	0	0	0	3	20	89	40	30	8	11	6	2	5	28	28	5	286
22	97	55	29	6	143	70	29	9	1	0	0	3	37	47	27	5	2	99	299	185	71	11	1	8	1235
23	4	0	2	1	0	2	1	0	0	0	0	1	3	12	21	19	6	13	1	21	0	2	8	2	120
24	2	4	1	1	1	2	3	0	0	0	0	1	7	25	11	8	9	6	300	316	24	74	26	15	834
25	10	2	5	1	3	2	1	1	0	0	0	0	33	31	29	22	10	17	1	7	28	0	243	433	879
26	205	94	38	4	8	4	4	2	0	0	0	0	78	121	8	1	49	186	66	15	5	19	10	0	919
27	0	2	3	0	5	1	3	1	0	0	0	4	7	38	66	101	100	33	6	4	4	8	0	0	388
28	1	1	0	1	1	3	2	4	0	0	0	4	101	128	96	60	8	25	18	3	5	2	2	1	466
29	1	1	2	3	33	28	1	3	0	0	0	0	2	32	39	11	13	8	2	6	3	1	2	0	190
30	0	0	0	4	1	3	0	0	0	0	0	0	1	21	18	17	36	5	0	12	37	0	5	1	164
KWh	428	225	138	105	258	174	97	38	4	10	31	266	860	1229	890	675	530	589	1033	1223	460	365	743	818	11190

Pakistan Meteorological Department

October 2006

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	4	3	1	0	0	0	0	0	0	0	0	7	22	7	6	13	24	1	3	8	0	0	0	100
2	5	1	1	1	2	1	2	1	2	0	0	6	33	42	24	7	4	2	178	5	5	15	1	1	337
3	1	1	0	0	2	1	2	2	0	0	0	0	19	83	35	18	16	12	5	16	8	1	1	0	224
4	0	2	3	0	1	1	0	2	0	0	0	0	8	35	45	26	40	9	9	16	0	2	0	0	202
5	3	5	2	3	5	5	3	1	0	0	0	0	8	101	170	47	13	1	12	6	3	0	0	1	389
6	1	1	1	2	0	13	11	6	0	0	0	0	2	20	30	9	4	2	10	8	1	0	0	1	121
7	0	1	2	5	4	1	1	0	0	0	0	0	4	31	31	13	10	2	5	9	2	9	2	1	132
8	0	0	0	0	1	1	0	0	0	0	0	0	6	18	10	3	9	11	0	1	8	14	8	8	101
9	2	0	0	0	0	0	1	0	0	0	0	0	22	25	11	5	225	156	23	2	14	0	7	28	522
10	87	20	14	30	1	2	8	0	0	0	0	0	27	80	75	43	29	8	1	3	1	7	0	0	437
11	0	0	0	2	0	1	1	1	0	0	0	23	88	42	12	5	6	1	8	6	1	20	7	3	227
12	2	2	1	0	0	0	0	2	0	0	0	1	31	38	15	4	3	9	55	5	2	162	118	28	478
13	8	12	10	11	15	8	1	0	0	0	0	0	2	5	5	22	54	92	68	71	8	0	0	0	392
14	2	0	0	0	0	0	3	0	0	0	5	12	30	12	25	60	271	130	63	3	1	0	1	1	620
15	23	18	1	0	0	1	0	0	0	0	0	5	85	76	1	2	0	0	2	4	10	5	1	4	240
16	2	3	0	1	2	2	0	1	0	0	0	2	2	11	23	17	7	5	5	6	3	1	0	1	94
17	1	2	8	2	5	2	1	0	0	0	0	0	12	38	44	46	15	0	4	0	8	15	9	2	213
18	4	0	1	3	1	1	5	3	0	0	0	0	21	45	41	26	15	20	9	5	0	3	8	0	211
19	2	2	8	3	0	0	3	0	0	0	0	3	19	18	83	98	9	213	14	67	54	10	2	1	609
20	1	0	0	0	0	42	39	2	0	0	0	3	8	20	19	25	15	3	0	0	0	0	1	0	181
21	0	1	0	0	1	0	5	1	0	0	0	3	31	63	49	47	37	15	7	0	0	1	1	0	263
22	0	3	2	1	4	1	3	0	0	0	0	0	7	29	25	34	19	11	0	2	1	2	0	1	146
23	0	1	0	1	5	0	1	1	0	0	0	19	45	48	20	35	33	17	7	1	0	0	4	1	238
24	0	0	2	0	8	0	0	2	0	0	0	4	26	55	55	31	25	17	48	98	190	422	235	46	1264
25	20	30	17	2	1	4	0	0	1	0	0	1	1	2	28	11	19	12	273	349	135	85	3	7	1001
26	23	54	8	21	96	8	2	0	0	0	0	0	1	40	65	0	0	0	1	1	0	0	0	0	320
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	5	8	1	1	3	2	1	1	28
28	2	1	0	2	2	0	1	2	0	0	0	0	2	28	40	9	13	6	1	2	0	11	1	0	123
29	0	0	2	0	0	1	1	0	0	0	0	0	3	38	47	16	13	1	6	1	1	2	0	1	135
30	0	1	4	1	1	1	1	1	0	0	0	0	4	25	38	33	40	15	3	1	1	1	1	1	171
31	0	2	2	0	1	0	6	2	0	0	0	0	2	34	61	61	46	9	8	2	8	3	1	4	251
KWh	188	166	93	93	159	98	101	31	5	0	7	83	557	1126	1135	760	1007	812	826	695	475	795	412	144	9768

Pakistan Meteorological Department

November 2006

Dt./Hrs	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24 Hrs
1	2	5	2	4	6	1	6	4	0	0	0	0	14	36	47	31	45	14	2	0	1	1	3	5	231
2	2	1	1	1	1	0	4	1	0	0	0	0	9	29	67	33	25	1	0	0	1	10	1	0	188
3	2	1	0	2	1	0	0	0	0	0	0	1	10	53	35	16	18	5	2	0	4	5	0	0	157
4	8	0	3	4	1	2	2	1	0	0	0	0	5	39	36	44	34	2	3	0	12	14	2	5	215
5	13	8	10	11	4	18	3	1	0	0	0	0	2	20	34	43	64	21	2	1	8	8	4	0	275
6	5	8	4	16	7	17	2	4	0	0	0	0	16	34	45	27	42	52	0	8	1	12	11	16	326
7	2	5	6	0	3	1	6	7	1	0	0	0	8	41	53	38	29	7	3	0	8	23	7	4	252
8	12	1	7	3	3	2	2	4	0	0	0	0	8	55	57	48	55	7	4	0	5	8	3	7	290
9	1	1	0	8	1	0	1	0	0	0	0	0	0	0	15	42	2	0	0	2	2	10	0	1	86
10	0	2	0	0	0	0	1	0	12	4	5	17	13	1	1	1	0	8	20	3	111	84	3	105	391
11	49	23	45	35	59	103	0	0	0	14	6	3	0	1	4	0	0	0	2	0	40	28	2	0	416
12	9	17	4	4	2	0	2	2	0	1	0	0	0	0	0	0	9	8	6	17	1	88	27	0	198
13	0	8	0	0	0	0	0	1	0	0	0	11	19	4	0	0	1	1	1	0	1	2	10	2	61
14	1	1	1	2	3	3	4	2	0	0	0	0	0	3	32	27	4	0	0	1	0	0	1	1	87
15	0	0	0	0	0	1	0	2	4	3	5	2	7	9	28	58	4	6	1	1	0	3	3	1	142
16	7	7	1	11	0	0	0	1	0	0	0	0	30	2	13	182	64	96	172	101	10	7	13	12	729
17	10	5	3	5	5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	33
18	0	0	1	0	2	2	0	0	1	0	0	0	2	23	36	15	5	0	0	0	0	0	0	0	90
19	1	0	0	0	0	0	1	1	0	0	0	0	2	22	21	12	35	0	1	0	0	0	1	1	99
20	2	2	7	1	1	1	10	1	0	0	0	0	0	1	4	8	24	0	5	0	1	1	1	0	70
21	0	0	1	1	10	8	53	35	7	181	100	83	91	20	0	1	2	1	9	4	0	0	0	0	612
22	0	1	0	0	0	0	0	1	0	0	0	5	38	37	28	9	2	1	5	73	126	71	58	0	458
23	4	3	0	31	61	23	6	7	1	0	0	1	0	1	4	79	288	47	2	9	1	0	1	3	571
24	4	5	6	3	3	4	7	8	2	11	0	0	0	4	10	16	14	1	4	3	1	4	3	3	117
25	4	7	9	13	13	13	13	24	5	0	0	0	0	0	5	17	36	1	2	2	0	1	0	1	166
26	2	3	4	0	2	1	1	2	0	0	0	0	2	26	32	15	8	0	5	1	1	0	7	2	114
27	3	1	2	1	1	4	1	0	1	0	0	0	0	0	21	6	4	50	7	3	0	3	7	13	128
28	90	91	161	34	4	8	1	13	83	339	310	112	9	0	0	0	46	19	10	4	1	0	0	0	1333
29	2	1	41	199	4	2	6	6	3	8	11	4	1	0	0	0	6	0	1	5	3	3	5	5	315
30	3	7	9	4	1	1	4	3	0	1	0	1	4	27	36	36	37	6	2	7	2	0	0	0	189
KWh	237	214	325	391	201	216	136	131	125	563	437	242	291	490	664	804	902	356	274	248	342	387	173	189	8339

Pakistan Meteorological Department

December 2006

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	3	3	0	1	0	0	0	0	0	0	1	7	18	20	41	20	1	1	1	1	1	0	**120**
2	1	1	2	2	0	5	0	0	0	0	2	1	2	34	173	212	372	320	359	157	6	0	0	0	**1650**
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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
22	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8	13	8	1	2	5	6	**45**
23	11	4	5	8	5	5	4	7	8	21	12	1	0	0	1	1	1	0	0	0	0	0	0	0	**92**
24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5	15	2	17	189	311	**544**
25	185	185	157	89	59	39	97	53	3	106	97	45	32	18	2	4	1	5	19	17	10	9	15	23	**1274**
26	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**3**
27	2	1	0	0	1	2	1	3	0	0	0	2	0	8	9	5	8	62	39	53	32	34	49	25	**335**
28	13	30	17	33	25	39	61	7	41	1	1	24	2	3	17	3	5	2	1	1	2	0	0	1	**329**
29	1	0	0	0	0	1	0	2	0	0	0	0	0	1	6	6	6	0	3	2	0	1	0	0	**30**
30	2	0	1	0	1	2	1	0	0	0	0	0	5	19	34	29	45	1	0	0	0	0	0	0	**141**
31	0	0	1	0	2	0	0	2	0	0	0	0	0	0	21	31	159	42	10	15	43	27	27	37	**416**
KWh	**216**	**223**	**188**	**137**	**94**	**94**	**165**	**74**	**54**	**128**	**112**	**75**	**42**	**91**	**281**	**310**	**639**	**460**	**449**	**269**	**97**	**91**	**288**	**403**	**4980**

Pakistan Meteorological Department

January 2007

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	69	53	289	62	2	3	60	86	46	1	0	2	0	44	4	2	1	3	5	3	0	0	2	6	744
2	0	0	0	0	12	15	6	29	2	0	0	2	0	5	1	0	1	0	1	2	0	4	3	0	84
3	0	0	0	1	0	0	0	0	2	1	0	0	2	0	0	2	2	0	1	0	0	0	0	4	16
4	0	0	0	5	41	74	200	188	35	270	227	231	115	28	20	14	2	5	19	12	20	32	18	8	1564
5	0	0	0	0	0	0	0	5	9	2	3	8	6	10	1	15	21	1	2	4	0	1	0	3	94
6	3	6	0	0	0	0	2	17	22	17	21	1	27	41	21	78	35	9	1	1	6	21	112	295	737
7	201	106	20	12	0	4	3	5	45	23	4	0	2	40	34	10	0	5	3	5	7	3	15	14	563
8	0	0	8	62	30	20	27	32	7	0	11	27	46	35	24	16	25	27	18	21	26	41	9	15	525
9	0	2	55	111	74	108	56	23	2	4	8	22	7	20	21	12	14	11	17	27	29	0	0	5	628
10	21	27	0	0	3	55	68	51	9	0	8	0	2	2	3	10	6	4	4	6	3	0	0	1	285
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	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
15	6	51	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89
16	3	0	0	0	0	0	0	0	0	0	0	0	2	0	30	133	307	307	175	103	32	9	3	5	1110
17	8	21	28	0	0	4	11	17	10	60	1	0	0	0	0	1	0	1	0	0	0	0	4	0	165
18	0	3	0	0	0	0	19	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	29
19	0	0	0	0	0	0	0	1	3	11	45	8	1	2	0	1	1	1	0	0	7	3	0	1	86
20	8	12	6	2	0	0	9	43	98	11	1	0	1	4	5	9	20	18	14	19	22	17	17	14	350
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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	321	284	439	257	162	283	459	503	290	401	330	301	211	230	166	304	437	393	261	203	153	130	183	371	7073

February 2007

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	Daily
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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	40	29	23	1	21	26	147
20	7	23	20	9	11	6	4	13	50	54	26	22	17	17	99	86	5	96	29	1	0	16	9	13	634
21	144	194	125	22	32	11	10	15	33	9	0	0	0	0	0	0	0	0	0	2	0	0	0	9	607
22	4	3	1	0	1	0	11	2	19	1	1	0	0	0	0	1	2	16	2	45	42	66	46	41	303
23	19	21	27	29	26	26	25	25	30	26	9	0	0	0	0	0	0	3	14	58	127	66	44	56	631
24	57	39	57	36	33	40	38	41	17	12	7	0	4	24	47	81	165	35	0	0	1	0	0	4	740
25	223	399	270	420	409	355	33	41	17	0	0	0	0	21	219	97	48	6	136	119	11	13	1	1	2839
26	1	1	77	347	115	91	6	6	3	6	7	3	0	0	0	14	47	21	0	0	1	0	0	10	756
27	23	1	0	18	8	10	0	0	1	16	0	0	0	15	45	20	0	8	0	5	14	11	2	2	200
28	2	0	1	0	0	0	0	0	0	86	371	295	117	44	172	69	37	1	1	6	3	7	7	2	1222
KWh	478	682	578	881	635	540	128	142	170	210	422	322	138	121	583	368	305	191	223	266	223	180	129	164	8078

Pakistan Meteorological Department

March 2007

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	Daily
1	5	0	0	0	0	0	0	2	0	0	58	95	14	0	1	8	1	1	5	0	1	40	3	0	233
2	0	4	3	3	2	1	1	16	19	10	0	2	0	4	8	37	7	5	8	0	0	1	27	11	172
3	0	6	0	7	25	16	48	103	107	225	149	17	72	60	0	0	0	0	0	0	0	0	0	1	835
4	1	0	0	1	1	0	0	26	22	9	0	0	30	36	19	5	38	0	5	0	1	0	0	0	193
5	0	0	0	1	1	3	0	1	2	6	2	0	0	1	4	17	8	34	35	1	3	1	9	18	147
6	1	1	6	1	5	8	4	7	2	0	0	0	1	1	9	28	41	61	26	1	25	54	10	15	306
7	4	15	17	28	17	21	20	6	2	0	0	0	0	9	3	6	41	86	40	3	32	46	112	41	548
8	25	14	12	8	10	14	19	33	5	9	0	0	2	30	51	57	66	38	5	8	11	42	27	15	501
9	0	2	0	17	102	47	1	59	52	0	8	16	0	0	0	0	1	0	4	3	0	11	51	115	488
10	166	109	1	4	2	3	4	1	0	3	0	0	1	0	0	0	0	2	7	6	9	1	4	0	325
11	0	1	0	0	0	1	0	1	27	8	68	130	1	0	0	0	4	3	3	10	0	0	0	0	256
12	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	4
13	0	0	0	0	0	0	1	18	18	1	0	0	0	0	0	0	0	0	1	0	1	0	48	1	89
14	2	1	7	31	23	4	0	2	1	10	41	1	0	5	11	28	0	0	1	15	0	0	0	0	184
15	0	0	0	0	1	2	3	2	3	4	0	0	4	25	21	14	31	22	10	1	2	4	3	0	153
16	6	10	3	0	1	1	1	13	0	0	0	0	4	5	8	15	57	102	65	0	8	9	2	2	313
17	3	3	2	15	0	8	0	1	1	5	9	175	133	51	120	269	140	98	107	263	376	52	215	48	2094
18	1	7	29	7	40	7	5	56	52	11	1	79	90	105	101	63	203	182	103	56	84	126	10	0	1418
19	13	4	2	1	1	8	23	139	353	38	25	207	91	58	70	85	78	117	33	25	11	28	139	171	1720
20	55	26	58	19	87	60	38	16	10	1	0	17	55	0	0	0	0	0	16	64	40	7	0	0	571
21	0	2	3	12	1	25	21	7	1	4	2	0	13	1	2	19	17	12	17	5	13	7	0	1	184
22	2	1	2	7	0	0	1	3	2	0	0	0	0	0	11	17	6	10	13	2	101	115	83	51	427
23	22	39	24	25	30	24	32	25	8	9	7	0	0	2	2	2	8	66	5	5	2	4	15	16	372
24	44	26	36	20	33	11	36	18	0	0	0	3	6	28	59	53	49	46	34	2	1	11	7	28	553
25	2	1	1	1	5	3	2	0	0	0	0	4	0	10	7	15	53	88	34	5	16	15	20	32	316
26	10	9	30	19	17	11	17	7	2	1	0	1	0	5	61	98	61	8	0	4	9	2	0	2	373
27	5	7	14	5	3	12	10	3	2	0	0	0	1	3	7	73	130	108	28	2	34	76	35	12	567
28	14	35	41	32	17	15	17	13	2	0	0	0	0	0	4	0	1	3	4	33	43	23	8	14	320
29	12	9	2	5	11	30	33	136	290	120	163	33	63	9	0	0	1	1	2	21	39	60	32	27	1099
30	65	339	142	122	90	142	159	76	29	78	111	21	0	1	12	42	46	19	18	82	48	101	32	47	1822
31	79	23	93	9	29	111	105	149	171	106	38	15	66	58	24	23	47	228	113	53	20	10	176	15	1758
KWh	539	693	530	399	553	590	602	941	1183	659	682	819	648	506	613	975	1135	1340	743	667	928	844	1071	683	18343

April 2007

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	47	46	7	53	411	280	59	249	30	23	31	65	80	464	392	220	104	287	238	198	105	23	65	3504
2	33	21	26	17	7	3	3	1	0	1	12	16	47	7	1	16	117	285	135	3	10	4	10	24	797
3	6	36	0	25	13	13	18	7	11	0	0	28	28	7	23	6	1	0	0	3	6	8	2	6	247
4	6	6	1	5	3	18	4	3	0	0	0	0	0	0	4	23	56	47	0	0	1	4	1	2	186
5	5	0	0	18	33	319	450	177	23	2	2	0	7	76	76	67	86	24	486	581	220	106	51	47	2857
6	16	5	13	13	50	9	11	0	3	0	0	0	1	13	39	120	121	55	9	169	146	167	84	41	1085
7	20	20	21	30	25	10	5	7	2	0	4	3	31	100	120	169	110	74	17	8	28	72	83	75	1035
8	39	23	30	45	29	35	10	1	0	0	1	15	36	164	161	83	37	22	10	7	7	13	36	11	817
9	11	17	31	39	21	36	29	18	1	0	0	0	2	13	64	93	56	68	14	12	16	6	27	28	601
10	37	22	27	30	33	40	29	14	0	0	0	1	8	34	62	100	120	156	7	8	23	10	4	10	775
11	18	34	44	27	29	20	6	9	0	1	1	0	2	11	60	54	58	5	0	1	28	4	0	5	417
12	19	15	11	15	28	7	14	3	1	0	0	0	7	67	165	111	82	26	6	11	2	0	1	0	589
13	12	10	19	17	6	18	7	11	0	0	0	0	2	42	137	105	99	44	15	4	0	1	2	1	552
14	2	6	24	8	14	12	36	5	0	0	0	0	3	37	88	99	93	77	14	27	3	6	6	14	576
15	15	25	31	17	24	20	23	21	11	0	0	0	14	16	52	142	90	42	1	1	11	21	8	5	592
16	4	4	7	8	14	19	11	8	0	0	3	4	13	49	68	93	89	34	1	6	14	4	2	0	455
17	1	4	0	0	1	3	4	10	134	16	0	0	1	0	126	178	176	4	36	84	153	6	19	10	966
18	8	3	4	22	26	9	1	0	0	0	22	48	17	19	66	76	43	16	9	0	0	0	0	0	390
19	1	0	4	11	5	15	138	150	50	12	4	0	9	28	48	229	2	62	12	50	6	2	67	1	905
20	2	0	0	4	9	3	3	0	0	0	0	0	38	169	113	64	47	50	21	9	25	0	4	0	562
21	1	6	18	4	16	2	5	2	0	0	0	13	86	138	88	30	24	23	1	5	30	7	33	0	531
22	1	6	8	2	10	20	6	0	0	0	0	9	51	55	72	27	368	555	560	511	482	568	523	388	4219
23	287	112	66	37	17	8	5	3	0	0	0	7	79	74	90	28	18	4	4	7	31	39	104	112	1135
24	92	85	60	59	114	95	83	23	9	1	0	1	62	41	182	516	217	105	30	8	19	67	11	1	1881
25	2	1	6	3	0	2	1	2	0	0	0	3	93	208	108	149	85	28	15	2	6	18	11	1	745
26	3	1	8	4	3	2	4	6	0	0	0	3	8	181	221	132	117	103	24	26	6	1	2	4	859
27	10	4	31	9	11	14	19	16	0	0	0	3	16	98	125	115	139	52	9	22	16	17	13	5	746
28	3	7	9	19	21	21	19	11	0	0	1	1	19	92	73	66	53	8	1	2	41	6	8	0	481
29	12	7	18	13	24	34	8	10	0	0	0	0	2	40	63	71	535	547	571	498	482	226	81	44	3287
30	79	24	30	42	6	1	26	0	1	0	1	6	14	82	99	74	36	41	18	7	6	0	271	549	1413
KWh	773	552	595	552	642	1218	1258	578	497	65	75	194	758	1941	3058	3426	3297	2660	2313	2308	2016	1487	1491	1450	33205

Pakistan Meteorological Department

May 2007

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	555	302	66	22	31	21	21	6	0	0	1	0	1	37	34	19	12	22	22	1	11	2	4	0	1191
2	0	1	1	3	2	7	2	0	0	0	0	27	55	41	35	18	18	16	19	2	4	23	15	0	289
3	1	0	0	1	0	1	3	0	0	0	3	26	41	38	9	166	101	2	1	317	299	30	12	211	1263
4	290	202	97	20	55	16	0	1	0	0	0	0	0	10	73	170	118	49	374	416	58	29	21	27	2026
5	4	3	5	2	0	3	3	1	3	1	0	6	1	25	74	44	17	27	20	6	5	8	52	55	365
6	120	59	8	2	8	1	2	0	0	0	0	0	2	23	28	17	23	24	31	1	19	5	0	4	377
7	0	0	2	2	0	1	4	0	0	0	0	0	30	42	26	19	9	10	37	7	391	475	114	63	1233
8	141	237	66	31	24	47	44	23	14	0	0	1	9	34	15	3	467	229	57	22	7	19	4	2	1497
9	3	2	1	1	0	1	1	1	0	0	0	5	13	20	11	3	5	3	7	1	16	18	8	3	124
10	2	3	1	1	0	1	0	2	0	0	0	1	28	16	104	50	122	150	100	12	23	2	8	0	627
11	2	0	0	1	0	1	9	0	0	0	0	0	15	70	63	32	28	24	23	1	2	0	1	0	273
12	0	0	1	4	1	2	1	0	0	0	0	9	42	50	32	45	38	21	20	5	1	3	6	1	283
13	3	1	0	0	1	0	0	0	0	0	0	5	14	18	23	17	15	27	28	3	3	10	1	0	169
14	0	3	0	0	0	0	0	0	0	0	0	1	11	29	28	17	12	10	17	7	13	7	10	4	171
15	19	5	0	0	0	2	0	1	0	0	0	1	20	27	18	10	13	38	90	8	53	267	243	500	1316
16	276	51	154	41	8	6	3	0	1	0	0	1	17	22	23	34	35	77	15	15	39	71	308	101	1299
17	110	125	9	4	3	3	3	0	0	0	0	7	6	20	56	54	32	20	14	4	11	6	13	6	505
18	4	1	0	1	8	1	0	5	0	0	0	56	28	233	130	38	139	217	3	24	55	43	54	5	1046
19	36	40	6	44	1	1	0	1	0	5	0	0	92	179	10	3	4	111	476	354	311	452	336	18	2479
20	8	7	9	5	50	54	6	14	0	0	6	35	41	31	36	28	10	7	9	143	343	270	246	55	1415
21	30	80	7	4	3	2	21	29	60	68	10	0	193	344	564	538	59	35	6	13	42	3	2	1	2115
22	3	2	5	4	6	5	7	19	1	0	1	7	53	22	58	181	203	91	0	15	8	14	5	5	713
23	1	1	1	0	0	0	1	0	0	0	0	9	20	30	44	62	452	523	542	315	155	88	57	24	2326
24	18	8	1	0	1	0	0	0	0	0	0	0	0	26	71	50	428	506	352	510	243	128	146	14	2503
25	5	27	35	55	11	15	51	0	17	129	128	35	3	81	95	48	117	57	48	17	0	0	1	1	976
26	0	22	2	2	16	5	1	4	39	5	0	81	6	129	121	12	24	0	1	1	0	0	0	0	473
27	1	1	0	0	1	0	0	0	0	0	1	19	10	13	168	95	1	0	17	14	9	2	0	0	352
28	2	0	0	0	0	0	0	0	0	0	4	28	13	4	16	8	4	0	17	23	41	24	3	2	189
29	6	1	1	2	7	1	0	2	3	0	0	5	4	11	37	113	87	59	256	60	11	3	0	1	669
30	0	0	1	0	0	0	0	0	0	0	1	17	46	31	146	437	70	1	3	115	76	15	7	3	969
31	1	0	0	0	0	0	0	0	0	0	0	0	4	0	15	8	1	1	0	0	0	0	0	0	32
KWh	1641	1183	478	253	240	198	183	110	139	210	157	382	818	1655	2162	2343	2664	2358	2605	2433	2249	2019	1678	1107	29264

Pakistan Meteorological Department

June 2007

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	2	0	0	1	1	0	0	0	0	0	5	25	24	2	176	215	45	5	174	359	35	42	311	1422
2	194	74	12	12	16	15	5	2	8	2	0	0	1	2	6	1	0	0	34	34	0	11	557	543	1528
3	164	49	0	5	0	14	16	7	3	1	0	2	8	23	112	3	0	12	3	10	0	1	0	0	434
4	0	0	0	3	8	7	1	16	143	59	0	0	0	0	0	0	0	0	0	2	27	187	4	32	489
5	5	2	3	0	1	1	0	1	2	1	0	1	2	118	319	217	423	114	294	182	27	7	15	34	1769
6	11	19	0	2	1	1	0	0	0	0	0	0	0	4	7	16	35	212	48	18	7	1	0	2	385
7	1	1	3	5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	4	9	3	3	0	32
8	3	2	0	0	1	0	1	0	0	0	0	0	15	34	14	18	7	4	4	4	15	23	16	11	174
9	13	30	14	22	8	23	10	2	0	0	1	0	2	4	3	9	14	12	3	4	24	22	7	15	244
10	6	5	6	5	3	3	5	1	0	0	0	1	6	8	12	11	9	3	2	9	32	27	7	25	186
11	15	1	2	10	1	5	6	2	4	0	0	0	20	40	53	38	44	12	0	1	5	2	1	2	262
12	2	11	2	2	2	4	0	1	0	0	0	13	13	15	20	15	18	13	22	4	7	16	9	1	191
13	0	0	0	0	0	0	0	0	0	0	0	19	41	47	35	30	316	36	5	4	15	0	4	0	553
14	0	0	0	2	0	2	0	0	0	0	2	14	27	43	77	93	8	1	13	36	79	165	220	49	833
15	13	7	1	1	2	0	1	0	0	0	3	28	29	243	24	4	4	1	1	3	1	0	0	1	365
16	2	0	0	2	0	1	0	0	0	1	29	21	141	14	6	0	1	0	0	3	0	1	0	5	226
17	27	2	1	0	0	0	0	0	0	0	22	37	9	1	223	65	3	1	0	1	13	0	3	0	409
18	2	1	0	0	2	1	0	0	0	0	0	4	13	0	1	36	4	1	0	1	4	1	1	5	77
19	3	1	2	0	0	0	0	0	0	0	0	4	11	1	43	25	6	1	1	1	2	1	2	0	104
20	0	0	4	2	1	1	0	0	0	0	1	5	11	20	28	10	7	7	21	4	0	7	10	11	150
21	2	0	0	2	1	2	1	0	0	0	10	13	27	22	11	5	7	3	15	5	0	0	1	2	129
22	0	0	1	0	0	0	0	2	0	1	14	24	16	4	4	1	2	1	1	9	98	22	14	3	218
23	1	0	1	0	1	7	1	0	0	0	9	53	48	58	38	30	19	41	55	19	2	1	0	0	387
24	0	0	1	2	0	0	0	0	1	0	0	1	4	4	4	7	6	5	10	5	1	0	1	0	52
25	2	0	0	1	3	0	2	0	0	0	23	10	0	0	0	4	9	9	2	38	232	59	2	6	402
26	3	0	0	0	0	0	0	0	0	0	1	14	13	14	30	6	7	9	0	1	0	0	0	0	98
27	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	6
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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	469	208	54	77	54	88	52	33	164	67	115	272	485	744	1072	820	1165	544	541	576	958	592	921	1058	11127

Pakistan Meteorological Department

July 2007

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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	19	4	0	0	0	1	0	35
23	0	0	0	0	1	0	0	0	1	14	29	13	22	29	0	6	91	275	11	1	1	4	0	0	499
24	0	0	0	1	0	0	0	0	0	0	2	10	5	9	5	11	18	19	74	22	4	1	1	4	188
25	0	1	1	1	4	0	0	0	0	0	1	10	19	11	6	11	19	23	15	1	11	17	6	2	159
26	0	3	0	5	4	0	0	0	0	1	18	21	254	23	53	26	11	0	4	0	1	1	3	1	430
27	0	0	1	0	0	2	0	0	0	9	19	40	10	4	5	7	7	2	0	2	1	0	0	0	112
28	0	0	0	0	0	0	0	0	0	1	5	11	26	13	6	10	16	10	0	2	0	0	1	0	104
29	0	1	2	0	0	0	0	0	0	15	23	11	25	31	25	25	19	21	21	52	39	11	0	1	323
30	4	0	0	0	1	1	14	16	5	0	0	4	1	0	0	0	0	1	1	0	6	8	1	1	64
31	2	1	0	3	2	0	0	0	0	0	4	15	17	7	12	8	7	16	7	1	3	1	0	0	107
KWh	7	6	5	11	13	4	14	16	6	41	102	137	379	130	112	102	196	385	137	82	65	44	15	11	2019