

# WIND FARM AT GHARO, PAKISTAN: BASIS FOR SITE SELECTION

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## ABSTRACT.

Despite of tremendous growth in wind energy internationally, the technology did not pickup in Pakistan due to several factors and most significant of them being wind speed data and suitable wind regime. All international agencies/ investors required accurate wind data to even initiate feasibility studies. Wind speeds data was being collected all over the country at different heights from 2 meters to 10 meters for decades in Pakistan. This data was initially simulated to standard height of 30 meters and Wind maps for the country were prepared for each month based on monthly average wind speeds. Simultaneously a major project was initiated by the Ministry of Science and Technology through Pakistan Meteorological Department to collect data at 40 different locations astride coastal belt at suitable locations highlighted by the first study at a height of 10 meters and 30 meters. It was ensured that the data is collected in such a way that inland depth of wind belt/ high wind zone is also ascertained <sup>[1]</sup>.

This measured data was analyzed for high wind speeds months suitable for wind power generation and potential<sup>1</sup> wind regime was ascertained. This paper high lights these facts and clearly points out at a significant potential zone about 165 kilometers long in the predominant direction of wind and about 65 kilometers long for utilizing wind energy in the country <sup>[1]</sup>. The area of Gharo is located in this zone. This site has all the benefits like open flat terrain and homogenous topography, unobstructed layout, future expansion potential, near to the coast, in close proximity of Port Qasim and accessible through road structure.

## KEY WORDS

Site Selection, Wind speed, Land site features, Grid loading

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## 1. INTRODUCTION.

Gharo is small town located around 30 kilometers East of Karachi, Pakistan. This area is close to Pakistan Steel Mills that had a captive demand of electrical power of 210 MW for which the only energy distributing company (Karachi Electric Supply Company) showed its inability to provide requisite power due to its acute shortage of electrical power in the city of Karachi. While looking at different alternatives, Pakistan Steel Mills decided to evaluate the feasibility of utilizing wind power. The wind speed data was being recorded by Pakistan Meteorological Department at 26 [2] weather monitoring stations spread all over the country for around 50 years. The original data was recorded at different heights above ground and was simulated to standard height of 30 meters for each month that indicated high wind speed zone near Gharo. This initiative was followed by series of positive steps to collect wind data in the

country all along suitable regimes identified by this study.

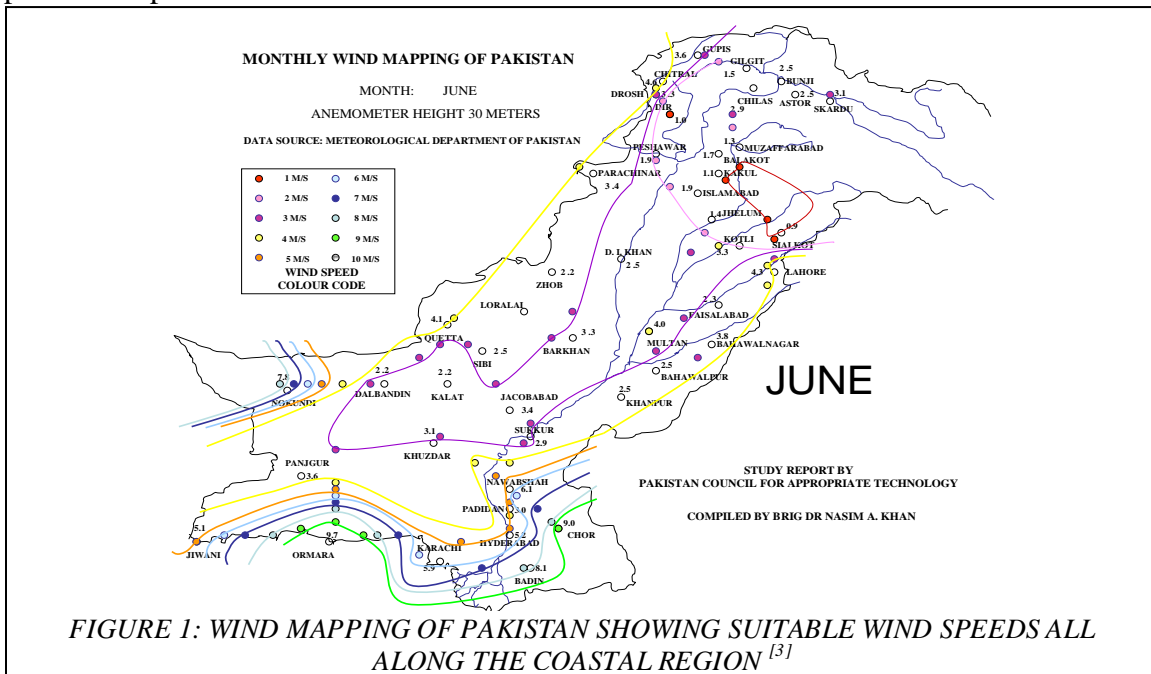
## 2. BASIS OF SITE SELECTION

Selection of site for wind power projects is a complex job. Various factors are involved that need to be addressed before finalizing the location where the project is proposed. Gharo site was selected on the basis of studies that revealed that the site has outstanding wind characteristics and adequate site features. An insight of features analyzed under this study is given under following headings.

### Wind Characteristics

#### 2.1.1 Suitable Wind Speeds.

Suitable wind speeds for power generation are available all along the coastal belt of Pakistan, as can be seen from wind map of June in Figure-1.



Wind mapping of Pakistan has also been done by National Renewable Energy Laboratory (NREL). The map developed as a result of this study as shown in Figure -2 validates the results of above shown mapping and indicates the potential wind corridors in the country. The map clearly indicates that the Gharo site is located within the vicinity of one of the best wind corridors in the country i.e. Gharo ~ Kati Bander Wind Corridor.

### 2.1.3 Suitable Wind Regime.

Initially the entire coastal belt was considered to have suitable wind regime, however detailed analysis of the data recorded by Pakistan Meteorological Department revealed that there is significant difference in wind speeds between the coastal belt in hilly Balochistan and deserts of Sindh [3]. Wind speeds in South Eastern zone that

### 2.1.2 Monthly Average Wind Speeds.

The Monthly Average Wind Speeds (MAWS) of the area as given in Table-1 [5] below portrays true picture of potential available at the site for generation of power through wind energy. In accordance with the international standards set forth for grading of sites as per wind speeds, the site is graded as an excellent site.

mainly includes coastal belt in Sindh, inland areas adjoining to the coast, districts of Balochistan near to Karachi and desert areas of Sindh Province, have been recorded much higher than the wind speeds in South Western Zone that includes all along the coast of Balochistan province. A comparison of this data at a height of 30 meters is shown in Figure-3 [3] below.

**TABLE 1: MONTHLY AVERAGE WIND SPEEDS FOR GHARO**

Month	Monthly Benchmark Wind Speed				
	30m	50m	60m	67m	80m
January	4.7	5.1	5.2	5.3	5.4
February	5.1	5.4	5.5	5.6	5.7
March	5.3	5.7	5.8	5.9	5.9
April	7.0	7.3	7.4	7.6	7.6
May	8.9	9.4	9.6	9.7	9.8
June	10.3	10.9	11.1	11.2	11.3
July	8.4	8.9	9.0	9.2	9.2
August	9.3	9.8	10.0	10.2	10.3
September	7.6	8.1	8.2	8.3	8.4
October	4.3	4.6	4.7	4.7	4.8
November	3.8	4.1	4.2	4.3	4.4
December	4.6	4.9	5.1	5.2	5.3
<b>Annual Average</b>	<b>6.6</b>	<b>7.0</b>	<b>7.1</b>	<b>7.2</b>	<b>7.3</b>

Above outcomes of the study resulted in limiting the analysis for selection of best wind sites to Coasts of Sindh Province and areas of Balochistan Province near to Karachi. Wind data of such sites, collected through Pakistan Meteorological Department's met mast stations, was analyzed. Further comparison of wind speed data of selected stations in Pakistan was done.

The results achieved from this comparison reveal that Kati Bandar and Gharo have better wind speeds as compared to other coastal sites. In certain months the difference in wind speeds in these two sites as compared to other sites reaches as high as 6 meters/second at a height of 30 meters during summer months as can be seen in Figure-4 below [5].

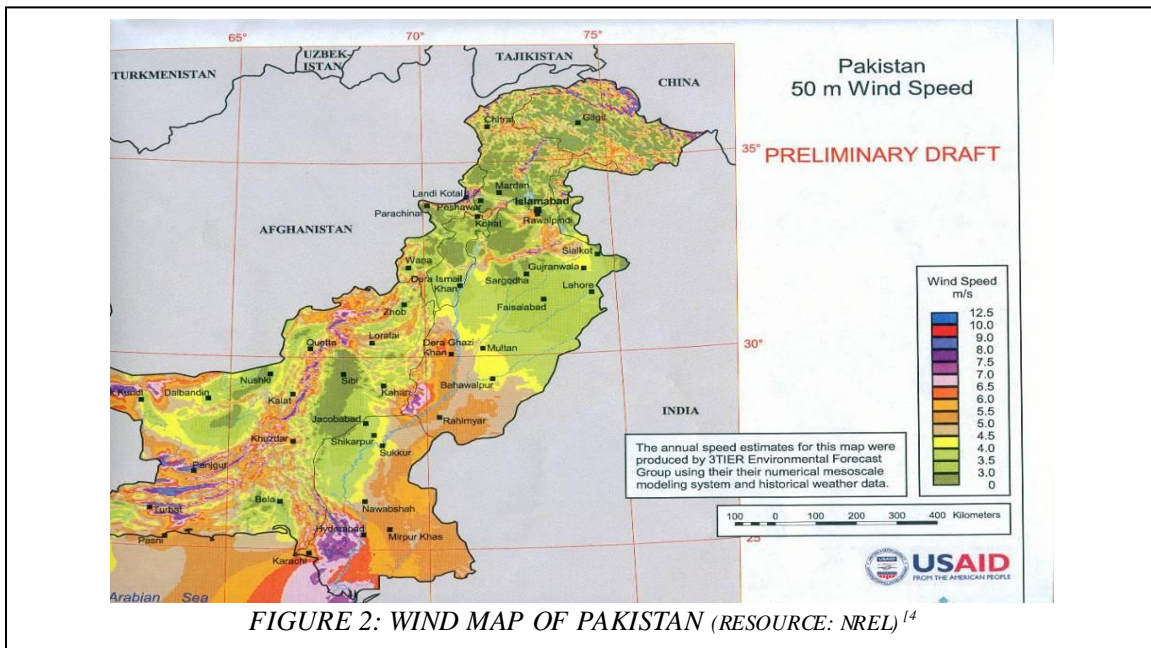


FIGURE 2: WIND MAP OF PAKISTAN (RESOURCE: NREL)<sup>14</sup>

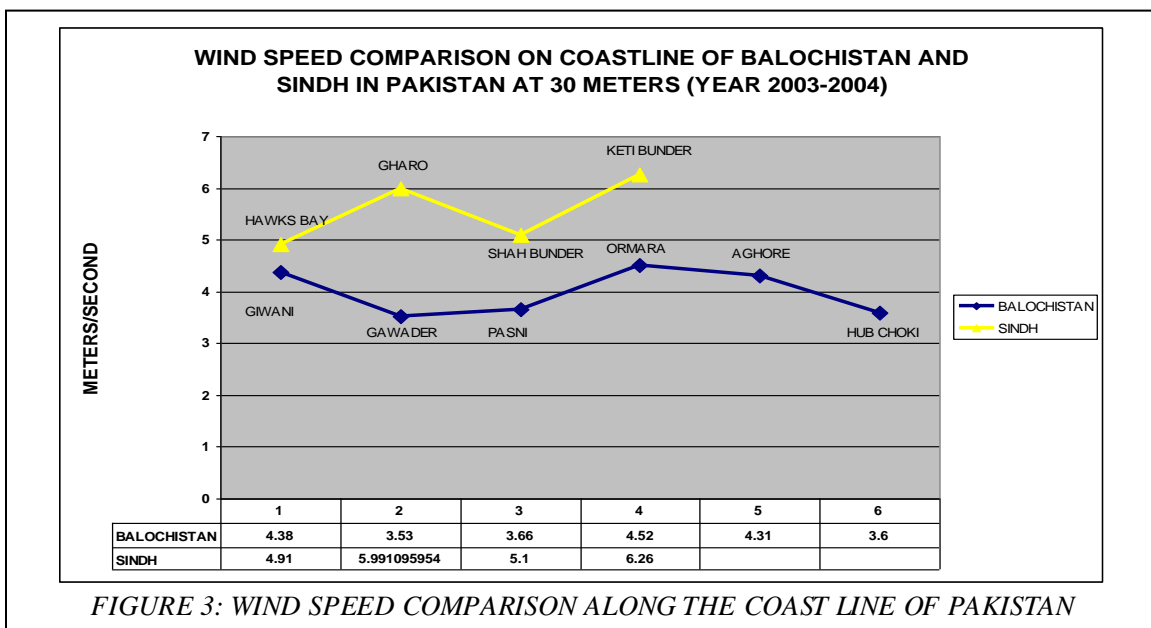


FIGURE 3: WIND SPEED COMPARISON ALONG THE COAST LINE OF PAKISTAN

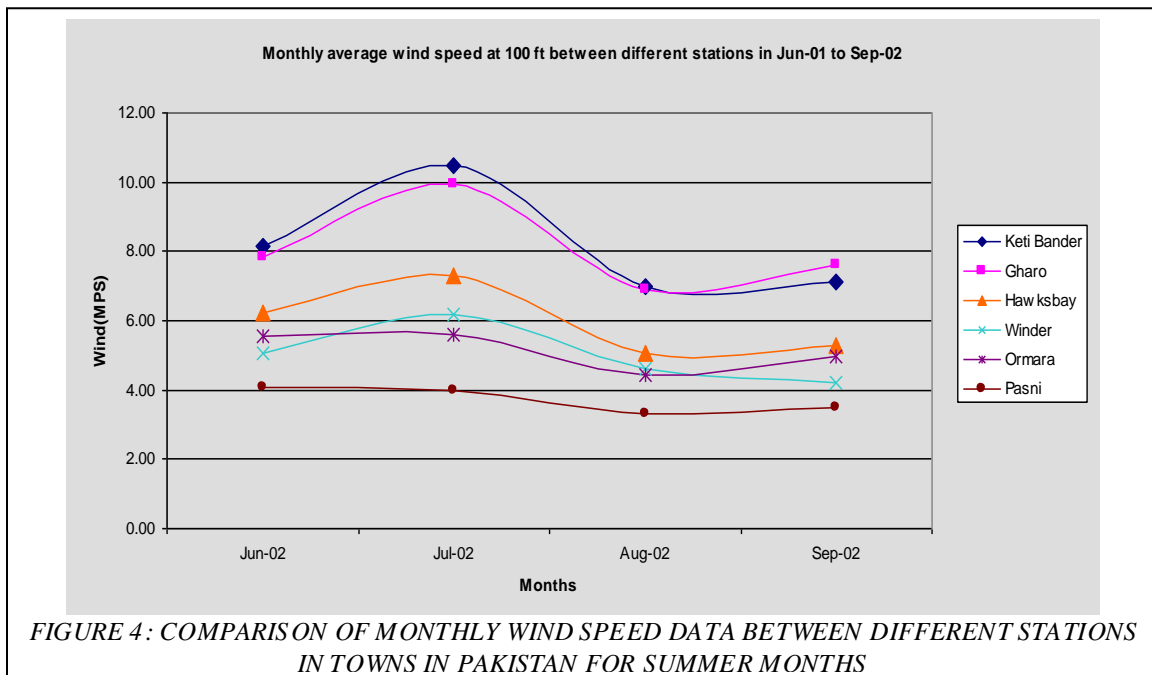
### 2.1.4 Adequate Wind Rose of the Area

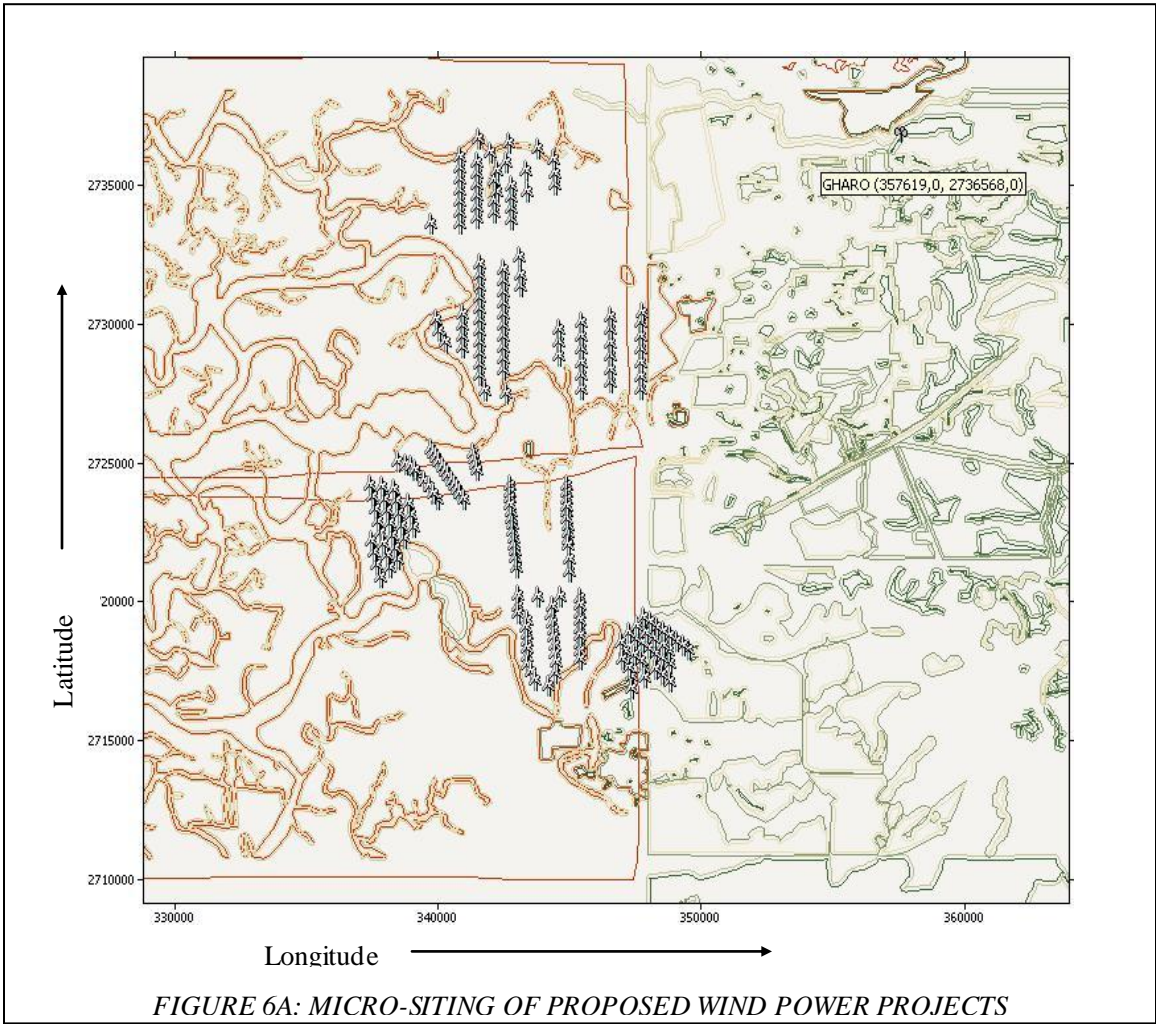
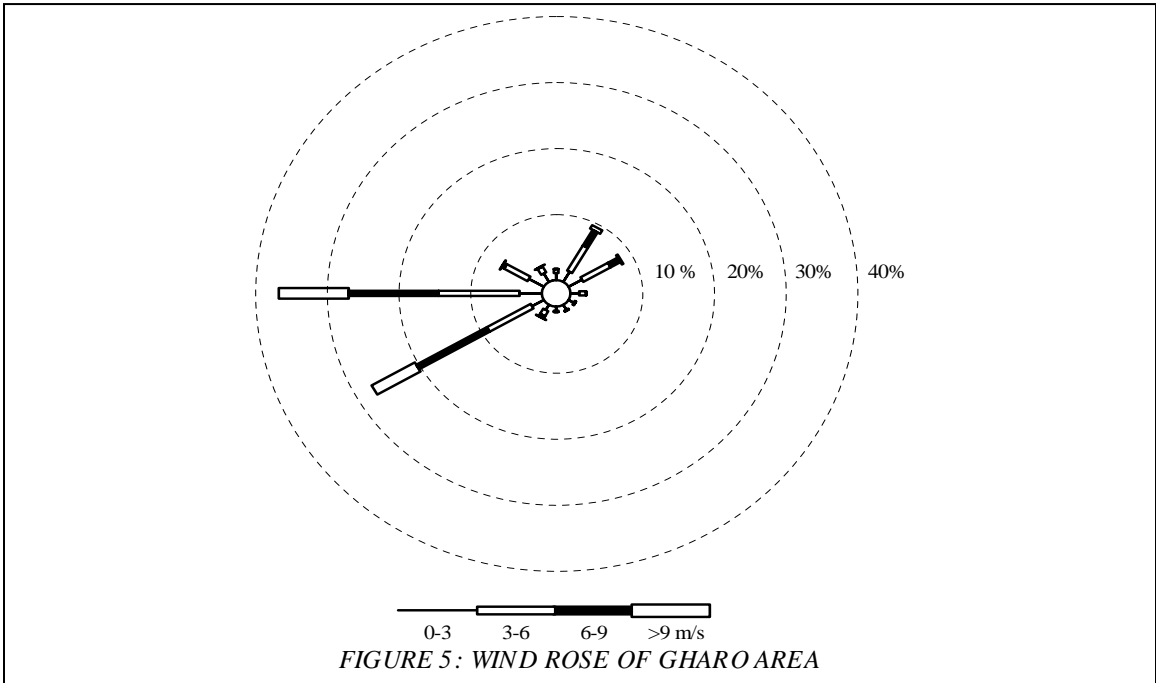
The other factor which is considered to be very essential for siting of wind farms is the direction of blow of wind. The wind direction of available data has also been determined. The most important prospect of wind speed at Gharo is that almost 70 % of the wind blows from one direction i.e. southeast direction. Wind rose developed in this regard is given at Figure-5 below <sup>[7]</sup>:

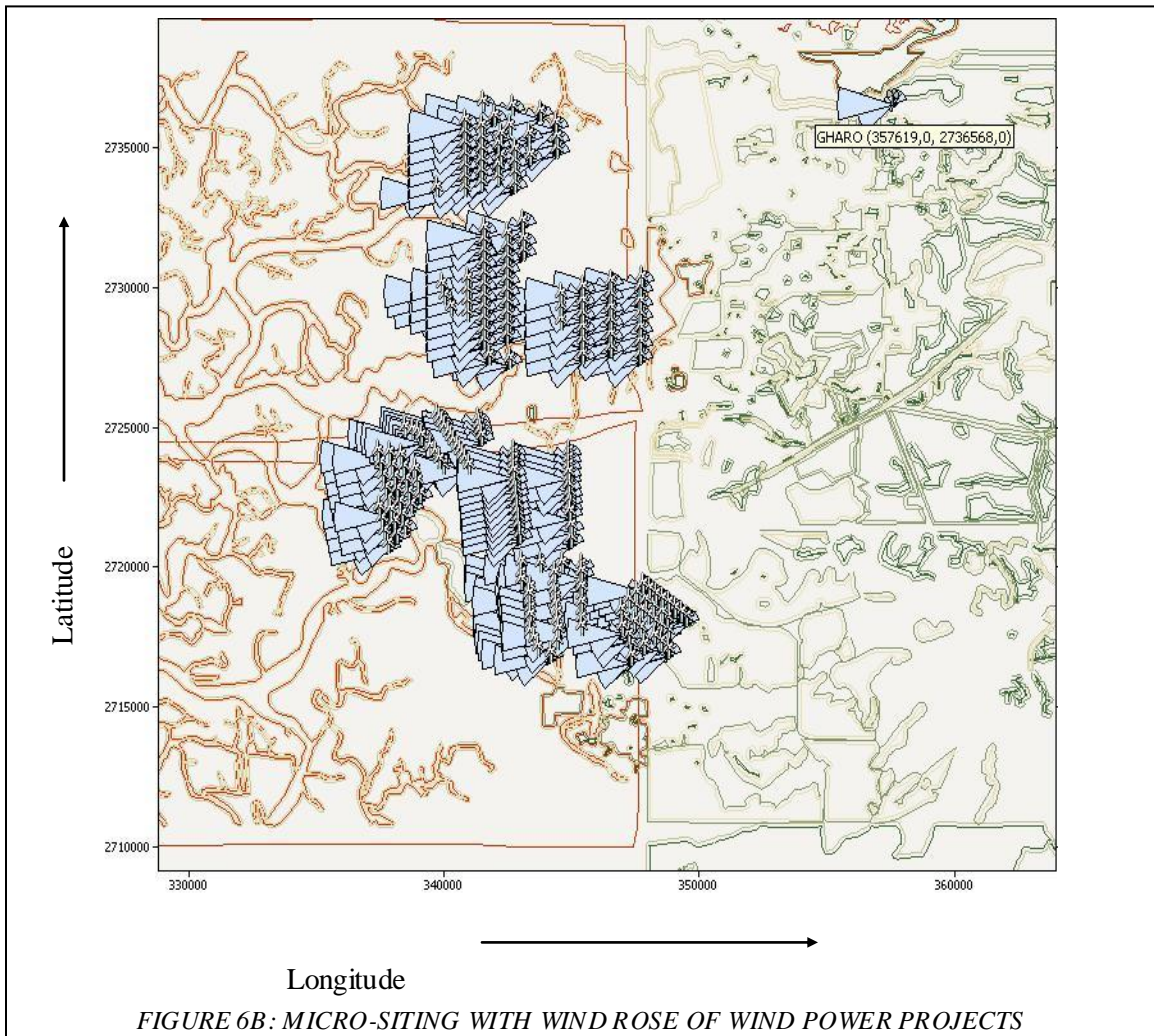
### 2.1.5 Apposite Capacity Factor

Availability wind potential in Gharo depicts that this is one of the best sites in the world that can generate power from wind. The study indicates that the average Capacity Factor that can be

attained at this site by installing wind farm power projects is 36.6% which is considered to be the best in the world. This Capacity Factor has been worked keeping in view the future upcoming projects and their cumulative wake loss. No other losses are incorporated in determining this Capacity Factor which are need to be addressed when wind power project is planned to be commissioned and should be taken care off during the feasibility analysis of wind power project. A bird view of micro siting of future planned projects in this site with their wind rose is given in figure-6a & 6b <sup>[5]</sup> below. Moreover, the capacity factor along with wake losses of these upcoming wind power projects is given in Table-2 <sup>[5]</sup> below.







**TABLE 2: CAPACITY FACTORS OF PROPOSED WIND POWER PROJECTS IN GHARO**

Site Description	Wind Farm wake losses %	Capacity Factor %	Hub Height m
Wind farm site 1	5.68	36.79	77.5
Wind farm site 2	10.6	39.45	80
Wind farm site 3	8.5	36.45	80
Wind farm site 4	11.7	36	80
Wind farm site 5	6.5	34.7	80
Wind farm site 6	6.8	35.7	80
Wind farm site 7	5.6	36.5	80
Wind farm site 8	4.19	37.6	80

**2.1.6 Absence of recorded cyclones.**

Amongst the two most suitable wind zones, Gharo and Kati Bandar reveal identical annual wind speeds as shown in Figure-7 [1]. The meteorological data has further revealed that this zone has not received any cyclone with wind speeds dangerous for wind turbines since past 50 years and based on interviews from local residents this time is estimated to be around 80 years. However Kati

Bandar is on the western edge of cyclone prone areas that hit coasts of Pakistan and India.

**2.1.7 Frequency of High wind Speed.**

The frequency of wind speed at Gharo as shown in Figure-8 [6] also shows that for most of the time wind speed is near cut-in speed of most of wind turbines and also that the wind gusts above 25 meters per second are not visible.

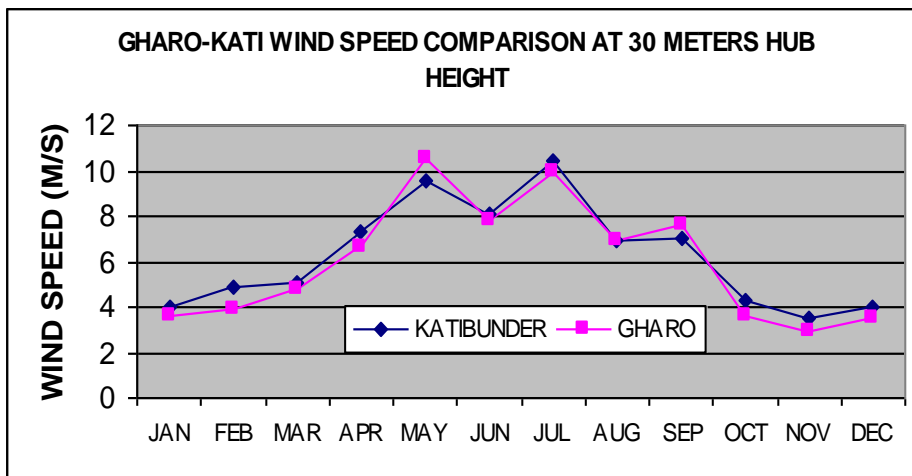


FIGURE 7: COMPARISON OF MONTHLY AVERAGE WIND SPEEDS AT 50 METERS THAT CLEARLY INDICATES THE SUITABILITY OF GHARO

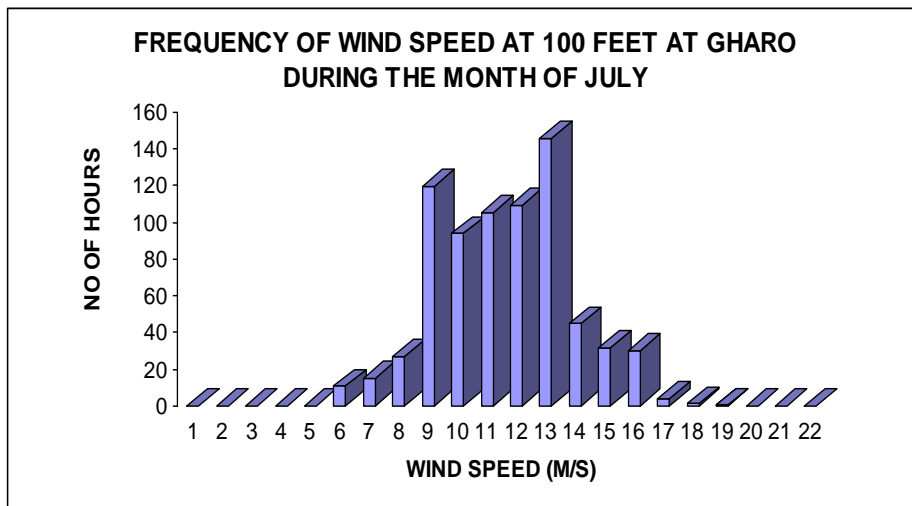


FIGURE 8: FREQUENCY OF WIND SPEED AT GHARO

### 2.2.1 Terrain and Topographical Conditions of the Area.

The terrain of the site is flat. There are no uphill and deep ditches, elevation with respect to sea level is same with minute rise. The contours are wide spread with equal levels in most parts of the area. The topography of the land is homogeneous and environment and habitat of the area are not much divergent. Vegetation cover in site is too less. Due to these facts, the land offers minimum shear and turbulence to the wind blowing from sea to inward land area [7]. This represents excellent terrain and topographical conditions for installation of wind turbines. The terrain and topographical conditions of the site can be viewed from the Figure-9 below [8]

### 2.2.2 Geographical Location of the Site.

Geographically, the site is located in such area where no developed infrastructure is available. However, site developments particularly required for wind farm projects can be done at site without disturbing the current site conditions. Moreover, population density is very rare, which minimizes all the expected negative impacts of wind power projects near to zero.

### 2.2.3 Flat open un-obstructed site.

The site selected for the wind farm is open and near creek to have no obstruction in future as shown in Figure-10. There is enough capacity to expand in future.



FIGURE 9 : VIEW OF TERRAIN AND TOPOGRAPHY OF A SITE AT GHARO



FIGURE 10: ONE OF THE PROPOSED WIND FARM SITES AT GHARO, PAKISTAN

## Grid Loading Patterns

### 2.3.1 Nearness of Load Centres.

The close vicinity of National Grid near Gharo was another major advantage. Electrical load centres were also near Gharo, especially the city of Karachi. The local power generation and

### 2.3.2 Summer Load Matching.

This wind data was simulated to 50 meters height as shown in Figure-12a [1]

distribution company also accepted the plan of power generation by wind energy and agreed to buy all power generated by Wind Energy. The demand and supply gap of Karachi Electric Supply Corporation (KESC), the only utility company in the city is shown in Figure-11 [2] that shows a gap of 400 MW to 800 MW of demand gap, and it can be seen that wind speed at this height is seldom below 4 m/s. These wind speeds match the hourly summer load in the national grid as shown in Figure-12b [2].

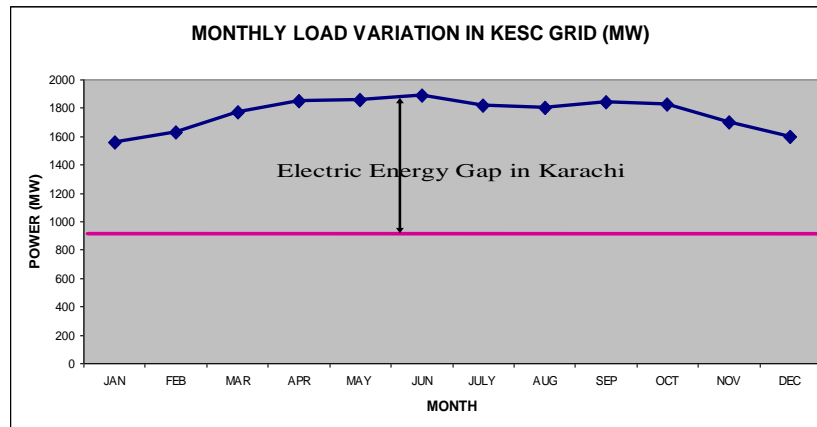


FIGURE 11: THE DEMAND AND SUPPLY GAP OF KARACHI ELECTRIC SUPPLY CORPORATION (KESC), THAT SHOWS A GAP OF 400 MW TO 800 MW.

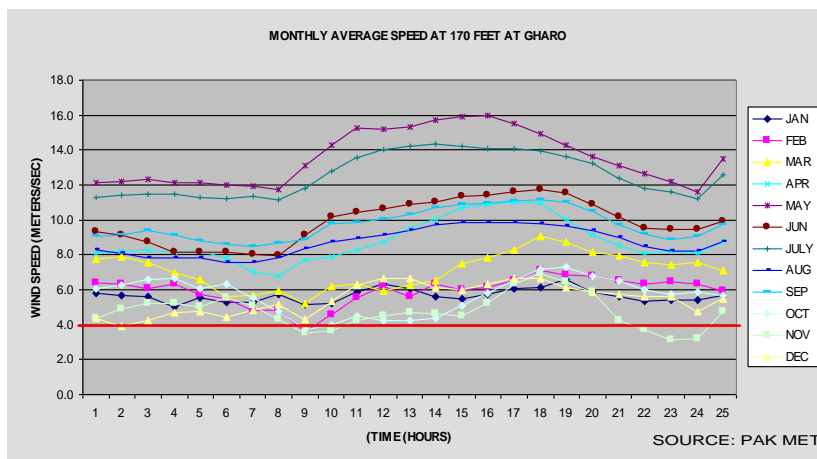


FIGURE 12A: MONTHLY AVERAGE WIND SPEED AT GHARO DURING DIFFERENT HOURS OF THE DAY

### 3. CONCLUSION.

Selection of appropriate site for any mega project like wind power project is one of the basic parameters for its success. This study gives out salient features and basic factors that are needed to be considered and addressed for selection of site for wind power project. A site like Gharo having good wind regime with appropriate wind speed data, having average capacity factor of 36.6% (determined after incorporating only wake losses), ideal land terrain and topography conditions and loading conditions in nearby grid can be graded as one of the best wind sites in the world. Availability of such a site that has resulted in registering the high wind zone is a real prospect for Pakistan to develop wind energy sector in the country. The qualities of Gharo land are a real sagacity for the investors to invest in wind energy projects in Pakistan. Alternative Energy Development Board has already initiated its activities to harness this much potential by installing wind farm projects through private investors. Based on the suitability of wind conditions and load matching in southern belt of the country the Planning Commission of Pakistan has agreed to

five year wind power generation program of 700 MW by 2010 <sup>[9]</sup> and incorporating 5 % share (i.e. 9700 MW ) in energy mix through renewable energies in vision 2030 <sup>[9]</sup>.

The basis for selection of a site for wind power project developed as of result of this study can be made a generalized criteria for identification and selection of new sites for wind power projects in the country. Even, this study can be made applicable to all the areas around the world where development of wind sector is just to start.

### 4. RECOMMENDATIONS

The parameters mentioned in this study are very much important for analyzing and selecting the site for wind power projects. These parameters should be made transformed to Standard Operation Procedure for identifying new venues and areas for initiation of wind power projects.

### ACKNOWLEDGEMENT

The data has been collected from Pakistan Meteorological Department and Karachi Electric Supply Corporation.

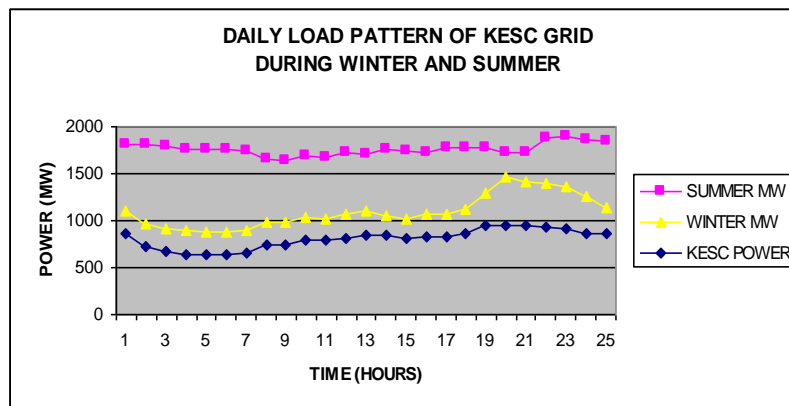


FIGURE 12B: DAILY LOAD PATTERN OF KESC GRID

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