

EXECUTIVE SUMMARY

Pakistan Meteorological Department has conducted a detailed Wind Power Potential Survey of Coastal Areas of Pakistan for which the Ministry of Science and Technology Provided necessary funding. This study was necessitated because, during the last few decades, demand for energy had increased manifold. Escalating cost of fossil fuels together with inherent environmental problems led to increased appreciation of non-conventional alternative low cost renewable sources of power generation. This study indicated that Tremendous potential exists for harvesting wind energy especially in the wind corridor around Gharo along Sindh Coast.

During this three years study Wind data was collected at 20 sites along the Sindh Coast. Three years wind data with on-minute average speed & direction, five-minute average temperature and ten-minute minimum and maximum wind speeds at 10 meters and 30 meters heights were collected and analysed. Wind speed at 50 meters height was computed from models, which gives annual average wind speeds of 8.5 m/s 7.0,7.0,6.7 and 6.6 m/s at Jamshoro, Katibandar, Nooriabad, Thatta and Gharo respectively. During six month's period from April though September, average wind speed at the above sites is more than 11.11, 8.87, 9.23, 8.6 and 8.63 m/s respectively.

At times, simple wind speed averages do not give a true picture of the wind power Potential of an area. Resultantly, "wind power density" has been computed and assigned to that areas. Therefore, monthly and annual wind power density has been computed for all the sites.

Annual power density at Jamshoro, Nooriabad, Talhar, Katibandar, Thatta, Thana Bulakhan, Hyderabad and Gharo is 770, 454, 445, 445, 374, 373 and 371 and 359 w/m² respectively. According to international wind classification, this power density categorizes Jamshoro, Nooriabad, Talhar and Katibandar as excellent sites; Thatta, Thana Bulakhan, Hyderabad and

Gharo as good sites for wind power generation monthly and annual values of wind generated electric power have also been computed on hypothetical 600 kW wind turbine. Annual power production from such a wind turbine comes out to 2.1 million kwh which shows a capacity factor of 40% for Jamshoro, 1.5 million kwh showing capacity factor of 29% for Katibandar, 1.5 million kWh showing capacity factor of 29% for Nooriabad, 1.4 million kwh showing capacity factor of 27% for Gharo and 1.3 million kWh showing capacity factor of 25% for Hyderabad.

Internationally it is accepted that, if any site has a capacity factor of 25% and above, then that site is suitable for the installation of economically viable commercial wind power farms. The above sites and their surrounding areas, therefore, can be classified as suitable sites for installing economically viable wind farms.

Summarily, identified wind corridor in Sindh covers an area of about 9,700 sq.kms. Gross wind power potential of this areas is 43000 MW and, keeping in view the area utilization constraints etc; the exploitable electric power generation potential of this area is estimated to be about 11000 MW.



An Investigation on Wind Power Potential

of

Sindh

(Based on three years data)

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 coriolis 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 I. First phase covers the coastal areas of Sindh and Balochistan Provinces.

2.1 Study Area:

The project area for the wind mapping is 1100 kilometers along Sindh and Balochistan coast spreading over latitude 25°N approximately and up to 100 kilometers deep northward over land from the coast.

The list of stations located along Sindh is given below.

Badin, Baghan, Chuhar Jamali, DHA Karachi, Gharo, Golarchi, HawksBay, Hyderabad, Jamshoro, Jati, Karachi, Kati Bandar, Matli, MirPurSakro, Nooriabad, Sajawal, Shah Bandar, Talhar, Thano Bula Khan, Thatta, as shown in the Map-1:



Map-1: (Shows the 20- sites selected along the sindh coast for wind power potential survey)

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 each levels, One-minute average wind direction at 30 meters height, five-minute average temperature and 10-minute minimum and maximum wind speed at each levels. 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 far as possible away from the local obstruction to the wind
- Selected location should be representative of the majority of the site.

Since tower erection 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 far 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 per international standards. 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 at 10 & 30 meters
- iii. Minimum wind speeds during 10 minutes at 10 & 30 meters
- iv. Wind direction One minutes average at 30 meters
- v. Temperature 5 minutes average in °C at 10 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 for three years period (2002 – 2005) at Renewable Energy Research Cell established at Meteorological Complex, Karachi. Period of analyzed data varies for different locations and is annexed as Appendix II.

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, diurnal variation in wind speed 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.

Keeping in view economic aspects, in this survey also the wind has been recorded at 10 & 30 meters. To calculate the wind speed at 50 meters, the following two methods have been used in this study.

3.1.1 *Log Law:*

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

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

Where

- U_* is the friction notify
- k is the von Karman constant
- Z_o is the roughness length
- D is the displacement height

The von Karman constant is generally taken as 0.4. The roughness length Z_o is related to the vegetation cover of the area. The values of roughness length are given in Table-1. The displacement height D is the height above the roughness elements where the flow is free. For most vegetation it is small and is generally treated as zero. For large roughness elements like trees and building in towns it is not negligible and is the order of the average height of 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:

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

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.

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

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_0 and power law exponent α for various types of terrain

Type of terrain	Z_0	α
Mud Flats, Ice	10^{-3} to 3×10^{-3}	
Calm Sea	2×10^{-4} to 3×10^{-4}	
Sand	2×10^{-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 Table- 2(C) in tabular form and also data of six windy stations in graphical form in Figure 1.

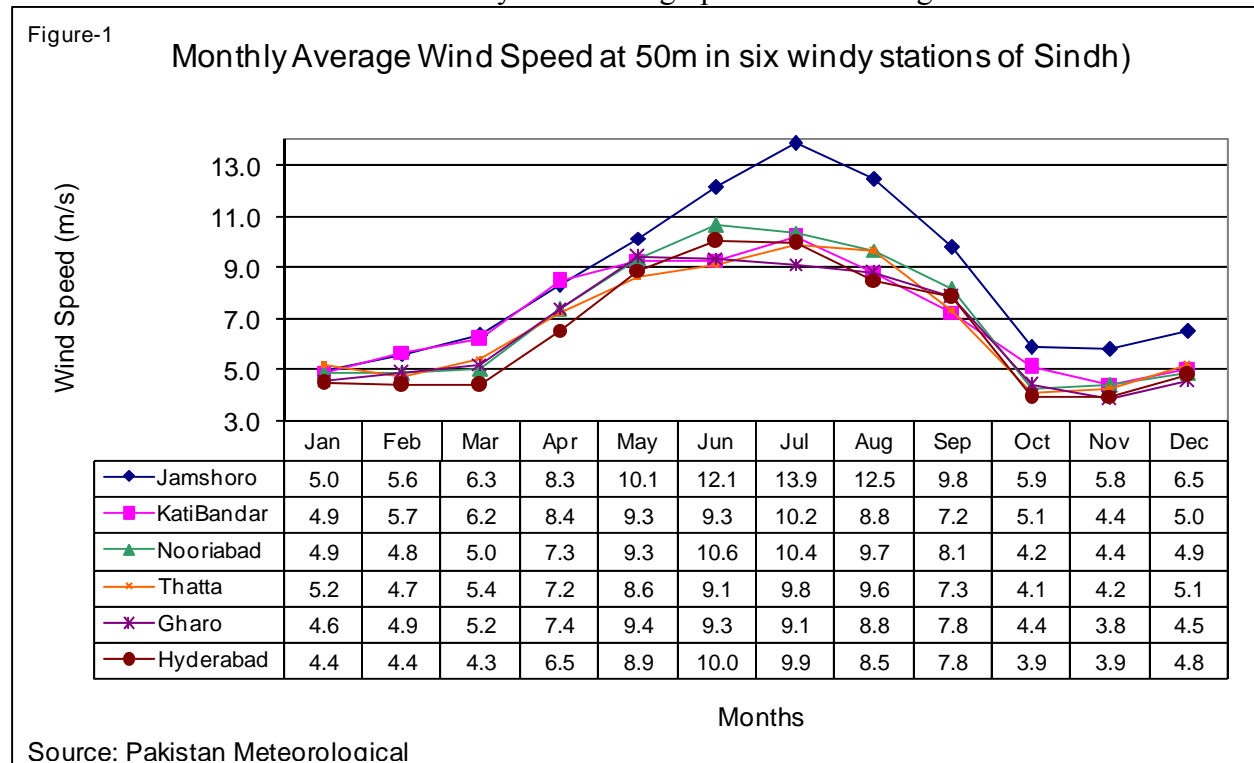
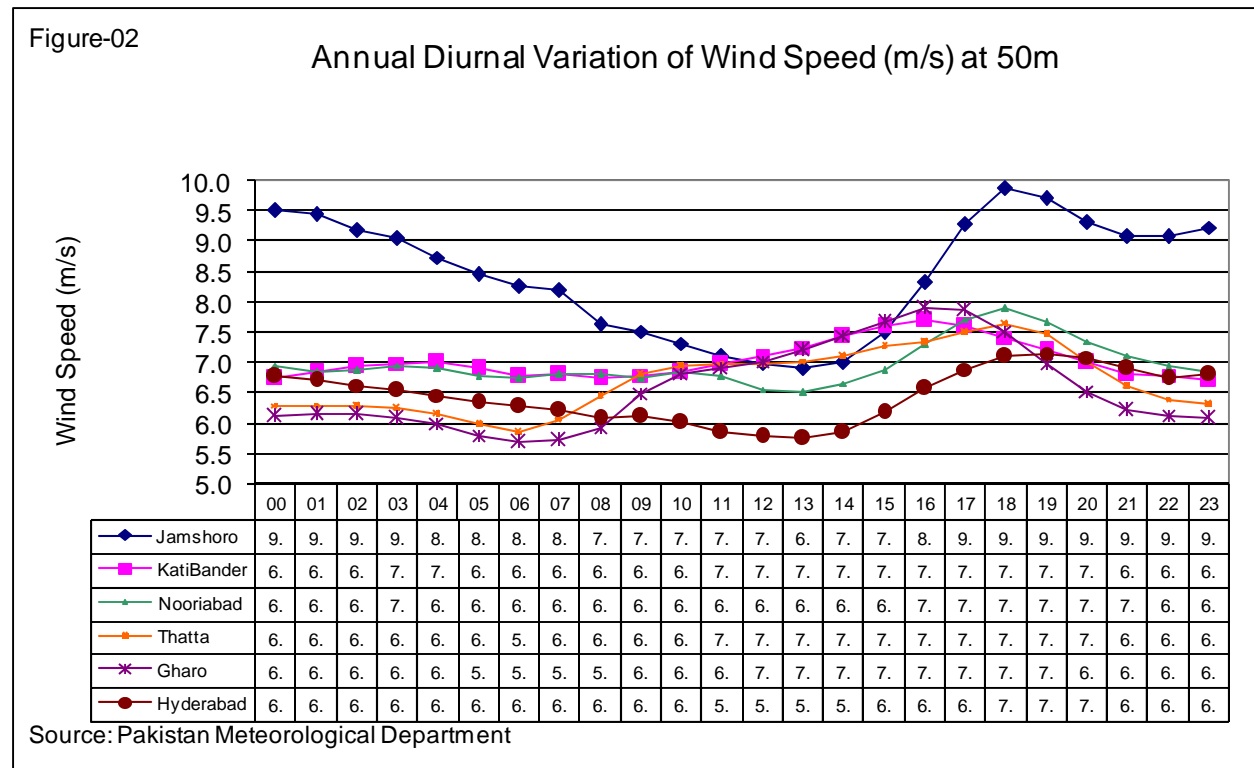


Figure-1 represents monthly average estimated wind speed at 50m heights at six most windy stations. The graph clearly depicts that the most windy months are April to September in these areas of Sindh region. We can see that Jamshoro is the region of most powerful wind and hence considered very good site to generate electric power potential. Moreover KatiBandar, Nooriabad, Thatta, Gharo, Hyderabad, Sajawal, Jati, Golarchi, Baghan, Talhar, MirPurSakro, Chuhar Jamali are suitable sites for power generation. The monthly average wind speed at 10, 20 & 50m height recorded at all stations in Sindh during three years, given in Table-2 (a,b & c).

3.2 Diurnal Wind speed Variation:

Fig-2 shows the annual diurnal wind speed variations at 50m heights at six most windy stations. We have already mentioned that Jamshoro, Kati Bandar, Nooriabad, Thatta, Gharo, Hyderabad is the region of sustainable wind. At Jamshoro the wind varies from minimum 6.9 m/s to maximum 9.9 m/s, at Kati Bandar it varies from minimum 6.8 m/s to maximum 7.7 m/s, at Nooriabad it varies from minimum 6.7 m/s to maximum 7.9 m/s, at Thatta it varies from minimum 5.8 m/s to maximum 7.6 m/s, at Gharo it varies from minimum 5.7 m/s to maximum 7.9 m/s, and at Hyderabad it varies from minimum 5.8 m/s to maximum 7.1 m/s, We can see that Jamshoro is the region of most powerful wind in the region hence considered very good site to generate electric power potential.



Average Wind Speed at 10m height in Sindh															
Table-2(a)	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nooriabad	10m	AWS	3.0	3.2	3.3	5.3	7.2	7.9	7.8	7.3	6.3	2.6	2.5	2.9	5.0
KatiBandar	10m	AWS	2.8	3.1	3.0	5.5	6.9	7.1	7.3	6.4	5.0	2.6	1.8	2.8	4.5
ShahBander	10m	AWS	2.6	2.9	3.3	4.8	6.3	6.5	6.3	6.1	4.8	2.6	2.2	2.6	4.2
Jamshoro	10m	AWS	2.4	2.5	2.7	4.0	5.4	6.7	7.7	6.7	5.4	2.3	1.9	2.4	4.2
HawksBay	10m	AWS	2.9	3.3	4.1	5.3	5.7	5.7	5.7	5.1	4.3	2.6	2.1	2.7	4.1
Hyderabad	10m	AWS	2.2	2.3	2.1	4.0	5.7	6.7	6.5	5.8	5.2	1.9	1.8	1.9	3.8
Gharo	10m	AWS	1.8	2.0	2.3	4.3	5.9	6.2	5.9	5.7	5.0	1.7	1.2	1.4	3.6
ChuharJamal	10m	AWS	2.8	2.6	2.6	3.9	5.1	5.5	5.3	4.5	3.0	1.6	1.7	2.4	3.4
DHA Karachi	10m	AWS	2.2	2.5	2.9	3.9	4.8	5.2	5.0	3.7	3.6	2.3	1.7	1.7	3.3
ThanoBulaKhan	10m	AWS	1.6	1.9	1.4	2.8	4.4	5.4	5.7	4.9	3.8	1.0	1.1	1.6	3.0
Jati	10m	AWS	1.7	2.0	2.3	3.2	4.3	5.1	4.5	4.5	3.2	1.6	1.3	1.6	2.9
MirpurSakro	10m	AWS	0.9	1.1	1.5	3.3	4.9	5.0	4.8	4.6	3.7	0.8	0.5	0.9	2.7
Golarchi	10m	AWS	1.7	1.8	1.6	2.6	3.4	4.3	3.9	3.4	2.6	1.2	2.0	1.6	2.5
Sajawal	10m	AWS	1.3	1.4	1.8	3.0	4.2	4.0	3.6	3.7	2.9	1.1	0.9	1.2	2.4
Baghan	10m	AWS	1.5	1.6	1.9	2.5	3.1	3.2	3.2	3.3	2.8	1.5	1.7	1.7	2.3
Thatta	10m	AWS	1.0	1.1	1.5	2.4	3.2	3.8	4.1	3.8	2.7	1.0	0.6	0.8	2.2
Karachi	10m	AWS	0.7	0.7	2.1	2.7	3.7	4.2	3.6	2.6	2.3	0.7	0.4	0.5	2.0
Badin	10m	AWS	0.4	0.7	0.7	2.2	3.7	4.0	3.8	2.8	2.5	0.4	0.7	0.4	1.9
Talhar	10m	AWS	1.1	1.1	0.6	1.6	2.6	2.9	2.7	2.0	1.1	0.3	0.4	0.9	1.4
Matli	10m	AWS	0.9	0.9	0.4	1.1	2.1	2.7	2.4	2.0	1.5	0.5	0.6	0.8	1.3

Average Wind Speed at 30m height in Sindh															
Table-2(b)	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Jamshoro	30m	AWS	3.7	4.4	5.0	6.7	8.4	10.2	11.6	10.3	8.2	4.5	4.3	4.9	6.9
Nooriabad	30m	AWS	4.2	4.3	4.4	6.6	8.6	9.7	9.5	8.8	7.5	3.7	3.7	4.2	6.2
KatiBandar	30m	AWS	4.1	4.7	5.1	7.4	8.3	8.4	9.1	8.0	6.5	4.2	3.5	4.2	6.1
Gharo	30m	AWS	3.6	3.9	4.2	6.3	8.2	8.3	8.0	7.7	6.8	3.5	3.0	3.5	5.6
Hyderabad	30m	AWS	3.6	3.6	3.6	5.6	7.8	8.8	8.8	7.5	6.9	3.2	3.2	3.8	5.5
ShahBander	30m	AWS	4.1	4.2	4.5	5.8	7.2	7.6	7.4	7.2	5.7	3.8	3.7	4.2	5.5
Jati	30m	AWS	3.8	3.9	4.2	5.4	6.5	7.7	6.8	6.7	5.2	3.3	3.3	3.8	5.1
Thatta	30m	AWS	3.7	3.4	3.9	5.3	6.5	7.1	7.7	7.4	5.5	3.0	3.0	3.6	5.0
Sajawal	30m	AWS	3.6	3.7	4.1	5.5	6.7	7.1	6.6	6.8	5.5	3.2	3.2	3.6	5.0
DHA Karachi	30m	AWS	3.3	3.9	4.5	5.6	6.5	6.8	7.4	6.6	5.5	3.5	2.9	3.1	5.0
ChuharJamal	30m	AWS	3.9	4.0	3.6	5.1	6.6	7.1	6.9	6.4	5.3	3.1	3.3	3.9	5.0
MirpurSakro	30m	AWS	3.3	3.5	3.8	5.2	7.0	7.2	7.2	6.6	5.6	2.9	2.7	3.4	4.9
HawksBay	30m	AWS	3.6	4.0	4.9	6.0	6.5	6.4	6.5	5.8	5.1	3.3	2.8	3.5	4.9
Golarchi	30m	AWS	3.8	3.8	3.6	4.7	6.1	7.3	6.8	6.0	4.9	3.0	4.3	3.7	4.8
Baghan	30m	AWS	3.7	3.8	4.0	5.1	6.0	6.5	6.3	6.4	5.2	3.3	3.3	4.0	4.8
Talhar	30m	AWS	2.6	3.0	3.4	5.4	7.0	7.3	6.8	6.0	5.0	2.4	2.0	2.4	4.5
ThanoBulaKhan	30m	AWS	2.6	3.0	2.1	4.4	5.8	7.4	7.4	6.5	5.7	1.8	1.8	2.7	4.3
Matli	30m	AWS	2.9	2.9	3.0	4.2	5.8	6.4	6.0	5.3	4.5	2.3	2.5	3.0	4.1
Badin	30m	AWS	2.0	2.1	2.2	4.9	6.5	6.9	6.1	5.8	4.6	2.3	2.0	1.9	4.0
Karachi	30m	AWS	1.7	1.9	3.2	4.3	5.5	5.8	5.2	4.5	4.1	1.5	1.2	1.8	3.4

Average Wind Speed at 50m height in Sindh															
Table-2(c)	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Jamshoro	50m	AWS	5.0	5.6	6.3	8.3	10.1	12.1	13.9	12.5	9.8	5.9	5.8	6.5	8.5
KatiBandar	50m	AWS	4.9	5.7	6.2	8.4	9.3	9.3	10.2	8.8	7.2	5.1	4.4	5.0	7.0
Nooriabad	50m	AWS	4.9	4.8	5.0	7.3	9.3	10.6	10.4	9.7	8.1	4.2	4.4	4.9	7.0
Thatta	50m	AWS	5.2	4.7	5.4	7.2	8.6	9.1	9.8	9.6	7.3	4.1	4.2	5.1	6.7
Gharo	50m	AWS	4.6	4.9	5.2	7.4	9.4	9.3	9.1	8.8	7.8	4.4	3.8	4.5	6.6
Hyderabad	50m	AWS	4.4	4.4	4.3	6.5	8.9	10.0	9.9	8.5	7.8	3.9	3.9	4.8	6.4
Sajawal	50m	AWS	4.9	5.0	5.6	7.1	8.4	8.9	7.4	8.6	7.1	4.4	4.5	5.0	6.4
Jati	50m	AWS	5.1	5.2	5.3	6.7	7.8	9.1	8.0	7.9	6.4	4.4	4.6	5.3	6.3
Golarchi	50m	AWS	5.1	5.1	4.9	6.2	7.7	9.1	8.5	7.5	6.4	4.1	5.6	5.1	6.3
Baghan	50m	AWS	4.9	5.0	5.2	6.7	7.9	8.6	8.3	8.4	6.6	4.2	4.1	5.3	6.3
ShahBander	50m	AWS	5.1	5.1	5.2	6.4	7.9	8.3	8.2	7.9	6.2	4.6	4.7	5.3	6.2
Talhar	50m	AWS	3.5	4.1	4.3	7.7	9.9	10.3	9.4	8.8	7.5	3.4	2.7	3.2	6.2
MirpurSakro	50m	AWS	4.5	4.7	4.9	6.3	8.2	8.5	8.6	7.7	6.6	3.9	3.8	4.7	6.0
DHA Karachi	50m	AWS	4.0	4.6	5.3	6.5	7.4	7.7	9.0	8.1	6.6	4.2	3.6	3.8	5.9
ChuharJamal	50m	AWS	4.4	4.9	4.3	5.9	7.6	8.0	7.9	7.5	6.5	3.9	4.1	4.7	5.8
Matli	50m	AWS	4.0	3.9	4.2	6.1	8.1	8.9	8.3	7.3	6.4	3.1	3.4	4.1	5.6
HawksBay	50m	AWS	4.0	4.4	5.4	6.4	7.1	6.9	7.1	6.2	5.6	3.7	3.2	4.0	5.3
Badin	50m	AWS	2.9	3.0	3.1	6.4	8.1	8.5	7.6	7.5	5.8	3.3	2.7	2.7	5.1
ThanoBulaKhan	50m	AWS	3.3	3.6	2.6	5.3	6.8	8.6	8.5	7.6	6.8	2.3	2.4	3.3	5.1
Karachi	50m	AWS	2.3	2.5	3.9	5.2	6.6	6.9	6.5	5.7	5.1	2.0	1.6	2.4	4.2

Figures 3 to 6 shows seasonal diurnal variation of wind speed. Figure-3 shows that during March to May period, in three years at 50 meters height the maximum wind speed reaches to 10.7m/s at Jamshoro and the minimum wind speed of 5.6 at Hyderabad. Figure-4 shows that it reaches to 14.4 m/s at Jamshoro and minimum wind speed of 7.6m/s during June to August period in three years.

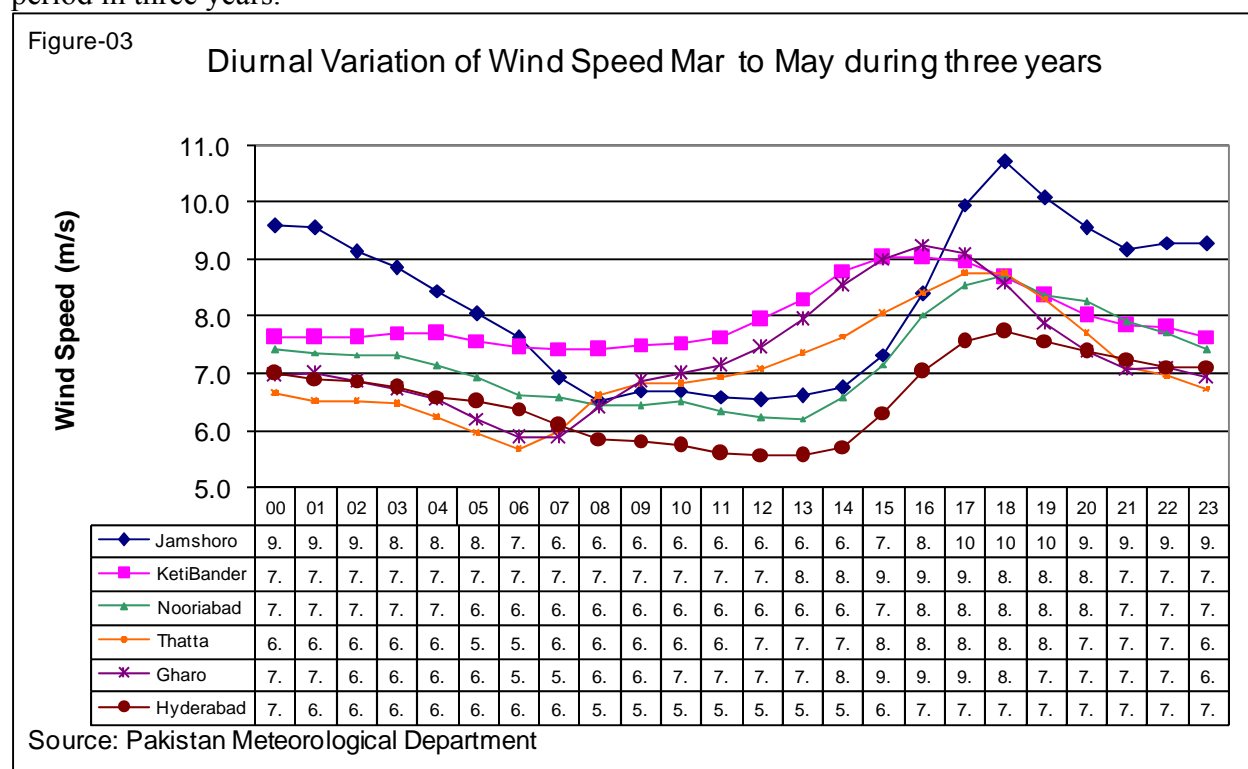


Table -3 (a)		Annual Diurnal Variation of Wind Speed (m/s)																		
Stations	Heights	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Jamshoro	AWS10m	4.1	4.0	3.9	3.8	3.7	3.5	3.5	3.7	4.1	4.4	4.4	4.3	4.2	4.2	4.2	4.5	4.9	5.0	4.8
KatiBander	AWS10m	1.5	1.5	1.5	1.5	1.4	1.3	1.4	1.5	1.8	2.1	2.4	2.5	2.7	2.9	3.1	3.1	3.0	2.7	2.3
Nooriabad	AWS10m	4.7	4.6	4.6	4.6	4.5	4.4	4.4	4.5	4.9	5.3	5.4	5.3	5.1	5.0	5.1	5.3	5.6	5.7	5.5
Thatta	AWS10m	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.7	2.1	2.5	2.7	2.8	2.8	2.9	2.9	3.0	2.9	2.7	2.5
Gharo	AWS10m	2.8	2.8	2.7	2.7	2.6	2.5	2.4	2.8	3.4	4.1	4.4	4.6	4.7	4.9	5.0	5.1	5.1	4.8	4.2
Hyderabad	AWS10m	3.5	3.4	3.4	3.3	3.3	3.2	3.2	3.4	3.9	4.2	4.2	4.2	4.2	4.2	4.2	4.4	4.7	4.6	4.2
Badin	AWS10m	1.4	1.4	1.4	1.4	1.4	1.3	1.4	1.7	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.2	1.9
Baghan	AWS10m	1.6	1.7	1.7	1.7	1.6	1.6	1.6	1.9	2.5	3.0	3.3	3.4	3.5	3.5	3.5	3.4	3.2	2.8	2.3
Chuhar Jamali	AWS10m	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.8	2.5	3.1	3.4	3.6	3.7	3.7	3.8	3.7	3.6	3.1	2.6
DHA Karachi	AWS10m	2.6	2.6	2.6	2.7	2.7	2.7	3.0	3.1	3.3	3.6	3.9	4.1	4.3	4.5	4.5	4.4	4.2	3.9	3.3
Golarchi	AWS10m	2.1	2.0	2.0	2.0	2.0	1.9	2.0	2.2	2.7	3.0	3.1	3.1	3.2	3.2	3.2	3.2	3.1	2.7	2.5
HawksBay	AWS10m	3.5	3.6	3.7	3.8	3.8	3.7	3.6	3.6	3.8	4.2	4.5	4.7	4.9	5.2	5.4	5.4	5.2	4.9	4.3
Jati	AWS10m	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.5	3.2	3.6	3.8	3.8	3.9	3.9	4.0	4.0	3.8	3.5	3.1
Karachi	AWS10m	1.5	1.5	1.5	1.5	1.4	1.3	1.4	1.5	1.8	2.1	2.4	2.5	2.7	2.9	3.1	3.1	3.0	2.7	2.3
Mirpursakro	AWS10m	1.8	1.8	1.8	1.8	1.7	1.7	1.7	2.1	2.8	3.4	3.7	3.7	3.8	3.9	3.9	3.9	3.8	3.5	2.9
Matli	AWS10m	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.2	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4
ShahBander	AWS10m	3.5	3.5	3.4	3.4	3.3	3.2	3.1	3.5	4.3	4.8	5.0	5.1	5.3	5.4	5.5	5.5	5.4	5.2	4.7
Sajawal	AWS10m	1.8	1.8	1.8	1.8	1.8	1.7	1.7	2.0	2.6	3.0	3.1	3.2	3.2	3.2	3.3	3.2	3.2	2.9	2.5
Talhar	AWS10m	1.0	1.0	1.0	0.9	0.9	0.9	0.9	1.2	1.7	2.0	2.1	2.1	2.1	2.1	2.1	2.1	1.9	1.6	1.4
ThanoBulaKhan	AWS10m	2.2	2.1	2.1	2.1	2.0	1.9	1.9	2.2	2.7	3.3	3.7	3.7	3.7	3.7	3.7	3.9	4.2	4.3	4.0

Table -3 (b)		Annual Diurnal Variation of Wind Speed (m/s)																		
Stations	Heights	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Badin	AWS30m	3.9	3.8	3.8	3.8	3.7	3.6	3.5	3.7	3.9	4.0	3.9	4.0	4.0	4.0	4.0	4.1	4.1	4.2	4.2
Baghan	AWS30m	4.2	4.3	4.3	4.3	4.2	4.2	4.1	4.4	4.8	5.1	5.3	5.5	5.5	5.6	5.7	5.8	5.7	5.5	5.1
Chuhar Jamali	AWS30m	4.1	4.1	4.1	4.1	4.0	3.9	3.9	4.1	4.4	4.8	5.1	5.2	5.2	5.3	5.4	5.4	5.4	5.3	5.2
DHA Karachi	AWS30m	4.3	4.4	4.4	4.5	4.5	4.5	4.6	4.6	4.8	5.1	5.3	5.6	5.8	6.0	6.1	6.0	5.9	5.6	5.1
Golarchi	AWS30m	4.7	4.7	4.7	4.6	4.6	4.5	4.4	4.6	4.7	4.8	4.9	4.9	4.9	4.9	5.0	5.0	5.1	5.1	5.2
Gharo	AWS30m	5.0	5.0	5.0	4.9	4.8	4.6	4.6	4.7	5.0	5.6	6.0	6.1	6.2	6.4	6.6	6.8	6.9	6.8	6.4
Hyderabad	AWS30m	5.6	5.6	5.5	5.4	5.4	5.2	5.2	5.2	5.3	5.4	5.4	5.2	5.2	5.2	5.3	5.5	5.9	6.1	6.1
Stations	Heights	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
HawksBay	AWS30m	4.3	4.5	4.6	4.6	4.6	4.5	4.4	4.4	4.5	4.7	5.0	5.2	5.5	5.7	5.9	6.0	5.9	5.6	5.1
Jamshoro	AWS30m	7.5	7.3	7.1	7.0	6.8	6.6	6.4	6.5	6.3	6.3	6.2	6.0	5.9	5.8	5.9	6.3	6.9	7.6	7.9
Jati	AWS30m	4.8	4.8	4.7	4.7	4.6	4.5	4.5	4.7	5.0	5.2	5.2	5.3	5.3	5.4	5.5	5.6	5.6	5.6	5.5
Karachi	AWS30m	2.8	2.8	2.8	2.7	2.7	2.6	2.7	2.8	3.0	3.3	3.7	3.9	4.1	4.4	4.6	4.7	4.7	4.3	3.9
KatiBander	AWS30m	5.8	5.8	5.9	5.9	5.9	5.8	5.7	5.8	5.9	6.1	6.1	6.2	6.4	6.5	6.6	6.8	6.9	6.7	6.5
Mirpursakro	AWS30m	4.4	4.4	4.4	4.4	4.4	4.3	4.2	4.4	4.7	5.1	5.4	5.4	5.5	5.6	5.6	5.7	5.7	5.6	5.4
Matli	AWS30m	4.2	4.1	4.0	4.0	3.8	3.8	3.7	3.8	3.9	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.1	4.2
Nooriabad	AWS30m	6.2	6.1	6.1	6.1	6.1	5.9	5.9	6.0	6.1	6.2	6.3	6.2	6.0	5.9	6.1	6.3	6.7	7.0	7.0
ShahBander	AWS30m	5.0	5.1	5.0	5.0	4.9	4.8	4.7	4.9	5.3	5.6	5.7	5.9	6.0	6.1	6.2	6.3	6.3	6.2	6.0
Sajawal	AWS30m	4.7	4.7	4.7	4.6	4.5	4.4	4.4	4.4	4.8	5.0	5.1	5.2	5.2	5.3	5.4	5.4	5.5	5.4	5.4
Talhar	AWS30m	4.4	4.4	4.3	4.3	4.2	4.1	3.9	4.1	4.3	4.5	4.6	4.5	4.5	4.5	4.6	4.6	4.6	4.6	4.7
Thatta	AWS30m	4.6	4.6	4.5	4.5	4.4	4.3	4.2	4.5	4.8	5.1	5.3	5.4	5.4	5.4	5.5	5.6	5.6	5.7	5.7
ThanoBulaKhan	AWS30m	3.6	3.5	3.5	3.5	3.4	3.3	3.2	3.4	3.7	4.2	4.5	4.6	4.5	4.5	4.6	4.9	5.4	5.8	6.0

Table – 3 (c)	Annual Diurnal Variation of Wind Speed (m/s)																			
Stations	Heights	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Jamshoro	AWS50m	9.5	9.4	9.2	9.0	8.7	8.5	8.3	8.2	7.6	7.5	7.3	7.1	7.0	6.9	7.0	7.5	8.3	9.3	9.9
KatiBander	AWS50m	6.7	6.8	6.9	7.0	7.0	6.9	6.8	6.8	6.7	6.8	6.8	7.0	7.1	7.2	7.4	7.6	7.7	7.6	7.4
Nooriabad	AWS50m	6.9	6.8	6.9	7.0	6.9	6.8	6.7	6.8	6.8	6.7	6.9	6.8	6.6	6.5	6.7	6.9	7.3	7.7	7.9
Thatta	AWS50m	6.3	6.3	6.3	6.2	6.1	6.0	5.8	6.1	6.4	6.8	6.9	7.0	7.0	7.0	7.1	7.3	7.3	7.5	7.6
Gharo	AWS50m	6.1	6.1	6.1	6.1	6.0	5.8	5.7	5.7	5.9	6.5	6.8	6.9	7.0	7.2	7.4	7.7	7.9	7.8	7.5
Hyderabad	AWS50m	6.8	6.7	6.6	6.5	6.4	6.3	6.3	6.2	6.1	6.1	6.0	5.8	5.8	5.7	5.8	6.2	6.6	6.9	7.1
Badin	AWS50m	5.2	5.2	5.1	5.1	5.0	4.8	4.7	4.8	4.9	5.0	4.9	4.9	5.0	5.0	5.1	5.1	5.2	5.4	5.5
Baghan	AWS50m	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.9	6.1	6.3	6.6	6.7	6.8	6.9	7.1	7.2	7.2	7.1	6.7
Chuhar Jamali	AWS50m	5.4	5.4	5.4	5.4	5.4	5.2	5.1	5.2	5.4	5.7	6.0	6.1	6.1	6.2	6.3	6.4	6.5	6.5	6.6
DHA Karachi	AWS50m	5.3	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.8	6.1	6.4	6.7	6.9	7.0	7.0	6.8	6.5	6.1
Golarchi	AWS50m	6.4	6.4	6.3	6.3	6.2	6.0	5.9	6.0	5.9	5.9	6.0	6.0	6.0	6.0	6.1	6.1	6.3	6.5	6.8
HawksBay	AWS50m	4.8	4.9	5.1	5.1	5.1	5.0	4.9	4.9	4.9	5.1	5.4	5.6	5.9	6.2	6.4	6.4	6.3	6.0	5.6
Jati	AWS50m	6.3	6.3	6.2	6.2	6.1	6.0	6.0	6.0	6.0	6.0	6.1	6.1	6.2	6.3	6.4	6.5	6.6	6.8	6.9
Karachi	AWS50m	3.6	3.5	3.5	3.5	3.4	3.4	3.4	3.5	3.7	4.0	4.4	4.7	5.0	5.3	5.6	5.7	5.7	5.4	4.8
Mirpursakro	AWS50m	5.6	5.7	5.7	5.7	5.7	5.5	5.4	5.5	5.6	6.0	6.3	6.4	6.5	6.5	6.6	6.8	6.8	6.8	6.6
Matli	AWS50m	5.8	5.7	5.6	5.5	5.4	5.3	5.2	5.3	5.3	5.5	5.6	5.6	5.6	5.7	5.8	5.8	5.9	5.7	5.8
ShahBander	AWS50m	6.0	6.0	6.0	5.9	5.9	5.7	5.6	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	6.9	6.9	6.9	6.8
Sajawal	AWS50m	6.4	6.3	6.3	6.2	6.1	6.0	5.8	5.8	5.9	6.1	6.3	6.3	6.4	6.5	6.6	6.8	6.9	7.0	7.1
Talhar	AWS50m	6.3	6.3	6.2	6.1	6.0	5.8	5.6	5.8	5.9	6.2	6.2	6.1	6.1	6.1	6.2	6.3	6.4	6.5	6.6
ThanoBulaKhan	AWS50m	4.4	4.3	4.4	4.3	4.2	4.1	4.0	4.1	4.4	4.8	5.2	5.2	5.2	5.1	5.2	5.5	6.1	6.7	7.1

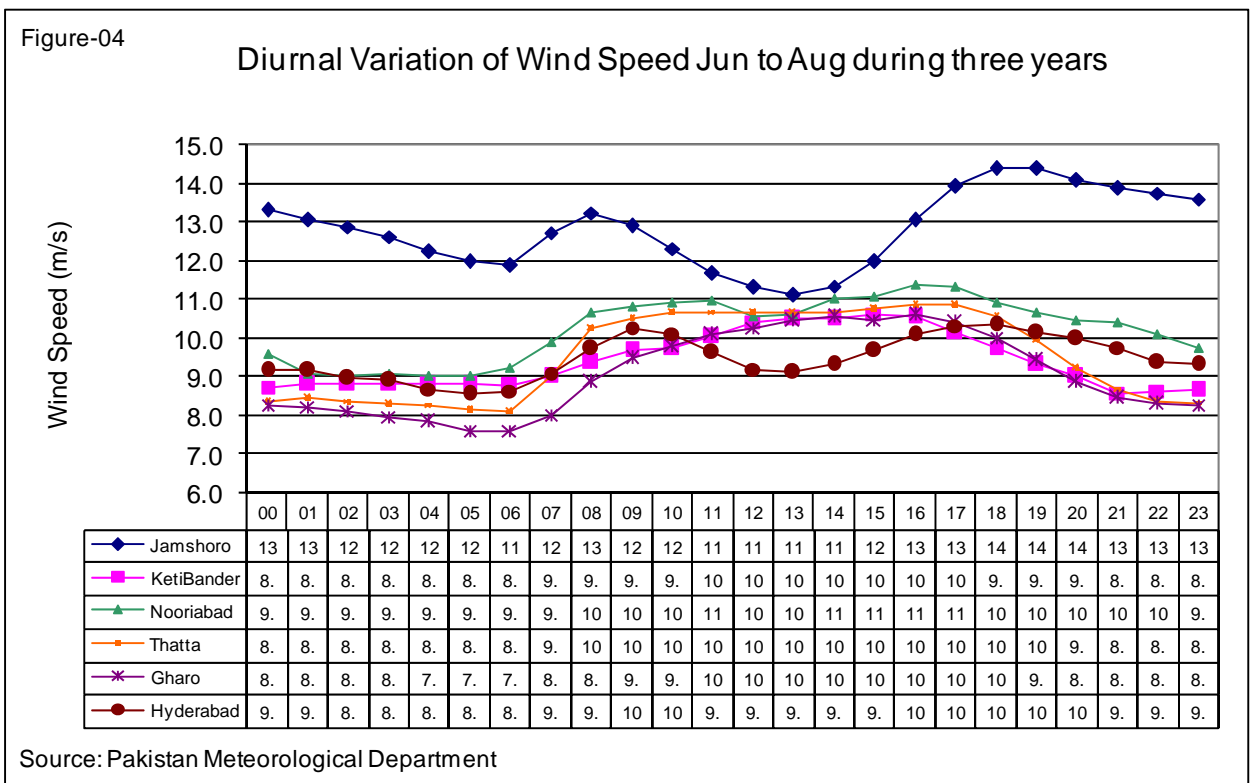


Table 4 (a)		Three years Average Diurnal Variation of Wind Speed (Mar to May) (m/s)																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS10m	4.1	4.0	3.8	3.7	3.5	3.3	3.1	3.3	3.7	3.9	4.0	3.9	3.8	3.8	3.8	4.2	4.7	5.5	5.5	4.8	4.5	4.2	4.1	4.0	4.0
KatiBander	AWS10m	2.1	2.1	2.1	2.0	1.9	1.7	1.7	2.0	2.4	2.7	3.1	3.3	3.8	4.2	4.4	4.5	4.4	4.0	3.4	2.8	2.5	2.2	2.3	2.2	2.8
Nooriabad	AWS10m	5.2	5.1	4.9	4.9	4.7	4.5	4.3	4.5	4.9	5.1	5.1	5.0	4.9	4.8	5.1	5.5	6.2	6.6	6.5	6.1	5.9	5.7	5.6	5.3	5.3
Thatta	AWS10m	1.9	1.7	1.7	1.7	1.6	1.5	1.5	1.8	2.3	2.5	2.7	2.8	2.9	3.0	3.2	3.3	3.3	3.2	3.0	2.7	2.4	2.1	2.0	1.9	2.4
Gharo	AWS10m	3.3	3.2	3.1	2.9	2.8	2.5	2.4	3.0	3.9	4.4	4.7	4.9	5.2	5.5	5.9	6.2	6.2	5.9	5.2	4.5	4.1	3.7	3.6	3.5	4.2
Hyderabad	AWS10m	3.6	3.5	3.5	3.4	3.3	3.2	3.2	3.4	3.9	4.1	4.1	4.0	4.0	4.0	4.0	4.5	4.9	5.2	4.8	4.4	4.2	4.0	3.9	3.8	3.9
Badin	AWS10m	1.7	1.6	1.6	1.5	1.5	1.4	1.5	2.2	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	2.9	2.9	2.5	2.2	2.1	1.9	1.8	1.7	2.2
Baghan	AWS10m	1.7	1.6	1.6	1.5	1.4	1.2	1.3	1.9	2.9	3.3	3.5	3.6	3.8	3.9	4.0	4.0	3.8	3.5	2.8	2.1	1.8	1.6	1.6	1.6	2.5
Chuhar Jamali	AWS10m	1.3	1.4	1.4	1.4	1.4	1.3	1.4	2.1	3.0	3.4	3.6	3.8	3.9	4.0	4.2	4.4	4.4	4.2	3.4	2.6	2.1	1.7	1.5	1.4	2.6
DHA Karachi	AWS10m	2.6	2.7	2.7	2.7	2.7	2.9	3.1	3.6	4.0	4.5	4.9	5.2	5.6	5.8	5.7	5.5	5.1	4.7	4.1	3.5	3.2	2.9	2.8	2.7	3.9
Golarchi	AWS10m	2.0	2.0	1.9	1.8	1.8	1.8	1.9	2.4	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.3	3.2	2.9	2.6	2.5	2.3	2.1	2.0	2.6
HawksBay	AWS10m	4.5	4.8	4.8	4.8	4.6	4.3	4.0	3.9	4.1	4.5	4.8	5.2	5.5	5.8	6.1	6.3	6.3	6.1	5.6	5.1	5.0	4.9	4.7	4.7	5.0
Jati	AWS10m	2.4	2.3	2.2	2.2	2.1	2.0	2.0	2.8	3.8	4.0	4.1	4.1	4.3	4.3	4.5	4.6	4.7	4.6	3.9	3.4	3.1	2.7	2.5	2.4	3.3
Karachi	AWS10m	2.1	2.1	2.1	2.0	1.9	1.7	1.7	2.0	2.4	2.7	3.1	3.3	3.8	4.2	4.4	4.5	4.4	4.0	3.4	2.8	2.5	2.2	2.3	2.2	2.8
Mirpursakro	AWS10m	2.0	2.0	2.0	1.9	1.9	1.7	1.8	2.5	3.6	4.0	4.1	4.3	4.5	4.7	5.0	5.2	5.2	5.0	4.0	3.0	2.5	2.2	2.0	2.0	3.2
Matli	AWS10m	1.0	0.9	0.9	0.8	0.8	0.8	0.8	1.1	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.5	1.6	1.4	1.2	1.2	1.1	1.1	1.0	1.2
ShahBander	AWS10m	3.7	3.7	3.6	3.6	3.5	3.3	3.3	3.9	5.0	5.4	5.4	5.6	5.9	6.1	6.4	6.6	6.6	6.5	5.8	5.1	4.6	4.2	4.0	3.9	4.8
Sajawal	AWS10m	2.0	2.0	2.0	2.0	1.8	1.7	1.8	2.5	3.4	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.2	3.6	3.0	2.6	2.4	2.1	2.1	3.0
Talhar	AWS10m	1.1	1.1	1.0	0.9	0.8	0.8	0.9	1.5	2.1	2.3	2.3	2.4	2.4	2.3	2.3	2.2	2.2	2.1	1.7	1.5	1.3	1.2	1.2	1.1	1.6
ThanoBulaKhan	AWS10m	1.9	1.9	1.8	1.8	1.6	1.6	1.6	2.0	2.4	3.0	3.3	3.4	3.4	3.4	3.6	4.0	4.6	5.1	4.8	4.0	3.3	2.5	2.3	2.1	2.9

Table 4(b)		Three years Average Diurnal Variation of Wind Speed (Mar to May) (m/s)																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS30m	7.5	7.5	7.1	6.9	6.6	6.3	5.9	5.6	5.5	5.7	5.7	5.6	5.5	5.6	5.7	6.2	7.1	8.3	8.8	8.1	7.7	7.3	7.4	7.3	6.7
KatiBander	AWS30m	6.5	6.5	6.4	6.5	6.4	6.3	6.2	6.3	6.5	6.6	6.7	6.8	7.1	7.4	7.9	8.1	8.1	8.1	7.7	7.4	7.0	6.8	6.8	6.6	6.9
Nooriabad	AWS30m	6.6	6.6	6.5	6.5	6.3	6.1	5.8	5.8	5.8	5.9	6.0	5.8	5.7	5.7	6.0	6.5	7.3	7.8	7.9	7.6	7.4	7.1	7.0	6.7	6.5
Thatta	AWS30m	4.8	4.7	4.7	4.6	4.5	4.3	4.1	4.4	4.9	5.2	5.2	5.3	5.5	5.7	5.9	6.2	6.4	6.6	6.5	6.1	5.6	5.2	5.0	4.9	5.3
Gharo	AWS30m	5.7	5.7	5.5	5.4	5.2	4.9	4.7	4.9	5.5	6.0	6.2	6.3	6.6	7.1	7.6	8.0	8.2	8.0	7.4	6.7	6.2	5.9	5.9	5.7	6.2
Hyderabad	AWS30m	5.8	5.7	5.7	5.6	5.4	5.3	5.3	5.1	5.2	5.2	5.1	5.0	5.0	5.1	5.6	6.3	6.7	6.7	6.5	6.3	6.1	6.0	5.9	5.6	
Badin	AWS30m	4.4	4.4	4.3	4.2	4.2	4.1	4.0	4.3	4.6	4.5	4.4	4.4	4.4	4.4	4.5	4.7	5.0	5.3	5.1	5.0	5.0	4.8	4.6	4.5	4.5
Baghan	AWS30m	4.3	4.3	4.3	4.1	4.0	4.0	4.0	4.4	5.1	5.4	5.6	5.7	5.9	6.2	6.5	6.6	6.7	6.5	5.7	4.9	4.5	4.3	4.3	4.3	5.1
Chuhar Jamali	AWS30m	3.6	3.7	3.7	3.7	3.7	3.6	3.6	4.1	4.8	5.1	5.4	5.6	5.7	5.8	6.0	6.3	6.5	6.5	5.8	5.1	4.5	4.0	3.8	3.7	4.8
DHA Karachi	AWS30m	4.6	4.7	4.6	4.6	4.5	4.6	4.7	4.9	5.2	5.7	6.0	6.5	7.0	7.3	7.2	7.1	6.7	6.3	5.8	5.3	5.0	4.8	4.8	4.6	5.5
Golarchi	AWS30m	4.5	4.5	4.5	4.4	4.4	4.3	4.3	4.6	4.8	4.8	4.8	4.8	4.8	4.8	5.0	5.2	5.4	5.5	5.6	5.3	5.2	4.9	4.8	4.6	4.8
HawksBay	AWS30m	5.3	5.6	5.7	5.7	5.5	5.2	4.8	4.7	4.7	5.1	5.4	5.8	6.2	6.5	6.8	7.0	7.0	6.8	6.4	6.0	5.9	5.8	5.6	5.5	5.8
Jati	AWS30m	4.8	4.7	4.7	4.6	4.6	4.5	4.5	4.8	5.4	5.5	5.5	5.5	5.6	5.8	6.0	6.3	6.6	6.7	6.3	5.8	5.5	5.1	4.9	4.8	5.4
Karachi	AWS30m	3.8	3.7	3.7	3.6	3.5	3.3	3.2	3.2	3.5	3.9	4.2	4.6	5.0	5.6	6.0	6.2	6.1	5.7	5.1	4.6	4.1	3.9	3.9	3.8	4.3
Mirpursakro	AWS30m	4.7	4.7	4.6	4.6	4.6	4.4	4.3	4.5	5.1	5.5	5.6	5.7	6.0	6.2	6.5	6.8	6.9	6.8	6.1	5.4	4.9	4.6	4.6	4.5	5.3
Matli	AWS30m	4.4	4.3	4.2	4.1	4.1	4.0	3.9	3.9	4.1	4.1	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.7	4.7	4.7	4.7	4.6	4.5	4.4	4.3
ShahBander	AWS30m	4.9	4.9	4.9	4.9	4.8	4.8	4.7	5.0	5.7	6.0	6.1	6.3	6.5	6.8	7.1	7.3	7.5	7.4	6.8	6.2	5.7	5.3	5.1	5.0	5.8
Sajawal	AWS30m	4.8	4.9	4.8	4.8	4.6	4.5	4.5	4.7	5.4	5.5	5.6	5.7	5.9	6.1	6.3	6.5	6.8	7.0	6.5	5.9	5.5	5.1	4.9	4.8	5.5
Talhar	AWS30m	5.3	5.3	5.1	5.0	4.9	4.8	4.7	5.0	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.2	5.5	5.7	5.8	5.9	5.9	5.7	5.5	5.4	5.3
ThanoBulaKhan	AWS30m	3.2	3.1	3.1	3.1	2.8	2.8	2.7	2.9	3.2	3.8	4.1	4.2	4.2	4.2	4.5	5.0	5.8	6.6	6.7	5.9	5.0	4.0	3.5	3.4	4.1

Table 4 (c)		Three years Average Diurnal Variation of Wind Speed (Mar to May) (m/s)																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS50m	9.6	9.6	9.1	8.8	8.4	8.1	7.6	6.9	6.5	6.7	6.7	6.6	6.5	6.6	6.8	7.3	8.4	10.0	10.7	10.1	9.5	9.2	9.3	9.3	8.3
KatiBander	AWS50m	7.6	7.6	7.6	7.7	7.7	7.6	7.4	7.4	7.4	7.5	7.5	7.6	7.9	8.3	8.8	9.0	9.0	9.0	8.7	8.4	8.0	7.8	7.8	7.6	8.0
Nooriabad	AWS50m	7.4	7.4	7.3	7.3	7.1	6.9	6.6	6.6	6.4	6.4	6.5	6.3	6.2	6.2	6.6	7.1	8.0	8.5	8.7	8.4	8.3	7.9	7.7	7.4	7.2
Thatta	AWS50m	6.7	6.5	6.5	6.5	6.2	5.9	5.7	6.0	6.6	6.8	6.8	6.9	7.1	7.3	7.6	8.0	8.4	8.7	8.7	8.3	7.7	7.1	7.0	6.7	7.1
Gharo	AWS50m	7.0	7.0	6.9	6.7	6.6	6.2	5.9	5.9	6.4	6.8	7.0	7.1	7.5	7.9	8.5	9.0	9.3	9.1	8.6	7.9	7.4	7.1	7.1	6.9	7.3
Hyderabad	AWS50m	7.0	6.9	6.9	6.7	6.6	6.5	6.4	6.1	5.9	5.8	5.7	5.6	5.6	5.6	5.7	6.3	7.0	7.6	7.7	7.6	7.4	7.3	7.1	7.1	6.6
Badin	AWS50m	5.9	5.9	5.8	5.7	5.6	5.5	5.3	5.5	5.7	5.6	5.4	5.4	5.4	5.4	5.6	5.8	6.2	6.7	6.6	6.6	6.6	6.4	6.2	6.0	5.9
Baghan	AWS50m	5.9	5.8	5.9	5.7	5.6	5.6	5.6	5.8	6.4	6.6	6.8	7.0	7.2	7.6	7.9	8.2	8.4	8.3	7.5	6.7	6.3	6.0	6.0	5.9	6.6
Chuhar Jamali	AWS50m	4.8	4.9	4.9	4.9	4.9	4.7	4.7	5.1	5.8	6.1	6.4	6.6	6.6	6.8	7.1	7.4	7.7	7.8	7.2	6.4	5.8	5.3	5.0	4.9	5.9
DHA Karachi	AWS50m	5.7	5.8	5.7	5.6	5.5	5.6	5.6	5.7	5.8	6.3	6.7	7.2	7.7	8.0	8.0	7.9	7.6	7.2	6.7	6.4	6.1	5.9	5.9	5.7	6.4
Golarchi	AWS50m	6.2	6.3	6.2	6.1	6.0	5.9	5.8	5.9	6.0	5.9	5.8	5.8	5.8	5.8	6.0	6.3	6.7	7.0	7.3	7.1	6.9	6.7	6.5	6.3	6.3
HawksBay	AWS50m	5.8	6.1	6.2	6.2	6.0	5.7	5.3	5.1	5.2	5.6	5.9	6.3	6.7	7.0	7.3	7.5	7.5	7.4	6.9	6.5	6.5	6.3	6.1	6.0	6.3
Jati	AWS50m	6.3	6.2	6.2	6.2	6.2	6.1	6.1	6.0	6.3	6.3	6.3	6.3	6.4	6.6	6.9	7.2	7.7	8.0	7.7	7.3	6.9	6.6	6.4	6.3	6.6
Karachi	AWS50m	4.8	4.7	4.6	4.5	4.5	4.2	4.0	4.0	4.2	4.5	4.9	5.3	5.8	6.4	6.9	7.2	7.2	6.8	6.2	5.6	5.1	4.9	4.8	4.8	5.2
Mirpursakro	AWS50m	6.0	6.1	6.0	6.0	5.9	5.7	5.6	5.6	6.0	6.4	6.5	6.6	6.9	7.1	7.5	7.8	7.9	7.9	7.2	6.7	6.1	5.9	6.0	5.8	6.5
Matli	AWS50m	6.3	6.2	6.0	5.8	5.8	5.7	5.5	5.5	5.7	5.8	5.9	5.9	5.9	6.0	6.1	6.2	6.5	6.7	6.7	6.7	6.7	6.6	6.4	6.4	6.1
ShahBander	AWS50m	5.6	5.7	5.7	5.7	5.7	5.6	5.6	5.7	6.3	6.6	6.6	6.8	7.1	7.4	7.7	8.0	8.1	8.0	7.5	6.8	6.4	6.0	5.8	5.7	6.5
Sajawal	AWS50m	6.6	6.7	6.6	6.6	6.3	6.2	6.1	6.2	6.7	6.7	6.8	6.9	7.1	7.3	7.5	7.9	8.3	8.6	8.3	7.8	7.4	7.0	6.7	6.5	7.0
Talhar	AWS50m	7.5	7.4	7.3	7.2	7.0	6.8	6.6	6.9	7.0	6.9	6.8	6.7	6.6	6.6	6.7	6.9	7.4	8.0	8.2	8.3	8.3	8.1	7.8	7.6	7.3
ThanoBulaKhan	AWS50m	4.0	3.9	3.9	3.9	3.6	3.6	3.4	3.5	3.7	4.4	4.8	4.8	4.9	4.9	5.1	5.7	6.7	7.6	7.9	7.2	6.1	4.9	4.4	4.2	4.9

Fig-5 shows the diurnal variation during September to November period in three years and during this period the maximum wind speed is 8.4 m/s at Jamshoro, 6.2m/s at Katibandar, 6.4m/s at Nooriabad 6.1 m/s at thatta 6.6 m/s Gharo, 5.9 m/s at Hyderabad at 50 meters height.

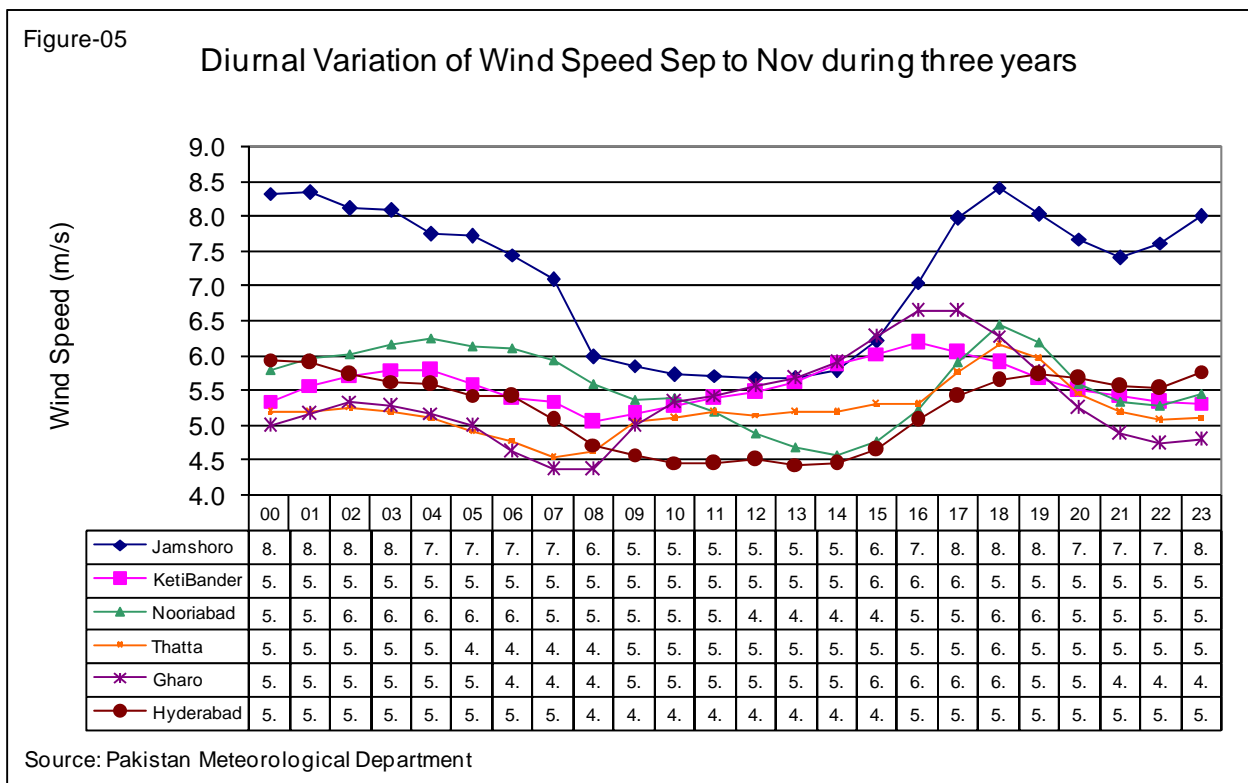


Table 5 (a)	Three years Diurnal Variation of Wind Speed Jun to Aug at 30m height																								
Station	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	11.0	10.8	10.6	10.4	10.1	9.8	9.8	10.6	11.1	10.9	10.4	9.9	9.6	9.4	9.6	10.2	11.0	11.8	12.1	12.0	11.7	11.5	11.4	11.2	10.7
KatiBander	7.9	7.9	7.9	7.9	7.9	7.8	7.8	8.0	8.4	8.7	8.7	9.0	9.3	9.4	9.4	9.6	9.5	9.2	8.9	8.5	8.2	7.8	7.8	7.8	8.5
Nooriabad	8.7	8.3	8.3	8.3	8.2	8.2	8.4	9.0	9.7	9.8	9.9	10.0	9.6	9.6	10.0	10.1	10.3	10.3	9.9	9.7	9.5	9.4	9.2	8.9	9.3
Thatta	6.4	6.4	6.3	6.2	6.2	6.1	6.1	6.9	7.8	8.0	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.3	7.8	7.3	6.8	6.5	6.4	7.4
Gharo	7.2	7.1	7.0	6.9	6.8	6.5	6.5	7.0	7.8	8.4	8.7	9.0	9.2	9.4	9.4	9.4	9.5	9.3	8.9	8.3	7.8	7.4	7.2	7.2	8.0
Hyderabad	8.0	8.0	7.8	7.8	7.6	7.4	7.5	8.0	8.6	9.1	9.0	8.6	8.3	8.2	8.4	8.7	9.0	9.2	9.2	8.9	8.8	8.5	8.2	8.1	8.4
Badin	5.7	5.6	5.6	5.5	5.4	5.2	5.3	5.9	6.7	6.9	6.8	6.8	6.7	6.6	6.8	6.9	7.0	7.1	6.9	6.6	6.4	6.1	5.9	5.7	6.3
Baghan	5.3	5.3	5.3	5.1	5.1	5.0	5.0	5.8	6.8	7.3	7.6	7.8	8.0	8.1	8.2	8.1	7.9	7.6	7.1	6.3	5.8	5.4	5.2	5.2	6.4
Chuhar Jamali	5.3	5.2	5.2	5.0	4.9	4.9	4.9	5.5	6.7	7.4	7.8	7.9	8.0	8.1	8.2	8.3	8.2	8.0	7.6	6.8	6.2	5.7	5.4	5.3	6.5
DHA Karachi	6.3	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.3	7.5	7.6	7.8	7.8	7.9	7.7	7.5	7.3	7.0	6.8	6.5	6.3	6.2	6.1	6.2	6.9
Golarchi	6.0	5.8	5.8	5.7	5.6	5.4	5.5	6.1	6.9	7.4	7.5	7.4	7.3	7.3	7.3	7.4	7.6	7.7	7.6	7.3	6.9	6.5	6.3	6.1	6.7
HawksBay	5.4	5.4	5.4	5.3	5.3	5.2	5.3	5.5	6.0	6.2	6.6	7.0	7.2	7.5	7.7	7.6	7.6	7.4	7.0	6.5	6.1	5.8	5.7	5.6	6.3
Jati	6.1	6.0	5.9	5.9	5.7	5.6	5.7	6.6	7.6	7.9	8.0	8.1	8.1	8.3	8.4	8.4	8.4	8.3	7.9	7.2	6.7	6.3	6.0	6.0	7.0
Karachi	4.3	4.3	4.3	4.2	4.2	4.2	4.4	4.7	5.4	5.6	5.8	6.0	6.3	6.5	6.5	6.4	6.3	6.0	5.7	5.2	4.8	4.7	4.5	4.4	5.2
Mirpursakro	5.9	5.9	5.8	5.8	5.7	5.5	5.6	6.3	7.2	7.8	8.2	8.4	8.6	8.6	8.6	8.7	8.5	8.3	7.8	7.0	6.5	6.1	5.9	5.8	7.0
Matli	5.4	5.2	5.1	5.0	4.8	4.8	4.8	5.4	6.2	6.7	6.8	6.7	6.6	6.6	6.6	6.7	6.7	6.8	6.5	6.1	5.8	5.5	5.4	5.4	5.9
ShahBander	6.9	6.9	6.6	6.5	6.2	5.9	5.9	6.6	7.5	7.9	8.1	8.3	8.4	8.5	8.7	8.7	8.6	8.4	8.1	7.7	7.1	6.8	6.7	6.9	7.4
Sajawal	6.3	6.1	6.0	6.0	5.9	5.7	5.6	5.9	6.9	7.5	7.6	7.6	7.7	7.7	7.8	7.9	7.9	7.9	7.6	7.0	6.4	6.2	6.1	6.0	6.8
Talhar	5.9	5.9	5.9	5.8	5.7	5.6	5.7	6.3	7.1	7.5	7.5	7.4	7.2	7.2	7.2	7.3	7.4	7.6	7.5	7.1	6.8	6.6	6.5	6.2	6.7
ThanoBulaKhan	6.5	6.3	6.3	6.1	6.1	5.9	5.8	6.4	7.3	7.7	7.5	7.3	7.0	7.0	7.1	7.6	8.1	8.4	8.6	8.4	7.9	7.4	7.0	6.7	7.1

Table 5 (b)	Three years Diurnal Variation of Wind Speed Jun to Aug at 50m height																								
Station	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	13.3	13.1	12.9	12.6	12.2	12.0	11.9	12.7	13.2	12.9	12.3	11.7	11.3	11.1	11.3	12.0	13.1	13.9	14.4	14.4	14.1	13.9	13.7	13.6	12.8
KatiBander	8.7	8.8	8.8	8.8	8.8	8.8	8.8	9.0	9.4	9.7	9.7	10.0	10.4	10.5	10.5	10.6	10.5	10.1	9.8	9.3	9.0	8.6	8.6	8.6	9.4
Nooriabad	9.6	9.1	9.0	9.1	9.0	9.0	9.2	9.9	10.7	10.8	10.9	11.0	10.6	10.6	11.0	11.1	11.4	11.3	10.9	10.6	10.5	10.4	10.1	9.7	10.2
Thatta	8.4	8.5	8.4	8.3	8.3	8.2	8.1	9.0	10.2	10.5	10.6	10.7	10.7	10.6	10.7	10.7	10.8	10.8	10.5	10.0	9.2	8.7	8.4	8.3	9.5
Gharo	8.3	8.2	8.1	8.0	7.8	7.6	7.6	8.0	8.8	9.5	9.8	10.1	10.3	10.4	10.5	10.5	10.6	10.4	10.0	9.4	8.9	8.5	8.3	8.3	9.1
Hyderabad	9.2	9.1	8.9	8.9	8.7	8.5	8.6	9.1	9.7	10.3	10.1	9.6	9.2	9.1	9.3	9.7	10.1	10.3	10.3	10.1	10.0	9.7	9.4	9.3	9.5
Badin	7.3	7.3	7.2	7.1	6.9	6.7	6.8	7.5	8.3	8.5	8.4	8.3	8.3	8.2	8.4	8.5	8.7	8.8	8.6	8.4	8.2	7.8	7.6	7.4	7.9
Baghan	7.1	7.1	7.1	6.9	6.8	6.8	6.7	7.6	8.8	9.3	9.6	9.9	10.1	10.3	10.4	10.4	10.3	10.0	9.5	8.5	7.8	7.3	7.1	7.1	8.4
Chuhar Jamali	6.5	6.5	6.4	6.3	6.2	6.1	6.0	6.7	8.0	8.9	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.4	9.0	8.1	7.4	7.0	6.6	6.5	7.8
DHA Karachi	7.6	7.6	7.7	7.9	8.0	8.2	8.3	8.4	8.7	8.8	8.9	9.1	9.2	9.2	9.2	8.9	8.6	8.4	8.0	7.8	7.6	7.4	7.3	7.4	8.3
Golarchi	7.7	7.5	7.4	7.3	7.2	7.0	7.0	7.7	8.6	9.1	9.3	9.1	9.0	8.9	9.0	9.1	9.4	9.6	9.5	9.1	8.7	8.3	8.0	7.7	8.4
HawksBay	5.9	5.9	5.8	5.8	5.7	5.7	5.7	5.9	6.4	6.7	7.0	7.4	7.7	8.0	8.2	8.1	8.0	7.9	7.5	7.0	6.6	6.3	6.2	6.1	6.7
Jati	7.4	7.3	7.2	7.2	6.9	6.9	6.9	7.8	8.9	9.2	9.3	9.3	9.4	9.6	9.7	9.8	9.7	9.7	9.4	8.6	8.0	7.6	7.3	7.3	8.4
Karachi	5.3	5.3	5.3	5.2	5.2	5.3	5.5	5.9	6.6	6.8	7.0	7.2	7.6	7.8	7.8	7.7	7.5	7.3	6.9	6.4	6.0	5.7	5.6	5.4	6.3
Mirpursakro	7.1	7.0	7.0	6.9	6.8	6.6	6.7	7.3	8.3	9.0	9.4	9.8	9.9	9.9	10.0	10.1	9.9	9.7	9.1	8.4	7.8	7.3	7.1	7.0	8.3
Matli	7.5	7.3	7.1	7.0	6.7	6.7	6.8	7.5	8.4	9.2	9.3	9.2	9.0	9.0	9.1	9.2	9.2	9.3	8.9	8.4	8.1	7.7	7.6	7.5	8.2
ShahBander	7.6	7.6	7.3	7.2	6.9	6.6	6.6	7.2	8.2	8.6	8.8	9.0	9.1	9.3	9.4	9.4	9.4	9.2	8.9	8.4	7.9	7.5	7.4	7.6	8.1
Sajawal	7.7	7.5	7.3	7.4	7.2	7.0	6.9	7.2	8.3	9.3	9.4	9.4	9.5	9.6	9.7	9.8	10.0	9.9	9.7	8.6	8.0	7.7	7.5	7.5	8.4
Talhar	8.4	8.5	8.4	8.2	8.1	8.0	8.1	8.9	10.0	10.5	10.5	10.3	10.1	10.1	10.1	10.2	10.5	10.7	10.7	10.2	9.8	9.4	9.2	8.8	9.5
ThanoBulaKhan	7.7	7.5	7.5	7.3	7.2	7.0	6.9	7.5	8.3	8.7	8.5	8.3	8.0	7.9	8.1	8.6	9.2	9.6	9.8	9.7	9.2	8.7	8.2	8.0	8.2

Fig-6 shows this variation during the period December to February in three years. At 50 meters heights the maximum wind speed is reach to 6.9 m/s at Jamshoro, 5.7 m/s at Katibandar, 5.5 m/s at Nooriabad, 5.3 m/s at Thatta and 5.3 m/s at Hyderabad . This is the period when we experience the relatively low wind speeds in the region.

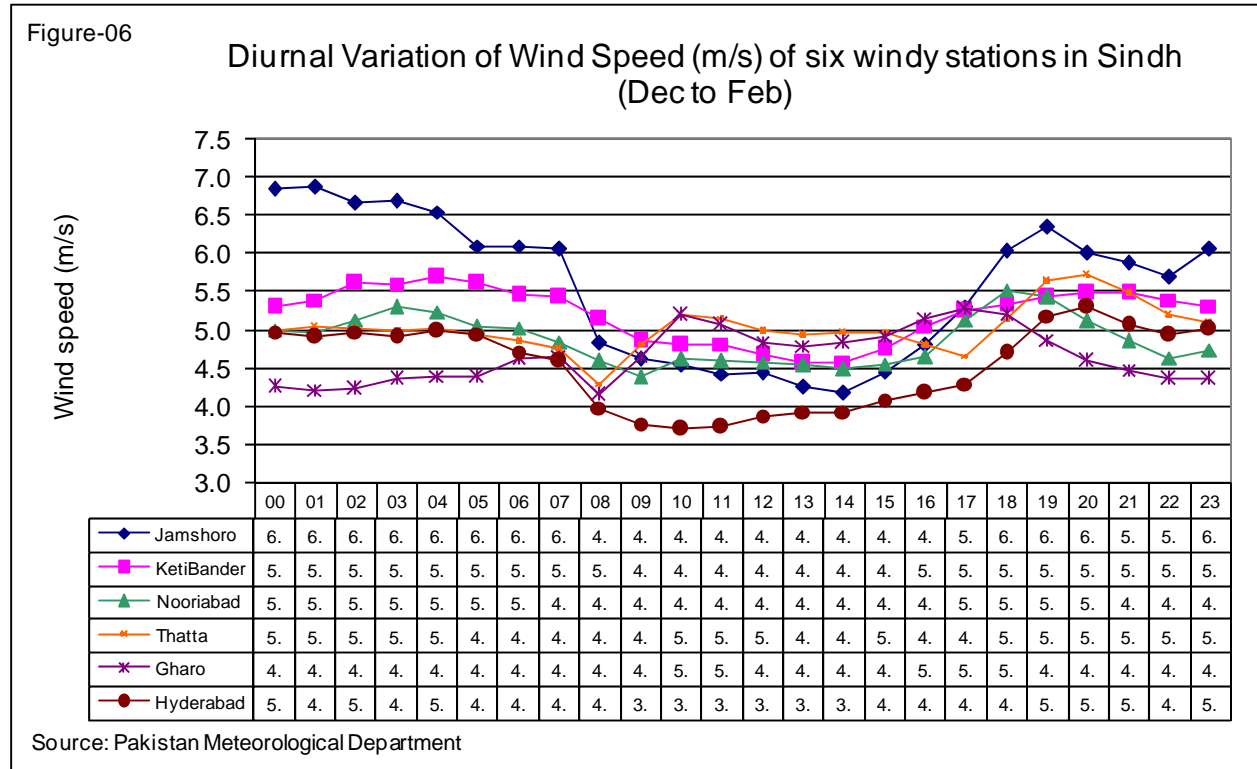


Table-6 (a)	Three Years Diurnal Variation of Wind Speed Sep to Nov at 30m height																								
Station	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	6.3	6.3	6.1	6.1	5.9	5.8	5.6	5.4	4.9	5.0	4.9	4.9	4.8	4.8	4.9	5.3	5.9	6.5	6.5	6.2	6.0	5.7	5.8	6.1	5.7
KatiBander	4.4	4.5	4.7	4.7	4.7	4.6	4.4	4.4	4.4	4.5	4.7	4.7	4.8	5.0	5.2	5.3	5.4	5.2	5.0	4.7	4.5	4.5	4.4	4.3	4.7
Nooriabad	5.1	5.2	5.2	5.3	5.4	5.3	5.2	5.1	5.0	4.9	5.0	4.7	4.5	4.3	4.1	4.3	4.7	5.3	5.6	5.4	4.9	4.7	4.6	4.8	4.9
Thatta	3.7	3.7	3.7	3.7	3.6	3.5	3.4	3.3	3.4	3.8	3.9	4.0	4.0	4.0	4.0	4.1	4.1	4.3	4.5	4.3	4.0	3.7	3.7	3.7	3.8
Gharo	3.9	4.1	4.2	4.1	4.0	3.9	3.6	3.5	3.6	4.3	4.6	4.7	4.9	5.0	5.2	5.5	5.7	5.6	5.2	4.6	4.2	3.9	3.8	3.8	4.4
Hyderabad	4.8	4.7	4.6	4.6	4.5	4.4	4.4	4.2	4.1	4.1	4.0	4.0	4.1	4.0	4.0	4.2	4.6	4.7	4.8	4.8	4.7	4.5	4.5	4.7	4.4
Badin	3.2	3.1	3.2	3.2	3.2	3.0	2.9	2.8	2.8	2.9	2.9	2.8	2.9	2.9	2.8	2.7	2.6	2.6	2.9	3.1	3.2	3.3	3.3	3.2	3.0
Baghan	3.7	3.8	3.9	3.9	3.8	3.7	3.5	3.6	3.5	3.8	4.1	4.3	4.3	4.4	4.4	4.4	4.4	4.2	4.0	3.7	3.6	3.5	3.6	3.5	3.9
Chuhar Jamali	3.6	3.6	3.7	3.7	3.7	3.5	3.4	3.1	3.1	3.4	3.6	3.7	3.8	3.8	3.9	3.8	3.7	3.7	4.0	4.0	3.8	3.6	3.6	3.5	3.6
DHA Karachi	3.4	3.4	3.5	3.6	3.5	3.4	3.3	3.2	3.3	3.7	4.0	4.3	4.7	5.1	5.4	5.4	5.3	4.9	4.3	3.9	3.6	3.3	3.3	3.3	4.0
Golarchi	4.2	4.3	4.3	4.3	4.2	4.1	4.0	3.9	3.8	3.9	4.1	4.1	4.1	4.1	4.0	3.9	3.7	3.7	3.9	4.1	4.2	4.2	4.2	4.2	4.1
HawksBay	3.2	3.4	3.5	3.6	3.6	3.5	3.4	3.3	3.3	3.5	3.7	4.0	4.4	4.7	5.0	5.1	5.0	4.5	4.0	3.3	3.0	2.8	2.7	2.9	3.7
Jati	4.1	4.1	4.1	4.1	4.1	4.0	3.9	3.8	3.7	3.9	3.9	3.9	3.9	4.0	4.0	3.9	3.9	3.9	4.0	4.0	4.1	4.0	4.0	4.1	4.0
Karachi	1.9	1.8	1.7	1.7	1.6	1.6	1.7	1.7	1.9	2.2	2.4	2.5	2.8	3.2	3.4	3.5	3.4	3.0	2.5	2.1	1.9	1.8	1.8	1.8	2.3
Mirpursakro	3.7	4.0	4.0	3.9	3.8	3.7	3.5	3.3	3.1	3.5	3.7	3.7	3.8	3.8	3.8	4.0	4.0	4.1	4.2	3.9	3.7	3.5	3.5	3.6	3.7
Matli	3.5	3.6	3.5	3.4	3.3	3.1	3.0	3.0	2.9	3.0	3.0	2.9	2.9	3.0	3.0	2.9	2.8	2.5	2.8	3.1	3.2	3.3	3.3	3.4	3.1
ShahBander	4.1	4.2	4.2	4.2	4.2	4.0	3.8	3.8	4.1	4.4	4.6	4.7	4.8	4.8	5.0	5.0	5.0	4.9	4.8	4.6	4.3	4.1	4.0	4.0	4.4
Sajawal	4.0	4.0	4.1	4.0	3.9	3.8	3.7	3.6	3.6	3.8	3.8	3.9	3.9	4.0	4.0	4.0	4.0	4.0	4.2	4.2	4.2	4.1	4.0	4.0	4.0
Talhar	3.7	3.7	3.6	3.5	3.4	3.2	2.8	2.7	2.8	3.1	3.1	3.0	3.0	3.0	3.0	3.0	2.8	2.7	2.9	3.1	3.3	3.4	3.5	3.5	3.2
ThanoBulaKhan	2.6	2.6	2.7	2.7	2.6	2.5	2.5	2.5	2.7	3.1	3.4	3.4	3.3	3.1	3.1	3.2	3.6	4.2	4.6	4.4	3.8	3.1	2.7	2.6	3.1

Table 6 (b)	Three Years Diurnal Variation of Wind Speed Sep to Nov at height 50m																								
Station	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	8.3	8.3	8.1	8.1	7.7	7.7	7.4	7.1	6.0	5.8	5.7	5.7	5.7	5.7	5.8	6.2	7.0	8.0	8.4	8.0	7.7	7.4	7.6	8.0	7.1
KatiBander	5.3	5.6	5.7	5.8	5.8	5.6	5.4	5.3	5.0	5.1	5.3	5.4	5.5	5.6	5.9	6.0	6.2	6.0	5.9	5.7	5.5	5.4	5.3	5.3	5.6
Nooriabad	5.8	5.9	6.0	6.2	6.2	6.1	6.1	5.9	5.6	5.3	5.4	5.2	4.9	4.7	4.5	4.7	5.2	5.9	6.4	6.2	5.6	5.3	5.3	5.4	5.6
Thatta	5.2	5.2	5.2	5.2	5.1	4.9	4.8	4.5	4.6	5.0	5.1	5.2	5.1	5.2	5.2	5.3	5.3	5.8	6.1	5.9	5.4	5.2	5.1	5.1	5.2
Gharo	5.0	5.2	5.3	5.3	5.2	5.0	4.6	4.3	4.3	5.0	5.3	5.4	5.5	5.7	5.9	6.3	6.6	6.6	6.3	5.7	5.2	4.9	4.7	4.8	5.3
Hyderabad	5.9	5.9	5.7	5.6	5.6	5.4	5.4	5.1	4.7	4.6	4.5	4.4	4.5	4.4	4.4	4.6	5.1	5.4	5.6	5.7	5.7	5.5	5.5	5.8	5.2
Badin	4.3	4.3	4.4	4.4	4.4	4.1	3.9	3.7	3.6	3.6	3.5	3.5	3.6	3.6	3.6	3.5	3.3	3.4	3.8	4.1	4.4	4.5	4.5	4.4	3.9
Baghan	4.9	5.1	5.2	5.2	5.1	4.9	4.7	4.6	4.4	4.6	5.0	5.1	5.2	5.2	5.3	5.4	5.4	5.3	5.2	4.9	4.8	4.8	4.8	4.7	5.0
Chuhar Jamali	5.0	5.0	5.1	5.1	5.2	4.9	4.7	4.3	3.9	4.2	4.4	4.5	4.5	4.6	4.7	4.7	4.7	4.9	5.4	5.6	5.3	5.0	5.0	4.9	4.8
DHA Karachi	4.3	4.3	4.5	4.5	4.4	4.3	4.1	3.9	4.0	4.3	4.7	5.0	5.5	5.9	6.1	6.2	6.2	5.8	5.3	4.9	4.5	4.2	4.2	4.1	4.8
Golarchi	5.9	5.9	6.0	5.9	5.7	5.6	5.4	5.2	4.8	4.8	5.0	4.9	5.0	5.0	4.9	4.7	4.6	4.8	5.3	5.7	5.9	5.9	5.9	5.9	5.4
HawksBay	3.6	3.8	4.0	4.0	4.1	4.0	3.9	3.8	3.7	3.8	4.1	4.3	4.7	5.1	5.4	5.5	5.4	5.0	4.4	3.8	3.4	3.2	3.1	3.3	4.1
Jati	5.6	5.6	5.6	5.6	5.5	5.4	5.2	5.0	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.9	5.3	5.4	5.5	5.5	5.5	5.6	5.1
Karachi	2.4	2.4	2.3	2.2	2.1	2.1	2.2	2.2	2.4	2.7	3.0	3.2	3.5	3.9	4.2	4.4	4.3	3.9	3.3	2.8	2.5	2.4	2.4	2.4	2.9
Mirpursakro	4.8	5.1	5.3	5.2	5.1	4.9	4.6	4.3	3.9	4.2	4.5	4.5	4.5	4.6	4.6	4.8	5.0	5.2	5.4	5.1	4.8	4.6	4.6	4.6	4.8
Matli	4.9	5.0	4.9	4.8	4.7	4.4	4.2	4.1	4.0	4.1	4.1	4.1	4.0	4.1	4.1	4.0	3.9	3.5	3.9	4.3	4.5	4.6	4.7	4.7	4.3
ShahBander	5.1	5.1	5.2	5.2	5.1	5.0	4.8	4.7	4.7	4.9	5.1	5.2	5.4	5.4	5.5	5.6	5.5	5.6	5.6	5.5	5.2	5.1	5.0	5.0	5.2
Sajawal	5.7	5.7	5.8	5.6	5.4	5.3	5.2	4.8	4.6	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.3	5.7	5.9	5.9	5.8	5.7	5.6	5.3
Talhar	5.3	5.4	5.2	5.1	4.8	4.6	4.1	3.9	4.0	4.4	4.4	4.2	4.2	4.2	4.2	4.2	4.0	3.9	4.3	4.6	4.9	5.0	5.1	5.1	4.5
ThanoBulaKhan	3.3	3.3	3.4	3.4	3.3	3.2	3.1	3.2	3.2	3.6	3.9	3.9	3.8	3.5	3.5	3.7	4.2	5.0	5.6	5.6	4.7	4.0	3.4	3.3	3.8

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 $3 < X \leq 4$ 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

$$R.F = \text{probability } P(V_i) = \text{Frequency of given wind speed} / \text{Total period}$$

3.4.3 Annual Cumulative Wind Frequency:

Fig-7 shows the annual cumulative Wind Frequency distribution at three heights 10, 30 and 50 meters. The analysis indicate that at a height of 50 meters, out of 17486 hours in three years at Jamshoro during 14210 hours the wind speed is greater than or equal to 5 m/s at Kati Bandar out of 26194 hours in three years during 21497 hours the wind speed is greater than or equal to 5 m/s, at Nooriabad out of 26149 hours in three years during 22007 hours the wind speed is greater than or equal to 5 m/s, at Thatta out of 17527 hours in three years during 13210 hours the wind speed is greater than or equal to 5 m/s, at Gharo out of 25995 hours in three years during 19969 hours the wind speed is greater than or equal to 5 m/s, and at Hyderabad out of 26264 hours in three years during 19711 hours the wind speed is greater than or equal to 5 m/s which generally is enough to generate the electric power.

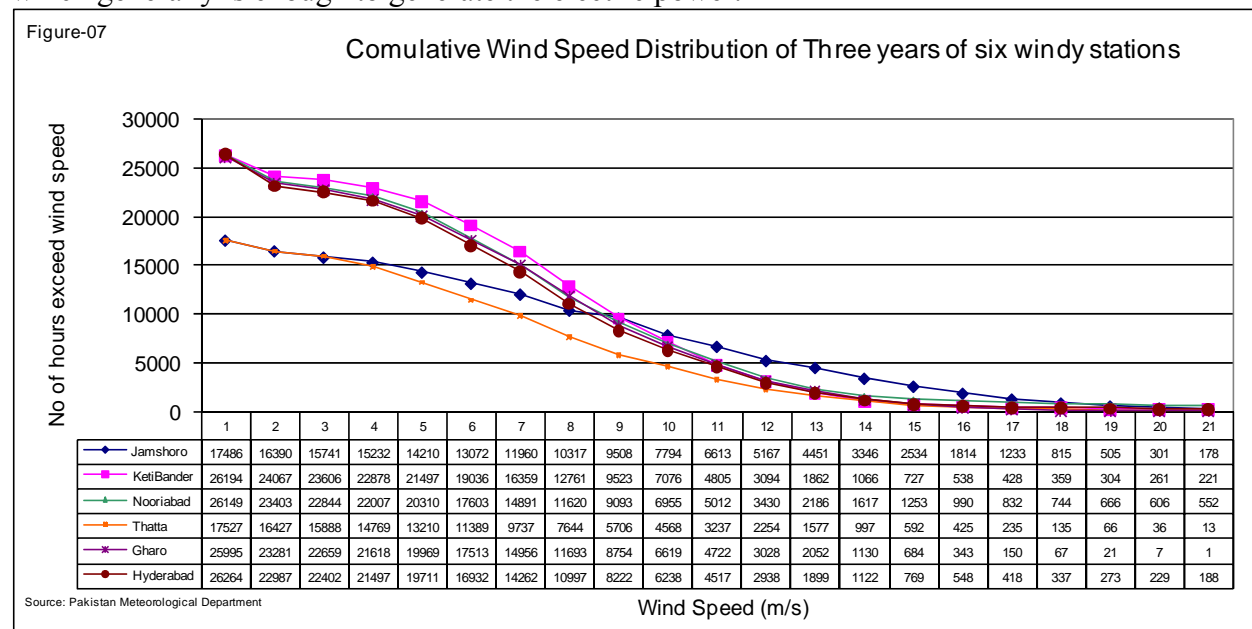


Table -7 (a)		Three years Diurnal Variation of Wind Speed Dec to Feb																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS10m	2.2	2.1	2.1	2.0	2.1	1.9	1.9	1.8	2.0	2.9	3.0	3.1	3.2	3.1	3.1	3.2	2.8	2.4	2.2	2.1	2.2	2.1	2.1	2.5	
KatiBander	AWS10m	2.4	2.6	2.7	2.7	2.8	2.8	2.8	2.8	3.2	3.8	3.9	3.9	3.7	3.5	3.4	3.3	3.2	2.9	2.3	2.1	2.1	2.2	2.3	2.4	2.9
Nooriabad	AWS10m	2.7	2.7	2.6	2.6	2.7	2.6	2.6	2.6	2.9	3.6	3.8	3.8	3.7	3.7	3.6	3.6	3.7	3.7	3.1	2.9	2.7	2.6	2.5	2.7	3.1
Thatta	AWS10m	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.6	0.8	1.5	1.8	1.9	1.8	1.7	1.7	1.6	1.3	0.9	0.7	0.7	0.7	0.6	0.5	0.5	1.0
Gharo	AWS10m	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.6	2.6	3.0	3.0	2.9	2.8	2.9	2.8	2.8	2.3	1.7	1.3	1.1	1.0	0.9	0.9	1.8
Hyderabad	AWS10m	1.7	1.8	1.8	1.8	1.7	1.6	1.6	1.6	2.1	2.7	2.7	2.7	2.8	2.9	2.9	2.9	3.0	2.6	1.8	1.9	1.9	1.8	1.8	1.8	2.2
Badin	AWS10m	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.9	1.1	1.2	1.2	1.2	1.2	1.1	0.8	0.4	0.2	0.2	0.3	0.3	0.2	0.2	0.5
Baghan	AWS10m	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.6	2.4	2.7	2.8	2.7	2.6	2.6	2.5	2.3	1.7	1.2	0.9	1.0	0.9	0.9	0.9	1.6
Chuhar Jamali	AWS10m	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	1.5	2.5	2.8	2.9	2.8	2.8	2.7	2.5	2.2	1.4	0.8	0.7	0.7	0.6	0.7	0.6	1.4
DHA Karachi	AWS10m	1.5	1.6	1.6	1.8	1.8	1.8	1.8	1.8	2.1	2.5	2.7	2.8	2.9	3.1	3.2	3.2	3.2	2.8	2.0	1.6	1.5	1.4	1.5	1.5	2.2
Golarchi	AWS10m	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.8	2.2	2.3	2.4	2.4	2.5	2.5	2.4	2.2	1.6	1.2	1.2	1.2	1.3	1.3	1.3	1.7
HawksBay	AWS10m	2.4	2.5	2.9	3.0	3.0	3.1	3.1	3.0	3.1	3.7	3.8	3.6	3.6	3.8	3.9	3.8	3.5	3.0	2.3	1.9	1.9	1.9	2.1	2.2	3.0
Jati	AWS10m	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.7	2.4	2.6	2.7	2.7	2.7	2.7	2.6	2.4	1.8	1.4	1.4	1.4	1.3	1.3	1.3	1.8
Karachi	AWS10m	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.8	1.1	1.2	1.2	1.3	1.4	1.4	1.3	0.9	0.6	0.4	0.3	0.3	0.3	0.3	0.7
Mirpursakro	AWS10m	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.9	1.9	2.3	2.2	2.2	2.1	2.1	1.9	1.8	1.4	0.7	0.4	0.3	0.2	0.2	0.2	1.0
Matli	AWS10m	0.9	0.8	0.8	0.9	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.7	0.6	0.7	0.8	0.8	0.8	0.8	0.8
ShahBander	AWS10m	2.0	2.0	2.0	2.1	2.2	2.1	2.1	2.1	2.5	3.4	3.7	3.7	3.7	3.7	3.6	3.6	3.4	3.0	2.6	2.4	2.2	2.1	2.1	2.0	2.7
Sajawal	AWS10m	0.8	0.8	0.9	0.9	1.0	0.9	0.9	0.9	1.2	1.8	2.0	2.0	2.1	2.1	2.1	2.0	1.8	1.2	1.0	1.0	1.0	0.9	0.8	0.8	1.3
Talhar	AWS10m	0.6	0.5	0.5	0.5	0.6	0.5	0.5	0.5	1.0	1.6	1.7	1.8	2.0	2.1	2.1	2.1	1.8	1.1	0.5	0.5	0.6	0.6	0.6	0.6	1.0
ThanoBulaKhan	AWS10m	0.8	0.8	0.7	0.8	0.8	0.7	0.6	0.7	1.0	1.8	2.7	3.1	3.2	3.2	3.1	3.1	3.2	2.8	2.1	1.7	1.3	1.1	0.9	0.9	1.7

Table -7 (b)		Three years Diurnal Variation of Wind Speed Dec to Feb																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS30m	5.0	4.8	4.7	4.7	4.6	4.4	4.4	4.3	3.7	3.8	3.7	3.6	3.5	3.3	3.3	3.5	3.7	3.9	4.1	4.3	4.1	4.0	4.0	4.1	4.1
KatiBander	AWS30m	4.3	4.4	4.6	4.6	4.6	4.6	4.5	4.5	4.4	4.4	4.4	4.4	4.2	4.1	4.1	4.2	4.4	4.4	4.2	4.2	4.2	4.3	4.3	4.3	4.4
Nooriabad	AWS30m	4.2	4.2	4.3	4.4	4.4	4.2	4.2	4.0	4.0	4.0	4.2	4.2	4.2	4.1	4.1	4.2	4.2	4.6	4.7	4.5	4.3	4.1	3.9	4.0	4.2
Thatta	AWS30m	3.4	3.5	3.5	3.5	3.5	3.4	3.4	3.3	3.0	3.6	3.9	3.9	3.7	3.7	3.7	3.7	3.4	3.3	3.6	3.9	3.9	3.8	3.6	3.5	3.6
Gharo	AWS30m	3.1	3.1	3.1	3.2	3.2	3.3	3.4	3.5	3.3	3.9	4.4	4.3	4.1	4.1	4.1	4.2	4.3	4.3	4.0	3.6	3.4	3.3	3.2	3.2	3.7
Hyderabad	AWS30m	3.8	3.8	3.9	3.8	3.9	3.8	3.6	3.6	3.3	3.3	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.6	3.7	4.0	4.1	3.9	3.8	3.9	3.7
Badin	AWS30m	2.3	2.2	2.2	2.1	2.1	2.0	1.9	1.7	1.4	1.6	1.7	1.8	2.0	2.0	2.0	2.0	1.9	1.8	2.1	2.3	2.4	2.4	2.4	2.3	2.0
Baghan	AWS30m	3.7	3.8	3.9	3.9	3.9	4.0	3.9	3.9	3.6	3.8	4.1	4.1	4.0	3.9	3.9	3.8	3.8	3.6	3.5	3.5	3.6	3.6	3.7	3.6	3.8
Chuhar Jamali	AWS30m	3.7	3.8	3.9	3.9	3.8	3.7	3.6	3.6	3.0	3.3	3.5	3.6	3.6	3.5	3.5	3.4	3.2	3.2	3.5	3.8	4.0	4.0	4.0	3.8	3.6
DHA Karachi	AWS30m	2.9	3.1	3.2	3.2	3.2	3.2	3.3	3.2	3.2	3.4	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.0	3.6	3.2	3.0	3.0	3.0	2.9	3.4
Golarchi	AWS30m	4.1	4.1	4.1	4.1	4.1	4.0	3.8	3.6	3.3	3.2	3.4	3.4	3.5	3.6	3.6	3.6	3.6	3.4	3.8	4.0	4.1	4.2	4.1	4.2	3.8
HawksBay	AWS30m	3.3	3.5	3.8	3.9	4.0	4.1	4.1	4.1	4.0	4.1	4.2	4.1	4.1	4.2	4.3	4.2	4.0	3.6	3.0	2.6	2.6	2.8	3.0	3.1	3.7
Jati	AWS30m	4.2	4.2	4.1	4.0	4.1	4.0	3.9	3.7	3.2	3.3	3.6	3.7	3.7	3.7	3.7	3.7	3.6	3.5	3.7	4.0	4.2	4.3	4.3	4.2	3.9
Karachi	AWS30m	1.3	1.3	1.4	1.5	1.4	1.4	1.4	1.4	1.2	1.6	2.2	2.4	2.3	2.5	2.6	2.7	2.8	2.6	2.1	1.8	1.5	1.4	1.4	1.2	1.8
Mirpursakro	AWS30m	3.2	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.1	3.5	3.9	3.8	3.7	3.6	3.6	3.5	3.4	3.3	3.4	3.4	3.3	3.3	3.2	3.2	3.4
Matli	AWS30m	3.3	3.3	3.3	3.3	3.2	3.2	3.1	2.9	2.4	2.2	2.3	2.4	2.6	2.7	2.8	2.8	2.7	2.5	2.7	3.1	3.3	3.5	3.4	3.3	2.9
ShahBander	AWS30m	4.2	4.3	4.3	4.3	4.4	4.3	4.3	4.1	3.8	4.0	4.2	4.2	4.2	4.2	4.1	4.1	4.0	4.0	4.1	4.2	4.2	4.2	4.3	4.1	4.2
Sajawal	AWS30m	3.7	3.7	3.8	3.8	3.8	3.6	3.6	3.6	3.1	3.3	3.5	3.6	3.6	3.6	3.6	3.6	3.5	3.2	3.4	3.8	3.9	3.9	3.8	3.8	3.6
Talhar	AWS30m	2.8	2.8	2.8	2.8	2.8	2.7	2.5	2.4	2.0	2.3	2.5	2.7	2.8	2.9	3.1	3.0	2.9	2.5	2.4	2.6	2.8	2.7	2.8	2.8	2.7
ThanoBulaKhan	AWS30m	2.0	2.0	2.0	2.1	2.0	1.9	1.9	1.8	1.8	2.2	3.1	3.5	3.6	3.7	3.6	3.7	3.9	3.9	3.9	3.8	3.1	2.5	2.3	2.2	2.8

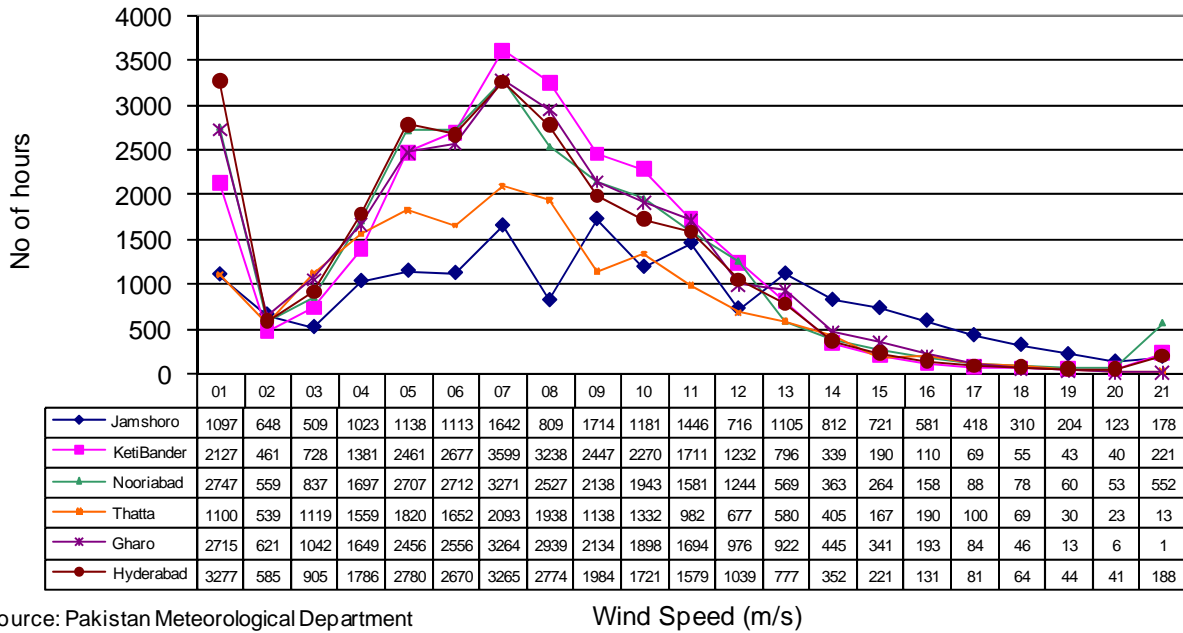
Table – 7 (c)		Three years Diurnal Variation of Wind Speed Dec to Feb																								
Station	Height	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg
Jamshoro	AWS50m	6.8	6.9	6.6	6.7	6.5	6.1	6.1	6.0	4.8	4.6	4.5	4.4	4.4	4.2	4.2	4.4	4.8	5.3	6.0	6.3	6.0	5.9	5.7	6.0	5.6
KatiBander	AWS50m	5.3	5.4	5.6	5.6	5.7	5.6	5.4	5.4	5.1	4.8	4.8	4.8	4.7	4.6	4.6	4.7	5.0	5.2	5.3	5.4	5.5	5.5	5.4	5.3	5.2
Nooriabad	AWS50m	5.0	5.0	5.1	5.3	5.2	5.0	5.0	4.8	4.6	4.4	4.6	4.6	4.6	4.5	4.5	4.5	4.6	5.1	5.5	5.4	5.1	4.8	4.6	4.7	4.9
Thatta	AWS50m	5.0	5.0	5.0	5.0	5.0	4.9	4.8	4.7	4.3	4.8	5.2	5.1	5.0	4.9	4.9	5.0	4.8	4.6	5.1	5.6	5.7	5.5	5.2	5.1	5.0
Gharo	AWS50m	4.2	4.2	4.2	4.3	4.4	4.4	4.6	4.6	4.1	4.6	5.2	5.0	4.8	4.8	4.8	4.9	5.1	5.3	5.2	4.9	4.6	4.5	4.4	4.3	4.6
Hyderabad	AWS50m	5.0	4.9	5.0	4.9	5.0	4.9	4.7	4.6	4.0	3.8	3.7	3.7	3.9	3.9	3.9	4.1	4.2	4.3	4.7	5.2	5.3	5.0	4.9	5.0	4.5
Badin	AWS50m	3.3	3.2	3.1	3.1	3.0	2.8	2.7	2.4	2.0	2.2	2.4	2.5	2.7	2.8	2.8	2.8	2.7	2.6	3.0	3.4	3.5	3.5	3.4	3.3	2.9
Baghan	AWS50m	5.2	5.4	5.4	5.5	5.5	5.6	5.5	5.5	4.7	4.6	4.9	4.9	4.7	4.6	4.7	4.6	4.7	4.7	4.8	5.0	5.2	5.2	5.2	5.1	5.1
Chuhar Jamali	AWS50m	5.1	5.2	5.3	5.3	5.2	5.1	4.9	4.8	3.8	3.7	4.0	4.0	4.0	4.0	3.9	3.8	3.8	4.0	4.7	5.2	5.6	5.5	5.5	5.3	4.6
DHA Karachi	AWS50m	3.7	3.9	4.0	4.0	4.0	4.0	4.1	4.0	3.9	3.9	4.2	4.2	4.3	4.5	4.7	4.8	4.9	4.8	4.5	4.1	3.9	3.8	3.8	3.7	4.2
Golarchi	AWS50m	5.9	5.9	5.9	5.8	5.8	5.6	5.4	5.1	4.1	3.8	4.0	4.1	4.1	4.3	4.3	4.4	4.4	4.5	5.4	5.8	6.0	6.0	6.0	6.0	5.1
HawksBay	AWS50m	3.8	4.0	4.3	4.5	4.5	4.7	4.7	4.6	4.5	4.4	4.6	4.5	4.5	4.6	4.6	4.5	4.3	3.9	3.4	3.1	3.1	3.3	3.5	3.6	4.1
Jati	AWS50m	6.1	6.1	6.0	5.8	5.8	5.7	5.6	5.3	4.1	3.9	4.1	4.3	4.2	4.3	4.3	4.3	4.3	4.5	5.2	5.8	6.1	6.2	6.2	6.2	5.2
Karachi	AWS50m	1.8	1.7	1.9	2.0	2.0	1.9	1.9	1.9	1.7	2.1	2.8	3.0	2.9	3.1	3.3	3.5	3.7	3.5	2.9	2.5	2.1	1.9	1.9	1.7	2.4
Mirpursakro	AWS50m	4.6	4.6	4.7	4.8	4.8	4.8	4.8	4.8	4.3	4.4	4.8	4.7	4.6	4.5	4.5	4.3	4.3	4.4	4.7	4.7	4.6	4.6	4.5	4.5	4.6
Matli	AWS50m	4.5	4.5	4.5	4.5	4.3	4.3	4.2	4.0	3.2	3.0	3.1	3.3	3.5	3.7	3.8	3.8	3.8	3.4	3.7	4.2	4.6	4.8	4.7	4.5	4.0
ShahBander	AWS50m	5.6	5.6	5.7	5.7	5.7	5.6	5.5	5.4	4.5	4.4	4.7	4.7	4.6	4.6	4.6	4.6	4.5	4.7	5.1	5.3	5.4	5.6	5.7	5.5	5.1
Sajawal	AWS50m	5.5	5.4	5.6	5.4	5.4	5.2	5.2	5.1	4.2	4.1	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.3	4.9	5.5	5.7	5.7	5.6	5.6	5.0
Talhar	AWS50m	4.0	3.9	4.0	3.9	3.9	3.8	3.6	3.4	2.6	2.9	3.1	3.2	3.4	3.5	3.7	3.7	3.6	3.4	3.4	3.7	3.9	3.9	4.0	4.0	3.6
ThanoBulaKhan	AWS50m	2.7	2.7	2.6	2.7	2.6	2.6	2.5	2.4	2.2	2.5	3.5	3.9	4.0	4.2	4.1	4.2	4.4	4.6	5.0	4.9	4.0	3.3	3.0	2.9	3.4

3.4.4 Wind Frequency Distribution:

Fig-8 shows the annual frequency distribution. We can see that at 50 meters height, Jamshoro out of 17486 hours in three years, during 1138 hours wind speed is 5 m/s, 1113 hours speed is 6 m/s, 1642 hours speed is 7 m/s, 809 hours speed is 8 m/s. KetiBandar out of 26194 hours speed during 2461 hours wind speed is 5 m/s, 2677 hours speed is 6 m/s, 3599 hours speed is 7 m/s, 3238 hours speed is 8 m/s. At Nooriabad is out of 26149 hours during 2707 hours wind speed is 5 m/s, 2712 hours speed is 6 m/s, 3271 hours speed is 7 m/s, 2527 hours speed is 8 m/s. At Thatta 9 out of 17527 Hours, during 1820 hours the wind speed is 5m/s, 1652 hours speed is 6 m/s and 2093 hours is 7m/s. At Gharo out of 25995 hours during 12426 hours wind speed is 5 m/s, 2556 hours speed is 6 m/s, 3264 hours speed is 7 m/s, and 2939 hours speed is 8 m/s. At Hyderabad out of 26264 hours during 19711 hours wind speed is 5 m/s, 16732 hours speed is 6 m/s, 14262 hours speed is 7 m/s, 10997 hours speed is 8 m/s and so on. This also indicates good wind potential in this area.

Figure-08

Annual Wind Frequency distribution during three years of six windy stations



Source: Pakistan Meteorological Department

Wind Speed (m/s)

Table-8 (a)		Cumulative Wind Speed Distribution in Three years																				
Station	Freq	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
Jamshoro	CWS10m	17486	15473	12233	10114	8517	6092	4846	3638	1684	966	502	242	51	20	7	1	0	0	0	0	0
KatiBander	CWS10m	26194	21656	19154	17407	15154	10779	8502	6375	3099	1860	1050	597	275	204	158	104	83	68	48	40	33
Nooriabad	CWS10m	26149	21623	19850	18176	15896	11925	9785	7724	4404	2987	1936	1222	601	426	317	215	184	156	118	100	86
Thatta	CWS10m	17527	12372	7908	5673	3669	1161	518	208	26	7	2	0	0	0	0	0	0	0	0	0	0
Gharo	CWS10m	25995	18978	16127	14536	12651	8396	6121	4122	1549	813	392	159	20	5	1	0	0	0	0	0	0
Hyderabad	CWS10m	26264	19773	17332	15609	13183	8704	6561	4686	2064	1160	593	287	93	61	43	24	18	14	8	6	5
Badin	CWS10m	25728	12808	9211	7384	5478	2546	1376	643	113	37	11	3	1	1	1	0	0	0	0	0	0
Baghan	CWS10m	25217	19868	12293	8306	4882	2496	510	188	65	10	4	2	1	1	1	0	0	0	0	0	0
Chuhar Jamali	CWS10m	26249	14516	11667	10063	8092	4321	2704	1564	458	220	104	51	19	13	10	6	5	4	2	2	1
DHA Karachi	CWS10m	17465	13998	10882	9092	7028	3979	2539	1466	441	225	126	80	47	37	30	23	19	16	12	9	8
Golarchi	CWS10m	24935	20608	12403	8749	5739	1857	838	331	104	9	2	1	0	0	0	0	0	0	0	0	0
HawksBay	CWS10m	25913	20266	18757	17447	14897	9404	6742	4463	1718	920	473	229	65	38	23	12	8	6	4	3	2
Jati	CWS10m	25631	21946	13933	10516	7712	3747	2303	1312	358	153	55	16	1	0	0	0	0	0	0	0	0
Karachi	CWS10m	25937	14100	10228	8073	5857	2697	1677	1053	490	308	187	114	63	52	45	39	35	32	27	24	21
Mirpursakro	CWS10m	26234	15101	12688	11243	9415	5592	3806	2390	789	367	150	54	12	6	3	1	1	1	0	0	0
Matli	CWS10m	26238	12439	7288	4668	2615	641	230	78	17	9	6	4	1	1	1	0	0	0	0	0	0
ShahBander	CWS10m	26213	24513	19749	16174	13097	8446	6239	4408	2834	1127	598	282	40	12	4	1	1	0	0	0	0
Sajawal	CWS10m	24935	18618	11321	8108	5501	2410	1432	794	205	79	27	3	0	0	0	0	0	0	0	0	0
Talhar	CWS10m	25747	12039	7350	5220	3410	1164	559	253	48	19	6	2	0	0	0	0	0	0	0	0	0
ThanoBulaKhan	CWS10m	26261	15772	13265	11824	10200	7022	5280	3642	1384	716	361	178	59	36	23	11	7	5	2	1	1

Station	Freq	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
Jamshoro	CWS30m	17486	16393	15560	14577	13016	11817	9554	8058	6644	5417	4045	3147	2070	1442	807	427	250	119	65	29	13
KatiBander	CWS30m	26194	24010	23094	22061	20115	15185	12480	10075	6340	4593	3204	2084	888	639	477	315	262	223	170	148	130
Nooriabad	CWS30m	26149	23401	22309	21230	19165	14624	12384	10336	6864	5210	3803	2664	1552	1210	977	721	638	572	475	430	388
Thatta	CWS30m	17527	16416	14898	13321	11256	7266	5653	4288	2272	1508	956	583	199	101	45	5	1	0	0	0	0
Gharo	CWS30m	25995	23264	21806	20305	17966	13240	11035	8980	5512	3993	2763	1764	715	409	214	44	15	5	0	0	0
Hyderabad	CWS30m	26264	22976	21758	20377	17857	13219	10749	8617	5504	4043	2811	1822	837	589	441	285	228	186	129	105	87
Badin	CWS30m	25728	19250	17627	16004	13114	7769	5938	4412	2223	1412	856	461	146	81	52	26	20	16	10	9	7
Baghan	CWS30m	25217	24430	22428	19558	15678	8961	6566	4770	2359	1494	887	278	136	60	25	4	1	0	0	0	0
Chuhar Jamali	CWS30m	26249	22023	20819	19860	17039	10075	7411	5485	2952	1927	1199	709	230	111	54	18	12	8	5	3	3
DHA Karachi	CWS30m	17465	16310	14874	13244	11220	7819	5999	4333	1882	1003	486	223	44	15	4	0	0	0	0	0	0
Golarchi	CWS30m	24935	23515	21264	19152	16011	12045	6405	4706	3303	1498	885	486	135	63	28	11	1	0	0	0	0
HawksBay	CWS30m	25913	21623	20462	19336	17136	12023	9258	6728	3138	1854	1025	527	169	99	64	35	26	21	12	9	7
Jati	CWS30m	25631	24637	22735	20597	17334	9810	7174	5347	2861	1889	1186	465	230	112	49	7	2	0	0	0	0
Karachi	CWS30m	25937	18510	16099	14204	11583	7129	4963	3245	1389	783	429	225	56	22	8	2	1	1	0	0	0
Mirpursakro	CWS30m	26234	22595	21533	20230	17015	10622	8289	6288	3329	2204	1399	857	436	329	254	160	125	97	59	44	33
Matli	CWS30m	26238	22081	20019	17908	14160	7491	5375	3652	1599	938	560	365	205	156	122	80	65	52	33	26	21
ShahBander	CWS30m	26213	25504	24078	22075	18740	12204	9244	7022	4108	2871	1885	733	404	211	91	19	8	4	3	2	1
Sajawal	CWS30m	24935	23541	21382	19167	15715	9073	6834	5193	3780	1964	1275	777	271	138	63	9	2	0	0	0	0
Talhar	CWS30m	25747	20779	19164	17819	15064	9429	7143	5385	2878	1888	1192	683	236	121	63	22	15	11	6	4	3
ThanoBulaKhan	CWS30m	26261	17886	16429	15278	13494	10298	8782	7291	4552	3257	2227	1411	555	328	199	93	70	57	43	37	33

Station	Freq	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
Jamshoro	CWS50m	17486	16390	15741	15232	14210	13072	11960	10317	9508	7794	6613	5167	4451	3346	2534	1814	1233	815	505	301	178
KatiBander	CWS50m	26194	24067	23606	22878	21497	19036	16359	12761	9523	7076	4805	3094	1862	1066	727	538	428	359	304	261	221
Nooriabad	CWS50m	26149	23403	22844	22007	20310	17603	14891	11620	9093	6955	5012	3430	2186	1617	1253	990	832	744	666	606	552
Thatta	CWS50m	17527	16427	15888	14769	13210	11389	9737	7644	5706	4568	3237	2254	1577	997	592	425	235	135	66	36	13
Gharo	CWS50m	25995	23281	22659	21618	19969	17513	14956	11693	8754	6619	4722	3028	2052	1130	684	343	150	67	21	7	1
Hyderabad	CWS50m	26264	22987	22402	21497	19711	16932	14262	10997	8222	6238	4517	2938	1899	1122	769	548	418	337	273	229	188
Badin	CWS50m	25728	19423	18521	17441	15777	13006	10803	7952	5484	4061	2673	1575	1051	514	297	154	94	62	42	34	24
Baghan	CWS50m	25217	24437	23787	21963	18885	15390	11414	9201	6398	4705	3246	2226	1343	902	470	290	140	83	33	20	6
Chuhar Jamali	CWS50m	26249	22025	21295	20540	19391	16389	13460	9408	6261	4436	2946	1814	1194	615	355	179	96	61	39	32	22
DHA Karachi	CWS50m	17465	16314	15826	14476	12495	10505	8434	6124	4200	2752	1648	928	545	285	148	87	42	26	16	14	12
Golarchi	CWS50m	24935	23534	22527	21090	18782	16077	12778	9165	6588	4563	3272	2093	1290	774	408	220	107	53	28	12	5
HawksBay	CWS50m	25913	21627	20967	20125	17940	14445	11523	7798	5118	3178	1688	835	368	184	106	65	45	34	25	19	15
Jati	CWS50m	25631	24638	23857	22267	19910	16897	12460	9570	6045	4328	2621	1659	940	510	284	107	55	17	7	2	1
Karachi	CWS50m	25937	18598	17303	15867	13757	11165	8574	5864	3617	2325	1364	715	419	213	112	58	33	23	14	12	8
Mirpursakro	CWS50m	26234	22645	22128	21458	20122	16823	13718	9666	6438	4479	2867	1666	1076	623	464	345	274	215	177	146	114
Matli	CWS50m	26238	22110	21155	19795	17545	14199	11829	8714	6184	4751	3020	2053	1341	827	536	391	276	224	164	138	108
ShahBander	CWS50m	26213	25497	24850	23311	20554	16988	12711	9454	6306	4424	2833	1592	850	443	213	100	40	14	6	4	3
Sajawal	CWS50m	24935	23601	22723	21264	18888	15952	13057	9688	6738	5143	3515	2227	1548	883	527	262	129	67	21	9	2
Talhar	CWS50m	25747	20748	19828	18804	17436	14859	12952	10185	7863	6464	4960	3856	2875	2037	1312	919	515	394	155	122	49
ThanoBulaKhan	CWS50m	26261	18079	17170	16228	14899	12962	11141	9070	7195	5644	4084	2632	1701	927	539	283	160	112	79	67	57

Fig-9 gives this frequency distribution in percentage. At 50 meters heights we find at Jamshoro during 6.5% of time wind is 5m/s, 6.4% of the time 6m/s, 9.4% of the time it is 7m/s and 4.6% of the time it is 8m/s. At KetiBandar during 9.4% of time wind is 5m/s, 10.2% of the time 6m/s, 13.8% of the time it is 7m/s and 9.7% of the time it is 8m/s. At Nooriabad during 10.4% of the time wind speed 5m/s, 10.4% of the time 6m/s, 12.5% of the time it is 7m/s and 9.7% of the time it is 8m/s. At thatta during 10.4% of the time wind speed 5m/s, 9.4% of the time 6m/s, 11.9% of the time it is 7m/s and 11.1% of the time it is 8m/s. At Gharo during 9.4% of the time wind speed 5m/s, 11.9% of the time 6m/s, 11.1% of the time it is 7m/s and 6.5% of the time it is 8m/s. At Hyderabad during 10.5% of the time wind speed 5m/s, 10.2% of the time 6m/s, 12.5% of the time it is 7m/s and 10.6% of the time it is 8m/s. This appears to be reasonably enough to generate power from the wind.

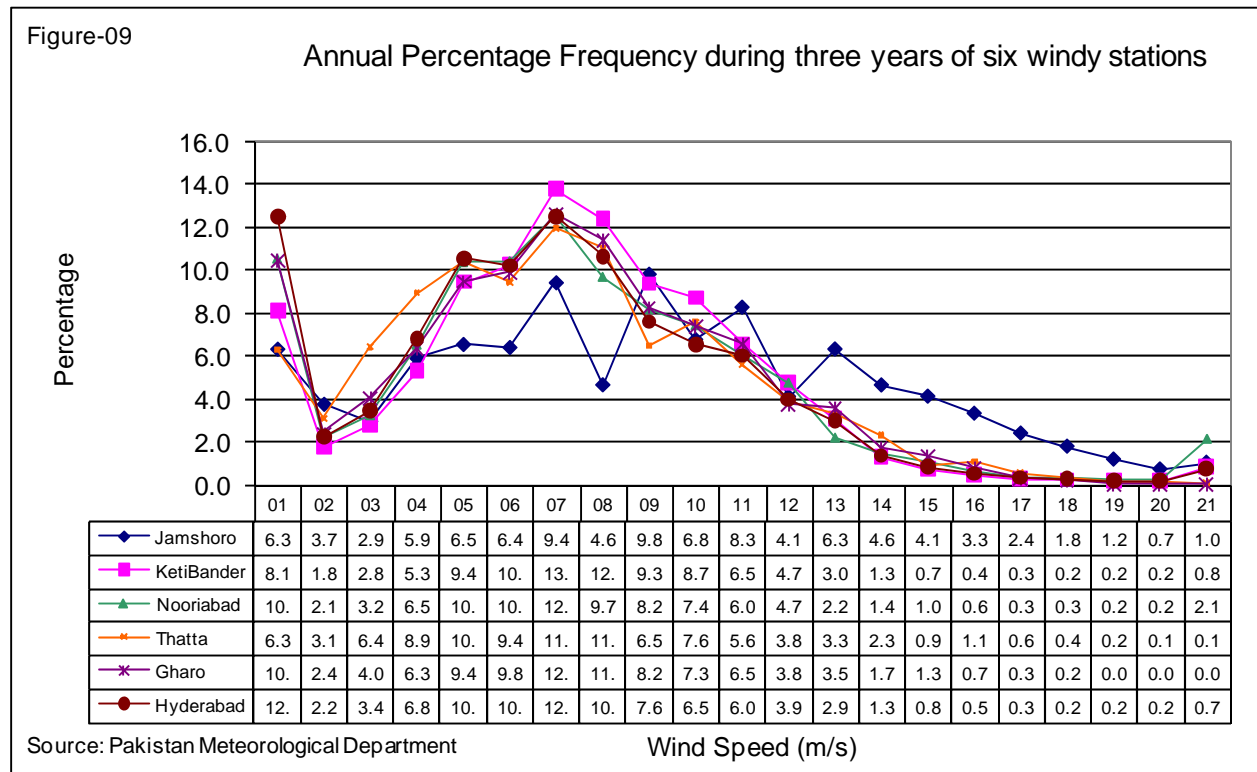


Table – 9 (a)		Three years Annual Wind Frequency Distribution																					
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD10m	2013	3240	2119	1597	2425	1246	1208	1953	719	464	260	191	31	13	6	1	0	0	0	0	0	17486
KatiBander	WFD10m	4538	2503	1746	2253	4375	2277	2128	3276	1239	811	453	322	70	47	54	20	16	20	8	7	33	26194
Nooriabad	WFD10m	4527	1773	1674	2280	3971	2140	2062	3320	1417	1051	714	621	175	109	102	32	27	38	17	14	86	26149
Thatta	WFD10m	5155	4464	2235	2005	2508	642	311	182	19	6	1	0	0	0	0	0	0	0	0	0	0	17527
Gharo	WFD10m	7018	2851	1591	1884	4255	2275	1999	2573	736	421	234	139	15	4	1	0	0	0	0	0	0	25995
Hyderabad	WFD10m	6491	2441	1723	2426	4479	2143	1875	2623	904	566	306	194	33	18	19	6	5	6	2	2	5	26264
Badin	WFD10m	12920	3597	1826	1906	2932	1170	733	530	76	26	8	2	0	0	0	0	0	0	0	0	0	25728
Baghan	WFD10m	5349	7575	3987	3424	2386	1986	322	123	55	6	2	1	0	0	0	0	0	0	0	0	0	25217
Chuhar Jamali	WFD10m	11733	2849	1603	1971	3771	1617	1140	1105	239	115	53	33	6	3	4	1	1	2	0	1	1	26249
DHA Karachi	WFD10m	3467	3115	1790	2064	3049	1440	1073	1025	216	100	45	33	10	6	7	4	4	4	2	2	8	17465
Golarchi	WFD10m	4327	8205	3654	3010	3882	1019	507	227	95	7	2	0	0	0	0	0	0	0	0	0	0	24935
HawksBay	WFD10m	5647	1509	1310	2551	5493	2662	2279	2744	798	447	244	164	27	14	12	3	2	2	1	1	2	25913
Jati	WFD10m	3684	8014	3417	2805	3964	1444	991	954	205	98	39	16	0	0	0	0	0	0	0	0	0	25631
Karachi	WFD10m	11837	3872	2155	2216	3160	1020	625	563	182	121	73	51	11	7	6	4	3	5	3	3	21	25937
Mirpursakro	WFD10m	11133	2412	1445	1829	3823	1785	1417	1600	422	217	96	43	6	2	2	0	0	0	0	0	0	26234
Matli	WFD10m	13799	5150	2620	2054	1974	411	152	61	8	3	2	2	0	0	0	0	0	0	0	0	0	26238
ShahBander	WFD10m	1700	4764	3575	3077	4651	2207	1831	1575	1707	528	316	242	28	7	3	1	0	0	0	0	0	26213
Sajawal	WFD10m	6317	7296	3213	2607	3092	978	637	590	126	52	24	2	0	0	0	0	0	0	0	0	0	24935
Talhar	WFD10m	13708	4689	2130	1810	2246	605	306	204	30	13	4	2	0	0	0	0	0	0	0	0	0	25747
ThanoBulaKhan	WFD10m	10489	2507	1441	1624	3178	1742	1638	2258	668	355	184	118	23	13	12	4	2	3	1	0	1	26261

Table – 9(b)		Three Years Annual Wind Frequency Distribution																					
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD30m	1093	834	983	1561	1198	2263	1496	1414	1227	1373	898	1077	627	635	380	178	131	53	37	16	13	17486
KatiBander	WFD30m	2184	916	1033	1946	4930	2705	2405	3735	1747	1389	1120	1196	249	163	162	53	39	52	22	18	130	26194
Nooriabad	WFD30m	2748	1093	1079	2065	4541	2240	2048	3472	1654	1406	1139	1112	342	233	256	83	67	96	45	42	388	26149
Thatta	WFD30m	1111	1518	1577	2064	3991	1613	1365	2016	764	552	373	383	98	56	40	4	1	0	0	0	0	17527
Gharo	WFD30m	2731	1458	1502	2339	4726	2205	2055	3468	1519	1229	999	1049	306	195	170	29	11	5	0	0	0	25995
Hyderabad	WFD30m	3288	1218	1381	2520	4639	2469	2132	3113	1461	1232	989	985	248	147	156	57	42	57	23	18	87	26264
Badin	WFD30m	6478	1623	1623	2890	5345	1831	1526	2189	811	556	395	315	65	29	26	6	4	6	2	2	7	25728
Baghan	WFD30m	786	2002	2870	3881	6716	2395	1797	2411	865	607	609	142	76	36	21	2	1	0	0	0	0	25217
Chuhar Jamali	WFD30m	4225	1204	960	2821	6964	2663	1927	2532	1025	728	490	479	119	58	36	6	4	4	1	1	3	26249
DHA Karachi	WFD30m	1155	1436	1630	2025	3401	1820	1666	2450	880	517	263	179	29	11	4	0	0	0	0	0	0	17465
Golarchi	WFD30m	1420	2252	2111	3142	3966	5639	1700	1403	1805	613	399	351	73	35	17	10	1	0	0	0	0	24935
HawksBay	WFD30m	4291	1160	1127	2200	5114	2765	2530	3590	1284	829	498	358	70	35	30	9	6	8	3	2	7	25913
Jati	WFD30m	994	1902	2138	3263	7524	2637	1827	2486	972	703	721	235	118	63	43	5	1	0	0	0	0	25631
Karachi	WFD30m	7427	2411	1896	2621	4454	2167	1718	1856	606	354	204	169	34	15	6	1	0	0	0	0	0	25937
Mirpursakro	WFD30m	3638	1063	1303	3215	6393	2333	2001	2959	1125	804	542	421	107	74	95	35	28	38	15	11	33	26234
Matli	WFD30m	4157	2062	2111	3748	6669	2115	1723	2053	661	379	195	160	50	34	42	15	13	19	7	6	21	26238
ShahBander	WFD30m	709	1426	2003	3335	6536	2960	2222	2914	1238	986	1152	330	193	120	71	12	3	2	1	1	1	26213
Sajawal	WFD30m	1393	2159	2216	3451	6643	2239	1641	1412	1816	689	499	506	133	75	55	7	2	0	0	0	0	24935
Talhar	WFD30m	6024	2843	3095	5571	10670	7207	5950	8621	4628	4169	3157	3385	1218	1031	798	314	237	202	104	76	531	69829
ThanoBulaKhan	WFD30m	8374	1458	1151	1783	3196	1516	1491	2740	1295	1030	816	856	227	129	107	23	13	14	6	5	33	26261

Table – 9 (c)		Three years Annual Wind Frequency Distribution																					
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD50m	1097	648	509	1023	1138	1113	1642	809	1714	1181	1446	716	1105	812	721	581	418	310	204	123	178	17486
KatiBander	WFD50m	2127	461	728	1381	2461	2677	3599	3238	2447	2270	1711	1232	796	339	190	110	69	55	43	40	221	26194
Nooriabad	WFD50m	2747	559	837	1697	2707	2712	3271	2527	2138	1943	1581	1244	569	363	264	158	88	78	60	53	552	26149
Thatta	WFD50m	1100	539	1119	1559	1820	1652	2093	1938	1138	1332	982	677	580	405	167	190	100	69	30	23	13	17527
Gharo	WFD50m	2715	621	1042	1649	2456	2556	3264	2939	2134	1898	1694	976	922	445	341	193	84	46	13	6	1	25995
Hyderabad	WFD50m	3277	585	905	1786	2780	2670	3265	2774	1984	1721	1579	1039	777	352	221	131	81	64	44	41	188	26264
Badin	WFD50m	6305	902	1080	1663	2771	2203	2851	2467	1423	1388	1098	524	537	217	143	60	32	20	8	10	24	25728
Baghan	WFD50m	779	650	1824	3078	3495	3976	2213	2803	1693	1459	1020	883	441	431	181	150	56	50	13	14	6	25217
Chuhar Jamali	WFD50m	4223	731	755	1149	3002	2929	4052	3148	1825	1490	1132	620	579	260	176	83	35	22	7	10	22	26249
DHA Karachi	WFD50m	1151	488	1350	1981	1990	2070	2311	1924	1448	1105	720	383	260	137	61	45	16	10	2	3	12	17465
Golarchi	WFD50m	1401	1007	1437	2307	2705	3299	3613	2577	2025	1291	1179	803	516	365	188	113	54	25	16	7	5	24935
HawksBay	WFD50m	4286	660	842	2186	3495	2922	3724	2680	1940	1490	853	467	184	77	41	20	11	9	6	4	15	25913
Jati	WFD50m	993	781	1590	2357	3013	4437	2890	3525	1717	1707	962	719	429	227	176	52	39	10	5	1	1	25631
Karachi	WFD50m	7339	1295	1437	2109	2592	2591	2711	2246	1292	961	649	296	206	101	54	25	10	9	2	4	8	25937
Mirpursakro	WFD50m	3588	517	670	1336	3300	3104	4052	3229	1959	1612	1201	590	453	159	119	71	59	38	32	31	114	26234
Matli	WFD50m	4128	955	1361	2250	3346	2370	3115	2530	1433	1731	967	713	513	291	145	115	52	59	26	31	108	26238
ShahBander	WFD50m	716	647	1539	2757	3567	4276	3258	3148	1882	1591	1241	742	407	230	114	59	26	8	2	1	3	26213
Sajawal	WFD50m	1334	878	1459	2376	2936	2894	3369	2949	1595	1628	1288	679	665	356	265	134	62	46	12	7	2	24935
Talhar	WFD50m	4999	920	1024	1368	2578	1907	2767	2322	1400	1503	1104	981	838	725	393	404	121	239	33	73	49	25747
ThanoBulaKhan	WFD50m	8181	909	941	1329	1937	1821	2071	1875	1551	1559	1452	932	773	389	255	123	48	32	12	10	57	26261

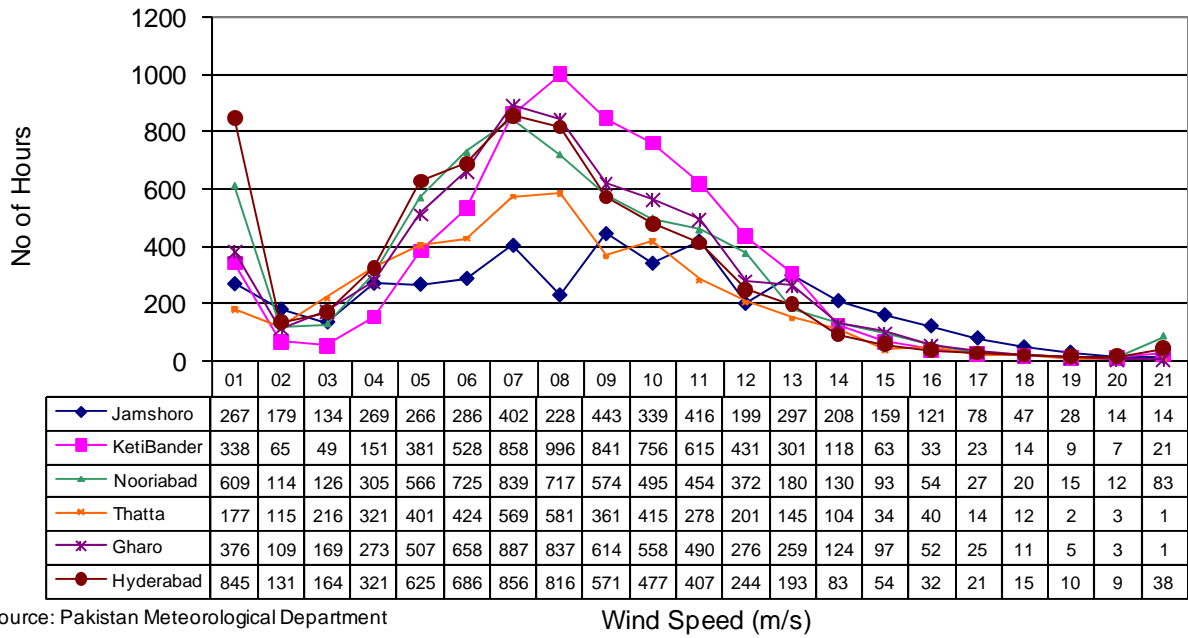
3.4.5 *Seasonal Wind Frequency Distribution:* Figures 11–14 gives seasonal wind frequency distribution and figures 15–18 give this distribution in percentage.

March – May

Fig-10 shows this distribution during the months of March to May at 50 meters heights in the period of three years. We can see that in this period at Jamshoro during 266 hours we get 5m/s, 286 hours 6m/s, 402 hours 7m/s, 228 hours 8m/s. At Keti Bandar during 381 hours we get 5m/s, 528 hours 6m/s, 858 hours 7m/s, 996 hours 8m/s. At Nooriabad during 566 hours we get 5m/s, 725 hours 6m/s, 839 hours 7m/s, 717 hours 8m/s. At Thatta during 401 hours we get 5m/s, 424 hours 6m/s, 569 hours 7m/s, 581 hours 8m/s. At Gharo during 507 hours we get 5m/s, 658 hours 6m/s, 887 hours 7m/s, 837 hours 8m/s. At Hyderabad during 686 hours we get 5m/s, 856 hours 6m/s, 816 hours 7m/s, 571 hours 8m/s and 751 hours wind speed reaches to 9m/s.

Figure-10

Frequency Distribution Mar to May during three years



Station	Frequency	Wind Frequency Distribution Mar to May																				Total	
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20		21
Jamshoro	WFD10m	437	734	527	520	822	365	302	424	131	74	36	19	2	1	1	0	0	0	0	0	0	4394
KatiBander	WFD10m	917	305	304	522	1187	695	675	1101	413	241	115	72	15	10	11	4	3	4	2	1	4	6599
Nooriabad	WFD10m	906	273	424	596	1060	612	554	834	394	302	232	177	62	39	24	5	4	4	2	1	4	6509
Thatta	WFD10m	853	1302	751	627	659	138	58	24	1	0	0	0	0	0	0	0	0	0	0	0	0	4413
Gharo	WFD10m	1175	604	400	502	1224	663	588	753	204	115	71	26	4	1	0	0	0	0	0	0	0	6331
Hyderabad	WFD10m	1524	484	423	689	1274	598	485	621	223	140	81	40	6	3	3	1	1	1	0	0	1	6597
Badin	WFD10m	2728	972	564	568	946	379	235	181	21	5	1	0	0	0	0	0	0	0	0	0	0	6600
Baghan	WFD10m	1094	2054	1117	950	670	592	97	34	12	0	0	0	0	0	0	0	0	0	0	0	0	6620
Chuhar Jamali	WFD10m	2441	774	509	545	1065	508	343	310	58	19	5	1	0	0	0	0	0	0	0	0	0	6579
DHA Karachi	WFD10m	410	706	506	534	982	473	370	341	53	17	4	0	0	0	0	0	0	0	0	0	0	4396
Golarchi	WFD10m	763	2033	1005	793	955	233	99	37	16	1	0	0	0	0	0	0	0	0	0	0	0	5934
HawksBay	WFD10m	950	310	257	524	1305	806	748	927	315	197	124	88	17	10	8	3	2	2	1	0	1	6592
Jati	WFD10m	520	1795	1027	886	1235	453	308	303	61	21	5	1	0	0	0	0	0	0	0	0	0	6615
Karachi	WFD10m	1895	1028	638	670	1119	426	291	265	62	42	28	23	3	1	1	0	0	0	0	0	0	6493
Mirpursakro	WFD10m	2147	611	409	542	1119	563	451	510	139	69	29	7	1	0	0	0	0	0	0	0	0	6597
Matli	WFD10m	3700	1252	570	459	444	110	38	12	1	0	0	0	0	0	0	0	0	0	0	0	0	6587
ShahBander	WFD10m	211	692	802	955	1317	689	574	547	463	166	100	76	9	2	1	0	0	0	0	0	0	6605
Sajawal	WFD10m	1015	1650	990	827	957	368	274	287	72	30	15	2	0	0	0	0	0	0	0	0	0	6486
Talhar	WFD10m	3265	1164	577	499	681	216	111	71	9	4	1	0	0	0	0	0	0	0	0	0	0	6599
ThanoBulaKhan	WFD10m	2750	569	370	439	793	423	389	519	166	89	52	26	6	3	3	1	0	0	0	0	0	6599

Table-10 (b)	Wind Frequency Distribution Mar to May																						
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD30m	264	228	229	394	291	546	387	450	373	409	227	256	127	116	56	23	12	3	1	1	1	4394
KatiBander	WFD30m	368	70	104	292	913	777	773	1214	586	476	395	418	82	47	38	13	9	8	4	3	10	6599
Nooriabad	WFD30m	607	183	170	409	1076	669	594	876	436	389	373	306	117	81	91	26	17	22	9	8	50	6509
Thatta	WFD30m	179	298	320	455	1064	535	444	600	208	138	84	72	12	4	1	0	0	0	0	0	0	4413
Gharo	WFD30m	379	234	238	465	1194	624	607	1001	456	359	314	260	87	55	45	8	4	2	0	0	0	6331
Hyderabad	WFD30m	846	231	258	558	1107	695	646	904	376	302	258	217	61	37	41	12	10	13	4	3	17	6597
Badin	WFD30m	1197	404	336	593	1526	604	481	692	278	193	153	98	24	9	7	2	1	1	0	0	0	6600
Baghan	WFD30m	119	285	578	1078	1908	729	575	720	246	170	164	32	11	3	1	0	0	0	0	0	0	6620
Chuhar Jamali	WFD30m	1173	317	174	536	1503	704	567	719	336	227	146	129	30	12	6	1	0	0	0	0	1	6579
DHA Karachi	WFD30m	110	247	317	415	972	533	489	762	273	158	78	40	2	0	0	0	0	0	0	0	0	4396
Golarchi	WFD30m	302	462	442	710	964	1505	465	353	444	133	80	62	9	3	1	0	0	0	0	0	0	5934
HawksBay	WFD30m	674	253	228	417	1147	739	747	1115	457	320	225	165	39	22	20	6	4	6	2	2	6	6592
Jati	WFD30m	130	332	407	725	2003	824	599	763	306	212	219	56	26	9	3	0	0	0	0	0	0	6615
Karachi	WFD30m	999	513	459	652	1380	695	587	727	233	136	74	34	3	1	0	0	0	0	0	0	0	6493
Mirpursakro	WFD30m	620	192	249	737	1653	726	615	866	338	230	164	107	30	19	23	8	5	7	2	2	4	6597
Matli	WFD30m	1031	338	387	851	1806	624	527	547	205	121	61	41	13	9	10	4	3	5	2	1	4	6587
ShahBander	WFD30m	80	204	365	866	1617	790	642	868	367	281	325	96	51	34	12	4	1	0	0	0	0	6605
Sajawal	WFD30m	345	335	386	783	1603	728	525	483	538	246	199	202	57	32	21	2	0	0	0	0	0	6486
Talhar	WFD30m	808	213	218	564	1549	820	596	794	345	250	204	151	46	24	14	2	1	1	0	0	0	6599
ThanoBulaKhan	WFD30m	2428	309	230	384	706	385	375	648	308	254	228	196	62	36	31	6	3	3	1	1	5	6599

Table-10 (c)	Wind Frequency Distribution Mar to May																						
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD50m	267	179	134	269	266	286	402	228	443	339	416	199	297	208	159	121	78	47	28	14	14	4394
KatiBander	WFD50m	338	65	49	151	381	528	858	996	841	756	615	431	301	118	63	33	23	14	9	7	21	6599
Nooriabad	WFD50m	609	114	126	305	566	725	839	717	574	495	454	372	180	130	93	54	27	20	15	12	83	6509
Thatta	WFD50m	177	115	216	321	401	424	569	581	361	415	278	201	145	104	34	40	14	12	2	3	1	4413
Gharo	WFD50m	376	109	169	273	507	658	887	837	614	558	490	276	259	124	97	52	25	11	5	3	1	6331
Hyderabad	WFD50m	845	131	164	321	625	686	856	816	571	477	407	244	193	83	54	32	21	15	10	9	38	6597
Badin	WFD50m	1123	275	250	283	571	599	860	823	475	474	366	175	176	69	47	16	10	4	2	2	3	6600
Baghan	WFD50m	118	93	276	633	966	1206	639	854	525	444	294	252	118	111	42	32	8	7	1	1	0	6620
Chuhar Jamali	WFD50m	1164	211	145	206	569	673	963	831	516	458	341	177	170	74	47	19	8	3	1	1	2	6579
DHA Karachi	WFD50m	110	80	223	368	470	588	748	631	463	335	239	90	41	8	2	0	0	0	0	0	0	4396
Golarchi	WFD50m	285	226	292	483	631	791	946	666	563	338	276	192	110	77	32	18	6	2	1	0	0	5934
HawksBay	WFD50m	670	151	177	436	756	714	1005	786	614	520	353	205	92	43	25	13	8	6	4	3	12	6592
Jati	WFD50m	131	153	282	480	714	1261	824	1039	544	470	285	212	109	60	40	8	4	0	0	0	0	6615
Karachi	WFD50m	991	236	337	515	718	820	886	756	471	358	251	89	48	11	4	1	0	0	0	0	0	6493
Mirpursakro	WFD50m	588	111	149	244	741	916	1147	927	575	459	326	159	113	42	30	17	14	8	7	6	18	6597
Matli	WFD50m	1011	168	202	337	720	681	909	730	427	484	270	222	163	94	53	37	15	20	7	9	26	6587
ShahBander	WFD50m	82	102	264	639	943	1191	900	779	514	422	344	199	113	61	25	13	7	3	1	0	0	6605
Sajawal	WFD50m	300	189	250	428	593	724	917	840	546	488	424	235	242	126	99	47	22	12	3	1	0	6486
Talhar	WFD50m	826	210	234	197	471	467	779	780	486	457	365	327	278	247	149	146	44	86	13	26	14	6599
ThanoBulaKhan	WFD50m	2361	247	192	242	401	434	453	455	372	385	368	232	207	105	70	37	15	9	3	2	10	6599

June – August

Fig-11 shows wind frequency distribution during the months of June to August at 50 meters in the period of three years. We can see that in this period at Jamshoro during 63 hours we get 5m/s, 104 hours 6m/s, 121 hours 7m/s, 109 hours 8m/s, 206 hours 9m/s. At KetiBandar during 273 hours we get 5m/s, 365 hours 6m/s, 607 hours 7m/s, 681 hours 8m/s, 764 hours 9m/s, 936 hours 10m/s and 804 hours 11m/s. At Nooriabad during 241 hours we get 5m/s, 104 hours 6m/s, 121 hours 7m/s, 109 hours 8m/s, 206 hours 9m/s. At Thatta during 167 hours we get 5m/s, 241 hours 6m/s, 416 hours 7m/s, 544 hours 8m/s, 455 hours 9m/s. At Gharo during 238 hours we get 5m/s, 627 hours 6m/s, 790 hours 7m/s, 793 hours 8m/s, 802 hours 9m/s. At Hyderabad during 256 hours we get 5m/s, 351 hours 6m/s, 549 hours 7m/s, 647 hours 8m/s, 709 hours 9m/s.

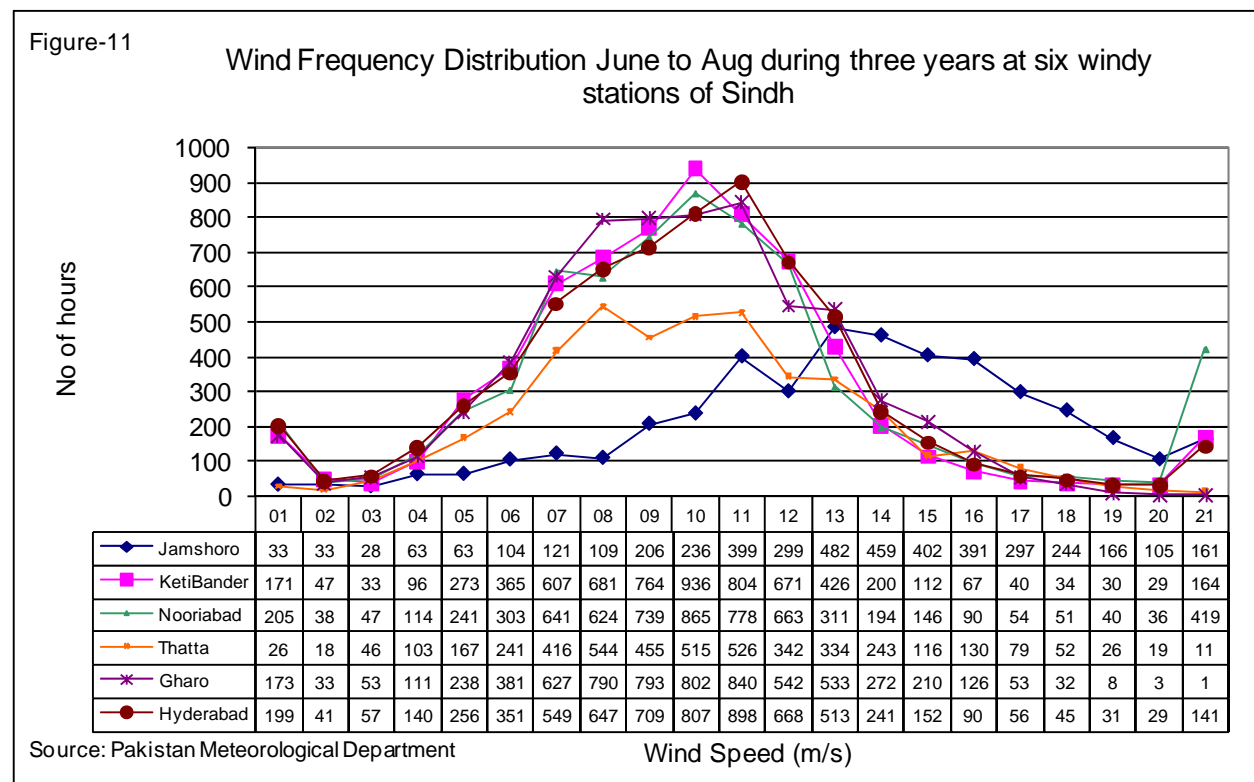


Table-11 (a)		Three Years Wind Frequency Distribution Jun to Aug																						
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total	
Jamshoro	WFD10m	44	114	102	160	523	440	567	1173	502	351	210	168	29	12	6	0	0	0	0	0	0	0	4402
KatiBander	WFD10m	244	152	145	268	839	684	791	1504	689	502	307	231	50	34	38	14	11	13	5	5	23	6550	
Nooriabad	WFD10m	256	114	97	181	640	555	705	1521	747	594	399	378	101	63	69	24	21	31	14	12	79	6600	
Thatta	WFD10m	135	542	633	842	1416	436	231	149	17	5	1	0	0	0	0	0	0	0	0	0	0	4408	
Gharo	WFD10m	303	203	188	361	1329	948	938	1383	442	264	145	103	11	3	0	0	0	0	0	0	0	6620	
Hyderabad	WFD10m	333	180	156	284	1056	804	896	1532	581	379	205	141	25	14	15	4	4	5	2	1	4	6621	
Badin	WFD10m	1130	801	592	742	1470	627	402	292	38	12	4	2	0	0	0	0	0	0	0	0	0	6112	
Baghan	WFD10m	386	1327	1201	1183	912	861	149	58	27	4	1	1	0	0	0	0	0	0	0	0	0	6110	
Chuhar Jamali	WFD10m	1249	479	374	598	1570	773	613	652	153	83	42	27	4	2	2	0	0	0	0	0	0	6621	
DHA Karachi	WFD10m	712	207	191	376	972	601	487	533	133	69	35	31	9	6	7	3	3	4	2	2	7	4389	
Golarchi	WFD10m	246	783	846	1087	1888	573	311	151	65	5	1	0	0	0	0	0	0	0	0	0	0	5956	
HawksBay	WFD10m	375	192	193	459	1507	889	842	1154	338	180	85	48	5	2	1	0	0	0	0	0	0	6272	
Jati	WFD10m	185	551	604	800	1654	763	579	580	133	72	32	14	0	0	0	0	0	0	0	0	0	5967	
Karachi	WFD10m	1264	1019	715	867	1405	456	273	264	113	77	45	27	7	5	6	3	3	5	3	3	21	6581	
Mirpursakro	WFD10m	661	478	387	593	1540	829	726	901	250	136	62	33	4	2	2	0	0	0	0	0	0	6605	
Matli	WFD10m	1579	1592	997	936	1110	252	96	37	4	1	0	0	0	0	0	0	0	0	0	0	0	6604	
ShahBander	WFD10m	72	193	264	432	1294	884	879	805	1049	324	194	151	17	4	2	1	0	0	0	0	0	6565	
Sajawal	WFD10m	357	866	808	911	1385	463	285	251	49	20	9	1	0	0	0	0	0	0	0	0	0	5406	
Talhar	WFD10m	1484	1463	817	777	1039	272	133	93	15	6	2	1	0	0	0	0	0	0	0	0	0	6102	
ThanoBulaKhan	WFD10m	883	342	235	318	992	755	839	1349	425	233	118	85	17	9	9	3	2	2	0	0	1	6619	

Table-11 (b)		Three Years Wind Frequency Distribution Jun to Aug																					
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD30m	29	47	44	93	84	145	164	220	358	576	429	649	418	466	302	149	117	50	35	15	12	4402
KatiBander	WFD30m	189	52	53	150	555	443	514	1228	779	694	603	697	153	106	112	36	27	40	16	14	92	6550
Nooriabad	WFD30m	205	70	57	122	448	379	480	1192	734	706	575	647	187	129	145	50	44	65	32	29	306	6600
Thatta	WFD30m	26	56	95	167	570	463	540	1000	441	346	251	280	80	49	37	4	1	0	0	0	0	4408
Gharo	WFD30m	173	70	80	154	586	499	630	1408	716	642	545	659	191	124	114	19	6	2	0	0	0	6620
Hyderabad	WFD30m	199	81	89	174	523	410	525	1204	772	742	624	686	172	103	107	42	30	41	18	14	66	6621
Badin	WFD30m	564	146	135	277	1033	728	738	1190	461	324	219	201	39	19	17	4	3	5	2	1	7	6112
Baghan	WFD30m	89	184	261	396	1145	729	720	1166	489	358	373	95	57	29	17	2	1	0	0	0	0	6110
Chuhar Jamali	WFD30m	343	158	157	347	1160	726	739	1282	536	411	291	305	80	42	28	5	3	3	1	1	2	6621
DHA Karachi	WFD30m	15	45	78	166	606	570	658	1147	472	300	164	128	25	10	4	0	0	0	0	0	0	4389
Golarchi	WFD30m	100	191	219	328	510	1149	728	743	1014	376	253	237	54	28	16	9	1	0	0	0	0	5956
HawksBay	WFD30m	296	92	112	317	1172	842	844	1336	538	347	199	139	23	9	5	1	1	0	0	0	0	6272
Jati	WFD30m	63	142	192	315	931	646	709	1229	538	416	446	165	84	49	36	5	1	0	0	0	0	5967
Karachi	WFD30m	634	359	275	548	1397	909	797	862	312	190	118	130	30	13	5	1	0	0	0	0	0	6581
Mirpursakro	WFD30m	252	127	134	279	961	695	777	1403	610	472	321	274	68	49	65	25	21	28	11	9	25	6605
Matli	WFD30m	411	217	215	414	1370	897	869	1207	399	230	122	108	34	23	30	11	9	13	5	4	16	6604
ShahBander	WFD30m	83	94	163	282	797	588	707	1372	685	589	731	207	126	76	53	6	2	1	1	1	1	6565
Sajawal	WFD30m	70	158	181	308	896	606	636	609	945	352	247	256	66	39	32	4	1	0	0	0	0	5406
Talhar	WFD30m	353	124	120	261	926	697	728	1289	540	388	269	268	63	32	25	5	3	5	1	1	3	6102
ThanoBulaKhan	WFD30m	847	167	106	154	445	395	533	1234	699	600	487	577	152	87	71	15	9	10	4	3	25	6619

Table-11 (c)		Wind Frequency Distribution Jun to Aug																					
Station	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD50m	33	33	28	63	63	104	121	109	206	236	399	299	482	459	402	391	297	244	166	105	161	4402
KatiBander	WFD50m	171	47	33	96	273	365	607	681	764	936	804	671	426	200	112	67	40	34	30	29	164	6550
Nooriabad	WFD50m	205	38	47	114	241	303	641	624	739	865	778	663	311	194	146	90	54	51	40	36	419	6600
Thatta	WFD50m	26	18	46	103	167	241	416	544	455	515	526	342	334	243	116	130	79	52	26	19	11	4408
Gharo	WFD50m	173	33	53	111	238	381	627	790	793	802	840	542	533	272	210	126	53	32	8	3	1	6620
Hyderabad	WFD50m	199	41	57	140	256	351	549	647	709	807	898	668	513	241	152	90	56	45	31	29	141	6621
Badin	WFD50m	530	104	95	138	277	395	716	925	693	690	634	295	313	126	81	37	20	11	6	7	20	6112
Baghan	WFD50m	88	56	159	276	354	673	442	782	721	619	561	512	260	275	121	105	43	38	11	11	5	6110
Chuhar Jamali	WFD50m	341	75	97	185	438	610	873	943	741	672	623	335	320	151	106	53	22	14	5	6	13	6621
DHA Karachi	WFD50m	15	18	66	150	249	395	600	658	625	557	369	242	186	119	54	43	16	10	2	3	11	4389
Golarchi	WFD50m	99	83	130	256	377	443	695	580	854	626	530	464	296	229	127	80	43	21	15	6	5	5956
HawksBay	WFD50m	295	48	79	294	728	750	1214	913	718	611	337	183	61	22	10	3	1	1	0	0	0	6272
Jati	WFD50m	62	54	131	230	388	648	581	910	718	684	545	417	241	151	122	40	31	8	4	1	0	5967
Karachi	WFD50m	587	269	203	368	590	792	984	927	596	451	324	175	139	82	46	22	9	7	2	3	7	6581
Mirpursakro	WFD50m	251	57	79	154	349	538	840	1007	847	762	680	352	270	100	77	46	40	26	22	23	85	6605
Matli	WFD50m	407	100	126	209	376	388	705	933	703	909	580	405	279	168	73	68	34	32	18	18	75	6604
ShahBander	WFD50m	82	45	129	283	423	610	720	958	773	781	747	465	258	147	77	41	17	4	1	1	3	6565
Sajawal	WFD50m	69	58	110	206	291	353	592	723	592	628	631	341	320	191	142	76	36	31	9	5	2	5406
Talhar	WFD50m	350	61	68	119	248	230	477	635	532	717	599	523	446	395	192	221	70	126	19	41	32	6102
ThanoBulaKhan	WFD50m	790	153	90	130	205	296	451	599	672	775	804	563	482	251	169	81	32	21	8	7	41	6619

September – November

Fig-12 shows wind frequency distribution during the period from September to November in three years. We can see that at 50 meters height. At Jamshoro during 1378 hours we get 5m/s, 306 hours 6m/s, 503 hours 7m/s, 236 hours 8m/s and during 514 hours 9m/s. At KetiBander during 970 hours we get 5m/s, 963 hours 6m/s, 1018 hours 7m/s, 724 hours 8m/s and during 427 hours 9m/s. At Nooriabad during 909 hours we get 5m/s, 788 hours 6m/s, 858 hours 7m/s, 584 hours 8m/s and during 455 hours 9m/s. At Thatta during 582 hours we get 5m/s, 455 hours 6m/s, 488 hours 7m/s, 401 hours 8m/s and during 188 hours 9m/s. At Gharo during 822 hours we get 5m/s, 713 hours 6m/s, 831 hours 7m/s, 671 hours 8m/s and during 425 hours 9m/s. Similarly at Hyderabad during 864 hours we get wind speed of 5m/s, 749 hours 6m/s, 872 hours 7m/s, and 661 hours 8m/s and for 430 hours 9m/s.

Similarly at Hyderabad during 864 hours we get wind speed of 5m/s, 749 hours 6m/s, 872 hours 7m/s, and 661 hours 8m/s and for 430 hours 9m/s.

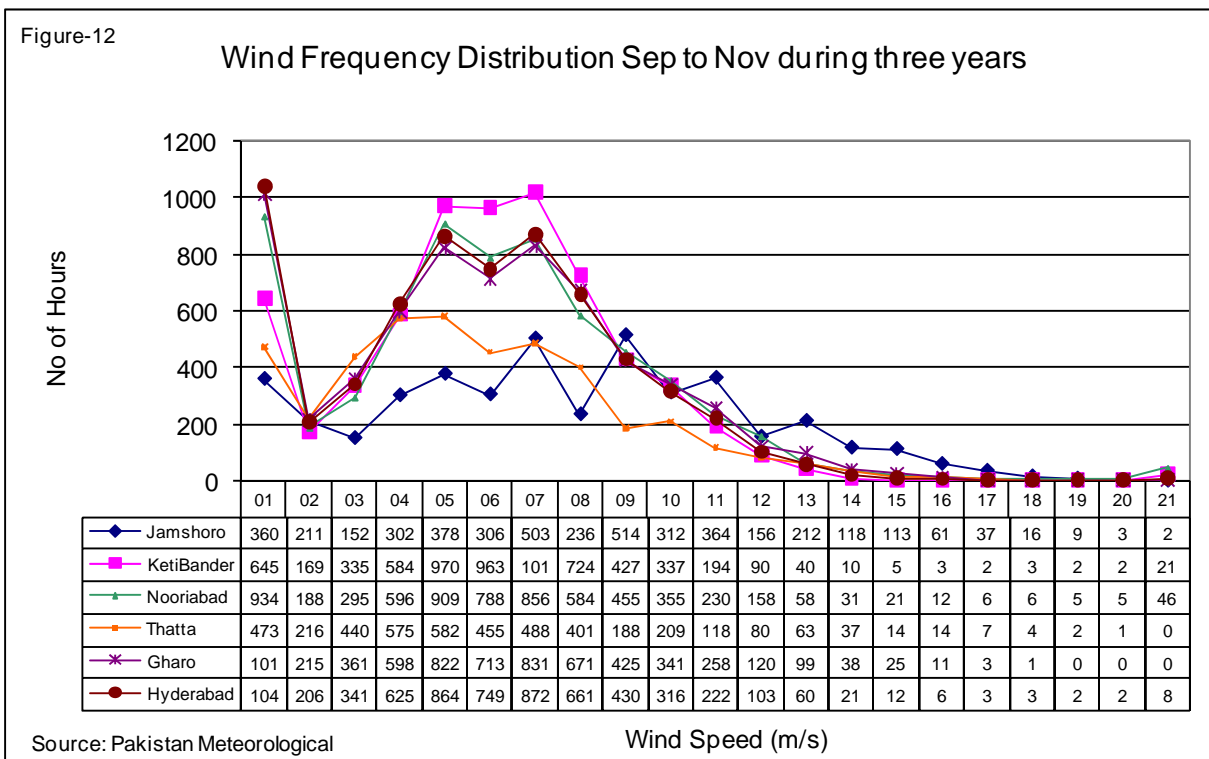


Table -12 (a)		Three Years Wind Frequency Distribution Sep to Nov																					
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD10m	717	1098	645	415	548	275	243	294	76	35	13	4	0	0	0	0	0	0	0	0	0	4363
KatiBander	WFD10m	1522	1134	669	710	1131	455	357	396	85	41	17	10	2	2	3	1	1	2	1	1	5	6544
Nooriabad	WFD10m	1511	650	552	730	1081	490	436	613	198	119	67	55	11	6	8	3	2	3	1	1	3	6539
Thatta	WFD10m	1850	1294	471	338	329	59	19	7	0	0	0	0	0	0	0	0	0	0	0	0	0	4366
Gharo	WFD10m	2487	858	454	505	983	439	349	344	74	32	14	8	0	0	0	0	0	0	0	0	0	6548
Hyderabad	WFD10m	2084	821	531	658	1113	450	347	380	86	43	19	12	2	1	1	0	0	0	0	0	0	6547
Badin	WFD10m	4047	940	418	432	397	142	85	48	15	8	3	0	0	0	0	0	0	0	0	0	0	6537
Baghan	WFD10m	1875	1929	945	819	534	364	52	20	10	1	0	0	0	0	0	0	0	0	0	0	0	6550
Chuhar Jamali	WFD10m	4399	589	317	343	516	163	93	80	18	11	6	5	1	1	2	1	1	1	0	0	1	6548
DHA Karachi	WFD10m	1142	990	514	569	625	213	138	116	24	12	4	1	1	0	1	0	0	0	0	0	1	4351
Golarchi	WFD10m	1609	2534	900	633	632	136	64	27	9	1	0	0	0	0	0	0	0	0	0	0	0	6545
HawksBay	WFD10m	2170	487	401	717	1387	542	386	349	61	24	9	7	2	1	2	0	1	1	0	0	1	6548
Jati	WFD10m	1534	2522	904	639	664	154	74	48	7	3	1	0	0	0	0	0	0	0	0	0	0	6549
Karachi	WFD10m	3889	949	472	441	438	101	49	28	7	3	1	0	0	0	0	0	0	0	0	0	0	6379
Mirpursakro	WFD10m	3836	595	310	371	732	291	194	162	28	11	3	1	0	0	0	0	0	0	0	0	0	6533
Matli	WFD10m	4204	1250	516	310	223	28	8	4	1	1	1	1	0	0	0	0	0	0	0	0	0	6548
ShahBander	WFD10m	643	1815	1097	825	1125	395	259	167	163	31	16	9	0	0	0	0	0	0	0	0	0	6545
Sajawal	WFD10m	2444	2151	701	501	515	121	66	42	3	1	0	0	0	0	0	0	0	0	0	0	0	6545
Talhar	WFD10m	4943	870	281	203	184	35	16	13	3	1	0	0	0	0	0	0	0	0	0	0	0	6549
ThanoBulaKhan	WFD10m	3439	724	373	373	696	327	260	259	53	23	10	5	0	0	0	0	0	0	0	0	0	6543

Table-12 (b)		Three Years Wind Frequency Distribution Sep to Nov																					
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD30m	358	266	333	475	353	733	427	369	299	278	176	150	73	48	19	5	1	0	0	0	0	4363
KatiBander	WFD30m	648	413	458	803	1796	679	506	672	240	149	88	51	6	3	5	2	2	3	1	1	16	6544
Nooriabad	WFD30m	935	377	375	723	1434	561	471	758	305	213	141	123	31	19	17	6	5	8	4	4	30	6539
Thatta	WFD30m	477	603	589	674	1002	320	231	266	80	53	32	28	6	3	2	0	0	0	0	0	0	4366
Gharo	WFD30m	1023	507	556	793	1330	524	447	685	251	174	113	104	22	11	8	1	0	0	0	0	0	6548
Hyderabad	WFD30m	1049	450	513	797	1362	595	475	686	250	160	94	76	13	7	7	2	2	3	1	1	4	6547
Badin	WFD30m	1808	578	633	1067	1501	341	236	252	61	32	17	11	1	0	0	0	0	0	0	0	0	6537
Baghan	WFD30m	303	822	1150	1299	1566	475	326	379	98	62	55	10	4	1	0	0	0	0	0	0	0	6550
Chuhar Jamali	WFD30m	1433	352	343	1042	1966	516	306	331	106	67	41	35	6	2	1	0	0	0	0	0	0	6548
DHA Karachi	WFD30m	497	478	516	662	990	402	303	362	91	34	10	5	1	0	0	0	0	0	0	0	0	4351
Golarchi	WFD30m	557	827	722	1052	1121	1258	310	214	276	91	60	47	8	2	1	0	0	0	0	0	0	6545
HawksBay	WFD30m	1667	398	359	681	1448	631	500	601	147	71	26	13	2	1	1	0	0	1	0	0	1	6548
Jati	WFD30m	437	715	820	1159	2002	540	315	344	100	60	44	8	3	2	0	0	0	0	0	0	0	6549
Karachi	WFD30m	2736	670	501	687	953	362	229	172	41	18	7	3	1	0	0	0	0	0	0	0	0	6379
Mirpursakro	WFD30m	1361	372	476	1072	1653	461	368	468	134	78	41	29	6	4	5	1	2	1	0	0	1	6533
Matli	WFD30m	1469	710	717	1130	1616	350	228	229	48	23	10	9	3	2	2	0	0	1	0	0	0	6548
ShahBander	WFD30m	272	542	780	1166	1806	723	468	432	146	96	78	18	11	5	1	0	0	0	0	0	0	6545
Sajawal	WFD30m	490	827	828	1162	1829	467	300	215	260	77	45	37	6	2	1	0	0	0	0	0	0	6545
Talhar	WFD30m	1970	406	394	902	1636	472	292	305	78	43	26	21	3	1	0	0	0	0	0	0	0	6549
ThanoBulaKhan	WFD30m	2650	453	368	530	846	322	302	563	208	134	80	66	10	4	3	1	1	1	0	0	1	6543

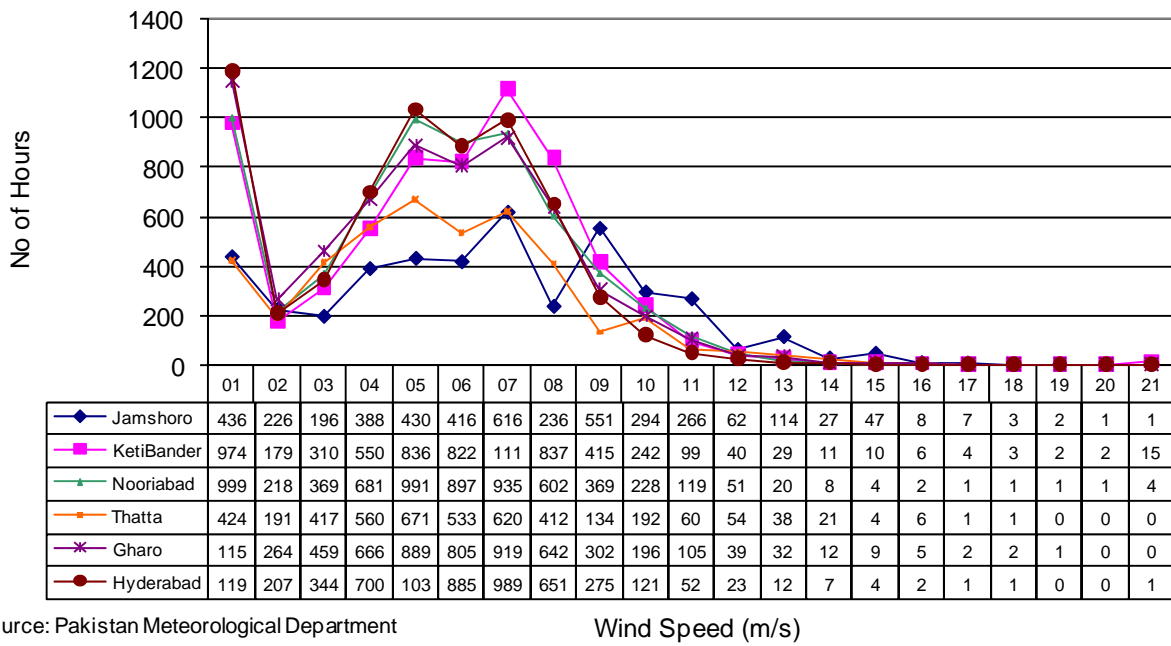
Table-12 (c)		Three Years Wind Frequency Distribution Sep to Nov																					
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD50m	360	211	152	302	378	306	503	236	514	312	364	156	212	118	113	61	37	16	9	3	2	4363
KatiBander	WFD50m	645	169	335	584	970	963	1018	724	427	337	194	90	40	10	5	3	2	3	2	2	21	6544
Nooriabad	WFD50m	934	188	295	596	909	788	856	584	455	355	230	158	58	31	21	12	6	6	5	5	46	6539
Thatta	WFD50m	473	216	440	575	582	455	488	401	188	209	118	80	63	37	14	14	7	4	2	1	0	4366
Gharo	WFD50m	1016	215	361	598	822	713	831	671	425	341	258	120	99	38	25	11	3	1	0	0	0	6548
Hyderabad	WFD50m	1042	206	341	625	864	749	872	661	430	316	222	103	60	21	12	6	3	3	2	2	8	6547
Badin	WFD50m	1798	269	402	722	1039	662	682	440	182	157	78	39	31	15	9	5	1	4	0	1	2	6537
Baghan	WFD50m	301	281	762	1255	1165	997	453	522	282	209	127	92	39	35	13	10	3	3	0	1	0	6550
Chuhar Jamali	WFD50m	1428	179	207	381	1077	801	1013	640	299	204	114	79	60	27	14	9	3	5	0	3	7	6548
DHA Karachi	WFD50m	495	169	445	621	622	581	530	366	237	147	67	35	23	8	3	1	0	1	0	0	0	4351
Golarchi	WFD50m	558	369	512	744	855	969	855	584	372	216	200	128	82	55	26	14	5	2	1	0	0	6545
HawksBay	WFD50m	1666	227	275	677	1012	768	819	495	311	178	73	28	10	4	2	1	1	1	0	0	2	6548
Jati	WFD50m	435	284	580	864	1015	1277	639	704	271	260	101	66	34	11	7	1	1	0	0	0	0	6549
Karachi	WFD50m	2718	372	378	552	620	538	511	363	153	98	46	15	10	3	2	0	0	0	0	0	0	6379
Mirpursakro	WFD50m	1354	173	221	484	1098	806	964	639	321	223	129	50	36	10	7	4	3	2	2	2	4	6533
Matli	WFD50m	1464	314	480	754	1012	610	719	483	204	247	94	65	49	21	11	7	3	4	1	2	3	6548
ShahBander	WFD50m	273	243	581	1002	1143	1145	748	641	307	236	122	56	26	14	7	2	0	0	0	0	0	6545
Sajawal	WFD50m	484	315	543	867	1001	849	862	675	280	283	179	77	73	29	18	6	2	1	0	0	0	6545
Talhar	WFD50m	1962	210	220	397	870	564	804	536	253	230	111	110	92	74	45	33	5	25	1	6	2	6549
ThanoBulaKhan	WFD50m	2623	236	292	418	563	468	485	399	315	282	224	115	71	28	13	4	1	3	1	1	2	6543

December – February

Fig-13 shows wind frequency distribution during the period from December to February in two years. We can see that at 50 meters height, at Jamshoro during 430 hours we get wind speed of 5m/s, 416 hours 6m/s, 616 hours 7m/s and during 236 hours 8m/s. At KetiBandar during 836 hours we get 5m/s, 822 hours 6m/s, 1115 hours 7m/s, 937 hours 8m/s and 415 hours we get 9m/s. At Nooriabad during 991 hours we get 5m/s, 897 hours 6m/s, 935 hours 7m/s, 602 hours 8m/s and 369 hours we get 9m/s. At Thatta during 671 hours we get 5m/s, 533 hours 6m/s, 620 hours 7m/s, 412 hours 8m/s and 134 hours we get 9m/s. At Gharo during 889 hours we get 5m/s, 805 hours 6m/s, 919 hours 7m/s, 642 hours 8m/s and 302 hours we get 9m/s. At Hyderabad during 1034 hours we get 5m/s, 885 hours 6m/s, 989 hours 7m/s, 651 hours 8m/s and 275 hours we get 9m/s. Actually this is the period when we get generally lower wind potential as compared to other seasons.

Figure-13

Wind Frequency distribution Dec to Feb in three years at six windy stations of Sindh



Source: Pakistan Meteorological Department

Wind Speed (m/s)

Table -13 (a)		Three Years Wind Frequency Distribution Dec to Feb																					
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD10m	815	1294	845	502	532	165	97	62	9	4	1	0	0	0	0	0	0	0	0	0	0	4327
KatiBander	WFD10m	1855	911	628	753	1219	443	305	274	52	27	14	10	2	1	2	1	1	1	0	0	1	6500
Nooriabad	WFD10m	1854	737	602	773	1189	484	366	353	78	36	15	11	2	1	1	0	0	0	0	0	0	6501
Thatta	WFD10m	2317	1326	380	198	104	9	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4340
Gharo	WFD10m	3053	1185	548	516	720	225	124	93	16	9	4	3	0	0	0	0	0	0	0	0	0	6497
Hyderabad	WFD10m	2550	956	613	795	1036	290	146	89	14	5	2	2	0	0	0	0	0	0	0	0	0	6499
Badin	WFD10m	5015	885	252	164	119	21	11	9	2	1	0	0	0	0	0	0	0	0	0	0	0	6478
Baghan	WFD10m	1994	2265	724	472	271	169	25	10	6	1	0	0	0	0	0	0	0	0	0	0	0	5937
Chuhar Jamali	WFD10m	3643	1007	404	485	621	173	92	63	10	3	1	0	0	0	0	0	0	0	0	0	0	6501
DHA Karachi	WFD10m	1202	1213	579	585	471	154	79	35	6	3	2	1	0	0	0	0	0	0	0	0	0	4330
Golarchi	WFD10m	1710	2854	904	497	408	77	32	11	5	0	0	0	0	0	0	0	0	0	0	0	0	6499
HawksBay	WFD10m	2152	520	458	851	1295	425	303	314	83	46	27	21	3	1	1	0	0	0	0	0	0	6501
Jati	WFD10m	1445	3146	882	479	410	74	31	23	5	3	1	0	0	0	0	0	0	0	0	0	0	6500
Karachi	WFD10m	4789	877	329	238	198	37	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	6484
Mirpursakro	WFD10m	4489	729	338	323	432	102	45	27	5	2	1	2	1	0	0	0	0	0	0	0	0	6498
Matli	WFD10m	4316	1055	536	349	197	22	10	8	2	1	1	1	0	0	0	0	0	0	0	0	0	6499
ShahBander	WFD10m	773	2065	1412	864	915	238	118	55	33	8	6	7	2	1	1	0	0	0	0	0	0	6498
Sajawal	WFD10m	2502	2631	715	367	235	25	12	9	2	1	1	0	0	0	0	0	0	0	0	0	0	6498
Talhar	WFD10m	4017	1192	456	331	342	83	46	27	2	1	0	0	0	0	0	0	0	0	0	0	0	6497
ThanoBulaKhan	WFD10m	3417	872	462	494	697	236	150	131	23	10	4	2	0	0	0	0	0	0	0	0	0	6499

Table -13 (b)		Three Years Wind Frequency Distribution Dec to Feb																					
Stations	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD30m	441	293	377	599	471	839	519	375	196	110	66	23	9	5	3	1	0	0	0	0	0	4327
KatiBander	WFD30m	979	381	419	700	1666	806	612	621	142	71	34	30	8	7	7	2	1	2	1	1	12	6500
Nooriabad	WFD30m	1002	463	477	811	1584	631	504	646	179	98	50	37	7	3	3	1	1	1	0	0	2	6501
Thatta	WFD30m	428	561	572	768	1355	294	150	150	36	15	6	4	0	0	0	0	0	0	0	0	0	4340
Gharo	WFD30m	1157	647	627	928	1615	558	372	374	96	55	27	25	7	4	4	1	0	0	0	0	0	6497
Hyderabad	WFD30m	1193	456	521	990	1646	770	486	319	64	28	13	7	2	1	1	1	0	0	0	0	0	6499
Badin	WFD30m	2909	494	518	954	1285	158	71	55	12	7	5	6	2	1	1	0	0	0	0	0	0	6478
Baghan	WFD30m	275	711	881	1107	2098	462	175	145	32	17	18	5	4	3	2	0	0	0	0	0	0	5937
Chuhar Jamali	WFD30m	1277	376	285	896	2336	718	314	201	46	23	12	11	2	2	1	0	0	0	0	0	0	6501
DHA Karachi	WFD30m	533	666	718	782	834	315	215	179	45	25	12	5	0	0	0	0	0	0	0	0	0	4330
Golarchi	WFD30m	461	771	728	1053	1371	1727	197	94	71	12	6	5	1	1	1	0	0	0	0	0	0	6499
HawksBay	WFD30m	1654	418	427	785	1347	553	439	539	143	91	48	42	7	3	3	1	1	1	0	0	0	6501
Jati	WFD30m	365	714	719	1063	2587	627	204	150	29	15	11	6	4	3	3	0	0	0	0	0	0	6500
Karachi	WFD30m	3058	870	661	734	723	201	105	95	19	10	5	2	0	0	0	0	0	0	0	0	0	6484
Mirpursakro	WFD30m	1404	373	444	1127	2127	451	241	222	43	25	16	11	3	3	2	1	1	1	1	1	3	6498
Matli	WFD30m	1246	796	792	1353	1877	244	99	69	9	4	2	2	1	0	1	0	0	1	0	0	1	6499
ShahBander	WFD30m	274	585	695	1020	2315	860	405	242	40	20	18	8	5	4	5	1	1	0	0	0	0	6498
Sajawal	WFD30m	488	839	821	1198	2315	438	181	106	73	14	8	10	3	2	2	0	0	0	0	0	0	6498
Talhar	WFD30m	1837	874	613	1028	1523	297	142	119	27	15	9	7	2	1	1	0	0	0	0	0	0	6497
ThanoBulaKhan	WFD30m	2450	528	447	716	1200	414	281	295	79	42	21	16	3	2	1	0	0	1	0	0	3	6499

Table -13 (c)		Three Years Wind Frequency Distribution Dec to Feb																					
Station s	Frequency	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total
Jamshoro	WFD50m	436	226	196	388	430	416	616	236	551	294	266	62	114	27	47	8	7	3	2	1	1	4327
KatiBander	WFD50m	974	179	310	550	836	822	1115	837	415	242	99	40	29	11	10	6	4	3	2	2	15	6500
Nooriabad	WFD50m	999	218	369	681	991	897	935	602	369	228	119	51	20	8	4	2	1	1	1	1	4	6501
Thatta	WFD50m	424	191	417	560	671	533	620	412	134	192	60	54	38	21	4	6	1	1	0	0	0	4340
Gharo	WFD50m	1150	264	459	666	889	805	919	642	302	196	105	39	32	12	9	5	2	2	1	0	0	6497
Hyderabad	WFD50m	1191	207	344	700	1034	885	989	651	275	121	52	23	12	7	4	2	1	1	0	0	1	6499
Badin	WFD50m	2854	253	334	520	884	547	593	279	73	68	21	15	17	7	6	3	1	2	0	0	0	6478
Baghan	WFD50m	272	221	627	915	1010	1100	679	644	164	187	38	26	25	11	6	4	2	2	1	1	1	5937
Chuhar Jamali	WFD50m	1291	266	307	377	918	845	1204	734	269	156	54	29	29	8	8	2	2	1	0	0	1	6501
DHA Karachi	WFD50m	531.7	220.4	616.3	841.7	649.2	506.6	432.5	268.9	123.3	66.0	44.5	15.5	10.5	2.1	0.6	0.1	0.0	0.0	0.0	0.0	0.0	4330
Golarchi	WFD50m	460	329	503	824	842	1096	1117	748	235	112	173	19	29	5	3	2	1	1	0	0	0	6499
HawksBay	WFD50m	1655	233	312	779	999	689	686	486	297	181	90	52	21	9	4	3	2	1	1	0	1	6501
Jati	WFD50m	365	291	597	783	897	1251	846	873	184	294	31	24	45	4	7	3	3	1	1	0	0	6500
Karachi	WFD50m	3042	418	519	675	665	441	329	200	72	54	29	17	10	6	2	2	1	2	0	1	1	6484
Mirpursakro	WFD50m	1396	176	222	453	1112	844	1101	655	215	168	66	28	35	7	5	3	2	1	1	1	7	6498
Matli	WFD50m	1245	373	553	949	1237	691	782	384	99	91	23	21	23	8	7	3	0	4	0	1	3	6499
ShahBander	WFD50m	278	257	565	833	1057	1330	890	770	287	151	29	23	10	7	5	4	2	1	0	0	0	6498
Sajawal	WFD50m	480	316	557	875	1051	969	998	711	177	229	55	26	31	10	6	4	2	2	0	0	0	6498
Talhar	WFD50m	1861	440	502	655	988	646	706	371	128	100	30	21	22	9	7	4	2	3	1	1	1	6497
ThanoBulaKhan	WFD50m	2407	273	367	539	768	623	682	422	193	118	56	22	13	5	3	1	1	0	0	0	4	6499

Similarly the above mentioned seasonal frequency distribution percentage terms have been presented in figures 14–17.

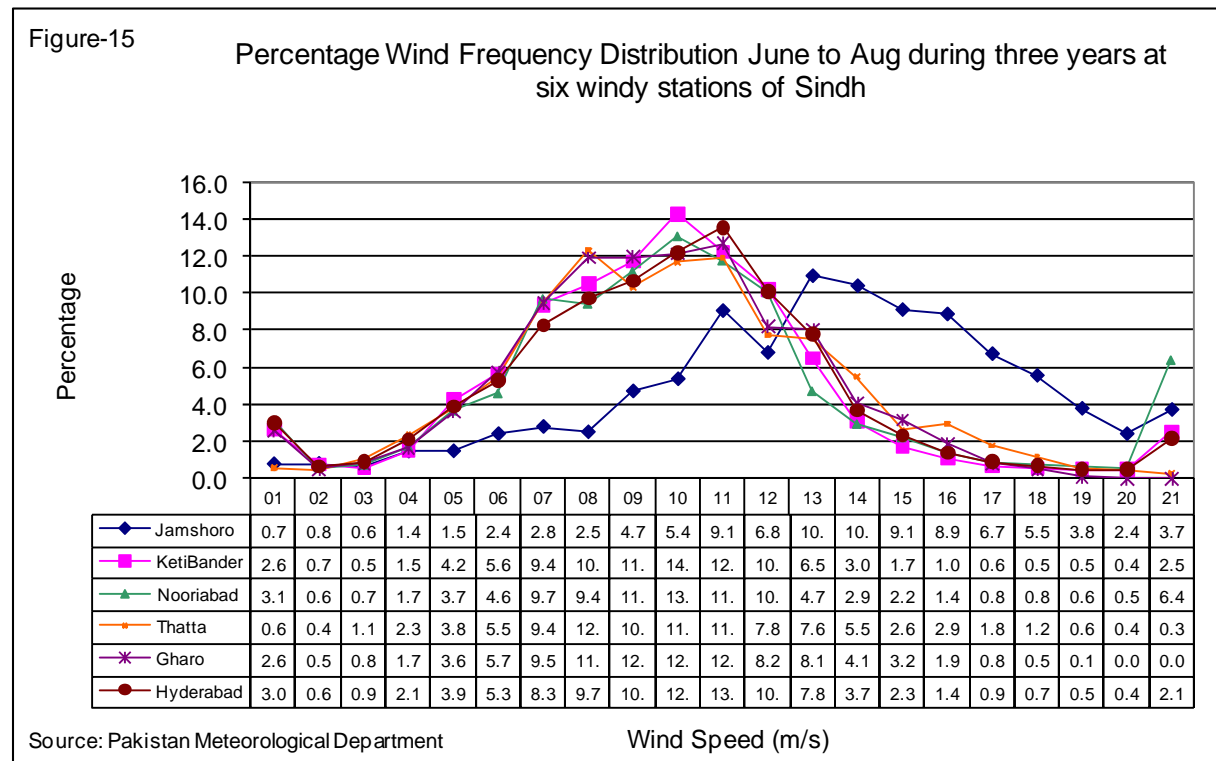
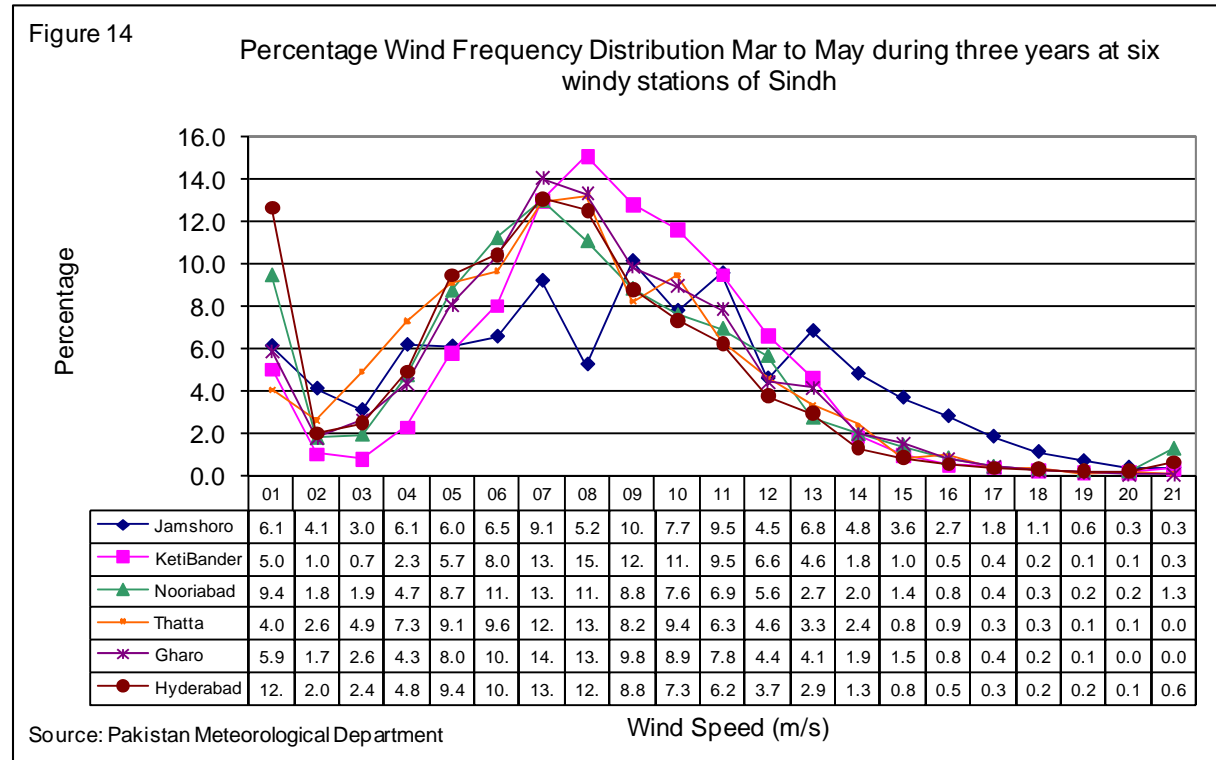
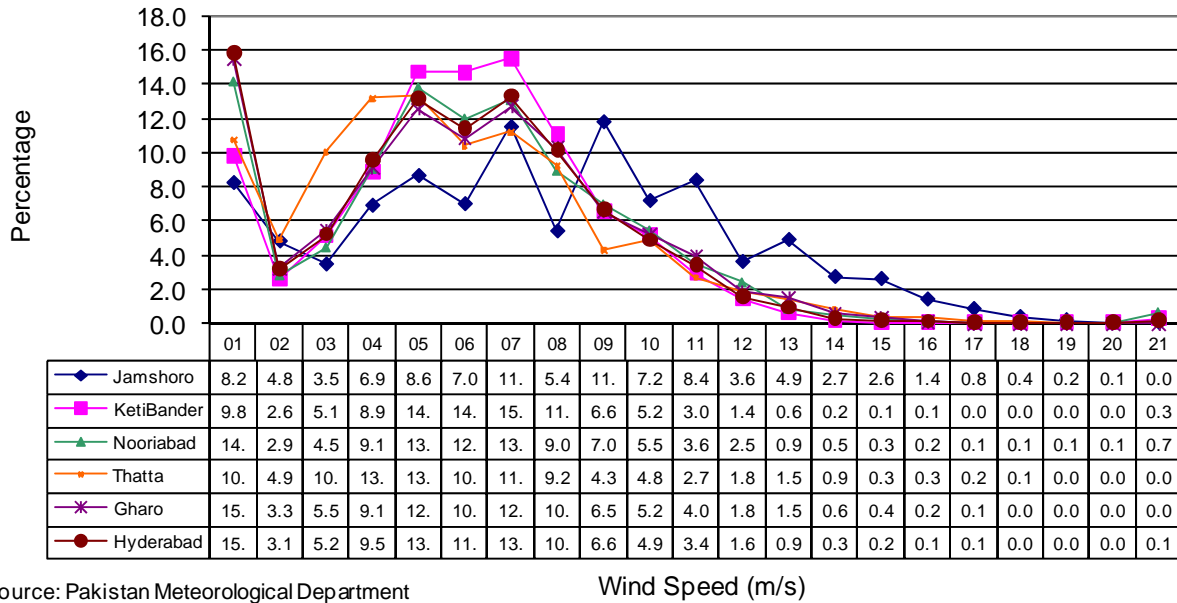


Figure-16

Percentage Wind Frequency Distribution Sep to Nov during three years at six windy stations of Sindh

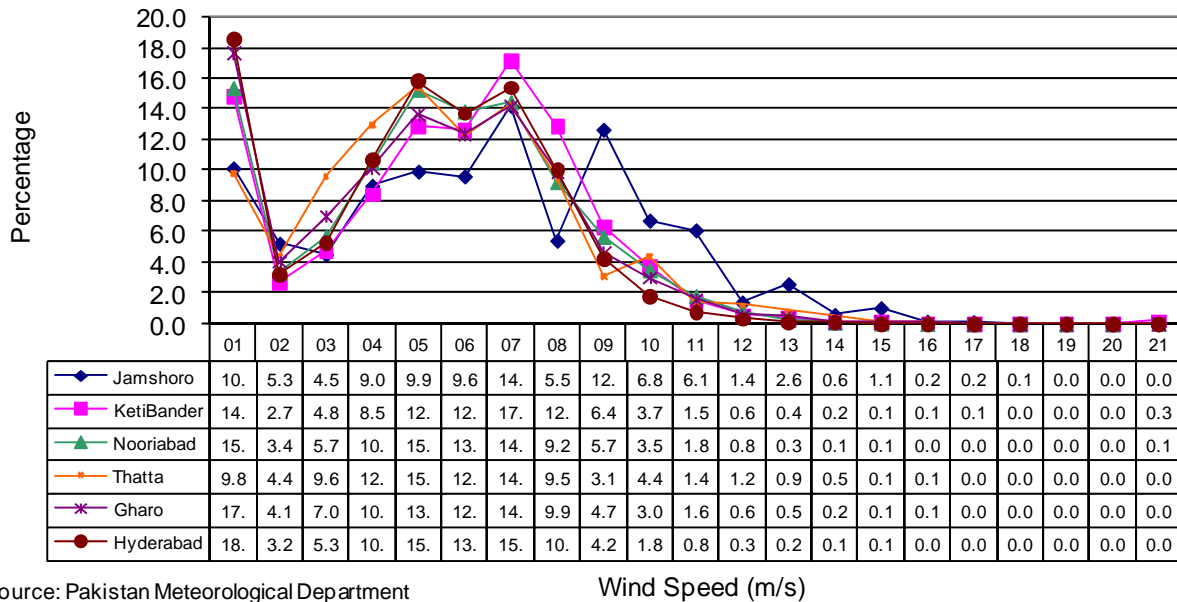


Source: Pakistan Meteorological Department

Wind Speed (m/s)

Figure-17

Percentage Wind Frequency Distribution Dec to Feb during three years at six windy stations of Sindh

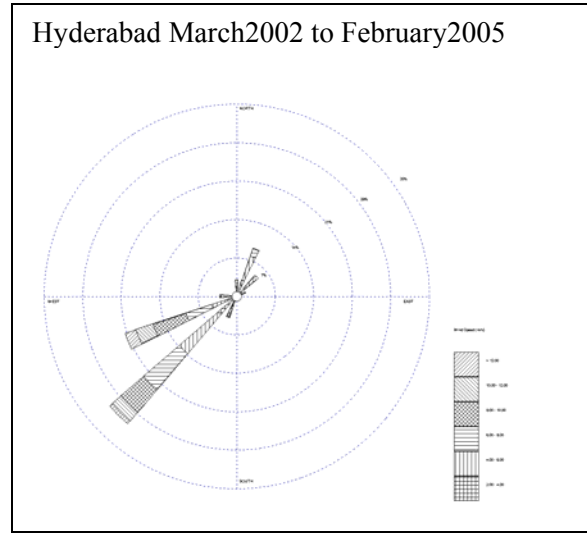
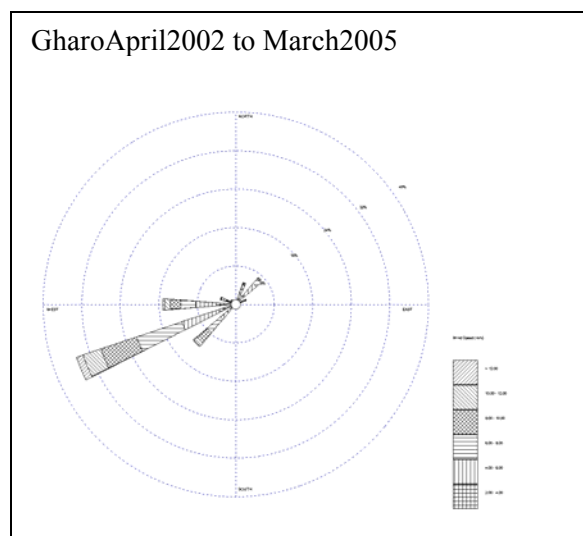
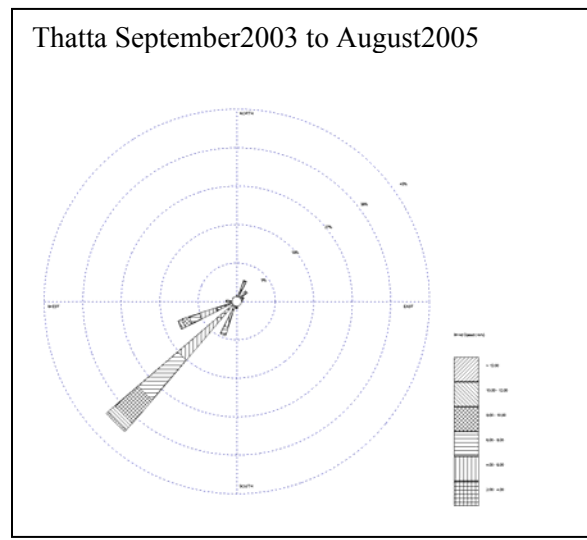
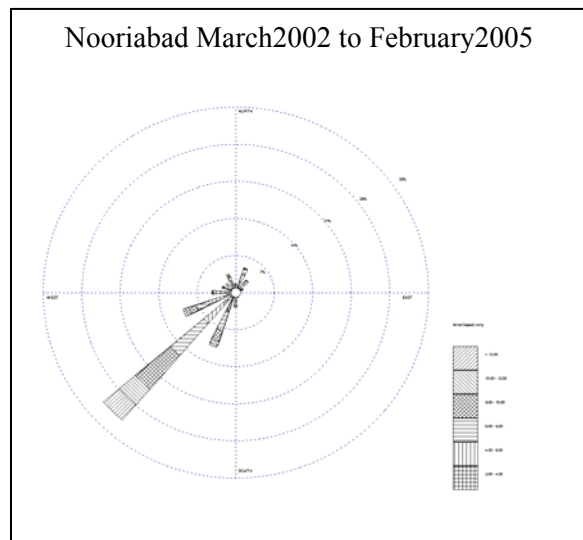
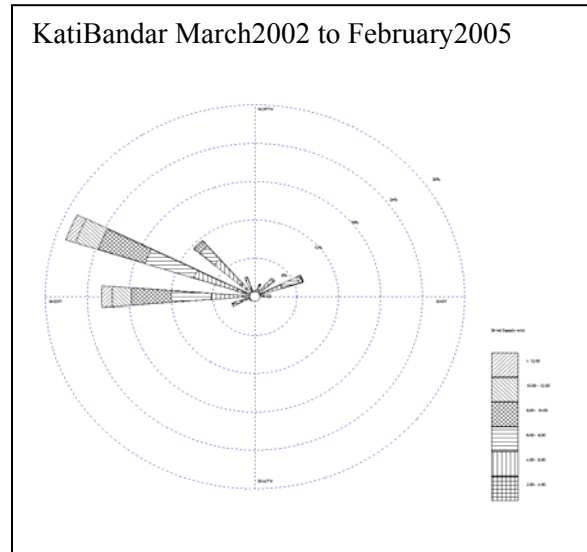
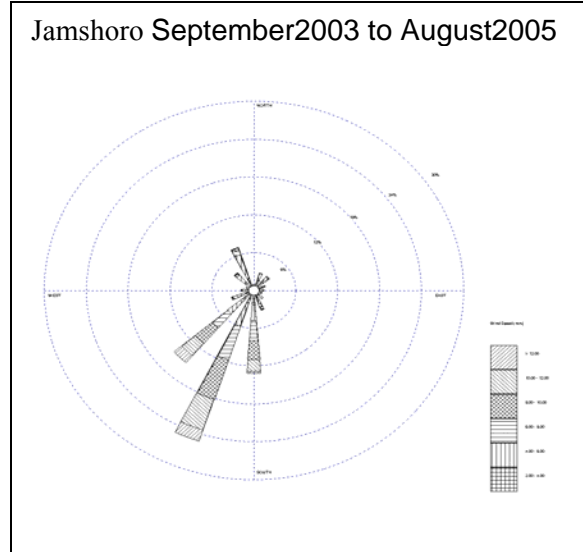


Source: Pakistan Meteorological Department

Wind Speed (m/s)

Wind Roses:

Most of the wind blows from south-southwest to west-southwest direction in Sindh region. However during summer season, a heat low exist over Balochistan and adjoining areas. Its trough usually extended southeastward causing most frequent wind direction found west-northwest at KatiBandar.



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

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

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

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

Where V_i is the central wind speed of bin 1 and $P(V_i)$ 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

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

3.6.3 *Standard Deviation*

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

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

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 14.

Table-14: International Wind Power Classification

Class	Resource Potential	30m Height		50m Height	
		Wind Speed m/s	Wind Power W/m ²	Wind Speed m/s	Wind Power W/m ²
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

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

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

From fluid dynamics, it can be proved that

$$\frac{dm}{dt} = \rho AV$$

Volume of cylindrical cross section can be written as

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

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

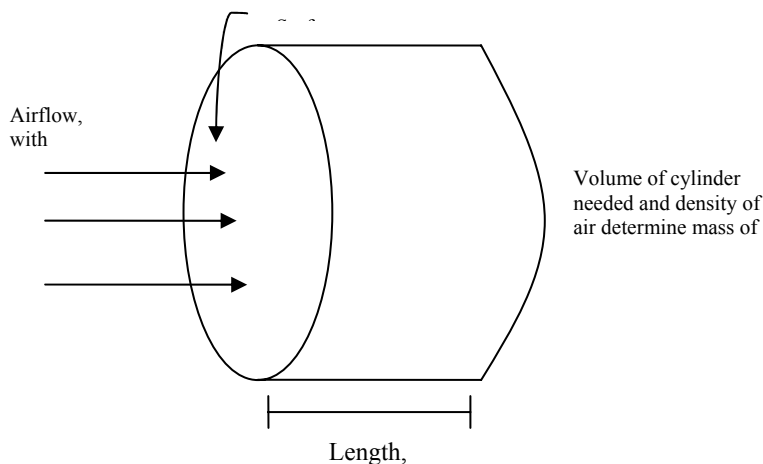
$$V = \pi r^2 Vt$$

Now mass of wind can be written as

$$M = \rho Avt$$

Differentiating $\frac{dm}{dt} = \rho AV \frac{d}{dt}(t) = \rho AV$

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



So the power is then,

$$\begin{aligned} P &= \frac{1}{2} \frac{dm}{dt} V^2 = \frac{1}{2} \phi A V T / t V^2 \\ &= \frac{1}{2} \phi A V^3 \end{aligned}$$

And power density

$$P/A = \frac{1}{2} \phi V^3$$

Density of wind at mean sea level is 1.225 kg/m³

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 range from 1.0 to 3 times greater than that calculated. For example, we take wind speed of 5, 7 and 8 m/sec respectively the respective power densities are 76 watt/m², 210 watt/m² and 313 watt/m². The average of which is 200 watt/m². On the other hand, the average wind speed is 6.7 m/sec and power density of average wind is 181 watt/m². 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 phenomena. 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 flexibility 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 cases of Weibull distribution.

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

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

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:

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

Where

E is the power density in watts / m^2

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

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

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 captures.

3.7.5 Weibull Parameters:

The Weibull parameters for three different heights 10 meters, 30 meters and 50 meters are given in Table-15A1, Table-15A2.

Table-15A1		Monthly & Annual Weibull Scale Parameters (m/s) for different stations in Sindh													
Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nooriabad	10m	C	3.6	3.8	4.0	6.0	8.1	8.8	8.8	8.2	7.1	3.1	3.0	3.5	5.7
KatiBandar	10m	C	3.3	3.6	3.5	6.1	7.8	7.9	8.2	7.2	5.7	3.1	2.2	3.3	5.2
Jamshoro	10m	C	2.8	2.9	3.2	4.5	6.0	7.5	8.6	7.5	6.0	2.6	2.3	2.8	4.9
SHAHBANDAR	10m	C	2.9	3.2	3.8	5.4	7.1	7.3	7.0	6.8	5.3	3.0	2.5	2.9	4.8
HawksBay	10m	C	3.4	3.9	4.5	6.0	6.4	6.5	6.4	5.8	4.9	3.2	2.7	3.3	4.7
Hyderabad	10m	C	2.7	2.8	2.7	4.5	6.4	7.5	7.4	6.5	5.8	2.3	2.2	2.4	4.4
Gharo	10m	C	2.3	2.5	2.8	4.9	6.7	6.9	6.6	6.4	5.6	2.2	1.7	1.9	4.2
ChuharJamal	10m	C	3.4	3.1	3.2	4.5	5.8	6.2	6.0	5.2	3.6	2.2	2.2	3.0	4.0
DHA Karachi	10m	C	2.6	3.0	3.3	4.4	5.4	5.8	5.7	4.2	4.2	2.7	2.1	2.1	3.8
ThanoBulaKhan	10m	C	2.1	2.4	1.9	3.4	5.1	6.1	6.5	5.6	4.4	1.5	1.6	2.1	3.6
Jati	10m	C	2.0	2.3	2.6	3.6	4.9	5.5	5.1	5.0	3.6	1.9	1.6	1.9	3.3
MirpurSakro	10m	C	1.4	1.6	2.0	3.8	5.5	5.6	5.4	5.2	4.3	1.3	1.0	1.4	3.2
Golarchi	10m	C	2.1	2.1	2.0	2.9	3.8	4.8	4.2	3.8	2.9	1.6	2.5	1.9	2.9
Sajawal	10m	C	1.6	1.8	2.2	3.4	4.7	4.5	3.6	4.2	3.3	1.5	1.3	1.6	2.8
Baghan	10m	C	1.9	2.0	2.3	2.9	3.5	3.7	3.6	3.7	3.2	2.0	2.1	2.0	2.7
Thatta	10m	C	1.4	1.5	1.8	2.8	3.6	4.3	4.6	4.2	3.1	1.4	1.1	1.3	2.6
Karachi	10m	C	1.2	1.2	2.6	3.2	4.2	4.7	4.2	3.0	2.8	1.2	0.9	1.0	2.5
Badin	10m	C	0.9	1.2	1.2	2.7	4.2	4.6	3.9	3.3	3.0	0.9	1.2	1.0	2.3
Talhar	10m	C	1.6	1.6	1.2	2.0	3.1	3.4	2.9	2.4	1.5	0.9	0.9	1.4	1.9
Matli	10m	C	1.3	1.3	0.9	1.5	2.5	3.1	2.9	2.4	1.9	1.0	1.0	1.3	1.8
Jamshoro	30m	C	5.3	5.1	5.7	7.6	9.5	11.5	13.1	11.6	9.3	5.2	5.0	5.7	7.8
Nooriabad	30m	C	4.8	4.8	5.1	7.4	9.6	10.4	10.5	9.7	8.3	4.2	4.3	4.8	7.0
KatiBandar	30m	C	4.7	5.3	5.8	8.2	9.4	9.4	10.1	8.9	7.2	4.7	4.0	4.8	6.9
Gharo	30m	C	4.1	4.4	4.8	7.1	9.2	9.3	9.0	8.7	7.6	4.0	3.5	4.0	6.3
Hyderabad	30m	C	4.2	4.2	4.2	6.3	8.7	9.9	9.8	8.5	7.7	3.7	3.7	4.3	6.3
Shahbander	30m	C	4.6	4.7	5.1	6.5	8.1	8.5	8.4	8.1	6.4	4.4	4.2	4.7	6.1
ChuharJamal	30m	C	4.5	4.7	4.3	5.8	7.5	8.0	7.8	7.3	6.0	3.7	3.9	4.5	5.7
Thatta	30m	C	4.2	3.9	4.4	6.0	7.3	8.0	8.6	8.2	6.2	3.4	3.4	4.1	5.6

Table-15A1		Monthly & Annual Weibull Scale Parameters (m/s) for different stations in Sindh													
Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Jati	30m	C	4.2	4.5	4.7	6.1	7.3	8.2	7.6	7.5	5.9	3.8	3.8	4.3	5.6
DHA Karachi	30m	C	3.8	4.4	5.0	6.3	7.3	7.6	8.3	7.4	6.1	4.0	3.3	3.5	5.6
MirpurSakro	30m	C	3.8	4.1	4.4	5.8	7.9	8.1	8.1	7.4	6.3	3.4	3.3	4.0	5.6
Golarchi	30m	C	4.4	4.4	4.2	5.6	7.0	8.3	7.5	6.9	5.7	3.5	4.9	4.4	5.5
HawksBay	30m	C	4.2	4.6	5.4	6.7	7.3	7.2	7.4	6.5	5.8	3.8	3.3	4.1	5.5
Sajawal	30m	C	4.1	4.2	4.7	6.2	7.7	8.1	7.1	7.7	6.2	3.6	3.6	4.1	5.5
Baghan	30m	C	4.1	4.2	4.5	5.8	6.8	7.3	7.1	7.1	5.8	3.7	3.7	4.4	5.4
Talhar	30m	C	3.1	3.6	4.0	6.0	7.9	8.2	7.2	6.8	5.7	3.0	2.5	2.9	5.0
ThanoBulaKhan	30m	C	3.2	3.5	2.7	5.0	6.6	8.3	8.4	7.4	6.5	2.4	2.3	3.2	5.0
Matli	30m	C	3.4	3.3	3.5	4.8	6.5	7.2	6.7	5.9	5.1	2.7	3.0	3.5	4.7
Badin	30m	C	2.6	2.7	2.7	5.5	7.3	7.8	6.4	6.5	5.2	2.8	2.6	2.5	4.5
Karachi	30m	C	2.2	2.4	3.7	5.0	6.2	6.5	6.0	5.2	4.6	2.0	1.7	2.3	4.0
Jamshoro	50m	C	6.7	6.4	7.2	9.4	11.4	13.6	15.6	14.0	11.1	6.7	6.6	7.4	9.6
KatiBandar	50m	C	5.6	6.3	7.0	9.4	10.5	10.4	11.1	9.9	8.2	5.7	5.0	5.7	7.9
Nooriabad	50m	C	5.6	5.5	5.7	8.2	10.4	11.2	11.3	10.5	9.1	4.9	5.0	5.5	7.8
Thatta	50m	C	5.8	5.3	6.1	8.1	9.8	10.3	11.1	10.9	8.2	4.7	4.7	5.8	7.6
Gharo	50m	C	5.2	5.5	5.9	8.4	10.6	10.6	10.3	9.9	8.8	5.0	4.4	5.2	7.5
Hyderabad	50m	C	5.1	5.0	5.0	7.3	10.0	11.2	11.1	9.6	8.8	4.5	4.5	5.4	7.3
Sajawal	50m	C	5.6	5.7	6.3	8.0	9.6	10.2	9.1	9.7	8.0	4.9	5.0	5.6	7.2
Golarchi	50m	C	5.8	5.8	5.6	7.1	8.7	10.3	9.4	8.7	7.2	4.6	6.4	5.8	7.1
Baghan	50m	C	5.5	5.6	5.9	7.6	8.9	9.7	9.4	9.4	7.5	4.8	4.6	5.9	7.1
Shahbander	50m	C	5.7	5.7	5.9	7.2	8.9	9.4	9.2	8.9	7.0	5.2	5.3	6.0	7.0
Jati	50m	C	5.7	5.8	6.0	7.5	8.7	9.7	9.1	8.9	7.2	4.9	5.2	6.0	7.0
Talhar	50m	C	4.0	4.7	4.9	8.6	11.2	11.6	10.1	9.9	8.4	4.0	3.3	3.7	7.0
MirpurSakro	50m	C	5.1	5.3	5.5	7.1	9.3	9.5	9.7	8.7	7.5	4.5	4.4	5.3	6.8
DHA Karachi	50m	C	4.6	5.2	6.0	7.4	8.4	8.7	10.2	9.1	7.4	4.8	4.1	4.4	6.7
ChuharJamal	50m	C	5.0	5.6	5.0	6.7	8.6	9.1	8.9	8.5	7.4	4.5	4.7	5.4	6.6
Matli	50m	C	4.6	4.4	4.9	6.9	9.1	9.8	9.3	8.3	7.2	3.6	4.0	4.6	6.4
HawksBay	50m	C	4.7	5.1	6.0	7.3	8.0	7.8	8.1	7.1	6.3	4.3	3.8	4.6	6.1
ThanoBulaKhan	50m	C	3.8	4.2	3.2	6.0	7.7	9.6	9.6	8.7	7.7	2.9	2.8	3.9	5.9
Badin	50m	C	3.4	3.5	3.6	7.3	9.2	9.7	8.0	8.4	6.6	3.8	3.2	3.3	5.8
Karachi	50m	C	2.8	3.0	4.6	6.0	7.5	7.8	7.3	6.4	5.8	2.5	2.1	3.0	4.9

Table-15A2		Monthly & Annual Weibull Shape Parameters for different stations in Sindh													
Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ShahBander	10m	K	1.7	1.6	1.9	2.4	2.8	2.8	2.8	3.1	2.4	1.6	1.7	1.7	1.7
HawksBay	10m	K	1.3	1.4	1.6	1.9	2.3	2.5	2.6	2.6	2.1	1.2	1.1	1.2	1.6
Golarchi	10m	K	1.5	1.5	1.6	1.9	2.2	2.7	2.3	2.5	2.0	1.4	1.3	1.5	1.6
KatiBandar	10m	K	1.3	1.4	1.4	2.4	2.9	2.4	2.4	3.2	2.5	1.2	1.3	1.3	1.5
Nooriabad	10m	K	1.3	1.5	1.4	1.9	2.4	2.2	2.5	2.6	2.5	1.3	1.3	1.3	1.5
Baghan	10m	K	1.3	1.3	1.5	1.6	2.0	2.1	2.0	2.1	1.8	1.2	1.3	1.3	1.5
Jati	10m	K	1.6	1.5	1.6	1.8	2.3	2.3	2.4	2.5	2.0	1.5	1.6	1.5	1.5
DHA Karachi	10m	K	1.4	1.5	1.6	2.0	2.5	2.7	1.6	1.6	1.7	1.3	1.2	1.3	1.4
Jamshoro	10m	K	1.5	1.5	1.5	1.9	2.2	2.5	4.2	3.5	2.5	1.4	1.6	1.6	1.4
Hyderabad	10m	K	1.3	1.3	1.1	1.8	2.2	2.6	2.6	2.8	2.5	1.1	1.2	1.1	1.4
Gharo	10m	K	1.1	1.1	1.2	2.0	2.6	2.7	2.6	2.8	2.5	1.0	0.9	0.9	1.4
Thatta	10m	K	1.2	1.3	1.4	1.8	2.1	2.1	3.0	2.7	1.9	1.2	1.4	1.2	1.4
Sajawal	10m	K	1.4	1.3	1.4	1.6	2.0	2.1	1.8	2.3	1.7	1.4	1.4	1.4	1.3
ChuharJamal	10m	K	1.0	1.0	1.0	1.3	1.7	1.7	1.7	1.3	1.0	0.8	0.9	1.0	1.1
ThanoBulaKhan	10m	K	1.0	1.1	0.8	1.2	1.5	2.0	2.0	2.0	1.6	0.8	0.8	0.9	1.1
MirpurSakro	10m	K	0.9	0.9	0.9	1.4	2.0	2.0	2.0	2.2	1.7	0.8	0.9	0.9	1.1
Matli	10m	K	1.1	1.0	1.0	1.1	1.4	1.6	1.6	1.5	1.3	1.0	1.0	0.9	1.1
Badin	10m	K	1.0	0.9	0.9	1.3	1.8	2.0	1.7	1.5	1.3	1.1	0.9	1.0	1.0
Talhar	10m	K	1.0	1.0	0.9	1.1	1.4	1.6	1.5	1.4	1.2	0.8	0.9	0.9	1.0
Karachi	10m	K	0.9	1.0	0.9	1.4	1.8	1.4	1.3	1.5	1.4	0.9	0.9	0.9	1.0
Shahbandar	30m	K	2.5	2.4	2.5	2.9	2.9	2.8	2.9	3.2	2.7	2.1	2.5	2.6	2.2
Baghan	30m	K	2.3	2.2	2.7	2.7	2.7	2.6	2.6	2.9	2.5	2.1	2.3	2.6	2.1
Jati	30m	K	2.4	2.3	2.6	2.7	2.8	2.6	2.8	3.0	2.6	2.1	2.4	2.6	2.1
Golarchi	30m	K	2.3	2.2	2.2	2.4	2.7	2.9	2.6	3.0	2.7	1.8	1.7	2.4	2.0
DHA Karachi	30m	K	1.7	2.0	2.2	2.7	3.1	2.9	4.8	3.6	3.0	1.7	1.8	1.6	2.0
KatiBandar	30m	K	1.7	1.9	2.4	3.1	2.8	2.8	2.3	3.1	2.9	1.6	2.0	1.8	1.9
Sajawal	30m	K	2.2	2.1	2.1	2.4	2.2	2.6	2.4	3.0	2.5	2.0	2.2	2.4	1.9
Thatta	30m	K	2.0	1.9	2.1	2.6	2.8	2.5	3.6	3.3	2.5	1.6	1.9	2.2	1.9
Jamshoro	30m	K	1.9	1.8	1.8	2.1	2.5	2.7	4.5	3.6	2.8	1.8	1.9	2.2	1.9
Gharo	30m	K	1.7	1.7	1.9	2.7	3.0	2.9	2.8	3.2	2.9	1.6	1.4	1.6	1.8
HawksBay	30m	K	1.4	1.6	1.7	2.1	2.5	2.7	2.8	3.0	2.5	1.3	1.3	1.4	1.8
ChuharJamal	30m	K	1.8	1.8	1.4	1.8	2.4	2.4	2.4	2.4	2.2	1.5	1.6	1.8	1.7
MirpurSakro	30m	K	1.7	1.7	2.0	2.1	2.6	2.3	2.3	2.7	2.4	1.5	1.6	1.8	1.7
Hyderabad	30m	K	1.8	1.8	1.6	2.2	2.3	2.6	2.5	3.0	2.8	1.6	1.7	1.8	1.7
Nooriabad	30m	K	1.7	1.8	1.7	2.1	2.4	2.2	2.4	2.4	2.4	1.5	1.8	1.7	1.6
Matli	30m	K	1.9	1.6	1.5	2.0	2.2	2.1	2.2	2.5	2.2	1.4	1.7	2.0	1.6
Talhar	30m	K	1.5	1.5	1.7	2.4	2.5	2.5	2.3	2.8	2.4	1.3	1.2	1.3	1.6
Badin	30m	K	1.2	1.2	1.3	2.3	2.4	2.4	1.8	2.8	2.2	1.4	1.3	1.2	1.4
Karachi	30m	K	1.1	1.1	1.5	1.8	2.4	2.2	2.0	2.1	2.0	0.9	1.0	1.0	1.3
ThanoBulaKhan	30m	K	1.2	1.2	0.9	1.3	1.5	2.0	2.0	2.1	1.9	0.9	1.0	1.2	1.2
SHAHBANDAR	50m	K	2.4	2.4	2.6	3.0	2.9	2.9	2.9	3.2	2.8	2.1	2.4	2.6	2.3
Jati	50m	K	2.2	2.2	2.5	2.9	2.9	2.7	2.9	3.2	2.8	2.0	2.1	2.3	2.2
Baghan	50m	K	2.2	2.2	2.6	2.7	2.7	2.6	2.6	2.9	2.5	2.1	2.2	2.4	2.1
KatiBandar	50m	K	1.7	2.0	2.4	3.3	3.0	2.8	2.5	3.2	3.0	1.8	2.0	1.8	2.0
DHA Karachi	50m	K	1.8	2.1	2.4	2.9	3.3	3.0	3.4	3.2	2.9	1.8	1.8	1.7	2.0
Golarchi	50m	K	2.2	2.1	2.1	2.4	2.7	2.8	2.5	2.9	2.7	1.8	1.7	2.2	2.0
Sajawal	50m	K	2.1	2.1	2.2	2.6	2.4	2.8	2.5	3.2	2.7	1.9	2.0	2.2	2.0
Gharo	50m	K	1.7	1.8	2.0	2.9	3.2	3.0	2.9	3.3	3.0	1.7	1.5	1.6	1.9
Thatta	50m	K	1.9	1.8	1.9	2.5	2.8	2.6	3.4	3.2	2.5	1.6	1.7	2.0	1.9
Jamshoro	50m	K	1.8	1.7	1.7	2.1	2.5	2.7	4.4	3.4	2.8	1.8	1.7	2.1	1.9
MirpurSakro	50m	K	1.6	1.7	2.0	2.3	2.9	2.4	2.5	2.9	2.6	1.5	1.5	1.7	1.8
HawksBay	50m	K	1.5	1.6	1.7	2.1	2.5	2.7	2.8	3.0	2.6	1.3	1.2	1.4	1.8
ChuharJamal	50m	K	1.6	1.8	1.4	1.8	2.5	2.5	2.4	2.6	2.1	1.5	1.6	1.8	1.8
Hyderabad	50m	K	1.8	1.8	1.6	2.3	2.4	2.7	2.6	3.1	2.9	1.6	1.7	1.8	1.8
Nooriabad	50m	K	1.8	1.9	1.8	2.2	2.5	2.3	2.5	2.5	2.5	1.6	1.8	1.8	1.7
Matli	50m	K	1.6	1.5	1.4	1.9	2.2	2.3	2.3	2.5	2.1	1.3	1.5	1.8	1.6
Talhar	50m	K	1.4	1.4	1.4	2.2	2.5	2.6	2.2	2.6	2.1	1.2	1.1	1.3	1.5
Badin	50m	K	1.1	1.1	1.2	2.3	2.6	2.5	1.8	2.7	2.1	1.3	1.2	1.1	1.4
Karachi	50m	K	1.0	1.1	1.4	1.9	2.6	2.2	2.0	2.0	2.0	0.9	0.9	1.0	1.3
ThanoBulaKhan	50m	K	1.2	1.3	0.9	1.4	1.5	2.1	2.0	2.1	2.0	0.9	1.0	1.2	1.2

3.7.6 Average Standard Deviation:

In Table-16 monthly average 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 and log law as explained in the earlier section.

Table-16		Monthly Standard deviation of Wind Speed of different stations in Sindh													
Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nooriabad	10m	Stdev	2.4	2.3	2.5	2.9	3.2	3.7	3.3	3.0	2.7	2.2	2.0	2.4	3.4
ChuharJamal	10m	Stdev	3.0	2.8	2.8	3.2	3.1	3.4	3.2	3.7	3.1	2.4	2.3	2.7	3.2
Jamshoro	10m	Stdev	1.7	1.8	1.9	2.2	2.6	2.8	2.0	2.1	2.3	1.7	1.3	1.6	3.1
KatiBandar	10m	Stdev	2.2	2.4	2.4	2.4	2.6	3.1	3.3	2.2	2.1	2.4	1.6	2.3	3.1
Hyderabad	10m	Stdev	1.9	1.9	2.1	2.3	2.8	2.8	2.7	2.3	2.2	1.9	1.7	1.9	2.9
ThanoBulaKhan	10m	Stdev	1.9	2.0	2.0	2.6	3.1	2.9	3.1	2.6	2.5	1.6	1.6	2.0	2.9
Gharo	10m	Stdev	1.8	2.0	2.1	2.3	2.4	2.4	2.4	2.2	2.2	1.9	1.6	1.8	2.8
HawksBay	10m	Stdev	2.4	2.5	2.6	2.9	2.7	2.4	2.3	2.1	2.2	2.4	2.2	2.4	2.7
MirpurSakro	10m	Stdev	1.4	1.7	1.9	2.5	2.5	2.6	2.5	2.3	2.3	1.4	1.0	1.4	2.6
ShahBander	10m	Stdev	1.6	1.8	1.9	2.1	2.5	2.5	2.4	2.1	2.1	1.7	1.3	1.6	2.6
DHA Karachi	10m	Stdev	1.7	1.8	1.9	2.1	2.0	2.1	3.4	2.5	2.2	1.8	1.6	1.5	2.4
Karachi	10m	Stdev	1.1	1.1	2.5	2.1	2.1	3.0	2.8	1.9	1.8	1.2	0.9	1.0	2.3
Jati	10m	Stdev	1.2	1.4	1.5	1.9	2.0	2.2	2.0	1.9	1.7	1.1	0.9	1.2	2.0
Badin	10m	Stdev	0.8	1.1	1.1	1.8	2.2	2.2	2.2	1.9	2.1	0.7	1.1	0.9	2.0
Sajawal	10m	Stdev	1.0	1.2	1.5	1.9	2.2	2.1	1.8	1.7	1.8	1.0	0.8	1.0	1.9
Thatta	10m	Stdev	1.0	1.1	1.2	1.4	1.6	1.9	1.5	1.5	1.5	1.0	0.7	0.9	1.7
Golarchi	10m	Stdev	1.3	1.3	1.1	1.5	1.6	1.7	1.7	1.4	1.4	1.0	1.7	1.2	1.7
Baghan	10m	Stdev	1.3	1.4	1.4	1.7	1.7	1.7	1.7	1.7	1.7	1.5	1.4	1.4	1.7
Talhar	10m	Stdev	1.4	1.4	1.2	1.7	2.0	2.0	1.8	1.6	1.2	1.0	0.9	1.3	1.6
Matli	10m	Stdev	1.1	1.1	0.9	1.2	1.7	1.8	1.7	1.4	1.4	0.9	0.9	1.2	1.5
Nooriabad	30m	Stdev	2.6	2.5	2.7	3.4	3.8	4.5	4.1	3.8	3.3	2.5	2.2	2.5	3.9
Jamshoro	30m	Stdev	2.6	2.7	3.0	3.4	3.6	4.1	2.9	3.2	3.1	2.6	2.4	2.4	3.9
ThanoBulaKhan	30m	Stdev	2.4	2.6	2.7	3.4	4.1	3.8	4.0	3.4	3.1	2.2	2.1	2.5	3.7
Hyderabad	30m	Stdev	2.2	2.2	2.4	2.7	3.6	3.6	3.7	2.8	2.6	2.1	2.0	2.2	3.5
KatiBandar	30m	Stdev	2.5	2.6	2.3	2.6	3.2	3.3	4.1	2.7	2.4	2.7	1.8	2.5	3.4
Gharo	30m	Stdev	2.3	2.4	2.3	2.5	2.9	3.1	3.1	2.6	2.6	2.2	2.2	2.3	3.3
ChuharJamal	30m	Stdev	2.4	2.4	2.8	3.0	2.9	3.2	3.1	2.9	2.6	2.3	2.3	2.3	3.0
MirpurSakro	30m	Stdev	2.1	2.2	2.1	2.5	2.9	3.3	3.3	2.7	2.4	2.1	1.9	2.1	3.0
Talhar	30m	Stdev	1.9	2.1	2.2	2.4	3.0	3.1	3.0	2.4	2.3	2.0	1.8	1.9	3.0
HawksBay	30m	Stdev	2.6	2.7	3.0	3.0	2.8	2.6	2.6	2.1	2.2	2.7	2.4	2.7	2.9
Badin	30m	Stdev	1.9	2.0	1.9	2.3	2.8	3.1	3.3	2.2	2.2	1.8	1.7	1.9	2.9
Thatta	30m	Stdev	1.9	1.9	2.0	2.2	2.5	3.0	2.3	2.5	2.4	1.9	1.7	1.8	2.8
Karachi	30m	Stdev	1.8	1.9	2.3	2.6	2.4	2.8	2.8	2.3	2.1	1.9	1.5	2.0	2.7
Sajawal	30m	Stdev	1.7	1.9	2.1	2.5	3.2	3.0	2.8	2.5	2.4	1.7	1.5	1.6	2.7
SHAHBANDAR	30m	Stdev	1.8	1.9	1.9	2.2	2.7	2.9	2.8	2.4	2.2	2.0	1.6	1.7	2.7
Matli	30m	Stdev	1.7	1.9	2.1	2.2	2.8	3.2	2.9	2.2	2.2	1.7	1.6	1.7	2.6
DHA Karachi	30m	Stdev	2.0	2.1	2.1	2.3	2.2	2.5	1.7	2.0	1.9	2.2	1.7	2.0	2.6
Golarchi	30m	Stdev	1.8	1.9	1.8	2.2	2.4	2.7	2.8	2.2	2.0	1.8	2.7	1.7	2.5
Jati	30m	Stdev	1.6	1.8	1.8	2.1	2.5	3.0	2.6	2.4	2.2	1.7	1.5	1.6	2.5
Baghan	30m	Stdev	1.7	1.8	1.6	2.0	2.4	2.7	2.6	2.4	2.2	1.7	1.5	1.6	2.4
Jamshoro	50m	Stdev	3.4	3.5	3.9	4.2	4.4	4.8	3.5	4.0	3.8	3.5	3.5	3.3	4.7
Talhar	50m	Stdev	2.6	3.0	3.2	3.6	4.3	4.3	4.3	3.6	3.8	2.9	2.6	2.6	4.4
ThanoBulaKhan	50m	Stdev	2.8	3.0	3.3	4.0	4.7	4.3	4.4	3.8	3.6	2.7	2.5	3.0	4.2
Nooriabad	50m	Stdev	2.9	2.8	3.0	3.6	4.0	4.7	4.3	4.0	3.5	2.8	2.6	2.8	4.1
Hyderabad	50m	Stdev	2.6	2.6	2.9	3.0	3.9	4.0	4.0	3.0	2.9	2.5	2.4	2.8	3.9
Matli	50m	Stdev	2.6	2.7	3.1	3.4	3.9	4.1	3.8	3.2	3.2	2.5	2.4	2.4	3.7
Badin	50m	Stdev	2.7	2.8	2.7	2.9	3.4	3.7	4.0	3.0	2.9	2.7	2.4	2.6	3.7
Thatta	50m	Stdev	2.9	2.7	2.9	3.1	3.3	3.8	3.2	3.3	3.2	2.7	2.6	2.7	3.7
Gharo	50m	Stdev	2.8	2.9	2.8	2.8	3.2	3.5	3.4	2.9	2.8	2.7	2.7	2.9	3.7
KatiBandar	50m	Stdev	3.0	3.0	2.7	2.7	3.4	3.6	4.3	3.0	2.6	3.0	2.4	2.9	3.6
ChuharJamal	50m	Stdev	2.9	2.8	3.3	3.5	3.3	3.4	3.5	3.1	3.3	2.8	2.8	2.7	3.5
MirpurSakro	50m	Stdev	2.9	2.9	2.6	2.9	3.1	3.7	3.7	2.9	2.7	2.8	2.7	2.8	3.5
Karachi	50m	Stdev	2.4	2.5	2.9	3.0	2.8	3.3	3.4	3.0	2.7	2.4	2.0	2.7	3.3
Sajawal	50m	Stdev	2.5	2.6	2.7	2.9	3.8	3.5	3.4	2.9	2.8	2.4	2.3	2.4	3.3
Golarchi	50m	Stdev	2.4	2.6	2.5	2.8	3.1	3.5	3.6	2.9	2.5	2.4	3.5	2.5	3.3
Baghan	50m	Stdev	2.3	2.4	2.1	2.7	3.2	3.6	3.4	3.1	2.9	2.1	2.0	2.4	3.2

Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
HawksBay	50m	Stdev	2.9	2.9	3.2	3.2	3.0	2.7	2.7	2.3	2.4	3.0	2.7	3.0	3.2
DHA Karachi	50m	Stdev	2.4	2.4	2.4	2.5	2.4	2.8	3.0	2.7	2.5	2.5	2.1	2.4	3.1
Jati	50m	Stdev	2.4	2.5	2.2	2.5	2.9	3.4	3.0	2.7	2.5	2.3	2.4	2.4	3.0
SHAHBANDAR	50m	Stdev	2.2	2.2	2.1	2.3	2.9	3.1	3.0	2.7	2.4	2.4	2.1	2.2	2.9

3.7.7 Power Density:

The monthly power densities for three different heights 10meters, 30meters and 50meters have also been given in Table-17.

Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nooriabad	10m	P/A(w/m2)	69.2	66.7	82.6	182.7	365.7	500.1	453.5	359.8	240.3	51.6	42.6	68.5	220.6
ChuharJamal	10m	P/A(w/m2)	153.3	114.2	115.3	159.8	186.3	239.9	210.9	255.5	156.4	103.3	84.0	100.1	168.0
KatiBandar	10m	P/A(w/m2)	56.2	67.1	66.9	159.5	291.7	343.3	389.1	218.0	122.6	67.3	20.3	60.7	162.8
Jamshoro	10m	P/A(w/m2)	27.2	29.3	38.5	80.9	161.8	284.0	353.1	242.9	144.0	25.8	13.7	23.5	160.0
Hyderabad	10m	P/A(w/m2)	35.1	34.4	46.0	84.2	202.3	277.0	264.7	175.4	133.9	31.8	24.7	35.4	123.3
ThanoBulaKhan	10m	P/A(w/m2)	38.5	40.3	54.8	84.6	161.6	188.5	230.6	137.5	94.7	31.5	30.4	49.3	116.8
HawksBay	10m	P/A(w/m2)	68.7	77.3	105.1	179.1	194.6	180.5	172.7	126.9	91.8	64.1	55.8	68.3	116.6
Gharo	10m	P/A(w/m2)	30.0	37.6	46.3	97.3	193.2	213.8	192.8	165.6	119.2	33.5	24.0	33.0	110.2
SHAHBANDAR	10m	P/A(w/m2)	24.3	35.2	48.0	106.6	228.8	247.6	220.9	194.0	106.2	27.6	14.9	24.3	108.2
MirpurSakro	10m	P/A(w/m2)	17.2	29.7	39.6	75.8	132.1	139.7	131.3	106.7	76.6	18.8	6.6	19.0	86.2
DHA Karachi	10m	P/A(w/m2)	25.6	31.3	40.8	70.5	105.1	128.0	215.8	87.3	70.5	29.7	20.1	15.6	72.6
Karachi	10m	P/A(w/m2)	7.5	8.1	97.2	49.4	67.3	136.4	112.8	34.2	29.1	10.8	4.1	5.2	61.8
Jati	10m	P/A(w/m2)	9.6	15.5	19.3	43.6	83.5	117.5	92.6	85.3	39.4	8.1	4.8	8.7	44.9
Badin	10m	P/A(w/m2)	2.3	8.5	7.5	31.0	70.3	79.4	62.1	40.9	44.2	2.0	8.4	3.7	42.3
Sajawal	10m	P/A(w/m2)	6.0	9.4	16.7	41.9	86.7	74.7	40.7	54.0	34.9	5.1	3.0	5.8	34.0
Golarchi	10m	P/A(w/m2)	11.2	12.1	7.8	22.4	42.0	73.6	53.3	36.8	19.9	5.8	23.9	9.2	26.9
Thatta	10m	P/A(w/m2)	5.4	5.8	8.3	19.8	37.3	60.3	59.4	47.8	25.6	5.4	1.7	3.9	26.3
Baghan	10m	P/A(w/m2)	10.9	12.6	14.7	26.8	37.0	39.7	38.1	40.6	31.4	15.1	14.0	13.1	25.3
Talhar	10m	P/A(w/m2)	14.6	15.6	9.6	23.9	39.2	43.1	31.5	19.9	8.3	9.3	5.2	13.1	23.5
Matli	10m	P/A(w/m2)	6.9	7.5	3.6	9.0	23.7	33.6	26.2	16.3	12.2	3.8	3.9	10.3	15.6
Jamshoro	30m	P/A(w/m2)	128.0	124.9	179.7	341.3	578.3	985.4	1246.0	908.3	498.5	125.2	105.6	136.3	423.8
Nooriabad	30m	P/A(w/m2)	109.7	105.0	127.5	319.4	617.0	858.5	791.6	634.2	401.7	88.7	73.5	104.1	361.3
KatiBandar	30m	P/A(w/m2)	102.8	131.3	137.3	336.1	522.2	534.4	724.1	428.5	234.9	111.5	50.6	102.8	281.3
Hyderabad	30m	P/A(w/m2)	68.6	68.1	81.5	184.0	474.1	644.0	635.2	372.7	290.4	54.5	47.8	74.9	253.9
ThanoBulaKhan	30m	P/A(w/m2)	64.6	82.1	124.9	195.7	375.2	459.7	486.1	318.8	226.8	62.2	46.5	75.2	242.9
Gharo	30m	P/A(w/m2)	73.1	84.6	94.2	228.8	472.8	499.7	461.3	387.5	277.4	67.0	54.6	72.3	232.7
ChuharJamal	30m	P/A(w/m2)	88.2	91.6	115.6	184.6	290.2	352.6	329.4	266.1	159.5	64.9	66.7	84.9	176.7
SHAHBANDAR	30m	P/A(w/m2)	66.4	73.7	87.1	168.8	334.5	388.2	364.8	315.7	165.0	64.3	50.0	69.4	173.5
MirpurSakro	30m	P/A(w/m2)	58.6	68.5	69.7	148.7	320.2	380.1	380.9	267.3	169.8	51.6	39.1	59.5	170.5
HawksBay	30m	P/A(w/m2)	95.7	107.7	161.1	237.3	269.2	246.1	258.3	172.1	127.4	93.6	66.2	98.8	160.7
Thatta	30m	P/A(w/m2)	57.9	49.3	68.0	141.5	246.6	336.1	365.3	331.7	162.3	43.0	33.1	51.1	155.2
Talhar	30m	P/A(w/m2)	36.8	54.0	65.8	149.2	332.0	370.1	265.2	201.7	127.3	40.4	29.7	37.1	147.0
Sajawal	30m	P/A(w/m2)	49.0	57.8	78.1	168.7	334.9	353.3	243.2	275.1	165.1	38.2	34.8	47.5	144.5
DHA Karachi	30m	P/A(w/m2)	53.3	68.3	91.8	159.2	229.5	276.9	312.9	229.1	141.1	63.1	33.7	45.0	139.1
Jati	30m	P/A(w/m2)	52.5	64.2	69.6	142.5	248.6	356.6	282.0	259.8	133.9	42.9	39.0	53.6	136.4
Golarchi	30m	P/A(w/m2)	62.2	65.7	57.2	118.8	216.1	351.0	279.0	202.2	116.9	38.5	121.7	58.6	135.5
Badin	30m	P/A(w/m2)	32.1	40.0	33.0	121.3	269.5	326.7	243.7	171.5	103.5	31.0	25.9	31.2	127.1
Baghan	30m	P/A(w/m2)	49.5	55.5	60.8	124.8	200.5	260.4	234.0	226.6	133.6	41.5	35.9	57.0	120.2
Matli	30m	P/A(w/m2)	35.7	39.4	49.7	89.9	205.0	290.6	224.1	137.5	100.8	27.1	27.0	35.7	106.9
Karachi	30m	P/A(w/m2)	30.3	31.1	64.9	113.7	166.9	207.4	171.8	107.8	79.8	38.1	16.0	38.6	99.3
Jamshoro	50m	P/A(w/m2)	277.3	261.0	372.9	644.1	1008.3	1619.3	2102.0	1606.9	859.0	280.0	274.9	315.0	770.5
Nooriabad	50m	P/A(w/m2)	159.7	149.6	178.9	420.5	772.8	1028.0	981.3	784.3	507.7	130.3	115.9	153.0	454.2
Talhar	50m	P/A(w/m2)	88.2	143.2	167.4	460.8	959.7	1030.2	750.8	643.7	461.8	120.3	81.0	90.5	445.4
KatiBandar	50m	P/A(w/m2)	171.9	206.8	239.7	494.0	710.9	716.4	929.7	582.6	336.0	171.2	103.4	168.5	395.9
Thatta	50m	P/A(w/m2)	176.3	137.7	193.6	364.0	584.8	720.9	807.1	769.8	380.8	115.6	105.9	156.1	374.3
ThanoBulaKhan	50m	P/A(w/m2)	111.7	134.1	233.1	323.8	571.0	682.6	704.6	502.4	376.1	117.8	86.9	127.2	373.5
Hyderabad	50m	P/A(w/m2)	121.2	113.8	137.3	283.4	686.6	908.3	887.0	532.4	426.5	96.2	87.8	149.5	371.5
Gharo	50m	P/A(w/m2)	139.3	162.0	167.4	363.7	712.0	730.4	685.4	575.6	420.6	125.9	110.0	146.4	359.5
Sajawal	50m	P/A(w/m2)	133.4	145.0	186.2	337.7	607.7	679.4	505.4	538.1	328.4	100.3	101.9	130.4	298.6
Matli	50m	P/A(w/m2)	101.0	106.7	160.9	279.4	552.6	696.1	577.2	384.2	285.4	78.0	77.7	94.7	292.9
MirpurSakro	50m	P/A(w/m2)	144.9	148.1	138.3	249.9	498.6	593.8	612.1	417.7	269.6	118.1	103.7	146.6	287.8

Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Golarchi	50m	P/A(w/m ²)	141.5	147.3	137.6	248.6	428.4	683.5	560.3	404.5	239.7	92.5	268.2	141.3	282.0
Baghan	50m	P/A(w/m ²)	120.5	127.6	133.5	281.1	458.3	616.8	549.6	515.9	286.4	85.4	74.0	145.5	275.9
ChuharJamal	50m	P/A(w/m ²)	144.3	158.0	176.4	284.7	432.2	503.7	490.5	404.4	309.8	113.0	117.6	138.5	275.8
Badin	50m	P/A(w/m ²)	102.0	111.5	93.8	269.0	513.0	605.5	457.6	383.6	218.7	92.5	64.5	89.8	265.2
Jati	50m	P/A(w/m ²)	137.9	146.5	143.5	266.0	411.4	582.6	465.6	427.5	235.9	96.0	112.4	151.5	252.1
SHAHBANDAR	50m	P/A(w/m ²)	128.2	127.7	134.5	231.2	432.5	509.3	479.4	420.4	221.1	112.5	106.3	140.2	247.3
DHA Karachi	50m	P/A(w/m ²)	89.7	114.0	151.9	251.0	346.4	404.5	620.3	447.6	257.8	103.9	65.2	83.6	240.5
HawksBay	50m	P/A(w/m ²)	132.4	142.3	213.1	297.6	346.4	304.7	331.8	218.6	167.4	130.4	100.2	137.4	208.6
Karachi	50m	P/A(w/m ²)	70.7	73.6	126.6	191.0	275.1	355.5	321.3	219.1	157.5	91.2	47.2	115.1	185.4

3.7.8 Average monthly Surface roughness:

The monthly surface roughness for different station in Sindh have also been given in Table-18D.

Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Badin	10m	Zo	5.592	24.031	5.648	4.363	2.557	2.080	2.124	3.617	3.144	8.136	6.041	20.100	7.286
Matli	10m	Zo	6.257	6.081	8.530	7.081	5.373	4.522	4.960	5.222	5.916	7.356	6.979	6.682	6.247
Talhar	10m	Zo	4.342	5.258	7.834	6.246	5.604	4.972	5.783	6.038	7.336	8.323	7.577	5.017	6.194
Thatta	10m	Zo	6.722	5.848	5.234	4.140	3.447	2.856	2.798	3.155	3.458	5.851	7.450	7.342	4.858
ChuharJamal	10m	Zo	4.394	4.925	6.089	3.630	2.654	1.168	1.396	2.955	4.167	6.546	7.371	5.538	4.236
Sajawal	10m	Zo	5.489	5.160	4.609	3.361	2.216	2.434	3.340	2.561	3.143	5.682	6.603	5.697	4.191
MirpurSakro	10m	Zo	6.477	5.745	4.632	1.365	0.897	0.895	1.330	0.890	1.193	6.758	7.659	6.960	3.733
Baghan	10m	Zo	4.235	4.422	3.815	3.487	3.120	3.294	3.155	3.315	2.799	2.805	4.079	3.201	3.477
Golarchi	10m	Zo	4.039	3.854	4.145	2.560	2.444	2.059	2.401	2.375	3.054	4.700	4.020	4.439	3.341
Karachi	10m	Zo	5.334	4.879	2.126	2.091	1.203	0.946	0.911	2.242	2.360	3.565	5.762	6.148	3.131
Jati	10m	Zo	4.262	3.486	2.725	2.374	1.338	1.165	1.137	0.912	1.429	2.952	4.827	4.574	2.599
Jamshoro	10m	Zo	2.863	2.423	2.704	1.972	1.412	1.224	1.219	1.330	1.237	3.326	4.013	3.401	2.260
Gharo	10m	Zo	3.213	3.177	2.732	1.009	0.531	0.380	0.523	0.453	0.515	3.594	4.526	4.839	2.124
ThanoBulaKhan	10m	Zo	1.621	1.421	1.266	1.814	0.625	0.627	0.694	0.812	1.269	3.500	1.952	2.095	1.474
DHA Karachi	10m	Zo	1.532	1.376	1.333	0.789	0.445	0.303	1.485	2.914	1.349	1.359	1.805	2.441	1.428
Hyderabad	10m	Zo	1.794	1.442	2.118	0.820	0.475	0.339	0.407	0.281	0.357	2.309	2.539	3.094	1.331
KatiBandar	10m	Zo	0.981	1.281	1.207	0.420	0.087	0.061	1.355	0.128	0.221	1.743	2.974	1.306	0.980
Nooriabad	10m	Zo	0.981	1.281	1.207	0.420	0.087	0.061	1.355	0.128	0.221	1.743	2.974	1.306	0.980
SHAHBANDAR	10m	Zo	1.535	0.919	0.405	0.047	0.007	0.039	0.042	0.054	0.064	0.938	2.108	1.769	0.661
HawksBay	10m	Zo	0.139	0.059	0.007	0.007	0.008	0.001	0.017	0.005	0.021	0.124	0.420	0.205	0.084

3.7.9 Average monthly temperature:

The monthly average temperature at 10, 30, 50m height for different stations in Sindh have also been given in Table-19.

Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Hyderabad	10m	Temp	21.9	24.8	32.0	35.3	37.2	36.6	32.9	33.1	33.5	32.1	27.9	24.6	31.0
Jamshoro	10m	Temp	17.2	21.4	28.2	31.8	33.8	34.0	32.1	30.9	26.7	28.5	23.6	18.9	27.3
ThanoBulaKhan	10m	Temp	17.0	20.5	26.7	31.1	32.4	32.4	30.3	29.5	28.9	28.4	23.4	18.7	26.6
ChuharJamal	10m	Temp	18.3	21.1	25.8	29.1	30.8	31.7	30.1	29.1	28.5	27.9	23.9	19.7	26.3
Karachi	10m	Temp	19.0	21.9	25.4	28.6	29.8	30.7	29.1	28.7	28.1	28.1	25.4	21.0	26.3
Golarchi	10m	Temp	17.6	21.0	25.7	29.4	31.0	31.5	30.0	28.6	27.9	27.5	25.7	19.2	26.3

Table-19		Monthly Average Temperature at different stations in Sindh													
Station	Height	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
DHA Karachi	10m	Temp	19.6	21.5	25.2	27.6	29.5	30.8	29.3	27.9	27.3	26.8	24.6	21.1	25.9
Sajawal	10m	Temp	18.0	20.8	25.7	28.7	30.3	30.8	29.3	28.4	27.4	27.4	23.7	19.6	25.8
MirpurSakro	10m	Temp	18.0	21.4	25.1	28.2	29.8	30.6	29.2	28.2	27.5	27.4	23.6	19.5	25.7
Baghan	10m	Temp	17.7	20.9	24.8	28.1	29.6	30.9	29.7	28.7	28.2	27.2	23.2	19.1	25.7
Badin	10m	Temp	16.7	20.1	25.6	29.4	31.1	31.4	30.1	28.2	27.7	27.2	22.4	18.2	25.7
SHAHBANDAR	10m	Temp	17.9	20.7	25.1	28.1	29.1	29.9	28.8	27.7	27.3	27.3	23.5	19.5	25.4
Talhar	10m	Temp	16.2	19.5	25.3	29.4	31.0	31.1	29.7	28.0	27.2	26.4	21.8	17.8	25.3
Gharo	10m	Temp	17.9	20.6	24.7	27.3	28.7	29.5	28.2	27.3	26.7	26.7	23.3	19.5	25.0
HawksBay	10m	Temp	19.1	20.7	24.1	27.0	27.9	28.7	27.8	26.5	25.8	26.5	24.4	21.0	25.0
Jati	10m	Temp	16.8	19.8	24.5	27.8	29.2	30.0	28.4	27.3	26.8	26.3	22.3	18.4	24.8
KatiBandar	10m	Temp	18.0	20.3	24.0	26.4	27.8	28.7	27.6	26.7	26.2	26.4	23.5	19.7	24.6
Nooriabad	10m	Temp	18.0	20.3	24.0	26.4	27.8	28.7	27.6	26.7	26.2	26.4	23.5	19.7	24.6
Thatta	10m	Temp	17.0	21.1	26.1	26.6	22.7	30.4	28.8	27.6	27.4	27.1	21.5	17.3	24.5
Matli	10m	Temp	14.8	17.6	23.8	26.2	28.4	27.5	25.4	24.6	23.9	23.8	20.0	16.1	22.7
Hyderabad	30m	Temp	21.8	24.7	32.0	35.3	37.1	36.6	32.8	33.1	33.5	32.0	27.9	24.6	31.0
Jamshoro	30m	Temp	17.2	21.3	28.1	31.7	33.8	34.0	32.1	30.9	26.6	28.4	23.6	18.9	27.2
ThanoBulaKhan	30m	Temp	17.0	20.4	26.6	31.0	32.4	32.3	30.3	29.5	28.9	28.4	23.3	18.7	26.6
ChuharJamal	30m	Temp	18.3	21.1	25.8	29.1	30.8	31.6	30.1	29.0	28.5	27.9	23.8	19.7	26.3
Karachi	30m	Temp	19.0	21.8	25.4	28.5	29.8	30.7	29.0	28.7	28.0	28.1	25.4	21.0	26.3
Golarchi	30m	Temp	17.6	21.0	25.7	29.3	30.9	31.5	29.9	28.6	27.8	27.5	25.7	19.2	26.2
DHA Karachi	30m	Temp	19.6	21.5	25.2	27.5	29.4	30.8	29.3	27.8	27.2	26.7	24.6	21.0	25.9
Sajawal	30m	Temp	18.0	20.8	25.7	28.6	30.2	30.8	29.2	28.4	27.4	27.3	23.7	19.6	25.8
MirpurSakro	30m	Temp	17.9	21.4	25.1	28.2	29.7	30.6	29.2	28.1	27.5	27.3	23.6	19.5	25.7
Baghan	30m	Temp	17.7	20.9	24.8	28.0	29.6	30.8	29.7	28.7	28.2	27.1	23.1	19.0	25.6
Badin	30m	Temp	16.6	20.1	25.6	29.4	31.0	31.3	30.1	28.1	27.7	27.1	22.4	18.2	25.6
SHAHBANDAR	30m	Temp	17.9	20.7	25.0	28.1	29.0	29.8	28.8	27.6	27.2	27.2	23.4	19.4	25.3
Talhar	30m	Temp	16.2	19.5	25.2	29.3	31.0	31.0	29.7	28.0	27.2	26.3	21.8	17.8	25.2
Gharo	30m	Temp	17.8	20.6	24.7	27.3	28.7	29.4	28.2	27.3	26.7	26.7	23.3	19.4	25.0
HawksBay	30m	Temp	19.1	20.7	24.1	27.0	27.9	28.7	27.7	26.5	25.8	26.5	24.3	21.0	24.9
Jati	30m	Temp	16.8	19.8	24.4	27.7	29.2	29.9	28.4	27.2	26.8	26.3	22.3	18.3	24.8
KatiBandar	30m	Temp	18.0	20.3	24.0	26.4	27.8	28.7	27.6	26.6	26.1	26.4	23.4	19.6	24.6
Nooriabad	30m	Temp	18.0	20.3	24.0	26.4	27.8	28.7	27.6	26.6	26.1	26.4	23.4	19.6	24.6
Thatta	30m	Temp	17.0	21.0	26.0	26.6	22.6	30.3	28.7	27.6	27.4	27.1	21.5	17.2	24.4
Matli	30m	Temp	14.8	17.6	23.8	26.2	28.4	27.4	25.4	24.5	23.9	23.7	19.9	16.1	22.6
Hyderabad	50m	Temp	21.8	24.7	32.0	35.3	37.1	36.5	32.8	33.1	33.5	32.0	27.8	24.5	30.9
Jamshoro	50m	Temp	17.1	21.3	28.1	31.7	33.7	34.0	32.0	30.8	26.6	28.4	23.5	18.9	27.2
ThanoBulaKhan	50m	Temp	16.9	20.4	26.6	31.0	32.4	32.3	30.3	29.5	28.9	28.4	23.3	18.6	26.5
ChuharJamal	50m	Temp	18.2	21.0	25.7	29.1	30.7	31.6	30.0	29.0	28.4	27.8	23.8	19.7	26.3
Karachi	50m	Temp	19.0	21.8	25.3	28.5	29.7	30.6	29.0	28.6	28.0	28.1	25.3	21.0	26.2
Golarchi	50m	Temp	17.5	21.0	25.6	29.3	30.9	31.4	29.9	28.5	27.8	27.4	25.6	19.1	26.2
DHA Karachi	50m	Temp	19.6	21.4	25.1	27.5	29.4	30.7	29.3	27.8	27.2	26.7	24.6	21.0	25.9
Sajawal	50m	Temp	17.9	20.7	25.6	28.6	30.2	30.7	29.2	28.3	27.3	27.3	23.6	19.5	25.8
MirpurSakro	50m	Temp	17.9	21.4	25.0	28.1	29.7	30.5	29.2	28.1	27.4	27.3	23.5	19.4	25.6
Baghan	50m	Temp	17.6	20.8	24.8	28.0	29.5	30.8	29.6	28.7	28.1	27.1	23.1	19.0	25.6
Badin	50m	Temp	16.6	20.0	25.5	29.4	31.0	31.3	30.0	28.1	27.6	27.1	22.3	18.1	25.6
SHAHBANDAR	50m	Temp	17.9	20.6	25.0	28.0	29.0	29.8	28.7	27.6	27.2	27.2	23.4	19.4	25.3
Talhar	50m	Temp	16.2	19.5	25.2	29.3	30.9	31.0	29.6	27.9	27.2	26.3	21.7	17.7	25.2
Gharo	50m	Temp	17.8	20.5	24.7	27.2	28.7	29.4	28.1	27.2	26.6	26.6	23.3	19.4	25.0
HawksBay	50m	Temp	19.0	20.6	24.0	26.9	27.9	28.6	27.7	26.4	25.7	26.4	24.3	20.9	24.9
Jati	50m	Temp	16.8	19.7	24.4	27.7	29.1	29.9	28.3	27.2	26.8	26.2	22.2	18.3	24.7
KatiBandar	50m	Temp	18.0	20.3	23.9	26.4	27.7	28.6	27.5	26.6	26.1	26.3	23.4	19.6	24.5
Nooriabad	50m	Temp	18.0	20.3	23.9	26.4	27.7	28.6	27.5	26.6	26.1	26.3	23.4	19.6	24.5
Thatta	50m	Temp	17.0	21.0	26.0	26.6	22.6	30.3	28.7	27.6	27.3	27.1	21.4	17.2	24.4
Matli	50m	Temp	14.7	17.6	23.7	26.2	28.3	27.4	25.3	24.5	23.9	23.7	19.9	16.0	22.6

Estimated 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 (Maxwell 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 (Maxwell 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 (Maxwell et al., 2002 Johnson, 1985)

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

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

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

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

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

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

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

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, H_i 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 Counihan offer mathematical solution for ‘fitting’ α to these environments (Manwell et al., 2002).

4.1 Hypothetical Wind Generated Electric Power:

Hypothetical wind generated electric power output at Badin 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 Badin along with the capacity factor are given in table 4

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

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

Table-17	Hypothetical wind generated electric energy output & capacity factor for a Bonus 600/44MK IV Turbine at 50m Height													
Station	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Badin	Input	101	109	90	256	486	573	435	367	209	89	63	89	256
	Output	31	33	29	92	150	162	117	127	76	30	22	28	71
	C.F.	8%	8%	7%	23%	38%	41%	30%	32%	19%	8%	6%	7%	18%
	KWh	35,128	34,688	33,332	100,652	169,143	177,366	132,722	143,276	83,007	34,158	23,907	31,393	947,930
Baghan	Input	119	125	129	269	436	585	523	492	274	82	72	144	266
	Output	47	49	52	100	141	165	157	157	99	32	28	56	91
	C.F.	12%	12%	13%	25%	36%	42%	40%	40%	25%	8%	7%	14%	23%
	KWh	53,028	51,706	58,357	109,103	159,537	180,885	177,553	177,352	107,840	36,242	30,809	63,720	1,208,573
Chuharjamali	Input	143	155	170	271	410	476	466	386	296	108	114	136	265
	Output	50	56	53	85	131	146	141	129	98	38	41	50	84
	C.F.	13%	14%	13%	22%	33%	37%	36%	33%	25%	10%	10%	13%	21%
	KWh	56,149	59,429	59,653	93,412	148,175	159,366	159,544	146,409	107,297	43,116	44,659	57,085	1,112,606
DHA karachi	Input	88	111	147	241	330	383	591	428	247	100	63	82	232
	Output	34	43	58	93	123	134	185	149	94	38	24	31	81
	C.F.	9%	11%	15%	23%	31%	34%	47%	38%	24%	10%	6%	8%	21%
	KWh	38,093	45,784	65,198	101,284	139,480	147,022	209,111	167,988	103,357	42,701	26,423	35,114	1,080,159
Gharo	Input	138	159	162	349	679	695	655	552	404	121	107	144	348
	Output	50	57	60	124	197	193	187	178	140	44	38	51	105
	C.F.	13%	14%	15%	32%	50%	49%	47%	45%	36%	11%	10%	13%	27%
	KWh	56,504	60,056	68,116	136,134	222,477	211,728	210,937	201,031	153,442	49,922	41,243	57,465	1,401,010
Golarchi	Input	140	144	133	237	406	646	532	386	229	89	259	139	271
	Output	55	55	51	87	135	182	156	134	88	34	80	54	91
	C.F.	14%	14%	13%	22%	34%	46%	39%	34%	22%	9%	20%	14%	23%
	KWh	61,753	58,481	57,559	95,105	152,285	199,082	176,299	151,313	95,789	38,192	87,360	61,131	1,215,164
Hawksbay	Input	131	140	207	286	331	291	318	210	161	125	97	135	202
	Output	44	49	69	97	114	106	115	83	63	40	32	44	69
	C.F.	11%	12%	17%	25%	29%	27%	29%	21%	16%	10%	8%	11%	17%
	KWh	50,190	51,873	77,486	105,889	129,247	116,348	130,183	93,874	69,459	45,481	34,977	50,290	916,622

Table-17	Hypothetical wind generated electric energy output & capacity factor for a Bonus 600/44MK IV Turbine at 50m Height													
Hyderabad	Input	118	110	130	265	637	845	835	501	401	91	84	145	352
	Output	44	42	46	93	167	202	199	161	137	34	32	53	100
	C.F.	11%	11%	12%	24%	42%	51%	50%	41%	35%	9%	8%	13%	25%
	KWh	49,960	43,913	51,743	101,994	188,669	220,552	225,185	182,367	150,131	38,075	34,960	59,541	1,332,563
Jamshoro	Input	275	255	356	608	947	1519	1984	1523	825	267	267	311	739
	Output	88	80	100	152	205	249	317	279	206	84	84	102	158
	C.F.	22%	20%	25%	38%	52%	63%	80%	71%	52%	21%	21%	26%	40%
	KWh	99,792	84,562	112,525	166,143	231,516	272,421	358,004	315,505	225,544	95,392	91,822	115,631	2,102,018
Jati	Input	137	144	139	255	392	554	445	410	226	92	110	150	244
	Output	53	56	55	97	136	164	148	144	87	36	43	58	87
	C.F.	14%	14%	14%	25%	34%	42%	37%	36%	22%	9%	11%	15%	22%
	KWh	60,333	59,095	62,394	106,489	153,536	179,300	166,870	162,350	95,152	40,760	46,575	66,049	1,164,833
Karachi	Input	70	72	122	182	262	337	306	209	151	87	46	112	178
	Output	22	23	42	65	96	110	98	74	57	23	14	29	53
	C.F.	6%	6%	11%	16%	24%	28%	25%	19%	14%	6%	4%	7%	13%
	KWh	24,783	24,372	47,172	70,960	108,658	120,437	111,221	83,717	62,170	25,502	15,466	33,141	709,405
Katibander	Input	170	203	232	475	681	684	890	560	323	165	100	166	383
	Output	60	73	86	161	192	188	201	177	119	58	39	60	116
	C.F.	15%	18%	22%	41%	49%	48%	51%	45%	30%	15%	10%	15%	29%
	KWh	67,449	77,006	97,631	176,644	217,222	206,125	227,406	200,573	130,011	66,115	42,610	67,744	1,545,360
Matli	Input	101	106	156	269	528	667	557	372	277	76	76	94	285
	Output	37	38	50	88	146	167	154	124	94	27	28	36	83
	C.F.	9%	10%	13%	22%	37%	42%	39%	32%	24%	7%	7%	9%	21%
	KWh	42,300	39,900	56,695	95,855	165,647	183,089	173,626	140,710	103,374	30,050	30,669	40,416	1,100,877
Mirpursakro	Input	143	145	134	239	474	563	583	399	258	113	101	144	277
	Output	50	52	51	87	153	158	164	136	96	39	36	52	88
	C.F.	13%	13%	13%	22%	39%	40%	41%	35%	24%	10%	9%	13%	22%
	KWh	56,899	54,806	57,477	95,348	172,722	173,234	184,996	154,178	105,186	44,412	39,363	58,874	1,174,084

Table-17	Hypothetical wind generated electric energy output & capacity factor for a Bonus 600/44MK IV Turbine at 50m Height													
Nooriabad	Input	158	147	174	404	740	981	940	754	489	125	113	150	439
	Output	57	54	61	124	185	199	208	187	148	44	42	55	114
	C.F.	14%	14%	15%	31%	47%	50%	53%	47%	37%	11%	11%	14%	29%
	KWh	64,347	57,191	68,675	135,313	208,651	217,701	234,705	211,920	161,654	50,056	46,219	62,254	1,524,546
Sajawal	Input	132	142	180	322	577	644	481	514	315	96	99	128	288
	Output	51	54	67	114	159	180	147	168	113	37	38	50	95
	C.F.	13%	14%	17%	29%	40%	46%	37%	43%	29%	9%	10%	13%	24%
	KWh	57,683	57,303	76,028	124,456	180,110	197,355	166,433	189,930	123,460	41,931	42,031	56,758	1,266,331
Shahbander	Input	127	125	130	221	412	484	457	403	212	108	103	138	239
	Output	50	50	52	86	140	156	151	143	82	42	41	55	87
	C.F.	13%	13%	13%	22%	36%	39%	38%	36%	21%	11%	10%	14%	22%
	KWh	56,887	52,568	58,778	94,621	158,856	170,368	170,424	161,151	90,239	47,532	44,844	62,111	1,159,571
Talhar	Input	88	141	162	439	909	975	714	616	443	116	79	90	430
	Output	31	47	51	132	202	211	172	173	129	37	26	30	99
	C.F.	8%	12%	13%	33%	51%	53%	43%	44%	33%	9%	7%	8%	25%
	KWh	35,566	49,334	57,892	144,246	228,142	230,883	193,997	195,526	140,639	41,521	28,263	34,369	1,316,039
Thanubulakhan	Input	111	132	215	307	538	644	669	478	359	112	84	126	358
	Output	35	41	39	77	112	157	158	135	109	28	24	38	78
	C.F.	9%	10%	10%	19%	28%	40%	40%	34%	28%	7%	6%	10%	20%
	KWh	39,886	43,405	44,054	84,168	127,071	171,533	178,359	152,219	119,008	31,667	26,787	43,033	1,033,512
Thatta	Input	175	135	186	350	570	684	770	737	365	111	104	155	362
	Output	63	50	67	118	172	181	216	205	122	40	39	58	108
	C.F.	16%	13%	17%	30%	44%	46%	55%	52%	31%	10%	10%	15%	27%
	KWh	71,169	52,763	75,646	129,534	194,563	198,011	244,126	232,067	133,455	44,946	42,306	65,790	1,439,669

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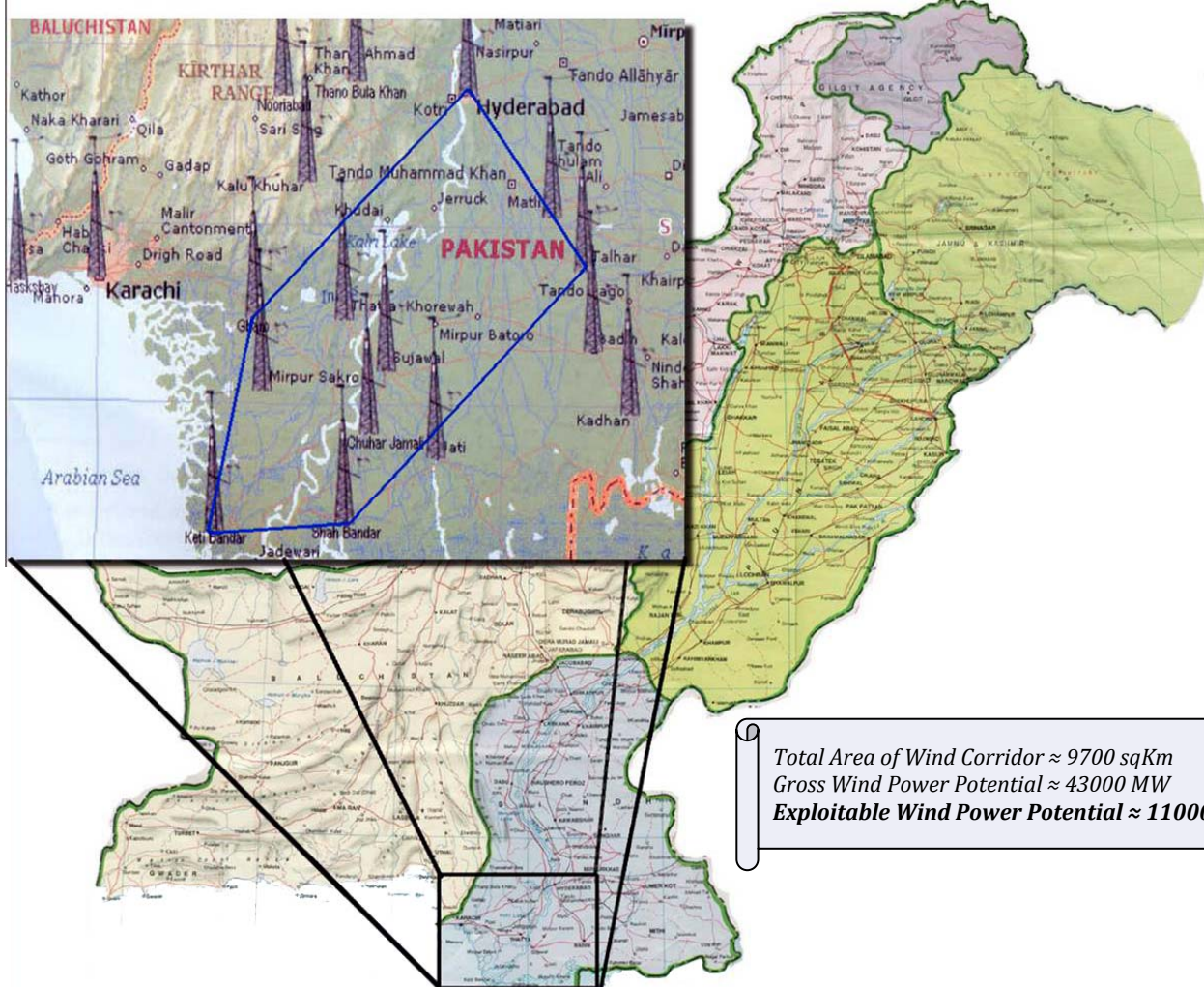
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 - (iv) Karachi Technical Report No. PMD-23/2004

Appendix

Detail of Stations and Period of Data used in the study.

S.No	Station Name	Length of Period
1	Badin	Mar 2002 to Feb 2005
2	Baghan	Sep 2002 to Aug 2005
3	ChuharJamali	Mar 2002 to Feb 2005
4	D.H.A.Karachi	Sep 2003 to Aug 2005
5	Gharo	Apr 2002 to Mar 2005
6	Golarchi	Jun 2002 to May 2005
7	HawksBay	Mar 2002 to Feb 2005
8	Hyderabad	Mar 2002 to Feb 2005
9	Jamshoro	Sep 2003 to Aug 2005
10	Jati	Sep 2002 to Aug 2005
11	Karachi	Apr 2002 to Mar 2005
12	KatiBandar	Mar 2002 to Feb 2005
13	Matli	Mar 2002 to Feb 2005
14	MirpurSakro	Mar 2002 to Feb 2005
15	Nooriabad	Mar 2002 to Feb 2005
16	Sajawal	Mar 2002 to Feb 2005
17	ShahBandar	Mar 2002 to Feb 2005
18	Talhar	Mar 2002 to Feb 2005
19	ThanoBulaKhan	Mar 2002 to Feb 2005
20	Thatta	Sep 2003 to Aug 2005

Sindh Wind Corridor



Total Area of Wind Corridor \approx 9700 sqKm
Gross Wind Power Potential \approx 43000 MW
Exploitable Wind Power Potential \approx 11000 MW

WIND MAPPING PROJECT

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