EFFECTIVENESS OF WIND FARMS IN PAKISTAN

Hashmi, H.N.[*], Malik, N.E.[**] Yousuf, I. [***]
* Director PG Studies, Civil Engineering Department
University of Engineering & Technology, Taxila-Pakistan
drhnh@yahoo.com

** Lecturer, Civil Engineering Department
University of Engineering & Technology, Taxila-Pakistan
naeemejaz_uns@hotmail.com

*** Research Scholar, Civil Engineering Department
University of Engineering & Technology, Taxila-Pakistan
ioyousaf@gmail.com

ABSTRACT
This paper highlights the effectiveness and benefits of wind farms in the energy sector of Pakistan under current energy crises scenario. Due to the developments made in various sectors of the country, the overall energy requirement has increased to a large extent. Present power generation capacity of the country is not much sufficient to meet with this power need. This has been resulting in widening of demand – supply gap in energy sector. Country's power generating system is feeding power to the national grid mainly generated through thermal power plants, which constitute almost 68% of total power generation capacity. Due to this fact, the energy sector has become dependent over imported fossil fuels as local fossil fuel reserves are too less. This has added to the energy insecurity of the country as fossil fuel reserves are depleting and there have been an international trend of price hike of these energy resources. Moreover, the thermal power projects have come out to be very much hazardous as far as the environmental issues are concerned and are being discouraged.

The wind data of various sites collected by the Government of Pakistan and its analysis manifests that Pakistan has been blessed with a wind corridor in general area from Hyderabad to Kati Bandar having immense potential to generate thousands of megawatts of electricity. Knowing the growing energy requirement of the country, and depleting energy resources within the country and all around the world, there is dire need to diversify energy mix in the country so that dependency over imported fuel may be reduced and some percentages of power requirements may be met through indigenously available wind energy potential. Wind energy, as a 'clean' resource of energy; as there is no carbon monoxide or other environmentally damaging emissions generated by wind energy plants, its potential available in the country, and capability to become operational to feed in national grid in a minimal time, it is recommended that installation of wind farms should be jump started to supplement the present power generation capacity of the country and to meet country's energy requirements.

KEYWORDS
Energy, Wind Data, Potential, Wind Farms, Effectiveness

INTRODUCTION

Energy is considered to be a basic component of all human activities and is considered very essential for the development of human society. Till now, world's major energy requirements are being met through the fossil fuels. But due to growing concerns of environmental pollution, energy security, rising energy cost and depletion of fossil fuels, the attention of the world has been distracted towards exploring alternate energy resources that can supplement present energy demands and in near future can meet with ever increasing energy requirements. Though various renewable energy resources are being explored all around the world and has successfully being deployed for meeting the energy requirements, however, wind energy has been considered to be the most effective, promising, readily available, technically and financially most feasible and environmentally clean source of energy. Global wind power capacity has doubled over the past four years, growing from 32,000 MW at the end of 2002 to approximately 64,000[1] MW at the end of 2006—an average annual growth of almost 25%.

Currently, Pakistan has a total installed electrical generation capacity of 19,650 MW [2], nearly double that of a decade ago and constituting roughly 15% of the country's total energy supplies. The share of thermal power in the generation mix has recently seen steady growth and now accounts for almost 68% of the total supply. This trend has been accelerated through the 1990s to the beginning of the new millennium by the induction of a significant capacity (5,928 MW)[2] of independent power producers (IPPs) and captive generation by industry (over 1,500 MW)[2], which is based entirely on natural gas, furnace oil, or diesel. Other than a dwindling share of hydroelectric power where new schemes have been stalled by financial and environmental constraints in recent decades, the commercial use of renewable energy does not exist in appreciable quantities in Pakistan.

The Government of Pakistan is very much keen to commence wind farm projects in the country to meet some percentage of the national energy requirement through renewable energy technologies. For this purpose the Government urges to assess the wind energy potential in the country to identify and earmark the potential sites where such projects can be installed viably. The Government has been attracting private investments in wind energy, and has been engaging them to install and commission wind farms in potential sites. On the word of the data collected by Pakistan Metrological Department, analysis done under the scope of this paper and negotiations carried out with different ministries and departments, the coastal sites in Thatta and Hyderabad districts in Sindh Province have come out to be the most promising sites for the installation of wind farm projects on commercial basis. Salient site features and effectiveness of wind farms under prevailing energy crises scenario are discussed under following headings.

WIND ENERGY PROSPECTS

Due to rapid industrialization and modernization in all parts of the world, the energy requirements of domestic and commercial sectors are soaring above. To date, major energy requirements of the world are being met through fossil fuels. But energy statistics of presently available energy resources shows that world is facing a major energy predicament as presently explored fossil fuel reserves are running out. This new development is threatening the energy security and sustainable development of human society. Moreover, the climatic studies carried out by different environmental organizations manifest that the utilization of fossil fuels has been a major cause of climate change and environmental disasters being faced at all pars of the world. The policy makers are now seeking at to integrate the energy and environment. Due to recent developments in this regard, a trend had been developed all around the world to set up power generation projects with a minimum environmental impact. Conventional energy resources and more significantly, thermal power projects have come out to be very much hazardous as far as the environmental issues are concerned. The nations have been striding to harness and utilize such resources of energy which can meet some percentage of their energy requirements with minimal environmental hazards and within limited financial impact that would not go beyond the purchaser limit. This eventually gave rise a trend to harness renewable energy technologies

Among the renewable source of energy available today for the generation of electrical power, wind energy stands foremost because of the relatively low capital cost involved and the short gestation period required to

commission wind electrical power systems. In the overall process of utilizing wind power, two essential components of technical data are needed viz., (i) the one relating to the wind resource available, and (ii) the other relating to the engineering performance characteristics of commercially available wind electric turbines. Historically speaking, the developments in the second one have taken place more or less to match with the first one. That is, progress in the design of wind electric generator (WEG) has taken place to match with the parameters of available wind resource. In optimizing the interaction between the two components to secure maximum generation of power, the wind resource plays a very important part.

Wind energy has come to stay as an important and a viable alternate source of energy. For securing maximum output of power using a given type of wind electric generator, an assessment of the wind resource available at any prospective site is essential. The available wind resource is governed by the climatology of the region concerned and has a large availability from one location to the and also from season to season at any fixed location. Hence the need to conduct wind resource surveys becomes extremely important in national programs for exploiting wind energy. A mean annual wind speed (at 10 m and 30 m above ground) of 18 kmph and 22 kmph[3] respectively is considered as the minimum required for economic generation of electricity. Preliminary site surveys carried out in late nineties and early years of this century indicated that with this criterion, only coastal areas of Sindh and Balochistan Provinces and some northern areas possess adequate wind resources.

Knowing the growing energy requirement of the country, and depleting energy resource within the country and all around the world, the Government of Pakistan deemed to diversify its energy mix so that dependency over imported fuel may be reduced and some percentages of power requirement may be met through indigenously available renewable energy technologies. As a result of this approach, wind assessment of the country was commenced. In first phase, wind mapping of coastal areas of Sindh and Balochistan provinces was carried out. Wind data generated by meteorological services in Pakistan have their limitations: for accurate analysis, dedicated wind monitoring systems have to be installed and their data made use of. Issue of reliability of wind data collected by met services is not the focus of this paper.

Data from 20 such wind monitoring stations in Pakistan have been collected and analyzed and the salient features of the wind resource are discussed. The data collected through the respective organizations and present developments made indicate that a wind corridor as mentioned in Figure 1 below is available in the general area from Hyderabad to Kati Bandar having immense potential to generate electricity.

Figure 1: Gharo-Keti Bandar Wind Corridor [4]

The bulk of this wind resource is derived from the energy of the great southwest monsoon system which blows over the Pakistan from June to September. This wind corridor extends up to the Rajhistan Province (India) where several wind farm projects have been installed by Government of India.

WIND DATA COLLECTION

Collection of data for wind speed is one of the prime prospects of this paper. Government of Pakistan has carried out wind survey to evaluate wind energy potential in various parts of the country, to locate wind energy potential sites and to develop feasibility of resource utilization for power generation. In this connection, Ministry of Science and Technology (MoST) was assigned target to collect wind data in collaboration with Pakistan Meteorological Department (PMD) in the coastal regions of Sindh & Balochistan provinces. So far, wind resource measurements have been made at about 46 locations in Pakistan covering the coastal areas of Sindh and Balochistan provinces. The wind monitoring stations are continuously being closed down after they have operated for the stipulated periods while new ones are being installed at other locations. Under the scope this paper the wind data of 20 promising sites was collected from respective departments. The PMD has collected wind data at 10m and 30m height. The wind data generated by the sensors are electronically recorded by data loggers and transferred onto EPROM (Erasable Programmable Read Only Memory) chips. The chips after collection from the outstations are deciphered and processed by computers at Karachi. The basic parameter recorded is the average hourly wind speed which is derived by averaging sixty 2-second samples in each hour. The monthly average wind speeds at 10m height is given in Figure 2 and at 30 m height given in Figure 3 below.

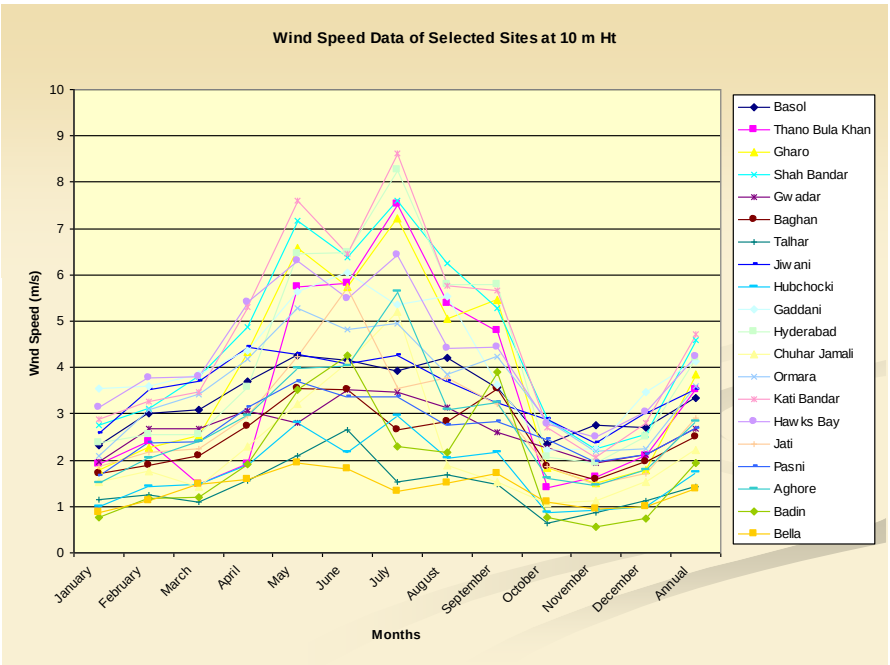

Figure 2: Wind data at 10 m height [5]

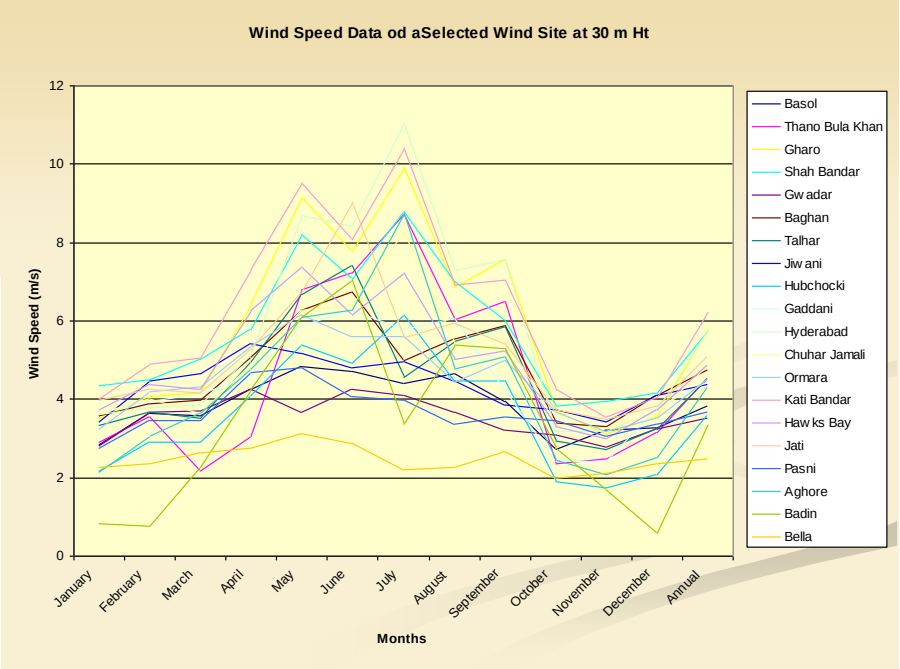

Figure 3: Wind data at 30 m height [5]

WIND DATA ANALYSIS

As mentioned above, meteorological observations from 20 offshore and coastal measurement sites have been carried out to determine wind and turbulence characteristics which will be experienced at planned offshore wind farms in coastal waters. Measurements at remote sites have also been recorded and to date, data recovery using this system has been above 95%. Though, reliability of this data is a big question due to inadequate mast erection and erroneous selection of site for recording the wind data.

The collected wind data was analyzed to find out the viability of data and feasibility of the wind farm projects under prevailing wind conditions at various sites. Different methods of estimating long-term wind resources based on short-term measurements at the sites had been evaluated and applied by the concerned departments to derive uncertainty estimates for the wind resource prediction. Given the uncertainties introduced by climate variability and extrapolation to hub-heights above the measurement height and the variability and complexity of wind and turbulence in coastal areas, there is currently no substitute for accurate on-site measurements for estimating the power production potential of individual sites.

In addition to the wind resource predictions, new analyses had been conducted on the data sets focusing on meteorology, turbulence, extreme winds and wind-wave interactions. Relationships between wind speed, turbulence and fetch are highly complex since the effect of the coastal discontinuity persists in wind speed and turbulence characteristics for considerable distances offshore. This distance has been found to extend to beyond 20 km from the coastline.

On the word of the wind data analyses, and negotiations with several stakeholders it has been evaluated that Pakistan is being blessed with such a huge wind potential that if all of it could be utilized can cater for future energy needs of the country. The reports generated by the ministries identified that in Sindh Province, district

Thatta, Karachi, Hyderabad and Badin and in Balochistan Province, district Gwadar and Makran Coastal Belt possess prospective sites for development, installation and commissioning of wind farm projects.

The market analyses of wind turbine generators (WTGs) indicate that the manufacturing industry has developed commercial WTGs of 5 MW capacity having hub height of 78 meters. The available wind potential demands that wind turbines of at least 750 kW capacity should be installed for power generation. The hub height of such turbines is nearly equal to 50m. In order to determine potential, the available wind data at 30m is being extrapolated. The results in this regard are given at Figure 4 below.

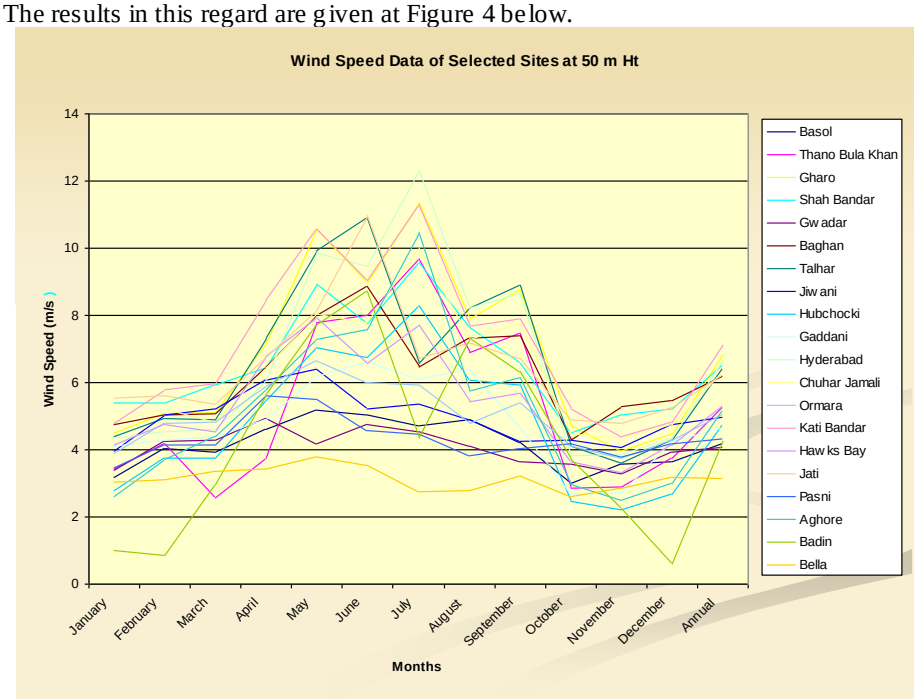

Figure 4: Wind data at 50 m height

IMPLEMENTATION OF WIND FARM PROJECTS

Designing and Implementation of a Wind Farm project is not a single job that could be managed through one Consultant or expert. It calls for specialized knowledge of Wind Energy Analyst and highly experienced Civil, Electrical and Mechanical Engineers. The first phase of engineering inputs requires preparation of Detailed Project Report (DPR) which calls for site specific data collection on: Wind, Grid and Location.

Though wind data has been collected at various sites. But in order to install wind farm at particular site, it is essential to collect site specific wind data because wind resource availability is highly site specific. It depends on several factors e.g. geographical location altitude, climatic conditions; topography etc. Wind resource may widely vary even at distance of few hundred meters. Annual average wind speed at a particular site is only an indicator. Since the power generation increases in cubic proportion with the wind speed, it is important to know the actual duration of wind speed over the year. At a particular site the wind speed would vary with the height above the ground depending on the roughness class of the site.

The other factor which is considered to be very essential for setting of wind farms is the direction of blow of wind. This parameter indicates the direction at which WTG should be commissioned so that its rotor should encounter maximum wind currents at one direction and generates maximum possible power from available potential. The wind direction of available data has also been determined. The GoP has been planning to install

first 50 MW[6] wind farm at Gharo area. The wind direction at the site has been determined and found out that maximum wind is blowing from southwest direction. Wind rose developed in this regard is given at Figure 5 below.

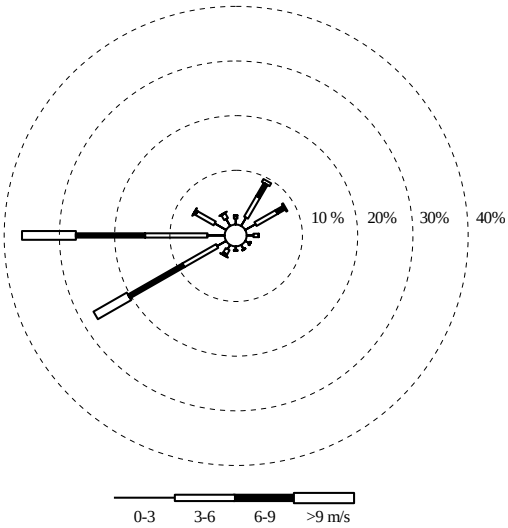

Figure 5: Wind Rose of Gharo Area

On the word of the collected that and the various developments going on, the Government has decided to commence installation of wind farm project in the Gharo, district Thatta as shown in Figure 6 below. The proposed wind farm is located in the Sindh province of Pakistan, approximately 50 km southeast of Karachi. The topography of the proposed area can be seen through at Figure 7 below. The proposed wind farm lies on a flat area of coastal terrain at approximately 2 m to 5 m above sea level. The general terrain at the site can be described as simple. Ground cover on the site is very sparse and is primarily composed of exposed earth with small scattered areas of scrubby bush. There are no major wind breaks on the site. Similar terrain is found to the north, south and west of the site. The coastline of the Arabian Sea is very irregular in this region with many channels extending inland for several kilometres. The main body of the Arabian Sea lies approximately 20 km west of the site. To the east of the site, the terrain gradually rises, and ground cover changes to become more agricultural, with some small areas of forestry.

Figure 6: Proposed Wind Farm Sites in Sindh Province [7]

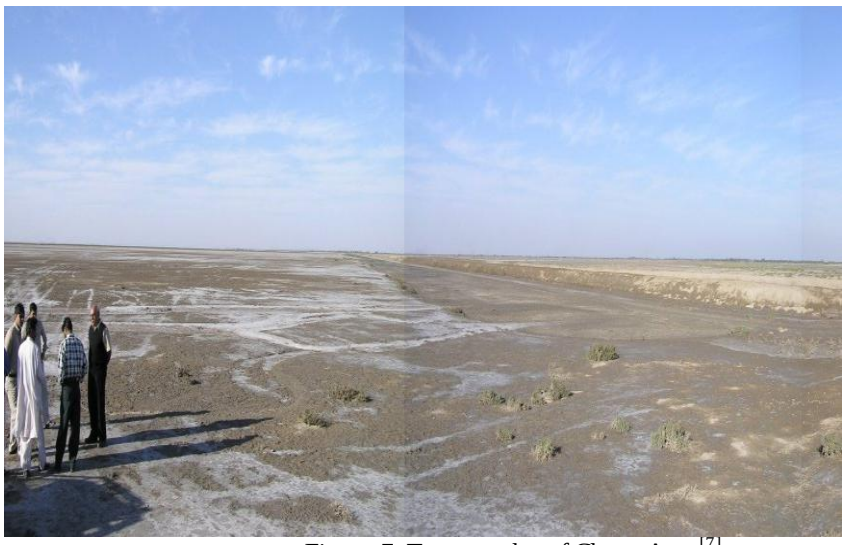

Figure 7: Topography of Gharo Area[7]

CONCLUSION

As a result of the thorough discussions and assessments it is concluded that wind energy presents a considerable opportunity for us to obtain significant part of the future energy needs from this sustainable source. The wind data collected under the scope of this project envisages that Pakistan has been blessed with enormous wind energy potential. Availability of such an appropriate wind resource gives us an opportunity to utilize this indigenous resource for mega scale projects in the potential sites of the country. If the opportunity is to be maximized, then we must ensure that the developments are taken forward with care and sensitivity so that both public and political support is maintained. Whilst the economics of wind energy already attractive if the full cost of electricity generated is considered.

It is vital that the general public and politicians should be properly educated for the benefits of wind energy and the message that came out as a result of this study should be disseminated widely. The message is that the wind energy is abundant, sustainable, clean, safe, economically competitive and creates jobs. Wind energy is ranked the number one in the world with a great potential of development in future. The development of an ambitious plan and implementation of wind farm projects in Pakistan would result in acquiring full benefits of the energy resource available in the country. It would facilitate the development of this technology in local industry which consequently will create more employment opportunities and economical activities in remote areas. Wind farms will help reducing environmental consequences due to reduction in dependency over fossil fuels for power generation.

AKNOWLEDGEMENT

Thanks to Alternative Energy Development Board and Pakistan Metrological Department for the data and information used in this study.

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